



FIELD SAMPLING PLAN

APPENDIX J

SOUTH DAYTON DUMP AND LANDFILL SITE MORaine, OHIO

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1.0 INTRODUCTION

This Field Sampling Plan (FSP) was prepared for the South Dayton Dump and Landfill (Site) in Moraine, Ohio by Conestoga-Rovers & Associates (CRA). CRA has prepared this FSP on behalf of the South Dayton Dump and Landfill Potentially Responsible Party Group (PRP Group).

The purpose of this FSP is to detail the sampling and data gathering activities to be used at the Site and to outline the procedures to be used to complete the field activities at the Site. The field activities to be completed were detailed in Letter Work Plans, which were previously submitted to the United States Environmental Protection Agency (USEPA). The following Letter Work Plans have been submitted to USEPA¹:

- Land Survey, Bathymetry Survey, and Geophysical Investigation Letter Work Plan (CRA, May 9, 2008)
- Leachate Seep Investigation Letter Work Plan (CRA, May 6, 2008)
- Test Pit/Test Trench Investigation Letter Work Plan (CRA, May 9, 2008)
- Landfill Gas/Soil Vapor Investigation Letter Work Plan (CRA, July 21, 2008)
- Groundwater Letter Work Plan (CRA, May 7, 2008)
- Shallow Groundwater Work Plan (CRA, December 17, 2010)
- Vapor Intrusion Investigation Work Plan (CRA, December 17, 2010)

The investigative tasks to be completed are discussed in detail in the individual Letter Work Plans. The above-referenced Letter Work Plans are provided as Appendix J-A through J-E, Appendix J-I, and Appendix J-J of this FSP.

The FSP incorporates comments received from USEPA on January 29, April 23, July 7, August 5, 21, and 28, and September 16, 2008.

¹ The PRP Group submitted a draft Remedial Investigation/Feasibility Study (RI/FS) Work Plan to USEPA in January 2007. USEPA provided the PRP Group with draft comments on the draft RI/FS Work Plan and the draft FSP in January 2008. The PRP Group and USEPA met in January, February, and March 2008 to discuss USEPA's proposal to implement a presumptive remedy for the on-Property portions of the Site and complete a conventional RI/FS for the off-Property portions of the Site. Through those discussions USEPA agreed to consider a series of Letter Work Plans (described in the text and included as Appendices J-A through J-E) that would serve to assess the components of a potential presumptive remedy for the Site and to produce information that could be used in a streamlined FS for portions of the Site. This FSP has been revised to address USEPA comments on the January 2007 draft FSP and to reflect the scope of work described in the final Letter Work Plans. The FSP also details the procedures to be used for investigative work that might reasonably be expected to be completed in the future.

1.1 ASSOCIATED DOCUMENTS

All activities discussed in this FSP will be performed in accordance with the Quality Assurance Project Plan (QAPP, CRA, May 2008) and Health and Safety Plan (HASP, CRA, May 2008) and HASP addendum update regarding Site trailer decontamination and cleaning and locating the trailer on-Site (CRA, August 2008).

1.2 PROBLEM DEFINITION/BACKGROUND INFORMATION

The purpose of the investigative activities and background information for the Letter Work Plans are presented in the following sections.

1.3 SITE DESCRIPTION

The Site background and physical setting are summarized in the following sections. The Site location is shown on Figure J-1.1. A layout of the Site, including Site buildings, surface water features, and Site and parcel boundaries, is provided on Figure J-1.2.

The Site is located at 1901 through 2153 Dryden Road and 2225 East River Road in Moraine, Ohio. The Site is bounded to the north and west by the Miami Conservancy District (MCD) floodway, the Great Miami River (GMR) Recreational Trail and the GMR beyond, to the east by Dryden Road and light industrial facilities beyond, to the southeast by residential and commercial properties with East River Road and a residential trailer park beyond, and to the south by undeveloped land with industrial facilities beyond. The Site has been defined in the Statement of Work (SOW) dated March 13, 2006, which is attached to the Administrative Settlement Agreement and Order on Consent (ASAO), as an area of approximately 80 acres, including the Valley Asphalt plant in the northernmost portion of the Site, an auto salvage yard in the southeast and a gravel pit/quarry pond in the southern part of the Site. The central 40 acres (described as 23 acres in some documents) of the Site were referred to as the South Dayton Dump and Landfill in some reports. More recent information including a map in Montgomery County Health District (MCHD) files, soil boring logs, drums found at Valley Asphalt, USEPA's air photo analysis, underground storage tank (UST) closure reports, and the deposition of Horace Boesch Jr. indicate that landfilling and/or other waste disposal/handling activities occurred across most of the Site.

Chemicals detected at the Site during previous investigations include, but are not limited to, arsenic, barium, nickel, lead, copper, polyaromatic hydrocarbons (PAHs),

polychlorinated biphenyls (PCBs), and chlorinated solvents. Five drums, which contained material that was classified as characteristically toxic for cadmium and lead and contained compounds including, but not limited to, PCBs, benzene, toluene, ethylbenzene, and xylenes (BTEX), and trichloroethene (TCE), were found at the Site and removed in 2000. Records also indicate asbestos waste was disposed at the Site.

A heavily vegetated man-made embankment, which according to Jack Boesch (February 2006 deposition of Horace (Jack) Boesch, Horace Boesch's son), was constructed of fill materials by the Site owners/operators, is present along the northern and western boundary of the northern (Lot 5054) and central (Lot 5177) portions of the Site along the GMR. Portions of the berm are located on the MCD property. The grassy area between the berm and the GMR is part of the 100-year floodway and is owned by the MCD. The topography of the Site is fairly variable, with a depressed area in the west-central portion of the Site, several mounded areas of fill, a ravine along the south-central part of the Site², and a low-lying area along the entire southern portion of the Site. An unpaved access road oriented east-west extends from the undeveloped City of Moraine Road Allowance through the center of the Site. Portions of the Site are within the 100-year floodway and the majority of the Site south of the Valley Asphalt property is also within the 100-year flood plain. Historic accounts from the landfill operator indicate that portions of the Site have flooded. The extent of flooding is not known; however, a 1959 aerial photo shows the extent of Site flooding during one event.

The Site has a fence around the majority of the central 25 acres (Lot 5177) while separate fencing encompasses most of the northern and southern parcels that are within the Site boundary. The south and western portions of the Quarry Pond are not fenced and there is not a fence between Valley Asphalt and the MCD floodway/recreational trail.

With the exception of Lot 3274, the entire Site is zoned 'M-2 General Industrial'. Lot 3274 is owned by MCD and is zoned 'C- Conservation'. Properties located adjacent to the Site, including the MCD property between the Site and GMR and the properties located between the Site and East River Road, are also zoned 'M-2 General Industrial' with the exception of the southern half of Lot 3275 which is zoned 'C-Conservation'. Properties located to the east of the Site, on the east side of Dryden Road, are zoned 'M-2 General Industrial', while properties southeast of East River Road and west of Dryden Road are zoned 'M-1 Light Industrial'.

2 The ravine is mentioned in several historic reports; however, the ravine was not observed during the CRA Site Inspections in November 17 and 18, 2005 and September 5, 2006. Part of the ravine is visible in the Preliminary Topographic Map, CRA, June 2008. The ravine is included in the discussion of the Site topography in accordance with USEPA comment SR-41 on the Preliminary Remedial Action Objectives Technical Memorandum (USEPA, November 7, 2006).

The property to the south of the Site, Lot 3264, is located adjacent to and south of Lot 3274 and is divided into three sections. The two portions of Lot 3264 that are immediately adjacent to Lot 3274 are owned by the Montgomery Board of County Commissioners. These two portions are zoned 'C- Conservation' and are used for a sewer lift station and a sewer right-of-way. The third portion of Lot 3264, which is approximately 19 acres in area and is wooded and undeveloped, is owned by the City of Moraine, and is zoned 'C- Conservation'. However, CRA understands that Scott Young of the City of Moraine Zoning Department has indicated to USEPA that the City of Moraine intends to change the zoning of the 19-acre portion of Lot 3264 to 'M-2 General Industrial'.

1.4 LAND USE

A summary of the local land use in the vicinity of the Site was obtained from reviewing the 1991 Dayton South, Ohio 7.5-minute United States Geologic Service (USGS) topographic quadrangle map. The local land use information was updated based on visual observations made during Site inspections in November 2005 and September 2006 and a review of recent aerial photos. Local land uses have been verified in part through visits to the Site and surrounding areas. Local land use in the one square mile that encompasses the Site consists of a mixture of residential, commercial, industrial, recreational, and transportation uses.

Residential properties are located more than 1,500 feet north of the Site beyond the opposite bank of the GMR. A small trailer park is located 200 feet east-southeast of the Site across Dryden Road. Seven residences bound the Site to the southeast along East River Road. Commercial and industrial properties bound the Site to the east and south, including a Dayton Power and Light (DP&L) maintenance facility. Additional commercial and industrial properties are located on the opposite bank of the GMR to the northeast, north, northwest, west, and southwest. The Montgomery County Sewage Disposal facility is located along the opposite bank of the GMR, southwest of the Site. Small and large cemeteries are located beyond the opposite bank of the GMR, to the northwest, and beyond I-75 to the east-southeast. Mineral extraction has occurred on properties beyond I-75 to the southeast.

Recreational and open space land uses occur along the banks of the GMR, which meanders northeast, north, northwest, west, and southwest of the Site. A hiking and biking trail is present on the north and west Site boundaries. A golf course is located west of the Site beyond the opposite bank of the GMR. Interstate highway I-75 is

present northeast, east, and south of the Site. Railroads are present east and west of the Site and various roadways are present surrounding the Site.

Properties located between the Site and East River Road, while zoned General Industrial (see Section 1.3), include a mix of residential dwellings and commercial operations. The residential dwelling on Lot 3253 backs on to an automotive repair shop. All of the other residential dwellings back on to an auto salvage yard, two lots of which are within the Site boundary (Lot 3753 and Lot 4423). A residential trailer park is located across Dryden Road, and south of the DP&L maintenance facility on Lot 2943, which is zoned 'M1 - General Industrial'. Other than these residences, properties located to the south and to the east of the Site are used for warehousing, manufacturing, commercial uses, and fuel dispensing.

1.5 SITE HISTORY

Information on the Site history is contained within USEPA, Ohio EPA, and MCHD files for the Site and on available historical aerial photographs and topographic maps (collectively referred to as file materials). The Payne Firm, Inc. (PFI) conducted a review of the Ohio EPA and the MCHD files in 1998. CRA completed further file reviews in November 2005 and December 2006.

Cyril Grillot and Horace Boesch acquired interests in portions of the approximately 40-acre central portion of the Site (Lots 5171, 5172, 5173, 5174, 5175, 5176, and 5177) starting in 1936. The properties to the north (currently Valley Asphalt), the vacant land and Quarry Pond to the south (Lot 5178 and lot 3274) and the property east of the Quarry Pond (Lots 3753, 4423 and 4610) were also owned by Grillot and Boesch. The land to the north (Lot 5054) was purchased by Horace Boesch in 1945 (a half interest was subsequently transferred to Cyril Grillot in 1951) and sold to Valley Asphalt in 1993. The Site was used for agricultural purposes in the 1930s and then as a sand and gravel quarry.

Cyril Grillot's brother, Alcine Grillot, began a landfill operation at the Site in the early 1940s. Landfill operations continued in the central portion of the Site until the death of the landfill's operator, Alcine Grillot, in 1996. The current owners of the properties located within the Site are Valley Asphalt, Jim City Salvage, MCD, Ronald Barnett, Kathryn A. Boesch, and Margaret C. Grillot. The northern portion of the Site is owned by Valley Asphalt.

1.6 PREVIOUS INVESTIGATIONS

The purpose of this section is to present a discussion of previous investigations related to the Site. This background information is required to support subsequent sections of this FSP and the Letter Work Plans that discuss the work to be performed (Section 2.0).

The following investigations have been conducted at the Site since 1985:

- Ohio Environmental Protection Agency (Ohio EPA), 1985, Preliminary Assessment for the South Dayton Dump and Landfill.
- Ecology and Environment, Inc. (EEI), 1991, Screening Site Inspection Report for South Dayton Dump, Moraine, Ohio. Prepared by EEI on behalf of USEPA.
- PRC Environmental Management, Inc. (PRC), 1995, Focused Site Inspection Prioritization Site Evaluation Report for the South Dayton Dump.
- PSARA Technologies, Inc. (PSARA), 1996, Installation of Groundwater Monitoring Wells at the South Dayton Dump, Moraine, Ohio. Prepared by PSARA on behalf of Ohio EPA.
- Ohio EPA, 1996, Site Team Evaluation Prioritization Report, South Dayton Dump and Landfill.
- PFI, 1998-2005. Groundwater monitoring well installations, groundwater sampling, analyses, and water level measurements.
- TCA Environmental, 2000, Environmental Remediation Report at Valley Asphalt. Prepared for Valley Asphalt.
- Memo from Ohio EPA to USEPA dated January 24, 2006, regarding "South Dayton Dump, Valley Asphalt Reconnaissance Brief".

Figure J-1.3 shows the locations of the existing groundwater monitoring wells installed at and around the Site. Figure J-1.4 shows the locations of the historical boreholes installed at and around the Site and the soil samples collected as part of the investigations listed above.

1.6.1 1985 OHIO EPA PRELIMINARY ASSESSMENT (PA)

The 1985 Ohio EPA investigation, which consisted of an aerial inspection of the Site and interviews, made the following conclusions and recommendations:

- the presence/disposal of hazardous chemicals at the Site posed a potential threat to groundwater beneath the Site and to the GMR
- groundwater flow is to the west toward the GMR³
- the Site was rated as a high priority for State and Federal action and the installation of groundwater monitoring wells was recommended

1.6.2 1991 EEI SCREENING SITE INSPECTION (SSI)

The 1991 EEI SSI investigation was completed on behalf of USEPA. The SSI consisted of the collection and analysis of surface and subsurface soil samples from the Site.

EEI collected nine surface and two subsurface (one-foot depth) soil samples and analyzed the soil samples for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PAHs, PCBs, and metals. EEI concluded that the soil samples contained these analytes at concentrations greater than background concentrations. Analytical results are presented in Table 2.2 of the draft RI/FS Work Plan (CRA, January 2007) and are summarized as follows:

- 1) *Chlorinated solvents (200 µg/kg [micrograms per kilogram] 1,2-DCE [1,2-dichloroethene], 4 µg/kg TCE and 11 µg/kg PCE [tetrachloroethene]) in surface soil sample S8 in eastern central area of Site on north side of ravine.*
- 2) *Highest levels of PCBs (4.2 mg/kg [milligrams per kilogram] Aroclor 1248 and 2.8 mg/kg Aroclor 1260 in surface soil sample S2 at edge of water-filled Large Pond and in vicinity of area where Alcine Grillo reportedly dismantled transformers from DP&L.*
- 3) *Highest SVOCs and PAHs in surface soil sample S3 south of north access road in center of Site near deteriorated drum (90 mg/kg total SVOCs) and S6 along western edge of central Site area 450 to 500 feet east of river (95 mg/kg total SVOCs).*
- 4) *Highest levels of inorganic chemicals generally in S3 and S8 (lead as high as 3,300 mg/kg, copper as high as 2,200 mg/kg, cadmium as high as 14 mg/kg, mercury as high as 0.31 mg/kg, and nickel as high as 402 mg/kg).*
- 5) *Highest level of arsenic in S9 (69 mg/kg) in central area of Site north of ravine.*
- 6) *Elevated OVA [organic vapor analyzer] readings detected near opening of former air curtain destructor.*

³ Based on CRA's review it appears that this determination was not made on the basis of monitoring well information — no wells were present at the time. Subsequent information collected by others during water level monitoring at new wells conflicts with this interpretation.

The locations of the samples shown on Figure J-1.4 are based on scanned copies of the report. Survey data for these sample locations are not available.

1.6.3 1995 PRC FOCUSED SITE INSPECTION PRIORITIZATION (FSIP)

The 1995 FSIP consisted of a Site inspection, a review of available information and evaluation of the potential threat to human health and the environment posed by the Site, and the development of recommendations to assess the Site further. The FSIP recommended the installation and sampling of groundwater monitoring wells and the collection and analysis of surface water samples.

1.6.4 1996 PSARA MONITORING WELL INSTALLATION

The 1996 PSARA report was completed on behalf of Ohio EPA. PSARA installed seven soil borings and temporary monitoring wells along the south-central, southwestern, western, and northwestern portions of the Site. PSARA collected soil samples for lithologic description and field screening. Methane was detected in the sample headspace at five boring locations. PSARA reported that a flame ionization detector (FID) reading of over 1,000 parts per million (ppm) was measured at one location.

The investigation included the collection of groundwater samples from the soil borings/temporary monitoring wells. The groundwater samples were analyzed for VOCs. The concentrations of all VOCs detected were below federal maximum contaminant levels (MCLs) for drinking water.

PSARA also installed three permanent groundwater monitoring wells in locations that were based on access constraints and the presumed historical groundwater flow direction. A monitoring well at the DP&L maintenance facility to the east of the Site was also utilized and considered a background location, but its location was not surveyed. The stratigraphic and instrumentation logs for these monitoring wells are provided in Appendix B of the draft RI/FS Work Plan (CRA, March 2007).

Boring logs for PSARA borings SD-001 to SD-007 included the following observations:

SD-001

This boring was installed to the northeast of the Quarry Pond, just north of the access road. Soil logs indicated six inches of soil over four inches of asphalt and eight inches of

brown silty clay with brick fill material. Green to gray staining and a faint hydrocarbon odor were noted in brown silty clay with small gravel at 8 to 10 feet below ground surface (ft bgs). No headspace readings were collected until the 14 to 16 ft bgs interval. The highest headspace readings for organic vapors including methane were 280 ppm for the 14 to 16 ft bgs interval, 160 ppm for the 16 to 18 ft bgs interval and 300 ppm for the 18 to 20 ft bgs interval. These headspace readings were detected in sand and sand and gravel with some clay/silt. The water table was observed at a depth of 12 ft bgs. TCE (4.5 micrograms per liter [$\mu\text{g/L}$]), 1,1-DCE (0.5 $\mu\text{g/L}$), benzene (1.2 $\mu\text{g/L}$) and toluene (1.5 $\mu\text{g/L}$) were detected in the groundwater sample collected from 19 ft bgs. Similar concentrations of these chemicals, along with 0.9 $\mu\text{g/L}$ of 1,2-dichloroethane (1,2-DCA), were detected in the second groundwater sample collected at 34 ft bgs.

SD-002

This boring was installed just north of the east-west access road, 450 feet east of SD-001. The soil boring log indicated black mottling, glass, and other debris fragments at 0 to 4 ft bgs, rusty brown mottles and streaks at 12 to 14 ft bgs. The highest headspace readings for organic vapors, including methane, were as follows: 400 ppm for the 20 to 22 ft bgs interval, 180 ppm for the 22 to 24 ft bgs interval and 160 ppm for the 24 to 26 ft bgs interval. These headspace readings were detected in gravel, sand and silt, and sand with clay and gravel. The water table was observed at 12 ft bgs. Groundwater samples were collected from the 22 and 32 ft bgs intervals. The groundwater sample collected from 22 ft bgs contained concentrations of 1,1-DCE (1.2 $\mu\text{g/L}$), cis-1,2-DCE (0.9 $\mu\text{g/L}$), benzene (0.8 $\mu\text{g/L}$), toluene (1.9 $\mu\text{g/L}$), and 1,2-DCE (0.5 $\mu\text{g/L}$). The groundwater sample collected from 32 ft bgs contained similar concentrations but also contained 0.9 $\mu\text{g/L}$ of vinyl chloride (VC).

SD-003

This boring was installed north of the northwest corner of the Quarry Pond. The soil boring was terminated at 6 ft bgs due to the presence of buried waste. A headspace reading of 540 ppm [comparison of FID and photoionization detector (PID) readings indicated mostly methane] was measured in very sticky black to brown sand with black-stained silt and clay in the 2 to 4 ft bgs interval. No groundwater samples were collected.

SD-004/004A

These borings were installed west of the north access road approximately 200 feet north of SD-003. The water table was observed at a depth of 12 ft bgs. Groundwater samples

were collected from 23 and 28 ft bgs. The groundwater sample collected from 23 ft bgs contained TCE (1.5 µg/L), 1,2-DCA (0.9 µg/L), benzene (0.8 µg/L), toluene (2.4 µg/L), ethylbenzene (0.8 µg/L), 1,2,4-trimethylbenzene (0.6 µg/L), o-xylene (0.5 µg/L), and m,p-xylenes (1.2 µg/L). The groundwater sample and duplicate sample collected at 28 ft bgs contained TCE (2/2.2 µg/L), 1,2-DCA (ND(0.5)/0.8 µg/L), benzene (0.6/0.5 µg/L), toluene (1.5/1.5 µg/L) and m,p-xylenes (0.7/0.7 µg/L).

SD-005

This boring was installed to the west of the north access road, approximately 50 feet west of the southwest corner of the concrete pad west/southwest of the air curtain destructor (ACD). The water table was observed to be at 18 ft bgs. Groundwater samples were collected from 28 and 43 ft bgs. The groundwater sample collected from 28 ft bgs contained benzene (0.7 µg/L), toluene (2.1 µg/L), m,p-xylenes (0.9 µg/L), and ethylbenzene (0.6 µg/L). The groundwater sample collected from 43 ft bgs contained benzene (1.6 µg/L), toluene (2.9 µg/L), m,p-xylenes (0.9 µg/L), ethylbenzene (0.7 µg/L), TCE (2.4 µg/L), 1,2,4-trimethylbenzene (0.5 µg/L), and o-xylene (0.7 µg/L).

SD-006/006A/006B

These three two to six foot deep borings were installed north of the northern access road and between 50 and 100 feet north-northwest of the ACD. Black slag-rich fill with cinders, ash, burnt wood fragments, and debris was encountered in all three borings. SD-006 was abandoned at 4 ft bgs due to headspace readings of 500 ppm (FID/PID comparison indicated mostly methane). Headspace readings of 1,000 ppm in the 2 to 4 ft bgs interval and in the 4 to 6 ft bgs interval were measured for SD-006A. SD-006B was abandoned at 2 ft bgs due to the presence of a strong organic odor. The water table was not encountered; therefore, no groundwater samples were collected.

SD-007

This boring was completed 75 feet northeast of the northeast corner of the former ACD. The boring was completed at 14 ft bgs. Soils encountered included fill containing slag, cinders, burnt wood, ash, glass, and black sand down to a depth of 12 ft bgs. The headspace readings (FID/PID comparison indicated mostly methane) were 100 ppm for the 8 to 10 ft bgs interval and 300 ppm for the 10 to 12 ft bgs interval. The water table was not encountered; therefore, no groundwater samples were collected.

PSARA collected one round of groundwater samples from each of the above temporary wells where groundwater was encountered. The groundwater analytical data, including

analytical parameters, are summarized in Table 2.5 of the draft RI/FS Work Plan. These data were consistent with the results of analyses of the groundwater samples from the existing monitoring wells.

1.6.5 1996 OHIO EPA SITE TEAM EVALUATION PRIORITIZATION (STEP)

The 1996 Ohio EPA STEP investigation was completed to determine if previous waste disposal at the Site had impacted the environment. The STEP included the following activities:

- review of Site background, setting, and hydrogeology
- collection of twelve soil samples (including one duplicate and one background), six sediment samples (including one duplicate), and five groundwater samples (including one duplicate and one background)

The complete results for the STEP sample program are provided in Tables 2.2 and 2.3 of the draft RI/FS Work Plan and summarized below:

Soil Sample S01

This subsurface soil sample was collected 4 to 4.5 ft bgs in a former drum area near the north-central area of Site (south of north access road and east of central north-south access road). Analytical results indicated PCE at a concentration of 59 µg/kg and other chemical concentrations.

Soil Sample S10

This surficial soil sample was collected from a depth of 0 to 4 inches bgs in an area of drums just to the south of the ACD. The sample contained TCE (11 µg/kg), cadmium (16.3 mg/kg), copper (191,000 mg/kg), lead (12,100 mg/kg), nickel (139 mg/kg), silver (7.6 mg/kg), zinc (11,500 mg/kg) and other chemical concentrations.

Soil Sample S11

This soil sample was collected from 3 to 4 inches bgs in the ravine located to the west of Lot 5175. The sample contained SVOCs (10.2 mg/kg), lead (252 mg/kg), and low concentrations of other inorganic chemicals.

Soil Sample S08

This surficial soil sample was collected near drums that were found along the western slope of Lot 5177 towards the GMR. The sample contained methylene chloride (16 µg/kg), SVOCs (12.2 mg/kg), Endosulfan II (5.4 µg/kg), and metals including, but not limited to, aluminum (14,300 mg/kg), antimony (278 mg/kg), arsenic (141 mg/kg), barium (13,000 mg/kg), chromium (62 mg/kg), copper (1,830 mg/kg), iron (59,500 mg/kg), lead (652 mg/kg), nickel (78.1 mg/kg), zinc (286 mg/kg), and cyanide (2.3 mg/kg).

Soil Sample S09

This surficial soil sample was collected near drums along western slope of Lot 5177 leading down to the GMR. The sample contained SVOCs (23.7 mg/kg) including butylbenzylphthalate (18 mg/kg), Aroclor-1254 (830 µg/kg), and Aroclor-1260 (1,200 µg/kg), along with metals including, but not limited to, arsenic (36 mg/kg), barium (824 mg/kg), beryllium (2.6 mg/kg), cadmium (3.9 mg/kg), chromium (50.7 mg/kg), copper (1,680 mg/kg), lead (1,990 mg/kg), nickel (85 mg/kg), zinc (291 mg/kg), and cyanide (3.7 mg/kg).

Sediment Sample S15

This sediment sample was collected from the northwest corner of Quarry Pond at a depth of 15 to 18 ft below the water surface. The sample contained TCE (0.8 µg/kg), SVOCs (7.6 mg/kg), Aroclor-1254 (660 µg/kg), alpha-Chlordane (12 µg/kg), Dieldrin (9.6 µg/kg), and Endrin (34 µg/kg). Inorganic chemicals were also detected in this sample.

Sediment Sample S16

This sediment sample was collected in the northeast corner of Quarry Pond at a depth of 15 to 18 ft below the water surface. The sample contained SVOCs (21.1 mg/kg) SVOCs, manganese (545 mg/kg), and other inorganic chemicals.

Sediment Sample S17

This sediment sample was collected off the bank of the GMR approximately 350 ft west of the center of the Site (center of Lot 5177). The sample contained TCE (0.7 µg/kg), SVOCs (23.1 mg/kg), mercury (0.65 mg/kg), and other inorganic chemicals.

Sediment Sample S18

This sediment sample was collected from the GMR at a location downstream of the Site. The sample contained SVOCS (9.1 mg/kg) and inorganic chemicals.

Sediment Sample S19

This sediment sample was collected in the GMR, 350 feet west of the former auto salvage yard (west of north part of Lot 5177) and contained SVOCS (17.6 mg/kg) and inorganic chemicals.

Groundwater Analytical Results:

Analytical results for the groundwater sample collected from MW-101 indicate chlorinated solvents including 1,1-DCA (13 µg/L), total 1,2-DCE (150 µg/L), and VC (4 µg/L). The groundwater sample collected from MW-102 contained chloroethane (22 µg/L), toluene (15 µg/L), and xylenes (4 µg/L). The groundwater sample collected from MW-104, located on DP&L property (used as a background well) contained arsenic (547 µg/L).

Ohio EPA used a criterion of three times the background concentration to determine if constituents detected in soil, sediment, and groundwater were of concern. Background concentrations at the Site were characterized by the collection and analysis of one soil sample (S07, southwest of Quarry Pond) and one groundwater sample (MW-104, east of the Site). The background sediment sample Ohio EPA used for the sediment evaluation (S19) was collected west of the Site, west of the Valley Asphalt, and is not actually representative of background concentrations. Based on this evaluation, the Ohio EPA concluded the following constituents were present in the samples collected at concentrations that were elevated above background.

<i>Parameter</i>	<i>Soil</i>	<i>Sediment</i>	<i>Groundwater</i>
Chlorinated VOCs	×		×
Acetone			×
Toluene			×
PAHs	×		
Phthalates	×		
Pesticides		×	×
Metals	×	×	× (potassium)
PCBs	×	×	

Note:

× = detected at a concentration at least three times the background concentration

There was no statistical evaluation of background soil and water quality, so this evaluation is somewhat qualitative.

The background sediment sample OEPA used for the sediment evaluation (S19) was collected west of the Site, west of Valley Asphalt, and is not actually representative of background concentrations.

Exposure Pathways

The STEP Report concluded that the human health soil exposure pathway was determined to be potentially complete at the Site due to a lack of access control, such as a fence.

The STEP Report also concluded that the groundwater exposure pathway was potentially complete. The uncertainty associated with this pathway was due to the undefined groundwater flow direction and the presence of other sources of groundwater contamination in the area.

With respect to surface water and sediments, the exposure pathway was determined to be potentially complete due to the detections in sediment samples.

The STEP report concluded that the presence of soil and debris piles, along with the 1996 PSARA data, resulted in a potentially complete air exposure pathway. The STEP Report identified that the presence of PAHs in some of the soil samples could be attributed to the Valley Asphalt plant. However, Alcine Grillot and soil boring logs also indicate asphalt was disposed at the Site.

1.6.6 1996 TO 2005 PFI SITE INVESTIGATIONS

Based on a review of the available Site history, the Site setting, and previous investigations conducted by others, PFI completed a series of investigations on behalf of Coolidge, Wall, Womsley & Lombard (representing some of the Site property owners), to aid in defining the environmental issues at the Site.

PFI supervised the drilling of thirteen soil borings at the Site in 1998 and 1999. PFI completed ten of the borings as 2-inch PVC groundwater monitoring wells (MW-201 through 204, MW-206 through 210, and MW-212), and one of the borings was completed as a piezometer (P-211). The boring logs indicate P-211 was constructed in the same

manner as existing monitoring wells (i.e., using 2-inch PVC). However, it appears that P-211 was only used for groundwater elevation measurements and no groundwater samples were collected and submitted for analysis from this location. The two remaining soil borings (GT-205 and GT-212) were not completed as monitoring wells due to the presence of heaving sands in the well completion interval.

PFI installed surface water elevation gauges in May 1998 at Quarry Pond, Large Pond, and Small Pond. PFI used these gauges to monitor surface water elevations in 1998 and 1999, in connection with the groundwater elevation measurements, which were collected approximately quarterly from June 1998 through August 2005.

PFI collected up to ten rounds of groundwater samples and analyzed the samples for the parameters indicated below. Note that the Target Compound List (TCL) was not utilized. 1,2,4-Trimethylbenzene, cis-1,2-DCE, ethylbenzene, and o-xylene were not included in the analyses. The analyses included total xylenes.

<i>Monitoring Round Date</i>	<i>Parameters Analyzed</i>
• January 1998	VOCs, Resource Conservation and Recovery Act (RCRA) Metals
• May 1998	VOCs, RCRA Metals, Natural Attenuation Indicators ⁴
• February 1999	VOCs, RCRA Metals, Natural Attenuation Indicators
• November 1999	VOCs
• May 2000	VOCs
• June 2001	VOCs
• June 2002	VOCs
• July 2004	VOCs
• October 2004	VOCs
• August 2005	VOCs

The groundwater analytical data are presented in Table 2.5 of the draft RI/FS Work Plan along with Ohio EPA's and PSARA's data. Table 2.5 of the draft RI/FS Work Plan also details those parameters that were not analyzed for in a given sample collection round.

⁴ Chloride; Nitrate; Ammonia as Nitrogen; Sulfate; Total Alkalinity; Total Organic Carbon; Methane; Ethane; Ethene; and Dissolved Iron

PFI sampled surface water and sediment samples at Quarry Pond during April 1999 and May 2000. PFI collected three surface water samples during each sampling event using a Bacon Bomb sampler and three sediment samples during each event using an Ekman Dredge. PFI analyzed the samples for VOCs and also analyzed the April 1999 sediment samples for total organic carbon (TOC).

1.6.7 SUMMARY OF RESULTS OF PFI INVESTIGATION

Based on the PFI results, groundwater quality at the Site has been impacted by chlorinated solvents and inorganic chemicals including, but not limited to, arsenic and lead. In particular, TCE has been detected consistently in groundwater samples from wells completed on the eastern (MW-202 and MW-210) and western (MW-201⁵) boundaries of the Site. TCE has also been detected on occasion in groundwater samples from MW-102 and MW-208, also located at the western and eastern margins of the Site, respectively.

PFI noted that breakdown products from the degradation of TCE (1,2-DCE and VC) have been consistently detected in groundwater samples collected from MW-101A (south-central portion of the Site). 1,2-DCE has also been consistently detected in groundwater samples collected from MW-210 at the southeast corner and once in a groundwater sample collected from MW-202 on the eastern margin of the Site. 1,2-DCE and VC have been detected on occasion in groundwater samples from MW-203 and MW-208 at the southern and eastern margins of the Site, respectively. However, as noted by USEPA, the presence of these "daughter" compounds could be attributed to co-solvent deposition rather than degradation.

In addition, PFI also noted that 1,1,1-TCA and its potential breakdown products have been detected in groundwater samples collected from monitoring wells installed at the Site. The presence of both parent and daughter compounds may indicate that natural attenuation is occurring at the Site. As noted above, the mere presence of these compounds does not definitively mean that biodegradation is occurring or that biodegradation and natural attenuation are effective remedial processes. Investigative activities would be needed to evaluate this line of evidence further.

PFI also collected sediment and surface water samples from Quarry Pond. PFI noted that two of the three sediment samples contained TOC (although the presence of TOC

⁵ Although groundwater samples collected from MW-103 in the late 1990s contained low concentrations of TCE, TCE has not been detected in groundwater samples collected from this well from 2000 and later.

may or may not be evidence of impact) and none of the surface water or sediment samples contained detectable concentrations of VOCs.

Notwithstanding the above discussion, PFI noted that seasonal fluctuations in water table depth can cause variations in groundwater flow direction(s) and hence may affect groundwater quality at a given monitoring well location. Repeated sampling events, scheduled to coincide with the variations in flow direction, would be required to confirm the reduction in concentration of chlorinated VOCs is not related to seasonal flow direction variation.

1.6.8 SUMMARY - 2000 TCA ENVIRONMENTAL REPORT - VALLEY ASPHALT

Valley Asphalt retained TCA to oversee the removal of contaminated soil and drummed waste identified on the Valley Asphalt property. Analytical results for the composite waste sample collected include:

- Aroclor 1254 (75 mg/kg)
- benzene (7 mg/kg)
- 2-butanone (2.5 mg/kg)
- chlorobenzene (1.7 mg/kg)
- ethylbenzene (84 mg/kg)
- 4-methyl-2-pentanone (18 mg/kg)
- toluene (530 mg/kg)
- TCE (64 mg/kg)
- xylenes (340 mg/kg)

It appears that five drums containing a solid material were removed, characterized as a characteristic hazardous waste (lead and cadmium) with PCBs, and disposed of at the Clean Harbors facility in Cincinnati, Ohio. A total of 2,217 tons of non-hazardous impacted soil containing VOCs was disposed at Waste Management's Stony Hollow Landfill in Dayton, Ohio.

TCA identified a drinking water well and production well located in the vicinity of the excavation area. TCA collected groundwater samples from these wells. No VOCs were detected in the samples collected from either well. The TCA report did not indicate whether the wells were subsequently abandoned.

The TCA report does not describe the condition of the excavation prior to being backfilled. However, CRA spoke with Dale Farmer, Ohio EPA's On-Scene Coordinator, on December 15, 2006 and he advised that the drums encountered had been crushed prior to being excavated and that there was a corner of a drum and other debris visible in the side wall of the excavation. The excavation was backfilled without any further investigation conducted. Mr. Farmer stated that no intact drums or complete drum carcasses were excavated nor were any complete drum carcasses observed in the sidewalls of the excavation.

In January 2006, Ohio EPA visited the Valley Asphalt property to determine the status of the two water wells that were reported by TCA in their 2000 Environmental Report. The report stated that TCA sampled the wells but did not detect any VOCs in the water samples. One of these two wells was identified on a sketch in the TCA report. This well, situated approximately 50 feet southwest of the drum excavation, was located by Ohio EPA on January 20, 2006, next to what appears to be a truck-wash area. Its location suggests it is potentially down gradient of the 2000 excavation. Ohio EPA meeting notes with TCA dated May 31, 2000 state that this well was used minimally for sanitary purposes; however, during reconnaissance on January 20, 2006, Mr. Hutch Rogge, project manager of John R. Jurgensen Co. (owner of Valley Asphalt), stated that he thought the well provided drinking water to the main office.

Upon inspecting the well, Ohio EPA noted that the well lacked a protective cover or sealing cap. The well casing was covered with a plastic bag. A large diameter concrete pipe surrounded the protective casing. The annular space was filled with trash, including a spray can. The employees were not familiar with any other wells located on the property.

1.7 BASIS

This FSP defines and details the field sampling and data gathering activities required to collect the necessary data to complete the work described in the five Letter Work Plans submitted to USEPA in May and July 2008. Based on discussions between the PRP Group and the USEPA, the Letter Work Plans have revised and refined this set of objectives to include the following specific tasks and associated objectives:

- Land survey, Bathymetry Survey, and Geophysical Investigation to meet the following objectives:
 - conduct a topographical survey of the entire Site by aerial photometry
 - survey locations of existing structures and features
 - establish benchmarks for future surveying uses
 - generate a current Site plan and an accurate topographical map of the Site
 - complete surficial metallic debris collection and staging
 - complete a bathymetry survey of the Quarry Pond to generate topographical information for the bottom of the Quarry Pond and information for use in future investigation and remedial action alternatives
 - complete a geophysical survey to identify buried metal and objects at the Site at surveyed locations and identify Site areas which may require additional investigation
- Leachate Seep Investigation to meet the following objectives:
 - completion of a seep inspection to identify the location, extent, and characteristics of seeps observed along Site embankments and in other on-Site and near-Site areas
 - characterize seeps observed along Site embankments and in other on-Site and near-Site areas
 - identify any area(s) that may require further investigation
- Test Pit/Test Trench Investigation to meet the following objectives:
 - collect data to assist in identifying the nature and delineating the extent of various types of landfilled materials above the water table
 - collect data to assist in characterizing landfill materials above the water table;
 - collect data to assist in characterizing leachate from unsaturated landfilled material
 - assess areas of the Site previously identified as specific areas of concern (i.e., Valley Asphalt drum removal area and UST area; Custom Delivery UST area; Lot 4423, etc.)
 - identify Site areas, which may require further investigation (for example leachate sampling and analysis, groundwater quality investigation, or other delineation work)

- Landfill Gas/Soil Vapor Investigation to meet the following objectives:
 - assess the presence of landfill gas (LFG) and soil vapor at locations within the Site
 - obtain current data in locations where historic information indicated potential LFG generation concerns
 - develop information to assist in calculating future landfill gas generation rates
 - develop information to assist in evaluating the need for and type of landfill gas control at the Site
- Groundwater Investigation to meet the following objectives:
 - define subsurface stratigraphy, including identifying till-rich zone(s) and sand and gravel aquifer zone(s) at locations beneath the Site to a depth of 100 feet below ground surface using Rotosonic drilling
 - collect data to assist in characterizing groundwater impacts
 - recognizing that there may be seasonal or event-related differences in groundwater elevation, flow conditions and contaminant concentrations, and that there may be more than one contaminant flow path and more than one source of groundwater contamination at the Site, attempt to: i) determine the appropriate screened interval(s) for shallow monitoring wells at Vertical Aquifer Sampling (VAS) locations through VAS data; ii) compare the screened intervals identified through VAS to the screened intervals and screen lengths in the existing wells; and iii) determine, based on these results and all existing data for the Site, if the screened intervals and screen length of the existing wells represent a zone of chemical impact in the shallow aquifer that is worthwhile to continue to monitor or not
 - characterize groundwater chemistry at Site monitoring wells through groundwater sampling and laboratory analysis
 - collect groundwater and surface water elevation measurements over time to identify horizontal hydraulic gradients, flow directions, and, if nested wells are proposed in Phase 2, vertical hydraulic gradients

The FSP also includes procedures for other field work (Section 3.0) that may be required as part of future investigations at the Site.

The sampling and data gathering procedures presented herein will augment the existing data available for the Site.

2.0 SAMPLING EQUIPMENT AND PROCEDURES

The following sections are presented in the order in which they were presented in the Investigative Work Plans. The sections below present procedures for field tasks as follows:

Section 2.1	Land Survey
Section 2.2	Bathymetry Survey
Section 2.3	Geophysical Investigation
Section 2.4	Leachate Seep Investigation
Section 2.5	Soil Sampling – Test Pit Test Trench Investigation
Section 2.6	Landfill Gas/Soil Vapor Investigation
Section 2.7	Groundwater Investigation

This FSP presents the procedures and methods that will be used to implement the field work. The investigative activities will be implemented in the following sequence in accordance with the Schedule submitted to USEPA on July 25, 2008, as amended:

- aerial photometry survey
- leachate seep investigation
- survey topography, all existing and new monitoring wells, surface water gauges, and land fill gas probe locations
- monitoring well assessment and repairs
- hydraulic monitoring (hydraulic monitoring will continue on a monthly basis throughout 2008)
- redevelop existing monitoring wells
- landfill gas and soil vapor probe installations and completion of two rounds of landfill gas and soil vapor monitoring (the second round will be completed two months following the first round)
- bathymetry survey of the Quarry Pond
- geophysical survey
- vertical aquifer sampling (VAS)
- test pit and test trench investigation
- installation of new shallow and deep groundwater monitoring wells
- completion of two rounds of groundwater monitoring

Summaries of the soil, leachate seep, and groundwater sampling and analyses programs associated with the 2008 investigative activities are provided in Tables J-2.1, J-2.2, and J-2.3, respectively. A summary of the surface water and sediment sampling and analyses programs associated with the 2008 investigative activities is provided in Table J-2.4.

Additional investigative activities, which may be completed at the Site, include surface water and sediment sampling, wetlands delineation, and collection of soil samples for geotechnical analysis.

2.1 LAND SURVEY

The current survey data available for the Site do not provide current accurate information about the topography of the Site. The available data are insufficient to develop and evaluate alternatives for remedial action that will meet the remedial action objectives for the Site.

The data collected will be used to fill the data gaps and allow the PRP Group and USEPA to develop and evaluate alternatives for remedial action that will meet the remedial action objectives for the Site.

The objectives of the Site Survey are as follows:

- conduct a complete topographical survey of the entire Site by aerial photometry
- survey locations of existing structures and features such as access roads, buildings, building foundations, fences, monitoring wells, etc.
- establish benchmarks for future surveying uses including but not limited to Site settlement monitoring
- generate a current Site plan for use in future investigation and remedial alternative evaluation activities
- generate an accurate topographical map of the Site for use in determining Site drainage patterns and for use in evaluating various landfill cap designs

A land surveyor registered in the State of Ohio will conduct the survey.

Survey data will be collected to complete topographic information in the area of the Site as bounded by the GMR to the north and west, Dryden Road to the east, East River Road

to the southeast and Lot 3264 to the south. The topographical survey was completed utilizing aerial survey techniques. The Site was flown over on April 2, 2008.

Horizontal locations, including, but not limited to, the locations of all boreholes, test pits, test trenches, monitoring wells, gas probes, and staff gauges, will be surveyed relative to the Ohio State Plane Grid Coordinates and in Decimal Degrees and elevations will be verified against the closest USGS benchmark monuments. Elevations will be surveyed relative to the 1988 North American Vertical Datum (NAVD 88) for vertical coordinates and the 1983 North American Datum (NAD 83) for horizontal coordinates. Horizontal locations will be surveyed to the nearest 0.5-foot accuracy. Elevations for all locations other than tops of monitoring well risers will be surveyed to the nearest 0.1-foot accuracy. Elevations for monitoring well risers will be surveyed to the nearest 0.01-foot accuracy. Five settlement monuments will be established within the central portion of the landfill on Lot 5177 for future use in settlement monitoring.

2.1.1 SURFICIAL METALLIC DEBRIS COLLECTION/STAGING

Prior to completing a geophysical investigation at the Site, CRA will retain a contractor to collect surficial metallic debris, empty drums and/or drum carcasses previously observed along the central access road and other areas across the Site, as necessary. The contractor will relocate this material to a central staging area located on-Site for interim storage in order to minimize its impact on the geophysical investigation. This debris will be managed as part of future waste characterization and consolidation activities, which will be conducted prior to implementing a remedy at the Site. Drums that are intact and have liquid or solid contents and are visually determined to be in poor condition will be left in place. The location and contents (based on visual observation) of these drums will be documented in a logbook and also marked on a Site plan. The location of drums left in place will be surveyed with a global positioning system (GPS) receiver, and reported in Ohio State Plane Grid Coordinates and in Decimal Degrees. These drum locations will be referenced to the same coordinate system used for the geophysical investigation, to allow surface metal locations to be easily matched to the geophysical maps.

The staging area will first be surveyed using the geophysical techniques identified below before it is constructed or used. After the geophysical investigation of the staging area, a staging pad will be constructed. The staging area will be installed with a containment berm and a 20-mil synthetic liner for leak and spill protection. The staging area will be located on Lot 5177 within the fenced in area of the Site for security

purposes. Once debris collection is completed the area will be covered with polyethylene sheeting to prevent the accumulation of storm water within the area.

More than one staging pad may be constructed depending on how much debris is relocated.

2.2 BATHYMETRY SURVEY

The objectives of the bathymetry survey are as follows:

- generate topographical information for the bottom of the Quarry Pond
- generate information for use in future investigation and remedial alternative evaluation activities

A bathymetry survey will be completed to define the bottom of the Quarry Pond utilizing an echosounder attached to a GPS receiver to maintain control of sub-meter positioning. The bathymetry data and survey line locations will be stored in a digital format using Bathylog (or equivalent) software. The echosounder and GPS will be programmed to collect respective data at 0.5- to 1.0-second time intervals. The standard operating procedures for a GPS unit are provided in Appendix J-F-1. The bathymetry survey will be completed along pre-determined survey lines spaced a maximum of 40 feet apart and oriented in an approximate north-south directions, which have been uploaded into the associated navigational software. Bathymetry data will also be collected on cross-lines oriented in an approximate east-west direction, and spaced a maximum of 150 feet apart. The standard operating procedures for the bathymetry survey are provided in Appendix J-F-2. Survey data will be used to complete a map of the Quarry Pond. Based on the results of the bathymetry survey an electromagnetic (EM) or magnetometer survey of the Quarry Pond will be completed to identify metallic anomalies (i.e., drums) on the bottom of the Quarry Pond.

Land versions of the EM and magnetometer will be used if the pond is shallow, and marine versions will be used if the pond is deep. Specifically, if the pond is less than 10 feet deep, EM61 and magnetometer surveys will be completed using raft-mounted land instruments. If the pond is between 10 and 20 feet deep, EM31 and magnetometer surveys will be completed using raft-mounted instruments. If the pond is between 20 and 30 feet deep, the EM survey will be completed using a marine EM instrument or an EM instrument with a 30-foot-depth of investigation; the magnetometer survey will be completed using raft-mounted land instruments. If the pond is more than 30 feet deep, EM and magnetometer surveys will be completed using marine instruments.

2.3 GEOPHYSICAL INVESTIGATION

The objectives of the geophysical investigation are as follows:

- identify buried metals and objects at the Site at surveyed locations
- identify Site areas which may require additional investigation

The investigation will use magnetic, EM, and ground penetrating radar (GPR) techniques to identify both ferrous and non-ferrous buried metal objects at surveyed locations to depths of up to 20 ft bgs. The magnetic survey will consist of total field and vertical gradient data collection. Magnetic field readings will be recorded at a background base station location during the course of the survey, to allow for correction of diurnal variation (i.e., magnetic drift), if necessary. The EM surveys will utilize an EM31-MK2 instrument (or equivalent), operating simultaneously in metal detection and conductivity modes, and an EM61 buried metal detector.

The EM61 survey will be used to detect the presence of buried metals objects in the shallow subsurface. The EM61 is a time domain instrument, which has an effective depth of investigation of approximately 10 ft bgs, and operates at a frequency of 150 Hz. The EM61 exhibits good lateral (or horizontal) resolution of buried metal objects (in the presence of one object or several objects situated in close proximity) in comparison to other EM methods, due to its stacked coil configuration. The coil separation for the EM61 is one foot. The EM31 survey will be used to detect the presence of buried metal objects in the deeper subsurface. The EM31 is a frequency domain instrument, which has an effective depth of investigation of approximately 17 ft bgs when carried at hip level and operating in horizontal dipole mode. The EM31 exhibits good lateral (or horizontal) resolution for individual buried metal objects but in situations where two or more objects are in close proximity to each other, the EM31 cannot delineate individual responses. This limitation can be attributed to the location of the transmitter and receiver coils at either end of a 13-foot long cylindrical boom. The EM31 operates at a frequency of 9.8 kiloHertz (kHz). The standard operating procedures for EM31 survey are provided in Appendix J-F-3. The standard operating procedures for the EM61 survey are provided in Appendix J-F-4.

The depth of investigation of a GPR survey is inversely proportional to the frequency of the instrument. That is, the higher the frequency, the more rapidly the GPR signal will attenuate or dissipate in the subsurface. Thus, the GPR survey will utilize a Ramac Rough Terrain Concept (RTC) low frequency system, with a 100 Mhz antenna (or

equivalent) to optimize the depth of investigation. This instrument is characterized by an in-line transmitter-receiver antenna configuration, which allows for relatively rapid GPR data acquisition in comparison to other instruments. The EM and GPR surveys will also identify buried conduits or pipelines at the Site, the locations of which will be recorded for future reference. Conduits can include electric, communication, water and gas lines as well as sewers and field tiles. Smaller conduits, however, may not be seen in surveyed areas where the ground is mostly clay with a high moisture content. The usefulness of GPR at this Site may be limited by any heterogeneity of landfilled materials and uneven terrain. It may be difficult to determine whether GPR survey results have been affected by de-coupling (bouncing) on the ground or signal scatter due to the ground matrix. The standard operating procedures for the GPR survey are provided in Appendix J-F-5.

Prior to conducting the surveys, a grid consisting of parallel lines will be established over the area of investigation (shown on Figure J-2.1). The grid will utilize a number of control points that will be surveyed for horizontal and vertical location at 150-foot intervals in the approximate north-south direction, and 160-foot intervals in the approximate east-west direction. Geophysical survey lines spaced 40 feet apart will be established between the control points and will be designated with a Cartesian coordinate system as required by instrument data loggers. In addition, perpendicular (approximate east-west) geophysical survey lines will be established at 150-foot intervals, along the lines joining the control points. Magnetic, EM, and GPR measurements will be recorded at 0.5-second time intervals, or, at a minimum, 0.7-foot distance intervals along these grid lines, and stored automatically in data loggers.

The areas of the Site in which the geophysical investigation will occur are presented on Figure J-2.1. It should be noted that existing material storage piles located on and adjacent to the Valley Asphalt (Lot 5054 and northern portion of Lot 5177) and Custom Delivery UST Removal area (located on the Southeast portion of Lot 5171) properties and existing building structures at the Site (Lots 4610, 5054, 5171, 5172, 5173, 5174, and 5175) will physically limit the extent of the geophysical survey to be conducted. Minor amounts of brush and tree cutting will be required to facilitate the geophysical survey. Survey lines will be cleared to a minimum width of 4 feet to facilitate geophysical surveying activities and to provide good GPR contact or coupling. The in-line transmitter-receiver configuration will ensure adequate coupling is maintained during the GPR survey since the width of the antennas along the geophysical survey lines is relatively narrow (approximately 6 inches wide). Any cleared brush will be removed from the survey lines to mitigate slip, trip and fall hazards, and to facilitate progress of the geophysical surveys.

The geophysical investigation results will be presented as colored, contoured plots. The results will be used to finalize the locations of test pits and trenches to determine waste boundaries and characteristics, as described below.

The surface geophysical investigation will consist of collecting data on 40-foot spaced grid lines with intermediate 20-foot spaced grid lines over anomalous areas. The decision to perform 20-foot grid spacings will be evaluated at a minimum on a weekly basis on-Site, following a preliminary data assessment, which is scheduled to occur on the weekends or on rain days. The 20-foot grid spacings will be surveyed immediately following this evaluation, or following brush-clearing of the 20-foot grid lines, where required. The geophysical instruments used to collect the geophysical data will include:

- GEM GSM-19 Proton Precession Magnetometer (or equivalent such as EG&G Geometrics G-858G cesium vapor magnetometer) to collect total magnetic field and magnetic gradient data
- Geonics, Inc. EM-31 Ground Conductivity Meter to collect quadrature (terrain conductivity) and in-phase (metal detection) data
- Geonics, Inc. EM-61 Buried Metal Detector to collect focused metal detection data
- Ramac RTC low frequency GPR system with a 100 Mhz antenna

The standard operating procedures for the magnetometer survey are provided in Appendix J-F-6.

An EM or magnetometer survey of the Quarry Pond will be conducted after the completion of the bathymetry survey. The bathymetry survey of the pond will allow for the proper selection of the geophysical survey equipment, based on the depth of the water column. The Quarry Pond geophysical survey will be completed using a GPS to ensure complete and effective coverage of the area has been completed. The survey will be conducted using a small boat with an outboard motor towing a non-metallic raft with the GPS and survey equipment.

The data will be used to identify areas of the Site that may require further investigation as part of the soil or groundwater sampling programs.

The magnetometer records total magnetic field data from two sensors, top and bottom. The difference in total magnetic field between the two sensors divided by the vertical distance between the sensors equals the magnetic gradient. Magnetometers detect the presence of ferro-metallic objects and are capable of lateral resolution of anomalies

(i.e., anomalous responses are often observed adjacent to the buried object in addition to directly over the object). This allows for greater line and station spacings, and relatively rapid coverage of an investigative area. During the course of the survey, repeat readings will be recorded at a base station location situated away from any source(s) of magnetic interference to assess the degree of naturally-occurring diurnal variation (i.e., magnetic drift).

The EM31 consists of transmitter and receiver coils located at opposite ends of a 14-foot long boom. In vertical dipole mode, this coil configuration yields an approximate depth of penetration of 20 feet, or 17 feet at hip level. The EM31 is capable of operating simultaneously in both terrain conductivity and metal detection modes. The EM31 will be utilized in metal detection mode, since this instrument is capable of inducing secondary fields in all conductive buried metallic objects. Terrain conductivity readings will also be measured, in order to delineate areas of conductive fill.

EM31 metal detection anomalies can be characterized by two types of responses. Large anomalies covering a relatively wide area are identified by elevated responses, whereas smaller anomalies are characterized by very low (negative responses). The explanation of these results can be attributed to the 14-foot separation between the transmitter and receiver coils of the EM31. When sources of anomalies are much larger than the 14-foot coil spacing, the signal received by the EM31 becomes saturated, resulting in an elevated reading. When an object is smaller than the 14-foot coil spacing, the secondary field induced in the object opposes the primary field, yielding a negative resultant field (expressed as a percentage of the primary field). Both elevated and negative metal detection anomalies indicative of buried metal will be identified in the EM31 survey results.

The EM61 is a time-domain buried metal detector that consists of two rectangular transmitting and receiving coils in a stacked configuration, connected to a data logger. The coils measure approximately 1.5 by 3 feet and are mounted to a wheeled cart. The transmitting coil emits 150 EM pulses per second into the ground at each measuring point. During the off time between transmitted pulses, receiver coils measure the decay of the transient electrical currents induced by the pulses. Electrical currents in moderately conductive earth materials (including moist clays, mineralized soils, etc.) dissipate rapidly, leaving only the more prolonged currents due to buried metal objects. The EM61 detects and measures the prolonged transient currents, yielding a result in millivolts (mV) proportional to the metallic content of the buried object, and inversely proportional to its depth of burial. Due to its stacked coil configuration, the EM61 is less susceptible to potential sources of interference including parked vehicles, fence lines, staged drums, power lines, etc. The EM61 survey will be completed along the survey

lines by automatically triggering a reading at 0.7-foot stations. The effective depth of penetration of the EM61 is approximately 10 feet.

The Ramac™ Rough Terrain Concept (RTC) low frequency GPR system transmits at 100 Mhz, and is characterized by an in-line transmitter-receiver antenna configuration. GPR systems utilize pulsed EM waves, which are emitted from a transmitting antenna. They are propagated into the ground and travel at velocities determined by the electrical properties of earth materials. As a GPR wave moving downward in the subsurface hits a buried object or boundary with different electrical properties, part of the wave energy is reflected back to the surface and is detected by a receiving antenna. The reflected wave is stored digitally and processed as a trace of signal versus amplitude. As the antennas are moved along a survey line, a series of traces are recorded at discrete points. When presented collectively, these traces display a profile of the subsurface. The depth of subsurface penetration is directly dependent upon the frequency of the GPR system and the conductivity of the soil. Signal attenuation is greater for higher frequencies and also greater for conductive soils.

The geophysical survey procedures will be as follows:

1. The geophysical survey grid setup will commence with surveying of the control points at 150-foot intervals in the north-south direction and 160-foot intervals in the east-west directions, as indicated on Figure J-2.1. Concurrently, brush clearing will commence between these control points, to facilitate additional grid setup described below.
2. The geophysical survey grid will be set up such that survey lines are spaced 40 feet apart. Wooden survey stakes labeled with the grid coordinates will be placed at 150-foot intervals along each gridline via surveying. Horizontal locations will be surveyed relative to the Ohio State Plane Grid Coordinates and in Decimal Degrees. Elevations will be surveyed relative to NAVD 88 for vertical coordinates and NAD 83 for horizontal coordinates. Horizontal locations will be surveyed to the nearest 0.5-foot accuracy. Elevations will be surveyed to the nearest 0.1-foot accuracy.
3. Geophysical data will be collected using a data logger on each geophysical instrument. The data recording for the magnetometer, EM31, EM61, and Ramac GPR system will be initiated for each station by the operator pressing the recording button. The station spacing for the magnetometer and EM31 will be approximately 5 feet and will be determined via pacing. The EM61 will be utilized in wheeled mode and will automatically trigger the data logger to record a reading at 0.7-foot intervals.

4. The magnetometer survey will also include the use of a base station to determine diurnal variation. The base station(s) will be set up in area(s) free of ferromagnetic waste and base station readings will be recorded several times a day during the course of the survey. Base station readings will be recorded at a minimum of every 4 hours, to verify that the diurnal variation in the earth's magnetic field is negligible (i.e., <50 nT). Solar forecasts will be reviewed on a daily basis and in instances where increased solar activity is forecast, the magnetic survey will be temporarily suspended.
5. Data reduction will include downloading from the data loggers to a computer. The downloaded data will be processed for location. Magnetometer data may be corrected for diurnal variation, if required.

The data will be contoured using SURFER® (Golden Software, Inc.). Separate contour plots for each data type will be prepared. Manual interpretation of the plots will be performed to assess the identified anomalies. This interpretation will include identification of anomalous areas for further investigation.

The GPR report will also include discussions of methodology, data processing and interpretation. Specific components to be included/addressed in the GPR report are:

- Justification of antenna frequency.
- Discussion of software and removal of noise (subtracting the avg. trace).
- Justification of applied gain functions.
- Selection of time frames chosen for signal amplification.
- Justification of soil velocities used in calculating primary wavelength and theoretical minimum vertical resolution.
- Calculation of the signal wavelength and theoretical minimum vertical resolution of each interpreted trace. For example, a signal with a 100 MHz frequency traveling through soil with a presumed soil velocity of 0.06 m/ns (wet clay), would have a primary wavelength of 60 cm. The resulting theoretical resolution would then be 15 cm (one quarter of the wavelength).
- Discussion of whether the scanned media is expected to contain objects with dimensions corresponding to the signal wavelength.
- Discussion of whether suspected debris has created scatter or interference.
- Potential attenuation from fluids.

- Depth calculation of any interpreted reflectors (depth = soil velocity x one way travel time).
- Include radargrams for all scanned traces.

2.4 LEACHATE SEEP INVESTIGATION

The data available for the Site do not provide sufficient information to characterize leachate seep quality or identify the nature and extent of leachate seeps at the Site. The available data would be insufficient to develop and evaluate alternatives for remedial action that will meet the remedial action objectives for the Site.

The objectives of the Leachate seep monitoring are to:

- complete a seep inspection to identify the location, extent, and characteristics of seeps observed along Site embankments and in other on-Site and near-Site areas
- characterize seeps observed along Site embankments and in other areas
- identify any area(s) that may require further investigation

The work associated with achieving these objectives is described further below.

2.4.1 VISUAL SEEP INSPECTION

CRA will complete a visual inspection of:

- the embankments and nearby areas on the west side of the Site (adjacent to the GMR)
- embankments and nearby areas to the north including to the north of the Valley Asphalt property
- areas surrounding the Quarry Pond
- embankments and nearby areas along the central access road
- embankments and nearby areas in the vicinity of the air curtain destructor
- embankments and the area in the vicinity of the Small Pond
- embankments and the area in the vicinity of the Large Pond

This assessment will consist of a visual inspection of the entire embankment surface, nearby areas, and low lying areas with an objective to document any evidence of

groundwater or leachate discharge from any portion of the bank and other nearby or low-lying areas. Specific items to be investigated include identifying erosion rills, areas of surface staining and/or stressed vegetation, and wet or saturated areas resulting from seeping liquid.

CRA will prepare a photographic log for the inspection. The photographic log will list the date of each photograph, a specific description of what the photograph depicts, its location, and the photographer.

Seep inspections will not be performed during precipitation events and will be performed no sooner than 24 hours after a precipitation event. To the extent practicable, given the project schedule and USEPA notification requirements, the PRP Group will schedule the seep inspection to occur after several days of dry conditions (based on long term weather forecasts). In the event of precipitation during the seep inspection, field activities will be suspended and will not recommence until 24 hours after the rain has ceased. The USEPA will be notified of any delays in the seep inspection. Also the weather conditions will be noted in the daily field logs.

Potential seeps encountered during the Survey, Geophysical Investigation, or other Site work will be flagged, and these areas will be inspected during the seep inspection if the potential seep is encountered prior to the Leachate Seep Investigation or at a later date if the potential seep is found after the Leachate Seep Investigation is completed and does not correspond to a previously identified seep.

2.4.2 SEEP CHARACTERIZATION

Should leachate seeps, surface staining, stressed vegetation, or other evidence of a leachate seep be identified in any of the embankments or in other areas, CRA will flag the location and survey it using a hand-held global positioning system (GPS) device and record the coordinates. CRA will then record the characteristics of each seep area including color of staining; area of staining; whether the seep is active or not active; estimate of seep flow; color of seep flow; presence of erosion, pooling, or odor; PID reading; and any other pertinent or identifying details. CRA will also record potential downgradient receptors for each seep, such as landfill interior (where capping alternatives will be evaluated in the FS), the GMR, Quarry Pond, etc. After surveying the location and recording seep observations, CRA will immediately proceed to collect leachate and/or soil samples (as detailed below) at the identified location before continuing on to the next area.

If an active seep is observed, liquid sampling will be attempted. The area located immediately beneath the seep will be dug out using a clean shovel or trowel. A clean sample jar or pail will be set into the dug out area and the liquid will be allowed to accumulate in the container. The liquid will be transferred to sample containers for submission to the analytical laboratory. As the volume of liquid may be limited, prioritization of requested analyses for the sample will be as follows: TCL VOCs, TAL metals and cyanide, TCL SVOCs, herbicides, pesticides, and PCBs.

CRA will attempt to place the sample jar or pail on an angle in order to encourage leachate to flow into the jar rather than dripping in. VOC sample vials will be filled by slowly, smoothly, and carefully transferring seep water from the large clean sample jar to the VOC vial, without splashing, and sealing the vial to ensure that no air bubbles are allowed to remain in the vial. VOC sampling will be conducted first, once sufficient liquid has been allowed to collect in the large clean sample jar. Trip blanks, field blanks and duplicate samples (if sufficient sample is available) will be collected in conjunction with the seep sampling. Trip blanks will be submitted with each sample shipment to the analytical laboratory. Field blanks will be collected at a frequency of one per every ten seep samples collected. Field duplicates will be collected at a frequency of one per twenty seep samples (sample volume permitting).

If a sufficient volume of liquid to fill sample jars is not produced by the seep, CRA will collect a sample of the surface soil in the area of the seep. The surface soil sample will be collected from a saturated portion of the soil immediately beneath the seepage. The surface soil sample will be collected as part of the leachate seep investigation fieldwork.

If no active seep is observed but indirect evidence of a seep is observed (i.e., erosion rills, stressed vegetation, etc.), then CRA will collect a soil surface soil sample from the area where the observation was made.

The surface soil samples will be analyzed for TCL VOCs, TCL SVOCs, herbicides, pesticides, PCBs, TAL metals, and asbestos. The surface soil samples will be collected in accordance with the soil sampling procedures outlined in Section 2.5 and the SOP in Appendix J-F-32.

Quality Assurance/Quality Control (QA/QC) samples will be collected as discussed in Section 4.0. Samples will be handled as discussed in Section 5.0.

2.4.3 IDENTIFY AREAS NEEDING FURTHER INVESTIGATION

The field observations and analytical data generated from any liquid seep or soil sampling will be reviewed and evaluated. Areas where stressed vegetation was observed may be considered as alternative sampling areas for the Test Pit/Test Trench Investigation. Analytical data will be evaluated against USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites. If liquid or soil analytical data indicate that there are constituents present at concentrations greater than USEPA RSLs, then the area where the sample was collected may require further investigation or assessment for the FS. If liquid or soil sample data do not exceed USEPA RSLs, then the area where the sample was collected will not require further leachate seep assessment for the purpose of completing the FS. Additional leachate seep assessment at these locations may, however, be required as part of Remedial Design (e.g., to evaluate seasonal and/or yearly fluctuations in leachate seeps).

If the soil samples contain constituents at concentrations greater than the applicable Ecological Screening Criteria and the seep area is outside the area to be evaluated for capping alternatives, then the area may require further assessment as part of the RI/FS for areas not addressed by the FS. If the seep is in the interior of the landfill (where capping alternatives will be evaluated in the FS), then the area will be noted and evaluated as part of the FS. The assessment and evaluation of data generated as part of this investigation will be presented in a technical memorandum. Modification or adjustments to further investigative work proposed for the Site in 2008 will be discussed with the USEPA prior to implementation.

2.5 SOIL SAMPLING-TEST PIT TEST TRENCH INVESTIGATION

The PRP Group would like to collect additional soil data for the Feasibility Study. The purpose of the soil sampling is to collect additional data to assist in characterizing the nature of the soil/landfilled materials at sampled locations.

All soil samples will be described using the Unified Soil Classification System (USCS) and will be screened using a PID. Field calibration, preventative maintenance, and standard operating procedures (SOPs) for the PID are described in Section 6.0. Soil will be characterized to determine chemical concentrations.

Soil test pit/test trench sampling SOPs are presented in Appendix J-F-31. QA/QC samples will be collected as discussed in Section 4.0. Samples will be handled as discussed in Section 5.0.

Soil samples may also be submitted for grain size, fraction of organic carbon (*foc*), plasticity index, porosity, permeability, and Atterburg limits.

All soil sample locations will be surveyed as discussed in Section 2.1.

Soil samples will or may be collected during each of the following investigations at the Site:

- Test Pit/Test Trench Investigation
- Leachate Seep Investigation
- Landfill Gas/Soil Vapor Investigation
- VAS
- Monitoring Well Installation

Soil sampling associated with the Test Pit/Test Trench Investigation is described in the following section. Soil sampling associated with other investigative activities will follow the same general principles as for the Test Pit/Test Trench Investigation as described in the section specific to those activities.

2.5.1 TEST PIT/TEST TRENCH EXCAVATION

The objectives of the test pit and test trench excavations and sampling are as follows:

- collect data to assist in identifying the nature and delineating the extent of various types of landfilled materials above the water table
- collect data to assist in characterizing landfill materials above the water table
- collect data to assist in characterizing leachate from unsaturated landfilled material
- assess areas of the Site previously identified as specific areas of concern [i.e., Valley Asphalt drum removal area, Valley Asphalt former UST area, Custom Delivery UST area, Lot 4423, etc.)
- identify Site areas which may require further investigation (e.g., leachate sampling and analysis, groundwater quality investigation, or other delineation work)

The test pit and test trench investigations will be completed after the Land Survey, Bathymetry Survey, and Geophysical Investigation and Leachate Seep Investigation have been completed. The locations of the test pits and test trenches may be adjusted

based on the results of these previously mentioned investigations and upon consultation with the USEPA.

The intent of the test pit and test trench activities is to identify areas that exhibit similar characteristics (i.e., visual, physical, and, to the extent the materials are analyzed, chemical composition). Test pits are proposed in locations where the PRP Group would like to collect additional information about the depth and nature of the fill material above the water table. The information will be used to verify the limits of fill and to assist in characterizing the nature of the landfilled materials present in the areas investigated.

Six test pits will be excavated in the central portion of the Site. Twenty-three test trenches will be excavated throughout the Site. Test pit and test trench locations are presented on Figure J-2.2.

The locations of the test pits and test trenches will be finalized based on the results of the geophysical investigation (the USEPA may be asked to approve moving, relocating, or adding test pit and test trench locations based on field observations, geophysical investigations, etc.). The nature and depth of fill material above the water table will be visually identified and recorded. Test trenching will focus on the perimeter of the PRP Group's preliminary direct contact presumptive remedy area, which was defined in the RI/FS Statement of Work and the area immediately beyond the perimeter. In addition, the test trenching will assist in identifying and characterizing fill material at locations along the western embankment of the Site. Excavations will be completed to the depth of the water table, where possible (as limited by the ability of the excavator to reach the depth of the water table, the stability of the walls of the excavation, and/or the presence of obstructions). If an obstruction is encountered during the excavation of a test trench, the location of the trench will be adjusted to avoid the obstruction. If excavation to the water table is not possible due to the depth of the water table or the stability of the fill material, the PRP Group will consider the need for additional investigation at the location in question during future investigation work. The potential impacts from saturated fill materials will be assessed as part of the groundwater investigation proposed for the Site (under separate cover). The utility of this information in the FS is discussed above.

Each test pit will be approximately 6 feet long by the width of the bucket (approximately 3 feet wide) and will extend to the water table, if the excavation can be completed safely to that depth (i.e., stable slopes and excavation sidewalls, no buried structures, etc.) and the excavator is capable of reaching that depth. Excavations will not be completed beyond the depth of the water table.

Each test trench will be approximately 30 feet long by 3 feet wide and will extend to the water table (if this can be excavated safely) and horizontally to the visual limit of fill. If the horizontal limit of fill is not determined in any planned 30-foot trench, to the extent practical (i.e., where not impeded by the presence of surface structures, property boundaries, unstable slopes or side walls, buried structures, etc.), the test trench lengths will be extended to attempt to visually locate the edge of the fill. This visual limit (both lateral and vertical) will be determined by the presence of undisturbed native soil in the excavation. CRA will also note if fill material appears to consist of re-located spoils from the gravel extraction operation versus undisturbed native material; however, the presence of relocated spoils will not be used as an indicator that other wastes have not been disposed at an individual location. Test trench excavation will continue in these areas to the depth of native material or the maximum reach of the excavator, whichever is less. The nature and depth of fill material will be visually identified and recorded. The procedures and equipment to be used to excavate trenches and visually characterize the fill material are described below.

An excavator or extended reach backhoe will be used to excavate the test pits. The reach of the excavator or backhoe will be at least 18 feet. Data regarding conditions at depths greater than those that can be reached by the excavator may be obtained during vertical aquifer sampling and monitoring well installation. The test pit excavation procedures are as follows:

1. Each test pit will be assigned a unique identification number. Prior to starting the test pit excavations, the locations of each test pit and trench will be staked in the field using the locations identified on Figure J-2.2. As noted above, the locations of the test pits may be adjusted based on the results of the Land Survey, Bathymetry Survey, and Geophysical Investigation, and the Leachate Seep Investigation and upon consultation with the USEPA.
2. The area immediately adjacent to the test pit will be covered with two layers of 6-mil polyethylene sheeting for stockpiling excavated fill material. The polyethylene sheeting and excavation spoils will be placed downwind of field personnel and in such a manner that water runoff from the fill material will be directed back into the excavation. If possible, fill material temporarily stockpiled on the liners will be backfilled into the open excavations before the contractor leaves the Site for the day. If the fill material cannot be backfilled at the end of the workday, the contractor will ensure the material is covered securely with a polyethylene liner to control potential emissions and to minimize the exposure of the material to rainwater. The contractor will also ensure that temporary fencing is placed around the stockpiled material and the open excavation.

3. The test pits will be approximately 3 feet wide and will extend to the depth of the water table, where possible and feasible (as limited by the ability of the excavator to reach that depth, the stability of the walls of the excavation, and/or the presence of obstructions). The lengths of individual test pits will be determined in the field by the field representative based on conditions encountered during excavation. If obstructions are encountered and sidewalls are stable, then the width or length of the test pit may be expanded to aid in excavating to depth. Excavation at each location will be completed in a controlled manner so as to minimize damage to any potentially intact drums. If a test pit cannot be excavated to the surface of the water table due to obstructions or sidewall instability, and the excavation equipment is capable of reaching that depth, the test pit will be relocated 50 feet (or a lesser distance if appropriate) from the original location and attempted again. If, during the excavation of a test pit, PID, particulate, or VC readings above the action levels in the HASP are recorded, excavation of the test pit will cease and the Site Supervisor (SS) will evaluate what actions (i.e., upgrade in level of personal protection equipment or termination and backfilling of test pit) are appropriate. If during the excavation of a test pit, combustible gas, oxygen, hydrogen sulfide, carbon monoxide, or radiation readings exceed (or in the case of oxygen fall below) an action level, the test pit excavation will be immediately stopped and the test pit backfilled, provided it is safe to do so. The test pit will be relocated 50 feet (or a lesser distance if appropriate) from the original location and attempted again. The location will be documented, and, if appropriate and safe to do so, may be investigated further during other investigative activities at the Site (i.e., Groundwater Investigation, Landfill Gas/Soil Vapor Investigation, etc.).
4. CRA will observe the materials excavated and record the nature of the materials on a test pit stratigraphy log. The test pits will be excavated in two to three foot increments to aid in accurately determining the depth of discrete layers of fill material and the fill material/native material interface. Where appropriate, and where it is safe to do so, CRA will measure the depth of the test pit excavation where specific layers of fill material are encountered and the total depth of the excavation. The observations will include a visual description of the types of material (i.e., undisturbed native soil, spoil from quarry operations, domestic refuse, industrial refuse, metallic debris, ash, fly ash, construction and demolition debris, foundry sand, asphalt, slag, or other appropriate description) and, if possible, a USCS description. Soils will be logged using the USCS by an on-Site geologist. Soil classification methods will include visual assessment, texture assessment, dry strength tests, toughness tests, and dilatancy tests, as appropriate depending on the nature of the soil encountered. The visual classification of waste materials is, by its very nature, somewhat arbitrary. The

on-Site geologist will be experienced in performing such observations, which will be based on the physical nature of the material encountered. As detailed below, samples of distinct fill materials will be retained in the event that the classification of specific materials needs to be revisited in future. Photographs of the material will also be included.

5. Empty drum overpacks will be maintained at the Site during excavation. Should an intact waste container be damaged during excavation the drum management procedures presented in Appendix J-F-8 will be implemented.
6. Each test pit will be backfilled with the excavated materials in reverse order to that in which they were removed. The test pits will be restored to match surface conditions prior to excavation. During backfilling of the test pit, the bucket of the excavator will be used to compact the material as it is placed in the excavation in order to ensure that any expansion of the materials that occurs during excavation is reversed and the test pits can be restored to grade.

Access of the general public and on-Site commercial/industrial workers to the investigative locations will be restricted by the SS and air monitoring (as discussed in the Site-Specific Health and Safety Plan, CRA, May 2008) will be used to ensure that any emissions generated during test pitting activities do not pose a risk to the general public or on-Site workers. On-Site commercial/industrial workers will be notified in advance of intrusive activities that may have the potential to generate emissions, where these intrusive activities are located proximally to an active on-Site commercial/industrial facility.

Test trenches will be excavated in the same manner as detailed above for test pits except that test trenches will be excavated to the top of the water table in a continuous length of approximately 30 feet or the horizontal limit of fill (if undisturbed native soil is encountered before reaching 30 feet) as discussed above.

To the extent possible given the available data for the Site, CRA will attempt to start the excavation in areas of fill (i.e., non-native) material and continue the excavation towards the presumed location of native material. If fill is encountered at the start of the trench, the trench will be excavated in the presumed direction of native material, e.g., away from the PRP Group's direct contact presumptive remedy area. If native material is encountered at the start of the trench, the trench will be excavated in the presumed direction of fill material, e.g., towards the PRP Group's direct contact presumptive remedy area. As noted above, if the horizontal limit of fill is not determined in any planned 30-foot trench, to the extent practical (i.e., where not impeded by the presence of surface structures, property boundaries, unstable slopes or side walls, buried

structures, etc.), the test trench lengths will be extended to attempt to visually locate the edge of the fill. Where further extension of a test trench is not feasible and/or practicable, the PRP Group may, in consultation with the USEPA Site representative(s), elect to abandon a test trench location and install an additional test trench off-set from the original location in the presumed direction of the native/fill material, as appropriate. As noted above, the locations of the test trenches may be adjusted based on the results of the Land Survey, Bathymetry Survey, and Geophysical Investigation and the Leachate Seep Investigation and upon consultation with the USEPA.

If clean backfill material is encountered during any of the test trenches proposed in the Valley Asphalt drum removal area, the Dayton Recycling UST removal area, or the Custom Delivery UST removal area, CRA will attempt to continue the test trench excavation away from the location of the clean backfill material or relocate the test trench outside the clean backfill material, as appropriate depending on the size of the original excavation.

The test trenches will be used to visually determine the limits of the fill and to provide information on the nature of the fill material at these locations.

2.5.2 TEST PITS AND TRENCH SAMPLING

The following sampling procedures and associated tasks will be performed as part of the test pit and test trench investigation:

1. CRA will prepare a photographic log of each test pit excavation during its progression. The photographic record will list the date of each photograph, a specific description of what the photograph depicts, its location, and the photographer.
2. The dimensions of each excavation and a description of the materials encountered during excavation will be recorded on a Test Pit Stratigraphy Log, an example of which is contained in Appendix J-G.
3. Samples of the fill materials encountered in the test pits and test trenches will be collected from each sidewall and the base of the excavation during the excavation. A minimum of one sample collected from each test pit and two samples collected from each test trench will be submitted to an analytical laboratory for analyses. The specific material selected for sampling and number of samples will be determined in the field by the CRA field representative in consultation with the USEPA Site representative(s). Sample selection will be

based on the visual appearance of the material (e.g., color, staining, grain size, etc.), location of the material prior to removal (e.g., adjacent to drums or base of excavation), and field instrument measurements (i.e., headspace readings using a PID). CRA will collect a sample of each visually distinct fill type for headspace analysis. Where fill material encountered is not visually distinct with depth, CRA will use visual and olfactory evidence of contamination and PID screening of the soil as it is excavated to identify appropriate samples for headspace screening. All olfactory evidence will be obtained taking care to limit exposure to any vapors and in accordance with the HASP. At a minimum, if fill material is not visually distinct with depth, samples will be collected for headspace screening approximately every five feet vertically. The headspace analysis will aid in the selection of the discrete samples to be analyzed from each excavation and in the selection of the sample(s) to be retained from each distinct fill type based on visual observations and headspace analysis (see below). The headspace VOC analysis and sample screening procedure is detailed in Appendix J-F-9. The observations will be recorded in the Test Pit Stratigraphy log. The samples will be collected directly from the bucket of the excavator and/or the stockpiled spoils immediately upon excavation to minimize any potential losses due to volatilization. Samples will be collected in the following order: VOCs, SVOCs, PCBs, pesticides, herbicides, and inorganics. Fill material samples will be collected in an attempt to characterize distinct fill zones or landfilled materials based on visual observations, PID readings, and the analytical data generated from the program as discussed below. CRA will also use representative fill samples retained (see below) from each test pit and test trench to compare fill types from different excavations. Samples of the same distinct fill zones or landfilled materials based on visual observations and headspace analysis will be collected from multiple test pit and test trenches where possible (i.e., where the same distinct fill zone or landfilled materials based on visual observations and headspace analysis are present in more than one test pit in recoverable quantities).

4. A portion of each sample will be placed in a separate container for headspace analysis using a PID. Results of the headspace analysis will be recorded in the Test Pit Stratigraphy log. A sample from each distinct fill type observed in each test pit and test trench will be retained in appropriate sampling containers maintained at appropriate temperatures so that samples may be submitted in the future (within the applicable sample holding time) for laboratory analysis. Field observations and field screening results will be reviewed with the USEPA's Site representative(s) on a daily basis.

5. Daily proposed sample submissions to the analytical laboratory will be reviewed with the USEPA's Site representative(s). At a minimum, samples of each distinct fill type (based on visual observations and headspace analysis) encountered at the Site will be submitted for the following analyses: TCL VOCs, TCL SVOCs, TCL herbicides and pesticides, TCL PCBs, and TAL inorganics. Where field observations and field screening indicate that similar types of fill material in different test pits/test trenches may be from different sources (e.g., visually similar materials in two distinct and separate layers within a trench or at widely varying depths within adjacent trenches, or visually similar materials in different trenches in different areas of the Site), additional samples may be submitted. Additional samples may also be submitted where visually similar fill materials are potentially impacted by different contaminants (e.g. visually similar materials where one has a strong odor or the other a high organic vapor content as measured using a PID). Multiple samples of similar fill types based on visual observations and headspace readings encountered across the Site will be submitted for TCL/TAL laboratory analysis to assess the variability of the analyzed materials within the Site. Ash fill materials encountered will be collected and submitted for dioxin and furan analyses. Up to 10 samples of ash will be submitted for dioxin and furan analyses if ash is encountered in at least 10 separate excavations. If potential friable asbestos-containing materials (ACM) (i.e., ceiling tiles, wall board, pipe insulation, automotive brake pad manufacturing refuse, etc.) are encountered, a minimum of one sample of each distinct type of potential ACM will be submitted for asbestos analysis. A sampling summary is presented in Table J-2.1. The Health and Safety Plan includes provisions to assess worker exposure to potentially radioactive foundry sands.
6. Should leachate seeps be identified in any of the test pits or test trenches, samples will be collected. For shallow leachate seeps that can be reached by hand from the edge of the test pit or trench, the area located immediately beneath the seep will be dug out using a clean shovel or trowel. A clean sample jar or pail will be set into the dug out area and the liquid will be allowed to gently accumulate in the container. If the depth of the excavation prohibits field personnel from safely conducting the liquid collection, sufficient saturated material in and around the seep will be excavated and placed on a polyethylene sheet and the liquid allowed to drain into a container. A field blank sample of distilled deionized water poured onto clean polyethylene sheeting will also be collected. The liquid will be transferred to sample containers for submission to the analytical laboratory. As the volume of liquid may be limited, prioritization of requested analyses for the sample will be as follows: TCL VOCs, TCL SVOCs,

TCL herbicides and pesticides, TCL PCBs, and TAL inorganics. A sampling summary is presented in Table J-2.2.

7. A composite sample of each fill type (i.e., construction and demolition debris, ash, and cinders, etc.) will be prepared from the retained samples of the representative fill types from the test pits and test trenches (within applicable holding times) and submitted to the analytical laboratory for Toxicity Characteristic Leaching Procedure (TCLP) preparation with subsequent analysis of the resultant leachate for VOCs, SVOCs, herbicides, pesticides, and metals. Samples will also be analyzed for PCBs, corrosivity, ignitability, and reactive cyanide and sulfide. A minimum of one composite sample will be submitted for each fill type. The parameters and associated analytical methods are specified in Table J-2.1.
8. Duplicate photographs and the corresponding photographic record will be provided to USEPA and the Ohio EPA at the completion of this investigation.

The soil samples will be screened and collected in accordance with the relevant SOPs in Appendix J-F-9, J-F-31, and J-F-32. QA/QC samples will be collected as discussed in Section 4.0. Samples will be handled as discussed in Section 5.0.

The following protocol will be used to determine the number of samples to be submitted for laboratory analysis. A minimum of one soil sample collected from each test pit and two soil samples collected from each test trench will be submitted to the analytical laboratory for analysis. Specific samples to be submitted for laboratory chemical analysis will be selected by the CRA field representative in consultation with the USEPA's Site representative(s) on a daily basis. Depending on the nature of materials encountered in an individual test pit, the number of samples for each medium may vary. For example, if no drums or only minimal amounts of drum remnants are observed in a test pit, samples of drum contents would not be collected. In addition, the number of samples submitted for laboratory chemical analysis may increase or decrease depending on headspace results, field observations, the spatial distribution and types of existing data, and the number and types of samples collected.

The intent of the test pit and test trench investigation is to identify locations that exhibit similar characteristics (i.e., visual, physical, and, to the extent the materials are analyzed, chemical composition). Test pits may be grouped together based on similar field observations. Where grouping occurs, CRA will select samples from the entire grouping for chemical analysis. The CRA field representative will establish the groupings, identify which test pits and test trenches will compose a given grouping, and select fill samples for submission to the analytical laboratory for analysis. Fill materials will only

be grouped together where the fill materials are present in the same area of the Site and where laboratory holding times allow. Inherent in the grouping of fill types is the presumption that analytical data and other results obtained will be representative of the entire grouping. CRA will attempt to evaluate this presumption through replicate sampling in wide-spread fill types at a frequency of one replicate sample for every five grouped samples. The test pit and test trench locations that are grouped together along with the corresponding sample identification number(s) will be identified in the Test Pit Stratigraphy log. Sample selection will be performed such that fill types from multiple different locations are selected.

Potential exposure to possible low-level radiation at the Site during test pit and test trench investigative work shall be monitored with a low-level radiation meter (e.g., Victoreen survey meter). All radiation monitoring shall be conducted in the breathing zone. Radiation monitoring is only expected to be required if material resembling foundry sands is identified during the test-pitting and test-trenching activities. If the radiation level exceeds 0.6 m rem/hr, the Site will be evacuated and the Site Health and Safety Manager and Project Manager will be contacted.

2.6 LANDFILL GAS/SOIL VAPOR INVESTIGATION

Twenty soil gas probes will be installed at the Site, including the properties along Dryden Road. Soil gas probe locations are presented on Figure J-2.3. Soil gas probes will be installed and LFG/soil vapor samples will be collected in order to:

1. assess the presence of LFG and soil vapor at locations within the Site (pressure, methane, lower explosive limit (LEL), carbon dioxide and oxygen; and other chemicals at the detection limits listed in Table J-2.5)
2. obtain current data in locations where historic information indicated potential landfill gas generation concerns
3. develop information to assist in calculating future landfill gas generation rates for the FS
4. develop information to assist in evaluating the need for and type of landfill gas control at the Site for the FS

The procedures for installation of the probes are described below.

Five gas probes will be installed in the central portion of the Site to evaluate the presence of methane and non-methane VOCs organic compounds (NMOC) in the zone where the LFG/soil vapors will most readily migrate at these locations. Three probes will be

installed in the vicinity of the former USTs and the Valley Asphalt drum removal area to assess the landfill gas and soil vapor quality in the zone where the LFG/soil vapors will most readily migrate at these locations.

Fourteen probes are proposed to be installed on or adjacent to the Site boundary and in the vicinity of the commercial properties and structures along Dryden Road and west of East River Road to assess LFG and soil vapor quality in the zone where the LFG/soil vapors will most readily migrate at these locations.

2.6.1 GAS PROBE INSTALLATION

Soil gas probes will be installed using a 50-mm (2-inch) diameter Geoprobe dual-tube direct push technique to minimize formation disturbance. The borehole for each gas probe will be advanced to a target depth in the unsaturated zone (a maximum of 20 ft bgs or 2 feet above the water table, whichever occurs first) corresponding to the bottom of the soil gas probe screened interval. Soil and fill materials encountered will be logged. The soil log information recorded will include a visual description of the types of material (i.e., undisturbed native soil, spoils from quarry operations, domestic refuse, industrial refuse, metallic debris, ash, fly ash, construction and demolition debris, foundry sand, asphalt, slag, or other appropriate description) and, if possible, a USCS description. Soils will be logged using the USCS by CRA's staff. A photograph of each core sample collected will be taken and a photographic log will be documented in the field notes. Should groundwater be encountered in any gas probe borehole, the tube will be pulled up a minimum of 2 feet above the water table. The void that is formed when the tube is pulled will be filled using No. 3 silica sand. The groundwater elevation of the nearest monitoring well will be used to determine the targeted depth of the borehole for the gas probes.

LFG and soil vapor will not preferentially migrate through discrete intervals of fill material at the Site unless impermeable layers are present between the discrete intervals of fill material. Based on the available Site geological data, intervals that are impermeable to LFG/soil vapor have not been identified. Further, LFG and soil vapor migration to ambient air or into a building will occur from the shallow soil horizon. Accordingly, the screened interval of the gas probes will be installed in soil strata with a notably higher permeability than the surrounding geologic strata. The gas probe screen will be set as shallow as possible within the higher permeability stratum. In order to prevent short circuiting of ambient air into the gas probe and, consequently, dilution of LFG/soil vapor samples, the top of the gas probe screen will be installed a minimum of three feet below ground surface. The final depth of the gas probe screen will be

dependent on the conditions observed at each location and will be determined in the field. The proposed soil vapor sampling program has been established to collect and analyze LFG/soil vapor samples that are representative of soil vapor quality in the most permeable zone in the vicinity of the probe, which is the zone where LFG and NMOC will migrate. If these soil borings encounter multiple, discrete permeable zones that appear to have vastly different LFG/soil vapor impacts based on field screening, then CRA will either consult with USEPA's field representative(s) and install more than one gas probe at that location or identify that area as potentially requiring additional characterization in later stages of investigation or remediation at the Site.

The average depth of the unsaturated zone across the Site is approximately 20 ft bgs; therefore, a target maximum depth of 20 ft bgs is based on the need to place the gas probes in the unsaturated zone near the surface where LFG/soil vapor, if present, will diffuse and migrate.

The purpose of this investigation is to assess the migration potential and generation rate(s) of methane and NMOC in the soil gas at sampled locations. If gas probes are installed in the 2-foot interval above the water table, the gas probes will periodically be saturated and will not generate meaningful data. The proposed gas probe locations specified will address LFG/soil vapor concentrations at locations near potential receptors.

The screened interval will be selected based on field observations that will identify the presence of landfill materials or, in the absence of such materials, a comparatively permeable region in the unsaturated zone that would be expected to transmit LFG and/or soil vapor. The selection of the most permeable zone will be based on soil descriptions and characterizations using the Unified Soil Classification System (USCS). Where landfilled materials are present, the screen will be placed at a depth immediately above the landfilled materials. If the landfilled material extends to within three feet of the surface and it is, therefore, not possible to set the screen above the landfilled material, the screen will be placed within the landfilled material, with the screened interval set as close to the top of the landfilled materials as possible but deep enough to minimize the breakthrough of ambient air from the surface (i.e., 3 to 5 ft bgs).

The gas probes will be completed using 13-mm (0.5-inch) diameter schedule 40 PVC continuous piping (i.e., no joints) with a screened interval length of 0.3 m (1 foot). The void space between the screened interval and formation will be filled with No. 3 silica sand (i.e., sand pack) to approximately 0.2 m (8 inches) above the top of the screened interval. One foot of dry granular bentonite will be placed on the top of the sand pack. Hydrated bentonite will be placed on top of dry granular bentonite to just below ground

surface. The sand pack and bentonite seal will be placed as the Geoprobe is withdrawn to ensure that the formation does not collapse around the screened interval or riser. A lockable surface casing will be set in concrete at ground surface around each soil gas probe.

Soil samples will be collected from the surface and subsurface during the soil gas probe installation for the analyses of soil physical properties (i.e., grain size analyses, *foc*, plasticity index, porosity, permeability, and Atterburg limits). The soil gas probe completion details are summarized in Figure J-2.4. The soil gas probe stratigraphic and instrumentation logs are presented in Appendix J-G. The soil gas probe installation SOP is provided in Appendix J-F-33.

2.6.2 LANDFILL GAS/SOIL VAPOR SAMPLING

CRA will complete two rounds of LFG/Soil Vapor sampling. The sampling will consist of:

- i) measurement of gas pressure
- ii) screening for methane (v/v) and LEL and oxygen (v/v)
- iii) collection of Summa™ canister samples for VOC analysis

The initial LFG/soil vapor sampling will be conducted one week following soil gas probe installation. Following soil gas probe installation, one week is considered to provide more than sufficient time for any formation disturbances created by drilling activities to dissipate and for equilibrium conditions to be re-established in the unsaturated zone. As a result, the soil vapor samples are considered representative of conditions in the sampled intervals at the time the samples are collected. Soil gas sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., greater than 0.5 inches after California Environmental Protection Agency (CalEPA, 2003)]. This would avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen soil gas concentrations, or possibly prevent soil gas sample collection (i.e., such as in cases where the soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration will be given to allowing a greater amount of time for rainfall events to dissipate. The potential influence of rainfall events on soil gas concentrations is less of a concern in cases where the gas probes are located beneath impervious ground cover (e.g., pavement or building foundation). Landfill gas and soil vapor monitoring SOPs are provided in Appendices J-F-10 and J-F-11, respectively.

The three sampling elements are described below.

i) Measurement of Gas Pressure

A pressure gauge will be attached to the hose barb on the LFG probe to measure the static gas pressure. The pressure gauge will be sufficiently sensitive to record gas pressure to 0.1 pounds per square inch (psig). The highest value obtained during gas pressure readings will be recorded. The ambient barometric pressure will be recorded at each gas probe when soil gas pressure readings are being taken. Also the ambient barometric trends will be noted (i.e., rising, falling, steady).

Two rounds of gas pressure measurements will be collected, separated by at least one month. Additional information regarding the pressure measurement procedures is provided in the Landfill Gas Monitoring SOP in Appendix J-F-10.

ii) Screen for Methane, LEL, and Oxygen

A Gas Extraction Monitor will be used to draw a sample from each probe to measure and record the methane, LEL, carbon dioxide and oxygen readings. The Gas Extraction Monitor SOP is provided as Appendix J-F-12. Additional detail regarding the screening procedures is provided in the Landfill Gas Monitoring SOP in Appendix J-F-10. The highest values obtained during sampling will be recorded. The ambient and soil gas temperatures will be recorded at each gas probe when soil gas readings are being taken. Also the ambient barometric trends will be noted (i.e., rising, falling, steady).

Two rounds of this sampling will be completed separated by at least one month.

iii) Summa™ Canisters

One round of soil gas samples will be collected during the first round of methane measurements using six-liter capacity Summa™ canisters fitted with a laboratory calibrated critical orifice flow regulation device sized to allow the collection of the soil gas sample over a one-hour sample collection time. The one-hour sample collection time for a six-liter capacity Summa™ canister corresponds to a maximum soil gas sample collection flow rate of approximately 100 milliliters per minute (mL/min). This soil gas sample collection flow rate corresponds to the lower end of the maximum flow rate recommended in the soil gas sampling protocol recently developed by CalEPA (CalEPA, 2003). A flow rate of 100 mL/min is recommended to limit VOC stripping from soil and prevent the short-circuiting of ambient air from ground surface that would

dilute the soil gas sample. The low flow rate of 100 mL/min will increase the likelihood that a representative sample of in situ conditions is collected. Prior to sample collection, soil gas probe purging will be conducted at a maximum flow rate of 200 mL/min. Three soil gas probe volumes (calculated based on casing and sand pack volume) will be purged to remove potentially stagnant air from the internal volume of the soil gas probe. Once the flow rate is set for a canister, the time it will take to fill up the canister will be calculated and the sampler will retrieve the canister and turn off the flow at the calculated time to prevent the valve from being open after the canister is filled.

The Summa™ canister samples will be analyzed for methane, and for VOCs using USEPA method TO-15. The VOCs included in USEPA method TO-15 (with the addition of naphthalene) and the best method detection limits that the contract laboratory can achieve are listed in Table J-2.5. The laboratory's ability to achieve the best possible detection limits will be highly dependent on the presence of matrix interferences.

QA/QC measures to be implemented during the soil gas sampling event include maintaining a minimum negative pressure in the Summa™ canisters following sample collection, collection of one field duplicate sample, collection of an ambient air sample, and the analysis of a trip blank Summa™ canister. Further details regarding the soil gas probe sampling protocol and the applied QA/QC measures are presented in Appendix J-F-10.

2.7 GROUNDWATER INVESTIGATION

The following hydrostratigraphic units may exist at the Site based on available information:

- Upper Aquifer Zone – a zone of glacio-fluvial sand and gravel facies;
- Till-Rich Zone – a zone of discontinuous low permeability till facies interspersed with sand and gravel facies; and
- Lower Aquifer Zone – a zone of glacio-fluvial sand and gravel facies.

Additional data are needed to more fully characterize these zones and their interaction on Site. The general objectives for the groundwater investigation include the following:

- Define subsurface stratigraphy, including identifying till-rich zone(s) and sand and gravel aquifer zone(s) at locations beneath the Site to a depth of 100 ft bgs (or deeper as appropriate) using Rotasonic drilling. The subsurface stratigraphy will be

defined based on soil descriptions and characterizations using the Unified Soil Classification System (USCS).

- Collect data to assist in characterizing groundwater impact.
- Recognizing that there may be seasonal or event-related differences in groundwater elevation, flow conditions and contaminant concentrations, and that there may be more than one contaminant flow path and more than one source of groundwater contamination at the Site, attempt to: i) determine the appropriate screened interval(s) for shallow monitoring wells at VAS locations through VAS data; ii) compare the screened intervals identified through VAS to the screened intervals and screen lengths in the existing wells; and iii) determine, based on these results and all existing data for the Site, if the screened intervals and screen length of the existing wells represent a zone of chemical impact in the shallow aquifer that is worthwhile to continue to monitor or not.
- Characterize groundwater chemistry at Site monitoring wells through groundwater sampling and laboratory analysis.
- Collect groundwater and surface water elevation measurements over time to identify horizontal hydraulic gradients, flow directions, and, if nested wells are proposed in Phase 2, vertical hydraulic gradients.

In an effort to meet these objectives, the groundwater investigation will proceed in two Phases. Phase 1 will include three main work tasks: VAS borings, synoptic water level measurements, and groundwater sampling for laboratory analysis. The groundwater data will be used to determine additional well locations for the next phase of work and the results from these three tasks will be summarized in a Technical Memorandum that will include recommendations for the scope of Phase 2, which is discussed in Appendix J-E. The Technical Memorandum will be prepared and then reviewed in a project team workshop, similar to the meetings held with USEPA and Ohio EPA in early 2008.

The sections below present procedures for field tasks related to groundwater investigations:

Section 2.7.1	Vertical Aquifer Sampling
Section 2.7.2	Monitoring Well Development
Section 2.7.3	Hydraulic Monitoring
Section 2.7.4	Groundwater Sampling
Section 2.7.5	Single-Well Response Testing

2.7.1 VERTICAL AQUIFER SAMPLING

Figure J-2.5 presents the locations of twenty-three on-Site VAS borings and two off-Site VAS borings (on the trailer park parcel - Lot 2943). The VAS boring locations, 24 and 25, are proposed on the trailer park parcel to evaluate off-Site conditions in the presumed downgradient direction from MW-210.

Additionally, the location of a soil boring that will be used to log the subsurface material below the large asphalt pile is presented on Figure J-2.5. All of these borings, including the boring installed through the large asphalt pile, will be completed using Rotasonic drilling techniques. This drilling technique offers the opportunity to document relatively undisturbed soil sample cores, advance to the desired depth, and produces less waste than hollow stem auger drilling techniques.

VAS will be completed to a maximum depth of 100 ft bgs at each Phase 1 location, and to a maximum depth of 200 ft bgs at Phase 2 locations. These borings will be completed using Rotasonic drilling techniques. All VAS samples will be analyzed for TCL VOCs, total arsenic, and lead. All of the groundwater samples collected during VAS and submitted to the laboratory will be unfiltered groundwater samples. Additional filtered groundwater samples may be collected during VAS if appropriate upon approval of USEPA. In addition, VAS samples collected from select sampling intervals from each boring will be analyzed for TCL SVOCs as discussed in further detail below.

The sampling intervals that will be submitted for TCL SVOC analysis will depend on boring locations, whether the borehole is advanced through fill (i.e., non-native) material, or through undisturbed native soil. The geophysical survey and, if the schedule permits, test pit/test trench work that will be completed prior to the groundwater work discussed in this section will help determine which VAS borehole locations are in fill material. The VAS borings determined to be located in fill material areas, or which have potential to be in fill material, will be completed first.

A total of four SVOC samples will be collected from each VAS boring as detailed below. In VAS borings drilled through fill (i.e., non-native) material, where the fill material extends below the water table, a maximum of three groundwater samples will be collected from the fill material for TCL SVOC analysis, and a minimum of one groundwater sample will be collected for TCL SVOC analysis from the native material directly beneath the fill material. The first sample in the fill material will be collected from the five-foot interval from the groundwater interface to five feet below the water table; subsequent groundwater samples collected from the fill material will be collected

from every second five-foot interval. SVOC samples of native material will be collected at each five-foot interval commencing at the interface between the fill and native material. The total number of samples collected from the fill (i.e., non-native) and from the native material at an individual VAS boring location will be dependant on the depth of fill material below the water table, i.e., if the fill material is sufficiently thick, three SVOC samples will be collected from the fill material and one from the native material, whereas if the fill material is thinner, fewer SVOC samples will be collected from the fill material and more samples will be collected from the native material (for a total of 4 SVOC samples per boring).

In VAS borings completed in native soil or where the fill is located entirely above the water table, four samples for TCL SVOC analysis will be collected. The first sample will be collected from the five-foot interval beginning at the groundwater interface and the second from the five feet below the water table to 10 feet below the water table. The third TCL SVOC sample will be collected at elevations corresponding to deeper areas of fill material below the water table in adjacent VAS borings or based on stratigraphic information from previous borings and the Valley Asphalt well, as appropriate. The fourth TCL SVOC sample will be collected from elevations corresponding to the deepest fill material elevation to five feet below the bottom elevation of fill material observed in adjacent borings advanced in non-native fill material or based on stratigraphic information from previous borings and the Valley Asphalt well, as appropriate. Sample elevations will be discussed with USEPA field representatives before starting VAS borings in areas believed to be in native soil areas. At this time it is premature to say which locations are likely to be in native material. To the extent possible given current Site data, VAS borings will be completed in known fill areas prior to moving to areas where native material is known or believed to exist based on existing data or where no data with respect to the presence of fill exists.

The results of the VAS will be used to help select monitoring well locations (to be installed in Phase 2). The selection of monitoring well locations will be based on an analysis of VAS results and all existing data, including hydrostratigraphic data.

The proposed VAS borings are roughly laid out along four transects. The transects run approximately parallel to the section of the GMR northwest of the Site and continue toward the southeastern Site boundary. Following is a summary of the VAS boring locations, as identified along each transect, and the rationale for selecting each location. VAS boring locations may be revised based on the results of the Geophysical Survey and the Test Pit/Test Trench Investigation, which will be completed prior to the VAS sampling program, if scheduling permits. Any modifications to the VAS boring and sampling program will be discussed with the USEPA prior to implementation.

<i>Transect No.</i>	<i>VAS Location No.</i>	<i>Rationale for VAS Location</i>
1	1	VAS location along northwest Site boundary to serve as a presumed upgradient data point. This location may be moved farther north along the transect if possible, if fill is encountered.
	2	VAS location along northwest Site boundary and within 200 feet of MW-206 to evaluate aquifer data in vicinity of the well.
	3	VAS location along northwest Site boundary and within 200 feet of MW-201 and MW-103 to evaluate aquifer data in vicinity of these wells.
2	4	VAS location at northeast corner of Site boundary to serve as a presumed upgradient data point.
	5	VAS location to evaluate conditions in vicinity of, and in presumed downgradient direction of, former Dayton Recycling USTs. Off-set approximately 50 feet northwest of the transect.
	6	VAS location to evaluate conditions in vicinity (or in presumed downgradient direction within vicinity) of the Valley Asphalt drum removal in 2000. Off-set approximately 100 feet northwest of the transect.
	7	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. Off-set approximately 110 feet southeast of the transect.
	8	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. Off-set approximately 275 feet southeast of the transect.
	9	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. Off-set approximately 150 feet southeast of the transect.
	10	VAS location to evaluate the boundary between parcel 5054 (Valley Asphalt) and Lot 5177.
	11	VAS location to evaluate conditions at approximate center of PRP's preliminary direct contact risk area (and located roughly 200 to 300 feet from former air curtain destructor).
	12	VAS location to evaluate presumed downgradient boundary of PRP's preliminary direct contact risk area.
	13	VAS location to collect data at southwest corner of Site boundary.

<i>Transect No.</i>	<i>VAS Location No.</i>	<i>Rationale for VAS Location</i>
3	14	VAS location to evaluate conditions in vicinity of former Custom Delivery UST area. Off-set approximately 100 feet northwest of the transect.
	15	VAS location to evaluate aquifer conditions in vicinity of MW-202. Off – set approximately 225 feet southeast of the transect.
	16	VAS location to evaluate presumed downgradient boundary of PRP's preliminary direct contact risk area at northwest corner of Lot 5176. Off-set approximately 225 feet southeast of the transect.
	17	VAS location to evaluate presumed downgradient boundary of PRP's preliminary direct contact risk area in vicinity of MW-203. Off-set approximately 100 feet southeast of the transect.
	18	VAS location to evaluate presumed downgradient boundary of PRP's preliminary direct contact risk area in vicinity of MW-101A and MW-204. Off-set approximately 200 feet northwest of the transect.
	19	VAS location within 200 feet of MW-209 and MW-212 to evaluate aquifer data in vicinity of these wells. If this location requires offsetting during field operations, it will remain at least 100 feet away from the edge of the Quarry Pond.
	20	VAS location to collect data south of the Quarry Pond.
4	21	VAS location to evaluate conditions within vicinity of MW-210. Off-set approximately 50 feet southeast of the transect.
	22	VAS location east of the Quarry Pond to evaluate conditions at southeastern boundary of Site and Lot 4423.
	23	VAS location to collect data at southeast corner of Site.

Two additional locations, 24 and 25, are proposed on the trailer park parcel (Lot 2943) to evaluate off-Site conditions in the presumed downgradient direction from MW-210.

The soil boring that will be used to log the subsurface material below the large asphalt pile will be advanced to a depth of 5 to 10 feet below the first native material encountered beneath the large asphalt pile (as determined in the field). The borehole will be advanced via Rotasonic drilling techniques, but VAS samples will not be collected from this borehole location. During borehole advancement below the large asphalt pile, continuous soil cores will be observed, soil stratigraphy will be logged and cores will be screened for the presence of VOCs and methane in the same manner as the VAS borings. A photographic log will also be compiled from each 10-foot soil core interval at the asphalt pile borehole location.

Existing monitoring wells will be inspected, repaired as needed, and redeveloped to attempt to produce a silt free condition prior to water level monitoring and sampling.

The Rotosonic VAS procedure is as follows:

1. Ten-foot long core samples will be taken directly from the core barrel attached to the end of the drill string and extruded into cylindrical bags. Field measurements for VOCs and methane will be conducted along the cored material by piercing the plastic sleeve with the wand of the field instrument(s). Field measurements for VOCs will be conducted along the cored material by piercing the plastic sleeve with the wand of the PID. If condensation within the plastic sleeve interferes with the operation of the PID, e.g. during colder months, field measurements for VOCs may be obtained by cutting the bag open and moving the tip of the PID over the length of the undisturbed soil core. Where the PID screening is completed by cutting the bag open and elevated PID readings are measured, CRA will collect a sample of the core for headspace analysis by placing the sample in a plastic bag and completing the headspace analysis in accordance with Appendix J-F-9. In addition, where field screening indicates the potential presence of NAPL, the soils will be tested for the presence of non-aqueous phase liquids (NAPL) using the Sudan® IV dye test and/or another USEPA shaker test. Field calibration, preventative maintenance, and SOPs for the PID and Sudan IV ® dye test are contained in Section 6.0.
2. Should the presence of NAPL be detected in a boring, the interval of detection will be recorded and advancement of the boring will be terminated to prevent introducing NAPL into deeper intervals. USEPA will be notified of the presence of NAPL at the location and the borehole location will be sealed with bentonite grout via a tremie pipe using the positive displacement method. The PRP Group may, in consultation with the USEPA Site representative(s), elect to collect a soil sample at the impacted interval to assist in NAPL characterization. Soil samples from the interval where NAPL was identified will be collected in accordance with the sampling methodology outlined in Section 2.5 and the SOP provided as Appendix J-F-13. Available stratigraphic information from such locations (up to and including the interval with detected NAPL) will be reviewed and the location will be evaluated for additional work in Phase 2.
3. A representative soil sample from each lithology in each 10-foot core will be collected and classified using the USCS in accordance with ASTM Method D-2488-06 (ASTM Methods are provided in Appendix J-H). Each core will be photographed and described on an Overburden Stratigraphy Log, an example of which is provided in Appendix J-G.

4. During borehole advancement, the amount of water added during Rotasonic drilling will be recorded. Every effort will be made to minimize the amount of water added during drilling in order to reduce the amount of purging required and to ensure that samples are representative of the groundwater in the aquifer formation. Where the addition of water is required during Rotasonic drilling to overcome heaving sands, CRA will document the amount of water added. CRA will then remove twice this volume during pre-purge except where the nature of the formation prevents the removal of the required volume of groundwater as discussed further below in step 9.
5. The presence of significant quantities of silt within portions of the sand and gravel layers beneath the upper till layer at the Site greatly reduce the rate at which water can be removed from the formation at some VAS locations. The purge volume should be calculated using the length of the screened interval rather than the entire length of the water column in the inner core barrel. The drawdown within the core barrel should not exceed 20 percent of the length of the water column based on the original static water level following insertion of the well screen.
6. Groundwater samples will be collected at 5-foot or 10-foot intervals beginning at the 0 to 5-foot interval below the groundwater interface observed during borehole advancement, unless specified otherwise in the scope of work and approved by USEPA. Groundwater samples will be collected from each discrete interval through a 10-foot long, stainless steel slotted screen (or a 5-foot long, stainless steel slotted screen as described below) using a packer with a submersible pump system. A 5-foot length of No. 10 slot, 2-inch diameter stainless steel screen will be used at intervals where a distinct change in geology has been noted, or where the depth to native till material is 6 feet or less. The flow rate for purging of groundwater will be dependent on the capacity of the submersible pump and the transmissivity of the aquifer material. Efforts will be made to maintain low flow during purging as discussed below.
7.
 - i) The following purging procedure applies to the use of a 5-foot temporary well screen.

When using a 5-foot temporary well screen, the purging will be conducted with the pump intake set at the middle of the well screen. Upon purging two times the volume of water added during drilling (pre-purge), the flow rate will be reduced to the lowest sustainable flow rate and the minimum required screen volumes (i.e., three to five volumes of the screened zone) will be purged. VAS samples will not be collected from a 5-foot interval if attempts to purge and sample indicate the interval does not yield enough water to sample. Water samples will

only be collected after well stabilization is achieved (i.e., a minimum of 3 to a maximum of 5 well screen volumes are purged with monitoring of stabilization parameters, as presented in Step 8 below.

- ii) The following purging procedure applies to the use of a 10-foot temporary well screen.

When using a 10-foot temporary well screen, the purging will be conducted with the pump intake set 2.5 feet below the top of the well screen. Upon purging two times the volume of water added during drilling (pre-purge), the flow rate will be reduced to the lowest sustainable flow rate and the minimum required screen volumes (i.e., three to five volumes of the screened zone) will be purged, and a groundwater sample will be collected following the procedures provided in Steps 8, 9, and 10 below. Where a 10-foot temporary well screen is used, the submersible pump will then be lowered to a depth of 7.5 feet below the top of the temporary 10-foot screen (i.e., 2.5 feet above the bottom of the screen), and a second groundwater sample will be collected. Water samples will only be collected after well stabilization is achieved (i.e., a minimum of 3 to a maximum of 5 well screen volumes are purged with monitoring of stabilization parameters, as presented in Step 8 below.

- 8. Water samples will be collected and checked following each purged well volume for field measured parameters in order to show stability. The number of well volumes purged will be determined by comparing the results of the field parameters after each well volume. Field parameters will be monitored to evaluate the stabilization of purge groundwater. Field parameters include, but are not limited to, pH, temperature, conductivity, oxidation-reduction (redox) reaction potential (ORP), dissolved oxygen (DO), and turbidity. Groundwater samples will be collected once the parameters have stabilized. The groundwater will be considered stable after a maximum of five well volumes are removed or when three successive readings for pH, specific conductance, and temperature agree with the following limits:

pH	±0.1 pH unit
Specific conductance	±3 percent (temperature corrected)
Temperature	±1.0°C

- 9. For sampling intervals where no water was added to the formation during drilling and the nature of the formation restricts the flow of water during purging substantially, purging will continue for a maximum of two hours. For sampling intervals where water was added to the formation during drilling,

purging will continue for a maximum of four hours. CRA will record the total volume of water removed, and document reasons for not removing the required volume,

10. The groundwater sample for each interval will be collected directly from the pump discharge into the sample containers. VAS samples will be analyzed for TCL VOCs, total arsenic, lead, and dissolved arsenic and lead. QC samples will be collected for chemical analysis as discussed in the QAPP. Samples will be handled as discussed in Section 5.0.

All down-hole equipment such as augers, drill casings, drill rods, and samplers will be decontaminated as discussed in Section 7.0. Drill cuttings and decontamination water will be managed as discussed in Section 8.0.

2.7.1.1 SHALLOW MONITORING WELL INSTALLATION

Based on the results of Phase 1 of the Groundwater Investigation, the PRP Group may propose to install additional shallow monitoring wells at the Site. If required, shallow monitoring wells will be installed as detailed below.

Augers are available with inside diameters of 2.5, 3.25, 4.0, 4.25, 6.25, 8.25, and 10.25 inches. The most commonly used are 4.25 or 6.25 inches for 2-inch (5-cm) monitoring wells and 6.25 inches for 4-inch (10-cm) monitoring wells. Borings will be advanced using 6.25-inch inside diameter hollow stem auger (HSA) drilling techniques with continuous split-spoon sampling or the Rotasonic drilling method using a nominal 6-inch inside-diameter casing (in the event that attempts to install the boreholes for construction of the shallow monitoring wells using HSA drilling techniques are unsuccessful). The PRP Group anticipates that HSA drilling techniques will be successful for installation of the shallow monitoring wells. The following discussion regarding monitoring well installation and sampling assumes the use of HSA drilling methodology; however, in the event that Rotasonic drilling methods are required for the shallow monitoring wells, the methodology outlined in Section 2.7.1.1 will be employed.

Soil core samples from HSA drilling activities will be collected continuously for field screening and classification using 2-inch diameter split-spoon samplers, using the techniques described in ASTM Method D1586-08 (Appendix J-H-1). Soil core samples will be classified using the USCS in accordance with ASTM Method D2488-06 (see Appendix J-H-2) and stored in clear glass jars for future reference (note that these samples are not intended for laboratory analysis and are merely collected for visual reference purposes). The jars will be labeled with the CRA project number, the soil

boring identification number, the depth sampled, and the date. The stratigraphic sequence observed at each borehole will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G. The PRP Group does not propose to submit any soil samples for laboratory analysis. However, should conditions encountered in the field indicate that the data to be obtained through the submission of a soil sample(s) at a monitoring well location, the PRP Group, in consultation with the USEPA Site representative, will collect soil samples in accordance with the sampling methodology outlined in Section 2.5.

Removing augers in flowing sand conditions while installing monitoring wells may be difficult since the augers have to be removed without being rotated. A bottom plug or pilot bit assembly will be utilized to keep out soils and/or water that have a tendency to plug the bottom of the augers during drilling. If flowing sands are encountered, potable water (analyzed once for TCL VOCs, TCL SVOCs, and TAL inorganics) may be poured into the augers to equalize the pressure to keep the formation materials and water from coming up into the auger once the bottom plug is removed. Any water added during drilling and/or well installation will be measured. Twice the volume of water added during drilling and/or well installation will be removed prior to completing well development and purging for monitoring well sampling.

The two-inch diameter well screen and riser will be installed through the hollow-stem augers, which will provide a minimum of 2 inches clearance on all sides of the casing. Two-inch diameter number 10 slot, 5- or 10-foot long Schedule 40 PVC well screens and flush-threaded Schedule 40 PVC riser pipe allowing for approximately 3 feet of stick-up will be used to install the proposed shallow monitoring wells. Ten-foot long Schedule 40 PVC well screens will be used for water table wells. The positioning of the 10-foot long well screens relative to the water table will be determined based on the VAS data and/or groundwater results from sampling of the existing monitoring well network. Five-foot long Schedule 40 PVC well screens will be used for all other wells. A tremie pipe will be used to place a filter pack consisting of coarse silica sand (10-20 mesh) from the bottom of the well screen to 2 feet above the well screen, and 1 foot of fine (20-40 mesh) silica sand from 2 to 3 feet above the well screen. Approximately two to three feet of bentonite gravel will be placed above the filter sand to help provide a seal for the bentonite grout.

The boring annulus above the bentonite gravel layer will be backfilled with bentonite grout to within three feet of ground surface. A tremie pipe will be used to emplace the backfill material below the water table or to depths greater than 20 ft bgs.

The uppermost three feet of the boring annulus will be filled with concrete, forming a pad with a diameter of at least two feet at ground surface. The pad will be designed to slope away from the monitoring well. A lockable protective steel casing will be set in the concrete over the well riser. The well casing will extend to approximately 2.5 feet above ground surface, and will be fitted with a hinged cap. The well identification number will be permanently marked on the outer casing of all newly installed and existing monitoring wells. Typical shallow monitoring well completion details are provided on Figure J-2.6.

2.7.1.2 DEEP MONITORING WELL INSTALLATION

Based on the results of Phase 1 of the Groundwater Investigation, the PRP Group may propose to install additional deep monitoring wells at the Site. If required, deep monitoring wells will be installed as detailed below.

The deep monitoring wells (screened at depths of up to 200 ft bgs, dependant on the results of the VAS program) will be installed using the 6-1/4-inch inside-diameter HSA method or the Rotosonic drilling method using a nominal 10-inch inside-diameter casing (in the event that attempts to install the boreholes for construction of the deep monitoring wells using HSA drilling techniques are unsuccessful).

Deep monitoring wells will be screened across units that are identified as being most heavily impacted during the VAS program, which will be completed during Phase 1 of the Groundwater Investigation.

During the installation of deep monitoring wells, one soil sample from each distinct stratigraphic unit in the unsaturated zone will be collected from each borehole. The PRP Group does not propose to submit any soil samples for laboratory chemical analysis. However, should conditions encountered in the field indicate that data should be obtained through the submission of a soil sample(s) at a monitoring well location, the PRP Group, in consultation with the USEPA Site representative, will collect soil samples in accordance with the sampling methodology outlined in Section 2.5. Samples will be analyzed for all or a subset of the soil parameters shown in Table J-2.1, as appropriate.

The HSA lower aquifer monitoring well installation procedure is as follows:

1. The HSA drill rig will advance a 6-1/4-inch inside diameter hollow-stem auger. The lead auger will be a slotted auger. Soil samples will be collected continuously using 2-inch diameter split-spoon samplers using the techniques

described in ASTM Method D2488-06 (Appendix J-H-2). The stratigraphic sequence observed at each borehole will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G.

2. The HSA borehole will be advanced from ground surface to a maximum total depth of up to 200 ft bgs. The actual depth of the borehole will be determined based on the VAS sampling completed during Phase 1 of the Groundwater Investigation as detailed below.
3. The screened interval for the monitoring well will be selected based on the results of the VAS sampling completed during Phase 1 of the Groundwater Investigation. A tremie pipe will be used to emplace the backfill material below the water table or to depths greater than 20 ft bgs. The monitoring well screen and riser pipe, silica sand filter pack, and bentonite grout will be installed.
4. After installing the well screen and riser, the hollow-stem augers will be removed from the borehole.

The Rotosonic lower aquifer monitoring well installation procedure is as follows:

1. The Rotosonic drill rig will advance a 4-inch diameter (nominal) core barrel for sampling and will also advance a 6-inch diameter outer casing for the construction of the monitoring wells.
2. The Rotosonic borehole will be advanced from ground surface to a total depth of up to 200 ft bgs. The actual depth of the borehole will be determined based on the VAS sampling completed during Phase 1 of the Groundwater Investigation. The nominal 4-inch core barrel is advanced from 10 to 20 feet ahead of the nominal 10-inch diameter outer casing without the use of drilling fluids or air. The outer casing is then advanced to a depth of 10 feet less than the depth of the core barrel injecting some water to maintain a fluid head. The core sample is then retrieved from the inner core barrel.
3. Core samples will be taken directly from the core barrel attached to the end of the drill string and extruded into 10-foot long cylindrical bags. Field measurements for VOCs will be conducted along the cored material by piercing the plastic sleeve with the wand of the PID. If condensation within the plastic sleeve interferes with the operation of the PID, e.g. during colder months, field measurements for VOCs may be obtained by cutting the bag open and moving the tip of the PID over the length of the undisturbed soil core. Where the PID screening is completed by cutting the bag open and elevated PID readings are measured, CRA will collect a sample of the core for headspace analysis by placing the sample in a plastic bag and completing the headspace analysis in

accordance with Appendix J-F-9. Field calibration, preventative maintenance, and SOPs for the PID are discussed in Section 6.0.

4. A representative soil sample from each lithology in each core will be collected and classified using the USCS in accordance with ASTM Method D2488-06 (Appendix J-H-2). Each core will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G.
5. The screened interval for the monitoring well will be selected based on the results of the VAS sampling completed during Phase 1 of the Groundwater Investigation. A tremie pipe will be used to emplace the backfill material below the water table or to depths greater than 20 feet bgs. The monitoring well screen and riser pipe, silica sand filter pack, and bentonite grout will be installed. Two-inch diameter number 10 slot, 5- or 10-foot long Schedule 40 PVC well screens and flush-threaded Schedule 40 PVC riser pipe allowing for approximately 3 feet of stick-up will be used to install the proposed deep monitoring wells. After installing the well screen and riser, the outer casing will be removed from the borehole.

The deep monitoring wells will be constructed as described for the shallow monitoring wells. Deep monitoring wells installed below areas of the Upper Aquifer that are heavily impacted will be installed using a double-casing to isolate contaminated groundwater in the Upper Aquifer from groundwater in the Deep Aquifer. Any water used during drilling and/or well installation will be measured. Twice the volume of water used will be removed prior to purging the three to five slotted auger volumes. The pre-purge may be done at higher flow rates than the regular purging.

Field Standard operating procedures for Rotosonic drilling are provided in Appendix J-F-13. Typical deep monitoring well completion details are depicted on Figure J-2.7.

2.7.1.3 SHALLOW PIEZOMETER INSTALLATIONS/ VERTICAL AQUIFER SAMPLING

Based on the results of Phase 1 of the Groundwater Investigation, the PRP Group may propose to install shallow piezometers and/or conduct vertical aquifer sampling at the Site. If required, piezometers may be installed in order verify groundwater flow direction and aquifer response in the Upper Aquifer.

Shallow piezometers and VAS locations may be installed in the southern portion of the Site adjacent to residential properties that are potentially downgradient from the Site with regards to groundwater flow in order to achieve the following objectives:

- verify groundwater flow direction and aquifer response in the Upper Aquifer
- characterize potential groundwater impacts
- further characterize groundwater that is potentially migrating off-Site
- determine human health and ecological risks to exposure of shallow on-Site groundwater at these locations

If required, shallow piezometers will be installed using 50-mm (2-inch) diameter Geoprobe dual-tube direct push, 4.25- or 6.25-inch HSA drilling or Rotasonic drilling techniques, as appropriate. VAS locations, if required, will be installed using the Geoprobe dual tube direct push technique. The borehole for each piezometer or VAS location will be advanced to a target depth corresponding to the top of the Upper Aquifer or approximately 25 ft bgs.

The piezometers will be completed using 0.5-inch or 2-inch diameter schedule 40 PVC continuous piping with a screened interval length of 5 feet. Ten-foot long screens will be used for water table piezometers. For piezometers, the void space between the screened interval and the formation will be filled with No. 3 silica sand (i.e., sand pack) to approximately 2 feet above the top of the screened interval. Approximately 2 feet of dry granular bentonite will be placed on top of the sand pack and then hydrated bentonite will be placed to just below ground surface. The sand pack and bentonite seal will be placed as the Geoprobe, augers, or core is withdrawn to ensure that the formation does not collapse around the screened interval or riser. A lockable surface casing will be set in concrete at ground surface around the piezometer. Typical piezometer completion details are summarized on Figure J-2.8. The soil piezometer well stratigraphic and instrumentation logs are presented in Appendix J-G. All of the newly-installed piezometers will be developed by alternating cycles of surging and over-pumping or bailing at rates that are greater than those used during sampling, not sooner than 48 hours after grouting is completed.

Groundwater sampling procedures for VAS will follow the standard operating procedures outlined in Appendix J-F-34. Following groundwater sampling of the VAS locations, the temporary well screen will be removed, and the borehole will be backfilled with bentonite.

2.7.2 MONITORING WELL DEVELOPMENT

Existing monitoring wells will be inspected, repaired as needed and redeveloped to attempt to produce a silt free condition prior to water level monitoring and sampling. All of the newly-installed monitoring wells, piezometers, and temporary wells will be developed by alternating cycles of surging and over-pumping or bailing at rates that are greater than those used during sampling, not sooner than 48 hours after grouting is completed. A submersible pump may also be used to develop the wells by raising and lowering the pump intake throughout the screened interval. Other well development methods such as air-lift pumping, air surging, and backwashing are unsuitable for the development of small diameter wells.

Turbidity and other stabilization parameters will be measured at the beginning of each period of purging (following surging). Development will continue until the turbidity of the development water is equal to or less than 5 nephelometric turbidity units (NTUs). In the event that turbidity values of less than 5 NTUs cannot be achieved, well development may also be considered complete if all of the following conditions are met:

1. a volume of water has been purged that is equal to or greater than a minimum of ten well volumes in addition to any volume of water or fluid that was introduced into the well and/or formation during construction and development or an amount equivalent to two times the volume of water or fluid introduced during construction and development, whichever is greater.
2. temperature, pH, and conductivity have stabilized to within the following limits:

pH	± 0.1 pH unit.
Specific conductance	± 3 percent (temperature corrected).
Temperature	$\pm 1.0^{\circ}\text{C}$.

Turbidity will be measured using an HF Scientific DRT-15C Turbidimeter. Temperature, pH, and conductivity will be measured using a YSI Model 3560 instrument. Alternatively, equivalent instruments may be used. Field calibration procedures, preventative maintenance procedures, and SOPs are contained in Section 6.0. Decontamination procedures for the surge block and submersible pump are contained in Section 8.0. Decontamination fluids and purge water will be managed as described in Section 8.0.

Development data will be recorded on a Well Development and Stabilization Form, an example of which is in Appendix J-G. The monitoring well development SOP is presented in Appendix J-F-14.

2.7.3 HYDRAULIC MONITORING

Monitoring Wells

Synoptic water level measurement events (i.e., groundwater and surface water) will be conducted in order to get a better understanding of groundwater flow directions. Note that staff gauges or measurement points will first be required for the GMR, Quarry Pond and other surface water bodies. The reference elevations of the existing monitoring wells will be re-surveyed. Synoptic water level measurements will be completed at all existing and newly installed well installations on a monthly basis for the remainder of the 2008 calendar year. Hydraulic monitoring will be conducted a minimum of 24 hours before or after a groundwater sampling program has been conducted at the Site.

Water elevation measurements will be collected using an oil/water interface probe, or equivalent, and a reference point of known elevation on the monitoring well casing to determine the distance between the reference point and the water/light NAPL (LNAPL) level in the well. Water/LNAPL elevation measurements will be recorded on a field form or in a field log book. Water elevation measurements will be confirmed by taking a second reading immediately after the first reading is recorded. If there is a discrepancy between the first and second water level measurements, a third measurement will be made and the results recorded. The water level indicator is a battery-powered, self-contained instrument equipped with a cable and sensor that activates a buzzer and a light when it comes in contact with the water. The depth to water is read from permanent 0.01-foot increment markings on the cable. The reference point will consist of an indelible mark on the highest point of the well casing. All measurements will be recorded in a field logbook. Field calibration, preventative maintenance, and SOPs for water elevation measurements are discussed in Section 6.0.

The monthly synoptic water level measurements described above will continue through Phase 2. More detailed hydraulic monitoring would be completed by installing transducers in select wells and surface water bodies. The transducers will provide continuous water level measurements that will aid in the evaluation of groundwater/surface water interactions.

The water level indicator will be decontaminated as discussed in Section 7.0. Decontamination water will be managed as discussed in Section 8.0.

GMR elevation data will be obtained from three locations, including a surveyed point on the Dryden Road bridge. In addition, two pond gauges will be installed at Quarry Pond. The surface water gauges will consist of graduated rods driven into the river/pond sediments and calibrated by a survey. Details on surface water gauge installation and monitoring are presented in Section 2.8.

2.7.4 GROUNDWATER SAMPLING

Monitoring wells to be sampled include the 15 existing wells and the two supply wells located on the Valley Asphalt property (Lot 5054). Additional monitoring wells may be installed during Phase 2 of the Groundwater Investigation. The groundwater sampling SOP is presented in Appendix J-F-15.

A round of groundwater sampling for TCL VOCs, TCL SVOCs, TCL pesticides and herbicides, TCL PCBs and TAL metals will be completed at the existing monitoring wells. Groundwater sampling will be conducted using low flow/low stress sampling procedures as discussed below. The data will be compared with VAS results to assist in determining the adequacy of the existing monitoring wells. Hydraulic monitoring will be performed at all monitoring wells, piezometers, and temporary wells at the time of each sampling event.

The Phase 2 groundwater sampling will include two rounds of sampling from the newly installed monitoring wells and, if appropriate, the existing wells. The first round of samples will be collected two weeks after installation and development of the monitoring wells and the second round will be collected two months later. The analyses will include TCL VOCs, TCL SVOCs, TCL pesticides and herbicides, TCL PCBs, and TAL metals, and monitored natural attenuation (MNA) parameters. The MNA parameters included in the analysis will be consistent with the USEPA Region 5 Monitored Natural Attenuation Framework. The complete list of MNA parameters is provided in Table K.3.3 of the QAPP. The analytical parameters may be reduced for the second round of sampling. The PRP Group will propose reductions in analytes, as appropriate, for USEPA's approval.

The protocol described herein applies low flow/low stress methods to obtain samples that are representative of groundwater moving through the subsurface under natural conditions. Groundwater samples will be collected and analyzed for the parameters listed in Table J-2.3.

All downhole equipment, such as the water level indicator, oil water interface probe, dissolved oxygen probe, and pumps, will be decontaminated as discussed in Section 7.0. Purge water and decontamination water will be managed as discussed in Section 8.0.

The low flow/low stress sampling protocol will be as follows:

1. The groundwater level will be measured to the nearest 0.01 foot using a pre-cleaned oil/water interface probe or equivalent. Field calibration, preventative maintenance, and SOPs are discussed in Section 6.0.
2. The total depth of the monitoring well from the reference point (i.e., top of casing) will be measured to ± 0.01 foot using a pre-cleaned, weighted measuring tape, such as a water level plover. The measured well depth will be compared to the constructed well depth to evaluate the presence of any sediment accumulated at the well bottom. The use of a wide-based measurement device, such as a water level plover, may minimize penetration of any sediment, thus facilitating a reliable measurement. The measurement device will be lowered slowly to the well bottom to minimize mixing of the stagnant well casing water and to minimize agitation of solids into suspension. The depth of any well bottom sediment will be considered when positioning the pump intake to avoid mobilizing the sediment while purging. The total depth of the monitoring well will be measured a minimum of 24 hours prior to groundwater sampling or following collection of the groundwater sample.
3. Calculate the water volume in the well. Typically overburden well volumes consider only the quantity of water standing in the well screen and riser pipe; bedrock well volumes are calculated on the quantity of water within the open corehole and within the overburden casing.
4. Purging will be conducted using a pre-cleaned stainless-steel bladder pump with a Teflon® bladder. The pump discharge line and air supply line for the bladder pump operation will be polyethylene and dedicated to the well. The bladder pump will be secured to nylon rope (dedicated to the well) and positioned in the well at least 24 hours prior to commencement of purging and sampling activities. The bladder pump will be positioned such that the pump intake corresponds to the middle of the screen. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas that will be identified within the project. Peristaltic tubing placement should include a tubing "clamp" at the well head, to minimize vibration transfer into the water column.
5. Before starting the bladder pump, the water level will be measured again with the pump in the well, leaving the water level measuring device in the well when completed.

6. Purging of the monitoring well will be conducted using a pumping rate, designed to minimize drawdown, no greater than 500 mL/min, i.e., the same maximum flow rate to be used for sampling. Initial purging will begin using a pumping rate at 100 mL/min. The groundwater level will be measured while purging to ensure that less than 0.3 feet of drawdown occurs. The rate of pumping should not exceed the natural flow rate conditions of the well being sampled. The pumping rate may be gradually changed depending upon the amount of drawdown and the behavior of the stabilization parameters (see item 5 below). Pumping rate adjustments generally will be made within 15 minutes from the start of purging and then should remain constant for the duration of purging. While purging, the pumping rate and groundwater level will be measured and recorded every 5 minutes. If it is apparent that stabilization of the purged groundwater (see item 5 below) will not be achieved rapidly, these measurements may be made at longer time intervals to allow field staff to perform other sampling activities.
7. Stabilization of the purged groundwater is necessary prior to sampling to ensure that the samples obtained are representative of groundwater in the subsurface only and not influenced by stagnant groundwater stored in the well casing. Stabilization monitoring will be performed using a flow-through-cell. The field parameters pH, temperature, conductivity, ORP, DO, and turbidity will be monitored while purging to evaluate the stabilization of the purged groundwater. The field parameters will be measured and recorded every 5 minutes using both the Monitoring Well Record for Low-Flow Purging and Well Purging Field Information forms, examples of which are in Appendix J-G. Stabilization will be considered to be achieved when three consecutive readings are all within the range of the stabilization criterion presented below:

pH	±0.1 pH units of the average value of the three readings
temperature	±3 percent of the average value of the three readings
conductivity	±0.005 milliSiemens per centimeter (mS/cm) of the average value of the three readings for conductivity <1 mS/cm and ±0.01 mS/cm of the average value of the three readings for conductivity >1 mS/cm
ORP	±10 millivolts (mV) of the average value of the three readings;
DO	±0.3 mg/L
turbidity	±10 percent of the average value of the three readings, or a final value of less than 5 NTU

pH, conductivity, temperature, and ORP will be monitored using a YSI Model 3560 instrument. Turbidity will be measured using a HF Scientific

DRT-15C Turbidimeter. Dissolved oxygen will be measured using a YSI Model 52 instrument. Alternatively, equivalent instruments may be used. Field calibration, preventative maintenance, and SOPs are discussed in Section 6.0. At the start of purging, the purge water will be visually inspected for water clarity prior to connecting the flow-through-cell. If the purge water appears turbid, purging will be continued until the purge water becomes visibly less turbid before connecting the flow-through-cell. While purging, the meter readings will be monitored for evidence of meter malfunction. The following are common indicators of meter malfunctions:

- DO above solubility [e.g., oxygen solubility is approximately 11 milligrams per liter (mg/L) at 10° Celsius] may indicate a DO meter malfunction
- negative ORP and DO greater than 1 to 2 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have positive ORP and DO greater than 1 to 2 mg/L under oxidizing conditions)
- positive ORP and DO less than 1 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have negative ORP and DO less than 1 mg/L under reducing conditions)

Meter calibration fluids will be available for meter re-calibration in the field, if necessary.

In general, stabilization of the individual field parameters is expected to occur in the order listed above. Should stabilization not be achieved for all field parameters, purging will be continued until a maximum of 10 well screen volumes have been purged from the well. After purging 10 well screen volumes, purging will be continued if the purge water remains visibly turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization. In the event the monitoring well does not stabilize after the removal of 10 well screen volumes, the monitoring well will be redeveloped using the procedures described in Section 2.7.2. Following redevelopment, the monitoring well will be allowed to stabilize for a minimum of 48 hours prior to purging for stabilization parameter monitoring and sampling.

In the event that the groundwater recharge to the monitoring well is insufficient to conduct the low flow/low stress protocol, the well will be pumped to a depth no greater than 2 feet above the top of the screen and the water level allowed to recovered sufficiently to allow for sample collection. Wells whose water levels are within the screened zone, may be dewatered to within 2 feet of the bottom of the screen and are not subject to the above purging criteria.

Groundwater Sampling

Following purging and stabilization, groundwater sampling will be conducted using the following procedures:

- i) A new pair of disposable latex gloves will be used for each sample collected.
- ii) If an alternate pump is utilized, the first pump discharge volumes should be discarded to allow the equipment a period of acclimation to the groundwater.
- iii) The flow-through-cell will be disconnected prior to obtaining the sample. The discharge line from the pump will be positioned at the base of the sample bottle. All required preservatives will be added to the samples in the manner consistent with the appropriate methodology by either placing the preservative in the sample containers prior to sampling or adding at the sample location immediately after collection. The sample bottle will be filled from the bottom to the top and will be allowed to overflow before sealing (over flow is not recommended if the sample bottles have been prepared with preservatives prior to sample collection). Samples will be collected in the following order:
 - a) TCL VOCs
 - b) TCL SVOCs, pesticides, herbicides and PCBs
 - c) unfiltered TAL inorganics and general chemistry
 - d) filtered inorganics (if required)

Each VOC sample vial will be inspected for the presence of bubbles. If bubbles are observed, the sampler will attempt to add sample volume to the vial to remove the bubbles. If bubbles continue to form, indicating effervescence, the sample will be discarded and recollected. The laboratory will be notified that the samples are unpreserved and the analyses will be completed within the appropriate holding time (i.e., seven days).

Parameters that require filtering will be collected following the attachment of a disposable 0.45 micrometer (μm) in-line filter to the discharge tubing. The field filtering SOP is presented in Appendix J-F-16.

- iv) All equipment used during sampling, which may have come in contact with potentially contaminated waters, will be decontaminated. Latex gloves used during the collection of the samples will be disposed of. The

pump discharge line and air supply line will either be dedicated and left hanging in the well or disposed of after the well has been sampled.

- v) QC samples will be collected for chemical analysis as discussed in Section 4.0. Samples will be handled as discussed in Section 5.0.
- vi) Upon completion of the groundwater sampling event, a summary of the sampling event will be recorded on the Sample Collection Data Sheet – Groundwater Sampling Program form, an example of which is included in Appendix J-G.

2.7.5 SINGLE-WELL RESPONSE TESTING

Single-well response (slug) testing will be performed after the first phase of work has been completed. Single well response testing will allow for the determination of aquifer response for both the Upper and Lower Aquifer zones at the Site. Single well response tests will be completed at all existing and any newly installed wells.

Single-well response testing will involve displacement of the water in the wells by inserting or removing a known volume ("slug"). The slug will consist of a section of solid PVC rod of known volume. The slug will be raised and lowered using nylon rope. New rope will be used at each well.

Prior to slug testing, the static water level in the well will be measured using an oil/water interface probe, or equivalent, and a continuous recording transducer and datalogger system will be installed in the well. Field calibration and preventative maintenance are discussed in Section 6.0. Standard operating procedures for transducers are provided in Appendix J-F-17. The slug will then be quickly lowered into the water column, displacing a known volume of water and raising the water level instantaneously. The decrease in the water level (falling head test) will be monitored continuously by the datalogger. The falling head test data will be discarded for wells where the static water level is below the top of the screen. The groundwater table lies below the top of the screen in such wells and, as a result, the water in the gravel pack should drain quickly into the adjacent sand and gravel above the saturated zone. The flow of water is not immediately controlled by the saturated portion of the aquifer in this situation giving non-representative values.

Once the water level returns to static conditions, the slug will be quickly removed from the well, instantaneously dropping the water level. The increasing water level (rising head test) will be monitored continuously until the water level returns to static conditions.

Upon completion of the slug testing, the water level data will be used to calculate an estimated hydraulic conductivity using the method developed by Cooper et al. (1967), Bouwer and Rice (1976, Revised 1986), or Hvorslev (1951), or other appropriate methods depending on the aquifer condition (i.e., confined or unconfined) and the aquifer response. The slug will be decontaminated according to procedures in Section 7.0. Decontamination fluids will be managed as discussed in Section 8.0. Standard operating procedures for single-well response testing are provided in Appendix J-F-18.

2.8 SURFACE WATER

If required, surface water monitoring and sampling will be conducted at the Site in order to verify groundwater recharge/discharge and groundwater contaminant migration to surface water, and human health and ecological risks associated with exposure to Site surface water. As discussed in the Final Groundwater Letter Work Plan (CRA, May 7, 2008), at a minimum, 5 surface water gauges will be installed, two will be located in the Quarry Pond and three will be located in the GMR, to the northwest of the Site. The surface water gauges will be surveyed in order to conduct synoptic measurements of groundwater and surface water elevations.

2.8.1 STAFF GAUGE INSTALLATION

Five staff gauges will be installed at the Site. The gauges will be installed in a manner appropriate with the depth and flow velocity of the ditch, pond, or river to maintain the staff gauges in a stable position. Where appropriate, a benchmark location on an existing structure (e.g., bridge, pier, etc.) may be used as a surface monitoring location. Figure J-2.5 presents the recommended locations of staff gauges. The locations of any existing staff gauges will be surveyed and added to this figure. Surface water gauges will be established in Quarry Pond and the GMR, to the northwest of the Site. The gauges are being installed and monitored in order to fill existing hydrogeologic data gaps and understand the influence of the GMR on the groundwater flow regime. In addition, the surface water monitoring gauging station located at the sewage treatment plant across the river from the Site will be monitored.

2.8.2 SURFACE WATER HYDRAULIC MONITORING

Hydrologic data will be collected during the implementation of the Groundwater Letter Work Plan. Manual water level measurements will be collected using an electronic depth-to-water probe accurate to ± 0.01 feet. The measurements will be made from the survey mark or from the top of the staff gauge. The depth to surface water will be converted to elevations based on the surveyed elevation at each staff gauge location. Water level measurement events (groundwater and surface water) will be conducted on a monthly basis in order to get a better understanding of groundwater flow directions.

3.0 POTENTIAL ADDITIONAL ACTIVITIES

Additional investigative activities may be undertaken, depending upon the results of the activities discussed herein. Any such additional investigative activities will be conducted in accordance with work plans or technical memoranda that have been approved by USEPA.

The following presents additional activities, which may be conducted in future investigative/confirmatory sampling events at the Site. The following activities may or may not be completed as part of any future work at the Site.

3.1 BEDROCK WELL INSTALLATION

Should bedrock monitoring wells be advanced at the Site the following installation and construction techniques will be followed:

1. Polyethylene sheeting and plywood shall be laid out at each drilling location in order to contain any spills.
2. Advancement of each borehole through the overburden to bedrock, and as far into bedrock as reasonably necessary to install steel surface casing using an appropriately sized tricone bit or hollow stem augers. All bedrock wells will be logged geophysically. Since both the overburden and shallow portion of the bedrock potentially contain elevated concentrations of VOCs, the steel surface casing will likely extend to a depth of approximately 200 to 250 ft bgs. The final decision on depth to install surface casing will be made by the field representative. Bedrock is anticipated to occur at a depth of between 200 and 250 ft bgs.
3. Install steel surface casing set into the bedrock and grouted in place with cement grout, including filling the entire annular space between the steel casing and the borehole wall. The cement grout shall be allowed to cure for a period of at least 48 hours. It is intended that the steel surface casing shall act as the protective casing upon completion of the well installation, therefore the surface casing shall extend two to three feet above ground surface.
4. Test the integrity of the cement seal by filling the surface casing with potable water and routinely measuring the water level for a period of 15 minutes. The water level should not drop more than 0.3 feet, if the water level drops more than 0.3 feet during this time, the drilling sub-contractor will be directed to attempt to pull the casing and reinstall the cement seal or, in the likely event that the casing

cannot be removed, to remove the top six feet of the casing and abandon the borehole by backfilling using bentonite grout.

5. Advance the borehole by HQ or PQ coring, or equivalent, to a total depth of up to 50 feet below the top of competent bedrock order to determine major flow zone(s) within the bedrock.
6. Develop the borehole to a relatively sediment/cuttings free condition if conducting packer flow tests after completion of coring. The borehole may be developed using a combination of methods as follows. Initially the boreholes will be pumped, with either a submersible pump or an inertial pump. After the initial pumping the boreholes will be gently surged. Initial surging will be accomplished either by raising and lowering the submersible pump throughout the screened interval, bailing the borehole with a bailer, and/or backwashing the borehole. If the borehole is backwashed, it will be with either potable water or development water after the fines have settled out. Following the initial surging the borehole will be pumped again. If significant turbidity persists, the boreholes will be surged with a mechanical surge block and over pumped. In the event that packer flow testing is not conducted, the monitoring well constructed in the borehole will be developed consistent with the SOP for Monitoring Well Development (Appendix J-F-14).
7. Conduct packer flow tests of up to 1 hour duration for each test utilizing a submersible pump installed between inflatable packers at 5-foot intervals after coring to final depth, in order to determine flow rate from each interval;
8. Backfill the lower portion of the borehole, if required with bentonite gravel to the specified depth as determined by the field representative.
9. Complete the boreholes as monitoring wells with 2-inch diameter, number 10 slot, 5-foot long Schedule 40 PVC well screens and flush-threaded Schedule 40 PVC riser pipe allowing for approximately 3 feet of stick-up.
10. Place a coarse (10 to 20 mesh) sand pack around the screen extending to two feet above the screen.
11. Place a minimum of 1-foot of fine (20 to 40 mesh) silica sand from 2 to 3 feet above the well screen.
12. Place two to three feet of dry granular bentonite directly on top of the sand pack and then add hydrated bentonite to just below ground surface.
13. Backfill the remaining borehole annulus above the bentonite gravel seal with bentonite grout, using the positive displacement method, to ground surface within the surface casing.

14. Install lockable caps sized to fit on the steel surface casing enclosing the riser pipe at each monitoring well location.

Drill cuttings and decontamination water will be managed as discussed in Section 8.0.

3.2 PRIVATE/POTABLE WELL SAMPLING

While not currently proposed, sampling of private and/or potable groundwater supply wells may be required. If required, the PRP Group will collect the private/potable groundwater well samples in accordance with the procedures detailed below.

Taps selected for sample collection will be located as close along the distribution line as possible to the supply wells and upstream of any treatment system or storage/pressure tank. The piping system at each location will have to be understood prior to sampling to determine which tap(s) are to be sampled. All water treatment devices in use at the property (i.e., water softener, filtration unit, etc.) will be noted and samples will be collected prior to these devices. Leaking taps that allow water to flow out from around the stem of the valve handle and down the outside of the lip will be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap will be removed before sampling. The cold water tap will be opened for 10 to 15 minutes to flush the service line. A smooth-flaring water stream at moderate pressure without splashing will be obtained. Then, the sample will be collected without changing the water flow, which could dislodge some particles in the faucet. Samples will be analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, and additional parameters, if appropriate (see Table J-2.3). Field QC samples will be collected as discussed in Section 4.0. Samples will be handled as discussed in Section 5.0.

The well configuration (i.e., depth, casings, construction date), pumping system, piping system, (i.e., pipe type, lead-joint construction, etc.), and presence of treatment devices will be documented to the extent the information is readily available.

3.3 SURFACE WATER SAMPLING

Should surface water samples be collected at the Site the following sampling techniques will be followed.

Surface water and sediment samples will be collected at the same location (surface water samples will be collected first). QC samples will be collected for chemical analysis as

discussed in Section 4.0. Surface water samples will be collected and analyzed for the parameters listed in Table J-2.4 and additional parameters (e.g., dioxins and furans, pesticides, etc.) as appropriate.

All equipment will be decontaminated as discussed in Section 7.0. Decontamination water will be managed as described in Section 8.0.

Surface water samples will be collected at each area using a pre-cleaned sample containers attached to a pole or tied to a nylon rope. The sampling personnel will stay at the edge of the surface water so as not to disturb the water during sample collection. If samples cannot be collected using the pre-cleaned sample containers, surface water samples will be collected by filling the containers at a low flow rate (<100 mL/min) using a peristaltic pump and new disposable tubing.

Field parameters will also be measured for the surface water samples. pH, temperature, ORP, and conductivity will be measured using a YSI Model 3560 instrument. DO will be measured using a YSI Model 52 instrument. Turbidity will be measured using an HF Scientific DRT-15C Turbidimeter. Alternatively, equivalent instruments may be used. Standard operating procedure information is contained in Appendix J-F-19, J-F-20, J-F-21, J-F-22, and J-F-23. Field calibration and preventative maintenance are described in Section 6.0.

If required, sample volume for dissolved metals analyses will be collected into a laboratory-supplied container(s) containing no preservative. The sample will then be filtered using a peristaltic pump, new disposable tubing, and a new disposable in-line 0.45- μ m filter. The filtered sample will be discharged into the appropriate sample containers for submittal to the laboratory, with preservative, as appropriate. Filtered samples will be preserved within 20 minutes of sample collection. Any filtered samples would be in addition to unfiltered samples for the same parameters.

3.4 SEDIMENT SAMPLING

If sediment sampling is required to evaluate sediment quality at and/or adjacent to the Site, sediment samples will be collected in accordance with the following sampling techniques.

If surface water and sediment samples are to be collected at the same location, surface water samples will be collected first. Sediment sampling will be conducted at the Site in

order to characterize sediments and determine the nature and extent of sediment migration, contaminate adsorption, and bioconcentration.

Sediment samples will be analyzed for parameters as listed in Table J-2.4 and may include additional analytical parameters as appropriate. QC samples will be collected for chemical analysis as discussed in Section 4.0.

All equipment will be decontaminated as discussed in Section 7.0. Decontamination water will be managed as discussed in Section 8.0.

Sediment samples will be collected in accordance with the following protocols:

1. New disposable latex gloves will be used when collecting each sediment sample. Additional glove changes will be made as conditions warrant.
2. Prior to use, for each sample, all sampling equipment will be pre-cleaned using the prescribed rinse sequence.
3. Sediment samples will be collected from downstream locations working upstream (as applicable).
4. Samples will be collected using pre-cleaned hand tools to a maximum depth of 12 inches.
5. All samples will be homogenized in a pre-cleaned stainless steel bowl and then transferred into the appropriate sample bottles.

Samples collected for VOC analyses will not be homogenized but placed directly into the sample containers.

Sediment samples will be collected using a pre-cleaned stainless-steel ladle attached to a pole. The sediment will be transferred from the ladle directly to the sampling containers. Samples for VOC analyses will be collected first using the En Core™ sampler, and collecting the sample volume from the center of the stainless steel ladle. Samples for analysis of other parameters will be collected from the remaining material using glass jars. Samples for VOC analyses will be collected using the disposable En Core™ sampler.

En Core™ SOPs are presented in Appendix J-F-24. Samples will be managed as discussed in Section 5.0.

3.5 SITE RESTORATION/PROJECT CLOSEOUT

Final Site restoration/project closeout activities will be performed at the completion of investigative work. Site restoration/project closeout activities will include, but not necessarily be limited to, decontamination of equipment and materials and removal of investigation-derived waste as is required.

4.0 FIELD QUALITY CONTROL SAMPLING

4.1 GENERAL

The sampling and analysis program associated with the investigative activities are summarized in Tables J-2.1, J-2.2, and J-2.3. The tables also present a summary of field QC sampling for laboratory chemical analysis and summarizes the frequency of each type of field QC sample to be collected for each investigative activity.

The following types of field QC samples will be collected for laboratory chemical analysis:

- field duplicate samples
- equipment blank/decon water samples (field blanks)
- matrix spike/matrix spike duplicate (MS/MSD) samples
- trip blank samples

Each type of field QC sample for laboratory chemical analysis is discussed below.

4.2 FIELD DUPLICATE SAMPLES

During the investigative activities, field duplicate samples will be collected and submitted to the laboratory. Field duplicate samples will be collected in a manner whereby, as the sample fraction for each parameter is collected, the sample medium will be equally split between the investigative fraction and the duplicate fraction for that parameter. VOC fractions for aqueous samples will be filled continuously until an individual vial is completely filled before filling a vial for a duplicate sample. One field duplicate will be collected for each 10 or fewer investigative samples submitted.

4.3 EQUIPMENT BLANK SAMPLES

Equipment blank samples will be collected for any sampling activity that requires equipment decontamination. One equipment blank will be collected for each ten or fewer investigative samples submitted.

The equipment blank will be obtained by passing analyte-free laboratory-supplied, deionized water through a cleaned sampling apparatus (i.e., bladder pump or sampler) and collecting it in a clean container. Specifically, the equipment blank for the bladder

pump will be collected by attaching a short length of discharge tubing to the pump, turning the pump upside down and pouring laboratory-supplied deionized water through the pump and into the appropriate sample containers.

4.4 MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES

MS/MSD sample volumes are additional sample aliquots provided to the laboratory to evaluate the accuracy and precision of the sample preparation and analysis technique.

Two times the normal sample aliquot is required for VOCs, SVOCs, pesticides, and PCBs to conduct MS/MSD analyses. No additional sample volume is required for inorganics or general chemistry parameters. Sample collection is identical to the technique described for collection of field duplicates. Sample labeling identifies the respective sample location and the additional containers are labeled as the "MS/MSD" volume.

One MS/MSD sample will be collected for each 20 or fewer investigative samples submitted.

4.5 TRIP BLANK SAMPLES

Trip blank samples will be used to determine if the sample shipping or storage procedures have influenced the analytical results. Trip blanks will be prepared by the laboratory using deionized water and preservative and sent to the Site in the shipping container(s) designated for the project. These samples will be kept with the investigative samples then submitted to the laboratory for analysis with the investigative samples. The samples will not be opened.

Trip blanks will be analyzed for TCL VOCs only. One trip blank will be submitted for each cooler containing sample media for analysis of aqueous VOCs.

5.0 SAMPLE CUSTODY AND DOCUMENT CONTROL

CRA follows the USEPA Region 5 sample custody protocols described in "NEIC Policies and Procedures", EPA-330/9-78-001-R, revised August 1991. This custody is segregated into three parts: sample collection; laboratory analysis; and final evidence files. Final evidence files, including all originals of laboratory reports, are maintained under document control in a secure area.

A sample or evidence file is in a person's custody if:

- the item is in actual possession of a person
- the item is in the view of the person after being in actual possession of the person
- the item was in actual physical possession of the person and is secured in an appropriate container and arrangements are made to transport it to the laboratory via a bonded courier
- the item is in a designated and identified secure area

5.1 SAMPLE LABELING

The sample numbering system for the project has been designed to uniquely identify each sample from each sampling program and event. Each sample container will be labeled with a unique sample number that will facilitate tracking and cross-referencing of sample information and will be recorded in the field logbook. This numbering system consists of the sample matrix code, project reference number, sample collection date, sampler's initials, and sequential number beginning with 001 and continuing throughout the sampling program and event. The unique sample number will be recorded with the sample location in the field logbook at the time of sample collection. The field logbook will form part of the permanent field record. The sample numbering system to be used is described as follows (the information entered on the sample labels will be printed by the field sampler):

Example: MC-38443-MMDDYY- XX-NNN-D

Where:

- | | | |
|------------------|---|--|
| MC (Matrix Code) | - | designates types of sample (GW-groundwater, S-soil, SW-surface water, SD-sediment, SG – soil gas, W-field blank samples) |
| 38443 | - | Project reference number |
| MMDDYY | - | designates date of collection presented as month, day, and year |
| XX | - | sampler's first and last initials |
| NNN | - | Sequential sample number for event starting with 001 |
| D | - | designates type of field QC sample (D-field duplicate, E-equipment blank). This suffix will only be used for field QC samples. Field duplicate samples will not be designated as such on the chain of custody. Field duplicate samples will be numbered consistent with this system to avoid laboratory bias of field QC samples |

Samples designated for MS/MSD analysis will be identified as such in the remarks column of the chain-of-custody form. Trip blank samples are provided by the laboratory and labeled as such. Trip blank samples also will be numbered with a unique sample number. The sample numbering system to be used for such samples is described as follows (the information entered on the sample labels will be printed by the field sampler):

Example:

TRIP BLANK - MMDDYY-NNN

where:

- | | | |
|--------|---|--|
| MMDDYY | - | designates date of collection presented as month, day, year |
| N | - | designates sequential number of each type of the two samples, starting with 001 at the beginning of the investigative activities |

An example of the sample label is provided on Figure J-5.1.

5.2 FIELD CHAIN-OF-CUSTODY PROCEDURES

The sample packaging and shipment procedures summarized below will insure that the samples will arrive at the laboratory with the chain-of-custody intact. The Field QA Officer will be responsible for oversight of field documentation procedures.

5.2.1 FIELD PROCEDURES

1. The field sampler is personally responsible for the care and custody of the samples until they are transferred to another individual or properly dispatched to the laboratory. As few people as possible should handle the samples.
2. All containers will be labeled with unique sample numbers.
3. Sample labels will be completed for each sample using waterproof ink.

5.2.2 FIELD LOGBOOKS/DOCUMENTATION

Field logbooks will provide the means of recording data collecting activities performed. As such, entries will be described in as much detail as possible so that persons going to the Site could reconstruct a particular situation without reliance on memory.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel and will be stored in CRA's Cincinnati, Ohio office when not in use. Each logbook will be identified by a project-specific number, which includes the project number (38443).

The title page of each logbook will contain the following:

- person to whom, or task for which, the logbook is assigned
- project number
- project name
- the starting date for entries into the logbook
- the ending date for entries into the logbook

Entries into the logbook will contain a variety of information. At the beginning of each day's logbook entry, the date, start time, weather, names of all sampling team members present, and the signature of the person making the entry will be entered. The names of

individuals visiting the Site or field sampling team and the purpose of their visit will also be recorded in the field logbook.

All field measurements taken and samples collected will be recorded. All logbook entries will be recorded in ink, signed and dated. If an incorrect logbook entry is made, the incorrect information will be crossed out with a single strike mark, which is initialed and dated by the person making the erroneous entry. The correct information will be entered into the logbook adjacent to the original entry.

Whenever a sample is collected or a measurement is made, a detailed description of the location will be recorded in the logbook. Photographs taken at a location, if any, will also be noted in the logbook. All equipment used to obtain field measurements will be recorded in the field logbook. The sample numbering system (as described in Section 5.1) will be recorded in the field logbook correlating the unique sample number to the sample location and sample depth (if necessary). In addition, the calibration data for all field measurement equipment will be recorded in the field logbook.

Samples will be collected following the sampling procedures documented in this FSP. The equipment used to collect samples, time of sample collection, sample description, and volume and number of containers will be recorded in the field logbook.

5.2.3 TRANSFER OF CUSTODY AND SHIPMENT PROCEDURES

The sample packaging and shipping procedures summarized below will ensure that the samples arrive at the laboratory with the chain-of-custody intact.

1. The field sampler is personally responsible for the care and custody of the samples until they are transferred to another person or the laboratory. As few people as possible will handle the samples.
2. All sample containers will be identified by using sample labels, which include the date of collection, unique sample number, and analyses to be performed.
3. Sample labels will be completed for each sample using waterproof ink.
4. Samples will be placed in coolers containing ice immediately after collection.
5. Samples will be accompanied by a properly completed chain-of-custody form. An example chain-of-custody form is in Appendix J-G. The sample identification numbers will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign and record the date and time on the form. The chain-of-custody form

documents sample custody transfers from the sampler to another person, to the laboratory, or to/from a secure storage area.

6. All sample shipments will be accompanied by the chain-of-custody form identifying its contents. The chain-of-custody form is a four-part carbonless-copy form. The form is completed by the sampling team and, after signing and relinquishing custody to the shipper, retains the bottom (goldenrod) copy. The shipper, if different than the sampling team members, retains the pink copy after relinquishing custody to the laboratory. The yellow copy is retained by the laboratory and the fully executed top copy is returned as part of the data deliverables package.
7. Samples will be properly packaged for shipment (see Table J-5.1) and dispatched to the appropriate laboratory for analysis with a separate signed chain-of-custody form enclosed in and secured to the inside top of each shipping cooler. Shipping coolers will be secured with custody tape for shipment to the laboratory. The custody tape is then covered with clear plastic tape to prevent accidental damage to the custody tape.
8. If the samples are sent by common carrier, a bill of lading will be used and copies will be retained as permanent documentation. Commercial carriers are not required to sign the chain-of-custody form as long as the form is sealed inside the sample cooler and the custody tape remains intact.
9. If samples are not shipped to the laboratory the same day the samples are collected in the field, additional ice will be placed in the coolers, the coolers will be sealed and kept in a designated secure area until they are shipped to the laboratory as described above.

5.3 LABORATORY CHAIN-OF-CUSTODY PROCEDURES

Laboratory sample custody begins when the samples are received at the laboratory. The laboratory's sample custodian will assign a unique laboratory sample identification number to each incoming sample. The field sample identification numbers, laboratory sample identification numbers, date and time of sample collection, date and time of sample receipt, and requested analyses will be entered into the sample receiving log. The laboratory's sample log-in, custody, and document control procedures are detailed in the appropriate SOPs in the QAPP.

5.4 LABORATORY STORAGE OF SAMPLES

Following log-in, all samples will be stored within an access-controlled location and will be maintained properly preserved (as defined in Table J-5.1) until completion of all laboratory analyses. Unused sample aliquots and sample extracts/digestates/distillates will be maintained properly preserved for a minimum of 30 days following receipt of the final report by CRA. The laboratory will be responsible for the disposal of unused sample aliquots, samples, containers, and sample extracts/digestates/distillates in accordance with all applicable local, state, and federal regulations.

The laboratory will be responsible for maintaining analytical log books and laboratory data. Raw laboratory data files will be inventoried and maintained by the laboratory for a minimum period of seven years, after which time CRA will advise the laboratory regarding additional storage requirements, if any.

5.5 FINAL EVIDENCE FILES CUSTODY PROCEDURES

Evidential files for the entire project will be maintained by CRA and will consist of the following:

- i) project plan
- ii) project log books
- iii) field data records
- iv) sample identification documents
- v) chain-of-custody records
- vi) correspondence
- vii) references, literature
- viii) final laboratory reports
- ix) miscellaneous - photos, maps, drawings, etc.
- x) final report

The final evidence file materials will be the responsibility of the evidentiary file custodian (CRA's Project Manager) with respect to maintenance and document removal. Section XIV of the ASAO specifies that all records be maintained for a minimum of 10 years after commencement of construction of any remedial action. USEPA will be notified at least 90 days before the documents are scheduled to be destroyed. All records for the RI/FS will be maintained consistent with the requirements of the

ASAOC. Standard operating procedures for record keeping of site logbooks and photo logs is provided in Appendix J-F-25.

6.0 FIELD CALIBRATION, PREVENTATIVE MAINTENANCE, AND STANDARD OPERATING PROCEDURES

6.1 PHOTOIONIZATION DETECTOR (PID)

The PID(s) will be maintained and used according to the manufacturer's specifications. The operating manual is kept in the instrument case. Field calibration, including date, time, standard used, results, and corrective actions taken will be recorded in the field logbook. The PID will be calibrated at least once daily, prior to use. Recalibration will be undertaken at more frequent intervals if there is any indication of faulty performance. Calibration check results must be ± 10 percent of the true value. If the result is outside of ± 10 percent, the meter will be recalibrated. Field calibration will be carried out according to the manufacturer's procedure. All initial and continuing PID calibrations performed in the field will be carried out using two reference standards.

The SOP for using the PID is provided in Appendix J-F-26. Table J-6.1 summarizes calibration check frequency and control limits.

6.2 PH, TEMPERATURE, ORP, AND CONDUCTIVITY INSTRUMENT

pH, temperature, ORP, and conductivity will be measured using a YSI Model 3560 instrument, or equivalent. The instrument will be calibrated daily, or as necessary, if malfunction is suspected. Initial calibration will be performed in accordance with manufacturer's requirements. The SOPs are in Appendix J-F-19, J-F-20, and J-F-21. Table J-6.1 summarizes calibration check frequency and control limits.

6.3 TURBIDITY INSTRUMENT

Turbidity will be measured using an HF Scientific DRT-15C Turbidimeter, or equivalent. The instrument will be calibrated daily, or as necessary, if malfunction is suspected. Initial calibration will be performed in accordance with manufacturer's requirements. The SOPs for turbidity measurements are in Appendix J-F-23. Table J-6.1 summarizes calibration check frequency and control limits.

6.4 DISSOLVED OXYGEN INSTRUMENT

Dissolved oxygen will be measured using a YSI Model 52 instrument, or equivalent. The instrument will be calibrated daily, or as necessary, if malfunction is suspected.

Calibration will be performed in accordance with manufacturer's requirements. The SOPs are in Appendix J-F-22. Table J-6.1 summarizes calibration check frequency and control limits.

6.5 WATER LEVEL INDICATOR

Water level measurements will be collected using an oil/water interface probe, or equivalent. The instruments do not require field calibration. The only field maintenance required is battery replacement. The SOPs are in Appendix J-F-27.

Water level meters are calibrated against a primary standard (steel tape or chain) once every year. The calibration records for all water level meters will be maintained in a field file and be available for review upon request.

6.6 LANDFILL GAS EXTRACTION MONITOR

Landfill gas measurements will be collected using a Landtec Gas Extraction Monitor, GEM-500 meter indicator, or equivalent. The instrument will be calibrated daily, or as necessary, if malfunction is suspected. Calibration will be performed in accordance with manufacturer's requirements. The SOPs are in Appendix J-F-10. Table J-6.1 summarizes calibration check frequency and control limits.

6.7 FIELD SCREENING OF NAPL - SUDAN IV ® FIELD SCREENING DYE TEST

The Sudan IV ® Field Screening Dye Test (Sudan IV Test) is a field kit type which determines the presence or absence of NAPL. A representative soil sample is transferred to a single use vial. Potable water and a rapid dissolving dye cube are added to the vial and the contents are vigorously shaken. No calibration is required for the Sudan IV Test. The SOPs for the field screening of NAPL are in Appendix J-F-28.

6.8 VICTOREEN SURVEY METER

Potential exposure to possible low-level radiation at the Site during test pit and Test trench investigative work shall be monitored with a low-level radiation meter (e.g., Victoreen survey meter). All radiation monitoring shall be conducted in the breathing zone. Radiation monitoring is only expected to be required if material

resembling foundry sands is identified during the test-pitting and test-trenching activities. The meter is factory calibrated and does not require and field calibration. The SOPs are in Appendix J-F-29.

6.9 UTILITY CLEARANCE

Prior to conducting any intrusive work, it is imperative that utility clearance procedures be completed. The utility clearance process is a logistical requirement performed to identify utility presence, utility location, and special hazards that may exist when working in close proximity to public or private utilities. The utility check itself does not prevent all incidents but is one component of many activities that if all performed correctly will minimize the potential for utility conflicts.

The SOP for utility clearance activities is provided in Appendix J-F-30.

7.0 EQUIPMENT CLEANING PROTOCOLS

7.1 SAMPLING EQUIPMENT DECONTAMINATION PROCEDURES

Stainless steel split-spoon soil samplers and VAS samplers used for the collection of samples for chemical analysis, and stainless steel ladles used for the collection of sediment samples for chemical analysis will be cleaned prior to use and between each sampling point in accordance with the following procedure:

- brush with soapy (phosphate-free soap) water
- rinse with distilled water

The water level indicator, water level plover, surge block, slug, and dissolved oxygen electrode and cable will be cleaned prior to use and between each sampling point by the following procedure:

- sprays of potable or distilled water on the outside surfaces
- wipe outside surface with paper towel

The submersible pump used for well development and electric low-flow submersible pump, if used for groundwater purging and sampling, will be decontaminated prior to use and between each location according to the following procedures:

- spray the discharge tubing, reel, and pump with potable water to rinse off particulates
- pump soapy (phosphate-free soap) water solution through the pump and tubing for a minimum of 2 minutes
- circulate potable water through the pump and discharge tubing until all traces of soap are gone
- pump distilled water through the pump and tubing for a minimum of 5 minutes

Following the collection of each groundwater sample the bladder pump will be decontaminated in the following manner:

- Pre-Rinse - Place pump in a basin (e.g., barrel or new garbage can) with potable water

- Wash - Operate the pump in the basin with potable water and Alconox for 5 minutes. Flush or rinse other equipment with potable water and Alconox for 5 minutes
- Rinse - Operate pump in the basin with potable water for 5 minutes. Flush or rinse other equipment with potable water for 5 minutes
- Final Rinse - Operate pump in the basin with distilled or de-ionized water and pump out 1 to 2 gallons. Flush or rinse other equipment with distilled or de-ionized water
- The bladder pump will be wrapped in inert material (i.e., polyethylene sheeting or aluminum foil) for storage or transport

The tubing will be dedicated to each well and either left hanging within the well for reuse or disposed of after sampling of each well is completed.

7.2 DRILLING EQUIPMENT

The drill rig, augers, split-spoon samplers, Rotosonic core barrels and casings, and drill rods will be steam-cleaned before startup of field operations and after each boring using a high-pressure, high-temperature, hot water cleaner. The potable water used will come from an off-Site source free of contamination (a fire hydrant may be used). One sample of potable water will be analyzed for VOCs to verify water quality. In the event that the potable water source is changed, a sample will be collected from the new source.

Split-spoon samplers will be washed before each sample is collected using a brush and non-phosphate laboratory-grade detergent, such as Alconox[®], rinsed with potable water, and rinsed again with distilled water.

8.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

The IDW materials that are expected to be produced during the investigative activities include drill cuttings, development and purge water from monitoring wells, decontamination water, used personal protective equipment (PPE), and used disposable sampling equipment. Each of these waste streams will be managed as discussed below.

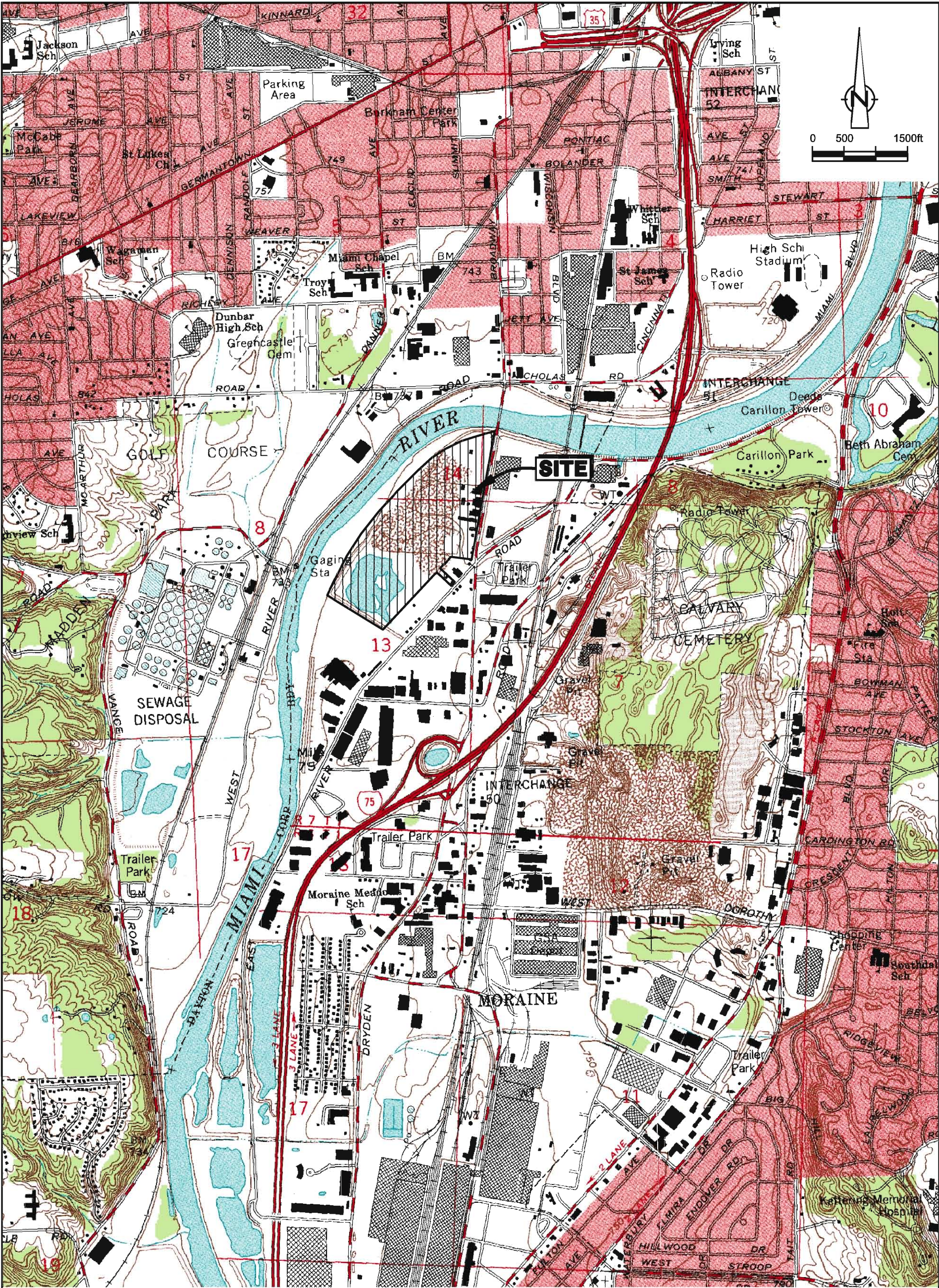
Drill cuttings will be placed in open labeled drums which will be located adjacent to the boring locations where they were generated. Development and purge water from monitoring wells and decontamination water will be contained in sealed drum adjacent to the monitoring well location where the water was generated. The disposal options for IDW will be evaluated as part of the FS. The options for management of drill cuttings include placement of the soil under a cap that may be constructed at the Site and off-Site disposal at a properly licensed facility.

Purge water collected from well development, VAS sampling and groundwater sampling and decon wash waters will be contained in closed top drums or polyethylene tanks. A large precleaned purge water tank (approximately 10,000 gallons) will be mobilized to the Site and staged in a central accessible area of the Site. The staging area selected for the purge water tank will be secured behind existing fencing which can be locked. Purge water for the activities identified above will be transferred to the tank for storage and sampling. The purge water stored in the tank will be sampled for VOC, SVOC, and TAL Inorganics for waste characterization purposes. Purge water will be loaded onto tank trucks or vacuum trucks for transport to a waste water treatment plant and/or treatment facility permitted for the treatment and disposal of such waste. CRA will provide advanced notification to the USEPA of waste characterization data and scheduled shipments of purge water from the Site.

Used PPE and used disposable sampling equipment will be placed in garbage bags and stored within a designated area of the Site. At the completion of field activities, the material will be disposed of at a sanitary landfill.

9.0 REFERENCES

- Bouwer, H. and Rice, R.C., 1976 Revised 1986. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells. Water Resources Research 12:423-28.
- Cooper, H.H., Bredehoeft, J.D., and Papadopulos, I.S., 1967, Response of a Finite-Diameter Well to an Instantaneous Change of Water, Water Resources Research, Vol. 3, No. 1, pp. 263-269.
- Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Groundwater Observations. U.S. Army Corps of Engineers Waterways Exp. Sta. Bulletin 36, Vicksburg, Miss.
- Ohio Environmental Protection Agency, February 1995. Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring.
- United States Environmental Protection Agency, August 1991. NEIC Policies and Procedures, EPA-330/9-78-0001-R.



SOURCE: USGS QUADRANGLE MAP
DAYTON SOUTH, OHIO



figure J-1.1
SITE LOCATION MAP
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



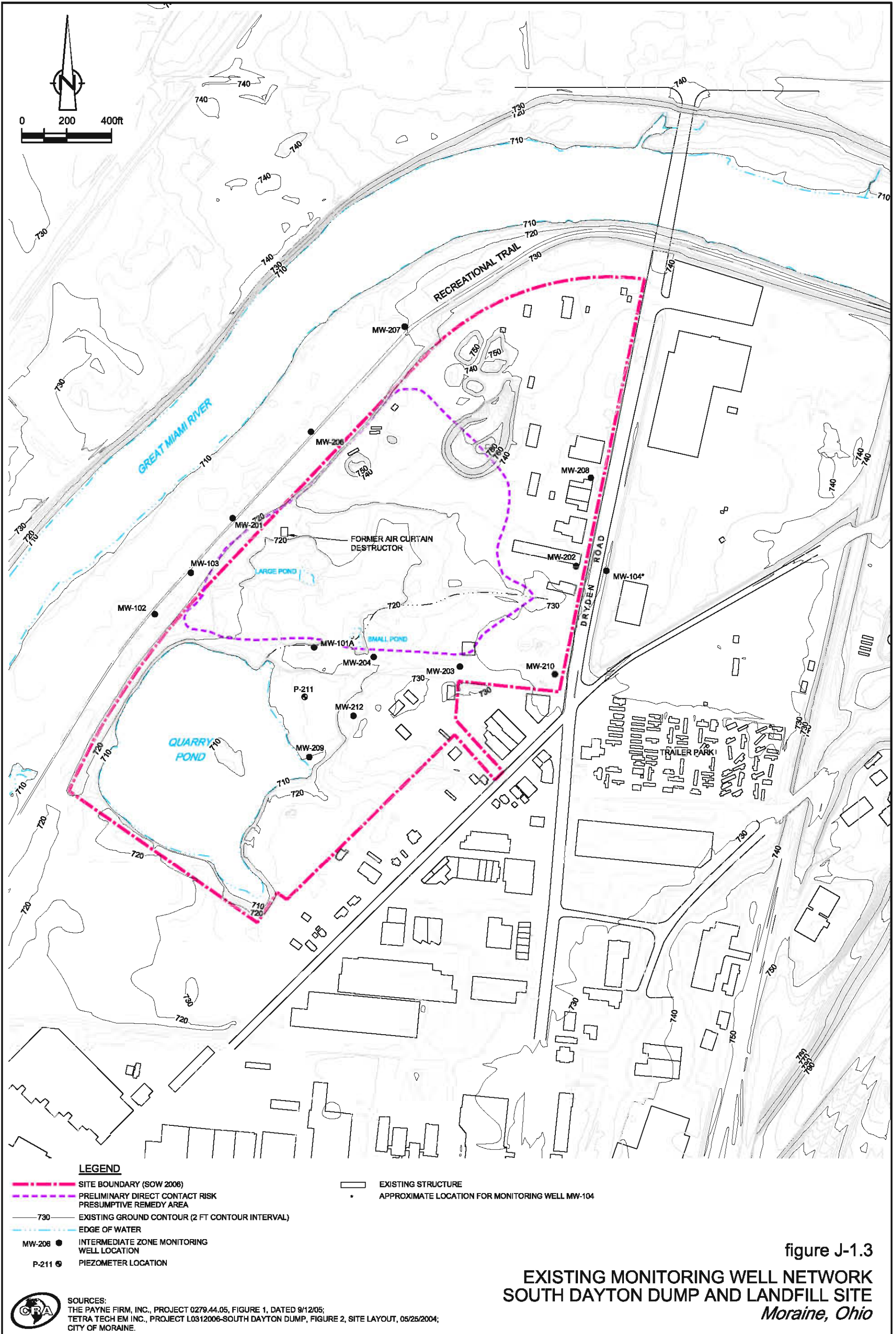


figure J-1.3
EXISTING MONITORING WELL NETWORK
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

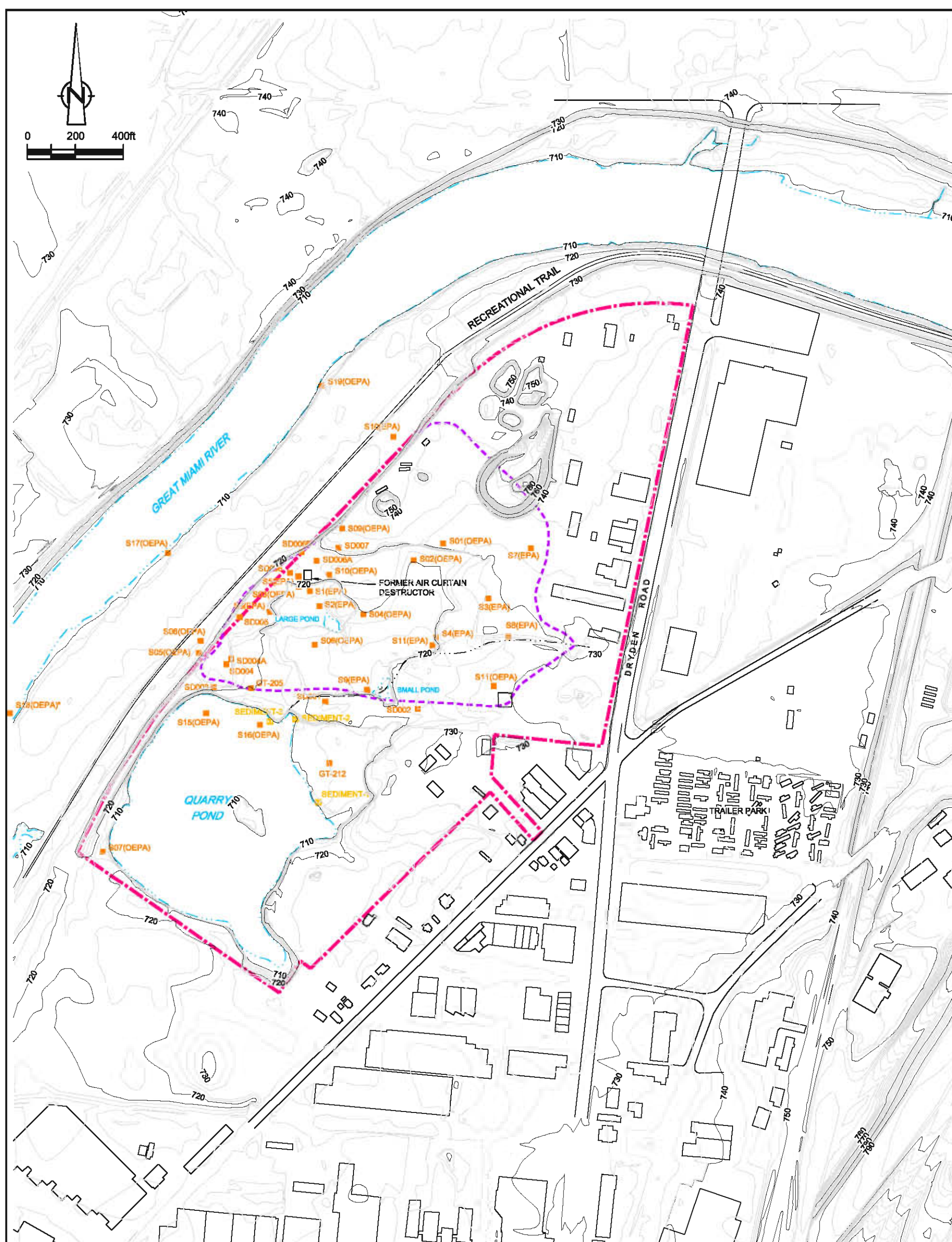


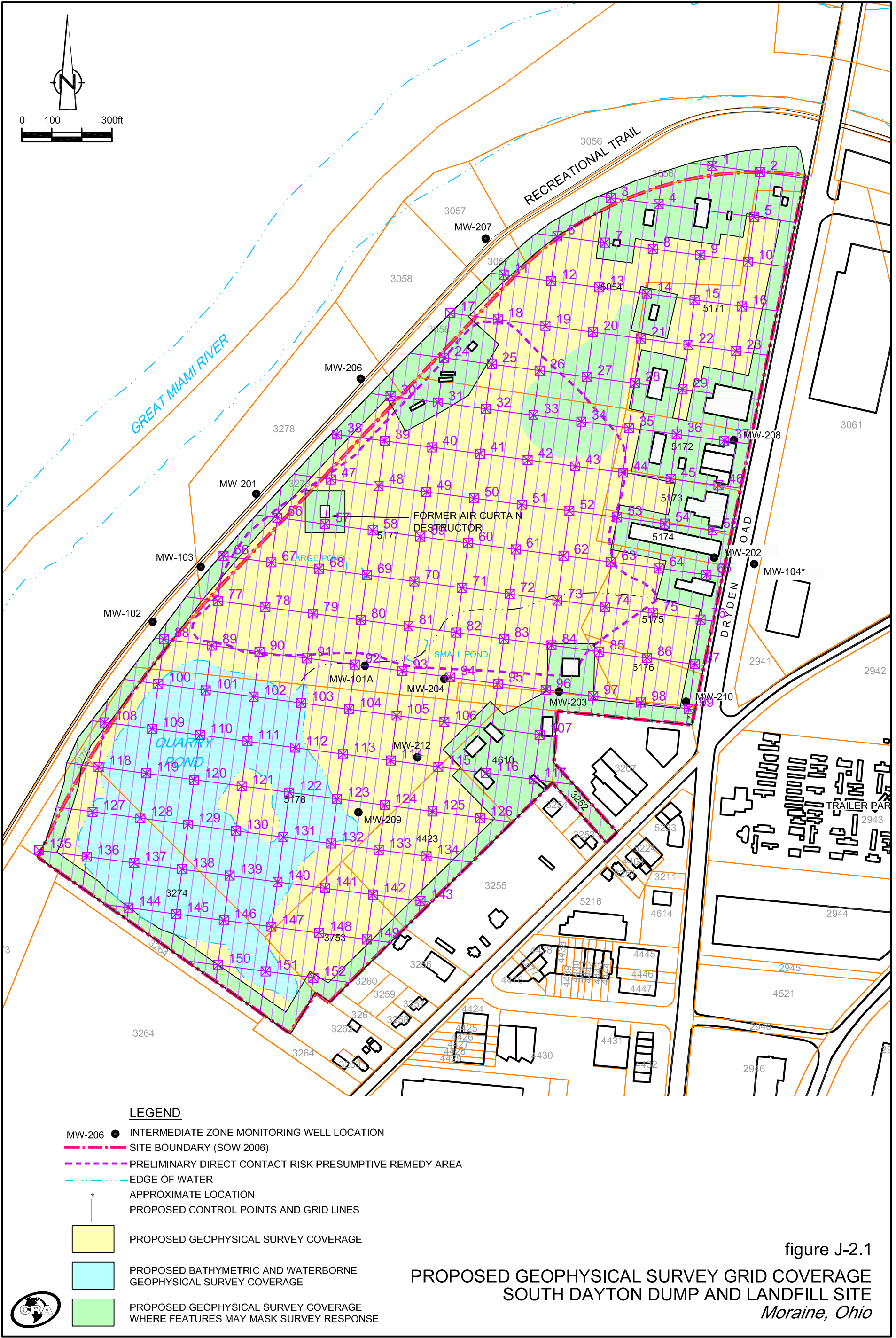
figure J-1.4

HISTORICAL SOIL SAMPLING AND BOREHOLE LOCATIONS SOUTH DAYTON DUMP AND LANDFILL SITE

Moraine, Ohio



SOURCES:
THE PAYNE FIRM, INC., PROJECT 0279.44.05, FIGURE 1, DATED 9/12/05;
TETRA TECH EM INC., PROJECT L0312006-SOUTH DAYTON DUMP, FIGURE 2, SITE LAYOUT, 05/25/2004;
CITY OF MORIAINE.



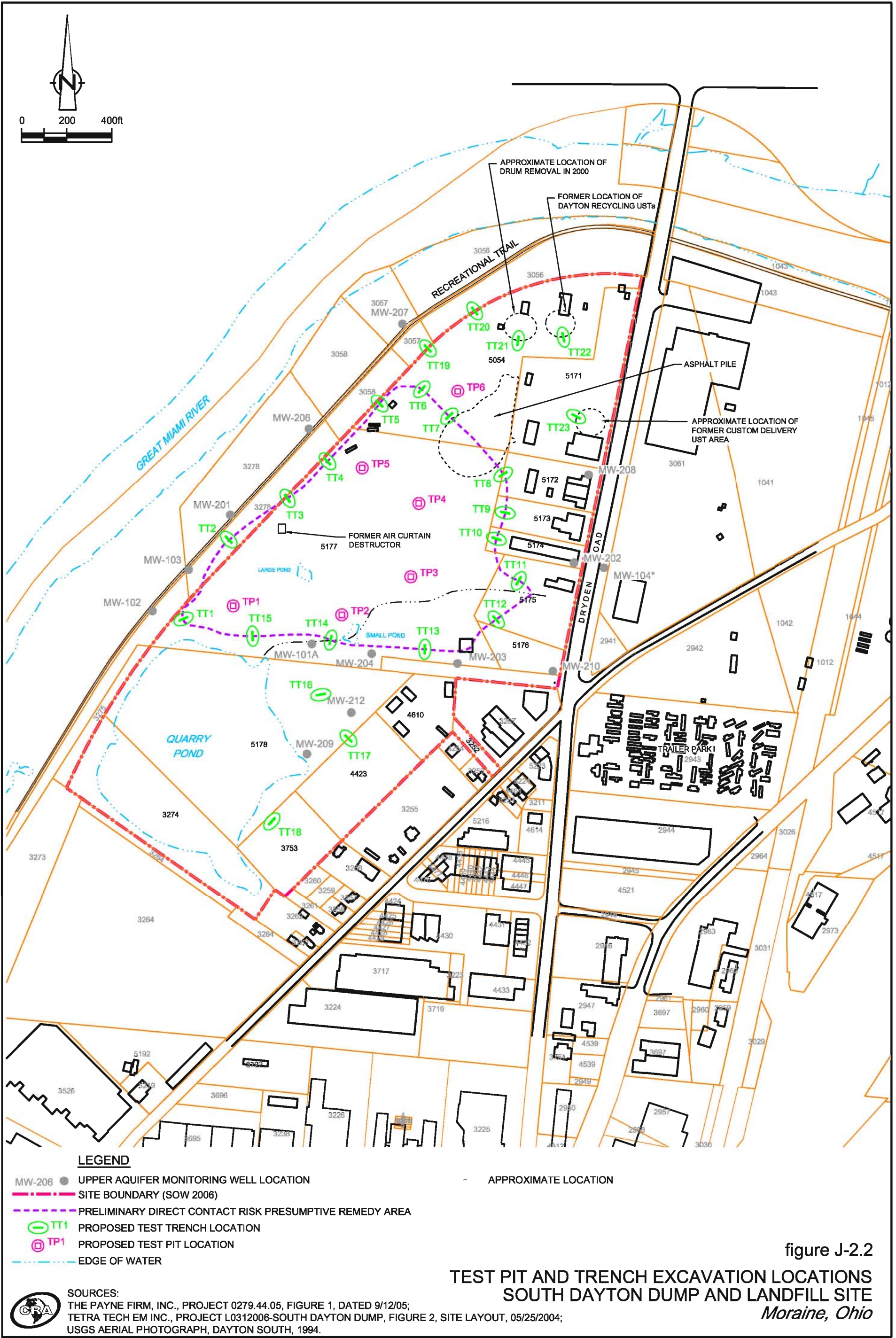


figure J-2.2

TEST PIT AND TRENCH EXCAVATION LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

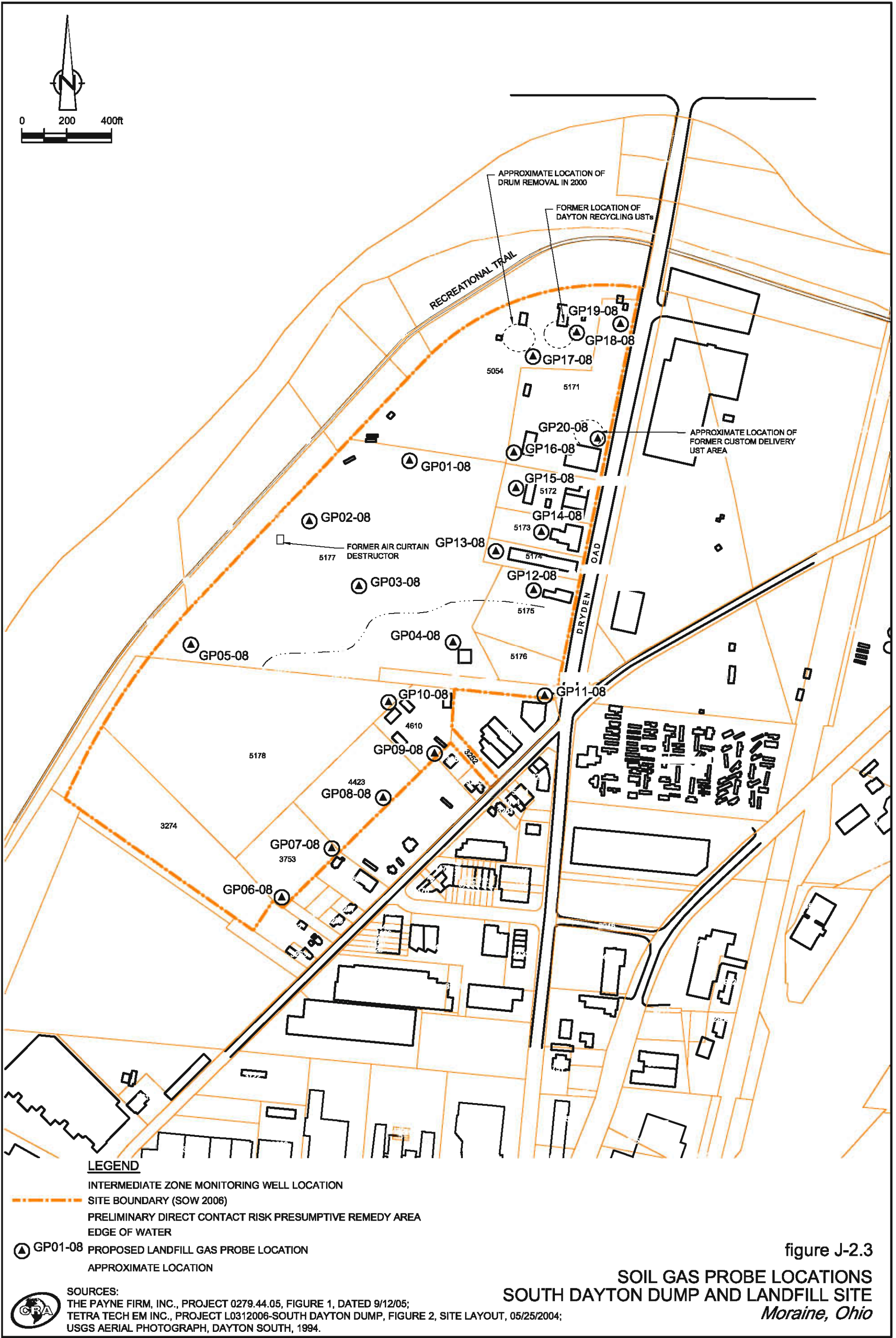
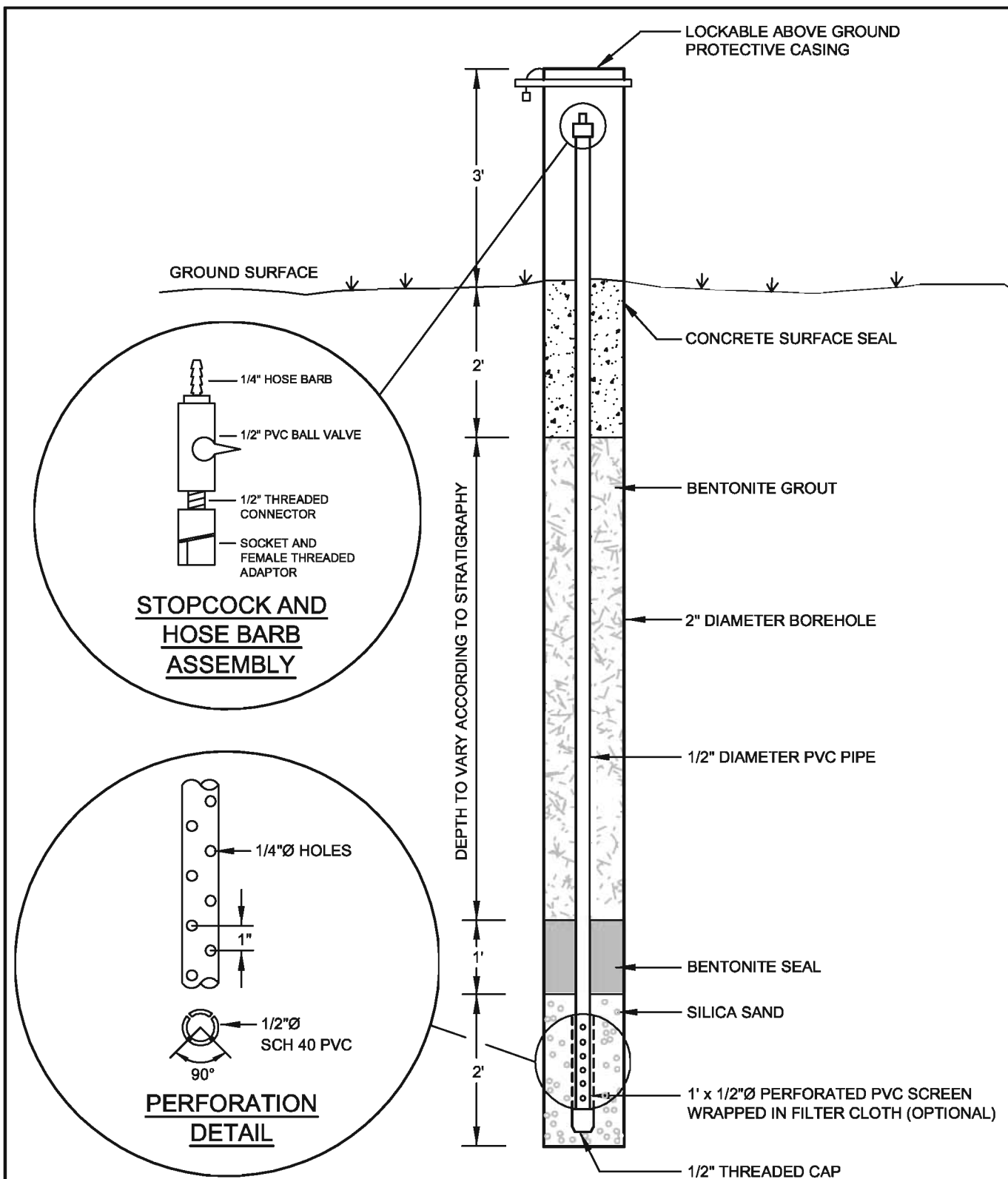


figure J-2.3
SOIL GAS PROBE LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



NOTE: GAS PROBE DEPTHS AND SCREEN LOCATIONS
TO BE VERIFIED IN THE FIELD, BASED
ON LOCAL SOIL CONDITIONS
CONNECTIONS AND ADAPTORS ARE
NOT TO BE GLUED

figure J-2.4

LANDFILL GAS/SOIL VAPOR PROBE DETAIL
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



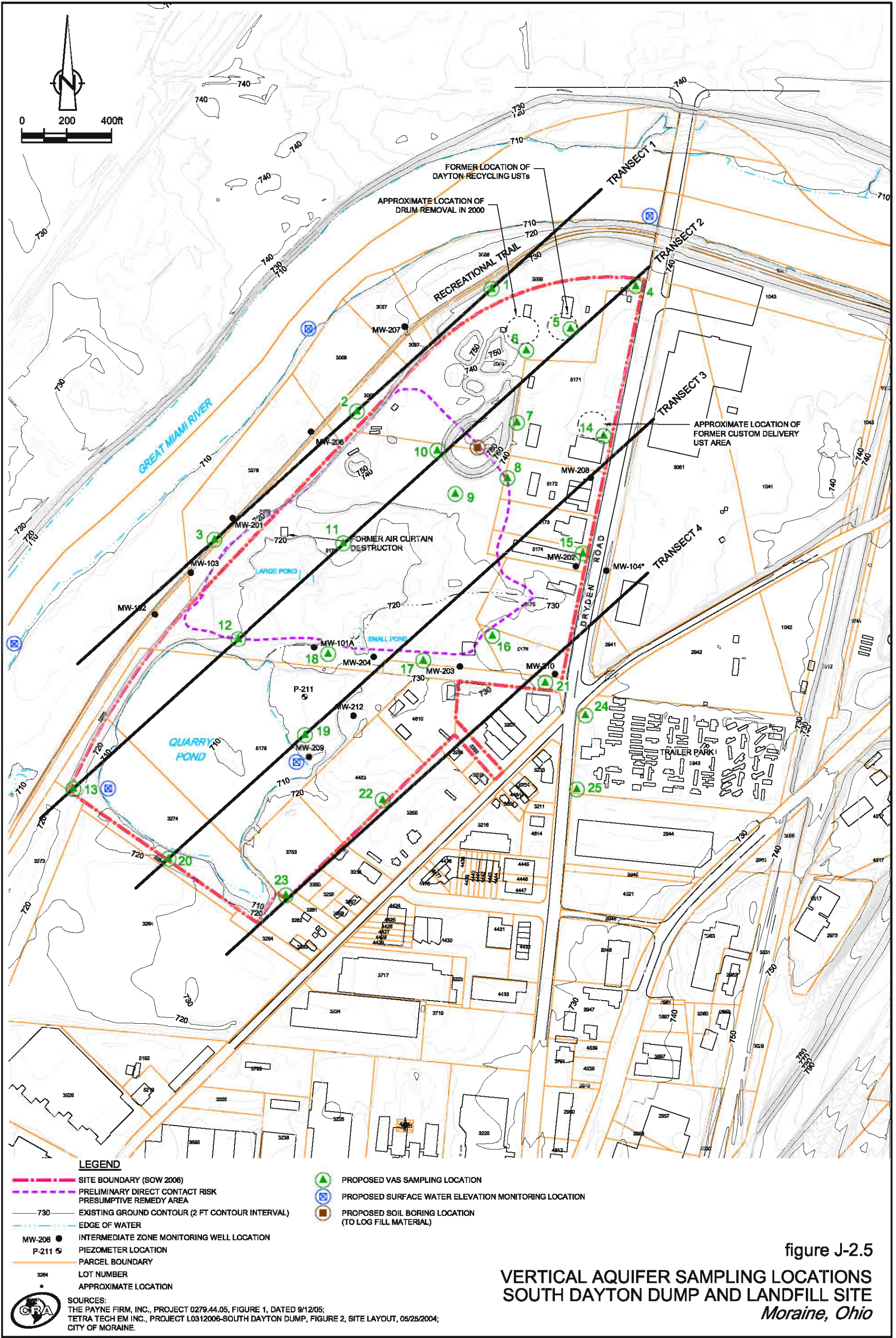


figure J-2.5
VERTICAL AQUIFER SAMPLING LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

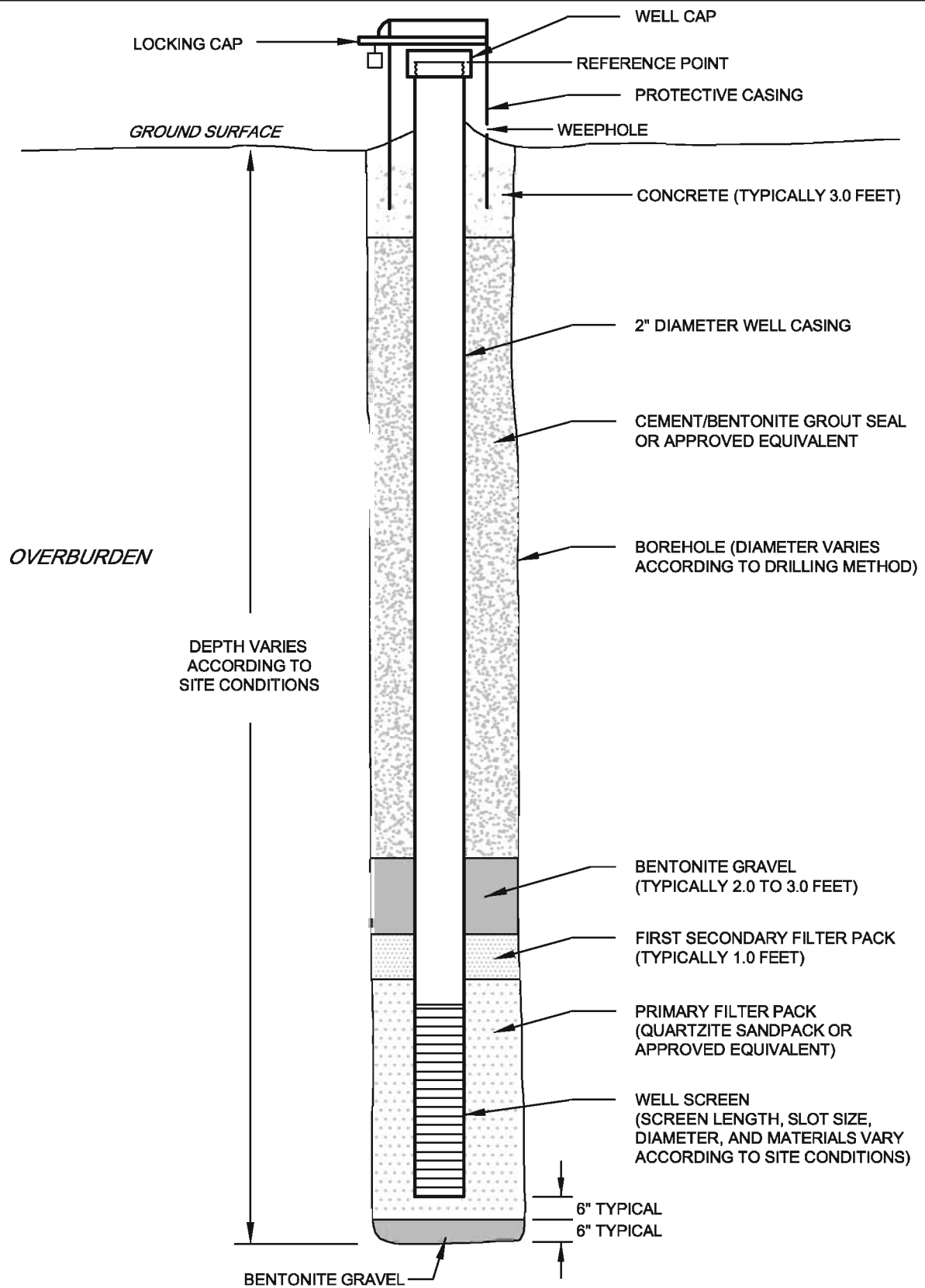


figure J-2.6

SHALLOW MONITORING WELL CONSTRUCTION DETAILS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



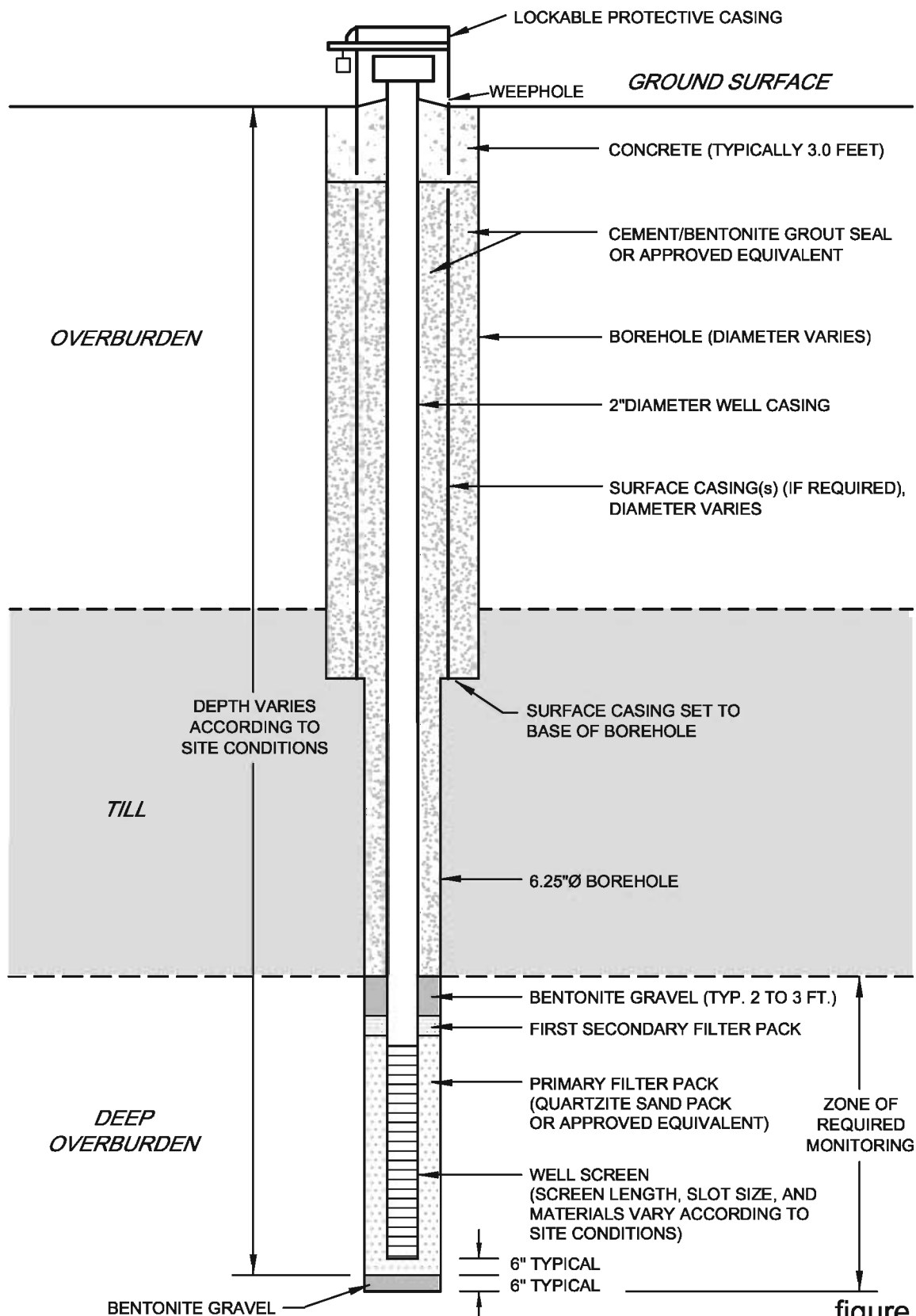


figure J-2.7

DEEP MONITORING WELL CONSTRUCTION DETAILS SOUTH DAYTON DUMP AND LANDFILL SITE Moraine, Ohio



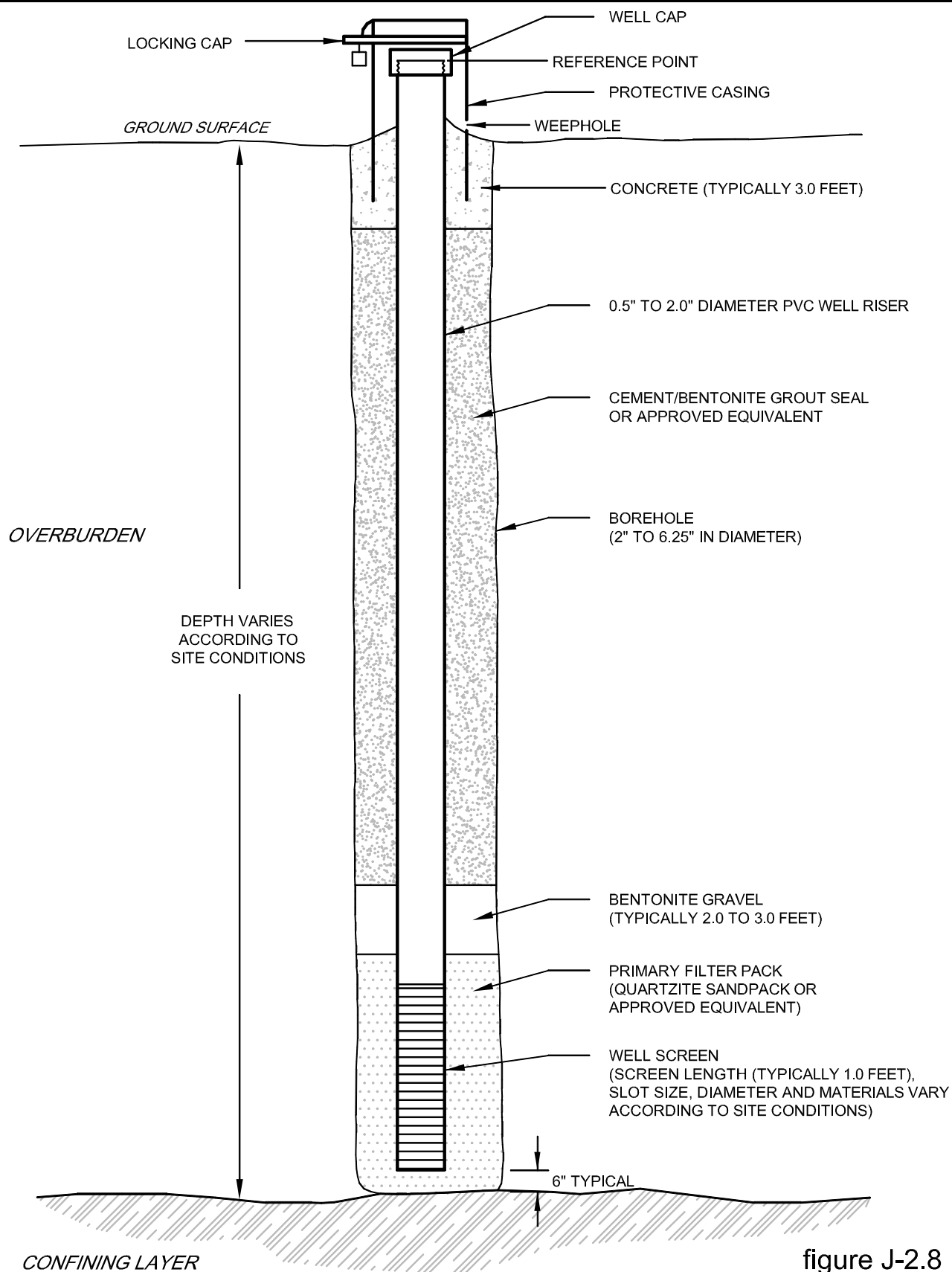


figure J-2.8

PIEZOMETER DETAIL
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



CONESTOGA-ROVERS & ASSOCIATES

JOB NAME: _____

JOB NO: _____

PRESERVED? YES ☐ (Circle) NO ☐

HNO₃ HCl NaOH H₂SO₄ NaOH/ZnOAc Other

MONTH/DAY/YEAR: _____ TIME: _____

SAMPLE ID: _____

SAMPLER'S SIGNATURE: _____

LAB SAMPLE ID: _____



figure J-5.1
SAMPLE LABEL
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

TABLE J-2.1

**SUMMARY OF SOIL SAMPLING AND ANALYSIS PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

Task/Event	Sample Matrix	Field Parameters	Laboratory Parameters	Sample Locations	Investigative Samples	Quality Control Samples ¹			Total ⁴
						Field Blanks ²	Field Duplicates	MS/MSD LCS/LCD ³	
Phase I - Surficial and Subsurface Soil Sampling									
Test Pit Sampling (5 foot intervals - 16 depths)	Solid	PID Screen / Visual Observation of Distinct Fill Types/Intervals	TCL VOCs, TCL SVOCs, TAL Inorganics ⁴ , TCL Herbicides and Pesticides, TCL PCBs, TCLP ⁶	6	6	1	1	1	9
Test Trench Sampling	Solid	PID Screen / Visual Observation of Distinct Fill Types/Intervals	TCL VOCs, TCL SVOCs, TAL Inorganics TCL Herbicides and Pesticides, TCL PCBs, TCLP ⁶	23	46	5	3	3	57
Soil Borings - Two Samples Each	Soil	PID Screen	TCL VOC, TCL SVOC, TAL Inorganics ⁵ , PCB	25	50	3	5	3	58
Soil Gas Sampling (Two Rounds)									
- Round 1	Air	PID Screen, LEL Screen	Methane, TCL VOC	5	5	--	1	1	6
- Round 2	Air	PID Screen, LEL Screen	Methane	5	5	--	1	1	6
Waste Characterization	Soil/Water	PID Screen	TCL VOC, TCL SVOC, TAL Inorganics ³ , PCB, MNA ⁴ TCLP Herbicides, TCLP Metals, Corrosivity, Ignitibility, Reactive Cyanide, Reactive Sulfide	TBD	TBD	--	--	--	TBD
Ash Fill Materials	Solid	Visual	Dioxins & Furans	TBD	TBD	--	--	--	TBD
Potential Asbestos Containing Materials	Solid	Visual	Asbestos	TBD	TBD	--	--	--	TBD

Notes:

- 1 - Quality control samples will include laboratory supplied trip blank samples for volatile sample analysis with each shipping cooler of aqueous investigative samples.
The actual quantity of field quality control samples will depend on field activities while maintaining the frequency specified in Section J 4.
- 2 - Field blank samples consisting of equipment rinsate blanks will not be collected when dedicated or disposable sampling equipment is employed.
- 3 - Matrix spike/matrix spike duplicate (MS/MSD) or laboratory control sample/laboratory control duplicate (LCS/LCD) in the case of air samples are required for each batch of 20 samples submitted.
- 4 - The total quantity does not include MS/MSD or LCS/LCD samples and is dependent on the actual quantity of field quality control samples collected.
- 5 - TAL Inorganics include 23 metals and total cyanide.
- 6 - MNA - Monitored Natural Attenuation Parameters include alkalinity, chloride, dissolved organic carbon, hardness, nitrate, nitrite, sulfate, sulfite, select metals (Ca, Mg, Mn), and dissolved gases.

TCL - Target Compound List
VOC - Volatile Organic Compounds
SVOC - Semi-volatile Organic Compounds

TAL - Target Analyte List
PCB - Polychlorinated Biphenyls
TCLP - Toxic Characteristics Leachate Procedure

MNA - Monitored Natural Attenuation Parameters
DO - Dissolve Oxygen
ORP - Oxygen Reduction Potential

TABLE J-2.2

**SUMMARY OF LEACHATE SEEP SAMPLING AND ANALYSIS PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

<i>Task/Event</i>	<i>Sample Matrix</i>	<i>Field Parameters</i>	<i>Laboratory Parameters</i>	<i>Sample Locations</i>	<i>Investigative Samples ⁵</i>	<i>Quality Control Samples¹</i>			<i>Total³</i>
						<i>Field Blanks²</i>	<i>Field Duplicates</i>	<i>MS/MSD LCS/LCD</i>	
Phase I - Leachate Seep Sampling									
Leachate Sampling (5 foot intervals - 16 depths)	Liquid	PID Screen	TCL VOCs, TCL SVOCs, TCL Herbicides and Pesticides, TCL PCBs, TAL Inorganics	TBD	TBD	--	--	--	TBD
Waste and/or Drum Characterization	Solid/Water	PID Screen	TCLP VOCs, TCLP SVOCs, TCLP Herbicides, TCLP Pesticides, TCLP Metals, PCBs, Corrosivity, Ignitibility, Reactive Cyanide, Reactive Sulfide	TBD	TBD	--	--	--	TBD

Notes:

- 1 Quality control samples will include laboratory supplied trip blank samples for volatile sample analysis with each shipping cooler of aqueous investigative samples.
- 2 Field blank samples consisting of equipment rinsate blanks will not be collected when dedicated or disposable sampling equipment is employed.
- 3 The total quantity is dependent on the actual quantity of samples and field quality control samples collected.
- 4 TAL Inorganics include the 23 metals and total cyanide.
- 5 Refers to the minimum number of investigative samples to be collected.
- 6 TCLP analysis will be completed on selected composite samples for the parameters listed under Waste and/or Drum Characterization as per the Letter Work Plan.

TCL - Target Compound List

VOC - Volatile Organic Compounds

SVOC - Semi-volatile Organic Compounds

TAL - Target Analyte List

PCB - Polychlorinated Biphenyls

TCLP - Toxic Characteristics Leachate Procedure

DO - Dissolve Oxygen

ORP - Oxygen Reduction Potential

TABLE J-2.3

**SUMMARY OF GROUNDWATER SAMPLING AND ANALYSIS PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

Task/Event	Sample Matrix	Field Parameters	Laboratory Parameters	Sample Locations	Investigative Samples	Quality Control Samples ¹			Total ⁴
						Field Blanks ²	Field Duplicates	MS/MSD LCS/LCD ³	
Phase I - Subsurface Groundwater Sampling - Two Rounds of Sampling for all Monitoring Wells									
Vertical Aquifer Sampling (VAS) (5 foot intervals - 16 depths)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP	TCL VOC	5	30	3	3	2	36
Shallow Groundwater Investigation (Geoprobe)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP	TCL VOC	6	6	1	1	1	7
Shallow Groundwater Investigation (New Monitoring Wells)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP, Iron (II)	TCL VOC, TCL SVOC, TCL pesticide and herbicide, TCL PCB, TAL Inorganics ⁵ , MNA ⁶	5	10	2	2	2	14
Shallow Source Area Groundwater (New Monitoring Well - Leachate)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP, Iron (II)	TCL VOC, TCL SVOC, TAL Inorganics ⁵ , PCB, MNA ⁶	1	2	2	2	2	6
Deep Groundwater Investigation (New Monitoring Wells)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP, Iron (II)	TCL VOC, TCL SVOC, TCL pesticide and herbicide, TCL PCB, TAL Inorganics ⁵ , MNA ⁶	3	6	2	2	2	10
Existing Monitoring Wells	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP, Iron (II)	TCL VOC, TCL SVOC, TCL pesticides and herbicide, TCL PCB, TAL Inorganics ⁵ ,	13	26	2	2	2	30
Private/Potable Well	Water	NA	TCL VOC, TCL SVOC, TAL Inorganics ⁵ , additional parameters if appropriate	TBD	TBD	--	--	--	TBD

Notes:

- 1 - Quality control samples will include laboratory supplied trip blank samples for volatile sample analysis with each shipping cooler of aqueous investigative samples. The actual quantity of field quality control samples will depend on field activities while maintaining the frequency specified in Section J 4.
- 2 - Field blank samples consisting of equipment rinsate blanks will not be collected when dedicated or disposable sampling equipment is employed.
- 3 - Matrix spike/matrix spike duplicate (MS/MSD) or laboratory control sample/laboratory control duplicate (LCS/LCD) in the case of air samples are required for each batch of 20 samples submitted.
- 4 - The total quantity does not include MS/MSD or LCS/LCD samples and is dependent on the actual quantity of field quality control samples collected.
- 5 - TAL Inorganics include 23 metals and total cyanide.
- 6 - MNA - Monitored Natural Attenuation Parameters include alkalinity, chloride, dissolved organic carbon, hardness, nitrate, nitrite, sulfate, sulfite, select metals (Ca, Mg, Mn), and dissolved gases.

TCL - Target Compound List
VOC - Volatile Organic Compounds
SVOC - Semi-volatile Organic Compounds

TAL - Target Analyte List
PCB - Polychlorinated Biphenyls
TCLP - Toxic Characteristics Leachate Procedure

MNA - Monitored Natural Attenuation Parameters
DO - Dissolve Oxygen
ORP - Oxygen Reduction Potential

TABLE J-2.4

**SUMMARY OF SURFACE WATER AND SEDIMENT SAMPLING AND ANALYSIS PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

Task/Event	Sample Matrix	Field Parameters	Laboratory Parameters	Sample Locations	Investigative Samples	Quality Control Samples ¹			Total ⁴
						Field Blanks ²	Field Duplicates	MS/MSD LCS/LCD ³	
Phase I - Surface Water Sampling									
Surface Water Guage Station (5 foot intervals - 16 depths)	Water	pH./Temperature, Conductivity, DO, Turbidity, ORP, Iron (II)	TCL VOC, TCL SVOC, TAL Inorganics ⁵ , TCL PCB, additional parameters (e.g., dioxins/furans, TCL	3	3	1	1	1	6
Phase I - Sediment Sampling									
Surface Water Guage Station	Soil	PID Screen	TCL VOC, TCL SVOC, TAL Inorganics ³ , PCB	3	3	1	1	1	6

Notes:

- 1 - Quality control samples will include laboratory supplied trip blank samples for volatile sample analysis with each shipping cooler of aqueous investigative samples.
The actual quantity of field quality control samples will depend on field activities while maintaining the frequency specified in Section J 4.
- 2 - Field blank samples consisting of equipment rinsate blanks will not be collected when dedicated or disposable sampling equipment is employed.
- 3 - Matrix spike/matrix spike duplicate (MS/MSD) or laboratory control sample/laboratory control duplicate (LCS/LCD) in the case of air samples are required for each batch of 20 samples submitted.
- 4 - The total quantity does not include MS/MSD or LCS/LCD samples and is dependent on the actual quantity of field quality control samples collected.
- 5 - TAL Inorganics include 23 metals and total cyanide.

TCL - Target Compound List

VOC - Volatile Organic Compounds

SVOC - Semi-volatile Organic Compounds

TAL - Target Analyte List

TCL VOC, TCL SVOC, TAL Inorganics⁵, PCB, MNA⁴

TCLP - Toxic Characteristics Leachate Procedure

MNA - Monitored Natural Attenuation Parameters

DO - Dissolve Oxygen

ORP - Oxygen Reduction Potential

TABLE J-2.5

**SOIL GAS PARAMETER LISTS AND TARGETED QUANTITATION LIMITS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

(5 foot intervals - 16 depths)

<i>Parameter</i>	<i>Targeted</i>	<i>Method</i>	<i>OSWER Draft Guidance</i>
	<i>Quantitation Limit (TQL) ¹</i>	<i>Detection Limits (MDL) ²</i>	<i>Targeted Soil Gas</i>
	<i>Air</i>	<i>Air</i>	<i>Concentrations ³</i>
<i>Compound</i>	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>Risk = 1×10^{-4}</i>
<i>Select Volatile Organic Compounds (VOC)</i>			
Acetone	24	5.9	3,500
Benzene	0.96	0.64	310
Bromodichloromethane	2.0	1.6	140
Bromoform	4.1	2.1	2,200
Bromomethane	16	7.8	50
2-Butanone	29	5.9	10,000
Carbon disulfide	31	6.2	7,000
Carbon tetrachloride	1.9	1.3	160
Chlorobenzene	1.4	0.92	600
Chloroethane	1.1	1.0	100,000
Chloroform	1.5	0.97	110
Chloromethane	1.6	0.82	900
Cyclohexane	1.7	1.4	N/A
Dibromochloromethane	3.4	1	100
1,2-Dibromo-3-chloropropane	9.6	3.9	2
1,2-Dibromoethane	3.1	1.5	2
1,2-Dichlorobenzene	2.4	1.2	2,000
1,3-Dichlorobenzene	2.4	1.2	1,100
1,4-Dichlorobenzene	2.4	1.2	8,000
Dichlorodifluoromethane	1.5	0.99	2,000
1,1-Dichloroethane	1.2	0.81	5,000
1,2-Dichloroethane	8.1	4.0	94
1,1-Dichloroethene	7.9	4.0	2,000
cis-1,2-Dichloroethene	7.9	3.2	350
trans-1,2-Dichloroethene	7.9	4.0	N/A
1,2-Dichloropropane	14	6.9	40
cis-1,3-Dichloropropene	1.8	0.91	200
trans-1,3-Dichloropropene	1.8	0.91	200
Ethylbenzene	1.3	0.87	2,200
2-Hexanone	2.0	1.6	N/A
Isopropylbenzene	2.5	2.0	4,000
Methylene chloride	1	0.69	5,200
4-Methyl-2-pentanone	41	8.2	800
Methyl tert-butyl ether	7.2	3.6	30,000
Naphthalene	2.6	1.3	30
Styrene	1.7	0.85	10,000
1,1,2,2-Tetrachloroethane	14	6.8	42
Tetrachloroethene	2.7	1.4	810
Toluene	7.5	3.8	4,000
1,2,4-Trichlorobenzene	37	18	2,000
1,1,1-Trichloroethane	1.6	1.1	22,000

TABLE J-2.5

**SOIL GAS PARAMETER LISTS AND TARGETED QUANTITATION LIMITS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

(5 foot intervals - 16 depths)

Parameter	Targeted	Method	OSWER Draft Guidance
	Quantitation Limit (TQL) ¹	Detection Limits (MDL) ²	Targeted Soil Gas
Compound	Air	Air	Concentrations ³
Select VOC (continued)	($\mu\text{g}/\text{M}^3$)	($\mu\text{g}/\text{M}^3$)	Risk = 1×10^{-4}
1,1,2-Trichloroethane	1.6	1.1	150
Trichloroethene	2.1	1.1	22
Trichlorofluoromethane	11	5.6	7,000
1,1,2-Trichloro-1,2,2-trifluoroethane	3.8	3.1	300,000
Vinyl chloride	7.6	3.8	280
Xylenes (total)	17	4.3	70,000

Notes:

- 1 Please note that these are targeted quantitation limits and are presented for guidance only. Actual quantitation limits are highly matrix dependent and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes.
- 2 Method Detection Limits (MDL) are also presented for guidance only. Actual MDLs will vary depending on sample specific preparation factors. The MDLs are also highly matrix dependant and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes. Laboratory MDLs are updated on a periodic basis and the MDLs in effect when the samples are analyzed will be used for reporting purposes.
- 3 Target Shallow Soil Gas Concentrations Corresponding to Target Indoor Air Concentrations Where the Soil Gas to Indoor Air Attenuation Factor = 0.1 in Table 2a (Risk = 1×10^{-4}) of draft guidance "Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" (USEPA, 2002).

TABLE J-5.1

**CONTAINER, PRESERVATION, SHIPPING AND PACKAGING REQUIREMENTS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

(5 foot intervals - 16 depths)

Matrix	Analyses	Sample Containers¹	Preservation²	Maximum Holding Time from Sample Collection³	Volume of Sample	Shipping	Normal Packaging
Groundwater, Residential Well Water							
	TCL VOC, Dissolved Gases	Three 40-mL septum top vials per analysis	Iced HCl to pH<2	14 days for analysis	Fill completely	Federal Express Priority 1	Bubble Wrap or Foam Chips
	TCL SVOC, TCL Pesticides/PCBs	Two 1-L amber glass bottles per analysis	Iced	7 days for extraction 40 days after extraction for analysis	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	TAL Metals, Dissolved Iron and Manganese	One 1-L polyethylene bottle	HNO ₃ to pH<2	6 months for analysis (mercury - 28 days)	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Cyanide	One 1-L polyethylene bottle	Iced NaOH to pH>12	14 days for analysis	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Chloride, Sulfate, Alkalinity, Nitrate, Nitrite	Two 1-L polyethylene	Iced	28 days for analysis (alkalinity - 14 days) (nitrate, nitrite - 48 hours)	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Dissolved Organic Carbon	One 40-mL septum top vial	Iced, H ₂ SO ₄ to pH<2	28 days for analysis	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Sulfide	One 500-mL polyethylene	Iced, 2 mL Zinc Acetate, NaOH to pH>9	7 days for analysis	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Ammonia	One 500-mL polyethylene	Iced	28 days for analysis	Fill to neck of bottle	Federal Express Priority 1	Bubble Wrap or Foam Chips

TABLE J-5.1

**CONTAINER, PRESERVATION, SHIPPING AND PACKAGING REQUIREMENTS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

(5 foot intervals - 16 depths)

<i>Matrix</i>	<i>Analyses</i>	<i>Sample Containers</i> ¹	<i>Preservation</i> ²	<i>Maximum Holding Time from Sample Collection</i> ³	<i>Volume of Sample</i>	<i>Shipping</i>	<i>Normal Packaging</i>
Soil, Sediment	TCL SVOC, Pesticides/PCBs	One 4-oz. glass jar	Iced	14 days for extraction 40 days after extraction for analysis	Fill to shoulder of jar	Federal Express Priority 1	Bubble Wrap or Foam Chips
Soil	TAL Inorganics	One 500-mL glass jar	Iced	6 months for analysis (mercury - 28 days) (cyanide - 14 days)	Fill to shoulder of jar	Federal Express Priority 1	Bubble Wrap or Foam Chips
	TCL VOC	Three 5-gram discrete samplers ⁴	Iced	48 hours for preparation 14 days for analysis	Fill completely	Federal Express Priority 1	Bubble Wrap or Foam Chips
	Geotechnical	Two 500-mL glass jars	None	None	Fill to shoulder of jar	Federal Express Priority 1	Bubble Wrap or Foam Chips

Notes:

- 1 Where possible, analyses will be combined into the minimum number of sample containers with respect to sample preservation requirements.
- 2 Samples requiring refrigeration will be shipped in coolers containing bagged, cubed ice. Following laboratory receipt and log-in, these samples will be stored at 4° ± 2°C.
- 3 Maximum holding times presented are technical holding times and are based on the time elapsed from sample collection.
- 4 En Core sampler or equivalent device.

TABLE J-6.1

**FIELD INSTRUMENT CALIBRATION AND QA SUMMARY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

(5 foot intervals - 16 depths)

<i>Instrument (1) (Analysis)</i>	<i>Method Reference</i>	<i># Standards Initial Calibration</i>	<i>Acceptance/ Rejection Criteria - Initial Calibration</i>	<i>Frequency of Calibration</i>	<i>Frequency of Initial Calibration Verification</i>	<i>Acceptance/ Rejection Criteria- Initial Calibration Verification</i>	<i>Frequency of Continuing Calibration Verification</i>	<i>Acceptance/ Rejection Criteria- Continuing Calibration Verification</i>	<i>Other Calibration Requirements</i>	<i>Required Field QA/QC</i>
YSI 3560 Water Quality Meter (pH, Temperature)	EPA 150.1	2	pH 7.00 buffer \pm 0.1 SU	At least daily, or as required (when CCV fails acceptance criteria)	As needed	Same as ICV	Every 10 samples	Same as ICV	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 0.2 SU of original.
(Conductivity)	EPA 120.1	NA	NA	Factory-calibrated	Daily	1.000 \pm 0.70 mmho	Every 10 samples	1.000 \pm 0.70 mmho	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 15% of original.
(ORP)	SM 2580 B	1	NA (ZoBell Solution Cal.)	At least daily, or as required (when CCV fails acceptance criteria)	As needed	\pm 10 mV	Every 10 samples	Same as ICV	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 10 mV of original.
YSI 52 (Dissolved Oxygen)	EPA 360.1	1	NA (moist air calibration)	At least daily, or as required (when CCV fails acceptance criteria)	As needed	\pm 10 %	Every 10 samples	Same as ICV	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 15% of original.
DRT-15C (Turbidity)	NA	NA	Factory-Calibrated	Daily	NA	\pm 10 %	Every 10	Same as ICV	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 15% of original.
MiniRae Classic PID (Organic Vapors)	NA	2	Instrument-Determined	Daily	NA	NA	Every 10 samples	\pm 10 %	None	None
Landtec Gas Extraction Monitor (Landfill Gas)	NA	1	Factory-Calibrated	Daily	As needed	\pm 10 %	Every 10	Same as ICV	None	Duplicate 1 of every 10 samples. (2) Duplicate must be \pm 15% of original.

Notes:

- (1) Equivalent instruments to those specified may also be used.
 (2) If less than 10 samples are analyzed, a duplicate is still required.
 ICV Initial Calibration verification.
 CCV Continuing Calibration verification.
 SU Standard pH units.

APPENDIX J-A

LAND SURVEY, BATHYMETRY SURVEY, AND GEOPHYSICAL INVESTIGATION LETTER WORK PLAN



**CONESTOGA-ROVERS
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May 9, 2008

Reference No. 038443

Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Karen:

Re: Final Land Survey, Bathymetry Survey, and Geophysical Investigation
South Dayton Dump and Landfill Site, Moraine, Ohio (Site)

This Letter Work Plan presents the South Dayton Dump and Landfill Potentially Responsible Party Group's (PRP Group's) approach for a land survey, bathymetry survey, and geophysical investigation of the Site. The work will help address data gaps and provide information to aid in the completion of a Feasibility Study (FS). The work will also allow for identification of surveyed areas that may require additional investigation or consideration prior to the beginning of intrusive fieldwork.

The PRP Group has prepared this Letter Work Plan based on discussions between the PRP Group and USEPA in February 2008 and April 2008. The Letter Work Plan incorporates comments received from USEPA on April 8, 2008.

SURVEYING

The objectives of the Site Survey are as follows:

- conduct a complete topographical survey of the entire Site by aerial photometry;
- survey locations of existing structures and features such as access roads, buildings, building foundations, fences monitoring wells, etc.;
- establish benchmarks for future surveying uses including but not limited to Site settlement monitoring;
- generate a current Site plan for use in future investigation and remedial alternative evaluation activities; and





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- generate an accurate topographical map of the Site for use in determining current Site drainage patterns and for use in evaluating various landfill cap designs.

All survey work completed throughout this project will be performed by a State of Ohio registered land surveyor.

Survey data will be collected to obtain current topographic information in the area of the Site as bounded by the Great Miami River (GMR) to the north and west, Dryden Road to the east, East River Road to the southeast and Parcel 3264 to the south. The topographical survey will be completed utilizing aerial survey techniques. The Site was flown over April 2, 2008. Ten targets were placed on the ground in the survey area to act as control points for ground truthing the survey. In addition the horizontal locations of all boreholes, test trenches, test pits, monitoring wells, gas probes and staff gauges will be surveyed by ground personnel and reported in Ohio State Plane Grid Coordinates and in Decimal Degrees and elevations will be verified against the closest USGS benchmark monuments. Elevations will be surveyed according to the 1988 North American Vertical Datum (NAVD 88) for vertical coordinates and the 1983 North American Datum (NAD 83) for horizontal coordinates. Horizontal locations will be surveyed to the nearest 0.5-foot accuracy. Elevations for all monitoring well reference points (new and existing) will be surveyed to the nearest 0.01-foot accuracy. Elevations for all other locations will be surveyed to the nearest 0.1-foot accuracy. Five settlement monuments will be established within the PRP Group's preliminary direct contact risk presumptive remedy area in the central portion of the landfill on Lot 5177 for future use in settlement monitoring. The settlement monuments will be surveyed to the nearest 0.01-foot accuracy. The settlement monument locations are provided on Figure 1. Additional settlement monuments may be required in other areas of the Site. The need for additional settlement monuments will be discussed with USEPA as further data with respect to the location of landfill materials are obtained.

SURFICIAL METALLIC DEBRIS COLLECTION/STAGING

Prior to completing a geophysical investigation at the Site, CRA will retain a contractor to collect surficial metallic debris, empty drums and/or drum carcasses previously observed along the central access road and other areas across the Site, as necessary. The contractor will relocate this material to a central staging area located on-Site for interim storage in order to minimize its impact on the geophysical investigation. This debris will be managed as part of future waste characterization and consolidation activities, which will be conducted prior to implementing a remedy at the Site. Drums that are intact and have liquid or solid contents and are visually



determined to be in poor condition will be left in place. The location and contents (based on visual observation) of these drums will be documented in a logbook and also marked on a Site plan. The location of drums left in place will be surveyed with a global positioning system (GPS) receiver, and reported in Ohio State Plane Grid Coordinates and in Decimal Degrees. These drum locations will be referenced to the same coordinate system used for the geophysical investigation, to allow surface metal locations to be easily matched to the geophysical maps.

The staging area will first be surveyed using the geophysical techniques identified below before it is constructed or used. After the geophysical investigation of the staging area, a staging pad will be constructed. The staging area will be installed with a containment berm and a 20-mil synthetic liner for leak and spill protection. The staging area will be located on Lot 5177 within the fenced in area of the Site for security purposes. Once debris collection is completed the area will be covered with polyethylene sheeting to prevent the accumulation of storm water within the area.

More than one staging pad may be constructed depending on how much debris is relocated. A typical staging cell construction detail is presented on Figure 2.

BATHYMETRY SURVEY

The objectives of the bathymetry survey are as follows:

- generate topographical information for the bottom of the Quarry Pond; and
- generate information for use in future investigation and remedial alternative evaluation activities.

A bathymetry survey will be completed to define the bottom of the Quarry Pond utilizing an echosounder attached to a GPS receiver to maintain control of sub-meter positioning. The bathymetry data and survey line locations will be stored in a digital format using Bathylog (or equivalent) software. The Echosounder and GPS will be programmed to collect respective data at 0.5- to 1.0-second time intervals. The bathymetry survey will be completed along pre-determined survey lines spaced 40 feet apart and oriented in an approximate north-south direction, which have been uploaded into the associated navigational software. Bathymetry data will also be collected on cross-lines oriented in an approximate east-west direction, and spaced 150 feet apart. Survey data will be used to complete a map of the Quarry Pond. Based on the results of the bathymetry survey an electromagnetic (EM) or magnetometer survey of the



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Quarry Pond will be completed to identify metallic anomalies (i.e., drums) on the bottom of the Quarry Pond.

Land versions of the EM and magnetometer will be used if the pond is shallow, and marine versions will be used if the pond is deep. Specifically, if the pond is less than 10 feet deep, EM61 and magnetometer surveys will be completed using raft-mounted land instruments. If the pond is between 10 and 20 feet deep, EM31 and magnetometer surveys will be completed using raft-mounted land instruments. If the pond is between 20 and 30 feet deep, the EM survey will be completed using a marine EM instrument or an EM instrument with a 30-foot-depth of investigation; the magnetometer survey will be completed using raft-mounted land instruments. If the pond is more than 30 feet deep, EM and magnetometer surveys will be completed using marine instruments.

GEOPHYSICAL INVESTIGATION

The objectives of the geophysical investigation are as follows:

- identify buried metals and objects at the Site at surveyed locations; and
- identify Site areas which may require additional investigation.

The investigation will use magnetic, EM, and ground penetrating radar (GPR) techniques to identify both ferrous and non-ferrous buried metal objects at surveyed locations to depths of up to 20 feet below ground surface. The magnetic survey will consist of total field and vertical gradient data collection. Magnetic field readings will be recorded at a background base station location during the course of the survey, to allow for correction of diurnal variation (i.e., magnetic drift), if necessary. The EM surveys will utilize an EM31-MK2 instrument (or equivalent), operating simultaneously in metal detection and conductivity modes, and an EM61 buried metal detector.

The EM61 survey will be used to detect the presence of buried metal objects in the shallow subsurface. The EM61 is a time domain instrument, which has an effective depth of investigation of approximately 10 feet below ground surface (bgs), and operates at a frequency of 150 Hz. The EM61 exhibits good lateral (or horizontal) resolution of buried metal objects (in the presence of one object or several objects situated in close proximity) in comparison to other EM methods, due to its stacked coil configuration. The coil separation for the EM61 is one foot. The EM31 survey will be used to detect the presence of buried metal objects in the deeper subsurface. The EM31 is a frequency domain instrument, which has an effective depth of



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investigation of approximately 17 feet bgs when carried at hip level and operating in horizontal dipole mode. The EM31 exhibits good lateral (or horizontal) resolution for individual buried metal objects but in situations where two or more objects are in close proximity to each other, the EM31 cannot delineate individual responses. This limitation can be attributed to the location of transmitter and receiver coils at either end of a 13-foot long cylindrical boom. The EM31 operates at a frequency of 9.8 kiloHertz (kHz).

The depth of investigation of a GPR survey is inversely proportional to the frequency of the instrument. That is, the higher the frequency, the more rapidly the GPR signal will attenuate or dissipate in the subsurface. Thus, the GPR survey will utilize a Ramac Rough Terrain Concept (RTC) low frequency system, with a 100-Mhz antenna (or equivalent) to optimize the depth of investigation. This instrument is characterized by an in-line transmitter-receiver antenna configuration, which allows for relatively rapid GPR data acquisition in comparison to other instruments. The EM and GPR surveys will also identify buried conduits or pipelines at the Site, the locations of which will be recorded for future reference. Conduits can include electric, communication, water, and gas lines as well as sewers and field tiles. Smaller conduits, however, may not be seen in surveyed areas where the ground is mostly clay with a high moisture content. The usefulness of GPR at this Site may be limited by any heterogeneity of landfilled materials and uneven terrain. It may be difficult to determine whether GPR survey results have been affected by de-coupling (bouncing) on the ground or signal scatter due to the ground matrix.

The areas of the Site in which the geophysical investigation will occur are presented on Figure 3. It should be noted that existing material storage piles located on and adjacent to the Valley Asphalt and Custom Delivery properties (Lots 5054 and 5177) and existing building structures at the Site (Lots 4610, 5054, 5171, 5172, 5173, 5174, and 5175) will physically limit the extent of the geophysical survey to be conducted. Minor amounts of brush and tree cutting will be required to facilitate the geophysical survey. Survey lines will be cleared to a minimum width of 4 feet, to facilitate geophysical surveying activities and to provide good GPR contact, or coupling. The in-line transmitter-receiver configuration will ensure adequate coupling is maintained during the GPR survey, since the width of the antennas along the geophysical survey lines is relatively narrow (approximately 6 inches wide). Any cleared brush will be removed from the survey lines to mitigate slip, trip and fall hazards, and to facilitate progress of the geophysical surveys.

Prior to conducting the surveys, a grid consisting of parallel lines will be established over the area of investigation (shown on Figure 3). The grid will utilize a number of control points that will be surveyed for horizontal and vertical location at 150-foot intervals in the approximate north-south direction, and 160-foot intervals in the approximate east-west direction.



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Geophysical survey lines spaced 40 feet apart will be established between the control points, and will be designated with a Cartesian coordinate system as required by instrument data loggers. In addition, perpendicular (approximate east-west) geophysical survey lines will be established at 150-foot intervals, along the lines joining the control points. Magnetic, EM, and GPR measurements will be recorded at 0.5 second time intervals or, at a minimum, 0.7-foot distance intervals along these grid lines, and stored automatically in data loggers.

The anticipated vertical beam widths or effective investigative depths for the EM31 and EM61 are approximately 17 feet bgs (at hip level) and 10 feet bgs, respectively, as specified by the manufacturer. The vertical beam width or effective depth of investigation for the GPR survey will be dependant on conditions encountered in the field and will be evident on the trace plots, once compiled. The horizontal beam width of these three surveys (EM31, EM61, and GPR) is relatively poor, and will generally be restricted to the trend of the geophysical survey line and immediate surrounding area (i.e., 2 to 3 feet off-line). The magnetometer survey is a passive geophysical method; therefore, beam width is perhaps not the most appropriate term in describing the radius of detection for this instrument. The concentration of magnetic flux of the induced field in a buried object is a function of the magnetic susceptibility of the buried object, the degree of degradation (i.e., rusting out) it has undergone, and the size and orientation of the buried object. However, magnetometer surveys can typically yield an anomaly on the order of several hundred nanoTeslas (nT) over objects such as drums buried approximately 20 feet bgs. In addition, the lateral or horizontal resolution of a magnetometer survey is good, whereby an elevated magnetic response can be observed 10 to 20 feet adjacent to the buried object.

The purpose of the proposed geophysical investigation will be to act as a "screening tool", by providing potential targets for intrusive work based on anomalous metal detection responses. As such, it is impossible to speculate what the nature or composition of any suspected metal detection targets are, or how many may be present, until the anomalies are excavated and ground-truthed. Further, the configuration of the instrument (EM31) or measured quantity (magnetic field) of some geophysical instruments precludes identification of individual buried metal objects when two or more of these objects are present adjacent to, or in close proximity to each other, both vertically and horizontally. The only exception whereby discrete anomalies in close proximity to each other may be delineated is with the EM61 survey results, in the shallow subsurface.

The data loggers will be referenced to the Site survey grid, and will not be tied into GPS automatically. This will allow for more rapid data acquisition and data assessment on-Site (since the coordinates will already be in a Cartesian system and won't require conversion from latitude/longitude). This will also allow for more accurate locating of anomalous responses along the geophysical survey lines. Following completion of the geophysical investigation, the



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location and extent of anomalous responses will be surveyed with a GPS system, and reported in Ohio State Plane Grid Coordinates and in Decimal Degrees (i.e., the same approach for the drums left in place).

The magnetometer, EM31, EM61, and GPR land surveys will be carried by operators, without the aid of a mobile system such as an ATV.

The geophysical investigation results will be presented as colored, contoured plots. The results will be used to finalize the locations of test pits and trenches.

The surface geophysical investigation will consist of collecting data on 40-foot spaced grid lines with intermediate 20-foot spaced grid lines over anomalous areas. The decision to perform 20-foot grid spacings will be evaluated at a minimum on a weekly basis on-Site, following a preliminary data assessment, which is scheduled to occur on the weekends or on rain days. The 20-foot grid spacings will be surveyed immediately following this evaluation, or following brush-clearing of the 20-foot grid lines, where required. CRA will discuss the results with USEPA and Ohio EPA's Site representative(s) as the work progresses; however, to accommodate the schedule, CRA does not intend to discuss the preliminary results with USEPA and Ohio EPA before starting 20-foot grids/concluding the survey.

Contour plots will be provided at appropriate intervals and color scales, to clearly accentuate anomalous responses.

The geophysical instruments used to collect the geophysical data will include:

- GEM GSM-19 Overhauser Proton Precession Magnetometer (or equivalent such as EG&G Geometrics G-858G cesium vapor magnetometer) to collect total magnetic field and magnetic gradient data;
- Geonics, Inc. EM-31 Ground Conductivity Meter to collect quadrature (terrain conductivity) and in-phase (metal detection) data;
- Geonics, Inc. EM-61 Buried Metal Detector to collect focused metal detection data; and
- Ramac RTC low frequency GPR system with a 100-Mhz antenna.

Instrument descriptions and survey procedures are provided in Attachment A.

The various geophysical surveys will be completed concurrently, to the extent practicable. Only one instrument of each type will be operated at any given time, to avoid potential interference



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of multiple signals, especially in the case of the EM31. Further, a minimum distance of 150 feet will be maintained between instruments at any given time, to avoid another source of potential interference.

An EM or magnetometer survey of the Quarry Pond will be conducted after the completion of the bathymetry survey. The bathymetry survey of the Quarry Pond will allow for the proper selection of the geophysical survey equipment, based on the depth of the water column. The Quarry Pond geophysical survey will be completed using a GPS to ensure complete and effective coverage of the area has been completed. The survey will be conducted using a small boat with an outboard motor towing a non-metallic raft with the GPS and survey equipment. Specifically, the non-metallic raft will be constructed of wood, or other non-conductive material such as fiberglass.

The data will be used to identify areas of the Site that may require further investigation as part of the soil or groundwater sampling programs (under separate cover).

All work will be performed in accordance with the Field Sampling Plan, and Site Specific Health and Safety Plan pending USEPA's approval of these documents. Prior to conducting the work, local utility location services will be contacted to locate any known utilities.

SCHEDULE

The land survey, bathymetry survey, and the geophysical investigation work will be initiated within fifteen days of USEPA approval of this Letter Work Plan. These field tasks will be conducted concurrently and will be completed within an eight-week period of time. The PRP Group will provide the USEPA with verbal notification of field activities at least 15 days in advance of the initiation of field activities. Data processing, plotting, and drafting requirements for the bathymetry survey, land geophysics surveys, and waterborne surveys will take six weeks to complete, after which draft plots of the survey results will be provided to the PRP Group.

REPORTING

An updated Site plan and topographical map, and AutoCAD files with coordinates will be provided to the USEPA within one month of completion of the proposed work (i.e., the aerial photometry survey and survey of existing features (e.g. monitoring wells, surface water gauges, etc.). A preliminary topographical map will be provided to USEPA one month after the



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completion of the aerial photometry survey. The topographic map will be prepared with a 10-foot contour interval. The contour interval may be adjusted if Site conditions warrant the use of a finer interval. Geophysical and bathymetry reports will be forwarded to the USEPA within two weeks of the PRP Group's receipt of the reports.

A map showing known and found utilities and other conduits will be provided concurrent with the geophysical and bathymetry reports.

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

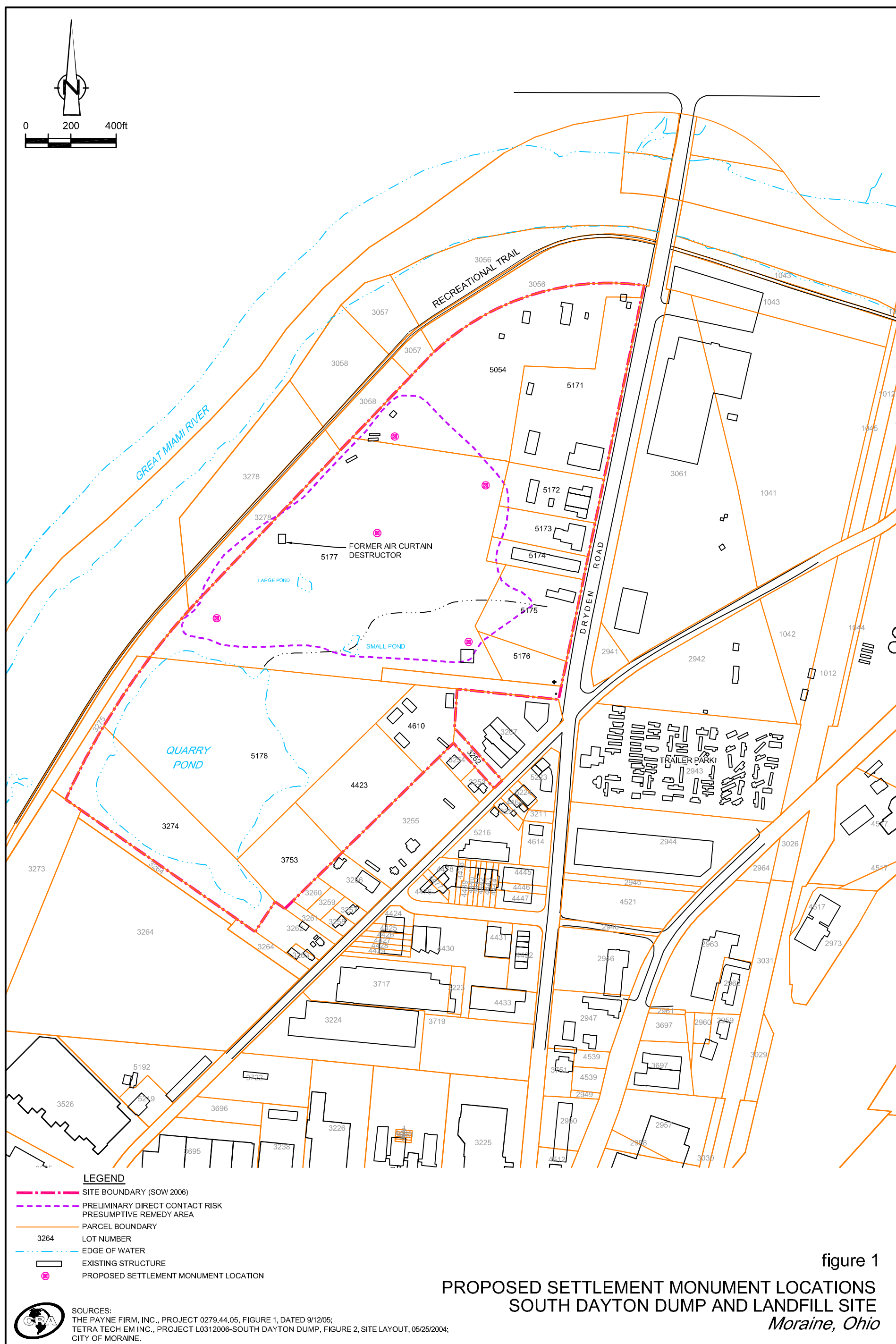
CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

LA/ca/28

Encl.

c.c. Matt Mankowski, USEPA (PDF)
 Matt Justice, Ohio EPA (PDF)
 Eric Kroger, CH2M Hill (PDF)
 Scott Blackhurst, Kelsey Hayes Company (PDF)
 Wray Blattner, Thompson Hine (PDF)
 Ken Brown, ITW (PDF)
 Jim Campbell, Engineering Management Inc. (PDF)
 Tim Hoffman, Representing Kathryn Boesch and Margaret Grillot (PDF)
 Paul Jack, Castle Bay (PDF)
 Robin Lunn, Mayer Brown (PDF)
 Roger McCready, NCR (PDF)
 Karen Mignone, Pepe & Hazard (PDF)
 Adam Loney, CRA (PDF)



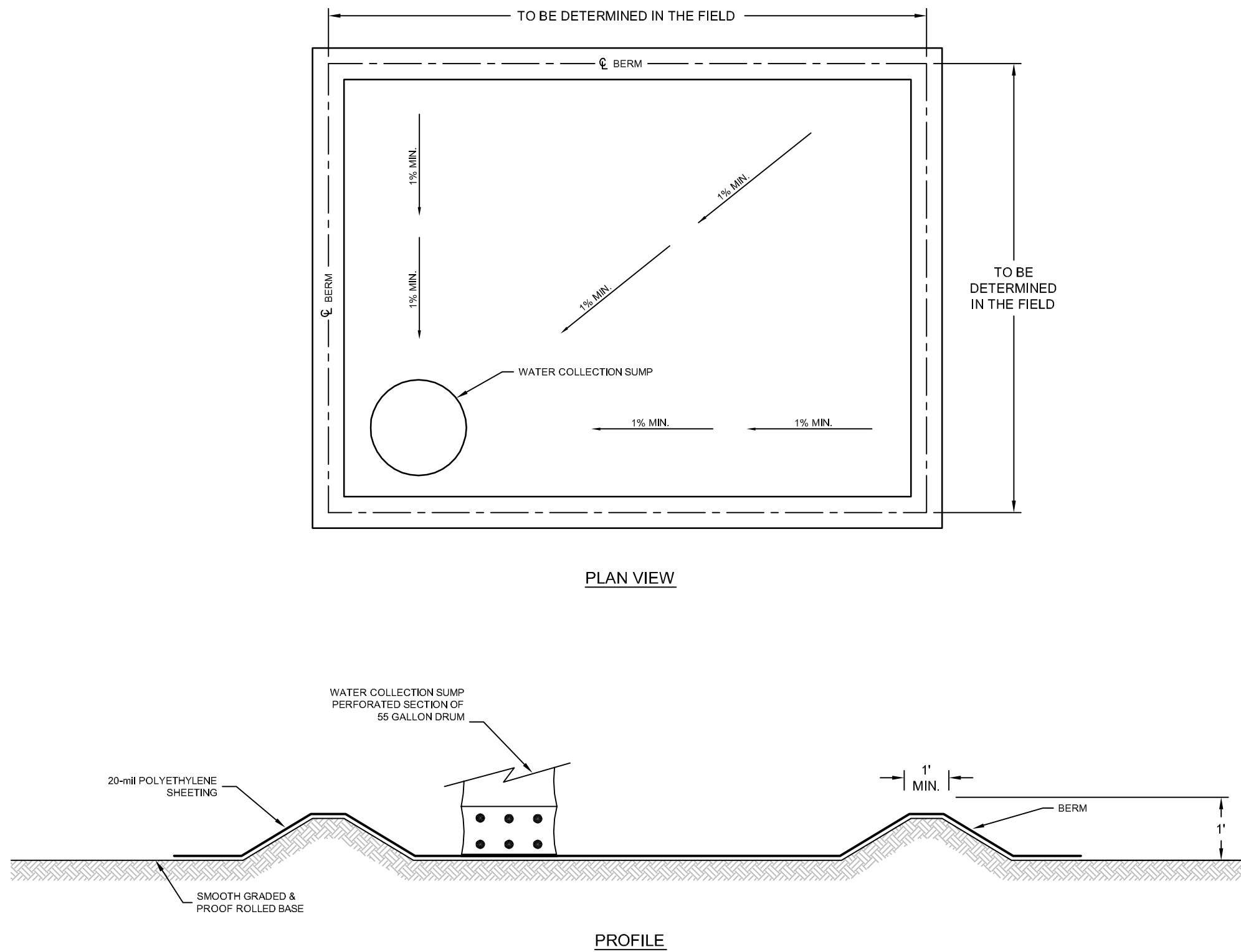
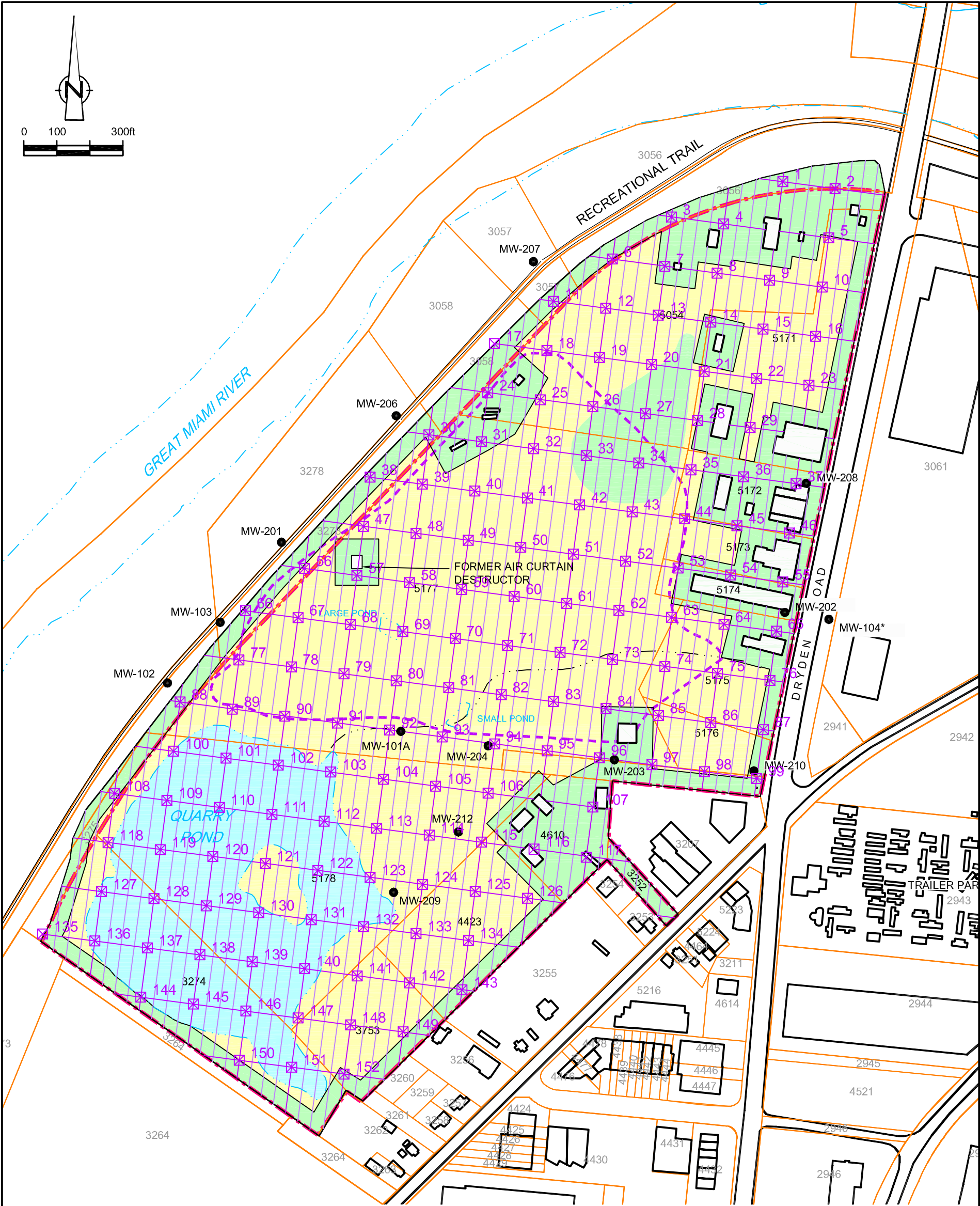


figure 2
STAGING PAD
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio





LEGEND

- MW-206 ● INTERMEDIATE ZONE MONITORING WELL LOCATION
- SITE BOUNDARY (SOW 2006)
- PRELIMINARY DIRECT CONTACT RISK PRESUMPTIVE REMEDY AREA
- EDGE OF WATER
- * APPROXIMATE LOCATION
- PROPOSED CONTROL POINTS AND GRID LINES
- PROPOSED GEOPHYSICAL SURVEY COVERAGE
- PROPOSED BATHYMETRIC AND WATERBORNE GEOPHYSICAL SURVEY COVERAGE
- PROPOSED GEOPHYSICAL SURVEY COVERAGE WHERE FEATURES MAY MASK SURVEY RESPONSE

figure 3
PROPOSED CONTROL POINTS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

ATTACHMENT A

INSTRUMENT DESCRIPTION AND SURVEY PROCEDURES

ATTACHMENT A

INSTRUMENT DESCRIPTION AND SURVEY PROCEDURES

Instrumentation Description and Survey Procedures

The magnetometer records total magnetic field data from two sensors, top and bottom. The difference in total magnetic field between the two sensors divided by the vertical distance between the sensors equals the magnetic gradient. Magnetometers detect the presence of ferro-metallic objects, and are capable of lateral resolution of anomalies (i.e., anomalous responses are often observed adjacent to the buried object in addition to directly over the object). This allows for greater line and station spacings, and relatively rapid coverage of an investigative area. During the course of the survey, repeat readings will be recorded at a base station location situated away from any source(s) of magnetic interference to assess the degree of naturally-occurring diurnal variation (i.e., magnetic drift).

The EM31 consists of transmitter and receiver coils located at opposite ends of a 14-foot long boom. In vertical dipole mode, this coil configuration yields an approximate depth of penetration of 20 feet. As indicated by the manufacturer of the EM31, Geonics Limited (www.geonics.com), the effective depth of investigation for the EM31 is 6 metres, or approximately 20 feet below ground surface (bgs) in horizontal dipole mode. At hip level, this depth decreases to approximately 17 feet bgs. The EM31 is capable of operating simultaneously in both terrain conductivity and metal detection modes. The EM31 will be utilized in metal detection mode, since this instrument is capable of inducing secondary fields in all conductive buried metallic objects. Terrain conductivity readings will also be measured, in order to delineate areas of conductive fill.

EM31 metal detection anomalies can be characterized by two types of responses. Large anomalies covering a relatively wide area are identified by elevated responses, whereas smaller anomalies are characterized by very low (negative responses). The explanation of these results can be attributed to the 14-foot separation between the transmitter and receiver coils of the EM31. When sources of anomalies are much larger than the 14-foot coil spacing, the signal received by the EM31 becomes saturated, resulting in an elevated reading. When an object is smaller than the 14-foot coil spacing, the secondary field induced in the object opposes the primary field, yielding a negative resultant field (expressed as a percentage of the primary field). Both elevated and negative metal detection anomalies indicative of buried metal will be identified in the EM31 survey results.

The EM61 is a time-domain buried metal detector that consists of two rectangular transmitting and receiving coils in a stacked configuration, connected to a data logger. The coils measure approximately 1.5 by 3 feet, and are mounted to a wheeled cart. The transmitting coil emits 150 EM pulses per second into the ground at each measuring point. During the off time between transmitted pulses, receiver coils measure the decay of the transient electrical currents induced by the pulses. Electrical currents in moderately conductive earth materials (including moist clays, mineralized soils, etc.) dissipate rapidly, leaving only the more prolonged currents due to buried metal objects. The EM61 detects and measures the prolonged transient currents, yielding a result in millivolts (mV) proportional to the metallic content of the buried object, and inversely proportional to its depth of burial. Due to its stacked coil configuration, the EM61 is less susceptible to potential sources of interference including parked vehicles, fence lines, staged drums, power lines, etc. The EM61 survey will be completed along the survey lines by automatically triggering a reading at 0.7-foot stations. The effective depth of penetration of the EM61 is approximately 10 feet.

The Ramac™ Rough Terrain Concept (RTC) low frequency GPR system transmits at 100 Mhz, and is characterized by an in-line transmitter-receiver antenna configuration. GPR systems utilize pulsed EM waves, which are emitted from a transmitting antenna. They are propagated into the ground, and travel at velocities determined by the electrical properties of earth materials. As a GPR wave moving downward in the subsurface hits a buried object or boundary with different electrical properties, part of the wave energy is reflected back to the surface and is detected by a receiving antenna. The reflected wave is stored digitally, and processed as a trace of signal versus amplitude. As the antennas are moved along a survey line, a series of traces are recorded at discrete points. When presented collectively, these traces display a profile of the subsurface. The depth of subsurface penetration is directly dependent upon the frequency of the GPR system, and the conductivity of the soil. Signal attenuation is greater for higher frequencies, and also greater for conductive soils.

The geophysical survey procedures will be as follows:

1. The geophysical survey grid setup will commence with surveying of the control points at 150-foot intervals in the north-south direction and 160-foot intervals in the east-west direction, as indicated on Figure 3. Concurrently, brush clearing will commence between these control points, to facilitate additional grid setup described below;
2. The geophysical survey grid will be set up such that survey lines are spaced 40 feet apart. Wooden survey stakes labeled with the grid coordinates will be placed at 150-foot intervals along each gridline via surveying. Horizontal locations will be surveyed relative to the Ohio State Plane Grid Coordinates and Decimal Degrees. Elevations will be surveyed relative to NAVD 88. Horizontal locations will be surveyed to the nearest 0.5-foot accuracy relative to NAD 83. Elevations will be surveyed to the nearest 0.1-foot accuracy;
3. Geophysical data will be collected using a data logger on each geophysical instrument. The data recording for the magnetometer, EM31, EM61 and Ramac GPR system will be initiated for each station by the operator pressing the recording button. The station spacing for the magnetometer and EM31 will be approximately 5 feet, and will be

determined via pacing. The EM61, will be utilized in wheeled mode, and will automatically trigger the data logger to record a reading at 0.7-foot intervals.

4. The magnetometer survey will also include the use of a base station to determine diurnal variation. The base station(s) will be set up in area(s) free of ferromagnetic waste and base station readings will be recorded several times a day during the course of the survey. Base station readings will be recorded at a minimum of every 4 hours, to verify that the diurnal variation in the earth's magnetic field is negligible (i.e. <50 nT). Solar forecasts will be reviewed on a daily basis and in instances where increased solar activity is forecast, the magnetic survey will be temporarily suspended;
5. Data reduction will include downloading from the data loggers to a computer. The downloaded data will be processed for location. Magnetometer data may be corrected for diurnal variation, if required; and
6. The data will be contoured using SURFER® (Golden Software, Inc.). Separate contour plots for each data type will be prepared. Manual interpretation of the plots will be performed to assess the identified anomalies. This interpretation will include identification of anomalous areas for further investigation.

The 20-foot grid spacing will be completed for anomalies exhibiting the following responses: an in-phase response of 10ppt above background for the EM31, a metal detection response of 500 mV above background for the EM61, and a total magnetic field response of 500 nT above background for the Overhauser magnetometer. Geophysical and bathymetry reports will be forwarded to the USEPA within two weeks of the PRP Group's receipt of the reports. The decision to perform 20-foot grid spacings will be evaluated at a minimum on a weekly basis, following a preliminary data assessment which is scheduled to occur on the weekends or on rain days. Grid spacings at intervals less than 20 feet are presently not being considered. Thus, an anomalous response that is detected along a trend between 2 or more adjacent survey lines will be considered to be continuous between these adjacent survey lines.

The GPR data processing will consist of background (noise) removal, application of low- and high-pass filters, and Automatic Gain Control (AGC) gain to optimize the response of the GPR traces. GPR reflectors suspected of representing buried metal drums will be interpreted on the basis of a characteristic arch-shaped response.

APPENDIX J-B

LEACHATE SEEP INVESTIGATION LETTER WORK PLAN



**CONESTOGA-ROVERS
& ASSOCIATES**

651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2
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www.CRAworld.com

May 6, 2008

Reference No. 038443

Ms. Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Karen:

Re: Final Leachate Seep Investigation Letter Work Plan
South Dayton Dump and Landfill Site, Moraine, Ohio (Site)

This Letter Work Plan presents the South Dayton Dump and Landfill Potentially Responsible Party Group's (PRP Group's) Work Plan for a Leachate Seep Investigation at the Site. A Site plan showing Site topography, including embankments, is provided on Figure 1. This work will help address data gaps and provide information to aid in the completion of a Feasibility Study (FS).

The PRP Group has prepared this Letter Work Plan based on the discussions between the PRP Group and USEPA in February and April 2008. The Letter Work Plan incorporates comments received from USEPA on April 2 and May 1, 2008.

The objectives of this Work Plan are to:

1. complete a seep inspection to identify the location, extent, and characteristics of seeps observed along Site embankments and in other on-Site and near-Site areas;
2. characterize seeps observed along Site embankments and in other areas; and
3. identify any area(s) that may require further investigation.

The work associated with achieving these objectives is described further below.

VISUAL SEEP INSPECTION

CRA will complete a visual inspection of:

- the embankments and nearby areas on the west side of the Site (adjacent to the Great Miami River);





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- embankments and nearby areas to the north including to the north of the Valley Asphalt property;
- areas surrounding the Quarry Pond;
- embankments and nearby areas along the central access road;
- embankments and nearby areas in the vicinity of the air curtain destructor;
- embankments and the area in the vicinity of the Small Pond; and
- embankments and the area in the vicinity of the Large Pond.

This assessment will consist of a visual inspection of the entire embankment surface, nearby areas, and low lying areas with an objective to document any evidence of groundwater or leachate discharge from any portion of the bank and other nearby or low-lying areas. Specific items to be investigated include identifying erosion rills, areas of surface staining and/or stressed vegetation, and wet or saturated areas resulting from seeping liquid.

CRA will prepare a photographic log for the inspection. The photographic log will list the date of each photograph, a specific description of what the photograph depicts, its location, and the photographer.

Seep inspections will not be performed during precipitation events and will be performed no sooner than 24 hours after a precipitation event. To the extent practicable, given the project schedule and USEPA notification requirements, the PRP Group will schedule the seep inspection to occur after several days of dry conditions (based on long term weather forecasts). In the event of precipitation during the seep inspection, field activities will be suspended and will not recommence until 24 hours after the rain has ceased. The USEPA will be notified of any delays in the seep inspection. Also the weather conditions will be noted in the daily field logs.

Potential seeps encountered during the Survey, Geophysical Investigation, or other Site work will be flagged, and these areas will be inspected during the seep inspection if the potential seep is encountered prior to the Leachate Seep Investigation or at a later date if the potential seep is found after the Leachate Seep Investigation and does not correspond to a previously identified seep.

SEEP CHARACTERIZATION

Should leachate seeps, surface staining, stressed vegetation, or other evidence of a leachate seep be identified in any of the embankments or in other areas, CRA will flag the location and survey it using a hand-held global positioning system (GPS) device and record the coordinates. CRA will then record the characteristics of each seep area including color of staining; area of staining; whether



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the seep is active or not active; estimate of seep flow; color of seep flow; presence of erosion, pooling, or odor; PID reading; and any other pertinent or identifying details. CRA will also record potential downgradient receptors for each seep, such as landfill interior (where capping alternatives will be evaluated in the FS), the Great Miami River, Quarry Pond, etc. After surveying the location and recording seep observations, CRA will immediately proceed to collect leachate and/or soil samples (as detailed below) at the identified location before continuing on to the next area.

If an active seep is observed, liquid sampling will be attempted. The area located immediately beneath the seep will be dug out using a clean shovel or trowel. A clean sample jar or pail will be set into the dug out area and the liquid will be allowed to accumulate in the container. The liquid will be transferred to sample containers for submission to the analytical laboratory. As the volume of liquid may be limited, prioritization of requested analyses for the sample will be as follows: Target Compound List (TCL) volatile organic compounds (VOCs), Target Analyte List (TAL) metals and cyanide, TCL semi-volatile organic compounds (SVOCs), TCL pesticides, and TCL polychlorinated biphenyls (PCBs).

CRA will attempt to place the sample jar or pail on an angle in order to encourage leachate to flow into the jar rather than dripping in. VOC sample vials will be filled by slowly, smoothly, and carefully transferring seep water from the large clean sample jar to the VOC vial, without splashing, and sealing the vial to ensure that no air bubbles are allowed to remain in the vial. VOC sampling will be conducted first, once sufficient liquid has been allowed to collect in the large clean sample jar. Trip blanks, field blanks and duplicate samples (if sufficient sample is available) will be collected in conjunction with the seep sampling. Trip blanks will be submitted with each sample shipment to the analytical laboratory. Field blanks will be collected at a frequency of one per every ten seep samples collected. Field duplicates will be collected at a frequency of one per twenty seep samples (sample volume permitting). The Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) provide additional details and instruction on sample collection, preservation, and quality assurance/quality control.

If a sufficient volume of liquid to fill sample jars is not produced by the seep, CRA will collect a sample of the surface soil in the area of the seep. The soil sample will be collected from a saturated portion of the soil immediately beneath the seepage. The surface soil sample will be collected as part of the leachate seep investigation fieldwork and will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides, TCL PCBs, TAL metals, and asbestos.

If no active seep is observed but indirect evidence of a seep is observed (erosion rills, stressed vegetation, etc.), then CRA will collect a surface soil sample from the area where the observation was made. The soil sample will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides, TCL PCBs, TAL metals, and asbestos.



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All work will be performed in accordance with the FSP, QAPP, and Site-Specific Health and Safety Plan (HASP) pending USEPA's approval of these documents.

IDENTIFY AREAS NEEDING FURTHER INVESTIGATION

The field observations and analytical data generated from any liquid seep or soil sampling will be reviewed and evaluated. Areas where stressed vegetation was observed may be considered as alternative sampling areas for the Test Pit/Test Trench Investigation. Analytical data will be evaluated against USEPA Region 9 Preliminary Remediation Goals (PRGs). If liquid or soil analytical data indicate that there are constituents present at concentrations greater than Region 9 PRGs, then the area where the sample was collected may require further investigation or assessment for the FS. If liquid or soil sample data do not exceed Region 9 PRGs, then the area where the sample was collected will not require further leachate seep assessment for the purpose of completing the FS. Additional leachate seep assessment at these locations may, however, be required as part of Remedial Design (e.g., to evaluate seasonal and/or yearly fluctuations in leachate seeps).

If the soil contains constituents at concentrations greater than the applicable Ecological Screening Criteria, and the seep area is outside the area to be evaluated for capping alternatives, then the area may require further assessment as part of the RI/FS for areas not addressed by the FS. If the seep is in the interior of the landfill (where capping alternatives will be evaluated in the FS), then the area will be noted and evaluated as part of the FS. The assessment and evaluation of data generated as part of this investigation will be presented in a technical memorandum. Modification or adjustments to further investigative work proposed for the Site in 2008 will be discussed with the USEPA prior to implementation.

SCHEDULE

The leachate seep inspection will begin within two weeks of USEPA approval of this Letter Work Plan, or the relevant sections of the FSP and QAPP, or USEPA's review of the HASP, whichever occurs later, and will be completed over a two-day period of time (weather permitting). The PRP Group will provide the USEPA with verbal notification 15 days in advance of the initiation of this activity, and will use extended weather reports in an attempt to time the event during dry weather or no sooner than 24 hours after a precipitation event.

REPORTING

The results of the seep inspection and any analytical results (if samples are collected) will be summarized and presented in a technical memorandum. The memorandum, which will include a



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description of the field work completed, any deviations from the proposed work and the rationale behind the change, photographs, a figure identifying areas inspected, a figure showing the location of identified seeps indicating which seeps, if any, were active at the time of the inspection, analytical summary tables, and analytical data reports, will be provided to the USEPA within one month of the completion of the proposed work. The technical memorandum will also include a table including seep descriptions and approximate elevations (from the Site survey). The data will be used in the FS and to identify potential areas where further investigation or assessment may be appropriate.

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

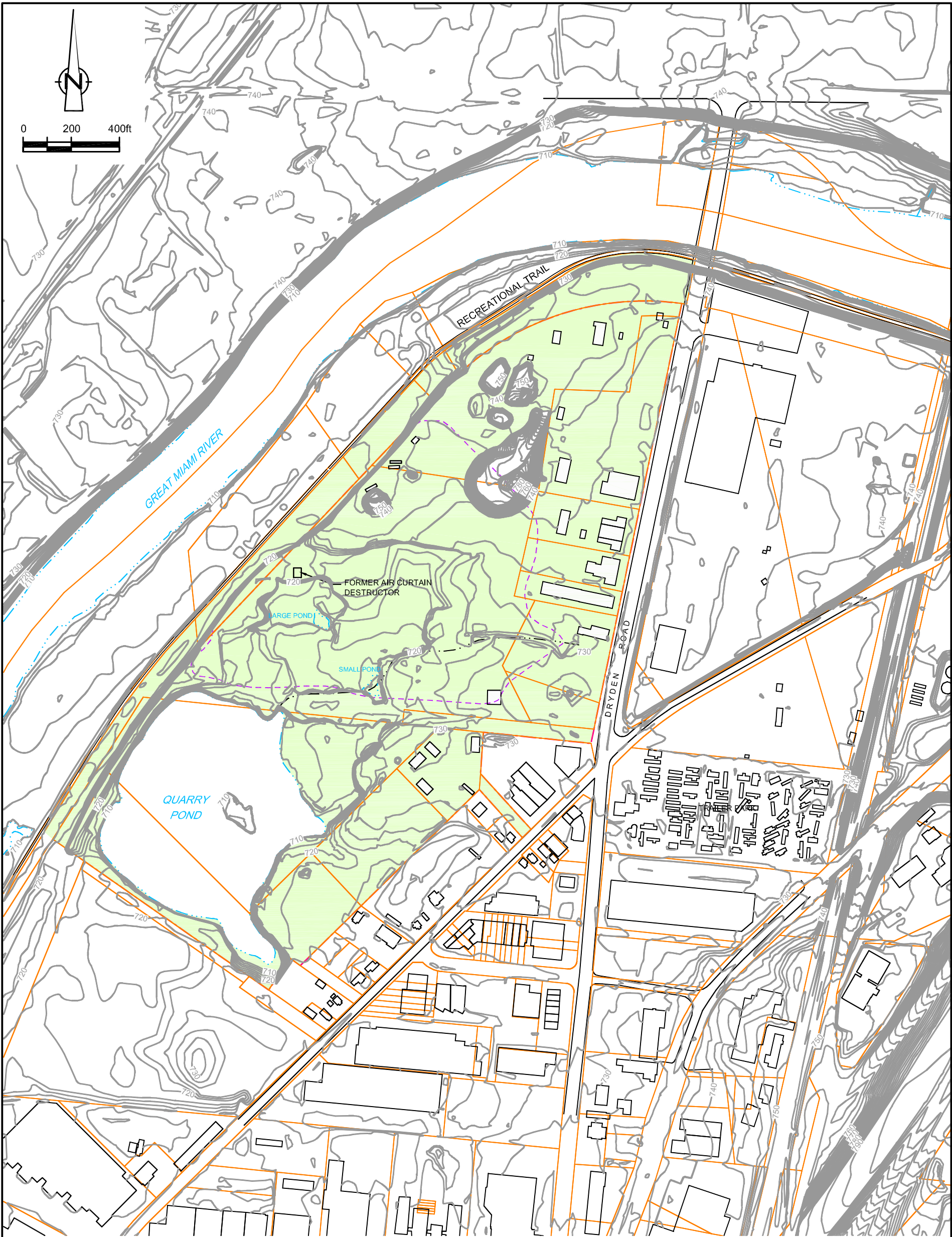
CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

AL/ca/27

Encl.

c.c. Matt Mankowski, USEPA (PDF)
 Matt Justice, Ohio EPA (PDF)
 Eric Kroger, CH2M Hill (PDF)
 Scott Blackhurst, Kelsey Hayes Company (PDF)
 Wray Blattner, Thompson Hine (PDF)
 Ken Brown, ITW (PDF)
 Jim Campbell, Engineering Management Inc. (PDF)
 Tim Hoffman, Representing Kathryn Boesch and Margaret Grillot (PDF)
 Paul Jack, Castle Bay (PDF)
 Robin Lunn, Mayer Brown (PDF)
 Roger McCready, NCR (PDF)
 Karen Mignone, Pepe & Hazard (PDF)
 Adam Loney, CRA (PDF)



LEGEND

- SITE BOUNDARY (SOW 2006)
- PRELIMINARY DIRECT CONTACT RISK PRESUMPTIVE REMEDY AREA
- 730--- EXISTING GROUND CONTOUR (2 FT CONTOUR INTERVAL)
- EDGE OF WATER
- PARCEL BOUNDARY
- AREA OF LEACHATE SEEP SURVEY



SOURCES:
THE PAYNE FIRM, INC., PROJECT 0279.44.05, FIGURE 1, DATED 9/12/05;
TETRA TECH EM INC., PROJECT L0312006-SOUTH DAYTON DUMP, FIGURE 2, SITE LAYOUT, 05/25/2004;
CITY OF MORAINÉ.

figure 1
LEACHATE SEEP INVESTIGATION
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

APPENDIX J-C

TEST PIT/TEST TRENCH INVESTIGATION LETTER WORK PLAN



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May 9, 2008

Reference No. 038443

Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Karen:

Re: Final Test Pit/Test Trench Investigation
South Dayton Dump and Landfill Site, Moraine, Ohio (Site)

This Letter Work Plan presents the scope of work for a test pit and test trench investigation of parts of the Site. Conestoga-Rovers & Associates (CRA) has prepared this Letter Work Plan on behalf of the South Dayton Dump and Landfill Potentially Responsible Party Group (PRP Group).

This Letter Work Plan is based on the February 12 and 27, 2008 discussions between the PRP Group and United States Environmental Protection Agency (USEPA) regarding the additional data that the PRP Group would like to collect for the Feasibility Study (FS). The Letter Work Plan also incorporates comments from the USEPA on a draft that was discussed at the February 27, 2008 meeting. The Letter Work Plan incorporates comments received from USEPA on April 15, 2008.

The objectives of the test pit and test trench excavation and sampling are as follows:

- collect data to assist in identifying the nature and delineating the extent of various types of landfilled materials above the water table;
- collect data to assist in characterizing landfill materials above the water table;
- collect data to assist in characterizing leachate from unsaturated landfilled material;
- assess areas of the Site previously identified as specific areas of concern [i.e., Valley Asphalt drum removal area, Valley Asphalt former underground storage tank (UST) area (a.k.a. Dayton Recycling), Custom Delivery UST area, Lot 4423, etc.); and
- identify Site areas, which may require further investigation (for example leachate sampling and analysis, groundwater quality investigation, or other delineation work).





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The test pit and test trench investigations will be completed after the Land Survey, Bathymetry Survey, and Geophysical Investigation, and Leachate Seep Investigation have been completed. A schedule, including a Gantt chart, for the investigative activities to be completed at the Site in 2008 was provided to USEPA on March 11, 2008. The locations of the test pits and test trenches may be adjusted based on the results of these previously mentioned investigations and upon consultation with the USEPA.

TEST PITS/TEST TRENCHES

Test pits and test trenches are proposed in locations where the PRP Group would like to collect additional information about the depth and nature of the fill material above the water table. The information will be used to verify the limits of fill and to assist in characterizing the nature of the landfilled materials present in the areas investigated.

Six test pits will be excavated in the central portion of the Site. Twenty-three test trenches will be excavated throughout the Site.

The locations of the test pits and test trenches will be finalized based on the results of the geophysical investigation (the USEPA may be asked to approve moving, relocating, or adding test pit and test trench locations based on field observations, geophysical investigation results, etc.). The nature and depth of fill material above the water table will be visually identified and recorded. Test trenching will focus on the perimeter of the PRP Group's preliminary direct contact presumptive remedy area, which was defined in the Remedial Investigation/Feasibility Study (RI/FS) Statement of Work (SOW) and the area immediately beyond the perimeter. In addition, the test trenching will assist in identifying and characterizing fill material at locations along the western embankment of the Site. Excavations will be completed to the depth of the water table, where possible (as limited by the ability of the excavator to reach the depth of the water table, the stability of the walls of the excavation, and/or the presence of obstructions). If an obstruction is encountered during the excavation of a test trench, the location of the trench will be adjusted to avoid the obstruction. If excavation to the water table is not possible due to the depth of the water table or the stability of the fill material, the PRP Group will consider the need for additional investigation at the location in question during future investigation work. The potential impacts from saturated fill materials will be assessed as part of the groundwater investigation proposed for the Site (under separate cover). The utility of this information to the FS is discussed above.

Test pits and test trenches will be excavated in the locations shown on Figure 1. As noted above, the locations of the test pits and test trenches may be adjusted based on the results of the



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Land Survey, Bathymetry Survey, and Geophysical Investigation, and the Leachate Seep Investigation and upon consultation with the USEPA. Each test pit will be approximately 6 feet long by 3 feet wide and will extend to the water table, if the excavation can be completed safely to that depth (i.e., stable slopes and excavation sidewalls, no buried structures, etc.) and the excavator is capable of reaching that depth.

Each test trench will be approximately 30 feet long by 3 feet wide, and will extend to the water table (if this can be excavated safely) and horizontally to the visual limit of fill. If the horizontal limit of fill is not determined in any planned 30-foot trench, to the extent practical (i.e., where not impeded by the presence of surface structures, property boundaries, unstable slopes or side walls, buried structures, etc.), the test trench lengths will be extended to attempt to visually locate the edge of the fill. This visual limit (both lateral and vertical) will be determined by the presence of undisturbed native soil in the excavation. CRA will also note if fill material appears to consist of re-located spoils from the gravel extraction operation versus undisturbed native material; however, the presence of relocated spoils will not be used as an indicator that other wastes have not been disposed at an individual location. Test trench excavation will continue in these areas to the depth of native material or the maximum reach of the excavator, whichever is less.

The nature and depth of fill material will be visually identified and recorded. The procedures and equipment to be used to excavate trenches and visually characterize the fill material are described below.

TEST PIT AND TEST TRENCH EXCAVATION PROCEDURES

An excavator or extended reach backhoe will be used to excavate the test pits and test trenches. The reach of the excavator or backhoe will be at least 18 feet. Data regarding conditions at depths greater than those that can be reached by the excavator may be obtained during vertical aquifer sampling and monitoring well installation. The PRP Group will provide the details of any soil sampling during VAS and any revisions to the Field Sampling Plan and Quality Assurance Project Plan to EPA for review and approval prior to conducting this work. The PRP Group will also submit any revisions to the Health and Safety Plan (HASP) to EPA for review prior to conducting this work.

The test pit excavation procedures are as follows:

1. Each test pit will be assigned a unique identification number. Prior to starting the test pit excavations, the locations of each test pit and test trench will be staked in the field



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- using the locations identified on Figure 1. As noted above, the locations of the test pits may be adjusted based on the results of the Land Survey, Bathymetry Survey, and Geophysical Investigation, and the Leachate Seep Investigation and upon consultation with the USEPA;
2. The area immediately adjacent to the test pit will be covered with two layers of 6-mil polyethylene sheeting for stockpiling excavated fill material. The polyethylene sheeting and excavation spoils will be placed downwind of field personnel and in such a manner that water runoff from the fill material will be directed back into the excavation. If possible, fill material temporarily stockpiled on the liners will be backfilled into the open excavations before the contractor leaves the Site for the day. If the fill material cannot be backfilled at the end of the workday, the contractor will ensure the material is covered securely with a polyethylene liner to control potential emissions and to minimize the exposure of the material to rainwater. The contractor will also ensure that temporary fencing is placed around the stockpiled material and the open excavation;
 3. The test pits will be approximately 3 feet wide and will extend to the depth of the water table, where possible and feasible (as limited by the ability of the excavator to reach that depth, the stability of the walls of the excavation, and/or the presence of obstructions). The lengths of individual test pits will be determined in the field by the field representative based on conditions encountered during excavation. If obstructions are encountered and sidewalls are stable, then the width or length of the test pit may be expanded to aid in excavating to depth. Excavation at each location will be completed in a controlled manner so as to minimize damage to any potentially intact drums. If a test pit cannot be excavated to the surface of the water table due to obstructions or sidewall instability, and the excavation equipment is capable of reaching that depth, the test pit will be relocated 50 feet (or a lesser distance if appropriate) from the original location and attempted again. If, during the excavation of a test pit, PID, particulate, or vinyl chloride readings above the action levels in the HASP are recorded, excavation of the test pit will cease and the Site Supervisor (SS) will evaluate what actions (i.e., upgrade in level of personal protection equipment or termination and backfilling of test pit) are appropriate. If during the excavation of a test pit, combustible gas, oxygen, hydrogen sulfide, carbon monoxide, or radiation readings exceed (or in the case of oxygen fall below) an action level, the test pit excavation will be immediately stopped and the test pit backfilled, provided it is safe to do so. The test pit will be relocated 50 feet (or a lesser distance if appropriate) from the original location and attempted again. The location will be documented, and, if appropriate and safe to do so, may be investigated further during other investigative activities at the Site (i.e., Groundwater Investigation, Landfill Gas/Soil Vapor Investigation, etc.);



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4. CRA will observe the materials excavated and record the nature of the materials on a test pit stratigraphy log. The test pits will be excavated in two to three foot increments to aid in accurately determining the depth of discrete layers of fill material and the fill material/native material interface. Where appropriate, and where it is safe to do so, CRA will measure the depth of the test pit excavation where specific layers of fill material are encountered and the total depth of the excavation. The observations will include a visual description of the types of material (i.e., undisturbed native soil, spoil from quarry operations, domestic refuse, industrial refuse, metallic debris, ash, fly ash, construction and demolition debris, foundry sand, asphalt, slag, or other appropriate description) and, if possible, a Unified Soil Classification System (USCS) description. Soils will be logged using the USCS by an on-Site geologist. Soil classification methods will include visual assessment, texture assessment, dry strength tests, toughness tests, and dilatancy tests, as appropriate depending on the nature of the soil encountered. The visual classification of waste materials is, by its very nature, somewhat arbitrary. The on-Site geologist will be experienced in performing such observations, which will be based on the physical nature of the material encountered. As detailed below, samples of distinct fill materials will be retained in the event that the classification of specific materials needs to be revisited in future. Photographs of the material will also be included;
5. Empty drum overpacks will be maintained at the Site during excavation. Should an intact waste container be damaged during excavation the drum management procedures presented in Attachment A will be implemented; and
6. Each test pit will be backfilled with the excavated materials in reverse order to that in which they were removed. The test pits will be restored to match surface conditions prior to excavation. During backfilling of the test pit, the bucket of the excavator will be used to compact the material as it is placed in the excavation in order to ensure that any expansion of the materials that occurs during excavation is reversed and the test pits can be restored to grade.

Access of the general public and on-Site commercial/industrial workers to the investigative locations will be restricted by the SS and air monitoring will be used to ensure that any emissions generated during test pitting activities do not pose a risk to the general public or on-Site workers. On-Site commercial/industrial workers will be notified in advance of intrusive activities that may have the potential to generate emissions, where these intrusive activities are located proximally to an active on-Site commercial/industrial facility.



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Test trenches will be excavated in the same manner as detailed above for test pits except that test trenches will be excavated to the top of the water table in a continuous length of approximately 30 feet or the horizontal limit of fill (if undisturbed native soil is encountered before reaching 30 feet) as discussed above.

To the extent possible given the available data for the Site, CRA will attempt to start the excavation in areas of fill (i.e., non-native) material and continue the excavation towards the presumed location of native material. If fill is encountered at the start of the trench, the trench will be excavated in the presumed direction of native material, e.g., away from the PRP Group's direct contact presumptive remedy area. If native material is encountered at the start of the trench, the trench will be excavated in the presumed direction of fill material, e.g., towards the PRP Group's direct contact presumptive remedy area. As noted above, if the horizontal limit of fill is not determined in any planned 30-foot trench, to the extent practical (i.e., where not impeded by the presence of surface structures, property boundaries, unstable slopes or side walls, buried structures, etc.), the test trench lengths will be extended to attempt to visually locate the edge of the fill. Where further extension of a test trench is not feasible and/or practicable, the PRP Group may, in consultation with the USEPA Site representative(s), elect to abandon a test trench location and install an additional test trench off-set from the original location in the presumed direction of the native/fill material, as appropriate. As noted above, the locations of the test trenches may be adjusted based on the results of the Land Survey, Bathymetry Survey, and Geophysical Investigation, and the Leachate Seep Investigation and upon consultation with the USEPA.

If clean backfill material is encountered during any of the test trenches proposed in the Valley Asphalt drum removal area, the Dayton Recycling UST removal area, or the Custom Deliveries UST removal area, CRA will attempt to continue the test trench excavation away from the location of the clean backfill material or relocate the test trench outside the clean backfill material, as appropriate depending on the size of the original excavation.

The test trenches will be used to visually determine the limits of the fill and to provide information on the nature of the fill material at these locations.



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TEST PIT AND TEST TRENCH SAMPLING

The following sampling procedures and associated tasks will be performed as part of the Test Pit/Test Trench Investigation:

1. CRA will prepare a photographic log of each test pit excavation during its progression. The photographic record will list the date of each photograph, a specific description of what the photograph depicts, its location, and the photographer;
2. The dimensions of each excavation and a description of the materials encountered during excavation will be recorded on a Test Pit Stratigraphy log, an example of which is contained in Attachment B;
3. Samples of the fill will be collected, from each sidewall and the base of the excavation during the excavation. A minimum of one sample collected from each test pit and two samples collected from each test trench will be submitted to an analytical laboratory for analyses. The specific material selected for sampling and the number of samples will be determined in the field by the CRA field representative and reviewed with the USEPA Site representative(s). Sample selection will be based on the visual appearance of the material (for example, color, staining, grain size, etc.), location of the material prior to removal (for example, adjacent to drums or base of excavation), and field instrument measurements [i.e., headspace readings using a photo-ionization detector (PID)]. CRA will collect a sample of each visually distinct layer of fill type for headspace analysis. Where fill material encountered is not visually distinct with depth, CRA will use visual and olfactory evidence of contamination and PID screening of the soil as it is excavated to identify appropriate samples for headspace screening. All olfactory evidence will be obtained taking care to limit exposure to any vapors and in accordance with the HASP. At a minimum, if fill material is not visually distinct with depth, samples will be collected for headspace screening approximately every five feet vertically. The headspace analysis will aid in the selection of the discrete samples to be analyzed from each excavation and in the selection of the sample(s) to be retained from each distinct fill type based on visual observations and headspace analysis (see below). The observations will be recorded in the Test Pit Stratigraphy log. The samples will be collected directly from the bucket of the excavator and/or the stockpiled spoils. The sample collection procedures are identified in the Field Sampling Plan. Fill material samples will be collected in an attempt to characterize distinct fill zones or landfilled materials based on visual observations, PID readings, and the analytical data generated from the program as discussed below. CRA will also use representative fill samples retained (see below) from each test pit and test trench to compare fill types from different excavations. Samples of the same distinct fill zones or landfilled materials



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based on visual observations and headspace analysis will be collected from multiple test pit and test trenches where possible, i.e., where the same distinct fill zone or landfilled materials based on visual observations and headspace analysis are present in more than one test pit in recoverable quantities;

4. A portion of each sample will be placed in a separate container for headspace analysis using a PID. Results of the headspace analysis will be recorded in the Test Pit Stratigraphy log. A sample from each distinct fill type observed in each test pit and test trench will be retained in appropriate sampling containers maintained at appropriate temperatures so that samples may be submitted in the future (within the applicable sample holding time) for laboratory analysis. Field observations and field screening results will be reviewed with the USEPA's Site representative(s) on a daily basis;
5. Daily proposed sample submissions to the analytical laboratory will be reviewed with the USEPA's Site representative(s). At a minimum, samples of each distinct fill type (based on visual observations and headspace analysis) encountered at the Site will be submitted for the following analyses: Target Compound List (TCL) volatile organic compounds (VOCs), TCL semi-volatile organic compounds (SVOCs), TCL herbicides and pesticides, TCL polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) inorganics. Where field observations and field screening indicate that similar types of fill material in different test pits/test trenches may be from different sources (e.g., visually similar materials in two distinct and separate layers within a trench or at widely varying depths within adjacent trenches, or visually similar materials in different trenches in different areas of the Site), additional samples may be submitted. Additional samples may also be submitted where visually similar fill materials are potentially impacted by different contaminants (e.g. visually similar materials where one has a strong odor and the other a high organic vapor content as measured using a PID).

Multiple samples of similar fill types based on visual observations and headspace readings encountered across the Site will be submitted for TCL/TAL laboratory analysis to assess the variability of the analyzed materials within the Site. Ash fill materials encountered will be collected and submitted for dioxin and furan analyses. Up to 10 samples of ash will be submitted for dioxin and furan analyses if ash is encountered in at least 10 separate excavations. If potential friable asbestos-containing materials (ACM) (i.e., ceiling tiles, wall board, pipe insulation, automotive brake pad manufacturing refuse, etc.) are encountered, a minimum of one sample of each distinct type of potential ACM will be submitted for asbestos analysis. A sampling summary is presented in Table 1. The HASP includes provisions to assess worker exposure to potentially radioactive foundry sands.



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6. Should leachate seeps be identified in any of the test pits or test trenches, samples will be collected. For shallow leachate seeps that can be reached by hand from the edge of the test pit or trench, the area located immediately beneath the seep will be dug out using a clean shovel or trowel. A clean sample jar or pail will be set into the dug out area and the liquid will be allowed to gently accumulate in the container. If the depth of the excavation prohibits field personnel from safely conducting the liquid collection, sufficient saturated material in and around the seep will be excavated and placed on a polyethylene sheet and the liquid allowed to gently drain into a container. A field blank sample of distilled deionized water poured onto clean polyethylene sheeting will also be collected. The liquid will be transferred to sample containers for submission to the analytical laboratory. As the volume of liquid may be limited, prioritization of requested analyses for the sample will be as follows: TCL VOCs, TCL SVOCs, TCL herbicides and pesticides, TCL PCBs, and TAL inorganics. A sampling summary is presented in Table 1. Sampling of leachate seeps identified during the Test Pit/Test Trench Investigation will be performed in accordance with the Leachate Seep Investigation Work Plan and the Field Sampling Plan (FSP);
7. A composite sample of each fill type (i.e., construction and demolition debris, ash, and cinders, etc.) will be prepared from the retained samples of the fill types from the test pits and test trenches and submitted to the analytical laboratory for Toxicity Characteristic Leaching Procedure (TCLP) preparation with subsequent analysis of the resultant leachate for VOCs, SVOCs, herbicides, pesticides, and metals. Samples will also be analyzed for PCBs, corrosivity, ignitability, and reactive cyanide and sulfide. A minimum of one composite sample will be submitted for each fill type. Where similar fill types are present in widely separated locations, additional samples may be submitted. The parameters and associated analytical methods are specified in Table 1; and
8. Duplicate photographs and the corresponding photographic record will be provided to USEPA and the Ohio Environmental Protection Agency (Ohio EPA) at the completion of this investigation.

The following protocol will be used to determine the number of samples to be submitted for laboratory analysis. Specific samples to be submitted for laboratory chemical analysis will be selected by the CRA field representative and reviewed with the USEPA's Site representative(s) on a daily basis. Depending on the nature of materials encountered in an individual test pit or trench, the number of samples for each medium may vary. For example, if no drums or only minimal amounts of drum remnants are observed in a test pit, samples of drum contents would not be collected. In addition, the number of samples submitted for laboratory chemical analysis



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may increase or decrease depending on headspace results, field observations, the spatial distribution and types of existing data, and the number and types of samples collected.

The intent of the test pit and test trench investigation is to identify locations that exhibit similar characteristics (i.e., visual, physical, and, to the extent the materials are analyzed, chemical composition). Test pits may be grouped together based on similar field observations. Where grouping occurs, CRA will select samples from the entire grouping for chemical analysis. The CRA field representative will establish the groupings, identify which test pits and test trenches will compose a given grouping, and select fill samples for submission to the analytical laboratory for analysis. Fill materials will only be grouped together where the fill materials are present in the same area of the Site and where laboratory holding times allow. Inherent in the grouping of fill types is the presumption that analytical data and other results obtained will be representative of the entire grouping. CRA will attempt to evaluate this presumption through replicate sampling in wide spread waste types at a frequency of one replicate sample for every five grouped samples. The test pit and test trench locations that are grouped together along with the corresponding sample identification number(s) will be identified in the Test Pit Stratigraphy log. Sample selection will be performed such that fill types from multiple different locations are selected.

All work will be performed in accordance with the FSP, Quality Assurance Project Plan (QAPP), and HASP pending USEPA's approval of the relevant sections of these documents.

SCHEDULE

The test pit and test trench investigation work will commence within two weeks of the submission of the Survey and Geophysical Survey Report to the USEPA. Field activities will be completed within three weeks. CRA plans to use a single excavator to complete the test pit/test trenching activities; however, a second excavator and field crew will be added if scheduling constraints so dictate. The PRP Group will provide the USEPA with verbal notification of field activities and the number of excavators to be used at least 15 days in advance of the initiation of field activities.

REPORTING

Results of the test pit and test trench investigation will be summarized and presented in a report. The report, which will include a description of the field work completed, any deviations from this Letter Work Plan and the rationale behind the change, photographs, logs, analytical



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summary tables, and analytical data reports, will be provided to the USEPA and Ohio EPA within one month of the receipt of analytical data from the laboratory. Monthly progress reports during the Test Pit/Test Trench Investigation fieldwork will include the information required for monthly progress reports in the RI/FS SOW (including test pit/test trench locations, headspace readings, visual fill descriptions, stratigraphic information, samples collected, and analytical data).

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

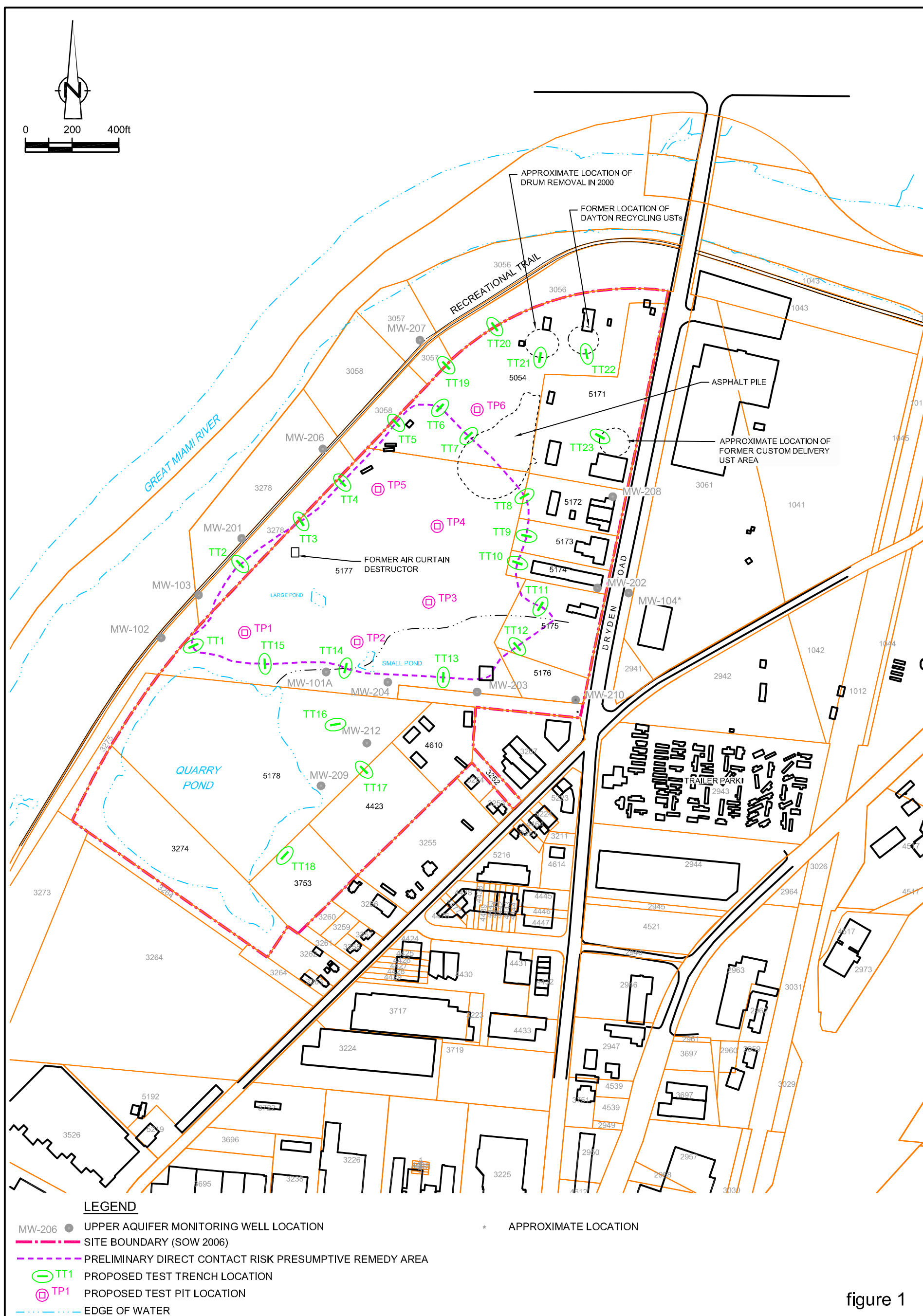
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Encl.

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Jim Campbell, Engineering Management Inc. (PDF)
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Paul Jack, Castle Bay (PDF)
Robin Lunn, Mayer Brown (PDF)
Roger McCready, NCR (PDF)
Karen Mignone, Pepe & Hazard (PDF)
Adam Loney, CRA (PDF)



TEST PIT AND TRENCH EXCAVATION LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
SITE LAYOUT: 05/25/2004: *Moraine, Ohio*



SOURCES:
THE PAYNE FIRM, INC., PROJECT 0279.44.05, FIGURE 1, DATED 9/12/05;
TETRA TECH EM INC., PROJECT L0312006-SOUTH DAYTON DUMP, FIGURE 2, SITE LAYOUT, 05/25/2004;
USGS AERIAL PHOTOGRAPH, DAYTON SOUTH, 1994.

TABLE 1

**SUMMARY OF TEST PIT/TEST TRENCH SAMPLING AND ANALYSIS PROGRAM
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

Task/Event	Sample Matrix	Field Parameters	Laboratory Parameters	Sample Locations	Investigative Samples ⁵	Quality Control Samples ¹			Total ³
						Field Blanks ²	Field Duplicates	MS/MSD LCS/LCD	
Test Pit Sampling	Solid	PID Screen / Visual Observation of Distinct Fill Types/Intervals	TCL VOCs, TCL SVOCs, TAL Inorganics ⁴ , TCL Herbicides and Pesticides, TCL PCBs, TCLP ⁶	6	6	1	1	1	9
Test Trench Sampling	Solid	PID Screen / Visual Observation of Distinct Fill Types/Intervals	TCL VOCs, TCL SVOCs, TAL Inorganics TCL Herbicides and Pesticides, TCL PCBs, TCLP ⁶	23	46	5	3	3	57
Ash Fill Materials	Solid	Visual	Dioxins & Furans	TBD	TBD	TBD	TBD	TBD	TBD
Potential Asbestos Containing Materials	Solid	Visual	Asbestos	TBD	TBD	TBD	TBD	TBD	TBD
Leachate Sampling	Liquid	PID Screen	TCL VOCs, TCL SVOCs, TCL Herbicides and Pesticides, TCL PCBs, TAL Inorganics	TBD	TBD	TBD	TBD	TBD	TBD
Waste and/or Drum Characterization	Solid/Water	PID Screen	TCLP VOCs, TCLP SVOCs, TCLP Herbicides, TCLP Pesticides, TCLP Metals, PCBs, Corrosivity, Ignitibility, Reactive Cyanide, Reactive Sulfide	TBD	TBD	--	--	--	TBD

Notes:

- 1 Quality control samples will include laboratory supplied trip blank samples for volatile sample analysis with each shipping cooler of aqueous investigative samples.
- 2 Field blank samples consisting of equipment rinsate blanks will not be collected when dedicated or disposable sampling equipment is employed.
- 3 The total quantity is dependent on the actual quantity of samples and field quality control samples collected.
- 4 TAL Inorganics include the 23 metals and total cyanide.
- 5 Refers to the minimum number of investigative samples to be collected.
- 6 TCLP analysis will be completed on selected composite samples for the parameters listed under Waste and/or Drum Characterization as per the Letter Work Plan.

TCL - Target Compound List
VOC - Volatile Organic Compounds
SVOC - Semi-volatile Organic Compounds

TAL - Target Analyte List
PCB - Polychlorinated Biphenyls
TCLP - Toxic Characteristics Leachate Procedure

DO - Dissolve Oxygen
ORP - Oxygen Reduction Potential

ATTACHMENT A

DRUM MANAGEMENT PROCEDURES

ATTACHMENT A

DRUM MANAGEMENT PROCEDURES

The following presents the procedures associated with drum identification, management and sampling:

- Markings on any drums or other waste containers encountered will be examined, documented, and photographed and keyed to a unique drum identification number;
- The contents of a representative number of drums or other waste containers encountered will be sampled. The containers to be sampled will be selected by the field representative. Samples will be collected in or near test pits from containers that are ruptured and whose contents are readily accessible. Samples from undamaged drums will be collected from the drum following placement in the overpack. Liquid samples will be analyzed for the parameters and using the methods specified in Table 1; and
- Empty drum overpacks will be maintained at the Site during excavation. Should an intact waste container be damaged during excavation, it will be immediately removed from the excavation and placed in an overpack. Any material that becomes visibly impacted by a release from a damaged waste container will also be removed from the excavation and placed on a separate sheet of polyethylene adjacent to the test pit. All overpack drums and excavated visibly impacted material will be handled in accordance with the procedures detailed in the Field Sampling Plan for handling investigation-derived wastes.

ATTACHMENT B

TEST PIT STRATIGRAPHY LOG

TEST PIT STRATIGRAPHY LOG

Page ____ of ____

Project Name:	Contractor:	Test Pit Designation:
Project Number:		Date Started:
Client:	Surface Elevation:	Date Completed:
Location:	Test Pit Method:	CRA Supervisor:

Completed by: _____ Date: _____

CRA

APPENDIX J-D

LANDFILL GAS/SOIL VAPOR INVESTIGATION LETTER WORK PLAN



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July 21, 2008

Reference No. 038443

Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Karen:

Re: Final Landfill Gas/Soil Vapor Investigation Letter Work Plan
South Dayton Dump and Landfill Site, Moraine, Ohio (Site)

This Letter Work Plan presents the South Dayton Dump and Landfill Potentially Responsible Party Group's (PRP Group's) Work Plan for a landfill gas (LFG) and soil vapor investigation at the Site. A Site plan with proposed LFG/soil vapor sampling probe locations is provided on Figure 1. This work will help address data gaps and provide information to aid in the completion of a Feasibility Study (FS). All work will be performed in accordance with the United States Environmental Protection Agency (USEPA) -approved Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Site-Specific Health and Safety Plan (HASP).

The PRP Group has prepared this Letter Work Plan based on the discussions between the PRP Group and USEPA in February 2008. The Letter Work Plan incorporates comments received from USEPA on May 7 and 28, 2008.

The objectives of this Letter Work Plan are to:

1. assess the presence of LFG and soil vapor at locations within the Site (pressure, methane, lower explosive limit (LEL), carbon dioxide and oxygen; and other chemicals at the detection limits listed in Table 1);
2. obtain current data in locations where historic information indicated potential landfill gas generation concerns;
3. develop information to assist in calculating future landfill gas generation rates for the FS. Four of the 20 gas probes are located within the limits of the Preliminary Direct Contact Risk – Presumptive Remedy Area (DC-PRA) and will provide information with respect to LFG/soil vapor generation within known municipal waste landfill areas at these locations. A total of 14 gas probe locations are proposed for installation along Dryden Road. Twelve of the 16 gas probes are located on commercial properties within 50 feet of occupied structures on Dryden Road. These gas probes will provide data near occupied structures; and





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4. develop information to assist in evaluating the need for and type of landfill gas control at the Site for the FS.

LANDFILL GAS/SOIL VAPOR INVESTIGATION

Gas probes will be installed to evaluate LFG and soil vapor concentrations at locations within the Site, including the properties along Dryden Road. Twenty gas probes will be installed. Gas probe locations are presented on Figure 1. The procedures for installation of the gas probes are described below.

Five gas probes will be installed in the central portion of the Site (four within the DC-PRA) to evaluate the presence of methane and non-methane organic compounds (NMOC) in the zone where the LFG/soil vapors will most readily migrate at these locations. Three gas probes will be installed in the vicinity of the former underground storage tank removals and the Valley Asphalt drum removal area to assess landfill gas and soil vapor quality in the zone where the LFG/soil vapors will most readily migrate at these locations.

Fourteen of the gas probes are proposed to be installed on or adjacent to the Site boundary and in the vicinity of the commercial properties and structures along Dryden Road and west of East River Road to assess LFG and soil vapor quality in the zone where the LFG/soil vapors will most readily migrate and, if present, would pose the greatest risk to any occupants of the buildings at these locations.

GAS PROBE INSTALLATION

Gas probes will be installed using a 50-mm (2-inch) diameter Geoprobe dual-tube direct push technique to minimize formation disturbance. The borehole for each gas probe will be advanced to a target depth in the unsaturated zone [a maximum of 20 feet below ground surface (ft bgs) or 2 feet above the water table, whichever occurs first].

Soil and fill materials encountered will be logged. The soil log information recorded will include a visual description of the types of material (i.e., undisturbed native soil, spoils from quarry operations, domestic refuse, industrial refuse, metallic debris, ash, fly ash, construction and demolition debris, foundry sand, asphalt, slag, or other appropriate description) and, if possible, a Unified Soil Classification System (USCS) description. Native soils will be logged using the USCS by CRA's staff. A photograph of each core sample collected will be taken and a photographic log will be documented in the field notes. Should groundwater be encountered in any borehole, the tube will be pulled up a minimum of 2 feet above the water table. The void that is formed when the



tube is pulled will be filled using No. 3 silica sand. The groundwater elevation of the nearest monitoring well will be used to determine the targeted depth of the borehole for the gas probes.

LFG and soil vapor will not preferentially migrate through discrete intervals of fill material at the Site unless impermeable layers are present between the discrete intervals of fill material. Based on the available Site geological data, intervals that are impermeable to LFG/soil vapor have not been identified. Further, LFG and soil vapor migration to ambient air or into a building will occur from the shallow soil horizon. Accordingly, in areas where landfilled materials are not present, the screened interval of the gas probes will be installed in soil strata with a notably higher permeability than the surrounding geologic strata. The gas probe screen will be set as shallow as possible within the higher permeability stratum. In order to prevent short circuiting of ambient air into the gas probe and, consequently, dilution of LFG/soil vapor samples, the top of the gas probe screen will be installed a minimum of three feet below ground surface. The final depth of the gas probe screen will be dependent on the conditions observed at each location and will be determined in the field. The proposed soil vapor sampling program has been established to collect and analyze LFG/soil vapor samples that are representative of soil vapor quality in the most permeable zone in the vicinity of the probe, which is the zone where LFG and NMOC will migrate. If these soil borings encounter multiple, discrete permeable zones that appear to have vastly different LFG/soil vapor impacts based on field screening, then CRA will either consult with USEPA's field representatives and install more than one gas probe at that location or identify that area as potentially requiring additional characterization in later stages of investigation or remediation at the Site. The methods and procedures to be used for field screening will be provided in the FSP.

The average depth of the unsaturated zone across the Site is approximately 20 feet bgs; therefore, a target maximum depth of 20 feet bgs is based on the need to place the gas probes in the unsaturated zone near the surface where LFG/soil vapor, if present, will diffuse and migrate.

The purpose of this investigation is to assess the migration potential and generation rate(s) of methane and NMOC in the soil gas at sampled locations. If gas probes are installed in the 2-foot interval above the water table, the gas probes will periodically be saturated and will not generate meaningful data. The proposed gas probe locations will also address LFG/soil vapor concentrations at locations near potential receptors.

The screened interval will be selected based on field observations that will identify the presence of landfill materials or, in the absence of such materials, a comparatively permeable region in the unsaturated zone that would be expected to transmit LFG and/or soil vapor. The selection of the most permeable zone will be based on soil descriptions and characterizations using the Unified Soil Classification System (USCS). The gas probe sampling and screened interval selection details are summarized in the Field Sampling Plan (FSP), CRA May 2008. Where landfilled materials are present, the screen will be placed at a depth immediately above the landfilled materials. If the landfilled material extends to within three feet of the surface and it is, therefore, not possible to set the screen above the landfilled material, the screen will be placed within the landfilled material, with



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the screened interval set as close to the top of the landfilled materials as possible but deep enough to minimize the breakthrough of ambient air from the surface (i.e., 3 to 5 feet bgs).

The gas probes will be completed using 13-mm (0.5-inch) diameter schedule 40 PVC continuous piping (i.e., no joints) with a screened interval length of 0.3 meters (1 foot). The void space between the screened interval and formation will be filled with No. 3 silica sand (i.e., sand pack) to approximately 0.2 meters (8 inches) above the top of the screened interval. One foot of dry granular bentonite will be placed on top of the sand pack and then hydrated bentonite will be placed to just below ground surface. The sand pack and bentonite seal will be placed as the Geoprobe is withdrawn to ensure that the formation does not collapse around the screened interval or riser. A lockable surface casing will be set in concrete at the ground surface around each gas probe. The gas probe completion details are summarized in the FSP. The gas probe stratigraphic and instrumentation logs are presented in the FSP.

Soil samples will be collected from the surface and subsurface during the gas probe installation for the analysis of soil physical properties (i.e., grain size analyses, fraction of organic carbon content, plasticity index, porosity, permeability, and Atterburg limits). The procedures for collecting soil samples are presented in the FSP.

LANDFILL GAS/SOIL VAPOR SAMPLING

CRA will complete two rounds of sampling. The sampling will consist of:

- i) measurement of gas pressure;
- ii) screening for methane (v/v), LEL, and oxygen (v/v); and
- iii) collection of Summa™ canister samples for VOC analysis.

The initial LFG/soil vapor sampling will be conducted one week following the installation of gas probes. One week is considered to be more than sufficient time for any formation disturbances created by drilling activities to dissipate and for equilibrium conditions to be reestablished in the unsaturated zone. As a result, the soil vapor samples are considered representative of conditions in the sampled intervals at the time the samples are collected.

Soil gas sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., >0.5 inches after California Environmental Protection Agency (CalEPA, 2003)]. This will help avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen soil gas concentrations, or possibly prevent soil gas sample collection (i.e., such as in cases where the soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration will be given to allowing a greater



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amount of time for rainfall events to dissipate. The potential influence of rainfall events on soil gas concentrations is less of a concern in cases where the soil gas probes are located beneath impervious ground cover (e.g., pavement or building foundation).

The three sampling elements are described below.

i) Measurement of Gas Pressure

A pressure gauge will be attached to the hose barb on the LFG probe to measure the static gas pressure. The pressure gauge will be sufficiently sensitive to record gas pressure to 0.1 pounds per square inch (psig). The highest value obtained during gas pressure readings will be recorded. The ambient barometric pressure will be recorded at each gas probe when soil gas pressure readings are being taken. The ambient barometric trends will also be noted (i.e., rising, falling, steady).

Two rounds of gas pressure measurements will be collected, separated by at least one month.

ii) Screen for Methane, LEL, Carbon Dioxide, and Oxygen

A Multimeter will be used to draw a sample from each probe to measure and record the methane, LEL, carbon dioxide, and oxygen readings. The highest values obtained during sampling will be recorded. The ambient and soil gas temperatures will be recorded at each gas probe when soil gas readings are being taken. The ambient barometric trends also will be noted (i.e., rising, falling, or steady).

Two rounds of this sampling will be completed, separated by at least one month.

The details regarding the calibration and maintenance frequency and procedures, instrument start up procedures, and recording of data for instruments used during the installation and sampling of the gas probes will be provided in the FSP. These instruments include PIDs, Multimeters, barometers, and thermometers. The FSP will specify gas probe purging rates and procedures. A copy of the supplier instrument calibration will be available for review in the field. All field calibration procedures and readings will be documented in the field logbook.

iii) Summa™ Canisters

One round of soil vapor samples will be collected during the first round of methane measurements using 6-liter capacity Summa™ canisters fitted with a laboratory calibrated critical orifice flow regulation device sized to allow the collection of the soil vapor sample over a 1-hour sample collection time. The Summa™ canisters will be fitted with a laboratory calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum soil gas sampling flow rate of 100 to 200 mL/min recommended by CalEPA (CalEPA,



2003). A flow rate of 100 mL/min is recommended to limit VOC stripping from soil, and prevent the short-circuiting of ambient air from ground surface that would dilute the soil vapor sample. The low flow rate of 100 mL/min will increase the likelihood that a sample representative of in situ conditions is obtained. Prior to sample collection, gas probe purging will be conducted at a maximum flow rate of 200 mL/min. Three gas probe volumes (calculated based on casing and sand pack volume) will be purged to remove potentially stagnant air from the internal volume of the gas probe. The FSP provides the soil gas purging and sampling procedures including the calculation of purge volume, maximum purge volume and maximum purging rates. Once the flow rate is set for a canister, the time it will take to fill up the canister will be calculated and the sampler will retrieve the canister and turn off the flow at the calculated time to prevent the valve from being open after the canister is filled.

The Summa™ canister samples will be analyzed for VOCs using USEPA method TO-15. The VOCs included in USEPA method TO-15 (with the addition of naphthalene) and the best method detection limits that the contract laboratory can achieve are listed in Table 1. The laboratory's ability to achieve the best possible detection limits will be highly dependent on the presence of matrix interferences.

Quality assurance /quality control (QA/QC) measures to be implemented during the soil vapor sampling event include maintaining a minimum negative pressure in the Summa™ canisters following sample collection, collection of one field duplicate sample, collection of an ambient air sample, and the analysis of a trip blank Summa™ canister. Further details regarding the gas probe sampling protocol and the applied QA/QC measures are presented in the FSP.

SCHEDULE

The LFG and soil vapor investigation will begin within four weeks of USEPA approval of this Letter Work Plan, or the relevant sections of the Field Sampling Plan and Quality Assurance Project Plan, or USEPA's review of the Health and Safety Plan, whichever occurs later and following completion of clearing and grubbing activities and, if scheduling permits, test pitting and test trenching activities. The LFG and soil vapor investigation will be completed over a two-week period. The second LFG sampling event (gas pressure, methane, LEL, and oxygen) will occur within six weeks of the first sampling event. The PRP Group will provide the USEPA with verbal notification at least 15 days in advance of the initiation of this activity.

All work will be performed in accordance with the FSP, QAPP, and HASP, pending USEPA's approval of the relevant sections of these documents.



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REPORTING

The results of the LFG and soil vapor investigation and analytical results will be summarized and presented in a technical memorandum. The memorandum will include a description of the fieldwork completed, any deviations from the proposed work, and the rationale behind the change, and photographs taken during the investigation. Figures detailing the actual installations, analytical summary tables, iso-concentration maps, and analytical data reports will also be included in the technical memorandum. The technical memorandum will be provided to the USEPA within one month of the completion of the proposed work. The data will be used in the FS and to assist in identifying potential areas where further investigation or assessment may be appropriate.

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

AL/ca/30

Encl.

c.c. Matt Mankowski, USEPA (PDF)
 Matt Justice, Ohio EPA (PDF)
 Brett Fishwild, CH2M Hill (PDF)
 Scott Blackhurst, Kelsey Hayes Company (PDF)
 Wray Blattner, Thompson Hine (PDF)
 Ken Brown, ITW (PDF)
 Jim Campbell, Engineering Management Inc. (PDF)
 Tim Hoffman, Representing Kathryn Boesch and Margaret Grillot (PDF)
 Paul Jack, Castle Bay (PDF)
 Robin Lunn, Mayer Brown (PDF)
 Roger McCready, NCR (PDF)
 Karen Mignone, Pepe & Hazard (PDF)
 Lou Almeida, CRA (PDF)
 Adam Loney, CRA (PDF)

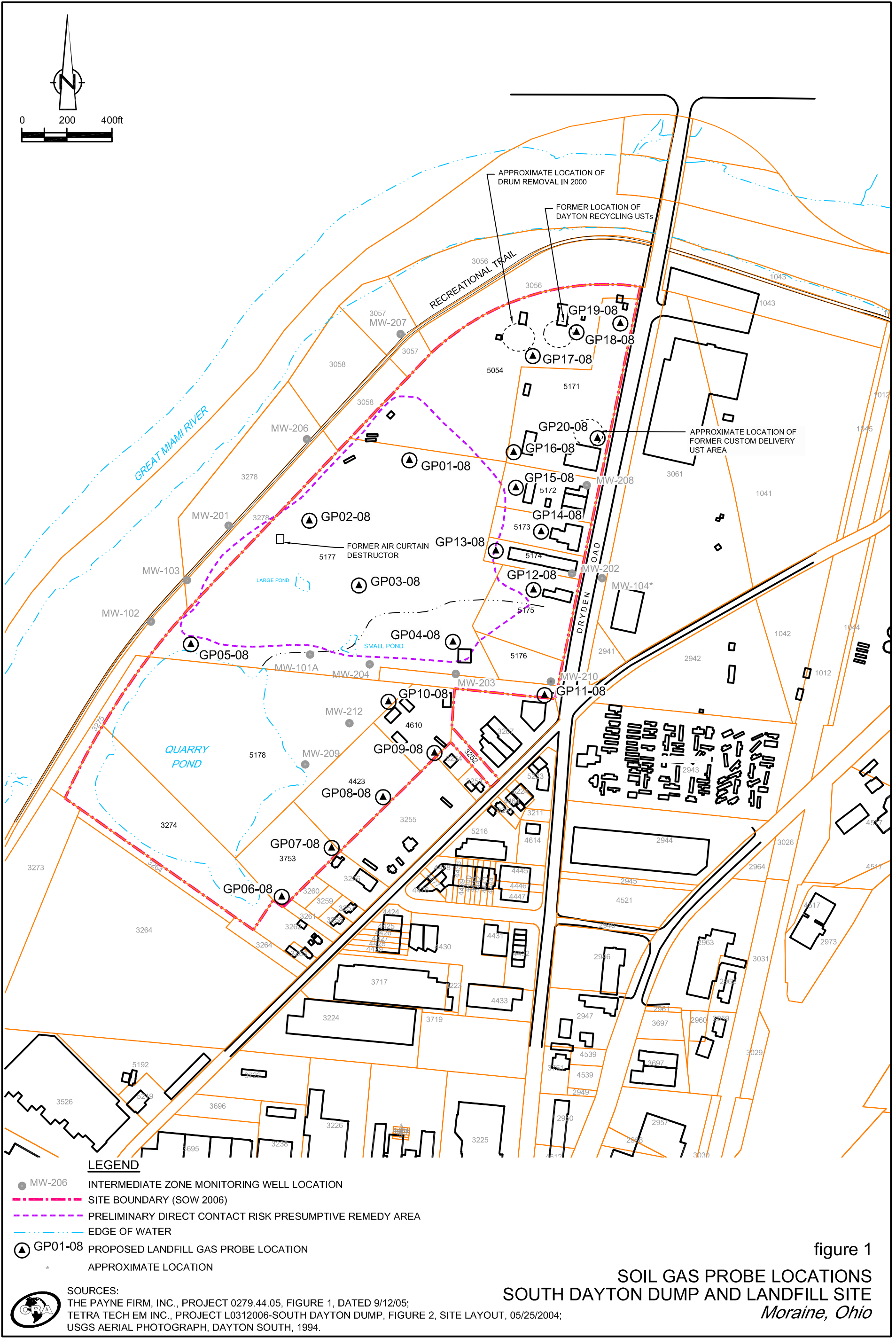


TABLE 1

**SOIL GAS PARAMETER LISTS AND TARGETED QUANTITATION LIMITS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

<i>Parameter</i>	<i>Targeted</i>	<i>Method</i>	<i>OSWER Draft Guidance</i>
	<i>Quantitation Limit (TQL) ¹</i>	<i>Detection Limits (MDL) ²</i>	<i>Targeted Soil Gas</i>
	<i>Air</i>	<i>Air</i>	<i>Concentrations ³</i>
	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>Risk = 1×10^{-4}</i>
			<i>($\mu\text{g}/\text{M}^3$)</i>
Select Volatile Organic Compounds (VOC)			
Acetone	24	5.9	3,500
Benzene	0.96	0.64	310
Bromodichloromethane	2.0	1.6	140
Bromoform	4.1	2.1	2,200
Bromomethane	16	7.8	50
2-Butanone	29	5.9	10,000
Carbon disulfide	31	6.2	7,000
Carbon tetrachloride	1.9	1.3	160
Chlorobenzene	1.4	0.92	600
Chloroethane	1.1	1.0	100,000
Chloroform	1.5	0.97	110
Chloromethane	1.6	0.82	900
Cyclohexane	1.7	1.4	N/A
Dibromochloromethane	3.4	1	100
1,2-Dibromo-3-chloropropane	9.6	3.9	2
1,2-Dibromoethane	3.1	1.5	2
1,2-Dichlorobenzene	2.4	1.2	2,000
1,3-Dichlorobenzene	2.4	1.2	1,100
1,4-Dichlorobenzene	2.4	1.2	8,000
Dichlorodifluoromethane	1.5	0.99	2,000
1,1-Dichloroethane	1.2	0.81	5,000
1,2-Dichloroethane	8.1	4.0	94
1,1-Dichloroethene	7.9	4.0	2,000
cis-1,2-Dichloroethene	7.9	3.2	350
trans-1,2-Dichloroethene	7.9	4.0	N/A
1,2-Dichloropropane	14	6.9	40
cis-1,3-Dichloropropene	1.8	0.91	200
trans-1,3-Dichloropropene	1.8	0.91	200
Ethylbenzene	1.3	0.87	2,200
2-Hexanone	2.0	1.6	N/A
Isopropylbenzene	2.5	2.0	4,000
Methylene chloride	1	0.69	5,200
4-Methyl-2-pentanone	41	8.2	800
Methyl tert-butyl ether	7.2	3.6	30,000
Naphthalene	2.6	1.3	30
Styrene	1.7	0.85	10,000
1,1,2,2-Tetrachloroethane	14	6.8	42
Tetrachloroethene	2.7	1.4	810
Toluene	7.5	3.8	4,000
1,2,4-Trichlorobenzene	37	18	2,000
1,1,1-Trichloroethane	1.6	1.1	22,000

TABLE 1

**SOIL GAS PARAMETER LISTS AND TARGETED QUANTITATION LIMITS
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTH DAYTON DUMP AND LANDFILL
MORaine, OHIO**

<i>Parameter</i>	<i>Targeted</i>	<i>Method</i>	<i>OSWER Draft Guidance</i>
	<i>Quantitation Limit (TQL) ¹</i>	<i>Detection Limits (MDL) ²</i>	<i>Targeted Soil Gas</i>
	<i>Air</i>	<i>Air</i>	<i>Concentrations ³</i>
	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>($\mu\text{g}/\text{M}^3$)</i>	<i>Risk = 1×10^{-4}</i>
<i>Select VOC (continued)</i>			
1,1,2-Trichloroethane	1.6	1.1	150
Trichloroethene	2.1	1.1	22
Trichlorofluoromethane	11	5.6	7,000
1,1,2-Trichloro-1,2,2-trifluoroethane	3.8	3.1	300,000
Vinyl chloride	7.6	3.8	280
Xylenes (total)	17	4.3	70,000

Notes:

- 1 Please note that these are targeted quantitation limits and are presented for guidance only. Actual quantitation limits are highly matrix dependent and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes.
- 2 Method Detection Limits (MDL) are also presented for guidance only. Actual MDLs will vary depending on sample specific preparation factors. The MDLs are also highly matrix dependant and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes. Laboratory MDLs are updated on a periodic basis and the MDLs in effect when the samples are analyzed will be used for reporting purposes.
- 3 Target Shallow Soil Gas Concentrations Corresponding to Target Indoor Air Concentrations Where the Soil Gas to Indoor Air Attenuation Factor = 0.1 in Table 2a (Risk = 1×10^{-4}) of draft guidance "Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" (USEPA, 2002).

APPENDIX J-E

GROUNDWATER LETTER WORK PLAN



**CONESTOGA-ROVERS
& ASSOCIATES**

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May 7, 2008

Reference No. 038443

Ms. Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Karen:

Re: Final Groundwater Letter Work Plan
South Dayton Dump and Landfill Site Moraine, Ohio (Site)

This Letter Work Plan presents the South Dayton Dump and Landfill Potentially Responsible Party Group's (PRP Group's) approach for investigation of subsurface and groundwater conditions at the Site. The work will help address data gaps and provide information to aid in the completion of a Feasibility Study (FS). All work will be performed in accordance with the United States Environmental Protection Agency (USEPA) -approved Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Site-Specific Health and Safety Plan (HASP).

The PRP Group has prepared this Letter Work Plan based on discussions between the PRP Group and USEPA in February and April 2008. The Letter Work Plan incorporates comments received from USEPA on March 26, 2008 and May 5, 2008.

GROUNDWATER WORK OBJECTIVES

The general objectives for the phases of work discussed within this document include the following:

- define subsurface stratigraphy, including identifying till-rich zone(s) and sand and gravel aquifer zone(s) at locations beneath the Site to a depth of 100 feet below ground surface using Rotasonic drilling;
- collect data to assist in characterizing groundwater impact;
- recognizing that there may be seasonal or event-related differences in groundwater elevation, flow conditions and contaminant concentrations, and that there may be more





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than one contaminant flow path and more than one source of groundwater contamination at the Site, attempt to: i) determine the appropriate screened interval(s) for shallow monitoring wells at Vertical Aquifer Sampling (VAS) locations through VAS data; ii) compare the screened intervals identified through VAS to the screened intervals and screen lengths in the existing wells; and iii) determine, based on these results and all existing data for the Site, if the screened intervals and screen length of the existing wells represent a zone of chemical impact in the shallow aquifer that is worthwhile to continue to monitor or not;

- characterize groundwater chemistry at Site monitoring wells through groundwater sampling and laboratory analysis; and
- collect groundwater and surface water elevation measurements over time to identify horizontal hydraulic gradients, flow directions, and, if nested wells are proposed in Phase 2, vertical hydraulic gradients.

Phase 1

In an effort to meet these objectives, Phase 1 will include three main work tasks VAS borings, synoptic water level measurements, and groundwater sampling for laboratory analysis.

1) VAS Borings

Figure 1 presents the locations of twenty-three on-Site VAS borings and two off-Site VAS borings (on the trailer park parcel). Additionally, the location of a soil boring that will be used to log the subsurface material below the large asphalt pile is presented on Figure 1. All of these borings, including the boring installed through the large asphalt pile, will be completed using Rotosonic drilling techniques. This drilling technique offers the opportunity to document relatively undisturbed soil sample cores, advance to the desired depth, and produces less waste than hollow stem auger drilling techniques. Additional details regarding Rotosonic drilling are provided in the FSP.

During borehole advancement, continuous soil cores will be observed, soil stratigraphy will be logged and cores will be screened with a photoionization detector (PID) for the presence of volatile organic compounds (VOCs), and screened for the presence of methane either by using a landfill gas meter (such as a Landtec GEM-500) or a flame-ionization detector (FID) calibrated for methane. Additionally, photographs will be taken of each 5-foot interval to obtain a photographic log of each borehole.



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Core samples will be collected directly from the core barrel attached to the end of the drill string and extruded into cylindrical bags. Field measurements for VOCs and methane will be conducted along the cored material by piercing the plastic sleeve with the wand of the field instrument(s). In addition, the soils will be tested for the presence of non-aqueous phase liquids (NAPL) using the Sudan IV® dye test and/or another USEPA-approved shaker test, as appropriate. Field calibration, preventative maintenance, and SOPs for the PID and Sudan IV® dye test are included in the FSP.

Should the presence of NAPL be detected in a boring, the interval of detection will be recorded and advancement of the boring will be terminated to prevent introducing NAPL into deeper intervals. USEPA will be notified of the presence of NAPL at the location and the borehole location will be sealed in accordance with industry standards. Available stratigraphic information from such locations (up to and including the interval with detected NAPL) will be reviewed, and the location will be evaluated for additional work in Phase 2.

During borehole advancement, the amount of water added during Rotosonic drilling will be recorded. Every effort will be made to minimize the amount of water added during drilling in order to reduce the amount of purging required and to ensure that samples are representative of the groundwater in the aquifer formation. Groundwater samples will be collected at 5-foot intervals beginning at the 0 to 5-foot interval below the groundwater interface observed during borehole advancement. Groundwater samples will be collected from each discrete interval through a 5-foot long, stainless steel slotted screen using an inflatable packer with a submersible pump system. The flow rate for purging of groundwater will be dependent on the capacity of the submersible pump and the transmissivity of the aquifer material. Efforts will be made to maintain low flow during purging. Upon purging of two times the volume of water added during drilling (pre-purge), the flow rate will be reduced to the lowest sustainable flow rate and the minimum required screen volumes (i.e., three to five volumes of the 5-foot screened zone), will be purged. During the screen purging, field parameters such as pH, temperature, conductivity, oxidation-reduction (redox) reaction potential (ORP), dissolved oxygen (DO), and turbidity will be monitored to evaluate the stabilization of the purged groundwater. Groundwater samples will be collected once the parameters have stabilized as detailed in the FSP. VAS samples will not be collected from a 5-foot interval if attempts to purge and sample indicate the interval does not yield enough water to sample.

VAS will be completed to a depth of 100 feet below ground surface (bgs) at each location. All VAS samples will be analyzed for Target Compound List (TCL) VOCs,



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total arsenic, and total lead. All of the groundwater samples collected during VAS and submitted to the laboratory will be unfiltered groundwater samples. In addition, VAS samples collected from select sampling intervals from each boring will be analyzed for TCL semi-volatile organic compounds (SVOCs) as discussed in further detail below. All of the groundwater samples collected during VAS and submitted to the laboratory will be unfiltered groundwater samples.

The sampling intervals that will be submitted for TCL SVOC analysis will depend on boring locations, whether the borehole is advanced through fill material (i.e., non-native material), or through native soil. The geophysical survey and, if the schedule permits, the test pit/test trench work that will be completed prior to the groundwater work discussed in this letter will help determine which VAS borehole locations are in fill material. The VAS borings determined to be located in fill material areas, or which have potential to be in fill material, will be completed first.

A total of four SVOC samples will be collected from each VAS boring as detailed below. In VAS borings drilled through fill (i.e., non-native) material, where the fill material extends below the water table, a maximum of three groundwater samples will be collected from the fill material for TCL SVOC analysis, and a minimum of one groundwater sample will be collected for TCL SVOC analysis from the native material directly beneath the fill material. The first sample in the fill material will be collected from the five-foot interval from the groundwater interface to five feet below the water table; subsequent groundwater samples collected from the fill material will be collected from every second five-foot interval. SVOC samples of native material will be collected at each five-foot interval commencing at the interface between the fill and native material. The total number of samples collected from the fill (i.e., non-native) material and from the native material at an individual VAS boring location will be dependant on the depth of fill material below the water table, i.e., if the fill material is sufficiently thick, three SVOC samples will be collected from the fill material and one from the native material, whereas if the fill material is thinner, fewer SVOC samples will be collected from the fill material and more samples will be collected from the native material (for a total of four SVOC samples per boring).

In VAS borings completed in native soil or where the fill material lies entirely above the water table, four samples for TCL SVOC analysis will be collected. The first sample will be collected from the five-foot interval beginning at the groundwater interface and the second from the interval from five feet below the water table to 10 feet below the water table. The third TCL SVOC sample will be collected at elevations corresponding to deeper areas of fill material below the water table. The fourth TCL SVOC sample will be



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collected from the five-foot interval commencing at the elevation corresponding to the deepest fill material elevation observed in nearby borings advanced in non-native fill material. Sample elevations will be discussed with USEPA field representatives before starting VAS borings in areas believed to be in native soil areas.

The results of the VAS will be used to help select monitoring well locations (to be installed in Phase 2). The selection of monitoring well locations will be based on an analysis of VAS results and all existing data, including hydrostratigraphic data.

The proposed VAS borings are roughly laid out along four transects. The transects run approximately parallel to the section of the Great Miami River (GMR) northwest of the Site and continue toward the southeastern Site boundary. Following is a summary of the VAS boring locations, as identified along each transect, and the rationale for selecting each location. VAS boring locations may be revised based on the results of the Geophysical Survey and the Test Pit/Test Trench Investigation, which will be completed prior to the VAS sampling program if scheduling permits. Any modifications to the VAS boring and sampling program will be discussed with the USEPA prior to implementation.

<i>Transect No.</i>	<i>VAS Location No.</i>	<i>Rationale for VAS Location</i>
1	1	VAS location along northwest Site boundary to serve as a presumed upgradient data point. This location may be moved farther north along the transect, if possible, if fill is encountered.
	2	VAS location along northwest Site boundary and within 200 feet of MW-206 to evaluate aquifer data in vicinity of the well.



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<i>Transect No.</i>	<i>VAS Location No.</i>	<i>Rationale for VAS Location</i>
1 cont'd.	3	VAS location along northwest Site boundary and within 200 feet of MW-201 and MW-103 to evaluate aquifer data in vicinity of these wells.
2	4	VAS location at northeast corner of Site boundary to serve as a presumed upgradient data point.
	5	VAS location to evaluate conditions in vicinity (or in presumed downgradient direction within vicinity) of former Dayton Recycling USTs. Off-set approximately 50 feet northwest of the transect.
	6	VAS location to evaluate conditions in vicinity (or in presumed downgradient direction within vicinity) of Valley Asphalt drum removal in 2000. Off-set approximately 100 feet northwest of the transect.
	7	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. Off-set approximately 110 feet southeast of the transect.
	8	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. VAS location to evaluate area downgradient of the large asphalt stockpile. Off-set approximately 275 feet southeast of the transect.
	9	VAS location to evaluate area presumed to be downgradient of material under the large asphalt stockpile. Off-set approximately 150 feet southeast of the transect.



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2 cont'd	VAS Location No.	<i>Rationale for VAS Location</i>
	10	VAS location to evaluate the boundary between Parcel 5054 (Valley Asphalt) and Parcel 5177.
	11	VAS location to evaluate conditions at approximate center of PRPs' preliminary direct contact risk area (and located roughly 200-300 feet from former air curtain destructor).
	12	VAS location to evaluate presumed downgradient boundary of PRP Group's preliminary direct contact risk area.
	13	VAS location to collect data at southwest corner of Site boundary.
	14	VAS location to evaluate conditions in vicinity of former Custom Delivery UST area. Off-set approximately 100 feet northwest of the transect.
3	15	VAS location to evaluate aquifer conditions in vicinity of MW-202. Off-set approximately 225 feet southeast of the transect.
	16	VAS location to evaluate presumed downgradient boundary of PRP Group's preliminary direct contact risk area at northwest corner of Parcel 5176. Off-set approximately 225 feet southeast of the transect.
	17	VAS location to evaluate presumed downgradient boundary of PRP Group's preliminary direct contact risk area in vicinity of MW-203. Off-set approximately 100 feet southeast of the transect.
	18	VAS location to evaluate presumed downgradient boundary of PRP Group's preliminary direct contact risk area in vicinity of MW-101A and MW-204. Off-set approximately 200 feet northwest of the transect.
	19	VAS location within 200 feet of MW-209 and MW-212 to evaluate aquifer data in vicinity of these wells. If this location requires offsetting during field operations, it will remain at least 100 feet away from the edge of the Quarry Pond.
4	20	VAS location to collect data south of the Quarry Pond.
	21	VAS location to evaluate conditions within vicinity of MW-210. Off-set approximately 50 feet southeast of the transect.
	22	VAS location east of Quarry Pond to evaluate conditions at southeastern boundary of Site and Parcel 4423.
	23	VAS location to collect data at southeast corner of Site.

Two additional locations, 24 and 25, are proposed on the trailer park parcel to evaluate off-Site conditions in the presumed downgradient direction from MW-210.



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The soil boring that will be used to log the subsurface material below the large asphalt pile will be advanced to a depth of 5 to 10 feet below the first native material encountered beneath the large asphalt pile (as determined in the field). The borehole will be advanced via Rotasonic drilling techniques, but VAS samples will not be collected from this borehole location. During borehole advancement below the large asphalt pile, continuous soil cores will be observed, soil stratigraphy will be logged and cores will be screened for the presence of VOCs and methane in the same manner as the VAS borings. A photographic log will also be compiled from each 5-foot soil core interval at this location.

Existing monitoring wells will be inspected, repaired as needed, and redeveloped to attempt to produce a silt free condition prior to water level monitoring and sampling. Redevelopment of wells and handling of investigative derived waste, including water from purging and pre-purging during VAS, will be performed in accordance with the USEPA-approved FSP.

2) Synoptic Water Level Measurements

Synoptic water level measurement events (groundwater and surface water) will be conducted in order to get a better understanding of groundwater flow directions. Note that staff gauges or measurement points will first be required for the GMR, Quarry Pond, and other surface water bodies. The reference elevations of the existing monitoring wells will be re-surveyed. Synoptic water level measurements will be completed using all permanent well installations and surface water measurement points once a month for the remainder of 2008. Any surface water measurement points that are disturbed during ongoing synoptic water level measurements will be immediately replaced and resurveyed. An oil/water interface probe will be used to monitor for the presence of light NAPL (LNAPL) in monitoring wells that are screened at the water table.

3) Groundwater Sampling

A round of groundwater sampling for TCL VOCs, TCL SVOCs, TCL pesticides and herbicides, TCL PCBs, and TAL metals will be completed at the existing monitoring wells. Groundwater sampling will be conducted using low flow field sampling procedures. The data will be compared with VAS results to assist in determining the adequacy of the existing monitoring wells.



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The results from these three tasks will be summarized in a Technical Memorandum that, using new and existing data including representative hydrostratigraphic data and groundwater/surface water flow maps, will support and include the work proposed for Phase 2. The Technical Memorandum will be prepared following receipt of VAS analytical results and will contain only initial rounds of synoptic water level measurements. The Technical Memorandum will be reviewed in a project team workshop, similar to the meetings held with USEPA and Ohio EPA in early 2008.

Phase 2

Phase 2 will consist of three main work tasks – monitoring well installation, groundwater sampling, and continuous hydraulic monitoring.

1) Monitoring Well Installations

New monitoring wells will be installed based on the results of the Phase 1 VAS and all existing data, including hydrostratigraphic and groundwater/surface water flow data. If appropriate, the existing wells will be incorporated into the groundwater monitoring well network. All newly installed monitoring wells will be developed following installation. Following development, slug tests will be completed in each new monitoring well and in existing wells that will be kept/incorporated in the monitoring well network.

2) Groundwater Sampling

The Phase 2 groundwater sampling will include two rounds of sampling from the newly installed monitoring wells and, if appropriate, the existing wells. The first round of samples will be collected two weeks after installation and development of the monitoring wells and the second round will be collected two months later. The analyses will include TCL VOCs, TCL SVOCs, TCL pesticides and herbicides, TCL PCBs, and TAL metals, and monitored natural attenuation (MNA) parameters. The MNA parameters included in the analysis will be consistent with the USEPA Region 5 Monitored Natural Attenuation Framework. The complete list of MNA parameters is provided in Table K.3.3 of the QAPP. The analytical parameters may be reduced for the second round of sampling. The PRP Group will propose reductions in analytes, as appropriate, for USEPA's approval.



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3) Continuous Hydraulic Monitoring

The monthly synoptic water level measurements described above would continue through Phase 2. More detailed hydraulic monitoring would be completed by installing transducers in select wells and surface water bodies. The transducers would provide continuous water level measurements that would aid in the evaluation of groundwater/surface water interactions. The data generated for this investigation would support the evaluation of remedial alternatives for the FS.

All work will be performed in accordance with the Field Sampling Plan, Quality Assurance Project Plan, and Site Specific Health and Safety Plan pending USEPA's approval of these documents.

SCHEDULE

Phase 1 fieldwork will be initiated within four weeks of USEPA approval of this Letter Work Plan, or the Field Sampling Plan, Quality Assurance Project Plan, and Site Specific Health and Safety Plan, and completion of the Geophysical Survey and, if the schedule permits, the Test Pit/Test Trench Investigation, whichever occurs later. The Phase 1 field tasks will be completed within a four-week period of time using two drill rigs working simultaneously. This schedule is subject to contractor availability and the actual drilling conditions encountered. The PRP Group will provide USEPA with written notification as much in advance as possible, but at least fifteen days in advance of the initiation of field activities. Phase 2 field work will begin following USEPA's approval of the Phase 1 Technical Memorandum. Monthly synoptic water level measurements will be taken throughout the remainder of 2008.

REPORTING

Phases 1 and 2 technical memoranda will be submitted to USEPA within two weeks of receipt of all data from the laboratory. The Phase 2 Technical Memorandum will provide a summary of results from monitoring well installation, groundwater sampling, and continuous hydraulic monitoring. Monthly progress reports during the Phase 1 and Phase 2 work will include the information required for monthly progress reports in the RI/FS SOW (including analytical data, groundwater/surface water elevations and stratigraphic information as it comes in).



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Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

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Encl.

c.c. Matt Mankowski, USEPA (PDF)
 Matt Justice, Ohio EPA (PDF)
 Eric Kroger, CH2M Hill (PDF)
 Scott Blackhurst, Kelsey Hayes Company (PDF)
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 Karen Mignone, Pepe & Hazard (PDF)
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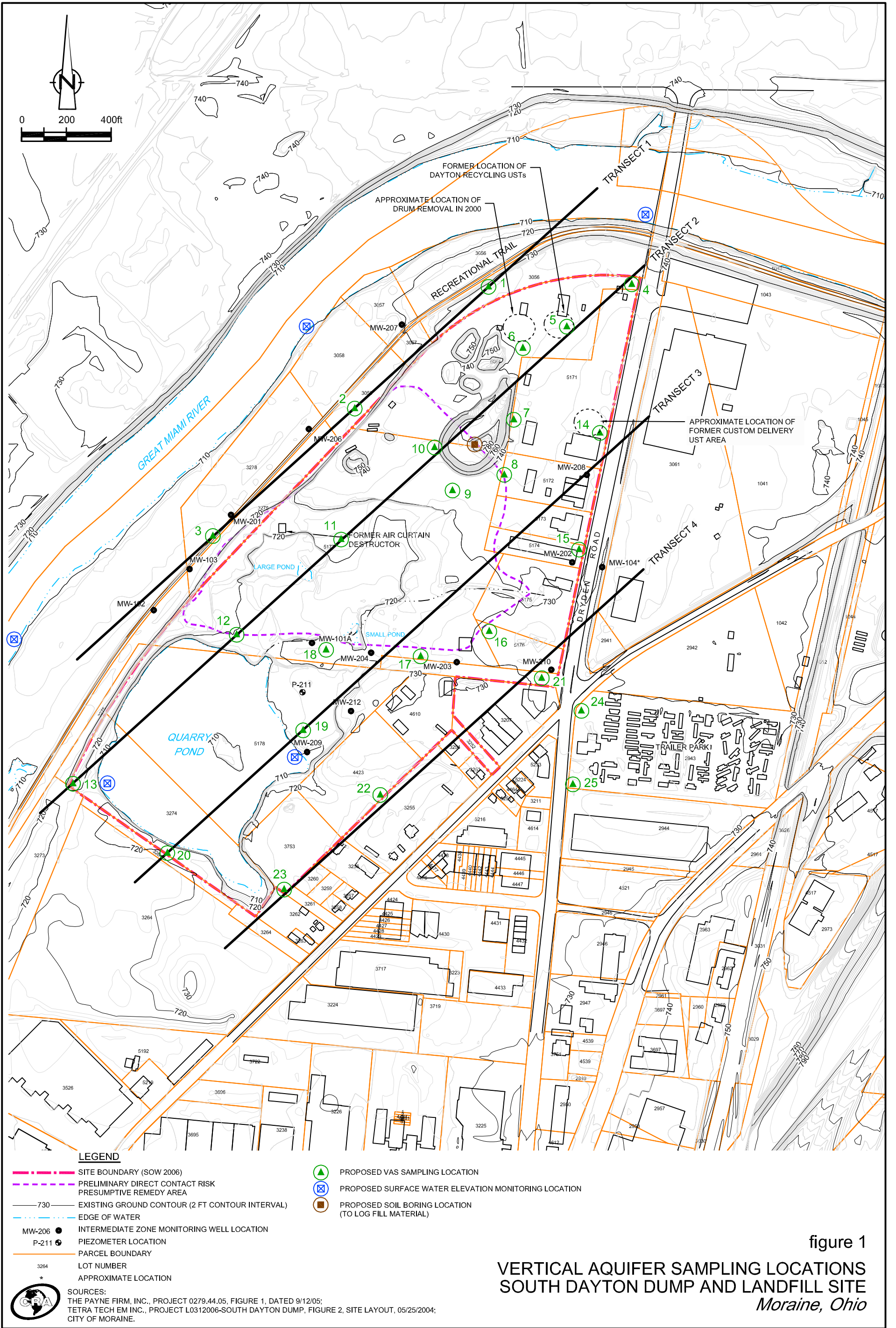


figure 1
VERTICAL AQUIFER SAMPLING LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio

APPENDIX J-F
FIELD STANDARD OPERATING PROCEDURES

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APPENDIX J-F-1
GLOBAL POSITIONING SYSTEM (GPS) UNIT OPERATION

STANDARD OPERATING PROCEDURE FOR GLOBAL POSITIONING SYSTEM (GPS) UNIT OPERATION

GPS surveying provides a system for establishing and documenting the location of drums, sampling points, structures and other Site features.

EQUIPMENT DECONTAMINATION

Equipment must be cleaned and decontaminated in accordance with the letter work plan or Quality Assurance Project Plan (QAPP) prior to returning to the office.

EQUIPMENT USE

The following hand held GPS units may potentially be used at the Site:

1. Trimble GeoXH handheld (accuracy to 10 centimeters) or equivalent
2. Leica GS50 (accuracy to 50 centimeters) or equivalent
3. Garmin eTrex Legend HCx handheld (accuracy to 3 meters) or equivalent

Hand held GPS meters with better than 50-centimeter accuracy will be used during the completion of bathymetry and electromagnetic surveys conducted at the Site. Meters with 3-meter accuracy will be used to identify the sample collection locations, the location of drums or other debris, and other Site features, where survey-level accuracy is not required. The GPS meters with an accuracy of approximately 3 meters will not be used to survey vertical aquifer sampling locations, monitoring well locations or other locations where survey-level accuracy is required.

When using the meter, field staff will ensure that the unit has been properly charged and decontaminated as needed. Due to the nature of the instruments, decontamination of the units will be limited to cleaning the units using alcohol wipes.

Field staff will be familiar with the unit operation and have read the users manual prior to operating the unit in the field.

The standard procedure for using the unit will be as follows:

1. Power up the unit in an area that has a clear and unobstructed view of the sky.
2. Allow the unit to acquire the necessary satellite links.

3. Once the unit has acquire the necessary satellite links, initialize the real time location mode (see appropriate user's manual).
4. When saving a waypoint (sample, drum location etc.) ensure that the unit is as close to the location as possible before storing the data. Ensure that a unique location identification number is used to store the location data and that a field log of the location identification number and description of the identification number are documented in the field log book.
5. Power down the hand held unit when surveying is complete.
6. Ensure that the electronic data are transferred to a computer or other data storage device (thumb drive, CD, etc.) using the procedures specified in the user's manual.
7. Transmit the data to the necessary project personnel as soon as possible with the field log information.

FOLLOW-UP ACTIVITIES

Once the surveying activities are complete and prior to returning to the office:

1. Check data reductions and closures.
2. Clean the equipment and, if necessary, decontaminate according to the work plan.

After returning to the office:

1. Return the equipment to the Equipment Manager.
2. Red tag any equipment that is damaged or out of calibration.
3. Complete, sign, date, and file the Quality System forms.
4. File the field book.

APPENDIX J-F-2
BATHYMETRY SURVEY

STANDARD OPERATING PROCEDURE FOR BATHYMETRY SURVEY

1.0 BATHYMETRY SURVEY STANDARD OPERATING PROCEDURE

1.1 GENERAL

A bathymetry survey is typically used to generate topographical information for the bottom of a water body. Bathymetry surveys consist of measuring the height of the water column or depth to where sediment is first encountered in the water body. The survey is generally conducted using a transducer that transmits a sound pulse from the water surface and records the signal that bounces back from the bottom of the water body. The time interval between initiation of the sound pulse and receipt of the reflected signal from the bottom of the water body is used to calculate the height of the water column. Typically, a GPS unit is combined with the transducer to record the location of the reading. Fluctuations in water surface elevation are monitored using a staff gauge over the duration of the survey such that corrections can be made for any fluctuations that may have occurred.

1.2 PRIOR PLANNING AND PREPARATION

The following shall be taken into consideration prior to conducting the bathymetry survey:

- i) Review with the Project Manager the Work program, project documents, Job Safety Analysis (JSA) and site-specific Health and Safety Plan (HASP).
- ii) Complete an equipment requisition form and gather all equipment and supplies required to complete the bathymetry survey.
- iii) Assemble the updated site plans, establish survey coverage area(s) and determine survey limitations.
- iv) Obtain site access.
- v) Determine survey notification needs with the Project Coordinator. Client, regulatory agency, and landowner notifications made as required.

1.3 FIELD PROCEDURES

Once the prior planning and preparation activities are completed, the bathymetry survey can proceed. The typical series of events which will take place are:

- Charge equipment batteries
- Mobilize boat and motor to site
- Equipment setup and assembly
- Equipment calibration
- Laptop computer setup
- Test to ensure equipment is working properly
- Field note completion, review, and checking
- Documentation submitted to appropriate staff and files

i) Charge Equipment Batteries

Prior to mobilizing to the job site it is very important to ensure that all batteries are fully charged. A battery charger should be included on the equipment list. All equipment batteries should be charged nightly.

ii) Equipment Setup and Assembly

The equipment used to complete the bathymetry survey includes:

- Boat and motor (including boating safety equipment)
- 12 V batteries
- Valeport soundbar 2-digital bar checker
- Trimble GPS DSM 132 unit
- ODOM Hydrotrac Echosounder (includes paper trace and transducer)
- Laptop computer
- Trimble Hydropro data collection and navigational system software
- Staff gauge

Outlined below is a general description of how the equipment is assembled and used.

Ensure the boat and motor are in good working order. Check boat for leaks and that the motor is in good operating condition prior to launch from shore. Ensure there is a full tank of gas and check the oil in the motor. Also ensure the appropriate boating safety equipment is on board in accordance with the HASP.

The Hydrotrac Echosounder consists of a transducer and recorder/transceiver of the acoustic information. A Trimble GPS DSM 132 antenna will be mounted above the transducer, where the digital outputs of both instruments will be connected to a laptop computer, all of which will be powered by 12 V batteries. The transducer and antenna configuration will be securely mounted to the side of the boat such that the transducer is submerged below the water surface. Mounting the GPS above the transducer will allow for collection of depth data and positioning information simultaneously. The Trimble GPS DSM 132 will be configured to use differential GPS (DGPS) using Omni Star corrections for sub-meter positioning. The ODOM Hydrotrac Echosounder and Trimble GPS will be programmed to collect data at a minimum of 0.5- and 1.0-second time intervals, respectively.

For each bathymetry survey the average speed of the sound of water must be measured to calibrate the Hydrotrac Echosounder. The Valeport soundbar 2-digital bar checker will be used to measure this value which is reported in meters per second (m/s). This is further discussed in the Equipment Calibration section.

The collected depth data and GPS point locations will be stored in digital format using the Trimble Hydropro software. In addition, the ODOM Hydrotrac Echosounder will also record the data simultaneously in an analog strip chart to verify the digital depth sounding results.

The navigational component of the Trimble Hydropro software allows the user to pre-program survey lines in Universal Transverse Mercator (UTM) coordinates. The use of the navigational component will allow the boat operator to maintain control of sub-meter positioning along survey lines. The GPS data will be streamed through the software to provide the operator with a current position in UTM coordinates on the computer screen, in relation to the position of the programmed survey line. The software can then direct the operator where to steer to maintain survey line positioning. The bathymetry survey will be completed along pre-determined survey lines spaced 40 feet apart and oriented in an approximate north-south direction, and on the cross-lines oriented in an approximate east-west direction, spaced 150 feet apart, which will be programmed into the navigational software.

A staff gauge will be placed in the body of water to monitor the rise or fall of the water level over the duration of the survey. Measurements will be taken from the top of the staff gauge (of known elevation) to the water surface. Measurements will be taken at the beginning of each day (prior to any data collection), periodically throughout the day, and upon completion of each day, such that corrections to the data can be made for any fluctuations that may have occurred.

iii) Equipment Calibration

Prior to collecting data, the ODOM Hydrotrac Echosounder must be calibrated for the average speed of the sound of water (m/s). This measurement is taken in the deepest portion of the water body using a Valeport soundbar 2-digital bar checker. The average speed of the sound of water is measured over the depth of the water column and is reported in meters per second (m/s). This value is then used to calibrate the ODOM Hydrotrac Echosounder.

iv) Laptop Computer Setup

Prior to collecting any survey data it is important to ensure the lap top software is set up correctly for the following parameters:

- Trimble Hydropro software is programmed for the survey line coverage.
- Measure the average speed of the sound of water to calibrate the ODOM Hydrotrac Echosounder.
- Ensure GPS is connected and feeding differential data for sub-meter position accuracy.
- Ensure ODOM Hydrotrac Echosounder is working properly and feeding digital data.
- Choose an appropriate data collection rate for Trimble GPS and ODOM Hydrotrac Echosounder.

v) Test to ensure equipment is working properly

Prior to collecting data it is very important to test the equipment to ensure the equipment is working properly. Make any necessary adjustments prior to collecting data.

vi) Field note completion and review

The bathymetry survey must be recorded in field notes and indicate the following:

- Project information
- Type of survey
- Date of survey

- Operator name
- Survey line spacing
- Staff gauge measurements

vii) Documentation Submitted to Appropriate Staff and Files

Copies of field notes will be sent to the field file.

1.4 FOLLOW UP ACTIVITIES

The following activities shall be completed at the conclusion of the field work:

- Equipment shall be cleaned and returned to the rental supplier.
- Ensure site is securely locked and return site keys to the client, if applicable.
- Survey the top elevation of the staff gauge.
- Copies of field notes shall be sent to file.
- Data processing - Upon return from the field all survey data will be processed. The survey data will be used as the basis to complete a contoured map of the depth of water column for the water body.

1.5 CONTACT INFORMATION

The following CRA personnel may be contacted regarding Bathymetry Surveys, procedures or for additional information:

<i>Contact</i>	<i>Office</i>	<i>Phone Number</i>	<i>Fax Number</i>
Joe Rothfischer	Waterloo	519-884-0510	519 725-1158
Andrew Madery	Waterloo	519 884-0510	519 725-1158
Sandy Serena	Waterloo	519 884-0510	519 725-1158

APPENDIX J-F-3

EM31 SURVEY

STANDARD OPERATING PROCEDURE FOR EM31 SURVEY

1.0 EM31 SURVEY STANDARD OPERATING PROCEDURE

1.1 GENERAL

Electromagnetic (EM) surveys are useful as preliminary non-intrusive investigations for the location of buried metallic objects as well as for the detection of conductive contaminant plumes. One instrument commonly utilized for these investigations is the EM31, which can operate simultaneously as a buried metal detector and a soil conductivity meter.

The EM31 consists of transmitter and receiver coils located at opposite ends of a 14-foot long boom. In vertical dipole mode, this coil configuration yields an approximate depth of penetration of 20 feet, or 17 feet at hip level. The basic principle of operation can be described as follows. The transmitter coils emit a primary electromagnetic (EM) signal which penetrates the shallow subsurface. In the presence of a metallic conductor, the primary field induces circular eddy currents in the object which oppose the primary field. In conductive soils, the magnitude of the eddy current loops is directly proportional to terrain conductivity in the vicinity of those loops. A portion of the induced magnetic field created by the loops is recorded by the receiver coils, and results in an output voltage that is linearly related to the terrain conductivity in units of milliSiemens per meter (mS/m).

The EM31 is commonly used to detect and locate the following buried metal objects or conductive features:

- Metallic drums and pipes
- Underground storage tanks (USTs)
- Limits of buried waste
- Leachate plumes
- Salt (brine) contamination

The benefits of an EM31 Survey are:

- Non – invasive
- Quick data acquisition with one operator
- Real time data display
- Quick data processing and turn around

1.2 PRIOR PLANNING AND PREPARATION

EM31 survey data is collected in three modes,. In 'auto' mode data is collected at a rate of up to one reading per 0.5 seconds.

The following shall be taken into consideration prior to conducting the EM61 survey:

- i) Review with the Project Manager the Work program, project documents, Job Safety Analysis (JSA), and site-specific Health and Safety Plan (HASP).
- ii) Complete an equipment requisition form and gather all equipment and supplies required to complete the EM61 Survey.
- iii) Pre-survey planning must be performed with the geophysicist to determine type of data collection, grid setup, survey line spacing and orientation.

EM31 survey data can be collected in the following three modes: station by station or manual mode, continuous or auto mode with fiducial markers, or GPS-auto mode. The first two modes require a reference grid, with line spacing, location and layout designed to optimize the detection of survey targets. Small grids can generally be established by the operator, while larger extensive grids require grid points to be surveyed in using total station or GPS survey equipment. These reference points are typically set up on a 100-foot or 150-foot spacing in a grid pattern, depending on survey line spacing. The GPS-auto mode is used to record data in wide open and relatively flat areas. In this mode data is collected at a time interval specified by the operator with the location of the data point referenced by the GPS receiver. Survey line alignment should be designed perpendicular to the target feature (if known), i.e., for E – W pipe alignment, survey lines must be run N –S.

Additional preparation prior to mobilization to the EM31 survey location includes:

- i) Complete an equipment requisition form and assemble all equipment and relevant supplies, including spare batteries.

- ii) Assemble the updated site plans, establish survey coverage area(s) and determine survey limitations.
- iii) Ensure GPS grid reference points (staked) have been established and obstacles and brush have been removed.
- iv) Check EM31 availability and status, ensure all components are present and in working order.
- v) Obtain site access.
- vi) Determine survey notification needs with the Project Coordinator. Verify that the Client, regulatory agency, and landowner have been notified.

1.3 FIELD PROCEDURES

1.3.1 REFERENCE GRID SETUP

Prior to commencement of the EM31 survey, reference grids will be established over each area of investigation. The grid line spacing, location and layout will be designed to optimize the detection of the target. As previously indicated, in order to ensure complete survey coverage of the area(s) of interest, the EM31 survey will be completed using line spaced determined by the Project Geophysicist. In order to facilitate use of the EM31 data logger, each reference grid will be designated with a Cartesian coordinate system (X,Y) prior to data collection.

With the reference grids established using GPS surveyed reference points, individual survey lines will be established between the control points. Lines will be marked using plastic pin flags and wooden stakes at predetermined spacings throughout the area of interest. Reference points will also be established as fiducial marker locations, and will be utilized during the survey to maintain correct data point position.

1.3.2 EQUIPMENT ASSEMBLY

The EM31 consists of the following 4 components: the receiver coil boom, the transmitter coil boom, the console (with boom mounts), and a data logger. The EM31 is assembled by placing the data logger (generally a Polycorder 600) directly into the console, and locking it in with two screws. The transmitter and receiver coils are labelled, and must match the labels on the boom mounts. The assembly sequence can be summarized as follows:

- i) Using identifier labels, attach the receiver and transmitter coil booms to the boom mounts on the console.
- ii) Attach shoulder carrying strap and console pad.
- iii) Insert the Polycorder and secure using the screws.
- iv) Adjust the carrying strap so that the instrument comfortably rests on the hip.
- v) Set MODE switch to OPER position and rotate RANGE switch to BATT position.
- vi) If meter reads above ± 4.4 , the batteries (C size) have sufficient power. All of the batteries for the EM31 will be checked on a daily basis, to ensure sufficient power. Batteries for the EM31 are not rechargeable. Should batteries not have sufficient power, spare batteries will be used as replacements.

1.3.3 EQUIPMENT CALIBRATION QA/QC

The EM31 requires periodic calibration by the manufacturer in accordance with the manufacturer's specifications, and also in accordance with CRA's ISO 2001 registration. A copy of the most recent calibration completed by Geonics for the EM31 is available.

The following calibrations will also be completed on a daily basis during the course of the survey: zero adjustment and equipment functional check. These calibration procedures can be further described as follows.

1.3.3.1 ZERO ADJUSTMENT

The EM31 will be checked on a daily basis prior to commencement of surveying to ensure that it is properly zeroed (i.e., reading 0 ± 1 mS/m). Prior to data collection a zero adjustment will be completed for the EM31, if the initial check indicates that the EM31 is not properly zeroed. This procedure, which is performed with only the transmitter coil connected, is conducted as follows:

- i) Turn the instrument on using the MODE switch, set to OPER position and check the zero reading.
- ii) Turn the RANGE switch to 1,000 mS/m; tolerance for this check is ± 1 mS/m on the conductivity meter.
- iii) If a zero adjustment is required, adjust the DC Zero Control at the side of the console box using a small screwdriver to obtain a zero value.

1.3.3.2 EQUIPMENT FUNCTIONAL CHECK

The functional check for the EM31 consists of the following procedures:

- i) Set RANGE switch to 100 mS/m. (if reading on the meter is off-scale, i.e. >100 mS/m, set to 1000 mS/m.
- ii) Set MODE switch to OPER position and adjust the in-phase meter reading to zero using the COARSE and FINE COMPENSATION controls; tolerance for this check is +0.1 ppt.
- iii) To check the phase of the instrument, set the MODE switch to PHASE position. Note meter reading and rotate the COARSE control one step clockwise. If the conductivity meter reading remained the same (tolerance ± 0.2), the phase is already correct. Return COARSE control to its original position.
- iv) If there is a difference in the readings, with the COARSE control in its original position, adjust the PHASE potentiometer about 1/4 turn clockwise. Repeat the phase test. If the difference in readings has decreased, repeat procedure or if the difference has increased, the PHASE potentiometer should be rotated counter-clockwise.
- v) Always remember to set the COARSE control back to its original position. This can be confirmed by checking that the in-phase meter reads zero with the MODE switch set to OPER.
- vi) To check the sensitivity of the instrument, set MODE switch to COMP position and rotate COARSE control clockwise one step. The conductivity reading should change between 22 to 26 mS/m.

1.3.4 FILE SETUP AND DATA ACQUISITION

Once the initial tests and calibration have been completed, position the instrument so that it rests on the hip. Set MODE switch to OPER position and rotate the RANGE switch so that the conductivity meter reads in the upper two-thirds of the full range. Check the data logger rechargeable battery daily by switching on the data logger and at MODE prompt, press 0. Use arrow keys to select BATTERY, then press Enter. Switch on the data logger and at MODE prompt, press 0. Use arrow keys to select EM31, press ENTER.

Complete the file setup sequence as follows:

SET CLOCK (y/n): N

FILE: Enter filename (Use Shift keys to select letters)

PHASE Q/I/B: Select what parameter to record (**Q**uadphase/**I**nphase/**B**oth)

MODE V/H/B: Select which dipole orientation to record (**V**ertical/**H**orizontal/**B**oth)

ORIENTATIONS 1/2: **1** or **2**

OPERATOR: Enter operator's name (typically operator's initials; press ENTER to store)

COMMENT: Enter comment (not mandatory, press ENTER to skip)

AUTO (Y/N): **Y**es or **N**o, and indicate time per reading

LINE: Enter line number, then ENTER

DIR W/E/S/N: Select direction of the line (Conventionally N or S)

START STATION: Enter start station, then ENTER

INCREMENT: Enter station increment

ENTER: Commences logging, or activates PAUSE mode during logging

NEW LINE: Press 4 (Enter survey line number, start station, and survey direction)

Press ESC Only use when finished logging

Other available options include the following:

MEMORY: Press 2 (confirm how much available data storage space is left on logger)

NEXT STN: Press 5 (automatically skips a station)

REVIEW DATA MODE: Press 6 (review previous station information)

COMMENT: Press 7 (enter a comment)

1.3.5 FIELD NOTES

Field notes will be recorded using a dedicated field/survey note book and will contain:

- Date
- Project Number/Name/Location
- File Name
- Operator
- Survey Type (EM61, EM31 etc)
- Survey Mode: (manual, auto, or GPS)
- Fiducial marker intervals
- Comments on the grid location, reference points, site conditions, and grid alignment

The header for recording line data will follow the following format:

<u>LINE NUMBER</u>	<u>START STATION</u>	<u>END STATION</u>	<u>COMMENTS</u>
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The "Comments" section will be used to record field observations such as the location of surficial metal objects, building foundations, variable terrain, overhead power lines, etc.

1.3.6 DATA DOWNLOAD

DAT31W is the download and data processing software provided by Geonics. The following steps comprise the download sequence:

- i) Attach the transfer cable to USB port using a serial adapter and plug it into the Polycorder data logger.
- ii) Open the DAT31W program and turn the Polycorder on.
- iii) Press 0 (zero) at the MODE prompt on the Polycorder and scroll to DUMP31W, click ENTER and the Polycorder will read "waiting for entry in the PC".
- iv) Select "Data Transfer" and then "Download EM31 Files for the Polycorder 600" and a window will prompt for the selection of files and will request the directory/folder where the data will be stored - click the "Download" button.

1.4 FOLLOW-UP ACTIVITIES

The following activities shall be performed at the completion of the field work.

1. The equipment will be cleaned and returned to the equipment administrator or equipment rental company. The equipment will be decontaminated at the site. No cleaning will be performed at any CRA office.
2. The EM31 data files will be processed as colored, contour plots. At the completion of the field investigation all data files will be merged, and processed as colored contour plots for each survey area. These plots will be superimposed on a base plan of the Site outlining the surveyed areas. Anomalies detected by the EM31 survey will be identified. The highest intensity metallic responses will be colored dark purple to red, background responses will be indicated in blue. All remaining intermediate responses will correspond to the color scale presented on the plot/figure.

3. The field book and project files will be stored at the CRA office.
4. A memo/report will be completed, outlining the results of the survey. The colored contour plots will be presented, in addition to recommendations, including intrusive activities, if necessary.
5. All final data, figures, memo/report will be checked by the Project Manager and Project Geophysicist.

1.5 CONTACT INFORMATION

The following CRA personnel may be contacted regarding EM31 survey procedures or additional information:

<i>Contact</i>	<i>Office</i>	<i>Phone Number</i>	<i>Fax Number</i>
Joe Rothfischer	Waterloo	519 884-0510	519 725-1158
Andrew Madery	Waterloo	519 884-0510	519 725-1158
Sandy Serena	Waterloo	519 884-0510	519 725-1158

APPENDIX J-F-4

EM61 SURVEY

STANDARD OPERATING PROCEDURE FOR EM61 SURVEY

1.0 EM61 SURVEY STANDARD OPERATING PROCEDURE

1.1 GENERAL

Electromagnetic (EM) surveys are useful as preliminary non-intrusive investigations for the location of buried metallic objects. One Instrument commonly utilized for buried metal investigations is the EM61 manufactured by Geonics Limited.

The EM61 consists of rectangular transmitting and receiving coils measuring approximately 1.5 by 3.0 feet, connected to a Juniper Systems Pro4000 data logger. The transmitting coil emits 150 EM pulses per second into the ground at each measuring point. During the off-time between transmitted pulses, the receiver coil measures the decay of the transient electrical currents induced by the pulses. Electrical currents in moderately conductive earth materials (including moist clays, mineralized soils, etc.) dissipate rapidly, leaving only the more prolonged currents due to buried metal objects. The EM61 detects and measures the prolonged transient currents, yielding a result in millivolts (mV) proportional to the metallic content of the buried object, and inversely proportional to its depth of burial. A single 55-gallon drum can be generally be detected to depths of approximately 10 feet below ground surface (bgs).

The EM61 is commonly used to detect and locate the following buried metal targets:

- Drums
- Disposal sites
- Unexploded ordinance (UXOs)
- Underground storage tanks (USTs)
- Metallic pipes

The benefits of an EM61 survey are:

- Non – invasive
- Quick data acquisition, in wheel mode track spacing is fixed at 0.63 feet per data point and is independent of instrument speed
- Stacked coil design (transmitter/receiver) reduces cultural interference

- Real time data display
- Quick data processing and turn-around

1.2 PRIOR PLANNING AND PREPARATION

The following shall be taken into consideration prior to conducting the EM61 survey:

- Review with the Project Manager the Work program, project documents, Job Safety Analysis (JSA), and site-specific Health and Safety Plan (HASP).
- Complete an equipment requisition form and gather all equipment and supplies required to complete the EM61 Survey.
- Pre-survey planning must be performed with the geophysicist to determine type of data collection, grid setup, survey line spacing and orientation.

EM61 survey data is collected in two modes, wheel-odometer mode or GPS-auto mode. In odometer mode data recording intervals and record instrument position on the survey line are controlled by an odometer-counter located on the right instrument wheel. Trigger interval is fixed by the manufacturer at 0.63 feet. Factors that can affect accuracy of increments are tire pressure and the ground conditions of the survey area (i.e., grassed, pavement, rocks, uneven ground). This mode requires the reference grid line spacing, location and layout to be designed to optimize the detection of survey targets. Small grids can generally be established by the operator, while larger extensive grids require grid points to be surveyed in using total station or GPS survey equipment. These reference points are typically set up on a 100-foot or 150-foot spacing in a grid pattern, depending on survey line spacing. The GPS-auto mode is used to record data if the odometer mode is either not available or impractical to use. In this mode data is collected at a time interval specified by the operator with the location of the data point referenced by the GPS receiver. Survey line alignment should be designed perpendicular to the target feature (if known), i.e., for E - W pipe alignment, survey lines must be run N -S.

Additional preparation prior to mobilization to the EM61 survey location includes:

- Complete an equipment requisition form and assemble all equipment and relevant supplies.
- Assemble the updated site plans, establish survey coverage area(s) and determine survey limitations.

- iii) Ensure GPS grid reference points (staked) have been established and obstacles and brush have been removed.
- iv) Check EM61 availability and status, ensure all components are present in working order.
- v) Obtain site access.
- vi) Determine survey notification needs with the Project Coordinator. Verify that the Client, regulatory agency, and landowner have been notified.

1.3 FIELD PROCEDURES

1.3.1 REFERENCE GRID SET-UP

Prior to commencement of the EM61 survey, reference grids will be established over each area of investigation. The grid line spacing, location and layout will be designed to optimize the detection of the target. As previously indicated, in order to ensure complete survey coverage of the area(s) of interest, the EM61 survey will be completed using line spacings determined by the project geophysicist. In order to facilitate use of the EM61 data logger, each reference grid will be designated with a Cartesian coordinate system (X,Y) prior to data collection.

With the reference grids established using GPS surveyed reference points, individual survey lines can be established between the control points. Line are marked using plastic pin flags and paint to mark the grid surface at predetermined spacings throughout the area of interest.

1.3.2 EQUIPMENT ASSEMBLY

The coils are assembled, and then the wheels and the cart handle are connected to the coil frame. The coil assembly is connected to the Backpack with a power cable, and the data logger (PRO4000) is connected from the Backpack using a serial cable. Prior to data connection the rechargeable battery is connected to the backpack and the volume is turned up to ensure the battery is functioning. These procedures are described in detail as follows:

- i) Assemble EM61 coil assembly including wheels, Juniper Digital Data Recorder, and Backpack (console) with battery, ensuring correct connector cable connections are made, and console mode knobs are set appropriately.

- ii) Turn Power on to Backpack (console) and Juniper Digital Data Recorder and allow to warm-up 5 to 10 minutes.
- iii) The ProShell operating program should be in operation on the Juniper Digital Data Recorder. If not, and the following is displayed on the logger screen C:\>, execute ProShell by typing the characters "ps" and pressing the "ENTER" key.
- iv) From the ProShell menu, select and execute the file "EM61MK2.EXE", by pressing the "ENTER" key twice.
- v) From the EM61MK2 Main Menu, select and execute the Monitor/Null option.
- vi) The Monitor/Null Menu will be displayed and a calibration period lasting no longer than ten seconds will be initiated.
- vii) Once the calibration is finished, check that readings from all four channels are being displayed and updated at a rate of approximately 10 cycles per second.

1.3.3 FILE SET-UP AND DATA ACQUISITION

From the main menu select 'Create File' option and 'ENTER' key. Press 'F3' (Overwrite File) use the date as the new file name i.e. July 1, 2008 would have a file name JULY01A. "A" designates the first file "B" the second, etc. Press 'F1' and "ENTER" key and exit to the main menu.

The 'Survey Set Up' option will need to be completed prior to logging data and includes:

- Operation Mode
- Station Interval (value may have changed after odometer calibration has been completed)
- Line Number
- Line Increment
- Line Direction
- Start Station Number
- Station Increment positive or negative

Once these values have been entered, press 'F1' (OK) and exit.

When ready to collect data, select 'Log Data' option from the main menu. The EM61 will briefly read 'calibrating' for a few seconds, followed by "Standby". Press "ENTER" to

start logging. The equipment can be paused at anytime by pressing "ENTER". At the end of the survey line pause the equipment and press "F1" (next line set up) and repeat.

It is necessary when recording data or calibrating to allow the equipment to warm up for 5 to 10 minutes. Throughout the survey check the battery voltage to ensure manufacturers minimum voltage (10.5 V) required for operation is maintained.

1.3.4 EQUIPMENT CALIBRATION QA/QC

The EM61 requires periodic calibration by the manufacturer in accordance with the manufacturer's specifications, and also in accordance with CRA's ISO 2001 registration. A copy of the most recent calibration completed by Geonics for the EM61 is available.

The following calibrations will also be completed for each new data file during the course of the survey: null calibration and odometer/wheel calibration. These calibration procedures can be further described as follows.

1.3.4.1 NULL CALIBRATION

Prior to data collection, a null calibration must be performed to zero the instrument to reduce/eliminate external noise. Each new file created will require null calibration to be performed. With the equipment running, select Null Mode in the data logger. Move the EM61 across the area to be surveyed while watching the mV readings on the screen to ensure that the values are representative of the site's background response or as low as possible and press 'OK'. This will reset the mV value to zero.

1.3.4.2 ODOMETER/WHEEL CALIBRATION

In wheel/odometer mode, the manufacturer's specified spacing for data collection is fixed at 0.63 feet for cold tires. With the time of season (heat/cold) and changing terrain, the odometer must be calibrated between every file to account for daytime heating and surface roughness. Setup a temporary file in the data logger. Measure and mark a known distance (using an existing grid line). Set the EM61 on the line, and with the instrument in data collection mode move the instrument along the line to a known end point. At the end of the line check the distance recorded by the instrument; if it does not correspond to the actual distance measured adjust the interval value accordingly and repeat the steps above.

1.3.5 FIELD NOTES

Field notes will be recorded using a dedicated field/survey note book and will contain:

- Date
- Project Number/Name/Location
- File Name
- Operator
- Survey Type (EM61, EM31 etc.)
- Survey Mode: (wheel)
- Comments on the grid location, reference points, site condition, and grid alignment

The header for recording line data will follow the following format:

<u>LINE NUMBER</u>	<u>START STATION</u>	<u>END STATION</u>	<u>COMMENTS</u>
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The 'Comment' section will be used to record field observations such as the location of surficial metal objects, building foundations, changes in terrain, overhead power lines, etc.

1.3.6 DATA DOWNLOAD

Connect the data logger (Juniper Pro4000) to the computer using COM1 on the logger to the USB port on the computer. Create a file to download the data and open Juniper's Lynx software. Click on the 'Connection' tab and wait until connected and click on the 'Download from remote' tab. Check to ensure all data are present using the DAT61MK2 software provided by Geonics.

1.4 FOLLOW-UP ACTIVITIES

The following activities shall be performed at the completion of the field work.

- i) The equipment will be cleaned and returned to the equipment administrator or equipment rental company. The equipment will be decontaminated at the site. No cleaning will be performed at any CRA office.

- ii) The EM61 data files will be processed as colored, contour plots. At the completion of the field investigation all data files will be merged, and processed as colored contour plots for each survey area. These plots will be superimposed on a base plan of the site outlining the surveyed areas. Anomalies detected by the EM61 survey will be identified. The highest intensity metallic responses will be colored dark purple to red, background responses will be indicated in blue. All remaining intermediate responses will correspond to the color scale presented on the plot/figure.
- iii) The field book and project files will be stored at the CRA office.
- iv) A memo/report will be completed, outlining the results of the survey. The colored contour plots will be presented, in addition to recommendations, including intrusive activities, if necessary.
- v) All final data, figures, memo/report will be checked by the project manager and project geophysicist.

1.5 CONTACT INFORMATION

The following CRA personnel may be contacted regarding EM61 survey procedures or for additional information:

<i>Contact</i>	<i>Office</i>	<i>Phone Number</i>	<i>Fax Number</i>
Joe Rothfischer	Waterloo	519 884-0510	519 725-1158
Andrew Madery	Waterloo	519 884-0510	519 725-1158
Sandy Serena	Waterloo	519 884-0510	519 725-1158

APPENDIX J-F-5
GROUND PENETRATING RADAR SURVEY

STANDARD OPERATING PROCEDURE FOR GROUND PENETRATING RADAR SURVEY

1.0 GROUND PENETRATING RADAR (GPR) SURVEY STANDARD OPERATING PROCEDURE

1.1 GENERAL

Ground Penetrating Radar (GPR) is a non-intrusive geophysical survey technique that can be utilized for various geologic investigations. However, limitations of GPR surveys include signal attenuation (i.e., dissipation) in conductive soils and/or fill, as well as conductive groundwater or seawater. In addition, heavily vegetated or wooded terrain may affect the degree of contact or coupling of the GPR antennas with the ground, thus decreasing the signal penetration into the subsurface. An experienced geophysicist should be consulted during contemplation and design of any geophysical survey.

In heavily vegetated or wooded terrain, a RAMAC Rough Terrain Concept Antenna (RTA) series RAMAC GPR system may be utilized. This system consists of an external PC/Monitor, a radar control unit, transmitting and receiving antennas, and a hip-chain odometer. This system utilizes radar antennas which are mounted on an in-line configuration that is pulled along a survey line.

GPR systems utilize high frequency (MHz range) EM signals to investigate the subsurface. Pulsed EM waves emitted from a transmitting antenna are propagated into the ground, and travel at velocities determined by the electrical properties of earth materials. If a wave hits a buried object or boundary with different electrical properties as it moves downward, part of the wave energy is reflected back to the surface and is detected by a receiving antenna. The reflected wave is stored digitally, and processed as a trace of signal versus amplitude. As the antennas are moved along a survey line, a series of traces are recorded at discrete points. When presented collectively, these traces display a profile of the subsurface.

GPR surveys are commonly used for the following applications:

- Stratigraphic investigations
- Determining depth to bedrock
- Fracture and void detection within bedrock
- Detection of buried Underground Storage Tanks (USTs)
- Utility line locates

The benefits of a GPR survey are:

- Non – invasive
- Quick data acquisition
- Real time data display
- Quick data processing and turn-around

1.2 PRIOR PLANNING AND PREPARATION

The following shall be taken into consideration prior to conducting the GPR survey:

- i) Review with the Project Manager the Work program, project documents, Job Safety Analysis (JSA) and site-specific Health and Safety Plan (HASP).
- ii) Pre-survey planning must be performed with the geophysicist to determine grid setup, survey line spacing, and orientation.

Additional preparation prior to mobilization to the GPR survey location includes:

- i) Complete an equipment requisition form and assemble all equipment and relevant supplies.
- ii) Assemble the updated site plans, establish survey coverage area(s), and determine survey limitations.
- iii) Ensure GPS grid reference points (staked) have been established and obstacles and brush have been removed.
- iv) Check GPR availability and status, ensure all components are present and in working order.
- v) Obtain site access.
- vi) Determine survey notification needs with the Project Coordinator. Verify that the client, regulatory agency, and landowner been notified.

1.3 FIELD PROCEDURES

Upon completion of planning and preparation activities, the GPR survey can proceed. The GPR survey typically consists of the following:

- Charge equipment batteries
- Reference grid setup
- Assemble the equipment
- PC/Monitor setup
- Test unit to ensure equipment is working properly
- Field note completion, review, and checking
- Data download
- Documentation submitted to appropriate staff and files

i) Charge Equipment Batteries

Prior to mobilizing to the job site, ensure that all batteries (antenna batteries and radar control unit batteries) for the RAMAC GPR system are fully charged. Battery chargers will be included on the equipment list for projects that are expected to last more than a single day. All equipment batteries shall be charged nightly.

ii) Reference Grid Setup

Prior to commencement of the GPR survey, reference grids will be established over each area of investigation. The grid line spacing, location, and layout will be designed to optimize the detection of the target. As previously indicated, in order to ensure complete survey coverage of the area(s) of interest, the GPR survey will be completed using line spacings determined by the project geophysicist. Each reference grid will be designated using a Cartesian coordinate system (X,Y) prior to data collection.

With the reference grids established using GPS surveyed reference points, individual survey lines can be established between the control points. Lines can be marked using wooden stakes, plastic pin flags, or paint to mark the grid surface at predetermined spacings throughout the area of interest.

iii) Assemble the Equipment

The equipment shall be assembled according to manufacturer's specifications. The transmitting antenna and receiving antenna are mounted on an in-line configuration that is connected to the radar control unit via fiber optic cables. Each antenna is outfitted with a rechargeable battery pack.

The radar control unit is mounted in a backpack and is connected to the external PC/Monitor via a parallel communication cable. A rechargeable battery supply is used to supply both the radar control unit and PC/Monitor. The PC/Monitor is mounted on a chest plate that is attached to the backpack's front shoulder straps. The hip-chain odometer is connected to the radar control unit via a serial port connection and worn on the hip of the operator. The hip-chain odometer is used to measure survey line distance as the operator traverses a survey line.

iv) PC/Monitor Setup

Prior to collecting data it is important to ensure the PC/Monitor is set up correctly for all data collection parameters. These parameters include: antenna size, time window/depth, velocity, acquisition mode, sampling interval, antenna spacing, and signal position.

These parameters can be accessed by selecting the "Tools" option on the main menu of the PC/Monitor. Selecting "Tools" will present the options menu to change the antenna, time window, velocity, acquisition mode, and point distance parameters. Each parameter should be reviewed and changes made as necessary to ensure the proper settings have been selected. This can be completed as follows from the "Tools" menu:

1. Select "Antenna" (using the turn-push button, the setting to be changed is chosen and the button pressed to activate it), choose the appropriate antenna (i.e., 25 MHz, 50 MHz, or 100 MHz).
2. Select "Time Window" and choose the appropriate time window/depth of investigation required.
3. Select "Velocity" and choose the appropriate velocity of the subsurface medium. Velocity can vary depending on the type of subsurface material.
4. Select "Acquisition Mode" and choose "Wheel", for type of distance recorder.
5. Select "Wheel" and choose hip-chain as the type of distance odometer. A hip-chain is used as the odometer method to measure distance traveled along each survey line.

6. Select "Point Distance" and choose the appropriate sampling interval for data collection. This interval should not be larger than the size of the object being investigated.

Once all the parameters have been chosen, the changes must be saved. Select "Save" before exiting the screen.

Acquisition Parameters should also be reviewed to determine if adjustments are necessary and can also be accessed from the "Tools" menu. Acquisition Parameters require specific data regarding antenna separation and measurement direction associated with the selected GPR antenna. Adjustments to the acquisition parameters should be completed as necessary to ensure the proper settings have been selected and can be completed as follows from the "Acquisition Parameters" menu:

1. Select "Antenna Separation" and enter the appropriate distance between antennas. This distance is different for different antenna configurations.
2. Select "Measurement Direction" and choose "Forward", the direction the data will be collected in.

Again, once all parameters have been chosen, the changes must be saved. Select "Save and Exit" before exiting the screen.

Signal Parameters should also be reviewed to determine if adjustments are necessary and can also be accessed from the "Tools" menu. Signal Parameters require specific adjustments to the GPR signal to optimize first arrival in the time window. Adjustments to the signal parameters should be completed as necessary to ensure the proper settings have been selected and can be completed as follows from the "Signal Parameters" menu:

1. Select "Adjust Signal Position" and adjust the GPR signal to optimize first arrival in the time window.

Again, once all parameters have been chosen, the changes must be saved. Select "Save and Exit" before exiting the screen.

Once the PC/Monitor has been properly set up for the data collection parameters, data collection can begin. For each survey line, data traces are saved digitally. Data collection is initiated and recorded in a data file by selecting "New" on the Main Menu screen. To stop collecting data, select "Stop" on the same menu screen.

As a measurement is started, the data are automatically saved in a data file. Each data file is given a unique auto-selected file name by the PC/Monitor (i.e., DAT_0001.rd3). For each survey line the operator will record the survey line number, start station, end station, length of survey line, and the associated data file name in a field book along with any comments (i.e., record field observations such as the location of surficial metal objects, building foundations, changes in terrain, overhead power lines, etc.).

v) Test Unit to Ensure Equipment is Working Properly

Prior to collecting data, the equipment will be tested to ensure that all components are working properly. Test measurements shall be completed to ensure the odometer is working properly and the PC/Monitor parameters are correct. Any necessary adjustments shall be completed prior to collecting data.

vi) Field Note Completion and Review

The GPR survey information will be recorded in a standard bound "survey" type field book. The field book shall identify the following:

- Date of survey
- Project information - number, name, and location
- Operator name
- Type of survey
- PC/Monitor parameter settings (i.e., antenna size, antenna spacing, time window/depth, velocity, sampling interval, acquisition mode - hip chain)
- Survey grid information (i.e., grid tie-in information, control point tie-in, etc.)
- Survey line spacing
- For each survey line record: survey line number, start station, end station, length of survey line, data file name, any comments (i.e., surficial metal objects or sources of interference, changes in terrain, overhead power lines, etc.)

viii) Data Download

Collected survey data will be downloaded from the PC/Monitor to a USB removable hard drive. The data will then be copied from the USB removable hard drive to a laptop or PC for data processing.

ix) Documentation Submitted to Appropriate Staff and Files

Copies of field notes will be sent to the field file. The field book will be kept at a CRA office.

1.4 FOLLOW UP ACTIVITIES

The following activities shall be completed at the conclusion of the field work:

- i) Ensure grid tie-in information is collected and/or grid control points are surveyed.
- ii) Equipment shall be cleaned at the Site, and subsequently returned to the rental supplier.
- iii) Copies of field notes shall be sent to file. The field book will be stored at a CRA office.
- iv) Data processing and write up.

1.5 CONTACT INFORMATION

The following CRA personnel may be contacted regarding GPR Surveys, procedures, or for additional information:

<i>Contact</i>	<i>Office</i>	<i>Phone Number</i>	<i>Fax Number</i>
Joe Rothfischer	Waterloo	519-884-0510	519-725-1158
Sandy Serena	Waterloo	519-884-0510	519-725-1158
Andrew Madery	Waterloo	519-884-0510	519-725-1158

APPENDIX J-F-6
MAGNETOMETER SURVEY

STANDARD OPERATING PROCEDURE FOR MAGNETOMETER SURVEY

1.0 MAGNETOMETER SURVEY STANDARD OPERATING PROCEDURE

1.1 GENERAL

Magnetometer surveys are useful as preliminary non-intrusive investigations for the location of buried ferro-metallic objects. One instrument commonly utilized for buried metal investigations is the GEM GSM-19 Overhauser Magnetometer (GSM-19).

The magnetometer records total magnetic field data from two sensors, top and bottom. The difference in total magnetic field between the two sensors divided by the vertical distance between the sensors equals the magnetic gradient. Magnetometers detect the presence of ferro-metallic objects, and are capable of lateral resolution of anomalies (i.e., anomalous responses are often observed adjacent to the buried object in addition to directly over the object). This allows for greater line and station spacings, and relatively rapid coverage of an investigative area. During the course of the survey, repeat readings will be recorded at a base station location situated away from any source(s) of magnetic interference to assess the degree of naturally-occurring diurnal variation (i.e., magnetic drift).

The GSM-19 consists of one sensor for the magnetometer and two for the gradiometer connected to a data console. Sensors are dual-coils designed to reduce noise and improve gradient tolerance. The coils are electrostatically shielded and contain a proton rich liquid in a sealed bottle radio frequency (RF) resonator.

The magnetometer is commonly used to detect and locate the following buried metal targets:

- Drums
- Disposal sites
- Underground storage tanks (USTs)
- Metallic pipes

Limitations of a magnetometer survey include interference from metallic objects such as:

- overhead powerlines
- buildings
- other large ferro-metallic objects

1.2 PRIOR PLANNING AND PREPARATION

The following shall be taken into consideration prior to conducting the magnetometer survey:

- i) Review with the Project Manager the Work program, project documents, Job Safety Analysis (JSA), and site-specific Health and Safety Plan (HASP).
- ii) Pre-survey planning must be performed with the geophysicist to determine type of data collection, grid setup, survey line spacing and orientation.

Additional preparation prior to mobilization to the magnetometer survey location includes:

- i) Complete an equipment requisition form and assemble all equipment and relevant supplies.
- ii) Assemble the updated site plans, establish survey coverage area(s) and determine survey limitations.
- iii) Ensure GPS grid reference points (staked) have been established and obstacles and brush have been removed.
- iv) Check magnetometer availability and status, ensure all components are present in working order.
- v) Obtain site access.
- vi) Determine survey notification needs with the Project Coordinator. Verify that the Client, regulatory agency, and landowner have been notified.

1.3 FIELD PROCEDURES

1.3.1 REFERENCE GRID SET-UP

Prior to commencement of the magnetometer survey, reference grids will be established over each area of investigation. The grid line spacing, location and layout will be

designed to optimize the detection of the target. As previously indicated, in order to ensure complete survey coverage of the area(s) of interest, the magnetometer survey will be completed using line spacings determined by the project geophysicist. Each reference grid will be designated using a Cartesian coordinate system (X,Y) prior to data collection.

With the reference grids established using GPS surveyed reference points, individual survey lines can be established between the control points. Lines are marked using stakes, plastic pin flags, or paint to mark the grid surface at predetermined spacings throughout the area of interest.

1.3.2 EQUIPMENT ASSEMBLY

Equipment should be assembled in accordance with manufacturer's specifications. Assembly of the equipment consists of installing the sensor at the top of the staff that is mounted on a backpack harness. The sensor cables are connected to the GSM-19 console that is worn on the front of the operator, which is attached to the front straps of the backpack harness. The magnetometer is powered by a 12-Volt built-in rechargeable battery. All data are stored digitally in the GSM-19 console.

1.3.3 FILE SET-UP AND DATA ACQUISITION

Prior to collecting data, it is important to ensure the GSM-19 console is set-up correctly for all data collection parameters. These parameters include: survey mode, positioning system, time, filename, cycle time, tuning, and AC filters.

These parameters can be accessed in the "Survey Menu". The "Survey Menu" can be accessed from the "Main Menu" by pressing "A" on the GSM-19 console. Each parameter should be reviewed and changes made as necessary to ensure the proper settings have been selected. This can be completed as follows from the "Survey Menu":

2. Select "Survey Mode" and choose the appropriate survey mode (i.e., mobile, base, grad, walkmag, or walkgrad).
3. Select "Position" and choose the appropriate positioning system to be used for the survey grid (i.e., Line/Station Grid System). Line/Station Grid System allows the operator to utilize a Cartesian coordinate system to enter the line number, and start and stop stations in relation to the survey grid.

4. Select "Time" and ensure the correct date and time are entered in to the console. Ensuring correct time is entered is important for conducting the magnetic drift correction at the data correction stage.
5. Select "File" to enter the name of the data file. Typical file naming convention uses the date as the new file name. For example July 1, 2008 would have a file name JULY1A. The "A" designates the first file, then "B" would designate the second file, etc. and continued for each separate file collected in a day.
6. Select "Cycle Time" and choose the appropriate cycle time (data collection time interval between readings) for the survey mode selected. (i.e., 0.5 to 2.0 seconds for walking modes).
7. Select "Tuning" and choose the appropriate tuning method to be utilized (i.e., auto-tune). The "Tuning Initialize" is a function responsible for finding the precession signal (similar to a radio station). This allows the unit to automatically scan through its range for the initial tuning setting. Once tuning is initialized, the value of the tuning parameter depends on the auto-tune setting. The Auto-tune function tracks the precession signal as it changes in amplitude.
8. Select "AC Filter" and choose whether a filter is required. AC filtering controls whether 50 Hz or 60 Hz filters are added for suppression of noise from powerlines.
9. Select "Sensors" and set the distance between gradiometer sensors. This change is only allowed once per file before the first reading is taken.

Once all parameters have been properly selected, data collection can begin. Data collection is initiated and recorded in a data file by pressing "A" to start the survey and then "C" to start walking. To stop collecting data press and hold "A" until the display becomes blank.

1.3.4 BASE STATION SET-UP/ TIE-POINT ACQUISITION

In order to correct for diurnal variation, the magnetometer survey shall include the use of a base station (tie-point correction location). The base station will be established in an area free of ferro-magnetic debris, and tie-point readings will be recorded several times a day during the course of the survey. Tie-point readings will be recorded at a minimum of every 4 hours, to verify that the diurnal variation in the earth's magnetic field is negligible (i.e., <50 nT). Tie-point corrections will involve collecting repeated magnetic measurements at the tie-point location throughout the day, as the operator collects data along the survey grid. Solar forecasts will be reviewed on a daily basis and

in instances where increased solar activity is forecast, the magnetic survey will be temporarily suspended.

The tie-point corrections option is accessed from the "Survey Menu". The "Survey Menu" can be accessed from the "Main Menu" by pressing "A" on the GSM-19 console. The operator will then choose "Tie-Point". The operator will then determine if the noise of the reading is acceptable. If the reading is acceptable the operator will select "OK" and the system will record the reading. The system will then return to the reading menu such that the operator can continue collecting data along the survey grid. The above steps will be repeated each time the operator collects a tie-point correction reading.

1.3.5 FIELD NOTES

Field notes will be recorded using a dedicated field/survey note book and will contain:

- Date
- Project Number/Name/Location
- File Name
- Operator
- Survey Type
- Survey Mode: (walking grad)
- Comments on the grid location, reference points, site condition, and grid alignment

The header for recording line data will follow the following format:

<u>LINE NUMBER</u>	<u>START STATION</u>	<u>END STATION</u>	<u>COMMENTS</u>
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The 'Comment' section will be used to record field observations such as the location of surficial metal objects, building foundations, changes in terrain, overhead power lines, etc.

1.3.6 APPLY DIURNAL CORRECTIONS

All data collected will be corrected for diurnal variations as required. As discussed in the Base Station Set-up/Tie-Point Acquisition section above, the magnetometer survey will include the use of a base station (tie-point correction) to determine diurnal variation. The operator will choose a tie-point (base station) in the survey grid.

Tie-point corrections will involve repeated measurement of magnetic values at the tie-point location. At a minimum of every 4-hours, the operator will return to the tie-point location and take a reading, while continuing to make regular measurements along the grid. This will continue for the duration of the day. Upon completion of the day, the operator will apply the tie-point correction to the data. This is completed as outlined below.

From the Main Menu of the GSM-19 console the operator can access the "Tie-point" menu option. Once inside the "Tie-Point" menu, the operator will select "diurnal correction". This option will automatically correct the survey data for diurnal variation using linearly interpolated tie-points. Once the correction has been applied the data can then be downloaded for processing.

1.3.7 DATA DOWNLOAD

Collected survey data will be downloaded from the GSM-19 console to a computer or lap top computer.

1.4 FOLLOW-UP ACTIVITIES

The following activities shall be performed at the completion of the field work.

- i) The equipment will be cleaned and returned to the equipment administrator or equipment rental company. The equipment will be decontaminated at the site. No cleaning will be performed at any CRA office.
- ii) The magnetometer data files will be processed as colored contour plots. At the completion of the field investigation all data files will be merged, and processed as colored contour plots for each survey area. These plots will be superimposed on a base plan of the site outlining the surveyed areas. Anomalies detected by the magnetometer survey will be identified.
- iii) The field book and project files will be stored at the CRA office.
- iv) A memo/report will be completed, outlining the results of the survey. The colored contour plots will be presented, in addition to recommendations, including intrusive activities, if necessary.
- v) All final data, figures, memo/report will be checked by the project manager and project geophysicist.

1.5 CONTACT INFORMATION

The following CRA personnel may be contacted regarding magnetometer survey procedures or for additional information:

<i>Contact</i>	<i>Office</i>	<i>Phone Number</i>	<i>Fax Number</i>
Joe Rothfischer	Waterloo	519 884-0510	519 725-1158
Andrew Madery	Waterloo	519 884-0510	519 725-1158
Sandy Serena	Waterloo	519 884-0510	519 725-1158

APPENDIX J-F-7

**HOLLOW-STEM LEAD-SLOT AUGER BOREHOLE ADVANCEMENT AND SAMPLE
COLLECTION**

STANDARD OPERATING PROCEDURE FOR HOLLOW-STEM LEAD-SLOT AUGER BOREHOLE ADVANCEMENT

The SOP for the hollow-stem lead-slot auger for investigation outside/within the Disposal Areas is as follows:

1. The drill rig, augers, cutting bits, and associated equipment will be decontaminated prior to starting and between boreholes following procedures in Section 7.2 of the FSP. All split-spoons and sampling equipment will be decontaminated between samples following procedures in Section 7.1 of the FSP
2. The drill rig is set up at the drilling location.
3. The boring is advanced from waste material surface using 4.25-inch inside diameter hollow-stem augers. The lead auger is a slotted auger.
4. Continuous waste material samples will be collected using 3-inch outside diameter split-spoons to the bottom of waste. During borehole advancement, leachate fluid sampling and NAPL level monitoring will be conducted. At the waste material/native soils contact, DNAPL field screening will be conducted.
5. Following the collection of the DNAPL screening sample noted above, the borehole will be advanced into native material. Continuous soil samples will be collected during borehole advancement using a 2-inch outside diameter split-spoon.
6. Once the water table within the upper aquifer has been encountered, groundwater samples will be collected at 5-foot intervals beginning no deeper than 5 feet below the top of the water table. The water table position in each borehole will be determined through the visual examination of split-spoon soil samples for saturated conditions and the measurement of water levels within the hollow-stem augers.

Where the water table is coincident with the leachate level or with the waste material/native soils contact, vertical aquifer sampling will begin at five feet below the waste material/native soils contact.

Groundwater samples will be collected by means of a Grundfos (or equivalent) submersible pump. The pump assembly would consist of the pump and an inflatable packer attached to stainless steel riser pipe. The purpose of the packer is to isolate the lead-slot auger from the water column above it. The pump/packer assembly will be lowered into the annulus of the hollow-stem augers such that the pump is near the mid-point of the lead auger with the packer at the top of the lead-slot auger. Any water lost during drilling will be measured and twice that volume will be removed prior to purging 3 to 5

lead-slotted auger volumes. This pre-purge may be done at higher flow rates than the regular purging. At each sample interval, approximately 3 to 5 lead-slot auger volumes of groundwater will be purged prior to sample collection (the slotted auger volume is approximately 4 gallons). The purge rate will not exceed 2 gallons per minute and will be done at the same flow rate as sampling.

The number of auger volumes purged will be determined by comparing the results of the field parameters after each volume. Stabilization parameters will be measured with a flow through cell. VAS sampling activities will be recorded using the Monitoring Well Purging Record. The groundwater will be considered stable after a maximum of five auger volumes are removed or when three successive readings for pH, specific conductance, turbidity and temperature agree within the following limits:

pH	± 0.1 pH unit
Specific conductance	± 3% (temperature corrected)
Temperature	± 1.0 °C
Turbidity	= or < 5 NTU

Following the completion of purging of each sample interval, the pump flow rate will be reduced to the lowest sustainable flow rate.

7. Collect a groundwater sample for vertical profiling as per procedures presented in Section J 2.7.1 of FSP utilizing the low flow rate discharge from the submersible pump for collecting the sample. The groundwater sample for each interval will be collected directly from the pump discharge into the sample containers. The groundwater samples will be handled, stored, and analyzed consistent with the procedures in Section J5.0 of the FSP.
8. Following the collection of each groundwater sample, the pump/packer assembly will be removed from the annulus of the hollow-stem augers. The pump/packer assembly will be decontaminated between samples following procedures in Section J 7.1 of the FSP.
9. Upon completion of borehole advancement and upper aquifer VAS, the borehole will be filled with bentonite grout (Aqua Guard or Quik-Grout) emplaced via a tremie pipe while withdrawing the augers from the borehole.

Procedures for related activities are provided in the FSP and include:

- Decontamination (Section J 7.0)
- Handling of Investigation Derived Waste (Section J 8.0)
- Field Quality Control Sampling (Section J 4.0)

- Sample Custody and Document Control (Section J 5.0)
- Field Calibration, Preventative Maintenance, and Standard Operating Procedures (Section J 6.0)

APPENDIX J-F-8
DRUM MANAGEMENT

STANDARD OPERATING PROCEDURE FOR DRUM MANAGEMENT

The following presents the procedures associated with drum identification, management and sampling:

- Markings on any drums or other waste containers encountered will be examined, documented, and photographed and keyed to a unique drum identification number;
- The contents of a representative number of drums or other waste containers encountered will be sampled. The containers to be sampled will be selected by the field representative. Samples will be collected in or near test pits from containers that are ruptured and whose contents are readily accessible. Samples from undamaged drums will be collected from the drum following placement in the overpack. Liquid samples will be analyzed for the parameters and using the methods specified in Table 1; and
- Empty drum overpacks will be maintained at the Site during excavation. Should an intact waste container be damaged during excavation, it will be immediately removed from the excavation and placed in an overpack. Any material that becomes visibly impacted by a release from a damaged waste container will also be removed from the excavation and placed on a separate sheet of polyethylene adjacent to the test pit. All overpack drums and excavated visibly impacted material will be handled in accordance with the procedures detailed in the Field Sampling Plan for handling investigation-derived wastes.

APPENDIX J-F-9
SOIL VOC SCREENING

STANDARD OPERATING PROCEDURE FOR SOIL VOC SCREENING

Scope and Application: This method is applicable to screening VOCs in the headspace of soil samples.

Method: Photoionization Detector (PID)

Sensitivity: Approximately 0.5 ppm depending on background

Optimum Range: Background to 2,000 ppm

Sample Handling: Determined on site

Reagents and Apparatus:

1. Mini Rae Plus Classic Photoionization Detector (PID) 10.6 eV and 11.7 eV lamp choice;
2. Calibration gas (commercially available standard cylinders containing isobutylene);
3. Calibration apparatus and tubing; and
4. Battery chargers.

Procedure:

1. Calibrate meter using the instrument manufacturer's calibration procedure attached.
2. The samples for VOC headspace screening will be prepared in the field by filling a 2- or 4-ounce soil jar to one-half its volume and sealing with a teflon-lined closure. Alternately, a polyethylene bag with zipper-type closure (e.g., Ziploc brand) may be used. The remaining sample will be placed in the appropriate jars for the analyses required.
3. Allow the sample for VOC headspace screening to remain at ambient temperature for a minimum of 10 minutes. This will allow for VOCs in the soil to reach equilibrium in the headspace of the container.
4. Remove the lid of the soil jar or open the bag slightly and insert the probe of the meter into the headspace.

5. Take the highest reading from the meter or readout of the instrument.
6. Record the reading in the field logbook.
7. Recheck calibration with calibration gas after a minimum of every 10 samples and after the last sample.

Quality Control:

1. Calibration check results must be ± 10 percent of the true value. If the result is outside of ± 10 percent, recalibrate the meter as specified above.
2. Duplicate samples are not analyzed since the headspace VOC readings will vary considerably as the soil VOCs volatilize.

Interferences and Limitations:

Humid conditions will cause a negative bias to the reading. The photoionization detection principle used by the instruments will not detect all VOCs. The instrument is most sensitive to aromatic, alkene and alkyne VOCs.

APPENDIX J-F-10
LANDFILL GAS MONITORING

STANDARD OPERATING PROCEDURE FOR LANDFILL GAS MONITORING

Monitoring combustible gas, pressure, and water levels at landfills is required to assess the presence, migration, and extent of landfill gases. Monitoring and sampling of landfill gas can be conducted at wells, gas probes, within landfill gas collection system piping, at the landfill surface, within buildings and structures, in soils adjacent to landfills, and in the ambient air above a landfill.

Landfill gas is primarily composed of two major gases: methane (CH₄) and carbon dioxide (CO₂). Other components of lesser quantity include nitrogen (N₂), oxygen (O₂), and odorous compounds. VOCs are also found in landfill gas at low or trace concentrations, usually at parts per million or parts per billion levels. A further trace compound commonly found in landfill gas is hydrogen sulfide (H₂S), which, in addition to being corrosive, presents a health and safety issue at low concentrations. The composition of landfill gas is variable from landfill to landfill and at different locations within a landfill.

Landfill gas investigations should be designed by considering the geology and hydrogeology of the site, the type and age of the waste, waste cell construction techniques, the operating period of the site, any existing gas control measures, the potential for off-site impacts, data from past monitoring rounds, and other factors that may be relevant.

Typical goals of landfill gas investigations include:

- to assess compliance with provincial/state, or federal air quality standards, methane limits in buildings, or methane levels in soil at the site property line
- to evaluate the potential for landfill gas migration in the vicinity of buildings or off site
- to assess the effectiveness of landfill gas control measures
- to identify the quality and quantity of component gases for design or evaluation of disposal via flaring/treatment or use as an energy source (methane)
- to identify the trace volatile components in landfill gas associated with corrosion of landfill gas handling equipment, odors, or other problematic conditions
- to record and evaluate parameters related to landfill gas collection or migration such as: groundwater level, gas flow, gas pressure, and gas concentration

The following sections discuss landfill gas monitoring primarily as it relates to migration monitoring which is the landfill gas monitoring activity that CRA is most commonly involved in. Activities such as gas system monitoring or air quality testing are site specific. Assistance in developing programs for landfill gas monitoring of any type may be obtained by contacting the appropriate personnel within CRA.

PRIOR PLANNING AND PREPARATION

Careful planning should be carried out prior to conducting field work.

Several of the field instruments used by CRA for various landfill gas monitoring tasks are listed below:

- portable combustible gas meter (lower explosive limit (LEL), percent by volume)
- oxygen meter (incorporated into some combustible gas meters)
- magnehelic pressure gage [0 to 2 in. W.C., 0 to 10 in. W.C., 0 to 2 pounds per square inch (psi)]
- digital manometer (typically 0 to 20 in W.C.)
- liquid manometers
- electronic water level indicator
- pitot tube
- digital thermometer

"in. W.C." inches of water column. 1 in W.C. = 0.036 psi = 0.25 kPa.
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In addition to the above, appropriate PPE must be utilized by trained personnel in accordance with the HASP. PPE may include the following:

- protective suits (Tyveks), hard hats, boots, gloves, goggles, etc.
- respirator
- confined space entry kit including; air monitor, harness, lifting device, Self-Contained Breathing Apparatus (SCBA) (two each), standby and rescue personnel, and communications and transportation equipment

Therefore, prior to conducting LFG monitoring, CRA staff should:

1. Review the HASP with the Project Coordinator. Monitoring personnel and Project Coordinators must fully understand the objectives and methodology for the field program.
2. Ensure that all parties have been notified that monitoring on site is scheduled. Monitoring locations may, at times, be located on private lands. Coordination of property access should always be discussed with the Project Coordinator in advance of field activities. Where applicable, a Property Access/Utility Clearance Data Sheet (QSF-019) must be completed for the field activity.
3. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any vendors that do not have full approval status on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work, QSF-031 for U.S work) is necessary for all vendors who complete field services. Prior to mobilization on site, the vendor must submit the form to the Regional Health and Safety Manager for review and approval (if not already posted on QSL-004).
4. Assemble the necessary information which may include the site plan, probe and/or gas extraction well details, monitoring port details, data recording sheets, and previous monitoring data (if available). Determine number of points to be measured and the data required for each location.
5. Complete a Field Equipment Requisition Form (QSF-014) and assemble all equipment and supplies required per the Landfill Gas Monitoring Equipment and Supply Checklist (Form SP-26). Ensure that the equipment selected fully meets the objectives of the Work Plan and HASP.
6. Obtain monitoring probe/chamber and site access keys.
7. Determine notification needs with the Project Coordinator.
8. Contact CRA's Chemistry group to arrange/determine:
 - sampling equipment
 - cooler
 - shipping details
 - start date
 - laboratory
 - expected sampling duration

These considerations should have been incorporated during development of the site-specific Work Plan and should be discussed with the Project Coordinator.

EQUIPMENT DECONTAMINATION

On all sites, equipment coming in contact with the leachate or groundwater, including manual water level measuring devices, will be decontaminated as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with deionized water.
3. Air dry for as long as possible.

In addition, the following steps may be added when sampling for VOCs and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap equipment if possible in aluminum foil to prevent contamination.

All sampling equipment (pumps and tubing) involving air sampling with a pump must be sufficiently purged of all contaminated air. This should be done according to manufacturer's specifications where available. Typically this will involve allowing atmospheric air to run through the pump and sensors for a sufficient period of time so as to flush out contaminated air.

EQUIPMENT

The landfill gas monitoring personnel must familiarize themselves with each type of equipment to be used, and must fully understand the use and limitations of the equipment. The calibration of meters/ detectors should be verified prior to each use.

PRESSURE MEASUREMENT EQUIPMENT

Monitoring of the gage pressure (or vacuum) at monitoring probes provides useful data for assessing the migration of combustible gas at a site. The following describe the three most common tools for measuring pressure for landfill gas monitoring. Pressure measurements are referenced relative to atmospheric pressure (i.e., gage readings). All devices listed below are subject to influence by wind blowing across the open gage

port/hose and by significant changes in barometric pressure. Care should be taken to shelter the open port/hose.

Whenever practical, a record of hourly barometric pressure readings should be obtained for the 24-hour period immediately prior to the monitoring round. These data could be obtained from an on-site weather station or a nearby weather station. Barometric pressure data will identify any significant (sudden) changes in barometric pressure that occur prior to or during monitoring that may affect the pressure readings in the probes.

U-Tube Manometer

A U-tube manometer is used to measure positive, negative, or differential pressures in inches of water column (in. W.C.) (or displaced fluid), psi, or other units. A U-shaped tube is filled about half way with fluid (to zero point) with both ends opened to the atmosphere. Application of a positive or negative pressure by connection of one end to the probe will result in a change in fluid level; the total difference in fluid level represents the pressure (or vacuum). These types of manometers can be made of glass, rigid plastic, or flexible plastic tubing. Accuracy of vertical U-tube manometers is generally limited to ± 0.1 in. W.C. This may be improved somewhat by use of an inclined manometer. Fluid manometers are subject to cold weather effects. Care must be taken to ensure the correct gage fluid with a known specific gravity is used.

Magnehelic Pressure Gage

A magnehelic pressure gage senses changes in gas pressure through the use of an internal diaphragm. When connected to a probe, subsurface gas pressures are indicated in inches of water column or other units. This gage is capable of reading both positive, negative and differential pressure conditions. Separate gages are available to accommodate varying ranges of gas pressure and measurement accuracy. The more accurate (low range) gages must be held in a vertical plumb and level position for accurate readings. Magnehelic gages should be handled carefully and should be re-zeroed and recalibrated regularly.

Digital Manometer

The digital manometer is used to measure both static and differential pressures of the system at the extraction wells. The manometer should measure pressure/vacuum in the range of from 0 to 40.0 in WC pressure or vacuum with a measurement accuracy of ± 0.1 . For finer adjustments to the LFG collection system, a manometer with a range of 20.0 in WC may be required. Static pressure is measured relative to atmospheric

pressure by connecting the positive (+) tubing lead from the manometer to the monitoring port being sampled. The pressure should only be recorded once the monitoring port ball valve is opened and pressure equilibrium is attained. Any fluctuating/pulsating pressures should also be noted.

Care must be taken when obtaining pressure readings to insure that connections are tightly sealed. Any liquid in the monitoring tubes will cause errors in the readings taken.

PORTABLE LFG ANALYZER

The portable LFG analyzer permits field measurement of combustible gas (methane), carbon dioxide, oxygen, and balance gas concentrations in the LFG. The high range measures from 0 to 100 percent combustible gas by volume for all gases. The unit is calibrated for combustible gas using methane in air.

A typical unit used for LFG measurements is a LandTec GA-90/GEM500/GEM2000. This is a portable analytical unit that measures methane, carbon dioxide and oxygen on a percent by volume basis, and provides a read-out for balance gases (typically) nitrogen. A LandTec unit comes equipped with a sample pump that draws landfill gas through tubing and filters for measurement. Typically, a manometer or other instrument used to measure gas pressure is used prior to utilizing the LandTec in order to screen for positive pressure and to avoid introduction of liquid water into the LFG analyzer.

The portable LFG analyzer is operated by connecting the meter's tubing to the monitoring port being sampled. Sampling is continued until sufficient volume has been purged through the sample lines to ensure that a representative sample has been evacuated through the instrument. A reading may be taken when a stable concentration is indicated on the display.

Care must be taken when obtaining gas readings to ensure that connections are tightly sealed.

A portable LFG analyzer does not meet the requirements for use as a personal safety device. This unit is to be used for analytical purposes only and may not be used to detect the presence of combustible gases for confined space entry. A portable air monitor is required for confined space entry.

ADDITIONAL PORTABLE COMBUSTIBLE GAS METERS

The choice of an appropriate gas meter is dependent on the characteristics of the required measuring point, the type of data required, and the accuracy required. Guidance as to the proper instrument should be discussed with the Project Coordinator or employees within CRA familiar with LFG monitoring.

While they do have slightly different meanings, the terms combustible, explosive, flammable, and ignitable are often used interchangeably. Most of the gas sensing devices respond to all combustible gases present. As such, the concentrations measured are usually expressed as an equivalent to a known calibration gas. In the context of landfill gas monitoring, calibration gas for combustible gas meters should be a methane/air (LEL) or a methane/CO₂/N₂ (percent VOC) mix. Results from meters calibrated with other combustible gases (i.e., hexane) may be converted to methane equivalents as long as no other combustible gases are present in the sample. As most of these units do not differentiate combustible gases, results obtained should always be reported as the concentration of combustible gas and not as the concentration of methane or propane or hexane, etc.

Methane is explosive in concentrations ranging between approximately 5 and 14 percent by volume in air; thus, 100 percent of the LEL is generally taken to equal 5 percent of methane in air. For lower concentrations of methane, often the percent LEL is reported, since monitoring often is mandated based on concentrations at or below the LEL. Combustible gas content measured in the field may be expressed as the equivalent percent methane by volume in air. Alternatively, concentration may be expressed as the equivalent percentage of the LEL of methane in air. Monitoring results must clearly state which units the levels are being reported in.

Most of the portable combustible gas meters which are readily available are sensitive to varying degrees to the following:

- extreme cold, high humidity, dust
- rough handling
- incorrect sample flow rates and pressures

Care must be taken to understand the limitations of the instrument to avoid erroneous results. The most common operator error with these instruments is to force gas through the unit at excessive flow or pressure or to connect the meter directly to a high vacuum source.

While flame ionization detectors (FIDs) and photoionization detectors (PIDs) are commonly used for environmental monitoring, these units are not generally utilized for landfill gas monitoring. The undifferentiated organic content of landfill gas is usually not of interest in landfill gas investigations. FIDs and PIDs may be useful as a component of a HASP at a landfill.

Portable combustible gas meters may be equipped with a variety of sensors. A discussion of all possible sensor variations is outside the scope of this manual. Some comments regarding the five most common combustible gas sensors available are provided below.

Catalytic Oxidation Detectors

Catalytic sensors typically consist of a pair of filaments. One filament is coated with a catalyst (usually platinum or palladium) that oxidizes the gas mixture thereby increasing its temperature and the other filament is uncoated and not exposed to the gas. The temperature difference generates an unbalanced electrical signal that is proportional to the concentration of the combustible gas. These types of sensors are useful in measuring relatively low concentrations of combustible gas in air, for example, percent LEL of methane. However, they will respond to any combustible gas, and therefore must be calibrated for the specific gas under investigation. The catalytic sensor usually requires oxygen levels above 14 percent by volume to sustain oxidation; therefore, measurement of samples with low oxygen may result in erroneous readings.

Catalytic sensors may be "poisoned" temporarily (by sulfur or halogen compounds) or permanently (by lead or silicone compounds). Therefore care must be taken when monitoring at locations where these compounds may be present. Frequent calibration checks are required when the sensor is exposed to these atmospheres.

Thermal Conductivity Detector

The thermal conductivity detector (TCD) measures the cooling effect that the flow of sample gas has when passed over a heated wire filament. This is compared to the cooling effect of a known concentration of a standard calibration gas at the same flow rate. The response is proportional to the concentration of combustible gas which may be present.

These detectors can measure high concentrations (up to 100 percent, by volume) of combustible gases but are not as sensitive at low concentrations. This sensor is not as susceptible to "poisoning" or low oxygen environments as the catalytic sensor.

Mixtures of gases (such as methane and carbon dioxide) can cause inaccuracies in the instrument because each gas affects the thermal conductivity of the cell in a different manner. Therefore it is essential the instrument be properly calibrated with an appropriate gas mixture (i.e., methane and carbon dioxide for landfill gas monitoring).

When an instrument has dual scales for both LEL and percent by volume of combustibles, typically both catalytic combustion and thermal conductivity detectors are incorporated into the instrument.

Infrared Gas Analyzer

Infrared gas sensors measure the concentration of a selected gas species in an air mixture by measuring the infrared absorption of the selected gas. Typically this equipment consists of an infrared source and an infrared detector. Percent methane by volume and LEL readings are available with this type of sensor. The wavelengths of the analyses must be selected to reduce interference or false positive readings. As this type of unit measures the infrared absorption signature of the compound, manufacturers indicate that readings represent the concentration of the actual compound that the unit is calibrated for. Units with infrared sensors often offer options to measure other gases, including CO₂, O₂, and N₂.

Solid State Sensor

Semiconductor sensors utilize a principle similar to that of catalytic combustion, but rather than using a catalyst to react, they have a semiconductor material "doped" with impurities to selectively oxidize selected compounds of interest. This type of sensor is relatively new for portable gas detectors and this sensor type can be tuned to respond to a wide variety of compounds.

Electrochemical Sensor

The electrochemical sensor is commonly used to detect a specific gas (i.e., toxic gas sensor). The sensor consists of a gas sensitive electrode using a permeable membrane and a special electrolyte with reference electrode. The rate of the reaction is proportional to the concentration of gas in the sample. Typically oxygen and hydrogen sulfide are the most common type of electrochemical sensors used in landfill gas monitoring. These

sensors typically lose some sensitivity due to moisture and are susceptible to corrosion and chemical "poisoning". These sensors have a limited shelf life (approximately 1 year) regardless of instrument use.

FLOW METER

The volumetric flow meter is used in LFG collection systems to determine the flow of the LFG stream being collected for in-depth monitoring and analysis of the LFG collection wellfield. The volumetric/mass flow meter may be used to measure flow of the gas in any straight section of pipe, however the accuracy of this data will be dependent on the amount of straight pipe before and after the sample port location (ideally five pipe diameters upstream and ten pipe diameters downstream of the sampling port, but actual dimensions must be consistent with manufacturer's specifications). Based on the model, the unit may also measure gas velocity, temperature, differential pressure, and humidity. The most reliable unit will have dynamic compensation for gas density, temperature, and pressure.

The volumetric/mass flow meter is generally operated by inserting a probe directly into the gas stream being sampled. Sample readings are taken at specified intervals in the gas collection piping, which are averaged to represent the flow rate of the entire gas stream.

Care must be taken when obtaining volumetric flow readings to ensure that the probe is orientated correctly in the gas flow and that the connections are tightly sealed.

Alternatively, a pitot tube may be used for flow measurement. However, it is noted that accuracy is reduced somewhat with the use of a pitot tube and its usage is extremely sensitive to operator experience.

PORTABLE AIR MONITOR

The portable air monitor (gas detector) is required to verify the safety of the atmosphere in any confined space prior to entry. Confined space entry is not normally required to complete a round of collection system monitoring, however, should any entry into chambers become necessary, confined space entry procedures must be followed.

It should be noted that the air monitor is a personal safety device and is not recommended for analytical purposes. Direct sampling of LFG may damage the monitor.

WATER LEVEL METER

The water level meter is used to determine the depth of leachate that may have accumulated in each vertical extraction well or probe. The primary purpose of this measurement is to determine how much of the perforated piping of the well is available to collect LFG in each well, or to monitor leachate or water levels within a probe. When combined, the complete set of data for each vertical well indicates a profile of leachate levels over the covered area of the landfill for leachate management purposes.

The water level meter consists of a length tape measure with a probe attached on the end which detects the presence of moisture upon contact with the probe end. The probe is inserted directly into the leachate monitoring port of the extraction well and the tape is extended into the well until either the unit indicates that it has encountered moisture or the bottom of the well has been reached without encountering any moisture.

LANDFILL GAS PROBE AND EXTRACTION WELL MONITORING PROCEDURES

Once the prior planning and preparation activities are completed, gas monitoring can proceed. It is important to note that probe/well pressure is always measured first, followed by combustible gas and finally water or leachate level measurement (where applicable). Upon completing the Landfill Gas Monitoring Equipment and Supply Checklist (Form SP-26) and commencing monitoring, the typical series of events which will take place are:

1. Probe/well identification and inspection.
2. Pressure/vacuum measurement.
3. Gas concentration measurement.
4. Water/leachate level measurement.
5. Field adjustments (where necessary or applicable).
6. Field note completion, review, and check.
7. Documentation submitted to appropriate staff and files.

It is important to note that when monitoring a landfill gas extraction system well field, prior to and after conducting the monitoring in the field, system parameters should also be monitored at the blower building (housing flare/utilization/blower equipment).

System parameters that should be recorded include at a minimum:

- In-line gas levels are measured using the methods described below as well as read from the panel
- Gas temperatures and composition
- System pressure/vacuum on each side of the blower(s)
- Gas flow rate
- Blower operating set-points
- Other site-specific parameters including engine or flare operating parameters

When conducting any monitoring event, record technician name, date, temperature, barometric pressure (start and end of sampling event as available), and weather conditions.

Probe/Well Identification and Inspection

Once at the site and prior to gas measurements, confirm that the probe or gas extraction well has been correctly identified and located. Frequently, sites under evaluation have numerous monitoring probes or probes located in clusters and misrepresentation can easily occur. The monitoring personnel should be alerted to potential stopcock switching, mislabeled locations, or unlabeled probes or gas wells.

Proper probe or well locations can be verified by comparison of the probe and well log details to measured well details (i.e., total well depth, casing diameter, casing stick-up or stick-down distances), field ties, and site plans.

Once the correct monitoring probe/well is identified, the time of the sampling event should be recorded, and a thorough inspection will be completed and recorded in the field book. If it is a LFG extraction well, the initial valve position should be noted. Determine if the cap and lock are secure or if they have been tampered with. If the probe/well is unlocked, replace the lock. Any cracks in the protective casing and/or surface seal should be noted, as well as any surface water ponding in the vicinity of the probe/well.

Note the results of the probe/well inspection (even if it is in perfect condition) and inform the Project Coordinator of any repairs required. Arrange to have any unmarked probes/wells permanently stamped for proper identification. A temporary marking at the time of monitoring should also be performed.

Pressure/Vacuum Measurement

Pressure/vacuum measurements should always be taken prior to combustible gas concentration measurement. Sampling combustible gas first will affect the pressures.

To monitor pressures, the following procedures are implemented in the following order:

1. The positive lead of the pressure gage is connected to the hose barb (if supplied) on the probe and to the upstream side (i.e., landfill site) of the well. Some sites may require other methods to sample the probe or well. Discuss this with the Project Coordinator prior to going out in the field. Ensuring a gastight seal is the primary goal. The positive lead ensures that a positive reading on the meter indicates pressure and a negative reading indicates a vacuum. If magnehelic gages are used, the lead may have to be switched to obtain a reading.
2. Open the stopcock.
3. The probe pressure/vacuum reading is obtained. Record the time of the reading. Any fluctuations in the pressure reading are to be noted and the reading is recorded. If the pressure reading fluctuates, record both the maximum and minimum readings.
4. Close the stopcock.
5. If monitoring a gas well, the pressure/vacuum on the downstream side of the control valve must be monitored after measuring the system vacuum. Repeat steps 1 to 4 above at the second monitoring port.

Combustible Gas Concentration Measurement

To monitor combustible gas concentration in the probe or gas extraction well, the following procedures are implemented in the following order:

1. The combustible gas meter is turned on and allowed to acclimatize. The unit is purged with fresh air and the zero is checked and adjusted if necessary. (The unit should have had a calibration check prior to going to the field.)
2. The combustible gas meter hose is connected to the probe, or for a gas extraction well, to the monitoring port on the upstream side of the well, and the stopcock valve is opened.
3. A sufficient volume of gas (USEPA Method 25c specifies two probe volumes) of the probe and filter pack are purged from the probe prior to reading in order to

allow it to stabilize. A minimum of 110 percent and maximum of 330 percent of the probe and pack volume should be purged prior to taking a reading. The required purge volume should be established prior to going to the field. The flow rate of the combustible gas meter (hand aspirator may be required if meter does not have pump) is typically less than a liter of sample per minute. Higher flow rates are available with sample pumps or vacuum pumps to purge the probe quickly. Care must be exercised to avoid drawing liquids into the portable LFG analyzer, as this will damage the sensors.

4. Monitor the combustible gas concentration after purging and record the stabilized reading (any fluctuations in the reading are to be noted, and record the range of readings). Combustible gas monitoring should begin with the gas meter set to measure the high concentration range (usually 0 to 100 percent by volume). If the reading is less than 5 percent by volume, the instrument should be set to measure the low range (usually 0 to 100 percent LEL). Following this procedure will avoid damaging the instrument. The meter should be fully purged with fresh air after each reading.
5. For a gas extraction well, repeat for the downstream LFG monitoring port (as applicable) to confirm readings obtained for the upstream monitoring port and verify that there is no air intrusion into the system through the wellhead assembly.
6. If the combustible gas meter has other sensors, measure and record these levels.

During field monitoring, all personnel should exercise caution due to the potentially hazardous nature of LFG.

FIELD NOTE COMPLETION AND REVIEW

The pressure, combustible gas concentration, and water levels must be recorded in a standard bound "survey" type field book and/or appropriate site-specific forms. The logbook should identify the following:

1. Identification of sample location/measurement point.
2. Date and time of measurement.
3. Reference point and reference point elevation.
4. Measurement method and identification numbers of equipment used.
5. Depth to water level.

6. Presence of immiscible liquids.
7. Odor (if noted).

The recorded data must be compared to previous results if they are available. While seasonal and weather-related variations in combustible gas and water level occur, any major changes should be noted. All probes and wells which exhibit a significant change should be re-checked immediately prior to moving to the next location. The Project Coordinator must be advised of any significant changes in trends before leaving the site since verification readings or samples may be required.

FOLLOW-UP ACTIVITIES

The following activities will be performed at the completion of the field work.

1. Review and compare newly obtained data with historic data and flag unusual or extreme readings for review.
2. Ensure monitoring probe/well and site access keys are returned.
3. The equipment will be cleaned and returned to the Equipment Coordinator. All equipment will be cleaned at the site.
4. Monitoring forms and field notes will be sent to the file. The field book will be stored at the appropriate CRA office.

REFERENCES

The following references provide further information on conducting landfill gas monitoring:

Conestoga-Rovers & Associates. 1996. Guidance Document for Landfill Gas Management. Environment Canada; Waste Treatment Division.

APPENDIX J-F-11
SOIL GAS PROBE SAMPLING

STANDARD OPERATING PROCEDURE FOR SOIL GAS PROBE SAMPLING

The soil vapor samplers must familiarize themselves with the equipment available, and understand the equipment limitations and use. The following soil gas collection procedure outlines the most common method used by CRA in assessing the vapor intrusion pathway. The typical series of events that will take place are:

- i) Sample location identification/inspection (see below for additional information)
- ii) Air monitoring (see below for additional information)
- iii) Decontamination (see below for additional information)
- iv) Field notes completion, review, checking

Further details regarding items i) to iii) are provided below.

i) Sample Location Identification/Inspection

Once at the site and prior to soil gas sampling, confirm that the sample location (i.e., soil gas probe location) has been correctly identified and located.

ii) Air Monitoring

Prior to inserting the soil gas probe sampling assembly, measure the background air quality with a photoionization detector (PID) to establish baseline levels. Repeat this measurement at the borehole before the soil gas probe sampling assembly is inserted. If either of these measurements exceed any air quality criteria established in the HASP, then air purifying respirators (APRs) or supplied air systems will be required.

iii) Decontamination

All drilling, soil gas sampling, and monitoring equipment must be decontaminated on site. If the site has a specific cleaning protocol, it must be followed.

SOIL GAS SAMPLING PROTOCOL

The following sections describe the protocol for soil gas sampling from permanent soil gas probes, permanent sub-slab soil gas probes, or temporary soil gas probes.. For

evaluating vapor intrusion, permanent soil gas probes are preferable to allow for multiple soil gas sampling events. More than one soil gas sampling event is often required when assessing vapor intrusion to address seasonal variations and temporal variability commonly observed in soil gas concentrations. Temporary soil gas probes are suitable for conducting a screening level assessment where the results could assist in locating future permanent soil gas probes, or as a preliminary evaluation of the extent of VOC impacts to the subsurface (e.g., such as in the case of a soil gas survey).

Soil gas sampling should commence a minimum of 24 hours following installation of the soil gas probes, to allow time for disturbances created by drilling to dissipate and allow the formation to return to an equilibrium condition. In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for equilibrium conditions to become re-established (e.g., 72 hours). Soil gas sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., >0.5 inches after Cal EPA (2003)]. This will avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen soil gas concentrations, or possibly prevent soil gas sample collection (i.e., such as in cases where the soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for rainfall events to dissipate. The potential influence of rainfall events on soil gas concentrations is less of concern in cases where the soil gas probes are located beneath impervious ground cover (e.g., pavement or building foundation).

A summary of the steps involved in soil gas sampling is presented below:

- i) Soil gas samples for assessing the vapor intrusion pathway will be collected using certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for soil gas sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability. Consideration should be given to using smaller capacity canisters to reduce sample volume and increase confidence that the soil gas sample is drawn from the formation immediately surrounding the probe screen during sampling. Larger volume samples can promote drawing ambient air down the annulus of the soil gas probe which can dilute the soil gas sample. The use of the smaller canister sizes becomes more critical in fine-grained soil conditions where the formation may not give up significant soil gas volumes (in this case, ambient air infiltration down the soil gas probe annulus can be more problematic).

- ii) The Summa™ canisters will be fitted with a laboratory calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum soil gas sampling flow rate recommended by Cal EPA (2003) of 100 to 200 mL/min. The 100 mL/min maximum flow rate translates to sample collection times of 10, 17, or 60 minutes, respectively, for 1-, 1.7-, or 6-liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the soil gas probe annulus that would dilute the soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the soil gas sample is drawn from immediately surrounding the screened interval.
- iii) A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory. Using the same vacuum gauge throughout the entire sampling process will eliminate discrepancies between vacuum measurements that can arise from using different gauges with a potentially different sensitivity and/or calibration.
- iv) The canister will be connected to the soil gas probe valve at the surface casing using the sampling assembly that is depicted on Figure 15.5. The sampling assembly is connected using short lengths [e.g., 1-foot (0.3 m)] 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and air-tight stainless steel or brass tee-connectors and tee-valves (e.g., Swagelok® type). The canister will be connected to the soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of soil gas probe, vacuum gauge, pump, and canister). A tee-valve will be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing will be used for each sample.
- v) Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas probe casing/sand pack must be removed. The soil gas probes will be purged prior to sampling using the personal sampling pump at a flow rate of less than 200 mL/min. This ensures that the collected soil gas sample is representative of actual soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be

used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.

- vi) Prior to purging, a vacuum, or tightness, test will be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 15.2.4. Briefly, this first leak-testing step (the vacuum test) will consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the soil gas probe closed. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. Further details of the vacuum test are described below.
- vii) Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps will be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. The tracer compound is either monitored for in the field using a meter connected in-line to sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the soil gas samples (e.g., isopropanol). The set-up requirements of the tracer compound leak-testing step are described below.
- viii) Following the vacuum test, and the set-up for the tracer compound leak-testing step, the soil gas probe purging will commence by opening the valve to the soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™ canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas will be monitored using a portable photoionization detector (PID) meter. The PID meter will be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary from approximately 300 mL/min to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump likely will increase the purging flow rate temporarily until a reading from the PID meter is obtained. PID readings will be recorded and entered in the field logbook and chain of custody form. The PID readings will provide the

laboratory with an indication of whether a sample could require dilution before analysis.

- ix) Following purging, the valve to the personal sampling pump will be closed, and the valves to the soil gas probe and Summa™ canister will be opened to draw the soil gas sample into the canister concurrent with continuing to apply the leak-testing tracer compound. The vacuum gauge reading will be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10-inches mercury (Hg) for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the soil gas probe does not produce sufficient soil gas to permit sample collection.
- x) To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 0.5 to 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain of custody procedures.
- xi) The vacuum gauge provided by laboratory will be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.
- xii) If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they will be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi.
- xiii) The canisters will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all soil gas sampling data.
- xiv) The canisters will be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the

chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The soil gas samples will be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. Quality control/quality assurance (QA/QC) measures implemented during the soil gas sampling event will include the two-step leak testing procedure (see Section 15.2.4), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample.

SOIL GAS PROBE LEAK TESTING

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing will be conducted in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air tight
- Step 2 - Tracer Test: used to ensure that ambient air during soil gas sample collection is not drawn down the soil gas probe annulus through an incomplete seal between the formation and the soil gas probe casing

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly will be connected to the soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test will consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the soil gas probe. The pump will

then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.

- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure will be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) will be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in the dilute solution of isopropanol will be wrapped around the soil gas probe surface casing and ground surface immediately surrounding the surface casing. Soil gas probe surface casing then will be covered over using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface will be accomplished using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the soil gas probe purging, remove the paper towels from the solution wringing out the towels so they are very damp, but not dripping,

before placed them around the vapor probe and sealing them in place using the plastic sheeting.

- The isopropanol solution will be kept fresh, with new solution being made every hour. The solution will be mixed at a central location away from the sampling activities. The isopropanol will be kept tightly capped and kept away from all sampling equipment. The solution will be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel will wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.
- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapours emitted from dilute isopropanol solution will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007). The starting concentration will be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly will be monitored during purging and soil gas sample collection using a helium meter installed in-line with the sampling assembly just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.
- A containment unit is constructed to cover the soil gas probe surface casing. The containment unit will consist of an over-turned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the

containment unit will be confirmed using the helium meter and recorded in the field logbook. Helium will continue to be introduced to the containment unit during soil gas probe purging and sampling, but care will be taken not to increase the pressure within the containment unit beyond that of atmospheric pressure.

- During soil gas probe purging and sampling, the helium meter will be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the containment unit), the soil gas probe will be judged to permit significant leakage such that the collected soil gas sample will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007).
- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

FIELD INSTRUMENTATION CALIBRATION

Sampling or monitoring equipment used in the soil gas and outdoor air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. Field calibration of the personal sampling pump and PID meter will be carried out prior to sampling activities.

The vacuum gauge used to measure canister vacuum will be calibrated and provided by the laboratory. The vacuum gauge will be returned to the laboratory for the laboratory to obtain vacuum measurements prior to sample analysis (checking canister integrity was maintained during shipment). Using a common vacuum gauge will avoid variations in vacuum measurements that can arise due to using different vacuum gauges.

REFERENCES

- Cal EPA, 2003. Advisory – Active Soil Gas Investigations, Department of Toxic Substances Control, January 28.
- Cal EPA, 2005. Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion in Indoor Air. Department of Toxic Substances Control, (revised February 7).

- ITRC, 2007. Vapor Intrusion Pathway: A Practical Guide, January.
- U.S. EPA, 1988. The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis, May.
- USEPA, 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition, EPA/625/R-96/010b, January 1999.
- U.S. EPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, March 2006. EPA/600/R-05/147.

APPENDIX J-F-12
GAS EXTRACTION MONITOR

STANDARD OPERATING PROCEDURE FOR GAS EXTRACTION MONITOR

Scope and Application: This method is applicable to screening methane, carbon dioxide, and oxygen content in landfill gas.

Method: Infrared Gas Analyzer

Sensitivity: ± 1 percent methane by volume
 ± 1 percent carbon dioxide
 ± 1 percent oxygen by volume

Optimum Range: 0 to 100 percent methane
0 to 100 percent carbon dioxide
0 to 25 percent oxygen

Sample Handling: Determined on site

Reagents and Apparatus:

1. Landtec Gas Extraction Monitor, GEM-500 or equivalent
2. Calibration gas (commercially available standard cylinders containing methane, carbon dioxide, oxygen)
4. Calibration apparatus and tubing
5. Battery chargers

Setting Up Gas Extraction Monitor:

1. Ensure the inlet filter is clean by using an Allen key to unscrew the inlet port from the instrument body. Replace inlet filter if needed.
2. Thread the inlet port back into the instrument body and tighten.
3. Check to ensure the sample hose's filter/water trap assembly is clean by disassembling the threaded plastic housing. Replace the filter if needed. Re-thread the plastic housing back together and tighten.

Field Calibration in Procedure:

1. Turn the instrument on by pressing the "Red" button. Press button [0] to exit the MAIN MENU Screen. Press button [1] to enter the GENERAL UTILITIES Screen.
2. Press button [9] for more OPTIONS. Press button [5] for GAS CALIBRATION Screen.
3. Press button [1] to enter the ZERO METHANE Screen. Ensure the instrument is in fresh air.
4. Press button [5] to turn on the GEM-500 sample pump, let purge for approximately 1 minute.
5. Press button [1] to perform the instrument ZERO calibration. If "CH₄ Not Zeroed" was displayed, ensure the instrument is in clean air and re-zero the instrument. If "CH₄ Zeroed" appeared on the display, press the [0] button twice to return to the GAS CALIBRATION Screen.
6. Press button [3] to enter the O₂ CALIBRATION Screen. Press button [2] to calibrate O₂ Span Screen.
7. Press button [5] to turn on the GEM-500 sample pump, let purge for approximately 1 minute.
8. Press button [1] and input the oxygen concentration of the atmosphere (20.8 percent) on keyboard of the GEM-500.
9. Press button [1] to confirm the calibration.
10. Press button [0] until the MAIN MENU Screen appears. The instrument is ready for field use.

Procedure:

1. Connect GEM-500 to a "T" connector of the gas probe so as to measure methane concentration. The "T" connection will be connected to the sample port. Record initial readings for the GEM-500. The valve will then be closed and the "T" connection removed from the gas probe.
2. A personal sampling pump will be added to the sampling train with its intake connected to the sample port and its discharge connected to the "T" connector (GEM-500 is still connected to the "T" connection). The personal sampling pump will be turned on and operated at a low flow rate. Readings will be collected every 30 seconds.
3. Readings will be collected until three consecutive readings are recorded that are within 10 percent of the average of the last three readings. If the aforementioned

stabilization criteria cannot be attained, then readings will be recorded until such time as a maximum of five readings have been collected.

4. Configure GEM-500 so as to measure oxygen concentration and record reading in the field logbook.
5. Configure GEM-500 so as to measure carbon dioxide concentration and record reading in the field logbook.
6. Disconnect personal pump from sampling port. The sampling train will continue to operate for a period of 1 minute, drawing in ambient air, to purge the train of sample.
7. Repeat steps 1 through 6 for each sample.

Quality Control:

1. Calibration check results must be within 10 percent of the true value. If the result is outside of 10 percent, recalibrate the instrument s specified above. Record the calibration standard in the field logbook.
2. Duplicate samples are not analyzed since the headspace readings will vary considerably as volatilization in the soil occurs.

Interferences:

In the event that the GEM-500 is operating during the winter months, the instrument will be stored and maintained in an ambient temperature operating range between 10°F and 104°F.

APPENDIX J-F-13

**ROTONSONIC DRILLING METHOD
(VERTICAL AQUIFER SAMPLING AND MONITORING WELL INSTALLATION)**

**REVISED STANDARD OPERATING PROCEDURE FOR
ROTONSONIC DRILLING METHOD
(VERTICAL AQUIFER SAMPLING AND MONITORING WELL INSTALLATION)**

At each rotonsonic vertical aquifer sampling (VAS) borehole location, a nominal 4-inch diameter borehole will be advanced to a minimum depth of 100 feet below ground surface. In areas of significant groundwater impact, a temporary 7-inch diameter steel casing will be pushed into the upper aquifer prior to advancing the 6-inch diameter borehole into the lower aquifer. The requirement for a temporary 7-inch diameter casing will be based upon the results of the upper aquifer VAS. Continuous soil sampling will be conducted from ground surface to the termination of the borehole.

At each borehole location, rotonsonic VAS will begin at approximately the water table and will continue at 5- or 10-foot intervals as detailed below.

Full details of the rotonsonic borehole advancement and VAS procedures are described in Sections A and B of this SOP.

Monitoring wells may be installed in selected rotonsonic boreholes following procedures outlined in Section J 2.7.1.2 of the FSP.

A. Rotosonic Borehole Advancement

1. The drill rig, drill pipe, cutting bits, and associated equipment will be decontaminated prior to starting and between boreholes following the procedures outlined in Section J.7.2 of the FSP. All sampling equipment will be decontaminated between temporary well screen insertions following procedures outlined in Section J.7.1 of the FSP.
2. The drill rig is set up at the drilling location.
3. The inner core barrel (nominal 4-inch diameter) is advanced 10 feet into the ground without the use of drilling fluids or air.
4. The inner core barrel is removed from the borehole, the sample extruded from the core barrel by vibratory action and placed directly into 5-foot long sealed cylindrical plastic sleeves. The borehole may collapse partially or fully when the core barrel is removed. The soil samples are field screened with a PID and representative soil samples collected for geologic record and soil physical property analyses following procedures outlined in Section J.2.5 of the FSP.

5. The inner core barrel is re-advanced to the previously sampled depth. The 6-inch diameter outer casing is advanced to the same depth. If required, water is injected into the annulus between the 6-inch diameter casing and the 4-inch diameter core barrel to control heaving sands. The volume of water injected during the advancement of the 6-inch casing will be measured using an accurate metering device. Typically only a few gallons are lost to the formation during advancement of the outer casing. The inner core barrel is removed and cleaned out if necessary, if the borehole collapsed after the sample was collected. A fluid head is maintained within the outer casing during removal of the inner core barrel. Some of this fluid may be lost to the underlying formation material.
6. The inner core barrel (nominal 4-inch diameter) is advanced another 10 feet into the ground and the sample collected as noted in Step 4.
7. Continue borehole advancement in 10-foot intervals.

B. Rotosonic Vertical Aquifer Sampling

VAS will be conducted in the aquifers at depth intervals as described in Section J.2.7.1 of the FSP, at either 5-foot or 10-foot intervals beginning approximately at the top of the water table. VAS will be conducted as follows:

1. The inner core barrel is removed. The interval for groundwater sampling is selected based on the review of the extracted core. A groundwater sampling assembly (i.e., temporary well) is installed to the required depth. The temporary well consists of a 10-foot length of No. 10 slot, 2-inch diameter stainless steel screen coupled to a suitable length of 2-inch diameter stainless steel riser pipe over intervals where the same or similar geology has been observed. A 5-foot length of No. 10 slot 2-inch diameter stainless steel screen will be used at intervals where a distinct change in geology has been noted or where the depth to a native till material is 6 feet or less. An inflatable packer is attached to the top of the screen and is used to seal the inside of the 6-inch diameter outer casing from the formation (see attached figure provided by Bowser-Morner). If necessary due to borehole collapse, the temporary well will be pushed and/or vibrated to the required depth.
2. A Grundfos, or equivalent, 2-inch diameter submersible pump, attached to 1/2-inch diameter polyethylene tubing, is installed into the temporary well and set 2.5 feet below the top of the well screen in the upper portion of the 10-foot screened interval or in the center of the well screen where a 5-foot screen is used.

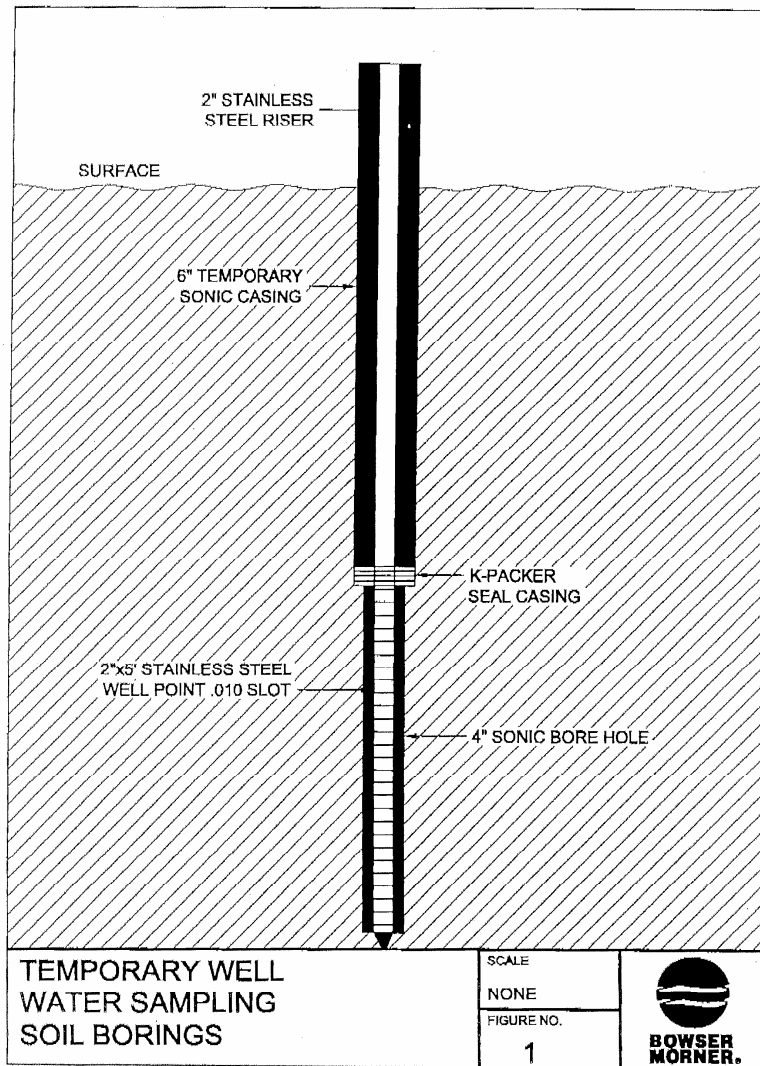
3. In order to collect representative water samples, the amount of water added during the preceding 10-foot advancement of the outer casing will be measured and twice that volume will be removed prior to purging. When using a 10-foot temporary well screen the purging will be conducted with the pump intake set 2.5 feet below the top of the well screen. When using a 5-foot temporary well screen, the purging will be conducted with the pump intake set at the middle of the well screen. This pre-purge may be done at higher flow rates than the regular purging and a further three to five well volumes will be removed prior to sample collection (one well volume equals the number of feet of water within the screen and riser pipe times 0.161 gallons per foot). The regular purging of the well will be done at the same rate as the low flow rate sampling. The water level will be measured within the 2-inch diameter riser pipe using a water level tape (Solinst Model 101 or equivalent) in order to determine well volume. The depth to the bottom of the screen is known. Where a 10-foot temporary well screen is used, the submersible pump will then be lowered to a depth of 7.5 feet below the top of the temporary 10-foot screen and a second groundwater sample will be collected following the procedures provided in B3, B4, and B5 of this SOP. In cases where a 5-foot temporary well screen is used the second groundwater sample will not be collected. In all cases water samples will only be collected after well stabilization is achieved (i.e., a minimum 3 to a maximum of 5 well volumes are purged with monitoring of stabilization parameters) as presented in B4 below.
4. Water samples will be collected and checked following each purged well volume for field measured parameters in order to show stability. Stabilization parameters will be measured using a flow through cell. VAS sampling activities will be recorded using the Monitoring Well Purging Record. The number of well volumes purged will be determined by comparing the results of the field parameters after each well volume. The groundwater will be considered stable after a maximum of five well volumes are removed or when three successive readings for pH, specific conductance, turbidity, and temperature agree within the following limits:

pH	±0.1 pH unit
Specific conductance	±3% (temperature corrected)
Temperature	±1.0 °C
Turbidity	= or <5 NTU

The flow rate for purging of groundwater will be dependent on the capacity of the submersible pump and the transmissivity of the aquifer material. The maximum purge rate would be approximately 2 gallons per minute. Upon

purging of the required screen volumes, the flow rate will be reduced to the lowest sustainable flow rate and sampling will be conducted after purging at least one sample tubing volume (1/2-inch tubing volume = 0.010 gal/foot).

5. Collect a groundwater sample for vertical profiling as per procedures presented in Section J.2.7.1 of the FSP, utilizing the low flow rate discharge from the submersible pump for collecting the sample. The groundwater sample for each interval will be collected directly from the pump discharge into the sample containers. The groundwater samples will be handled, stored, and analyzed consistent with the procedures in Section J.5.0 of the FSP.
6. Remove the temporary well from the outer casing and resume borehole advancement. The temporary well materials will be decontaminated between each temporary well screen insertion following procedures outlined in Section J.7.2 of the FSP. The Grundfos pump and tubing will be decontaminated between each temporary well screen insertion following procedures in Section J.7.1 of the FSP. If the polyethylene tubing becomes damaged or soiled beyond readily decontaminated conditions (i.e., purging of NAPL through the tubing) the tubing will be replaced.
7. Upon completion of borehole advancement and VAS, the borehole will be filled with bentonite grout (Aqua Guard or Quik-Grout) emplaced via a tremie pipe while withdrawing the outer casing from the borehole. If used, the temporary 7-inch steel casing will also be removed at this time.



APPENDIX J-F-14
MONITORING WELL DEVELOPMENT

STANDARD OPERATING PROCEDURE FOR MONITORING WELL DEVELOPMENT

1.0 INTRODUCTION

This procedure is for the development of groundwater monitoring wells that have been installed in overburden, top of bedrock, or deep bedrock formations. Before a newly constructed well can be used for water quality sampling, measuring water levels, or aquifer testing, it must be developed. Well development refers to the procedure used to clear the well and formation around the screen of fine-grained materials (sands, silts, and clays) produced during drilling or naturally occurring in the formation.

Well development is completed to remove fine-grained materials from the well but in such a manner as to not introduce fines from the formation into the sand pack. Well development continues until the well responds to water level changes in the formation (i.e., a good hydraulic connection is established between the well and formation) and the well produces clear, sediment-free water to the extent practical.

2.0 PROCEDURE

The well development procedures presented below are the recommended standards. However, due to variations in conditions, changes in these standards may be necessary in order to facilitate successful monitoring well development.

All of the newly-installed monitoring wells, piezometers, and temporary wells will be developed by alternating cycles of surging and overpumping or bailing at rates that are greater than those used during sampling, not sooner than 48 hours after grouting is completed. A submersible pump may also be used to develop the wells by raising and lowering the pump intake throughout the screened interval. Other well development methods such as air-lift pumping, air surging, and backwashing are unsuitable for the development of small diameter wells. The well development protocol will be as follows:

1. Open the monitoring well, take initial measurements (water level, total depth of monitoring well, pH, temperature, turbidity and conductivity), and record values in the Site field book. The groundwater level will be measured to the nearest 0.01 foot using a pre-cleaned oil/water interface probe or equivalent. Field calibration, preventative maintenance, and SOPs are contained in Section J.6.0. pH, conductivity, and temperature will be monitored using a YSI Model 3560 instrument, or equivalent. Turbidity will be measured using an HF Scientific DRT-15C Turbidimeter, or equivalent.
2. Develop the well by the appropriate method (i.e., surging, overpumping or bailing). Measure turbidity, pH, conductivity, and temperature (stabilization parameters) after each period of purging (following surging). Development will continue until the turbidity of the development water is equal to or less than 5 nephelometric turbidity units (NTUs). In the event that turbidity values of less than 5 NTUs cannot be achieved, well development may also be considered complete if all of the following conditions are met:
 - i. a volume of water has been purged that is equal to or greater than a minimum of ten well volumes in addition to any volume of water or fluid that was introduced into the well and/or formation during construction and development or an amount equivalent to two times the volume of water or fluid introduced during construction and development, whichever is greater; and

- ii. temperature, pH, and conductivity have stabilized to within the following limits:

pH	±0.1 pH unit.
Specific conductance	±3 percent (temperature corrected).
Temperature	±1.0°C.

Field calibration procedures, preventative maintenance procedures, and SOPs are contained in Section 6.0. Decontamination procedures for the surge block and submersible pump are contained in Section 8.0. Decontamination fluids and purge water will be managed as described in Section 8.0.

A. Surging

- i. Gently raise and lower a surge block or surge plunger inside the well (surge block may be affixed to the end of a length of drill rod or drill stem). The resulting surging motion forces water into the formation and loosens sediment to be pulled from the formation into the well. Initial surging will be gentle to ensure water can enter the well and that the surge block is loose enough to prevent damage to the well pipe or screen.
- ii. Periods of surging will be alternated with periods of water extraction (purging) or sand bailing (using a sand bailer) from the well so that sediment, brought into the well, is removed. For 5-foot long well screens in homogeneous formations, the surge block does not have to be operated within the screen interval. If the screened interval includes materials of high and low permeabilities, the surge block may have to be operated gently within the screen.
- iii. The first surging period should be approximately 5 minutes in duration, following which, the accumulation of sediment in the well should be measured. Subsequent surging periods should be performed over increasingly long time periods, keeping records of the rate of sediment entry into the screen. When the sediment accumulated at the bottom of the screen begins to block off a portion of the screen, the sediment should be purged. Purging should continue until the accumulated sediment is removed.
- iv. Measure turbidity, pH, conductivity, and temperature (stabilization parameters) after each period of purging (following surging).
- v. Repeat until sediment-free water is produced.

B. Overpumping

- i. Pump the well at a rate high enough to draw the water level in the well as low as possible, and allow it to recharge. Overpumping may be supplemented with the use of a bottom discharge/filling bailer for sediment removal.
- ii. Water will be removed throughout the entire water column in the well by periodically lowering and raising the pump intake.
- iii. Repeat until sediment-free water is produced.

C. Bailing

Bailers may be used to manually develop small diameter wells that have a high static water table or are relatively shallow in depth (<15 ft).

- i. Attach a bottom discharge/filling bailer to a string or rope. Lower the bailer down the monitoring well, holding onto the other end of the rope.
- ii. Surge the well using the bailer for 10 to 20 minutes prior to beginning bailing. The bailer will be operated throughout the screened interval to achieve the most effective surging action.
- iii. Use a bottom discharge/filling bailer to remove water and/or sediment by rapid short upward/downward motions of the bailer through the screened interval and/or bottom of the well.
- iv. Measure stabilization parameters, as detailed above, following the purging of each well volume (not including the groundwater removed during the first 10 to 20 minute pre-purge).
- v. Repeat until sediment free water is produced.
- vi. Remove the bailer from the well after development is completed.

The time period between development and groundwater sampling will be dependent upon the project objectives, and the chemicals of concern (COCs). When sampling for COCs sensitive to turbidity presence (i.e., SVOCs, PCBs, metals), an extended time period between the development activity and the sampling event will be observed. Sampling will be conducted in accordance with the following:

<i>Primary COC</i>	<i>Time Period Between Development and Sampling</i>
General Chemistry	24 hours
VOCs	24 hours
SVOCs, PCBs, Metals	2 weeks

Waste Disposal

- All waste generated will be disposed in accordance to the methods and procedures contained in Section 8.0 of the FSP.
- All water generated during cleaning and development procedures will be collected and contained in accordance with Section J8.0 of the FSP.
- Personal protective equipment, such as gloves, disposable clothing, and other disposable equipment, resulting from personnel cleaning and monitoring well development procedures, will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

3.0 EQUIPMENT/MATERIALS

- Appropriate health and safety equipment
- Knife
- Field book
- Well Development and Stabilization Form
- Well keys
- Graduated pails
- Surge blocks, surge plunger, bailers and/or pump and tubing
- Cleaning supplies (including non-phosphate soap, buckets, brushes, laboratory-supplied distilled/deionized water, tap water, aluminum foil, plastic sheeting, etc.)
- Water level meter
- pH/temperature/conductivity meter
- Turbidity meter
- Clear glass jars (e.g., drillers' jars)

4.0 REFERENCES

Environmental Protection Agency (1986), RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

Environmental Protection Agency (1987), A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001.

Environmental Protection Agency (1988), Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004.

APPENDIX J-F-15
GROUNDWATER SAMPLING

STANDARD OPERATING PROCEDURE FOR GROUNDWATER SAMPLING

1.0 INTRODUCTION

This procedure is for the collection of groundwater samples for laboratory analysis.

The objective of most groundwater quality monitoring programs is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of the groundwater within an aquifer [e.g., both dissolved and mobile colloid associated particulates (if present)].

One of the most important aspects of groundwater sampling is acquiring samples that are free of suspended silt, sediment, or other fine grained, or artificial (i.e., non-mobile) particulates. Fine grained materials may often have a variety of chemical components sorbed to the particle or have the ability to sorb chemicals from the aqueous phase to the particle which will bias the subsequent analytical results. In most cases, there will be no mobile colloid associated particulates. Where there are mobile particulates, a sample collected without the mobile particulates is not considered representative.

Constituents known to have an affinity for fine grained particulates are: polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and inorganics. Monitoring programs where these constituents are suspected or known to be prevalent must employ sampling methods that minimize non-mobile particulate presence.

The sampling method of "preference" for sites where particulate sorption is an issue is the "low stress/low flow" technique described within this SOP. Experience has shown that the "low stress/low flow" technique typically achieves representative groundwater samples with minimal particulate interference. In addition to the "low stress/low flow" technique, a "traditional sample method" (EPA 542S02-001) has been presented for the collection of constituents less sensitive to the presence of particulates (i.e., general chemistry parameters), or "direct-push sample methods" generally employed as a "pre-screening tool" to evaluate VOC presence. Direct-push sample procedures will result in groundwater samples with particulates present.

Lastly, in "extreme" cases "ultra-low flow" techniques have been employed at select sites where "low stress/low flow" methods were used, yet particulate-sensitive constituents continue to bias the analytical results. Ultra-low flow techniques are conducted at

purging rates below 100 mL per minute, and should only be utilized after careful review and a procedural variance has been approved.

2.0 PROCEDURAL GUIDELINES

The following describes three techniques for groundwater sampling: "Low Stress/Low Flow Methods", "Traditional Sample Methods", and "Direct-Push Methods".

"Low Stress/Low Flow Methods" will be employed when it is critical to collect groundwater samples truly representative of the groundwater present, and to minimize the impact of sediment/ colloid presence. Analyses typically sensitive to turbidity/sediment issues are VOCs, PCBs, SVOCs, and inorganic constituents.

The "Traditional Sample Methods" will be employed where the collection of parameters less sensitive to turbidity/sediment issues are being collected (general chemistry).

The "Direct-Push Methods" are typically employed for pre-screening areas for chemical presence to aid in determining well placement, or the need for further study.

Note: If non-aqueous phase liquids (NAPL) (light or dense) are detected in a monitoring well, groundwater sample collection will not be conducted and the Project Manager must be contacted to determine a course of action.

If deemed necessary to sample groundwater from below a LNAPL layer, a suggested sampling procedure has been presented at the end of this Procedural Guidelines section.

Preparatory Requirements

- Verify well identification and location using borehole log details and location layout figures. Note the condition of the well and inform the Project Manager of any required repair work.
- Prior to opening the well cap, measure the breathing space above the well casing with a PID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the Health and Safety Plan, field personnel should adjust their PPE accordingly.
- A minimum of 24 hours prior to commencing the groundwater purging/sampling tasks, water level and total well depth measurements must be obtained to determine the volume of water in the well. In some settings it may be necessary to allow time for the water level to equilibrate. This condition exists if a water tight seal exists at the well cap and the water level has fluctuated above the top of screen; creating a vacuum or pressurized area within the well casing. Three water level checks will verify static water level conditions or changing conditions. The groundwater level will be measured to the nearest 0.01 foot using a pre-cleaned oil/water interface

probe or equivalent. The total well depth will be measured, from a reference point (i.e., top of casing), to ± 0.01 foot using a pre-cleaned, weighted measuring tape, such as a water level plover. The measured well depth will be compared to the constructed well depth to evaluate the presence of any sediment accumulated at the well bottom. The total depth of the monitoring well will be measured a minimum of 24 hours prior to groundwater sampling or following collection of the groundwater sample.

- Calculate the water volume in the well. Typically overburden well volumes consider only the quantity of water standing in the well screen and riser; bedrock well volumes are calculated on the quantity of water within the open corehole and within the overburden casing.
- Estimate the natural groundwater flow rate into well to determine the approximate pumping rate for purging/sampling activities.

Well Purging and Stabilization Monitoring (Low Stress/Low Flow Method)

- The method of preference for groundwater sampling will be the low stress/low flow method described below.
- Bladder pumps/submersible variable rate pumps (i.e., Grundfos™ Rediflo or equivalent) or peristaltic pumps are typically employed. Purging will be conducted using a pre-cleaned stainless-steel bladder pump with a Teflon® bladder. The pump discharge line and air supply line for the bladder pump operation will be polyethylene and dedicated to the well. The bladder pump will be secured to nylon rope (dedicated to the well) and positioned in the well at least 24 hours prior to commencement of purging and sampling activities, to minimize well disturbance.
- Slowly lower the pump, safety cable, tubing and electrical lines into the well so that the pump intake is at a depth corresponding to the mid-point of the well screen. Peristaltic tubing placement should include a tubing "clamp" at the well head, to minimize vibration transfer into the water column. The pump or tubing intake must be at the mid-point of the well screen to prevent disturbance and re-suspension of any sediment in the screen base. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project.
- Before starting the pump, measure the water level again with the pump in the well leaving the water level measuring device in the well when completed.
- Purge the well at 100 to a maximum of 500 milliliters per minute (mL/min). Initial purging will begin using a pumping rate of 100 mL/min. The groundwater level will be measured while purging to ensure that less than 0.3 feet of drawdown occurs.

The rate of pumping should not exceed the natural flow rate conditions of the well being sampled. The pumping rate may be gradually changed depending upon the amount of drawdown and the behavior of the stabilization (field indicator) parameters. Pumping rate adjustments generally will be made within 15 minutes from the start of purging and then should remain constant for the duration of purging. Care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record adjustments made to the pumping rates and water levels immediately after each adjustment. While purging, the pumping rate and groundwater level will be measured and recorded every 5 minutes. If it is apparent that stabilization of the purged groundwater will not be achieved rapidly, these measurements may be made at longer time intervals, to allow field staff to perform other sampling activities.

- Calibrate field instrument and document calibration activity. Calibration shall be performed in accordance with manufacturer's recommendations and standard operating procedures
- During the purging of the well, monitor and record the field indicator parameters (pH, temperature, conductivity, oxidation-reduction (redox) reaction potential (ORP), dissolved oxygen (DO), and turbidity) approximately every 5 minutes. Stabilization monitoring will be performed using a flow-through-cell. Stabilization is considered to be achieved when the final groundwater flow rate is achieved, and three consecutive readings for each parameter are within the following limits:
 - pH ± 0.1 pH units of the average value of the three readings
 - temperature ± 3 percent of the average value of the three readings
 - conductivity ± 0.005 milliSiemen per centimeter (mS/cm) of the average value of the three readings for conductivity < 1 mS/cm and ± 0.01 mS/cm of the average value of the three readings for conductivity > 1 mS/cm
 - ORP ± 10 millivolts (mV) of the average value of the three readings;
 - DO ± 0.3 mg/L
 - turbidity ± 10 percent of the average value of the three readings, or a final value of less than 5 nephelometric turbidity units (NTU)

pH, conductivity, temperature, and ORP will be monitored using a YSI Model 3560 instrument. Turbidity will be measured using a HF Scientific DRT-15C Turbidimeter. Dissolved oxygen will be measured using a YSI Model 52 instrument. Alternatively, equivalent instruments may be used. At the start of purging, the purge water will be visually inspected for water clarity prior to connecting the

flow-through-cell. While purging, the meter readings will be monitored for evidence of meter malfunction. The following are common indicators of meter malfunctions:

- DO above solubility [e.g., oxygen solubility is approximately 11 milligrams per liter (mg/L) at 10 Celsius] may indicate a DO meter malfunction;
- negative ORP and DO greater than 1 to 2 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have positive ORP and DO greater than 1 to 2 mg/L under oxidizing conditions); and
- positive ORP and DO less than 1 mg/L may indicate either an ORP or a DO meter malfunction (i.e., should have negative ORP and DO less than 1 mg/L under reducing conditions).
- Meter calibration fluids will be available for meter re-calibration in the field, if necessary.
- Should stabilization not be achieved for all field parameters, purging is continued until a maximum of 10 well screen volumes have been purged from the well. Since low-flow purging (LFP) likely will not draw groundwater from a significant distance above or below the pump intake, the screen volume is based upon a 5-foot (1.4 m) screen length. After purging 10 well screen volumes, purging is continued if the purge water remains visually turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization. In the event the monitoring well does not stabilize after the removal of 10 well screen volumes, the monitoring well will be redeveloped. Following redevelopment, the monitoring well will be allowed to stabilize for a minimum of 48 hours prior to purging for stabilization parameter monitoring and sampling.
- If low-turbidity samples are critical to the project goals, purging will be extended until turbidity has been reduced to 5 NTU or less.
- The pump must not be removed from the well between purging and sampling.

Well Purging and Stabilization Monitoring (Traditional Method, EPA542S02-001)

- Typically peristaltic pumps or bladder pumps or submersible pumps are preferred. In most cases, including VOC sampling, bailer use is not desirable due to the "surging" action of bailer entry and removal.
- The pump intake/tubing is typically placed at the mid-point of the screen within overburden wells. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project Work Plan.

- Stabilization monitoring will be performed using a flow-through-cell. At the start of purging, the purge water will be visually inspected for water clarity prior to connecting the flow-through-cell. If the purge water appears turbid, purging will be continued until the purge water becomes visibly less turbid before connecting the flow-through-cell. Purge the well until three consecutive well volume measurements, recorded every 5 minutes, are within the following limits:
 - pH ± 0.1 pH units of the average value of the three readings
 - temperature ± 3 percent of the average value of the three readings
 - conductivity ± 0.005 mS/cm of the average value of the three readings for conductivity < 1 mS/cm and ± 0.01 mS/cm of the average value of the three readings for conductivity > 1 mS/cm
 - ORP ± 10 mV of the average value of the three readings
 - DO ± 0.3 mg/L
 - turbidity ± 10 percent of the average value of the three readings, or a final value of less than 5 nephelometric turbidity units (NTU)

If stabilization has not occurred within the first five well volumes removed, continue purging and monitoring until 10 well volumes have been pumped. After purging 10 well screen volumes, purging will be continued if the purge water remains visibly turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria and appear to be approaching stabilization. In the event that the monitoring well does not stabilize after the removal of 10 well screen volumes, the monitoring well will be redeveloped. Following redevelopment, the monitoring well will be allowed to stabilize for a minimum of 48 hours prior to purging for stabilization parameter monitoring and sampling. Purging rates should not exceed the natural flow rate of groundwater into the well. Elevated purging rates may result in excessive drawdown of the water column, introducing sediment/particulate presence.

- Groundwater turbidity may be evaluated by a visual examination for sediment/silt presence or use of a nephelometer. Work Plan-specific goals may exist for turbidity values which may require extending the purging, or require an alternate pumping system.
- Purging and stabilization activities using a bailer are generally performed at the top of the water column, within the riser pipe/above the well screen. This will minimize sediment disturbance/suspension in the screen area, and move water from the formation into the well screen/riser area in an effort to remove stagnant groundwater within the well. Bottom-loading bailers are generally employed. The

lowering and removal actions are performed slowly to minimize well disturbance. Once stabilization has been attained, the sample aliquots are collected directly from the bailer.

- In the event the well goes dry (poor yielding formations), the purging activities will be performed on 3 consecutive days, noting the field stabilization parameters on each day. After the third day of purging is complete, the sample collection will be performed once sufficient groundwater recharge has occurred.

Sampling Techniques

- If an alternate pump is utilized (i.e., traditional method), the first pump discharge volumes should be discarded to allow the equipment a period of acclimation to the groundwater.
- Disconnect the flow-through-cell prior to obtaining the sample. The discharge line from the pump will be positioned at the base of the sample bottle. Samples are typically collected directly from the pump discharge line with the groundwater being discharged directly into the appropriate sample container. Avoid handling the interior of the bottle or bottle cap and don new disposable latex gloves for each well sampled to avoid contamination of the sample. All required preservatives will be added to the samples in the manner consistent with the appropriate methodology by either placing the preservative in the sample containers prior to sampling or adding the preservative immediately after collection.
- Order of sample collection:
 - VOCs
 - SVOCs, pesticides, herbicides, and PCBs
 - Total organic carbon (TOC)
 - Total organic halogens (TOX)
 - Extractable organics
 - Total metals
 - Phenols
 - Cyanide
 - Sulfate and chloride
 - Nitrate and ammonia
 - Radionuclides

- Dissolved organic carbon (DOC) (field filtered)
- Dissolved metals (field filtered or lab filtered)
- For low stress/low flow sampling, samples should be collected at a flow rate between 100 and 250 mL/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 feet.
- The pumping rate used to collect a sample for VOCs should not exceed 100 mL/min. VOC sample vials (40 mL glass vials) should be filled directly from the pump discharge, until the vials are completely full and topped with a Teflon® cap. Once capped the vial must be inverted and tapped to check for headspace/air presence (bubbles). If air is present, the sampler will attempt to add sample volume to the vial to remove the bubbles. If bubbles continue to form, indicating effervescence, the sample will be discarded and recollected. The laboratory will be notified that the samples are unpreserved and the analyses will be completed within the appropriate holding time (i.e., seven days).
- Field filtration will be performed if required in accordance with the standard operating procedure. Sediment presence can interfere or bias sample results; false positive findings have been observed when turbid samples for hexavalent chromium (and other analytes) are analyzed. Field filtration can eliminate this concern; generally applicable to only inorganic/dissolved organic carbon (DOC)/PCB analysis. In-line disposable filter cartridges are generally the easiest and quickest method for field filtration.
- All equipment used during sampling, which may have come in contact with potentially contaminated waters, will be decontaminated. Latex gloves used during the collection of the samples will be disposed of. The pump discharge line and air supply line will either be dedicated and left hanging in the well or disposed of after the well has been sampled.
- Sample labels/sample identification. All samples must be labeled with:
 - A unique sample number
 - Date and time
 - Parameters to be analyzed
 - Project Reference ID
 - Sampler's initials
- Labels should be secured to the bottle(s) and should be written in indelible inks.
- Upon completion of the groundwater sampling event, a summary of the sampling event will be recorded on the Sample Collection Data Sheet – Groundwater Sampling Program form.

3.0 EQUIPMENT/MATERIALS

- pH meter, conductivity meter, nephelometer, ORP meter, DO meter, temperature gauge
- Field filtration units (if required)
- Purging/sampling equipment:
 - Peristaltic pump (not suitable for VOCs1/SVOCs, or drawing water from depths greater than 25 feet²)
 - Suction pumps (not suitable for LFP, VOCs/SVOCs, or depths greater than 25 feet)
 - Submersible pumps (suitable for VOCs/SVOCs only at low flow rates)
 - Air lift pumps (not suitable for VOCs/SVOCs)
 - Bladder pumps (suitable for LFR and VOCs/SVOCs)
 - Inertia pumps (gaining acceptability for VOCs/SVOCs)
 - Bailers
- Water level probe
- Sampling materials (containers, log book/forms, coolers, chain-of-custody)
- Health and Safety Plan

Note¹: Peristaltic pump use for VOC collection is acceptable on select EPA/RCRA sites; this technique has gained acceptance in select areas. Where it is permissible to collect VOCs using a peristaltic pump, collection must be performed at a low flow rate (Michigan allows VOC sampling with the peristaltic pump).

Acceptability of the collection of VOCs using the peristaltic pump should be evaluated before the sampling program commences, commonly performed during the project Work Plan development and approval process.

Note²: Exception is noted in locations that the suction line can be placed at the desired sample depth (i.e., 100 feet), and the natural recharge maintains a water level within 25 feet of the ground surface.

Field Notes

Field notes must document field activities and measurements collected during the sampling activities. The log book/field file should document the following for each well sampled:

- Identification of well
- PID readings before and after well opening (if required)
- Well depth
- Static water level depth and measurement technique
- Sounded well depth
- Presence of immiscible layers and detection/collection method
- Well yield – high or low
- Purge volume, pumping rate, and final disposition
- Time well purged
- Measured field parameters and meter calibration records
- Purge/sampling device used
- Well sampling sequence
- Sample appearance
- Sample odors
- Sample volume
- Types of sample containers and sample identification
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and method(s)
- Sample distribution and transporter
- Analytical laboratory
- Chain-of-custody number for shipment to laboratory
- Field observations on sampling event
- Name(s) of sampling personnel
- Climatic conditions including air temperature
- Problems encountered and any deviations made from the established sampling protocol

A standard log form for documentation and reporting groundwater purging and sampling events are presented on Form FMG 6.4-01-Well Purging Field Information, Form FMG 6.4-02-Sample Collection Data Sheet, and Form FMG 6.4-03-Monitoring Well Record for Low-Flow Purging.

Groundwater/Decontamination Fluid Disposal

The letter work plan will identify the required disposal procedures for groundwater and decontamination fluids. Groundwater disposal methods will vary on a case-by-case basis but may range from:

- Off-site treatment at private treatment/disposal facilities or public owned treatment facilities
- On-site treatment at Facility-operated facilities
- Direct discharge to the surrounding ground surface, allowing groundwater infiltration to the underlying subsurface regime
- Direct discharge to impervious pavement surfaces, allowing evaporation to occur

Decontamination fluids should be segregated and collected separately from wash waters/groundwater containers. Often small volumes of solvents used during the day can be allowed to evaporate if left in an open pail. In the event evaporation is not possible or practical, off-site disposal arrangements must be made.

4.0 REFERENCES

ASTM D5474 - Guide for Selection of Data Elements for Groundwater Investigations.

ASTM D4696 - Guide for Pore-Liquid Sampling from the Vadose Zone.

ASTM D5979 - Guide for Conceptualization and Characterization of Groundwater Systems.

ASTM D5903 - Guide for Planning and Preparing for a Groundwater Sampling Event.

ASTM D4448 - Standard Guide for Sampling Groundwater Wells.

ASTM D6001 - Standard Guide for Direct Push Water Sampling for Geo-Environmental Investigations.

USEPA Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (EPA/540/S -95/504).

USEPA RCRA Groundwater Monitoring Draft Technical Guidance (EPA/530-R-93-001).

APPENDIX J-F-16
FIELD FILTERING

STANDARD OPERATING PROCEDURES FOR FIELD FILTERING

Scope and Application: This method is applicable to groundwater sampling. Field filtration will be performed if dictated by the project Work Plan. Field filtering is required for some parameter, including but not limited to dissolved metals (unless samples are sent unpreserved to the laboratory and analyzed within 24 hours of collection) and dissolved organic carbon (DOC). Sediment presence can interfere or bias sample results; false positive findings have been observed when turbid samples for hexavalent chromium (and other analytes) are analyzed. Field filtration can eliminate this concern; generally applicable to only inorganic/DOC/PCB analysis. In-line disposable filter cartridges are generally the easiest and quickest method for field filtration.

Equipment: In-line disposable 0.45 µm filter cartridges.

Procedure:

1. Purge the monitoring well to achieve stabilization prior to sampling.
2. Attach the in-line disposal filter cartridge to the sample tubing.
3. Collect the groundwater sample.
4. Use a new filter at each location and discard used filters following appropriate procedures after each use.
5. Repeat steps 1 through 3 for each sample.

APPENDIX J-F-17
PRESSURE TRANSDUCERS

STANDARD OPERATING PROCEDURE FOR PRESSURE TRANSDUCERS

Pressure transducers and recorders are commonly used for short- and long-term monitoring programs, pumping tests, and single well response tests. Pressure transducers contain a pressure sensitive sensor, which measures the pressure effects of water and atmospheric air above the sensor. The pressure reading is then recorded on the transducer's logger at the required interval selected by the user.

There are several brands of pressure transducers available for use, most of which convert the pressure data to a corresponding head of water above the installed depth of the sensor using a simple calculation. To convert accurately to groundwater elevations, several depth to water readings are required. Not all pressure transducers correct for atmospheric pressure; therefore, the barometric pressure must be subtracted from the pressure readings if not automatically done. This is particularly important for data collection during long-term monitoring programs, as the changes in barometric pressure can have a substantial effect on the data being collected by the pressure transducer. Barometric pressure can be corrected by gathering barometric pressure data using a pressure transducer specifically designated for this task, then subtracting the barometric pressure data from the water level pressure data. As an alternative, barometric pressure data can be obtained from local weather office and the effects of the barometric pressure can be compensated for using a simple calculation. Used properly, a pressure transducer is a valuable tool when completing single well response tests, specifically when the hydraulic conductivity of the formation is too fast to monitor changes manually.

EQUIPMENT DECONTAMINATION

Equipment decontamination procedures for a fluid level-monitoring program are described in detail in Section J.7.1 of the FSP.

Equipment is decontaminated between monitoring locations and prior to leaving the site. Upon completion of the monitoring program, all equipment is decontaminated at the site and then returned clean to the appropriate field equipment manager.

For most groundwater, residential, and surface water fluid level monitoring programs, monitoring equipment (e.g., pressure transducers, water level indicators, oil/water interface probes, weighted tapes) are typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dries for as long as possible.

If required, the following steps may be added under specific monitoring programs when certain chemical compounds are present within the monitored media:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.
3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.

REFERENCE POINT

Fluid level measurements are made relative to a surveyed reference point. For groundwater level measurements, the reference point is usually the top of the well riser or casing. (The protective casing should not be used as a reference point.) The top of the well riser/casing is usually not level and/or square; therefore, the reference point must be clearly marked on the riser and noted in the field book. Clearly marking the reference point will eliminate future measurement errors. Measure and record the distance from the reference point to the ground surface. The elevation of the reference point should be determined to the nearest 0.01 foot (1 mm). Typically, the reference point is the highest point on non-level riser pipes.

EQUIPMENT SETUP AND USE FOR ELEVATION MONITORING

1. Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level measurements prior to pressure transducer installation.
2. Decontaminate the pressure transducer using the procedures identified above.
3. Calibrate the pressure transducer/datalogger to static conditions by inserting the pressure transducer into the well a minimum of 4 feet below the top of the water elevation (subject to field conditions and pressure rating of the transducer), record its depth, mark a reference point on the cable using masking tape, connect the electronic data recorder, and check the operation of the system (i.e., water levels are being recorded correctly).
4. Commence recording water levels immediately after installation. Typically the data recorder is set to record water levels at 1-second intervals. However, for

coarse materials (e.g., gravel or coarse sand) and bedrock with frequent and/or large fractures, a shorter time interval may be required (e.g., 0.1 or 0.5 seconds).

5. Prior to removing the pressure transducer from the well, the data should be field checked by transferring the data from the data recorder to an appropriate portable data storage device (i.e., flash drive, disk, etc.) and reviewing the data on the PC. The disk is a backup to ensure the data are not lost. Review of the data may indicate that sufficient data (i.e., 6 or more data points before 90± percent recovery) were not obtained (e.g., the well recovered completely or to a large extent while installing the pressure transducer).
6. At the completion of the test, the non-dedicated equipment shall be properly decontaminated per the letter work plan.

EQUIPMENT SETUP AND USE FOR SINGLE-WELL RESPONSE TESTING

1. Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level measurements prior to pressure transducer installation.
2. Decontaminate the pressure transducer using the procedures identified above.
3. Calibrate the pressure transducer/ and datalogger system to static conditions by inserting the pressure transducer to within 6± inches of the bottom of the well, record its depth, mark a reference point on the cable using masking tape, connect the electronic data recorder, and check the operation of the system (i.e., water levels are being recorded correctly).
4. Insert the pressure transducer to the previously established reference point, connect the data recorder, and continuously record water levels prior to and during single well response testing, i.e., slug testing. Typically the data recorder is set to record water levels at 1-second intervals. However, for coarse materials (e.g., gravel or coarse sand) and bedrock with frequent and/or large fractures, a shorter time interval may be required (e.g., 0.1 or 0.5 seconds). The water levels should also be checked manually to ensure that the well has recovered to 90± percent of the induced change prior to stopping water level recording. If water level measurements are made using either electrical water level indicators or a measuring tape with a plover, follow the procedures for water level monitoring.
5. Prior to removing the pressure transducer from the well, the data should be field checked by transferring the data from the data recorder to an appropriate portable data storage device (i.e., flash drive, disk, etc.) and reviewing the data on the PC. The disk is a backup to ensure the data are not lost. Review of the data may indicate that sufficient data (i.e., 6 or more data points before 90± percent recovery) were not obtained (e.g., the well recovered completely or to a large extent while installing the pressure transducer).
6. For those instances where the data recorded are insufficient, the recovery test must be redone, typically using a shorter time interval for water level recording.

The transducer should be reinserted to the same reference point and a volume of water (50± percent of well volume) rapidly removed using a method which will not damage the pressure transducer or electrical cable (e.g., high rate submersible pump).

7. Should the well recover to static within 20 minutes, consideration should be given to performing two tests to provide confirmatory data.
8. At the completion of the test, the non-dedicated equipment shall be properly decontaminated using the procedures identified above.

FOLLOW-UP ACTIVITIES

The following should be performed once groundwater level monitoring is completed:

1. Double check the letter work plan and QAPP to ensure all levels have been collected and confirm with the Project Coordinator.
2. Decontaminate all equipment at the site then return it clean to the appropriate field equipment manager.
3. Dispose of cleaning fluid as specified in the letter work plan.
4. Complete and file the appropriate forms, data sheets, and field notes. For groundwater, residential, leachate, and surface water fluid levels, these forms include:
 - Water Level Measurement Equipment and Supply Checklist;
 - Project Planning, Completion, and Follow-Up Checklist; and
 - Water Level Record.
5. Return site and well keys.

REFERENCES

For additional information pertaining to fluid level monitoring the user of this manual may reference the following:

ASTM 4750 - Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)

ASTM D6000 - Guide for Presentation of Water-Level Information from Ground-Water Sites

APPENDIX J-F-18
SINGLE-WELL RESPONSE TESTS

STANDARD OPERATING PROCEDURE FOR SINGLE-WELL RESPONSE TESTS

1.0 BACKGROUND

The purpose of the single-well response test is to obtain an estimate of a formation's hydraulic properties (i.e., hydraulic conductivity and transmissivity). The data available from a single-well response test is insufficient to obtain the well property of specific capacity and the formation property of storage coefficient. Longer-term pumping tests are required to estimate these two properties.

Permeability (k) is a function only of the formation properties and has the dimensions L^2 (e.g., cm^2).

Hydraulic Conductivity (K) is a function of both the formation and the fluid properties described by:

$$K = \frac{krg}{\mu}$$

where:

$$\begin{aligned}\square &= \text{fluid density (M/L}^3\text{)} \\ g &= \text{gravitational constant (L/t}^2\text{)} \\ \mu &= \text{fluid dynamic viscosity (M/Lt).}\end{aligned}$$

Note: by convention $M/Lt = 1 \text{ Pa}\cdot\text{sec} = 1,000 \text{ centipoise}$.

K has the dimensions L/t (e.g., cm/sec). Typically, $\square = 1 \text{ gm/cm}^3$ and $\mu = 1 \text{ centipoise}$ for water. Thus the terms permeability and hydraulic conductivity are often interchanged when referenced to water.

Transmissivity (T) - The rate at which water is transmitted through a unit width of formation under a unit hydraulic gradient. Typically expressed as: gallons per minute, through a vertical section of aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 1; or cubic meters per day through a vertical section of 1 meter width, extending the full saturated height of the aquifer under a hydraulic gradient of 1.

There are two types of single-well response tests (SWRTs); the slug test and the recovery test.

The slug test involves causing a sudden change in water level in a well and measuring the water level response within that well. Water level change may be induced by suddenly injecting or removing a known quantity or "slug" of water into or out of the

well, emplacement or removal of a solid slug [i.e., stainless steel, polyvinyl chloride (PVC)] into the water column, or a release of pressure in a tightly capped well.

The slug test is advantageous over a pumping test in that it does not require the disposal of large quantities of water that may be produced. This is of special importance when testing a potentially contaminated formation. However, a disadvantage of the slug test is that typically the slug is of small volume and only provides an estimate of the formation hydraulic properties immediately adjacent to the well. In addition, if the static water level is located within the screened interval and surrounding sand pack, the data may be useless, depending on the size of the slug, since the "data" will represent either the saturation or dewatering of the sand pack (which should be more permeable than the formation) and not of the formation.

An alternate single-well response test, which provides estimates of the hydraulic properties of a larger portion of the formation surrounding the monitored interval and which is not as sensitive to impacts from a partially saturated sand pack, is recovery monitoring after the completion of either well development or after sampling. After sample collection, if the well has recovered to a significant extent, it may be necessary to pump some additional water from the well prior to performing the recovery monitoring.

Note: It is common practice to pre-plan the schedule of single-well response tests such that the tests progress from "clean" to "dirty" areas in an effort to eliminate the potential for cross-contamination. Review previous analytical data (if available) to determine best testing sequence.

Historically, single-well response test water levels have been measured using the manual methods (i.e., electronic water level indicator). Manual methods have generally been replaced with the use of pressure transducers and electronic data recorders which provide the following two advantages:

- the water levels can be recorded at selected short time intervals (e.g., 0.5 sec) to allow evaluation of quickly recovering wells which previously could not be evaluated since the well recovered too quickly to obtain the necessary data by the manual method
- the data from the data recorders can be transferred directly to computer programs which calculate the formation properties, without the time consuming manual transposition and evaluation of data

The use of pressure transducers and recorders is the method preferred by CRA.

In order to provide reliable data, the tests must be performed over as short a period of time as possible. Barometric pressure can affect groundwater levels and therefore, observation of significant weather changes during the period of the tests must be noted. Tidal fluctuations, navigation controls on rivers, rainfall events, and groundwater pumping can also affect groundwater level measurements. Personnel performing the tests must note if any of these controls are in effect during the testing period. Due to possible changes during the testing period, it is imperative that the time of data collection at each location be accurately recorded.

2.0 PRIOR PLANNING AND PREPARATION

The following shall be considered prior to conducting a single-well response test.

1. Review the Work Plan and HASP with the Project Coordinator.
2. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any Vendors that do not have full approval status or not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-031) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
3. Contact the CRA Chemistry group to arrange (if necessary);
 - SSOW (Simplified Scope of Work)
 - Laboratory
 - Sample containers delivery
 - Preservatives if required
 - Coolers
 - Shipping details
 - Sample starting date
 - Expected duration of sampling program
4. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies per the Slug and Aquifer Test Equipment and Supply Checklist (Form SP-18). If a recovery test is to be performed after well development or sampling, it is expected that the equipment and supplies obtained pursuant to the Groundwater Sampling Equipment and Supply Checklist (Form SP-05) will be sufficient with the addition of pressure transducers, electronic data recorders, and portable computers. Ensure that the psi range of the pressure transducer is sufficient.
5. Obtain information on each monitoring well to be tested. Information shall consist of inside diameter of the well screen and well casing, borehole diameter, depth of well, static water level, and the length and depth setting of the screen. For slug tests, this information will be used to calculate the volume of the "slug" required. The volume of the slug should be sufficient to affect a minimum change of 6 inches in the well's water level. If the static water level is within the screened portion of the well, the volume calculation must account for the porosity of the sand pack (a value of 0.3 is generally assumed). For well recovery tests, the volume of water removed during development/purging/sampling

must be recorded on the Well Development and Stabilization Form (Form SP-06) or Well Purging Field Information Form (Form SP-07).

6. Arrange access to the site. Assemble well keys and site keys. Also consider site conditions (e.g., is snow removal required?).
7. Establish groundwater and spent decontamination fluid handling and disposal methods before testing activities start.
8. Pre-plan the testing sequence to insure "clean" wells are tested before "dirty" wells to reduce the potential for cross-contamination.
9. Determine testing notification requirements with the Project Coordinator. Have the client, landowner, and appropriate regulatory agencies been notified?

3.0 FIELD PROCEDURE

The following outlines the steps required to be performed for a single-well response test:

1. Recovery Test

a) After Well Development

- i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level measurements prior to development.
- ii) Prior to development, calibrate the pressure transducer and datalogger system to static conditions by inserting the pressure transducer to within $6\pm$ inches of the bottom of the well, record its depth, mark a reference point on the cable using masking tape, connect the electronic data recorder, and check the operation of the system (i.e., water levels are being recorded correctly).
- iii) Remove the transducer and develop the well. Since the purpose of well development is to remove any sediment within the well casing and to develop the sand pack by the removal of fine grained material from the sand pack, aggressive procedures (i.e., surging with bailers or solid slugs) throughout the depth of the water column are used. These procedures could damage the pressure transducer and electrical cable. Thus, it is not recommended that the pressure transducer be in the well during well development to prevent potential damage to the transducer.
- iv) Once development is complete, quickly insert the pressure transducer to the previously established reference point, connect the data recorder, and commence to record water levels immediately after completing well development. Typically the data recorder is set to record water levels at 1-second intervals. However, for coarse materials (e.g., gravel, coarse sand) and bedrock with frequent and/or large fractures, a shorter time interval may be required (e.g., 0.1 or 0.5 seconds). The water levels should also be checked manually to ensure that the well has recovered to $90\pm$ percent of the induced change prior to stopping water level recording. If water level measurements are made using either electrical water level indicators or a measuring tape with a plover, follow the procedures for water level monitoring.
- v) Prior to removing the pressure transducer from the well, the data should be field checked by transferring the data from the data recorder to a disk

and reviewing the data on the PC. The disk is a backup to ensure the data are not lost. Review of the data may indicate that sufficient data (i.e., 6 or more data points before 90± percent recovery) were not obtained (e.g., the well recovered completely or to a large extent while installing the pressure transducer).

- vi) For those instances where the data recorded are insufficient, the recovery test must be redone, typically using a shorter time interval for water level recording. The transducer should be reinserted to the same reference point and a volume of water (50± percent of well volume) rapidly removed using a method which will not damage the pressure transducer or electrical cable (e.g., high rate submersible pump).
- vii) Should the well recover to static within 20 minutes, consideration should be given to performing two tests to provide confirmatory data.
- viii) At the completion of the test, the non-dedicated equipment shall be properly decontaminated per the Work Plan.

b) After Well Purging/Sampling

- i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level monitoring prior to well purging.
- ii) Prior to development, calibrate the pressure transducer and datalogger system to static conditions by inserting the pressure transducer to within 6± inches of the bottom of the well, record its depth, mark a reference point on the cable using masking tape, connect the electronic data recorder, and check the operation of the system (i.e., water levels are being recorded correctly).
- iii) Well purging/sampling methods are non-aggressive methods designed to remove the existing water column and sediment within the well without inducing additional sediment migration into the well from the surrounding sand pack and formation. Thus, it is recommended that the pressure transducer be inserted into the well prior to the start of well purging unless the equipment used for well purging/sampling (e.g., bailer, inertia pump) has a high potential to damage the transducer or electrical cable.
- iv) Perform the appropriate steps outlined in 1.a) (After Well Development) above. Note that additional water removal may be required if the well has recovered to a significant degree during sample collection.

2. SWRT

The following steps need to be performed for a SWRT, assuming that the well has been previously developed:

- i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level monitoring.
- ii) Prior to development, calibrate the pressure transducer and datalogger system to static conditions by inserting the pressure transducer to within $6\pm$ inches of the bottom of the well, record its depth, mark a reference point on the cable using masking tape, connect the electronic data recorder, and check the operation of the system (i.e., water levels are being recorded correctly). Insert the pressure transducer at a sufficient depth below the water table so that upon insertion of a slug into the water column, the slug will not strike the pressure transducer. Check the operation of the transducer and data recorder.

Typically the data recorder is set to record water levels at 1-second intervals. However, for coarse materials (e.g., gravel or coarse sand) and bedrock with frequent and/or large fractures, a shorter time interval may be required (e.g., 0.1 or 0.5 seconds). The water levels should also be checked manually to ensure that the well has recovered to $90\pm$ percent of the induced change prior to stopping water level recording. If water level measurements are made using either electrical water level indicators or a measuring tape with a plopper, follow the procedures for water level monitoring.

Monitor the pressure transducer to ensure the water level has stabilized following insertion of the pressure transducer and prior to insertion of the slug.

- iii) Set the slug just above the static level.
- iv) Release the slug instantaneously. It is important that the slug is completely submerged in the water column.
This is called a "falling-head" test. Repeat the "falling head" test at least once. The "falling head" test is not to be used for water table wells, in which the water level is below the top of the screen.
- v) Upon 90 percent recovery of the induced change, remove the slug rapidly and completely from the water column being careful not to inadvertently raise the pressure transducer.
This is called a "rising-head" test. Repeat "rising head" test at least once.

- vii) Confirm the well has again recovered to 90 percent of the induced change and complete the test by performing steps v) through viii) outlined in 1.a) (After Well Development).

Water levels along with the well data and time shall be recorded on the Single-Well Response Test - Data form (Form SP-19) and in the site field book. Figure 10.3 provides definitions for the parameters listed on Form SP-19.

Under some conditions (i.e., very permeable formations) the slug test can best be conducted by simulating the withdrawal/injection of a slug of water by the release of pressure in a tightly capped well. The following steps need to be performed:

- i) Prepare the area around the well, performing well identification/inspection, air monitoring, and static water level monitoring.
- ii) Insert the pressure transducer at a sufficient depth below the water table. Check the operation of the transducer and data recorder.
- iii) Install sealed well cap with a pressure cap.
- iv) Increase the pressure in the well to lower the water level (usually a bicycle pump is a sufficient source of compressed air).
- v) Release the pressure by opening a valve on the well cap and allow well to recover.
- vi) Repeat the test three or four times.

4.0 FOLLOW-UP ACTIVITIES

The following activities shall be completed after the field program:

- a. The equipment shall be cleaned and returned to the equipment administrator and the appropriate form dated and signed. Note any equipment which requires maintenance or service.
- b. Make sure that completed copies of the field notes and the disk with the documented transducer are sent to the Project Coordinator and to file. The field book shall be stored at the CRA office.
- c. If groundwater has been removed, handle appropriately, including the collection of any samples to determine treatment/disposal options.
- d. Return keys to the key box.

5.0 REFERENCES

For additional information pertaining to the topics discussed in this SOP, please refer to the following:

ASTM D4043- Standard Guide for Selection of Aquifer-Test Method in Determining of Hydraulic Properties by Well Techniques

Driscoll, F.G. 1986. Groundwater and Wells; 2nd Edition, Johnson Filtration Systems Inc., St. Paul, Minnesota, 1,089 pgs.

Kruseman, G.P. and N.A. deRidder. 1991. Analysis and Evaluation of Pumping Test Data; International Institute for Land Reclamation and Improvement (ILRI), publication 47, Wageningen, Netherlands, 377 pgs.

APPENDIX J-F-19
PH/TEMPERATURE MEASUREMENT

STANDARD OPERATING PROCEDURE FOR pH/TEMPERATURE MEASUREMENT

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 150.1

Sensitivity: 0.01 pH unit; 0.1°C

Optimum Range: pH 1.00 to 12.00; temperature -5 to 50°C

Sample Handling: Determined on site

Reagents and Apparatus:

1. Temperature compensated pH meter, YSI Model 3560 Water Quality Monitoring System
2. Combination pH electrode YSI Model 3530
3. Thermilinear thermister YSI Model 3510 temperature probe
4. pH buffer solutions, pH 4.00, 7.00, and 10.00 (certified buffer solutions)
5. Distilled or deionized water in wash bottle

Calibration:

1. Switch On/Off key to On. Before connecting the pH electrode, zero the electronics with the shorting cap attached to the meter. Turn on the meter and set the pH function switch to pH. Connect the shorting cap to the pH input jack and set the manual temperature compensation knob to 25°C. Adjust the CAL control to indicate 7.00 ± 0.01 on the pH-mV display. Disconnect the shorting cap from the pH input and connect it to the mV input jack. The monitor is now zeroed.
2. Test the 3530 pH electrode for noise and offset as follows: Rinse the 3530 and the YSI 3510 Temperature Probe with pH 7.00 buffer to remove any contaminants. Connect the 3530 to the pH input jack and the 3510 to the TEMP input jack. Pour

pH 7.00 buffer into a 50 mL sample cup then immerse both of the sensors into the buffer at $25.0 \pm 0.1^{\circ}\text{C}$ (use the $^{\circ}\text{C}$ display to confirm the temperature). Allow the sensors to equilibrate. A display value other than 7.00 shows electrode background noise and offset. The 3530 background noise and offset at pH 7.00 should not exceed ± 0.2 pH units at 25°C . Replace pH probe if background noise exceeds this tolerance.

3. Set the function switch to pH ATC. Connect the 3510 to the pH ATC input jack. While the 3510 can be used in either location, the pH ATC function will not work unless the 3510 is connected to the pH ATC input.
4. Rinse the 3530 and a YSI 3510 Temperature Probe with pH 7.00 buffer to remove any contaminants. Connect the 3530 to the pH input jack and the 3510 to the TEMP input jack. Pour pH 7.00 buffer into a 50 ml sample cup, immerse both of the sensor into the buffer. Allow the sensors the equilibrate in the buffer until a stable reading is obtained. Read the temperature and adjust the pH manual temperature compensation knob to the same value. Adjust the CAL control knob for 700 ± 0.01 pH units in the display and discard the buffer. Rinse the sensors with deionized or distilled water, followed by a rinse of the next desired buffer (typically pH 4.00 or 10.00). Half fill another disposable 50 ml sample cup with the next buffer for calibration and immerse the sensors. Allow the sensors to equilibrate until a stable reading is obtained. The temperature of the two buffers should not differ by more than $\pm 0.1^{\circ}\text{C}$. Adjust the SLOPE control until the display is within 0.01 pH units of the buffers stated value. Discard the buffers. The pH system is now calibrated and ready for use.

Procedure:

1. Calibrate meter using calibration procedure.
2. Set up meter as outlined in the operating manual.
3. Pour the sample into clean sample jar or plastic cup.
4. Record temperature and pH of the sample in the logbook.
5. Rinse with water and pH 7.00 buffer.
6. Repeat steps 3 through 5 for each sample.
7. Recheck calibration with pH 7.00 buffer solution after every 10 or fewer samples and after the last sample.
8. Store pH electrode in soaker bottle when not in use.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates must be ± 0.2 pH units.

If the results are outside of the control limits, rinse electrodes and repeat analysis. If results are still outside of the control limits, recollect samples and repeat analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below). If drift is suspected to be the cause of the problem, clean the electrode and recalibrate. If drift is still apparent, replace electrode.
2. Calibration check results must be ± 0.10 pH unit of the true value. If the result is outside of ± 0.10 pH unit, rinse electrodes and check solution again. If still outside the control limit, recalibrate the meter and reanalyze all samples analyzed since the last in-control calibration.
3. All glassware is to be soap and water washed, tap water rinsed and distilled or deionized water rinsed prior to analyses.

Interferences:

Interferences in pH measurements occur with presence of weak organic and inorganic salts and oil and grease. If oil and grease are visible, note in logbook. Clean electrode with soap and water, followed by 10% HCl and deionized water rinse. Recalibrate meter before analysis of next sample.

APPENDIX J-F-20

OXIDATION-REDUCTION POTENTIAL (ORP) MEASUREMENT

STANDARD OPERATING PROCEDURE FOR OXIDATION-REDUCTION POTENTIAL (ORP) MEASUREMENT

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Standard Methods for the Examination of Water and Wastewater", APHA, 18th edition, 1992, Method 2580B.

Sensitivity: 1 mV

Optimum Range: -1,500 to 1,500 mV

Sample Handling: Determined on site

Reagents and Apparatus:

1. ORP meter, YSI Model 3560 Water Quality Monitor
2. ORP electrode assembly, YSI Model 3540
3. Thermilinear thermistor temperature probe, YSI Model 3510
4. ZoBell Solution, YSI Model 3682
5. Distilled or deionized water in wash bottle

Calibration:

1. Turn on the YSI 3500 Water Quality Monitor and set the pH function switch to mV.
2. Connect the shorting cap attached to the 3500 to the mV input jack. The display should read 000 ± 2 mV. This indicates that the 3500 electronics are zeroed.
3. Detach the shorting cap and connect the 3540 to the mV input jack. If a pH electrode is not attached to the pH input jack, connect the shorting cap to it.
4. Attach the 3510 to the TEMP input jack.
5. Rinse the 3540 and 3510 with distilled or deionized water, followed by a rinse with a small amount of reconstituted YSI 3682 ZoBell Solution.

6. Half fill a disposable 50 mL sample cup with ZoBell Solution and fully immerse the bulb of the 3540 and the end of the sheath of the 3510. Allow the sensors to equilibrate, and note the reading.
7. The displayed mV values is not temperature compensated and should be corrected to 25°C at 1.3 mV/°C. The temperature coefficient is in reverse proportion to the temperature.
8. Correct the value to 25°C using the following equation:

$$\text{Actual Value mV} = \text{Display Value} + [(\text{Display Temp.} - 25^{\circ}\text{C}) \times (1.3 \text{ mV})]$$

Procedure:

1. Calibrate meter using calibration procedure.
2. Set up meter as outlined in the instruction manual.
3. Record temperature and ORP of the sample in the field logbook.
4. Correct ORP to 25°C using the formula presented above.
5. Record corrected ORP in the field logbook.
6. Repeat steps 3 through 6 for each sample.
7. Recheck calibration with ZoBell solution after every ten or fewer samples and after the last sample.
8. Store electrode in soaker bottle when not in use.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates must be ± 10 mV.

If the results are outside of the control limits, rinse electrodes and repeat analysis. If results are still outside of the control limits, recollect samples and repeat analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below). If drift is suspected to be the cause of the problem, clean the electrode and recalibrate. If drift is still apparent, replace electrode.
2. Calibration check results must be 231 ± 10 mV. If the result is outside of this range, rinse electrodes and check solution again. If still outside the this range, recalibrate the meter and reanalyze all samples analyzed since the last in-control calibration.

Interferences:

Interferences in ORP measurements occur when the platinum electrode surface becomes coated. Clean the ORP electrode as follows:

1. Soft coatings should be removed by use of a wash bottle of water or by gently wiping with a soft cloth. Remove the bulb guard if necessary. Be careful not to scratch the platinum.
2. Hard coatings or organic chemicals should be removed by an appropriate chemical solvent, by gently scrubbing with a very fine cleansing powder such as "Softscrub", or by gently polishing with 600 grade wet silicon carbide paper. Wet a piece of the paper with water and gently polish the electrode with a circular twisting motion.

Note:

After cleaning the platinum surface, soak the electrode for a 8 to 24 hours in 4.0 pH buffer, then recheck it with YSI 3682 ZoBell Solution before further use.

APPENDIX J-F-21
CONDUCTIVITY MEASUREMENT

STANDARD OPERATING PROCEDURE FOR CONDUCTIVITY MEASUREMENT

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Specific Conductance

Reference: "Methods for Chemical Analysis of Water and Wastes"
EPA-600/4-79-020, revised March 1983, Method 120.1

Sensitivity: 0.1 mmhos/cm

Optimum Range: 0 - 100.0 mmhos/cm

Sample Handling: Determine on site

Reagents and Apparatus:

1. Conductivity meter - YSI Model 3560 Water Quality Monitoring System
2. Conductivity Cell - YSI Model 3520 Flow-Through Conductivity Cell (K=5/cm)
3. Thermilinear Thermister - YSI Model 3510 Temperature Probe
4. Deionized water
5. Conductivity standard, 1.0 mmhos/cm @25°C - YSI Model 3167

Notes:

The conductivity meter is factory calibrated. The calibration is checked using a solution of known conductance.

Calibration Check

Connect the 3520 cell and a 3510 Temperature Probe to the 3500, and remove them from the sample chamber. Set the conductivity function switch to 2 ATC. Rinse the inside and outside of the cell and the probe with about 1/3 the content of the 3167 bottle. Place both of the sensors into the remainder of the solution in the bottle and allow them to come to temperature equilibrium. Make sure that the 3250 body is immersed so that the liquid level is half way up the knurled portion of the cell. Read the displayed value and

determine if the cell/instrument is within specified accuracy. The displayed value is corrected to 25°C automatically and should be 1.000 ± 0.070 mmhos/cm. If the value is not within specification replace 3250 cell.

Procedure:

1. Check calibration of meter.
2. Set up meter as outlined in the operating manual.
3. Before any conductivity cell is used, it should be soaked in distilled or deionized water for at least one hour. To make conductivity measurements, connect a YSI 3520 Flow-Through Conductivity Cell to the 3500. Set the conductivity function switch to 2 and observe the displayed value after the reading is stable. The display reads out in mmhos/cm.
4. If the overrange signal (1._____) is displayed, the conductivity of the water being measured is greater than 1.999 mmhos/cm. Reset the function switch to 20. If the overrange signal is still displayed, reset to 100. If the overrange signal is still displayed, either the conductivity is greater than 100.0 mmhos/cm and the YSI 3500 Water Quality Monitor can not be used for conductivity determinations.
5. Record conductance readings in field logbook.
6. Repeat steps 3 through 5 for remaining samples.

Quality Control:

1. The quality control calibration check standard must be analyzed initially, after every 10 or fewer samples and after the last sample. If less than 10 samples are analyzed, the calibration standard is still required to be analyzed. The standard must be within ± 10 percent of the true value or the samples run after the last acceptable check standard are to be reanalyzed. Record the calibration standard in the field logbook.
2. Duplicate a minimum of 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicate values are to be within $\pm 15\%$ of each other. If outside of this range, reanalyze the samples. If still outside the acceptance range, recollect sample and reanalyze. If still out, replace probe.

APPENDIX J-F-22
DISSOLVED OXYGEN MEASUREMENT

STANDARD OPERATING PROCEDURE FOR DISSOLVED OXYGEN MEASUREMENT

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 360.1

Sensitivity: 0.1 mg/L as O₂

Optimum Range: 0.1 mg/L to 20 mg/L O₂

Sample Handling: Determined on site

Reagents and Apparatus:

1. Temperature compensated dissolved oxygen (DO) meter, YSI Model 52
2. DO probe, YSI 5739 Field Probe
3. DO probe electrolyte solution
4. DO membrane replacement kit
5. Distilled water in wash bottle

Setting Up DO Sensor:

The sensor is shipped dry and must be filled before use.

1. Unscrew sensor guard, remove o-ring and membrane, and rinse with distilled water.
2. Holding probe in left hand, successively fill the sensor body with electrolyte while pumping the diaphragm with a soft, blunt tool (e.g., pencil eraser). Continue filling and pumping until no more air bubbles appear. Add electrolyte until a large meniscus completely covers the gold cathode.
3. In a single, continuous motion, stretch membrane up, over, and down the sensor. Secure other end of membrane with forefinger.

4. Roll o-ring over probe (do not touch membrane) and trim off excess membrane using scissors or sharp knife.
5. Shake off excess electrolyte and reinstall sensor guard. Store in a humid environment until ready for use.

Calibration in Air:

1. Remove field probe from storage bottle. Switch on meter. Set function switch to O₂-TEMP. Allow meter to equilibrate for at least 15 minutes.
2. Replace probe in storage bottle and switch to CALIBRATE. Press CONFIRM when display reads "Calibrate in percent?".
3. Using up and down arrow keys, adjust the displayed value to correspond to the calibration value determined from the altitude or pressure chart on the back of the meter.
4. When the display has been adjusted to the proper value, press CONFIRM. The display will read "please wait" for a few seconds. The calibration value will then be displayed. The meter is now calibrated.

Procedure:

1. Calibrate meter using calibration procedure.
2. Set selector switch to O₂-TEMP. Slowly lower the probe down monitoring well. Allow probe to equilibrate for 3 to 5 minutes.
3. Gently move the probe up and down at an approximate rate of 1 foot per minute. Observe readings for stability.
4. Record result in the field logbook.
5. Repeat steps 2 through 4 for each sample.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates must be within 15 percent.

If the results are outside of the control limits, rinse electrode and repeat analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below). If unable to recalibrate, replace sensor membrane.

2. Calibration check results must be within 10 percent of the true value. Calibration check is performed by measuring DO of humid air in storage bottle (same as calibration procedure). If the result is outside of 10 percent, rinse electrodes and check solution again. If still outside the control limit, recalibrate the meter and reanalyze all samples analyzed since the last in control calibration.
3. Only distilled water is to be used for probe rinsing prior to analyses.

Interferences:

Interferences in DO measurements generally occur due to membrane coating. Clean probe as specified in the sensor manual.

The presence of other gases such as chlorine, nitrous and nitric oxide, hydrogen sulfide and sulfur dioxide interfere with DO measurements. The sulfur based compounds will tarnish the electrodes resulting in sluggish or erratic measurements. Polishing the electrodes as specified in the operating manual will restore the performance of the meter. Recalibrate meter before analysis of next sample.

APPENDIX J-F-23
TURBIDITY MEASUREMENT

STANDARD OPERATING PROCEDURE FOR TURBIDITY MEASUREMENT

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Nephelometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 180.1

Sensitivity: 0.01 Nephelometric Turbidity Unit (NTU)

Optimum Range: 0 - 20; 0 - 200 NTU

Sample Handling: Determined on site

Reagents and Apparatus:

1. Direct reading turbidity meter, HF Scientific Model DRT-15C
2. Cuvettes with screw tops
3. Battery charger
4. 0.02 NTU (nominal) reference standard
5. Distilled or deionized water in wash bottle

Calibration Check and Operation

The turbidimeter has been calibrated by the manufacturer and electronic calibration using freshly prepared formazin standards should only be performed if the electronic printed circuit board, the photodetectors or the light source has been replaced. The calibration procedure is presented in pages 5 and 6 of the operating manual (attached).

The procedures for calibration checks and the operation of the meter follows:

1. For accurate measurements in the low range rotate the cuvettes in the well to obtain the minimum reading. Mark the cuvette with one of the adhesive dots provided with the instrument so that orientation of the cuvette will be identical each time it is placed in the instrument.

2. To operate the turbidimeter, switch to the "20" range and place the Reference Standard (0.02 NTU) in the optical well.
3. With the light shield in place over the well, adjust the Reference Adjust knob to cause the meter to read the reference standard value on the scale. The unit is now ready for use in either range.
4. To make a measurement of a sample, clean one of the cuvettes and fill to within approximately 1/2-inch of top with sample. Place the top on the cuvette and carefully clean the outside surface of the cuvette with a lint free wiper such as KimWipes. Place the sample in the well and place the light shield over the well. Select the appropriate range for best readability. Record results in field logbook.
5. Repeat steps 3 and 4 for each sample.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates must be within ± 15 percent.

If the results are outside of the control limits, clean cuvettes and repeat analysis. If results are still outside of the control limits, recollect samples and repeat analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below).
2. Calibration check results must be ± 10 percent of the true value. If the result is outside of ± 10 percent, clean cuvettes and check solution again. If still outside the control limit, recalibrate the meter and reanalyze all samples analyzed since the last in-control calibration.
3. All glassware is to be soap and water washed, tap rinsed and distilled or deionized water rinsed prior to analyses.

Interferences:

Interferences in turbidity measurements are generally due to dirty or scratched cuvettes. Handle only the top one-third of the cuvettes and wipe clean using a lint-free wiper (KimWipes or equivalent).

APPENDIX J-F-24
EN CORE® SOIL VOC SAMPLER

STANDARD OPERATING PROCEDURE FOR EN CORE® SOIL VOC SAMPLER

The samples collected and analyzed for volatile organic compounds (VOCs) will be completed in accordance with SW-846 Method 5035/8260B. Samples for VOC analyses will be collected first, using the En Core® Sampler. In the case of a soil sample collected over the 0- to 2-foot bgs interval, the sample volume will be collected from the 18- to 24-inch bgs interval.

Samples for VOC analysis will be collected using the disposable En Core® sampler as follows:

- Hold coring body and push plunger rod down until small o-ring rests against tabs. This will assure that plunger moves freely.
- Depress locking lever on En Core® T-Handle. Place coring body, plunger end first, into open end of T-Handle, aligning the 2 slots on the coring body with the 2 locking pins in the T-Handle. Twist coring body clockwise to lock pins in slots. Check to ensure sampler is locked in place. Sampler is ready for use.
- Turn T-Handle with T-up and coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure that the plunger bottom is in position). Using the T-Handle, push sampler into soil until coring body is completely full. When full, the small o-ring will be centered in the T-Handle viewing hole. Remove sampler from soil. Wipe excess soil from coring body exterior.
- Cap the coring body while it is still on the T-handle. Push and twist the cap over the bottom until grooves on locking arms seat over the ridge on the coring body. CAP MUST BE SEATED TO SEAL SAMPLER.
- Remove the capped sampler by depressing the locking lever on the T-Handle while twisting and pulling the sample from the T-Handle.
- Lock the plunger by rotating the extended plunger rod fully counter-clockwise until the wings rest firmly against the tabs.
- Attach a completed circular label (from En Core® sampler bag) to the cap on the coring body.
- Return the full En Core® sampler to zipper bag.

APPENDIX J-F-25
FIELD LOG BOOKS AND PHOTO LOGS

STANDARD OPERATING PROCEDURE FOR FIELD LOG BOOKS AND PHOTO LOGS

FIELD LOG BOOKS

All field work activities performed or overseen by CRA field personnel must be accurately recorded in bound field log books.

Field log book records will be used in the compilation of project reports, assist in various design activities, and provide a legal record of the work.

Although CRA uses a number of different types of log book formats, all log books share certain common information and usage requirements. These are:

1. Log books must be bound so pages cannot be added or removed.
2. Information must be factual and complete.
3. All errors must be lined out with a single line, initialed, and dated.
4. At the end of each day, the current log book page should be "closed out" by signing just below the last entry.
5. Only black ballpoint pens should be used for entries. Beware of "rolling ball" type pens with water-soluble ink which will run and smear if exposed to moisture.
6. All pages must be consecutively numbered.
7. Each day's work must start on a new page (Daily Log only).
8. When filling out "free form" logs (Daily Log), be objective. Keep your personal feelings out of the log. Do not make slanderous statements.

In order for log books to be used and easily interpreted by various individuals within CRA, they must have common formats regardless of which office the work is being supported from.

It is understood that in many cases field projects have needs which require variations in the format and extent of the information recorded in the various field logs.

In certain special cases, the use of the field log books for direct entry of field data is impractical (i.e., in cases where data must be tabulated in a particular way or is so extensive that the physical width of the log book does not allow neat and accurate entry).

In these special cases, custom data entry spreadsheets may be produced as required by the supporting office's word processing staff. The data entry forms should use standard CRA typefaces and formatting where possible.

If custom field data entry sheets are used, they should be sequentially numbered and signed. A notation in the daily project diary indicating what data entry sheets have been used each day should be made.

At sites where CRA personnel rotate support time, field logs must be handed over in person or secured in a location accessible by multiple/controlled keys.

Whenever work is completed at field sites and the "office logs" are not on hand, daily verbal transfer of pertinent information should be made. Proper advance planning should eliminate the need for this.

PHOTOGRAPH LOG

Certain field projects require regular photographic documentation of all aspects of the project or key portions of the project. The Project Manager/Coordinator or field personnel should obtain approval from the client regarding their policy with respect to photographs at the site. Whenever a large volume of photographs are generated, or as required by certain Work Plans, a photograph log must be used to record data for each photograph. Section 3.6 outlines the recommended photographic documentation procedures for field activities.

In many cases, photographs can be documented directly in the daily project diary using the same information requirements specified in the example photograph log.

At a minimum, photographic documentation should be made of the following subjects:

1. Whenever specifically called for as part of the documentation process for a specific Field Procedure.
2. If any uncorrected field condition or action originating from site contractors or other on-site parties which is unsafe, illegal or in conflict with a published document (CRA or client) for which CRA is tasked with enforcing.
3. The chronological progress of all construction activities.
4. Panoramic views of the site depicting the site layout both prior to mobilization, during the conduct of work, and upon permanent or temporary demobilization from the site.

CAMERAS

Only high quality cameras should be used. Unless it is otherwise unavoidable, standard throw-away type cameras should be avoided.

When requisitioning a camera from CRA inventory or purchasing one specifically for a job, ensure that the camera has the following minimum features:

- date-package
- auto-exposure
- auto-flash
- weather resistant
- auto-rewind (for film cameras)
- an automatic or semi-automatic lens shield

If available and not inordinately expensive, cameras with zoom capability are useful.

Each photo should be documented in the photographic log. However, to insure that the subject of every photo can be easily identified at a later date, a data placard should be held in the field of view when taking each photograph. A small wipe-off dry marker-type "memo board" can be purchased at most office supply stores and is well suited for this task. If possible, choose a non-white board since a white one will reflect the cameras flash and "wash-out" the data on the board. Use the thickest black dry marker available.

Information written on the data placard should include: the direction you are facing, subject name (i.e., "TP-01" for test pit number one) and the date, if your camera does not have a date package.

Every picture taken on each roll should be logged no matter what the subject or quality of the photo is. This is necessary to preserve the "chain-of-photographs" in the log book.

Advance consideration should be given to camera protection, operation, and loading/unloading when one will be used inside a site exclusion zone. Nitrile or other heavy outer gloves can make camera operation difficult as well as interrupt the field of view or the camera's sensors.

When extended periods inside the site are anticipated, the amount of film required should be estimated. In some cases, two pre-loaded cameras may be necessary to avoid having to unload/load a camera wearing gloves. This also applies to conditions which could contaminate the interior of the camera during loading/unloading.

When working in areas of known contamination potential where full decontamination of all personnel and equipment is mandatory, some means of protecting the camera must be devised. In some cases, the disposable type "waterproof" cameras can be used.

Where non-digital, i.e., film cameras, are used, immediately upon removal from the camera, every roll of film must be marked with the roll sequence number. If the film tab has not been fully retracted by the camera during rewinding, manually retract it so that the film cannot be accidentally reloaded and double exposed.

Exposed film must be given the same security and confidentiality considerations as project log books. However, exposed film must be given additional physical protection to insure it is not damaged by exposure to water or excessive heat.

All film should be developed as soon as possible so that exposure quality can be checked. Photographs should be developed in duplicate in the 3 1/2 by 5-inch format.

APPENDIX J-F-26

PHOTOIONIZATION/FLAME IONIZATION DETECTORS

STANDARD OPERATING PROCEDURE FOR PHOTOIONIZATION/FLAME IONIZATION DETECTORS

Scope and Application: This method is applicable to screening methane and organic vapors in soil gas probes.

Method: Photoionization/Flame Ionization

Sensitivity: ± 25 percent of reading or ± 2.5 ppm, whichever is greater

Optimum Range: 0.5 to 500 ppm (photoionization)
1.0 to 10,000 ppm (flameionization)

Sample Handling: Determine on site

Reagents and Apparatus:

1. Foxboro TVA - 1000B Toxic Vapor Analyzer
2. Calibration gas (commercially available standard cylinders containing zero gas and 500 ppm methane gas)
3. Calibration apparatus and tubing
4. Battery charger

Procedure:

1. Connect the sample probe (electrical and sample line connections) to the appropriate receptors on the TVA-1000B.
2. Calibrate analyzer using the instrument manufacturer's calibration procedure on page 19 in Attachment A.
3. Monitoring with the TVA-1000B will be performed while traversing grid lines spaced 30 meters apart as specified in the Section 5.0 of the Work Plan.
4. The vapor concentration may be read immediately on either two displays - one mounted directly on the hand-held sample probe and the other on the instrument side pack itself.
5. Both FID and PID readings will be displayed and logged simultaneously, the relative response of the two detectors may indicate the identity of the compound being measured. For example, the PID will not respond to methane, but the FID

responds very well. Therefore, a high FID reading with virtually no PID response might indicate the presence of methane. Consequently, PIDs respond very well to some inorganic gases that FIDs cannot detect. Therefore, a high PID reading with no FID reading suggests the presence of an inorganic compound.

6. Readings will be made at approximately 2-meter intervals by placing the probe inlet within 5 to 10 centimeters of the ground surface.
7. Record all readings in the field logbook.

Quality Control:

1. Calibration check results must be ± 10 percent of the true value. If the results is outside of ± 10 percent, recalibrate the meter as specified above. Record the calibration standard in the field logbook.
2. Duplicate samples are not analyzed since the headspace methane and VOC readings will vary considerably as volatilization in the soil occurs.

Interference and Limitations:

Normal operating conditions require ambient temperature range between 32°F and 104°F, relative humidity range for FID is 20 to 95 percent and for PID it is 20 to 70 percent, noncondensing.

APPENDIX J-F-27

NON-AQUEOUS PHASE LIQUID (NAPL) AND WATER LEVEL MONITORING

STANDARD OPERATING PROCEDURE FOR NON-AQUEOUS PHASE LIQUID (NAPL) AND WATER LEVEL MONITORING

1.0 INTRODUCTION

This procedure is for monitoring the presence of dense and light non-aqueous phase liquids (DNAPL and LNAPL), monitoring of groundwater levels, and collection of NAPL samples for laboratory analysis in monitoring, observation, and extraction wells.

It should be noted that groundwater sampling and analysis should not be performed in locations where NAPL has been identified.

2.0 PROCEDURAL GUIDELINES

- Verify well identification and location using borehole log details and location layout figures. Note the condition of the well and inform the Project Manager of any required repair work.
- In areas known to be impacted with volatile organic compounds or, where no data exist, prior to opening the well cap, measure the breathing space above the well casing with a PID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the Health and Safety Plan, field personnel should adjust their PPE accordingly.
- In some settings, it may be necessary to allow time for the water level to equilibrate. This condition exists if a water tight seal exists at the well cap and the water level has fluctuated above the top of screen; creating a vacuum or pressurized area within the well casing. Three water level checks will be used to verify the static water level conditions or changing conditions.
- NAPL level measurements are best conducted using a dual phase oil/water interface probe (interface probe). The interface probe uses an optical liquid sensor, in conjunction with an electric circuit to detect the top of a phase-separated liquid and the interface between the phase layer and water (water level). Water level measurements will be conducted using a dual phase interface probe (or equivalent) to also allow the detection of any NAPL that may be present. The interface probe uses an optical liquid sensor, in conjunction with an electric circuit to detect the top of a phase-separated liquid and the interface between the phase layer and water. Where NAPL is known to be absent, a water level tape such as a Solinst™ electric water level tape (or equivalent) can be used to measure the depth to water.
- The procedure for use of the interface probe is:
 - For LNAPL:
 - Lower the probe tip into the center of the well until discontinuous beeping is heard (this indicates the top of the LNAPL has been detected). Grasp the calibrated tape at the reference point and note reading. Confirm the reading by slowly raising and lowering the probe to the level of the phase layer.
 - Once the top of the phase layer is confirmed, slowly lower the probe until a continuous sound is heard. This indicates that the water level has been encountered. Grasp the tape at the reference point and note the reading. Confirm this water level measurement three times, to verify static water level conditions or changing conditions, by slowly raising and lowering the probe to the water level.
 - Decontaminate the submerged end of the tape and probe prior to the next use in accordance with the Work Plan requirements.

- For DNAPL:
 - Lower the probe tip in the center of the well to the bottom of the well, a discontinuous beeping will be heard if DNAPL is present. Grasp the calibrated tape at the reference point and note reading.
 - Once the bottom of the well is confirmed, slowly raise the probe until a continuous sound is heard. This indicates that the water level has been encountered and represents the top of the DNAPL layer. Grasp the tape at the reference point and note the reading. Confirm this water level measurement three times, to verify static water level conditions or changing conditions, by slowly raising and lowering the probe to the water level.
 - Decontaminate the submerged end of the tape and probe prior to the next use.
- The procedure for obtaining water level measurements is:
 - Lower the probe tip into the center of the well until continuous beeping is heard (this indicates water has been detected). Grasp the calibrated probe at the reference point (i.e., top of casing) and note reading. Confirm the reading three times, to verify static water level conditions or changing conditions, by slowly raising and lowering the probe to the water level.
 - Decontaminate equipment prior to next use.
- Alternative NAPL measurement methods exist in the event an interface probe is unavailable or not functioning properly. These methods tend to be less accurate than the interface probe but may be used to establish an estimated NAPL measurement.
 - **Clear Bailer** – A clear bottom-loading bailer may be used to estimate NAPL thickness if floating or denser than water. If NAPL presence is suspected, the bailer is carefully lowered to the location of suspected NAPL presence (top of water column/base of water column), and slowly removed and examined for NAPL. If present, the column of NAPL within the clear bailer can be measured to estimate the NAPL thickness within the groundwater column.
 - **Weighted Cord** – Primarily used for DNAPL measurements, a weighted "cotton" string or cord may be lowered to the base of the well and inspected upon retrieval. Typically, the lower DNAPL layer will "coat" the string indicating the approximate thickness of this layer.

Well NAPL Sampling

- Prior to sampling, the level of NAPL in the well should be measured as identified above.
- Various sampling devices can be employed to acquire fluid samples from the top and bottom of the well, including the following:
 - Bottom-loading bailer
 - Double check value bailer (produces most reliable results)
 - Peristaltic pump for shallow wells (<25 feet in depth)
 - Inertia pump for deeper wells (up to 300 feet in depth)
- Transfer NAPL to sample containers for shipment to laboratory. NAPL can be sampled to evaluate the physical properties of the fluid or to evaluate chemical composition.
- Decontaminate equipment prior to next use.

<i>Note: Groundwater sampling shall not be performed in locations where NAPL is present.</i>
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3.0 EQUIPMENT/MATERIALS

- Water level tape
- Interface probe
- Bottom-loading bailer
- Double check valve bailer
- Peristaltic pump
- Inertia pump
- Letter Work Plan
- Health and Safety Plan

4.0 REFERENCES

- Cohen, Robert M., Mercer, James W. (GeoTrans, Inc.), Robert S. Kerr Environmental Research Laboratory "DNAPL Site Evaluation" Office Research and Development. U.S. Environmental Protection Agency
- Cohen, R.M., Brayda, A.P., Shaw, S.T., and Spaulding, C.P.; Fall 1992 "Evaluation of Visual Methods to Detect NAPL in Soil and Water", Groundwater Monitoring Review, Volume 12 No. 4, pp. 132-141.

APPENDIX J-F-28
FIELD SCREENING OF NAPL

STANDARD OPERATING PROCEDURE FOR FIELD SCREENING OF NAPL

Scope and Application: Soil samples collected as part of the vertical aquifer sampling program will be screened for the presence of non-aqueous phase liquids (NAPL) using the Sudan IV dye test

Equipment: SUDAN IV Test kit or approved equivalent

Procedure:

In the sample containers provided, add the following:

- Add 2 ml of each soil sample.
- Add 2 ml of water.
- Add 1 dropperful of Sudan IV.
- Agitate each tube.
- If LNAPL is present, it will appear as floating red droplets or as a floating red layer colored by Sudan IV. If DNAPL is present, it will appear as a red layer or red droplets at the bottom of the container

Please refer to the filed test method procedures for additional details and instruction on sampling handling.

APPENDIX J-F-29
RADIATION MONITORING

STANDARD OPERATING PROCEDURE FOR RADIATION MONITORING

Scope and Application: Potential exposure to possible low-level radiation at the Site during intrusive investigative work shall be monitored. Radiation monitoring is only required when entering new areas of the Site, and at the start of intrusive activities in a previously unscreened area. or if material resembling foundry sands is identified during the intrusive activities.

Equipment: Victoreen Survey Meter capable of accurately reading below 0.6 mRem/hr

Procedure:

1. The meter is factory calibrated and does not require field calibration.
2. Turn on the "on" switch.
3. For foundry sands, while holding onto the meter hold the meter within 2 feet of the foundry sands.
4. Record any measurable readings and, if screening a specific potential source, the distance from the suspected source of radiation.
5. Repeat steps 1 through 4 for each different foundry sand type, when entering new areas of the Site, and at the start of intrusive activities in a previously unscreened area.

APPENDIX J-F-30
UTILITY CLEARANCE

STANDARD OPERATING PROCEDURE FOR UTILITY CLEARANCE

Field activities which penetrate the ground surface (i.e., test pits, boreholes, well installations, and new construction, etc.) **must have a utility clearance performed in advance of any subsurface work.** The utility clearance process is a logistical requirement performed to identify utility presence, utility location, and special hazards that may exist when working in close proximity to these services. The utility check itself does not prevent all incidents but is one component of many activities that if all performed correctly will minimize the potential for utility conflicts. Typically, CRA field personnel are responsible for coordinating utility clearances and documenting completion of utility checks. CRA personnel cannot approve utility clearances; all utility clearance approvals must originate from a client, its authorized agent, or an outside utility group.

On public or private property the following must occur:

- CRA must carefully select the proposed drill or excavation site
- site selection must be conducted after a careful review of **all** available utility plans
- site selection must involve a physical examination of the proposed work area, checking for utility indicators (this cannot be performed from an office)

Note: The site selection process is one of the most important and difficult tasks for field personnel. Personnel selecting proposed drilling or excavation locations must draw on all source information and use physical evidence to identify potential conflicts and select successful activity locations.

- site selection must be well marked in the field using wooden stakes and/or white paint such that the proposed location is easily identified
- site selection must be documented in writing (i.e., field book sketches), noting field ties to the proposed location such that the location can be reproduced/laid out again if the marker is lost or moved
- site utility clearance (by landowner and One-Call Service) should be performed in the presence of CRA personnel and contractor personnel, which will enable CRA/contractor personnel to hear and see first hand the utility concerns present
- site utility clearance results should be documented by CRA for future reference

A number of utility clearance documentation methods exist such as:

- written field book reference - recording date of clearance check, group conducting clearance, sketch of utilities present, and record of clearance confirmation code/information number
- written utility clearance documentation from land owner (i.e., Private or Public) showing service checks completed and a sign-off of who conducted the checks
- completion of the CRA Property Access/Utility Clearance Data Sheet by the landowner, with contractor sign-off

Fact: Utility checking groups/private facility utility checking groups and One-Call-Systems may provide written sign-off that a check was conducted (but under no circumstances do any of these groups accept liability in the event of utility damage or personal injury). In fact a disclaimer usually accompanies any written documentation provided that states that the utility clearance service is a check only, utilities may or may not be positioned as marked and that the contractor breaking ground is ultimately responsible for damaged utilities.

The Property Access/Utility Clearance Data Sheet is typically required when the client or property owner does not have their own utility clearance form or documentation procedure.

The Property Access/Utility Clearance Data Sheet will permit the client to identify individual utility clearances or conflicts by initialing the appropriate services checked. Once complete, a sign-off is required to identify the person(s) assuming responsibility for the accurate completion of the utility checking and concurrence that the contractor is aware of the utilities present. Clients or contractor personnel reluctant to sign-off should be made aware that this is not a "liability release" but an indication that the checks were completed. If a utility is damaged and repair and/or liability costs are assigned this will likely be allocated to those that were negligent.

In all areas of the U.S. and Canada the "One-Call System" (or local equivalent) utility clearance services are available and must be contacted before excavation work occurs. **THIS IS THE LAW** in most areas, and certainly CRA's policy.

The "One-Call System" is a safety program designed to prevent utility damage and diminish the potential hazards posed to workers/public during subsurface activities. CRA personnel must be warned that not all utilities participate in these services and the level of service varies from area to area. Laws concerning utility participation within

"One-Call Systems" are changing; in many areas it is now mandatory that all service/utility groups must participate, in other areas participation is voluntary.

Further it should be noted that this service may be performed by "third" party private companies that have competitively bid for this work. Utility service personnel can only rely on the plans provided within their system and the equipment available. Subsequently, these services can and do make mistakes or may misinterpret the information available/data collected. Utility locates are considered an "art not a science"; consequently CRA personnel should be in attendance during location checks to observe and feel comfortable with the service being provided. It is not good practice to mark proposed work locations then complete a utility check without meeting the utility locator face to face to discuss the construction elements.

If a high comfort level is not achieved or other uncertainties exists, CRA can initiate extra activities, at minimal cost, to solve utility clearance concerns. The extra effort options may include one or more of the following:

1. Hand digging to expose utilities of concern (i.e., confirm exact utility position in one or more locations).
2. Hand augering at proposed drill or excavation location to "confirm the absence" of services at the proposed location (in northern climates this may require hand augering to depths beyond the frost line; also beware of utilities at excessive depth beyond hand methods).
3. Detection device screening at proposed activity location (i.e., surface detection equipment can be used to locate area service positions but can also indicate a lack of service presence in the proposed work area), have the utility locate service screen the proposed work area.
4. Hire a private utility locate service to conduct a utility clearance.

Private utility locate groups are a growing industry that has organized an association of membership: National Utility Locate Contractors Association (NULCA). This group can be contacted at 715-635-6004.

In the event of a utility "hit" or "near loss", the CRA Accident/Incident Reporting Form must be completed and submitted to the CRA Health and Safety group through the CRA Incident Hotline (1-866-529-4886).

APPENDIX J-F-31

TEST PIT AND TRENCH SOIL SAMPLE COLLECTION

STANDARD OPERATING PROCEDURE FOR TEST PIT AND TEST TRENCH SOIL SAMPLE COLLECTION

Test pits and test trenches are typically excavated to explore and define geologic conditions (or buried waste/debris) and to allow the collection of subsurface soil samples for geotechnical or chemical analysis. Test pits and test trenches give a more complete view of the subsurface soil conditions than soil borings. Test pits and test trenches are excavated using either a rubber-tired backhoe or track-mounted excavator, and can extend 10 to 15 feet (3.0 to 4.6 m) or more below ground surface.

The use of test pits and test trenches for investigation is determined on a site-specific basis. Experience from past projects has identified the following issues:

1. The nature and extent of contamination which may be encountered may be unknown. The Site-Specific Health and Safety Plan (HASP) and Task Hazard Analysis (THA) or Job Safety Analysis (JSA) must be specific to the level of Personal Protective Equipment (PPE); this may be Level A, B, C, or D.
2. Waste materials, including drums, may be encountered. A plan must be in place specifying how this material will be handled.
3. Air emissions of some compounds may occur. A plan must be in place to ensure that employees and the public are adequately protected.
4. Community relations concerns may exist (e.g., workers in chemically protective "moon suits"). A notification plan may be required.
5. All underground utilities must be located and documented using the CRA Subsurface Clearance Protocol.

PROCEDURES FOR TEST PIT/TEST TRENCH EXCAVATION AND SAMPLING

Once the prior planning and preparation activities are completed, the test pit excavation and subsurface soil sampling program can proceed. The typical series of events which takes place is:

1. Location and marking of test pit/test trench locations.
2. Final visual examination of proposed excavation area for utility conflicts.
3. Excavation of test pits and test trenches and collection of the soil samples.

4. Field screening of soil sample with specific air monitoring equipment (e.g., PID, LEL meter).
5. Description of soil sample and test pit.
6. Completion of Test Pit Stratigraphy Log, an example of which is contained in Appendix J-G.
7. Documentation, including photographs and/or videotape, as required.
8. Chemical sample preparation and packaging.
9. Backfilling of test pit/test trench excavation.
10. Surveying of test pit/test trench locations.
11. Field note completion and review.

LOCATION AND MARKING OF TEST PITS/FINAL VISUAL CHECK

Proposed test pit locations marked on the site plan are located in the field and staked. The proposed test pit locations are usually strategically placed to assess site conditions, former facilities, waste areas, etc.

Once the final location for the proposed test pit/test trench has been selected and utility clearances are complete, one last check of the immediate area is performed before excavation proceeds to confirm the locations of any adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers are opened and the conduit/sewer alignments confirmed.

Caution: *Do not assume site plan details regarding pipe alignments/position are correct. Visually check pipe position when excavating near sewers. Personnel should also be alert to the presence of additional piping, especially if the plans are outdated.*

If it is necessary to relocate a proposed test pit or test trench due to terrain, utilities, access etc., the Project Coordinator must be notified and an alternate location will be selected.

TEST PIT/TEST TRENCH LOCATION SETUP

The test pit/test trench location is set up as follows:

1. The excavator is positioned such that the excavation spoils are deposited by the excavator downwind of all staff.
2. A sheet of polyethylene is placed downwind of the test pit/test trench location to accept spoils, if required by the Work Plan or Field Sampling Plan (FSP).
3. To the extent practicable, the investigation area is set up such that water or liquids that may be excavated, freely drain back into the excavation.
4. The excavation begins at one location with the excavator backing up (as required) to extend the test pit or test trench.

SAMPLE COLLECTION

Soil samples will be collected from the backhoe/excavator bucket or stockpiled spoils. Samples which require a discrete depth interval are collected from the excavator bucket following excavation of all or a portion of the test pit. Samples are collected using a cleaned steel trowel, shovel, or stainless steel spoon. The samples will be collected directly from the bucket of the excavator and/or the stockpiled spoils immediately upon excavation, to minimize potential losses due to volatilization. VOC, SVOC, and PCB/pesticide samples will be collected first, in the order listed. Samples are placed in a stainless steel bowl and mixed (except VOCs).

Do not enter the test pit. (Confined Space Entry requirements apply and proper shoring of the excavation walls may be necessary.)

Sample selection will be based on the visual appearance of the material (e.g., color, staining, grain size, etc.), location of the material prior to removal (e.g., adjacent to drums or base of excavation), and field instrument measurements (i.e., headspace readings using a PID).

The location, number, and type of soil sample collected and the determination of the soil samples to be submitted to the laboratory for analysis will be as specified in the Work Plan and Field Sampling Plan. Record all soil samples collected in the sample log book. Labeling of samples shall be consistent with the Quality Assurance Project Plan (QAPP, CRA, May 2008).

Caution: *Personnel observing or sampling test pit operations must never stand within the "turning radius" or "reach-zone" of the excavation equipment. Operator error or equipment failure could result in severe injury or death if struck by the backhoe bucket or the backhoe itself. Stand opposite the backhoe well beyond the far end of the trench for communication.*

Personnel should also be alert to test pit side wall conditions which typically undermine the ground surface and create unstable soils surrounding the test pit area.

Discrete Grab Sampling From Test Pits and Test Trenches

When taking discrete grab samples from a test pit or test trench using an excavator bucket, the sampling location is considered a volume of soil in the bucket that has both a consistent soil type and a consistent level of contaminant impact. When sampling using an excavator bucket, the operator will dig to the desired depth and then provide a small volume of soil from a discrete position and depth in the test pit or test trench.

While sampling from the excavator bucket is preferred, especially for VOCs, samples may be collected from the soil stockpile immediately following placement by the excavator. Care should be taken to ensure that the soil sample collected from the stockpile is representative of the excavator bucket sample from the depth interval of interest. Sampling from the soil stockpiles should be performed using the same procedures as for sampling from the excavator bucket.

When collecting a discrete grab sample from the excavator bucket or soil stockpile, use the following procedure:

1. Scrape off the top 2 inches (5 cm) of soil at the sampling location in the excavator bucket/soil stockpile.
2. Using the sampling device (e.g., trowel, spoon) scoop the freshly exposed soil into the sample container. Ensure that the samples taken were not in contact with the excavator bucket to avoid the potential for cross-contamination.
3. Pushing the sample container into the soil in order to fill the container is not recommended. This could result in breaking the sample container and potential injury to field personnel (e.g., cutting hands on broken glass).

4. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil. For VOCs:
 - a. Samples should be collected as soon as possible following excavation of the soil and in a manner that minimizes disturbance of the sample.
 - b. VOC samples should be containerized by filling an En Core® Sampler in accordance with the sampling procedure detailed in Appendix J-F.24. For analysis of low-level VOCs (typically 1 to 200 mg/kg) soil may be sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil may be placed in a vial with a volume of methanol. For some soil sampling programs, multiple En Core® Samplers are required for each sample interval. Holding times for samples in EnCore® Samplers are 48 hours if not field preserved. Refer to the Work Plan and the QAPP for preservation requirements. Sample containers and preservatives shall be consistent with USEPA Method 5035.
 - c. The vial must be immediately capped and locked following sample collection. The sample should then be secured in a plastic bag and transferred to a cooler.
 - d. If other analyses requiring percent moisture determination are not being performed upon a sample, a separate 2 oz or larger sample must be collected to ensure that sufficient sample volume exists for the percent moisture determination.
5. Collect a field screening sample (in accordance with the Standard Operating Procedure for Soil VOC Screening in Appendix J-F.9) from the same sampling location as the discrete grab sample and at the same time.
6. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

Composite Sampling

A composite sample can be obtained by combining a number of discrete grab samples from a test pit/test trench sampling location (i.e., excavator bucket or soil stockpile). For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should be from a single stratigraphic unit and have (by visual observation) similar characteristics.

When taking composite samples from multiple excavator buckets, consider each excavator bucket of soil to be a sampling location. When taking a composite sample using the excavator, use the following procedure:

1. Pick a number of discrete sampling locations that will give a representative sample of the horizon of interest in the test pit.
2. From each of these sampling locations, obtain a soil sample from the excavator bucket using the same methodology described in the previous subsection for a discrete grab sample.
3. The sample container should be partially filled with soil from each discrete grab sampling location. As much as practical, try to put approximately the same volume of soil from each sampling location into the container.
4. Move to the next sampling location and obtain another discrete grab soil sample.
5. Collect a maximum of five surface samples (to avoid the complete dilution of any hot spots).
6. When the last location has been sampled, ensure the sample container is filled with soil, leaving no headspace.
7. Since composite samples are used for SVOCs and inorganic parameters, minimizing the sample collection time is not as important as when discrete samples for VOC analyses are being collected. However, the preferred practice is that the sampler take no longer than necessary to obtain the sample. Do not composite the soil for samples collected for VOC analyses as this will promote the loss of volatile compounds from the soil. All VOC samples will be discrete samples as detailed above.
8. Collect a field screening sample from the same sampling location as the composite sample and at the same time. As much as practical, try to put approximately the same volume of soil from each discrete grab sampling location into a zip-loc bag. The zip-loc bag should be no more than one quarter full after all the sub-samples have been added.

FIELD SAMPLE SCREENING

Upon collection of a soil sample, the soil is screened with a PID (HNu, Microtip, or equivalent) for the presence of undifferentiated organic vapors. The headspace VOC analysis and sample screening procedure is detailed in Appendix J-F-9.

Record this headspace reading on a Test Pit Stratigraphy Log or in the field book.

Note: Perform all headspace readings in an area that is not subject to wind.

Also, in winter it is necessary to allow the samples to equilibrate in a warm area (e.g., site trailer or van). This requirement is usually dictated by the Work Plan.

SAMPLE DESCRIPTION AND LOGGING OF TEST PITS

During the excavation of a test pit, samples may be collected to provide a geologic record, to assist the geologist/engineer in completing or characterizing the stratigraphic units, and to allow for physical or chemical testing.

Soil samples collected are described in the field using the modified USCS. The soil descriptions are recorded on the field form or field book in the following order:

1. USCS Soil Symbol of major component.
2. Native or fill.
3. Secondary and minor soil components.
4. Relative densities/consistency.
5. Grain size/plasticity.
6. Gradation/structure.
7. Color.
8. Moisture content.
9. Observations of odor or visual chemical presence (i.e., NAPL).

In addition to describing the soil properties, enter the following information into a Test Pit Stratigraphy Log:

1. Presence of groundwater and the rate of seepage (if groundwater is encountered).
2. Thickness of each stratigraphic unit.
3. Description of bedding plane features (e.g., continuous, discontinuous, graded, wavy bedding).
4. Description of joints, fractures and faults, if bedrock is encountered (number and orientation).

5. Any appearance of weathering.
6. Description of fill and waste materials.

The dimensions of each excavation and a description of the materials encountered during excavation will be recorded on the Test Pit Stratigraphy Log.

Note: When describing observed odors, be specific in terms of general odor category and strength of odor noted. Odors may typically be chemical, petroleum, or septic related, varying from slight, to moderate, to strong. Identification of specific chemical compounds (i.e., TCE or C-56 odor) is usually unnecessary and often inaccurate as a detailed analysis commonly shows an array of chemistry present.

When describing the presence of vegetative matter in the soil sample, do not use the term "organic" as this often leads to confusion with regards to the presence of organic chemicals (i.e., NAPL).

When describing the soil samples and the stratigraphy observed in the test pit or test trench, it is imperative that the sampler use consistent terms from one test pit to the next. As test pits/test trenches are installed, compare the stratigraphy of completed test pits/test trenches to the stratigraphy of the test pit/test trench you are currently excavating. Be aware of patterns and confirm all inconsistencies at the time the test pit/test trench is being excavated. Since soil stratigraphy is so important to understanding site conditions, soil samples are collected from each stratigraphic unit, and described in full.

CHEMICAL DESCRIPTION

Representative portions of the soil sample should be retained as a geologic record along with a description. Place the soil portions into labeled, sealable, sample containers (usually mason jars) without destroying any apparent stratification.

All geologic record samples are to be retained by the client. Geologic record samples must not returned to or placed in storage at a CRA office.

During soil examination and logging, carefully check for the presence of light or dense NAPL. NAPL may be present in gross amounts or present in small/minute quantities. The adjectives and corresponding quantities used when describing NAPL within a soil matrix are as follows:

<i>Visual Description</i>	<i>Fraction of Soil Pore Volume Containing NAPL</i>
Saturated	>0.5
Some	0.5 - 0.25
Trace	<0.25

A complete description of NAPL includes the following:

- color
- quantity
- density (compared to water) (i.e., light/floats or heavy/sinks)
- odor (if observed)
- viscosity (i.e., mobile/flowable, non-mobile/highly viscous-tar like)

The presence of an iridescent sheen by itself does not constitute NAPL presence, but may be an indicator that NAPL is close to the area.

NAPL presence within a soil matrix may be confirmed by placing a small soil sample within water, shaking, and observing for NAPL separation (i.e., light or dense) from the soil matrix.

Trace amounts of NAPL are identified/confirmed by a close visual examination of the soil matrix, [i.e., separate soil by hand (wearing disposable gloves)] and perform a careful inspection of the soil separation planes/soil grains for NAPL presence.

Often during the sample examination with a knife, an iridescent sheen will be noted on the soil surface (i.e., clay/silts) if the knife has passed through an area of NAPL.

Where NAPL is suspected based on the above observations, soils may be further field screened for the presence of NAPL using the Standard Operating Procedures for Field Screening of NAPL in Appendix J-F.28.

DOCUMENTATION

In addition to completing all field logs and books, prepare a photographic log of each test pit excavation during its progression. The photographic record shall list the date of

each photograph, a specific description of what the photograph depicts, its location, and the photographer

TEST PIT ABANDONMENT

Following completion of the test pit, backfill the excavation using the soil excavated from the pit. To the extent practicable, replace materials in the test pit in the same intervals from which they were extracted.

It should be noted that the material will tend to "bulk" after excavation. As a result, the excavator operator must be informed to compact the materials as they are replaced within the excavation.

RESTORATION

The test pit location must be fully restored. Ensure that restoration activities are properly designed and incorporated within the scope of services for the test pit contractor.

Restoration could include:

- landscaping
- paving
- concrete

FOLLOW-UP ACTIVITIES

Complete the following activities at the conclusion of the field work:

1. Double check the Work Plan to ensure all samples have been collected and confirm this with the Project Coordinator.
2. Ensure that all sample locations are surveyed such that the sample location could be readily re-established.
3. Clean equipment and return to the equipment administrator with the appropriate form dated and signed. Complete water disposal (if required), and cleaning fluid disposal requirements as specified in the Work Plan.

4. Notify the contract laboratory as to when to expect the samples. Enclose the chain-of-custody and covering letter, indicating the parameters and number of samples, in the sample cooler. Ensure that the CRA chemist has all relevant information required to track the progress of the sample analysis.
5. Submit a memo to the Project Coordinator indicating sampling procedures and observations (such as surface staining), grid layout, and all QA/QC documentation.
6. Prepare and distribute a Project Planning, Completion, and Follow-Up Checklist.

APPENDIX J-F-32
SURFICIAL SOIL SAMPLE COLLECTION

STANDARD OPERATING PROCEDURE FOR SURFICIAL SOIL SAMPLING

Soil sampling methods are dependent upon the sample interval of interest, the type of soil material to be sampled, and the requirements for handling the sample after retrieval. The most common method for collection of surficial soil samples is the use of a stainless steel trowel. Soil samples may also be collected with spoons and push tubes. Often a shovel is required to open a trench such that sampling can be conducted. Soil that has come in contact with the shovel cannot be used as sample material.

Surficial debris (e.g., grass cover) should be removed from the area where the sample is to be collected using a separate pre-cleaned device.

Surficial soil samples should be collected using the following procedure:

1. Collect surficial soil samples using a pre-cleaned stainless steel trowel or other appropriate tool (e.g., spoons, En Core® Sampler, or push tube, etc.). Each sample consists of soil from the surface to 6 inches-bgs. Sample in ditches only when there is no water present.
2. Use a new pair of disposable gloves at each sample location.
3. Prior to use, at each sample location, decontaminate all sampling tools as specified in the Work Plan or as described in Section J.7 of the FSP.
4. Use a pre-cleaned sampling tool to remove the sample from the layer of exposed soil. Place the collected soil directly into a clean, pre-labeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a pre-cleaned stainless steel bowl (samples for VOC analysis will not be homogenized to avoid volatilization of VOCs).
5. For VOCs:
 - a. Samples should be collected as soon as possible following disturbance of the soil and in a manner that minimizes disturbance of the sample.
 - b. VOC samples should be containerized by filling an En Core® Sampler in accordance with the sampling procedure detailed in Appendix J-F.24. For analysis of low-level VOCs (typically 1 to 200 mg/kg) soil may be sealed in a specially prepared vial with a solution of sodium bisulfate. For higher levels of VOCs, the soil may be placed in a vial with a volume of methanol. For some soil sampling programs, multiple En Core® Samplers are required for each sample interval. Holding times for samples in EnCore® Samplers are 48 hours if not field preserved. Refer

to the Work Plan and the QAPP for preservation requirements. Sample containers and preservatives shall be consistent with USEPA Method 5035.

- c. The vial must be immediately capped and locked following sample collection. The sample should then be secured in a plastic bag and transferred to a cooler.
 - d. If other analyses requiring percent moisture determination are not being performed upon a sample, a separate 2 oz or larger sample must be collected to ensure that sufficient sample volume exists for the percent moisture determination.
6. After collection, place the samples on ice or cooler packs in a laboratory-supplied cooler.

In the event that soil conditions are not as described in the Work Plan, or if there are unexpected distinct layers of soil present (e.g., a layer of high organic carbon content overlying a layer of fine-grained soil), sampling personnel should immediately report the conditions to the Project Manager for direction. Similarly, if a sampling location is in a gravel or paved area, sampling personnel should confirm with the Project Manager whether the surface samples are to be collected from the gravel/pavement sub-base material or from the first layer of soil beneath these layers.

Sampling team members should immediately report any conditions to the Project Manager that they believe may have a negative effect on the quality of the results.

It is generally inadvisable to collect samples containing excessive amounts of large particles such as gravel. Gravel presents difficulties for the laboratory in terms of sample preparation and the results may not be truly representative of contaminant concentrations in nearby soil.

All conditions at the time of sample collection are properly documented in a field log book. This includes a thorough description of the sample characteristics including grain size, color, and general appearance; date/time of sampling; and labeling information. The location of the sampling point is described in words, and three measurements are taken from adjacent permanent structures so that, if necessary, the sample location can be readily identified in the field at a future date. It is often advisable to have a licensed land surveyor accurately survey the locations.

Soil samples are homogenized in a stainless steel bowl prior to filling sample containers. This step can be bypassed if only one sample container is required to be filled, as long as

the laboratory will homogenize the sample upon receipt. It is important that soil samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample interval. When using a round bowl, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Fill the sample container completely, leaving no headspace.

Do not mix soil for samples for VOC analyses as this promotes the partial volatilization of compounds from the soil.

Discrete Grab Sampling Methodology for Surficial Soils

Discrete grab sampling is employed when the sampling location is considered to be a small area [approximately 1 square foot (0.1 square meter)] that has both a consistent soil type and a consistent level of contaminant impact.

When collecting a discrete grab surficial soil sample, use the following procedure:

1. Using the sampling device (e.g., trowel, spoon) scoop soil from the top 2 feet into the sample container. If the sample is being collected for VOC analyses, perform this step as quickly as possible in order to minimize the loss of volatile compounds from the soil.
2. Collect a field screening sample from the same sampling location as the discrete grab sample and at the same time. Scoop soil into a zip-loc bag until it is no more than one quarter full.
3. Do not mix the soil for samples collected for VOC analyses (for sample homogenization purposes) as this will promote the loss of volatile compounds from the soil. The laboratory will obtain a representative sample from the container by using coring techniques before the laboratory analysis is performed.

Composite Sampling Methodology for Surficial Soils

A composite sample can be obtained directly from the soil surface by combining a number of discrete grab samples from a number of sampling locations on the soil surface. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should have (by visual observation) similar characteristics.

When collecting a composite surface soil sample, use the following procedure:

1. Choose a number of discrete sampling locations that will give a representative sample of the defined composite area at each sampling location.
2. Using the sampling device (e.g., trowel, spoon), scoop the soil from the top 2 feet into the sample container. As much as practical, try to put approximately the same volume of soil from each sampling location into the container.
3. Move to the next sampling location and repeat steps 1 and 2.
4. Collect a maximum of five surface samples (to avoid the complete dilution of any hot spots).
5. When the last location has been sampled, ensure the sample container is filled with soil, leaving no headspace.
6. Since composite samples are used for semi-volatile organic compounds (SVOCs) and inorganic parameters, minimizing the sample collection time is not as important as when discrete samples for VOC analyses are being collected. However, the preferred practice is that the sampler take no longer than necessary to obtain the sample. Do not composite the soil for samples collected for VOC analyses as this will promote the loss of volatile compounds from the soil. All VOC samples will be discrete samples as detailed above.
7. Collect a field screening sample from the same sampling location as the composite sample and at the same time. As much as practical, try to put approximately the same volume of soil from each discrete grab sampling location into a zip-loc bag. The zip-loc bag should be no more than one quarter full after all the sub-samples have been added.

Since composite samples are not analyzed for VOCs, there is no reason to avoid mixing the sub-samples from the various sampling locations in the sample container (homogenization). However, since the laboratory will use coring techniques to ensure that a sample is representative of the entire container, there is no need to perform field homogenization of the soil within the sample container.

During the sampling program, the sampling team leader will stay in contact with the CRA chemist assigned to the project such that the CRA chemist can properly inform the contract laboratory of the progress of the work. This includes submitting sample summaries and/or copies of completed chain-of-custody forms to the CRA chemist.

APPENDIX J-F-33
GAS PROBE INSTALLATION

STANDARD OPERATING PROCEDURE FOR GAS PROBE INSTALLATION

Gas probes are typically installed on sites where gas migration is a concern. They are used to monitor for the presence of gases either on a site, or gases leaving a site by soil migration. Common locations for gas probes include landfills or anywhere soil gas contamination may exist. The process of installing gas probes is discussed within this Standard Operating Procedure (SOP).

The procedures described in this section pertain to installation of:

- Probes for monitoring landfill gas migration from a fill area
- Probes for monitoring soil vapor at sites
- Probes for monitoring landfill gas within the landfill

This section does not specifically address extraction wells for landfill gas and soil vapor extraction, however, many of the principles are similar and can be adapted. Note that unless otherwise specified, the terms probe and gas extraction well will be used interchangeably.

1.0 PRIOR PLANNING AND PREPARATION

Prior to installing a gas probe:

1. Review the Work Plan and HASP with the Project Coordinator. Understand the existing site geologic/hydrogeologic conditions such as the type of soil, level of water table or perched groundwater table, and properties of refuse (if installing a probe in a landfill) such as depth, leachate levels or perched leachate levels. Know the seasonally high and low water table and leachate elevations, and know if perched conditions exist.
2. Assemble all required equipment, materials, log books, and forms.
3. Coordinate with a drilling contractor to ensure the work can be completed and to provide them with all relevant information to complete the job prior to arriving on site.
4. Obtain information on the probes to be installed to ensure a complete understanding of the task to be performed. Required information for installation includes knowing the type of gas probe construction materials that are to be

used, including knowing the diameter of the probe, depth of probe (length of riser), type and amount of packing material, type of probe material, and planned location for each probe. Also determine if multilevel probes are required.

5. Determine the type of analyses that are required from the probes after installation, and the type of gas monitoring that is required during the drilling and installation of the probe.
6. Arrange access to the site, especially if the property owner is not our client. Obtain all necessary keys. Also consider site conditions (e.g., is snow removal required?).
7. Determine excess soil or refuse disposal procedures before commencing drilling activities.
8. Determine drilling or property access notification requirements with the Project Coordinator. Notify the client, landowner, and appropriate regulatory agencies and complete utility clearance activities in accordance with the FSP.
9. Understand and review the potential health and safety hazards associated with the task and with the site.

These considerations should have been incorporated during development of the Work Plan and should be discussed with the Project Coordinator.

2.0 EQUIPMENT DECONTAMINATION

On all sites, drilling and gas probe installation will be decontaminated as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

In addition, the following steps may be added when encountering soils or liquids with volatile organic compounds (VOCs) and metals:

1. Rinse with 10 percent nitric acid (only if samples are to be analyzed for metals).
2. Rinse with deionized water.

3. Rinse with appropriate solvent (pesticide grade isopropanol, methanol, acetone, hexane, if required).
4. Rinse again with deionized water.
5. Air dry for as long as possible.
6. Wrap equipment if possible in aluminum foil to prevent contamination.

Note that if drilling is being conducted by a subcontractor, they will be responsible for cleaning their own equipment. However, it is important for CRA personnel to understand and verify that proper procedures are being followed.

3.0 INSTALLATION PROCEDURES - GAS PROBES

The same drilling methods are typically used for gas probe installation as for monitoring well installation. Generally, if monitoring wells are being installed at a site at the same time as the gas probes, the same drilling method can be used for the gas probes.

Gas probes will be installed using a 2-inch diameter Geoprobe dual-tube direct push technique to minimize formation disturbance. The borehole for each gas probe will be advanced to a target depth in the unsaturated zone (a minimum of 2 ft above the water table).

Gas Probe Locations

Gas probe locations will primarily be selected in the Work Plan to provide a good geographical distribution across the site given the site conditions anticipated, and to suit the intended purpose of the study. Most often, the locations are not pre-verified to confirm clearance from underground or overhead utilities or to match the site's specific characteristics (i.e., traffic patterns, drainage patterns, etc.). Consequently, it is the Field Coordinator's task to select the exact location for each gas probe consistent with all of the site and study requirements. If a gas probe must be moved more than 20 feet from the initially identified location, the Field Coordinator must confirm the selected location's suitability with the Project Manager/Coordinator.

To the extent practicable, gas probes should be located adjacent to permanent features (i.e., fences, buildings, etc.) that offer some form of protection and a reference point for locating the gas probe. Gas probes located in high traffic areas or road allowance right

of ways are undesirable and should be avoided if possible. Low lying areas are also undesirable.

Annular Space

The borehole diameter must be of sufficient size such that the gas probe construction can proceed without any major difficulties. Particular attention should be paid to prevent bridging of fill or seal materials.

Instrumentation Details

The length of each gas probe assembly (i.e., perforated section and riser components) must be measured and recorded prior to insertion into the augers or borehole.

Filter Pack

The final depth of the gas probe screen will be dependent on the conditions observed at each location and will be determined in the field. For gas probes, the perforated interval and filter pack are to be placed:

- a minimum 3 feet below the ground surface. This depth may vary depending upon the ground surface (i.e., if the ground surface is paved, this depth could be reduced);
- in a soil strata with a notably higher permeability than the surrounding geologic strata if one exists. Strata with higher permeabilities have a greater potential for gas migration and therefore should be monitored; and
- a minimum of 2 feet above the water table.

A common problem with the installation of gas probes is flooding of gas probes. The problem is especially pronounced at sites with perched water tables. Gas probes are typically installed in the more permeable strata where perched water tables are most likely to exist. A thorough understanding of the hydrogeology of the site is necessary to install effective gas probes. Should groundwater be encountered in any gas probe borehole, the tube will be pulled up a minimum of 2 feet above the water table. The void that is formed when the tube is pulled will be filled using No. 3 silica sand.

As with monitoring wells, the filter pack of a gas probe should never extend through a confining layer causing two or more separate permeable layers to become connected.

Where landfilled materials are present, the screen should be placed at a depth immediately above the landfilled materials. If the landfilled material extends to within three feet of the surface and it is, therefore, not possible to set the screen above the landfilled material, the screen will be placed within the landfilled material, with the screened interval set as close to the top of the landfilled materials as possible but deep enough to minimize the breakthrough of ambient air from the surface (i.e., 3 to 5 ft bgs).

When placing the filter pack into the borehole, a minimum of 4 inches of filter pack material will be placed under the bottom of the probe screen to provide a firm footing. The filter pack will extend to approximately 8 inches above the top of the screened interval. The sand pack and bentonite seal will be placed as the Geoprobe is withdrawn to ensure that the formation does not collapse around the screened interval or riser.

Bentonite Seal (Plug)

A seal will be placed on top of the filter pack. This seal will consist of a high solids, pure bentonite material. Bentonite in either pellet or granular form is acceptable. Typically, pouring of the bentonite is acceptable in shallow gas probes [less than 50 feet (14 m)] where the annular space is large enough to prevent bridging and to allow measuring to ensure that the bentonite has been placed at the proper intervals. The bentonite seal will be placed above the filter pack and to a minimum 1 foot thick. Since gas probes are installed above the water table, potable water will be used to hydrate the bentonite.

Backfill

The annular space between the bentonite seal and the concrete surface seal will be backfilled with hydrated bentonite grout.

Where multiple probes are installed in a single borehole, the annular space between the bentonite seal above the lower probe and the bentonite seal below the upper probe will be filled with bentonite grout. The space between the uppermost probe and the surface is also filled with bentonite.

Aboveground Riser Pipe and Outer Protective Casings

The gas probe, when installed and grouted, will extend above the ground surface a minimum of 2.5 feet. A protective casing will be installed over the completed gas probe and grouted into place. The outer protective casing will be of steel construction with a hinged, locking cap that is tamperproof. The protective casing will have sufficient

clearance so that the stop cocks can be operated. A 6-inch protective casing is required for multilevel probes. The protective casings will have a minimum of two weep holes for drainage. These weep holes will be a minimum 1/4 inch in diameter and drilled into the protective casing just above the top of the level of concrete inside to prevent standing water inside the protective casing.

In cases where wells must be located in traffic areas, the wells will have to be flush-mount installations. For these wells, a waterproof protective casing is essential to ensure the integrity of the groundwater formation. The protective casings are grouted in place and usually fitted with bolts and rubber gaskets.

Flush-mount well installations are typically more problematic and maintenance intensive than above-grade installations and therefore should be avoided where possible.

INSTALLATION DOCUMENTATION

Details of each gas probe and extraction well installation should be recorded on a Stratigraphy Log (Overburden), or recorded within a standard CRA field book. The Well Instrumentation Log is provided for recording the overburden well instrumentation details, and can be used for gas probe installations. This figure must note:

- borehole depth
- probe perforation intervals
- filter pack intervals
- plug intervals
- grout interval
- surface cap detail
- gas probe material
- gas probe instrumentation (i.e., riser and screen length)
- gas probe diameter
- filter pack material
- backfill material detail
- stickup/flush-mount detail
- date installed

The soil stratigraphy encountered at probes and extraction wells outside of the limit of refuse must be recorded on a Stratigraphy Log Overburden. For installations within refuse, the character, composition, and moisture content must be recorded. Documentation should be in accordance with the Work Plan and FSP. A photograph of each core sample collected will be taken and a photographic log will be documented in the field notes.

Each gas probe installed must be surveyed in accordance with the FSP.

Each gas probe must be permanently marked to identify the gas probe number designation.

3.1 DRILLING IN PUTRESCIBLE REFUSE

Drilling on landfills is complicated by:

- the presence of explosive gases
- the presence of hydrogen sulfide (H₂S)
- the presence of organic vapors
- the potential unstable nature of the refuse
- the presence of refuse material, (e.g., mattresses, steel cables, etc.) that can affect the ability to remove the augers

Landfill gas is primarily composed of two major gases: methane (CH₄) and carbon dioxide (CO₂). Other components of lesser quantity include nitrogen (N₂), oxygen (O₂), and odorous compounds. VOCs are also found in landfill gas at low or trace concentrations, usually at parts per million or parts per billion level. A further trace compound commonly found in landfill gas is hydrogen sulfide (H₂S) which, in addition to being corrosive, presents a health and safety issue at low concentrations. The composition of landfill gas is variable from landfill to landfill and at different locations within a landfill.

The following is a list of recommended safety procedures to be applied when drilling on or near landfill sites:

1. A detailed HASP must be developed and implemented in accordance with CRA's health and safety policies.
2. Smoking is not permitted on or near the landfill site.
3. The drilling contractor will have its own HASP covering the work tasks to be undertaken. The drilling crew will be aware of the health and safety hazards associated with landfill gas.
4. Personnel will be alert to the potential for fires occurring at the borehole due to the possible presence of combustible gases and a source of ignition (sparking of the drill bit striking metal or rock). Pre-arrangements will be made to insure that any fire that occurs is immediately capable of being extinguished. The use of fire extinguishers (foam) or by smothering the fire with soil are the most likely method for extinguishing fires.

Note: *An old landfill can also represent a higher potential for fires because the upper zone of the borehole is more likely to have a high enough concentration of oxygen to be in the combustible range. A younger landfill is more likely to have little oxygen and a higher positive gas pressure and therefore the gas in the borehole is typically above the combustible range. The combustible zone would occur just above the borehole where the landfill gas mixes with oxygen in the atmosphere.*

5. Continuously monitor the breathing zone (3 to 5 feet) away from the borehole] for combustible gas, oxygen deficiency, and hydrogen sulfide with a direct reading alarm monitor or a personal air monitor. Check and record readings each hour.

Appropriate action levels for combustible gas and hydrogen sulfide are defined in the Site-Specific HASP.

Caution: *Respirators with air purifying cartridges will not be used as PPE in the presence of hydrogen sulfide. Exposure to hydrogen sulfide results in olfactory fatigue and there is no APR approved for use in an atmosphere containing hydrogen sulfide.*

6. Monitor organic vapors in the breathing zone once every hour while work is going on. Check combustible gas concentration concurrently. Record readings. Increase monitoring frequency if warranted.

Appropriate action levels for organic vapors are defined in the Site-Specific HASP.

Caution: Photoionization Detectors (PID) will not respond to methane as the ionization potential for methane is 14.98, which is higher than most standard PIDs. PIDs will not respond properly to organic vapors in an atmosphere containing greater than 1 percent by volume of methane. PIDs should never be exposed to high concentrations of corrosive gases such as landfill gas.

7. All personnel will be alert to the potential for "caving-in" of the edge of the borehole when larger diameter (greater than 1 foot), open hole drilling techniques are used. In such situations, all personnel required to work near the top of the borehole will use extreme caution.
8. In consideration of the above noted hazards, requirements for personnel to work in close proximity (i.e., within 6 feet) to the borehole will be minimized. When not specifically required to carry out a task at the borehole, all personnel will stand well clear of the area (i.e., greater than 14 feet from the borehole).
9. Open boreholes will not be left unattended. If drilling and probe/well construction cannot be completed by the end of the working day, the borehole will be secured. Such security shall include as a minimum:
 - capping of the borehole to prevent venting of gas. If Geoprobe rods are left in the hole they will be capped; and
 - open boreholes will be covered with plates/planking to fully span well beyond the opening. Polyethylene sheeting will be placed on top of the plates/planking and soil fill will be placed on top to prevent leakage of gas. Barricades will be erected enclosing the incomplete borehole. Appropriate signs will be posted on the barricade warning.
10. Personnel shall inform themselves of, and adhere to, any local rules or regulations which may also govern the work.

4.0 RESPIRATORY PROTECTION

The HASP must be followed with regard to respiratory protection.

5.0 FIELD PROCEDURES

The following presents the field procedure requirements and techniques for the completion of gas probe installations.

5.1 DESIGN CONSIDERATIONS

Diameter

The probe diameter should be kept to a minimum to reduce the volume of gas that must be purged from the probe during monitoring. If possible, the probe diameter should be large enough to allow water levels to be measured. Gas probes will be completed using 0.5-inch diameter Schedule 40 PVC continuous piping. Typically a 1/2-inch diameter gas probe is suitable since water levels can be measured in a 1/2-inch diameter probe with a thin line Solinst. Gas probes are typically not large enough for sampling of liquids and are not intended for this purpose.

Perforated Section and Filter Pack Material

The perforated section on the gas probe should be consistent with the desired monitoring interval and geologic conditions encountered. The perforated section of the gas probes will be 1 ft.

The gas probe perforations are typically drilled by hand into the riser pipe. A filter cloth covering the perforations is not required if sufficient size and gradation of the granular pack material is provided.

The preferred filter pack material for gas probes is pea gravel or No. 3 silica sand. Limestone as a pack material is generally not preferred unless no other options exist. The filter pack must have a higher permeability than the surrounding geologic strata. Since gas probes are not designed to be installed below the water table, it is not necessary to match the well screen and filter pack material to the geologic strata.

Monitoring Parts

A stopcock (small valve) and hose barb (connection for monitoring hose) will be installed on all gas probes. The stopcock should be 1/2-inch PVC ball valve. Brass valves are not recommended since the valves became difficult to operate with time. A

1/4-inch hose barb is recommended since most monitoring instruments can be connected to this size of hose barb. Figure J-2.4 provides a detail of this assembly.

Well Materials

The materials selected for well construction must be compatible with the gases anticipated to be present. Experience has shown that PVC risers are suitable for typical (municipal) landfill applications.

Where sampling will or may be conducted for VOCs, the PVC pipe sections, end caps, and stopcock and hose barb assemblies must not be solvent cemented. In general, it is preferable to use threaded or continuous PVC pipe to avoid any possible contamination from solvent cement at the joints.

In all cases, the stopcock and hose barb assembly must be removable to allow water levels to be measured.

5.2 FOLLOW-UP ACTIVITIES

Once the gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes in accordance with the Work Plan and FSP.
2. Submit all logs to for the generation of the final well log(s).
3. Arrange surveyor to obtain accurate horizontal and vertical control.
4. Accurately plot gas probe/boring locations on the site plan, since boring locations may change in the field due to underground/overhead utility interferences or other conditions.
5. Tabulate gas probe completion details.
6. Write up a summary of field activities including, but not necessarily limited to such items as drilling method(s), construction material, site geology.
7. The field book will be kept at the appropriate CRA office.

APPENDIX J-F-34
VERTICAL AQUIFER SAMPLING BY GEOPROBE

STANDARD OPERATING PROCEDURE FOR VERTICAL AQUIFER SAMPLING BY GEOPROBE

1.0 INTRODUCTION

Direct-push (a.k.a., Geoprobe) refers to the sampler being "pushed" into the soil material without the use of drilling to remove the soil. This method relies on the drill unit static weight, combined with rapid hammer percussion, to advance the tool string. Discrete soil samples are continuously obtained. It is important that the direct-push drilling method (i.e., Geoprobe) used minimizes the disturbance of subsurface materials.

This method is used extensively for initial site screening to establish site geology and delineate vertical and horizontal plume presence.

Standard Penetration Test (SPT) blow count values cannot be obtained when sampling with a direct-push discrete soil sampler.

The direct-push method is popular due to the limited cuttings produced and the speed of the sampling process, which can be much faster than the sample description and sample preparation process.

Discrete continuous soil samples are collected in tube samplers (various lengths) affixed with a cutting shoe and internal liner [polyvinyl chloride (PVC), Teflon, or acetate are available]. The soil sampler may be operated in "open-mode" (when borehole collapse is not a concern), or in "closed-mode" (when minimization of sample "slough" is desired). Closed-mode operation involves placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. At the required depth, the temporary drill-point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner, with soil, is removed for examination. Extra care must be taken when cutting open the sample tube; no open blade cutting tools may be used in the process, you must have an appropriate stabilizer/holder for the tube, and cut resistant hand protection must be included as part of the overall PPE.

The Geoprobe drilling method should not contaminate the subsurface soils and groundwater. It is extremely important that drilling does not create a hydraulic link or conduit between different hydrostratigraphic units. Groundwater in monitoring and extraction wells must not be contaminated by drilling fluids or the borehole

advancement process. Geoprobe drilling equipment will be decontaminated before use and between locations to prevent cross-contamination between VAS locations and sites. Geoprobe drilling equipment will be decontaminated between well locations regardless of whether or not contaminants are suspected. Section 7.0 in the FSP specifies the required decontamination procedures. At a minimum, decontamination procedures detailed in Section 7.0 of the FSP should be used during monitoring well design and construction.

A Geoprobe SP16 will be used for VAS activities. The Geoprobe SP16 is a direct push groundwater sampling device that consists of a well screen inside a steel sheath that is driven to the desired sample depth using standard Geoprobe rods. The Geoprobe SP16 is then deployed by retracting the steel sheath and exposing the well screen directly to the formation. The maximum well screen length of the Geoprobe SP16 is 41 inches. Generally, the full 41 inch well screen will be used for VAS activities. The Geoprobe SP16 tubing check valve is used to sample groundwater within the screen interval. A small bladder pump may be used to collect VOC samples. The VAS location will then be abandoned using grouting.

Finally, if required, precleaned construction materials are used in order to prevent the potential introduction of contaminants into a hydrostratigraphic unit.

2.0 PLANNING AND PREPARATION

Prior to undertaking utilizing a Geoprobe for VAS procedures:

1. Review the appropriate Work Plan and Site-Specific Health and Safety Plan (HASp), project documents, all available geologic and hydrogeologic mapping and reports, water well records, and historic site reports to become familiar with the geologic and hydrogeologic framework of the site and surrounding area. Review and become familiar with the health and safety requirements, and discuss the work activities with the Project Coordinator.
2. Assemble all required equipment, materials, log books, and forms.
3. Obtain a site plan and previous stratigraphic logs. Determine the exact number, location, and depth of wells to be installed.
4. If not performed as part of borehole advancement, complete a Property Access/Utility Clearance Data Sheet. In most instances, the utility clearances and property access will have been completed as part of the well drilling and advancements.

5. Determine notification requirements with the Project Coordinator. Have all regulatory groups, the client, landowner, drilling contractor, and CRA personnel been informed of the well design and installation program?
6. Determine the methods for handling and disposal of VAS and decontamination fluids. Generally, this is dealt with as part of the well advancement activities.

In addition to the above, the following may be required when conducting VAS activities:

1. Establish a water source for well installation and decontamination. Pre-plan the methods of handling and disposal of well installation and decontamination fluids.
2. Arrange with the drilling contractor/client to provide a means of containment and disposal of fluids.

3.0 EQUIPMENT DECONTAMINATION

Prior to use and between each borehole location, drilling and sampling equipment must be decontaminated in accordance with Section 7.0 of the FSP.

4.0 LOCATION AND MARKING OF VAS SITES/ FINAL VISUAL CHECK

The proposed VAS locations marked on the site plan are located and staked in the field. This should be completed several days prior to the drill rig arriving on site. VAS locations are required for the completion of utility locates. Generally, VAS locations are strategically placed to assess site hydrogeologic conditions.

Once the final VAS location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck can vacuum a large diameter hole to

check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

Caution: *Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.*

VAS locations are selected primarily to provide a good geographical distribution across the site. Most often, the VAS locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, nor to consider the site's specific characteristics (e.g., traffic patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

1. Select the exact location of each well consistent with the site and project requirements.
2. If a VAS location must be relocated more than 20 feet (5.7 m) from the initially identified location, confirm the new location's suitability with the Project Coordinator.
3. Ensure all utilities have been cleared prior to initiating borehole advancement activities.

5.0 VERTICAL AQUIFER SAMPLING BY GEOPROBE PROCEDURES

The direct push procedure will use the Geoprobe®, as follows:

1. The direct push drill rig will advance the borehole using methods consistent with ASTM Standard D6724-04 (Appendix J-H-4).
2. The direct push borehole will be advanced from ground surface to the top of the Upper Aquifer, a total depth of approximately 25 ft-bgs, or as ground conditions allow. Soil samples will be collected using Geoprobe® MacroCore® sampling techniques or equivalent. Soil samples will be collected throughout the entire length of the borehole.
3. Representative samples will be logged immediately after opening the acetate liner. Field measurements of undifferentiated VOCs will be conducted by placing representative soil samples into a closed sample container and allowing them to equilibrate. The VOCs in the headspace will then be measured by

placing the wand of the PID into the headspace. Field calibration, preventative maintenance, and SOPs for the PID are contained in Section 6.0 of the FSP.

4. The soil core will be logged by CRA personnel and soils will be classified using the USCS in accordance with ASTM Method D-2488-06 (Appendix J-H-2). Samples will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G.
5. VAS activities will be conducted beginning no deeper than 5 feet below the water table unless otherwise specified in the Work Plan. A pre-cleaned Geoprobe® SP16 groundwater sampler will be assembled as per manufacturer's operational procedure.
6. A pre-cleaned Geoprobe® SP16 groundwater sampler will be assembled as per manufacturer's operational procedure. A description of the Geoprobe® SP16 is provided in Section 1.0 of this SOP.
7. New 1/4-inch diameter tubing will be installed and attached to a peristaltic pump. Groundwater will be purged from the Geoprobe® SP16 groundwater sampler using the peristaltic pump. A minimum of three to five screen point well volumes will be purged at the same rate as the low flow sampling prior to commencing stabilization monitoring. Field measurements of pH, conductivity, turbidity, and temperature will be collected at approximate 5-minute intervals. If it is apparent that stabilization will not be achieved quickly, stabilization parameter measurements may be made at a greater time interval. Stabilization monitoring will be performed using a flow-through-cell. All field measurements will be recorded in the field book.

The groundwater will be considered stable after a maximum of five well volumes are removed or when three successive readings for pH, specific conductance, turbidity, and temperature agree within the following limits:

- pH ± 0.1 pH unit
 - Specific conductance ± 3 percent (temperature corrected)
 - Temperature $\pm 1.0^{\circ}\text{C}$
 - Turbidity = or < 5 NTU
8. Once field parameters have stabilized, groundwater samples will be collected directly from the discharge line in laboratory-supplied, analyte-specific sample containers and preserved according to laboratory requirements. Groundwater samples collected for VOC analysis will be collected from the tubing before it reaches the pump head, by crimping the tubing, detaching it from the pump, and pouring the water into the vial.

9. VAS samples will be analyzed for parameters determined based on the results of Phase I of the Groundwater Investigation. The Geoprobe® SP16 groundwater sampler will be decontaminated between samples following the procedures in Section 7.0 of the FSP.
10. Upon reaching the total depth of the VAS location, the downhole equipment will be removed from the borehole and the borehole will be backfilled with pure bentonite slurry grout.
11. All downhole equipment such as drill rods and sample tools will be decontaminated as discussed in Section 7.0 of the FSP.
12. Drill cuttings and decontamination water will be managed as discussed in Section 8.0 of the FSP.

6.0 SOIL SAMPLE COLLECTION FROM GEOPROBE DRILLING CORES

When borehole drilling, the core sample retrieved from the borehole is considered a discrete grab sample that has been taken from one sampling location, as long as both the stratigraphy of the entire sample and the level of contamination are consistent over the length of the core sample. If a single core sample contains soils from two different stratigraphic units, the soils from each of these stratigraphic units are considered separate discrete grab samples.

If a single core sample contains soils from a single stratigraphic unit, but visual observation indicated that some of the soil was heavily impacted with contaminants, while the rest of the soil was only lightly impacted, then the soils representing each of the two levels of contamination are considered two separate discrete grab samples.

If required, representative soil samples will be collected from the drilling cores in accordance with the following procedures.

- i. Once removed to the ground surface, open the discrete soil sampler by removing the cutting shoe, and extract the soil liner (with recovered soil) from the sampler body.
- ii. Place the soil liner into a holder and cut lengthwise (using a liner knife) to expose the collected soil core.
- iii. Perform PID screening for organic vapors and record readings.
- iv. Measure length of sample and record as the recovered length.

- v. Representative soil samples will be collected from Geoprobe drilling cores using a pre-cleaned stainless steel trowel or other appropriate tool (e.g., spoons or push tube).
- vi. Use a new pair of disposable gloves for each sample.
- vii. Prior to use, for each sample, decontaminate all sampling tools as specified in the Work Plan or as described in Section J.7 of the FSP.

Use a pre-cleaned sampling tool to remove the sample from the layer of exposed soil. For clayey or cohesive soils:

- a) Discard upper and lower ends of sample core (3 inches) if near the area to be sampled.
- b) Use a pre-cleaned stainless steel knife.
- c) Cut the portion of the core to be sampled longitudinally.
- d) With a sample spoon, remove soil from the center portion of the core and place in a pre-cleaned stainless steel bowl.
- e) Remove large stones and natural vegetative debris.
- f) Homogenize the soil and place directly into sample jars.

For sandy or non-cohesive soils, as sandy soils have less cohesion than clayey soils, it is not easy to cut the core longitudinally to remove the center of the sample. Therefore, with a stainless steel spoon, scrape away surface soils which have likely contacted the sampler and then sample the center portion of the soil core.

Note: *Samples for VOC analysis must not be homogenized. Collect soil samples for VOC analysis in En Core™ Samplers (refer to Appendix J-F-24). Completely fill the container. No air space (headspace) should remain in the sample container. VOC samples should be collected before any other samples and as soon as practicable following opening of the soil liner.*

- viii. Place the collected soil directly into a clean, pre-labeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a pre-cleaned stainless steel bowl (with the exception of samples for VOC analysis, which shall be placed directly in the sample jar and not homogenized in order to prevent volatilization of the VOCs).

Note: *Place all soil samples collected for chemical analysis immediately into a cooler with ice.*

APPENDIX J-F-35

COMPOSITE WASTE TYPE SAMPLING

STANDARD OPERATING PROCEDURE FOR COMPOSITE WASTE TYPE SAMPLING

Composite waste type sampling will be conducted for the retained samples of waste collected during the test pit/test trench investigation at the Site. Composite waste type sampling may also be used for disposal characterization of investigative derived waste (IDW) materials.

Test pits and test trenches are typically excavated to explore and define geologic conditions (or buried waste/debris) and to allow the collection of subsurface soil samples for geotechnical or chemical analysis. Test pits and test trenches give a more complete view of the subsurface soil conditions than soil borings.

CRA will use representative fill samples retained from each test pit and test trench to compare fill types from different excavations. Samples of the same distinct fill zones or landfilled materials based on visual observations and headspace analysis will be collected from multiple test pits and test trenches where possible (i.e., where the same distinct fill zone or landfilled materials based on visual observations and headspace analysis are present in more than one test pit in recoverable quantities). A sample from each distinct fill type observed in each test pit and test trench will be retained in appropriate sampling containers maintained at appropriate temperatures so that samples may be submitted in the future (within the applicable sample holding time) for laboratory analysis.

A composite sample of each fill type (i.e., construction and demolition debris, ash, and cinders, etc.) will be prepared from the retained samples of the representative fill types from the test pits and test trenches (within applicable holding times) and submitted to the analytical laboratory for Toxicity Characteristic Leaching Procedure (TCLP) preparation with subsequent analysis of the resultant leachate for semi-volatile organic compounds (SVOCs), pesticides, herbicides, and metals. Samples will also be analyzed for polychlorinated biphenyls (PCBs), corrosivity, ignitability, and reactive cyanide and sulfide. A minimum of one composite sample will be submitted for each fill type. Samples collected for TCLP volatile organic compound (VOC) analysis will not be composited. The parameters and associated analytical methods are specified in Table J-2.1.

SAMPLE COLLECTION

Soil samples to be retained, and ultimately used for composite samples, will be collected from the backhoe/excavator bucket or stockpiled spoils as detailed in Appendix J-F-31.

Sample selection will be based on the visual appearance of the material (e.g., color, staining, grain size, etc.), location of the material prior to removal (e.g., adjacent to drums or base of excavation), and field instrument measurements (i.e., headspace readings using a photoionization detector [PID]).

The location, number, and type of soil sample collected and the determination of the soil samples to be submitted to the laboratory for analysis will be as specified in the Work Plan and Field Sampling Plan. Record all soil samples collected in the sample log book. Labeling of samples shall be consistent with the Quality Assurance Project Plan (QAPP, CRA, May 2008).

The composite samples should be prepared as soon as possible following excavation of the soil and within the holding time as specified in the QAPP.

Composite Sampling

A composite sample can be obtained by combining a number of discrete grab samples from various test pit/test trench sampling locations. For preparation of a meaningful composite sample, the soils from the sub-samples taken from the different sampling locations should be from a single stratigraphic unit and have (by visual observation) similar characteristics.

When preparing composite samples from multiple retained discrete samples, use the following procedure:

1. Pick a number of discrete sampling locations that will give a representative sample of the horizon of interest in the test pits and/or test trenches.
2. From each of the sampling locations used for the composite sample, obtain a soil sample from the excavator bucket using the same methodology described in Appendix J-F-31. These samples will be retained in the appropriate sample jars at the appropriate temperature until such time as all the test pit/test trench locations to be included in the composite sample have been excavated and sampled. As noted above, the composite sample must be prepared and submitted to the laboratory prior to the expiration of the sampling holding time.
3. Soil samples are homogenized in a stainless steel bowl prior to filling sample containers. The stainless steel bowl should be partially filled with soil from each discrete grab sampling location. As much as practical, try to put approximately the same volume of soil from each sampling location into the container. This step can be bypassed if only one sample container is required to be filled, as long as

the laboratory will homogenize the sample upon receipt. It is important that soil samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample interval. When using a round bowl, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Fill the sample container completely, leaving no headspace.

4. Do not mix soil for samples for VOC analysis as this promotes the partial volatilization of compounds from the soil. For VOCs, the worst-case sample from the retained samples (based on field screening) will be submitted for analysis as a discrete sample. Additional VOC samples may be submitted if appropriate. Samples of IDW for TCLP VOC analysis will be collected based on field screening to ensure a representative sample is collected.
5. Composite a maximum of five separate samples (to avoid the complete dilution of any hot spots).
6. Ensure the sample container is filled with soil, leaving no headspace.
7. The sampler should take no longer than necessary to obtain the sample.

Note: Samples collected from different waste units/types should not be composited into one sample container without additional analytical and/or field screening data to determine if the materials are compatible.

FOLLOW-UP ACTIVITIES

Complete the following activities at the conclusion of the field work:

1. Double check the Work Plan to ensure all samples have been collected and confirm this with the Project Coordinator.
2. Clean equipment and return to the equipment administrator with the appropriate form dated and signed. Complete water disposal (if required), and cleaning fluid disposal requirements as specified in the Work Plan.
3. Notify the contract laboratory as to when to expect the samples. Enclose the chain-of-custody and covering letter, indicating the parameters and number of samples, in the sample cooler. Ensure that the CRA chemist has all relevant information required to track the progress of the sample analysis.
4. Submit a memo to the Project Coordinator indicating sampling procedures and observations, and all Quality Assurance/Quality Control documentation.

APPENDIX J-F-36

**STANDARD OPERATING PROCEDURE FOR
SUB-SLAB SOIL GAS PROBES**

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1.0 PRIOR PLANNING AND PREPARATION

Prior to installing a sub-slab gas probe:

1. Review the Work Plan and HASP with the Project Coordinator. Understand the existing site geologic/hydrogeologic conditions such as the type of soil, level of water table or perched groundwater table, and properties of refuse (if installing a probe in a landfill) such as depth, leachate levels or perched leachate levels. Know the seasonally high and low water table and leachate elevations, and know if perched conditions exist.
2. Assemble all required equipment, materials, log books, and forms.
3. Coordinate with a drilling/coring contractor (if one is retained) to ensure the work can be completed and to provide them with all relevant information to complete the job prior to arriving on site.
4. Obtain information on the probes to be installed to ensure a complete understanding of the task to be performed. Required information for installation includes knowing the type of gas probe construction materials that are to be used, including knowing the diameter of the probe, depth of probe (length of riser), type and amount of packing material, type of probe material, and planned location for each probe. Also determine if multilevel probes are required.
5. Determine the type of analyses that are required from the probes after installation, and the type of gas monitoring that is required during the drilling and installation of the probe.
6. Arrange access to the site, especially if the property owner is not our client. Obtain all necessary keys. Also consider site conditions (e.g., is snow removal required?).
7. Determine excess soil or refuse disposal procedures before commencing drilling/coring activities.
8. Determine drilling or property access notification requirements with the Project Coordinator. Notify the client, landowner, and appropriate regulatory agencies and complete utility clearance activities in accordance with the FSP.
9. Understand and review the potential health and safety hazards associated with the task and with the site.

These considerations should have been incorporated during development of the Work Plan and should be discussed with the Project Coordinator.

2.0 EQUIPMENT DECONTAMINATION

Prior to use between gas probe locations, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the Quality Assurance Project Plan (QAPP), or the methods presented in the following section.

The minimal procedures for decontamination of drilling or excavating equipment are:

1. Hot water and detergent wash (brushing as necessary to remove particulate matter).
2. Potable, hot water rinse.

Cover clean equipment with clean plastic sheeting to prevent contact with foreign materials.

On environmental sites, soil sampling equipment (e.g., split-spoons, trowels, spoons, shovels, and bowls) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with potable water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

3.0 INSTALLATION PROCEDURES - SUB-SLAB GAS PROBES

Sub-slab soil gas probes allow for collection of sub-slab soil gas samples from directly beneath the slab of a building. Note that sub-slab soil gas probes are not recommended when groundwater is present directly below the slab, as drilling through the slab could allow groundwater to enter the building. Sub-slab soil gas probes can be installed using different methods: (1) utilizing a small diameter hole, (2) a Vapor Pin™. The Vapor Pin™ may be installed in slabs that are least three (3)-inches thick, or four (4)-inches in the case of flush mount installations. Summaries of the steps involved in the installation of sub-slab soil gas probes is presented below:

Small Diameter Sub-Slab Soil Gas Probe

1. Prior to drilling holes into the building floor, the location of utilities coming into the building (e.g., gas, electrical, water, and sewer lines, etc.) will be identified. Avoid installing sub-slab soil gas probes near where utilities penetrate the slab as these may be entry points for downward ambient air migration through the slab during sub-slab soil gas sampling.
2. A rotary hammer drill or equivalent equipment will be used to drill a "shallow" [approximately 1-inch (2.5 cm) deep] outer hole [approximately 7/8 inches (2.2 cm) in diameter] that partially penetrates the floor slab. Cuttings may be removed using a towel moistened with distilled water or small portable vacuum cleaner.
3. The rotary hammer drill or equivalent equipment will be used to drill a smaller diameter inner hole, within the center of the outer hole, approximately 3/8 inch (9.5 mm) in diameter through the floor material and approximately 3 inches (7.6 cm) into the sub-slab bedding material to create an open cavity. The outer hole will be cleaned with a towel moistened with distilled water.
4. Chromatography grade 316 stainless steel or brass tubing will be cut to a length that allows the probe to float within the slab thickness to avoid obstruction of the probe with sub-slab bedding material. The tubing will be approximately 1/4-inch (6.4 mm) in diameter. Where necessary, the compression fittings will be stainless steel or brass (approximately 1/4-inch O.D. and 1/8-inch NPT) Swagelok® female thread connectors. Whenever possible, the probes will be constructed prior to drilling to minimize exposure time, or venting, of the sub-slab bedding material through the open hole.
5. The sub-slab soil gas probe will be placed in the holes so that the top of the probe is flush with the top of the floor. The top of the probe will have a recessed stainless steel or brass plug. A quick-drying, Portland cement slurry will be

injected or pushed into the annular space between the probe and the outer hole. The cement will be allowed to dry for at least 24 hours prior to sampling.

Vapor Pin™

Borings should be completed with the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified in the steps below as well as sufficient size to penetrate the expected thickness of the concrete present.

General List of Materials

Installation of Vapor Pins™ utilizes products available from Cox-Colvin & Associates, Inc. Equipment needed for installation includes:

1. Silicone sleeve
 2. Hammer drill
 3. 5/8-inch diameter hammer bit (Hilti™ TEYX 5/8" x 22" #00206514, or equivalent)
 4. 1½ inch diameter hammer bit (Hilti™ TEYX 1½" x 23" #00293032, or equivalent) for flush mount applications
 5. 3/4 inch diameter bottle brush
 6. Wet/dry vacuum with HEPA filter (optional)
 7. Vapor Pin™ installation/extraction tool
 8. Dead blow hammer
 9. Vapor Pin™ flush mount cover, as necessary
 10. Vapor Pin™ protective cap
 11. Equipment needed for abandonment:
 12. Vapor Pin™ installation/extraction tool
 13. Dead blow hammer
 14. Volatile organic compound-free hole patching material (hydraulic cement) and putty knife or trowel
-
1. *Flushmount Vapor Pin™ Installation Protocol* Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.

2. Set up wet/dry vacuum to collect drill cuttings.
3. Drill a 1 1/2- inch diameter hole at least 1 3/4 inches into the slab.
4. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
5. Drill a 5/8 inch diameter hole through the slab and at least six inches into the underlying soil to form a void.
6. Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.
7. Assemble the Vapor Pin™ assembly by threading the Vapor Pin™ into the extraction/installation tool and placing the silicone sleeve over the barbed end.
8. Place the lower end of the Vapor Pin™ assembly into the drilled hole. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer. Make sure the extraction/installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.
9. Unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation. During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder.
10. Place the protective cap on the Vapor Pin™.
11. Cover the Vapor Pin™ with a flush mount cover.
12. Allow 20 minutes or more for the sub-slab soil gas conditions to equilibrate prior to sampling.
13. Remove protective cap and connect sample tubing to the barb fitting of the Vapor Pin™.

3.1 INSTALLATION DOCUMENTATION

Details of each sub-slab soil gas probe installation should be recorded on CRA's standard Stratigraphic Log Overburden, or recorded within a standard CRA field book. The Well Instrumentation Log is provided for recording the overburden well instrumentation details, and can be used for sub-slab soil vapor probe installations. This figure must note:

- borehole depth
- slab thickness
- probe perforation intervals
- plug intervals
- surface cap detail
- sub-slab soil gas probe material
- sub-slab soil gas probe instrumentation (i.e., probe length)
- sub-slab soil gas probe diameter
- cement slurry seal detail
- stickup/flush-mount detail
- date installed

Each sub-slab soil gas probe installed must have accurate field ties to the center of the sub-slab soil gas probe from three adjacent permanent features of the structure within which the probe is installed, each located in a different direction from the installation.

Each sub-slab soil gas probe must be permanently marked to identify the sub-slab soil gas probe number designation.

4.0 RESPIRATORY PROTECTION

The HASP must be followed with regard to respiratory protection.

5.0 FOLLOW-UP ACTIVITIES

Once the sub-slab soil gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes.
2. All logs will be submitted to CRA's hydrogeology department who will be responsible for the generation of the final well log.
3. Arrange surveyor to obtain accurate horizontal and vertical control.
4. Gas probe/boring locations will be accurately plotted on the site plan, since boring locations may change in the field due to utility interferences or other conditions.
5. Tabulate sub-slab gas probe details.
6. A summary write-up on field activities including, but not necessarily limited to such items as drilling method(s), construction material, etc.
7. Field book will be kept at the appropriate CRA office.

6.0 FIELD INSTRUMENTATION CALIBRATION

Sampling or monitoring equipment used in the sub-slab soil gas and outdoor air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. Field calibration of the personal sampling pump and PID meter will be carried out prior to sampling activities.

The vacuum gauge used to measure canister vacuum will be calibrated and provided by the laboratory. The vacuum gauge will be returned to the laboratory for the laboratory to obtain vacuum measurements prior to sample analysis (checking canister integrity was maintained during shipment). Using a common vacuum gauge will avoid variations in vacuum measurements that can arise due to using different vacuum gauges.

7.0 SUB-SLAB SOIL GAS SAMPLING PROTOCOL

The following sections describe the protocol for sub-slab soil gas sampling from permanent sub-slab soil gas probes. For evaluating vapor intrusion, permanent sub-slab soil gas probes are preferable to allow for multiple sub-slab soil gas sampling events. More than one sub-slab soil gas sampling event is often required when assessing vapor intrusion to address seasonal variations and temporal variability commonly observed in sub-slab soil gas concentrations.

Sub-slab soil gas sampling should commence a minimum of 24 hours following installation of the sub-slab soil gas probes, to allow time for disturbances created by drilling to dissipate and allow the formation to return to an equilibrium condition. In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for equilibrium conditions to become re-established (e.g., 72 hours). Sub-slab soil gas sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., >0.5 inches after Cal EPA (2003)]. This will avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen sub-slab soil gas concentrations, or possibly prevent sub-slab soil gas sample collection (i.e., such as in cases where the sub-slab soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for rainfall events to dissipate. The potential influence of rainfall events on sub-slab soil gas concentrations is less of concern in cases where the sub-slab soil gas probes are located beneath impervious ground cover (e.g., pavement or building foundation).

A summary of the steps involved in sub-slab soil gas sampling is presented below:

- i) Sub-slab soil gas samples for assessing the vapor intrusion pathway will be collected using certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for sub-slab soil gas sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability. Consideration should be given to using smaller capacity canisters to reduce sample volume and increase confidence that the sub-slab soil gas sample is drawn from the formation immediately surrounding the probe screen during sampling. Larger volume samples can promote drawing ambient air down the annulus of the sub-slab soil gas probe which can dilute the sub-slab soil gas sample. The use of the smaller canister sizes becomes more

critical in fine-grained soil conditions where the formation may not give up significant sub-slab soil gas volumes (in this case, ambient air infiltration down the sub-slab soil gas probe annulus can be more problematic).

- ii) The Summa™ canisters will be fitted with a laboratory calibrated critical orifice flow regulation device sized to restrict the maximum sub-slab soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum sub-slab soil gas sampling flow rate recommended by Cal EPA (2003) of 100 to 200 mL/min. The 100 mL/min maximum flow rate translates to sample collection times of 10, 17, or 60 minutes, respectively, for of 1-, 1.7-, or 6-liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the sub-slab soil gas probe annulus that would dilute the sub-slab soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the sub-slab soil gas sample is drawn from immediately surrounding the screened interval.
- iii) A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory. Using the same vacuum gauge throughout the entire sampling process will eliminate discrepancies between vacuum measurements that can arise from using different gauges with a potentially different sensitivity and/or calibration.
- iv) The canister will be connected to the sub-slab soil gas probe valve at the surface casing using the sampling assembly that is depicted on Figure 15.5. The sampling assembly is connected using short lengths [e.g., 1-foot (0.3 m)] 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and air-tight stainless steel or brass tee-connectors and tee-valves (e.g., Swagelok® type). The canister will be connected to the sub-slab soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of sub-slab soil gas probe, vacuum gauge, pump, and canister). A tee-valve will be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing will be used for each sample.
- v) Prior to collecting a sub-slab soil gas sample, the stagnant air in the sampling assembly tubes and sub-slab soil gas probe casing/sand pack must be removed. The sub-slab soil gas probes will be purged prior to sampling using the personal

sampling pump at a flow rate of less than 200 mL/min. This ensures that the collected sub-slab soil gas sample is representative of actual sub-slab soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.

- vi) Prior to purging, a vacuum, or tightness, test will be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 15.2.4. Briefly, this first leak-testing step (the vacuum test) will consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the sub-slab soil gas probe closed. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. Further details of the vacuum test are described below.
- vii) Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps will be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the sub-slab soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the sub-slab soil gas probe and into the sub-slab soil gas sample. The tracer compound is either monitored for in the field using a meter connected in-line to sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the sub-slab soil gas samples (e.g., isopropanol). The set-up requirements of the tracer compound leak-testing step are described below.
- viii) Following the vacuum test, and the set-up for the tracer compound leak-testing step, the sub-slab soil gas probe purging will commence by opening the valve to the sub-slab soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™ canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas will be monitored using a portable photoionization detector (PID) meter. The PID meter will be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary

from approximately 300 mL/min to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump likely will increase the purging flow rate temporarily until a reading from the PID meter is obtained. PID readings will be recorded and entered in the field logbook and chain-of-custody form. The PID readings will provide the laboratory with an indication of whether a sample could require dilution before analysis.

- ix) Following purging, the valve to the personal sampling pump will be closed, and the valves to the sub-slab soil gas probe and Summa™ canister will be opened to draw the sub-slab soil gas sample into the canister concurrent with continuing to apply the leak-testing tracer compound. The vacuum gauge reading will be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10-inches mercury (Hg) for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the sub-slab soil gas probe does not produce sufficient sub-slab soil gas to permit sample collection.
- x) To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain of custody procedures.
- xi) The vacuum gauge provided by laboratory will be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.
- xii) If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they will be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi.

- xiii) The canisters will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all sub-slab soil gas sampling data.
- xiv) The canisters will be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The sub-slab soil gas samples will be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. Quality control/quality assurance (QA/QC) measures implemented during the sub-slab soil gas sampling event will include the two-step leak testing procedure (see Section 15.2.4), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample.

8.0 SUB-SLAB SOIL GAS PROBE LEAK TESTING

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the sub-slab soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing will be conducted in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air tight
- Step 2 - Tracer Test: used to ensure that ambient air during sub-slab soil gas sample collection is not drawn down the sub-slab soil gas probe annulus through an incomplete seal between the formation and the sub-slab soil gas probe casing

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly will be connected to the sub-slab soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the sub-slab soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of sub-slab soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test will consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the sub-slab soil gas probe. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.
- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure will be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly

(it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the sub-slab soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the sub-slab soil gas probe and into the sub-slab soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) will be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in the dilute solution of isopropanol will be wrapped around the sub-slab soil gas probe surface casing and ground surface immediately surrounding the surface casing. Sub-slab soil gas probe surface casing then will be covered over using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface will be accomplished using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the sub-slab soil gas probe purging, remove the paper towels from the solution wringing out the towels so they are very damp, but not dripping, before placed them around the vapor probe and sealing them in place using the plastic sheeting.
- The isopropanol solution will be kept fresh, with new solution being made every hour. The solution will be mixed at a central location away from the sampling activities. The isopropanol will be kept tightly capped and kept away from all sampling equipment. The solution will be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel will wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.

- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapors emitted from dilute isopropanol solution will not be considered reliable and representative of sub-slab soil gas concentrations within the formation (ITRC, 2007). The starting concentration will be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly will be monitored during purging and sub-slab soil gas sample collection using a helium meter installed in-line with the sampling assembly just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.
- A containment unit is constructed to cover the sub-slab soil gas probe surface casing. The containment unit will consist of an over-turned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the sub-slab soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to sub-slab soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the containment unit will be confirmed using the helium meter and recorded in the field logbook. Helium will continue to be introduced to the containment unit during sub-slab soil gas probe purging and sampling, but care will be taken not to increase the pressure within the containment unit beyond that of atmospheric pressure.
- During sub-slab soil gas probe purging and sampling, the helium meter will be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the

containment unit), the sub-slab soil gas probe will be judged to permit significant leakage such that the collected sub-slab soil gas sample will not be considered reliable and representative of sub-slab soil gas concentrations within the formation (ITRC, 2007).

- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

REFERENCES

- Cal EPA, 2003. Advisory – Active Sub-slab soil gas Investigations, Department of Toxic Substances Control, January 28.
- Cal EPA, 2005. Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion in Indoor Air. Department of Toxic Substances Control, (revised February 7).
- ITRC, 2007. Vapor Intrusion Pathway: A Practical Guide, January.
- U.S. EPA, 1988. The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis, May.
- USEPA, 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition, EPA/625/R-96/010b, January 1999.
- U.S. EPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, March 2006. EPA/600/R-05/147.

APPENDIX J-F-37

**STANDARD OPERATING PROCEDURE FOR
INDOOR AIR SAMPLING**

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LIST OF FORMS
(Following Text)

FORM 1	BUILDING PHYSICAL SURVEY QUESTIONNAIRE
FORM 2	INDOOR AIR SAMPLING FIELD DATA SHEET
FORM 3	INDOOR AIR SAMPLING INSTRUCTIONS TO BUILDING OCCUPANTS

1.0 INTRODUCTION

This Attachment presents the indoor air sampling protocol employed by Conestoga-Rovers & Associates to evaluate the potential presence of volatile organic compounds (VOCs) in indoor air due to subsurface soil and/or groundwater impacts. The protocol presented herein consists of conducting a physical survey of the building to be sampled in conjunction with interviewing building occupants, followed by collection of indoor air samples using 6-liter Summa™ canisters. This indoor air sampling protocol has been developed in consideration of the sampling procedures recommended in the following regulatory guidance documents:

- *“Indoor Air Sampling and Evaluation Guide”* dated April 2002 and prepared by the Massachusetts Department of Environmental Protection (MDEP) (MDEP, 2002)
- *“Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion – Interim Final”* dated December 15, 2004 (and revised February 7, 2005) and prepared by the California Environmental Protection Agency (Cal EPA) (Cal EPA, 2004)
- *“Draft Vapor Intrusion Pilot Program Guidance”* dated April 26, 2006 and prepared by the Indiana Department of Environmental Management (IDEM) (IDEM, 2006)
- United States Environmental Protection Agency (USEPA) – Region 5 - *Vapor Intrusion Guidebook*, October 2010 (USEPA, 2010)

Section 2.0 presents the physical building survey to be conducted that will enable a qualitative assessment of factors that potentially could influence indoor air quality. Section 3.0 presents the indoor air sample collection procedure, including quality assurance/quality control (QA/QC) measures and laboratory analytical methodology to be applied in the sample analysis.

2.0 PHYSICAL BUILDING SURVEY

A physical survey will be conducted of the buildings to be sampled. The physical survey will be conducted in conjunction with interviewing the occupants of the buildings. The purpose of the physical survey is to obtain data that will allow a qualitative assessment of factors that potentially could influence indoor air quality. The physical survey includes collecting data on aspects of the building configuration such as building layout, attached garages, utility entrances into the building, ventilation system design, foundation conditions, presence of foundation sump, building material types (e.g., recent carpeting/linoleum and/or painting), location of laundry facilities, etc. The physical survey also includes collecting data related to occupant lifestyle choices that could potentially influence indoor air quality such as use of cleaning products, dry-cleaner use, indoor storage of paints and/or petroleum hydrocarbon products, use of aerosol consumer products, smoking, etc.

The physical survey will be documented by completing the attached Form 1 - Building Physical Survey Questionnaire.

3.0 INDOOR AIR SAMPLE COLLECTION PROCEDURE

Indoor air samples will be collected from the buildings which are or may be occupied that have no slab (e.g., dirt or gravel floor). The indoor air sample will be collected from the lowest floor of the building. An outdoor ambient air sample will be collected concurrently with the indoor air sample from an upwind location on the building property. The indoor and ambient air samples will be collected using a Summa™ canister (6-litre capacity) equipped with a critical orifice flow regulation device sized to allow the collection of an air sample over an 8-hour sampling period. The critical orifice flow regulation device will be supplied and calibrated by the laboratory selected to conduct the sample analysis.

To the extent possible, the indoor air samples will be collected with windows and doors closed to represent appropriately conservative conditions during sampling. If possible, windows and doors should be kept closed for a period of at least 24 hours prior to sample collection. During summer months, air conditioners typically would be operating under closed windows/doors conditions, and the operation of an air conditioner can be allowed during sample collection. This would be representative of season-specific ventilation conditions, and with the expected pattern of operation of the building. Care will be taken to deploy the Summa™ canisters away from the direct influence of any forced air emanating from an air conditioning unit or central air conditioning vents.

The indoor air sampling procedure is described as follows:

- Samples will be collected from an occupied building and as close as practical to the center of the area, but away from high traffic areas to minimize the potential for disturbances during sample collection. Typically, sample canisters will be located between 1 to 1.5 meters above floor level.
- For each ambient air sample, a suitable upwind location (selected to minimize the potential for disturbances during sample collection) will be selected. The ambient air sample will be collected a minimum of 1 meter above grade (if possible) and located to minimize the potential for disturbance of the canister while providing protection from weather effects.
- Air sample canisters will be labeled with a unique sample designation number. Both the sample number and the sample location information will be recorded on the attached Form 2 – Indoor Air Sampling Field Data Sheet.
- The Summa™ canister vacuum will be measured immediately prior to canister deployment and recorded on Form 2 – Indoor Air Sampling Field Data Sheet.

- The critical orifice flow controller will be installed, as supplied by the laboratory, on the canister and the canister will be opened fully at the beginning of sample collection period and start time recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- At the start and the end of the 8-hour sample period, a portable photoionization detector (PID) will be used to screen for VOC presence in the sample area. Results of the PID monitoring were recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- Other data recorded on Form 2 – Indoor Air Sampling Field Data Sheet will include: outside and interior temperatures both at the start and end of the sample period, equipment serial numbers, sampler name, and any comments.
- Following equipment setup, the building occupant will be given the list of instructions to follow while the Summa™ canister sample is being taken in the building. The instructions are listed in the attached Form 3 - Indoor Air Sampling Instructions to Building Occupants. The date and completion time of the 8-hour sample period will be written on Form 3 and the occupant will be instructed that the sampling team would be back to pick up the canister after approximately 8 hours.
- The canister valve will be closed fully at the end of the sample period (after 8 hours) and the end time recorded on the field data sheet. If there is evidence of canister disturbance during the sample collection, this will be recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- The Summa™ canister vacuum will be measured immediately after canister retrieval at the end of the 8-hour sample period and recorded on the field data sheet. Any samples where the canister reached atmospheric pressure will be rejected and the canisters returned for cleaning. The minimum vacuum required to be considered a valid sample will be 1 to 2 inch Hg vacuum. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under CRA chain of custody procedures. The requirement for residual vacuum retained in the canister following sample collection is to ensure that a driving force was maintained to collect a steady flow rate until the end of the sampling event.
- The Summa™ canister vacuum will be measured by the laboratory immediately prior to sample analysis and recorded on the analytical data report.
- All canisters will be cleaned in accordance with United States Environmental Protection Agency (USEPA) Method TO-15 and documentation of the cleaning activities will be obtained from the laboratory.

3.1 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) samples will be collected during the indoor air sampling. QA/QC samples will include:

- the ambient air sample
- one duplicate

3.2 ANALYTICAL METHOD/LABORATORY

The soil vapor samples will be analyzed by a certified laboratory using the USEPA TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology.

3.3 DATA VALIDATION

A data validation for the air sample result will be conducted by CRA.

3.4 CANISTER CLEANING

Canister cleaning was completed in accordance with the applicable sections of Method TO-15.

4.0 REFERENCES

- Cal EPA, 2004. Guidance on the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air - Interim Final, Department of Toxic Substances Control, California Environmental Protection Agency, December 15 (revised February 7, 2005).
- IDEM, 2006. Draft Vapor Intrusion Pilot Program Guidance. Indiana Department of Environmental Management, April 26.
- MDEP, 2003. Indoor Air Sampling and Evaluation Guide, WSC Policy #02-430, Office of Research and Standards, Massachusetts Department of Environmental Protection, April.
- USEPA, 2010. Region 5 - Vapor Intrusion Guidebook, United States Environmental Protection Agency.

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

Address: _____

Building Owner: _____

Occupant Name: _____

Date: _____ Time: _____ Inspector: _____ Sample No.: _____

Contact Name: _____ Phone Number: _____

How long have you lived/worked in this home/building? _____

Occupation: _____

Number of Occupants Adults: _____

Children: _____

BUILDING TYPE: One story _____ Two storey _____ Brick _____ Siding _____ Stucco _____

DESCRIBE BUILDING: _____ **YEAR CONSTRUCTED:** _____

WEATHER SEALS: General Condition: Good _____ Fair _____ Poor _____

BASEMENT: None	<input type="checkbox"/>	Finished	Unfinished	Depth below reference point (meters)
Partial	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Full	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Crawl space	<input type="checkbox"/>	na	na	_____

Number of floors at or above grade: _____

Depth of basement below grade: _____ ft. Basement Size: _____ ft²

Foundation construction: Poured concrete ☐ Cinder block ☐ Stone ☐

Any visual evidence of leakage through basement walls or floor ☐

Floor Construction: Poured concrete ☐ Wood ☐ Earth ☐ Brick ☐ Other: _____

Floor condition (cracks, drains): _____

Condition at floor/wall joint (if visible): _____

Any exterior openings from the basement:

☐ Vents

☐ Fans

☐ Windows

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

- ☐ Wall openings
- ☐ Utility pipe penetrations
- ☐ Other: _____

Type of ground cover outside of building: grass / concrete / asphalt / other (specify): _____

Sub-slab vapor/moisture barrier in place? Yes / No / Don't know

Type of barrier: _____

Do you have a sump?: Yes ☐ No ☐

Where: _____

If yes, sealed ☐ open ☐ NA ☐

If yes, is there water in the sump?: Yes ☐ No ☐

Is this building serviced with municipal water? Yes ☐ No ☐

Do you have a water well?: Yes ☐ No ☐ Don't know ☐

Well location: _____

Do you drink the water obtained from the well? _____

What do you use the well for?: _____

Do you have a cistern?: Yes ☐ No ☐

If yes, describe its location: _____

Do you have a septic system?: Yes ☐ No ☐

If yes, describe its location: _____

If yes, describe how septic system is cleaned: _____

Have there ever been a fire in the building?: Yes ☐ No ☐

If yes, describe its location and extent: _____

Is there a laundry room located inside the house/building?: Yes ☐ No ☐

If yes, describe its location: _____

FURNACE: Location: _____

Type:	gas	<input type="checkbox"/>	Forced air	<input type="checkbox"/>
	oil	<input type="checkbox"/>	hot water	<input type="checkbox"/>
	electric	<input type="checkbox"/>	other	_____

Does furnace have outside combustion air vent? _____

Do you have a fireplace? Yes ☐ No ☐

Does the fireplace have an outside combustion air vent? Yes ☐ No ☐

Do you use kerosene space heaters? Yes ☐ No ☐

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

AIR CONDITIONER: None _____ Central _____ Room _____
(If yes, which rooms and capacities?) _____

RADON SYSTEM: ☐ Yes ☐ No

GARAGE: Do you have an attached garage? ☐ Yes ☐ No

1. When was the last time dry-cleaned clothes were brought into the house/building?
☐ 0 to 5 days ago ☐ 6 to 10 days ago ☐ More than 10 days ago ☐ Don't dry-clean
2. When was your carpet installed?
☐ In the last six months ☐ More than six months ago ☐ No Carpet
3. When was the last time your carpet was cleaned?
☐ In the last six months ☐ More than six months ago ☐ Never
4. Do you have any spot removers in the house?
☐ Yes ☐ No Details: _____
5. Do your hobbies include model building, arts and crafts, model railroading, or others that require paints, thinners, or glue?
☐ Yes ☐ No Details: _____
6. Do you perform automotive or other vehicle maintenance or repair at home?
☐ Yes ☐ No Details: _____
7. Please review the following list and check items you know are in your home
 - ☐ Latex caulk
 - ☐ Latex paint
 - ☐ Vinyl cove molding
 - ☐ Linoleum tile
 - ☐ Black rubber molding
 - ☐ Vinyl edge molding
 - ☐ Polystyrene foam insulation
 - ☐ Adhesive removers

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

- ☐ Aerosol spray paints
- ☐ Other paints
- ☐ Air fresheners
- ☐ Degreasers
- ☐ Deodorants
- ☐ Disinfectants
- ☐ Furniture Polish
- ☐ Solvents
- ☐ Caulking

8. Do you have pesticides in your home/building?

- ☐ Yes ☐ No ☐ Unsure

9. Do you have any spray insecticides in your home/building?

- ☐ Yes ☐ No ☐ Unsure

10a. Have you painted any area of the interior of your home/building in the last 12 months?

- ☐ Yes ☐ No

10b. If yes, please indicate what paint you used

- ☐ Enamel
- ☐ Vinyl
- ☐ Latex
- ☐ Other

11a. Have you painted the exterior of your building in the last 12 months? ☐ Yes ☐ No

11b. If yes, please indicate what paint you used

- ☐ Enamel
- ☐ Vinyl
- ☐ Latex
- ☐ Other

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

12. Where do you store your paint, thinner, pesticides, insecticides?

	<i>Paint</i>	<i>Thinner</i>	<i>Pesticides</i>	<i>Insecticides</i>
Garage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Basement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storage shed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> I don't store these items at home				

13. Have you purchased one of the following items in the last 12 months?

- | | | |
|---|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> Rubberized door mat | <input type="checkbox"/> Computer | <input type="checkbox"/> Wiring |
| <input type="checkbox"/> Plastic shower curtain | <input type="checkbox"/> Printer | <input type="checkbox"/> Linoleum |
| <input type="checkbox"/> Wood stains or paint | <input type="checkbox"/> VCR | |

14. Do you have a computer printer in your home/building?

- ☐ Yes ☐ No

15. Do you have a VCR in your home/building?

- ☐ Yes ☐ No

16. Do you use cleaners to maintain your VCR/building?

- ☐ Yes ☐ No

If yes, what type? _____

17. Do you have pets residing in this building?

- ☐ Yes ☐ No

If yes, what type? _____

If yes, number _____

18. Does anyone in the building smoke? ☐ Yes ☐ No

19. Questions asked by Occupant that require follow-up.

FORM 2: INDOOR AIR SAMPLING FIELD DATA SHEET

A) General Information

Sample Identification Number: _____

Site Address: _____

Sample Canister Location: _____

Sample source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sample Date: _____ Sampler: _____

Sample Time: _____ Start: _____ Stop: _____

Shipping Date: _____

Canister Type: 400 mL - 1.0 L Summa Canister/6 L Summa Canister/Other (specify): _____

Canister Serial No.: _____

Flow Controller Serial No.: _____

Were "Instructions for Occupants" followed?

☐ Yes ☐ No

B) Sampling Information

	<u>Start</u>		<u>Stop</u>	
	<u>Ambient</u>	<u>Interior</u>	<u>Ambient</u>	<u>Interior</u>
Temperature	_____	_____	_____	_____

	<u>Start</u>	<u>Stop</u>
Canister Pressure Gauge Reading:	_____	_____
Time:	_____	_____
PID Reading (ppm):	_____	_____
Basement Depth (ft below grade):	_____	_____
Window Marked:	<u>Yes/No</u>	_____

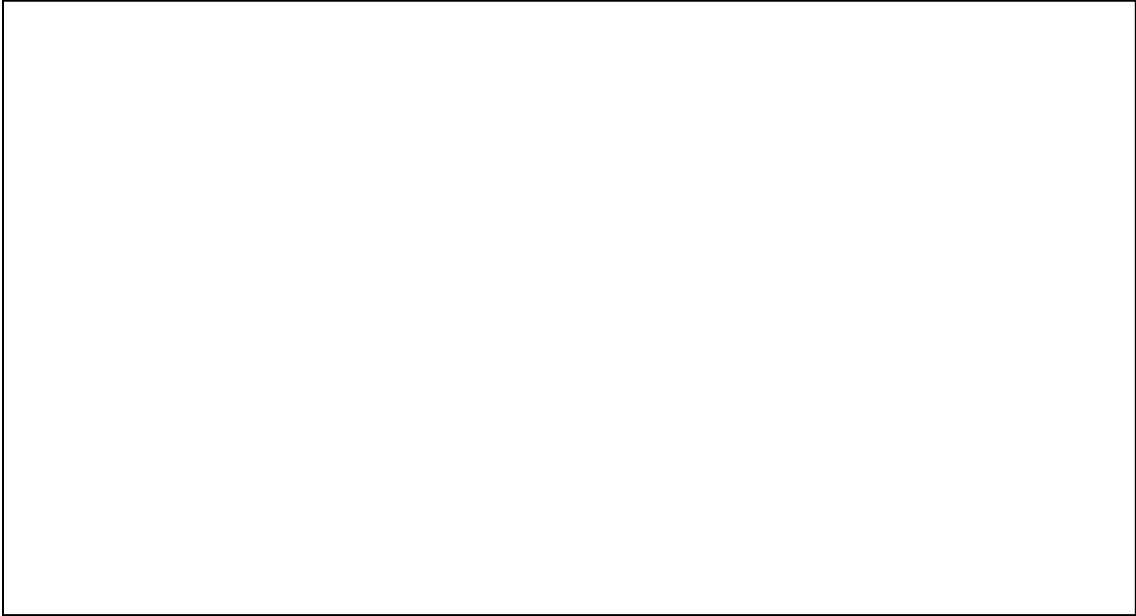
Was there significant precipitation within 12 hours prior to (or during) the sampling event?

☐ Yes ☐ No

Describe the general weather conditions: _____

FORM 2: INDOOR AIR SAMPLING FIELD DATA SHEET

Provide Drawing of Sample Location(s) in Building



C) Comments

1. The duration of this test is approximately 8 hours.
2. The canister is made of clean stainless steel. It does not contain any moving parts or chemicals.
3. Do not handle or move a canister during testing.
4. Do not smoke around the canister.
5. To the extent possible, leave doors and windows closed during testing.
6. To the extent possible, do not use paint, solvents, glues, and spray cans during testing.
7. If possible, do not bring dry cleaning into the building during the testing.
8. We will be back tomorrow to pick up the canister about this time.

Canister pick up: Day_____

Time_____

Thank you for your cooperation.

APPENDIX J-F-38

**VERTICAL AQUIFER SAMPLING/TEMPORARY
MONITORING WELL INSTALLATION AND
SAMPLING BY GEOPROBE®**

ATTACHMENT A

**STANDARD OPERATING PROCEDURE FOR
VERTICAL AQUIFER SAMPLING /TEMPORARY MONITORING WELL INSTALLATION
AND SAMPLING BY GEOPROBE®**

1.0 INTRODUCTION

Shallow vertical aquifer sampling (VAS) boreholes and temporary monitoring wells may be installed via direct-push Geoprobe methods.

Direct-push (a.k.a., Geoprobe) refers to the sampler being "pushed" into the soil material without the use of drilling to remove the soil. This method relies on the drill unit static weight, combined with rapid hammer percussion, to advance the tool string. Discrete soil samples are continuously obtained. It is important that the direct-push drilling method (i.e., Geoprobe) used minimizes the disturbance of subsurface materials.

This method is used extensively for initial site screening to establish site geology and delineate vertical and horizontal plume presence.

Standard Penetration Test (SPT) blow count values cannot be obtained when sampling with a direct-push discrete soil sampler.

The direct-push method is popular due to the limited volume of cuttings produced and the speed of the sampling process, which can be much faster than the sample description and sample preparation process.

Discrete continuous soil samples are collected in tube samplers (various lengths) affixed with a cutting shoe and internal liner [polyvinyl chloride (PVC), Teflon, or acetate are available]. The soil sampler may be operated in "open-mode" (when borehole collapse is not a concern), or in "closed-mode" (when minimization of sample "slough" is desired). Closed-mode operation involves placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. At the required depth, the temporary drill-point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner, with soil, is removed for examination. Extra care must be taken when cutting open the sample tube; no open blade cutting tools may be used in the process,

you must have an appropriate stabilizer/holder for the tube, and cut resistant hand protection must be included as part of the overall PPE.

The Geoprobe drilling method should not contaminate the subsurface soils and groundwater. It is extremely important that drilling does not create a hydraulic link or conduit between different hydrostratigraphic units. Groundwater in monitoring and extraction wells must not be contaminated by drilling fluids or the borehole advancement process. Geoprobe drilling equipment will be decontaminated before use and between locations to prevent cross-contamination between VAS boreholes or temporary monitoring well locations and sites. Geoprobe drilling equipment will be decontaminated between well locations regardless of whether or not contaminants are suspected. Section 7.0 in the FSP specifies the required decontamination procedures. At a minimum, decontamination procedures detailed in Section 7.0 of the FSP should be used during monitoring well design and construction.

A Geoprobe SP16 will be used for shallow VAS and temporary monitoring well activities. The SOP for the Geoprobe SP16 Groundwater Sampler is included in Attachment A (addendum to the FSP). The Geoprobe SP16 is a direct push groundwater sampling device that consists of a well screen inside a steel sheath that is driven to the desired sample depth using standard Geoprobe rods. The Geoprobe SP16 is then deployed by retracting the steel sheath and exposing the well screen directly to the formation. The maximum well screen length of the Geoprobe SP16 is 32 inches. Generally, the full 32-inch well screen will be used for VAS and temporary monitoring well activities. Groundwater samples will be collected through the stainless steel screen using a mechanical bladder pump set at a flow rate of 100 milliliters per minute (mL/min) (a peristaltic pump may also be use). The SOP for the mechanical bladder pump is included in Attachment A (addendum to the FSP). The VAS or temporary monitoring well location will then be abandoned using grouting.

Finally, if a permanent monitoring well is required, pre-cleaned construction materials are used in order to prevent the potential introduction of contaminants into a hydrostratigraphic unit. Permanent monitoring well installation is discussed in Section 2.7 of the FSP.

2.0 PLANNING AND PREPARATION

Prior to undertaking shallow VAS or temporary groundwater monitoring well installation and sampling utilizing a Geoprobe the following procedures will be followed:

1. Review the appropriate Work Plan and Site-Specific Health and Safety Plan (HASP), project documents, all available geologic and hydrogeologic mapping and reports, water well records, and historic site reports to become familiar with the geologic and hydrogeologic framework of the site and surrounding area. Review and become familiar with the health and safety requirements, and discuss the work activities with the Project Coordinator.
2. Assemble all required equipment, materials, log books, and forms.
3. Obtain a site plan and previous stratigraphic logs. Determine the exact number, location, and depth of wells to be installed.
4. If not performed as part of borehole advancement, complete a Property Access/Utility Clearance Data Sheet. In most instances, the utility clearances and property access will have been completed as part of the well drilling and advancements.
5. Determine notification requirements with the Project Coordinator. Have all regulatory groups, the client, landowner, drilling contractor, and CRA personnel been informed of the well design and installation program?
6. Determine the methods for handling and disposal of cuttings, purged groundwater, and decontamination fluids. Generally, this is dealt with as part of the well advancement activities.

In addition to the above, the following may be required when conducting VAS or temporary monitoring well installation and sampling activities:

1. Establish a water source for well installation and decontamination. Pre-plan the methods of handling and disposal of well installation and decontamination fluids.
2. Arrange with the drilling contractor/client to provide a means of containment and disposal of fluids.

3.0 EQUIPMENT DECONTAMINATION

Prior to use and between each borehole location, drilling and sampling equipment must be decontaminated in accordance with Section 7.0 of the FSP.

4.0 LOCATION AND MARKING OF VAS/TEMPORARY MONITORING WELL SITES/FINAL VISUAL CHECK

The proposed investigative locations marked on the site plan are located and staked in the field. This should be completed several days prior to the drill rig arriving on site. Investigative locations are required for the completion of utility locates. Generally, VAS or temporary monitoring well locations are strategically placed to assess site hydrogeologic conditions.

Once the final VAS or temporary monitoring well location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

Caution: Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.

Investigative locations are selected primarily to provide a good geographical distribution across the site. Most often, the VAS or temporary monitoring well locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, or to consider site-specific physical characteristics (e.g., traffic

patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

1. Select the exact location of each well consistent with the site and project requirements.
2. If a VAS or temporary monitoring well location must be relocated more than 20 feet (5.7 m) from the initially identified location, confirm the new location's suitability with the Project Coordinator.
3. Ensure all utilities have been cleared prior to initiating borehole advancement activities.

To the extent practical, wells should be located adjacent to permanent structures (e.g., fences, buildings) that offer some form of protection and a reference point for future identification. Wells located in high traffic areas or road allowances or low-lying wet areas are undesirable, but may be unavoidable.

5.0 PROCEDURES FOR VERTICAL AQUIFER SAMPLING/TEMPORARY MONITORING WELL INSTALLATION AND SAMPLING BY GEOPROBE

The direct push procedure will use the Geoprobe, as follows:

1. The direct push drill rig will advance the borehole using methods consistent with ASTM Standard D6724-04 (Appendix J-H-4 of the FSP).
2. The direct push borehole will be advanced from ground surface to the top five feet of shallow groundwater. Soil cores will be collected using Geoprobe® MacroCore® sampling techniques or equivalent. Soil cores will be collected throughout the entire length of the borehole.
3. Representative samples will be logged immediately after opening the acetate liner. Field measurements of undifferentiated VOCs will be conducted by placing representative soil samples into a closed sample container and allowing them to equilibrate. The VOCs in the headspace will then be measured by placing the wand of the PID into the headspace. Field calibration, preventative maintenance, and SOPs for the PID are contained in Section 6.0 of the FSP.
4. The soil core will be logged by CRA personnel and soils will be classified using the USCS in accordance with ASTM Method D-2488-06 (Appendix J-H-2). Soil stratigraphy will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G of the FSP.

5. Following the field screening and logging of the soil stratigraphy at each borehole, the Geoprobe will be offset approximately 1 foot from the borehole in order to collect a groundwater sample while preventing drawdown.
6. VAS will be conducted beginning no deeper than 5 feet below the water table unless otherwise specified in the Work Plan. Temporary monitoring well sampling will be conducted within the top 5 feet of the water table unless otherwise specified in the Work Plan.
7. A pre-cleaned Geoprobe® SP16 groundwater sampler will be assembled as per manufacturer's operational procedure. A description of the Geoprobe® SP16 is provided in Section 1.0 of this SOP.
8. New 1/4-inch diameter tubing will be installed and attached to a peristaltic or bladder pump. Groundwater will be purged from the Geoprobe® SP16 groundwater sampler using the pump. A minimum of three to five screen point well volumes will be purged at the same rate as the low flow sampling prior to commencing stabilization monitoring. Field measurements of pH, conductivity, turbidity, and temperature will be collected at approximate 5-minute intervals. If it is apparent that stabilization will not be achieved quickly, stabilization parameter measurements may be made at a greater time interval. Stabilization monitoring will be performed using a flow-through-cell. All field measurements will be recorded in the field book.

The groundwater will be considered stable after a maximum of five well volumes are removed or when three successive readings for pH, specific conductance, turbidity, and temperature agree within the following limits:

- pH: ± 0.1 pH unit
 - Specific conductance: $\pm 3\%$ (temperature corrected)
 - Temperature: $\pm 1.0^{\circ}\text{C}$
 - Turbidity: or < 5 NTU
9. Once field parameters have stabilized, groundwater samples will be collected directly from the discharge line in laboratory-supplied, analyte-specific sample containers and preserved according to laboratory requirements. Groundwater samples collected for VOC analysis will be collected from the tubing before it reaches the pump head, by crimping the tubing, detaching it from the pump, and pouring the water into the vial.
 10. VAS and temporary monitoring well samples will be analyzed for parameters detailed in the Work Plan. The Geoprobe® SP16 groundwater sampler will be

decontaminated between samples following the procedures in Section 7.0 of the FSP.

11. Upon reaching the total depth of the VAS or temporary monitoring well location, the downhole equipment will be removed from the borehole and the borehole will be backfilled with pure bentonite slurry grout.
12. All downhole equipment such as drill rods and sample tools will be decontaminated as discussed in Section 7.0 of the FSP.
13. Drill cuttings and decontamination water will be managed as discussed in Section 8.0 of the FSP.

6.0 SOIL SAMPLE COLLECTION FROM GEOPROBE DRILLING CORES

When borehole drilling, the core sample retrieved from the borehole is considered a discrete grab sample that has been taken from one sampling location, as long as both the stratigraphy of the entire sample and the level of contamination are consistent over the length of the core sample. If a single core sample contains soils from two different stratigraphic units, the soils from each of these stratigraphic units are considered separate discrete grab samples.

If a single core sample contains soils from a single stratigraphic unit, but visual observation indicated that some of the soil was heavily impacted with contaminants, while the rest of the soil was only lightly impacted, then the soils representing each of the two levels of contamination are considered two separate discrete grab samples.

If required, representative soil samples will be collected from the drilling cores in accordance with the following procedures.

- i. Once removed to the ground surface, open the discrete soil sampler by removing the cutting shoe, and extract the soil liner (with recovered soil) from the sampler body.
- ii. Place the soil liner into a holder and cut lengthwise (using a liner knife) to expose the collected soil core.
- iii. Perform PID screening for organic vapors and record readings.
- iv. Measure length of sample and record as the recovered length.

- v. Representative soil samples will be collected from Geoprobe drilling cores using a pre-cleaned stainless steel trowel or other appropriate tool (e.g., spoons or push tube).
- vi. Use a new pair of disposable gloves for each sample.
- vii. Prior to use, for each sample, decontaminate all sampling tools as specified in the Work Plan or as described in Section J.7 of the FSP.
- viii. Use a pre-cleaned sampling tool to remove the sample from the layer of exposed soil. For clayey or cohesive soils:
 - a) Discard upper and lower ends of sample core (3 inches) if near the area to be sampled
 - b) Use a pre-cleaned stainless steel knife
 - c) Cut the portion of the core to be sampled longitudinally
 - d) With a sample spoon, remove soil from the center portion of the core and place in a pre-cleaned stainless steel bowl
 - e) Remove large stones and natural vegetative debris
 - f) Homogenize the soil and place directly into sample jars

For sandy or non-cohesive soils, as sandy soils have less cohesion than clayey soils, it is not easy to cut the core longitudinally to remove the center of the sample. Therefore, with a stainless steel spoon, scrape away surface soils which have likely contacted the sampler and then sample the center portion of the soil core.

Note: Samples for VOC analysis must not be homogenized. Collect soil samples for VOC analysis in En Core™ Samplers (refer to Appendix J-F-24 of the FSP). Completely fill the container. No air space (headspace) should remain in the sample container.

- ix. Place the collected soil directly into a clean, pre-labeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a pre-cleaned stainless steel bowl (with the exception of samples for VOC analysis, which shall be placed directly in the sample jar and not homogenized in order to prevent volatilization of the VOCs).

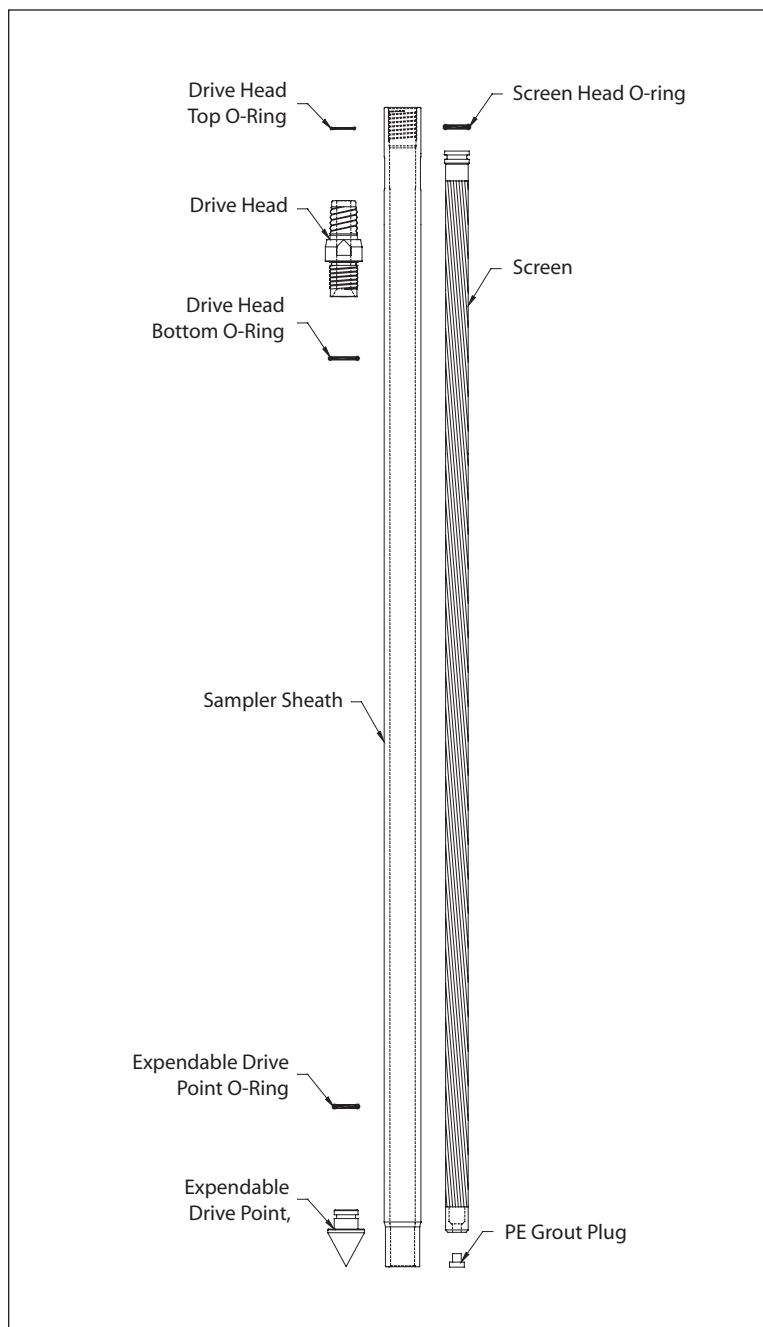
Note: Place all soil samples collected for chemical analysis immediately into a cooler with ice.

GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3142

PREPARED: November, 2006



GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS



**Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image® are
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**Screen Point 16 Groundwater Sampler is manufactured
under U.S. Patent 5,612,498**

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1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 16 (SP16) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may choose to use this sampler in soils where driving is difficult.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

(continued on following page)

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

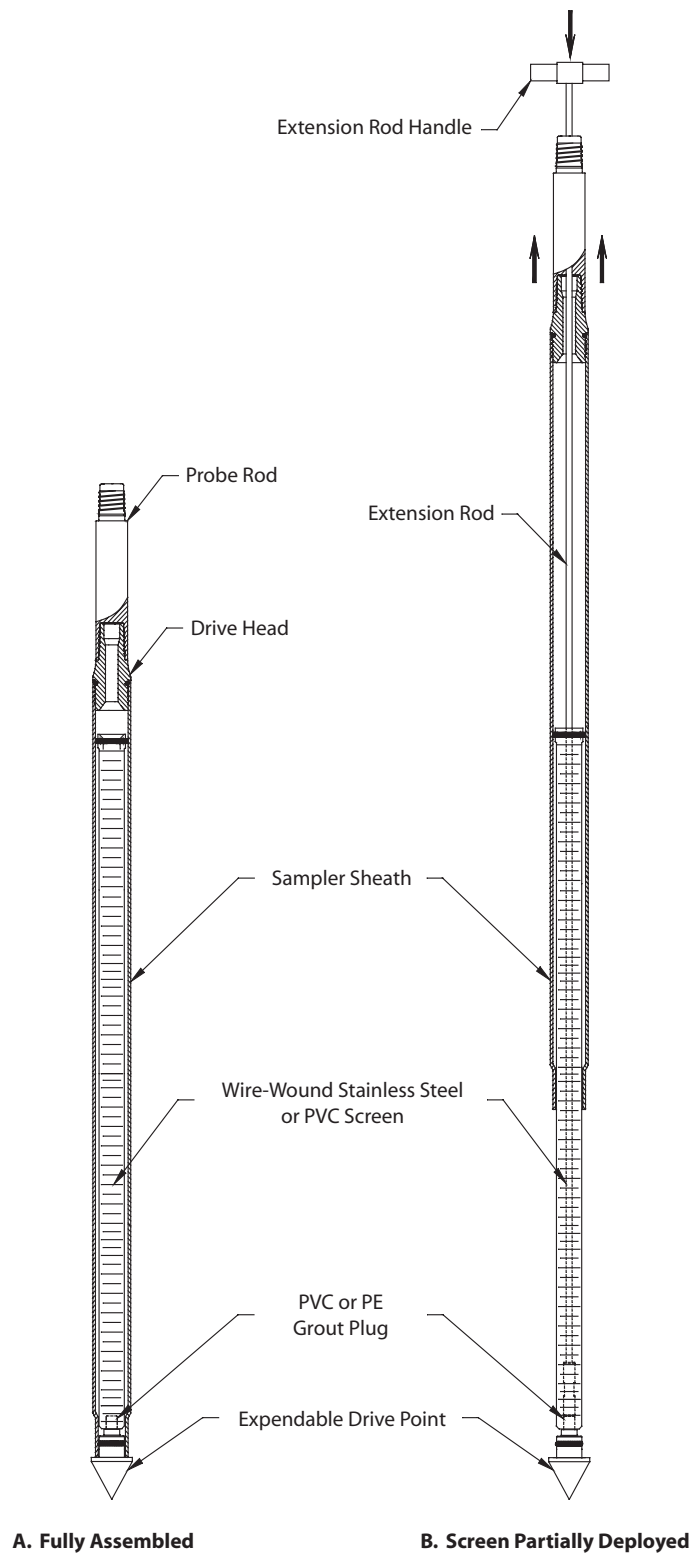


FIGURE 2.1
Screen Point 16 Groundwater Sampler

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

SP16 Sampler Parts	Part Number
SP16 Sampler Sheath.....	15187
SP16 Drive Head, 0.5-inch bore, 1.5-inch rods*	18307
SP16 O-ring Service Kit, 1.5-inch rods (<i>includes 4 each of the O-ring packets below</i>)	15844
<i>O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)</i>	15389
<i>O-rings for Bottom of SP16 Drive Head (Pkt. of 25)</i>	13196
<i>O-rings for GW1520 Screen Head (Pkt. of 25)</i>	GW1520R
<i>O-rings for SP16 Expendable Drive Point (Pkt. of 25)</i>	GW1555R
Screen, Wire-Wound Stainless Steel, 4-Slot*	GW1520
Grout Plugs, PE (Pkg. of 25)	GW1552K
Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)*	GW1555K
Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods (<i>includes 1 each of:</i> <i>15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K</i>)	15770

Probe Rods and Probe Rod Accessories	Part Number
Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer)	12787
Pull Cap, 1.5-inch probe rods	15090
Probe Rod, 1.5-inch x 60-inch*	11121

Extension Rods and Extension Rod Accessories	Part Number
Screen Push Adapter.....	GW1535
Grout Plug Push Adapter.....	GW1540
Extension Rod, 60-inch*	10073
Extension Rod Coupler.....	AT68
Extension Rod Handle	AT69
Extension Rod Jig.....	AT690
Extension Rod Quick Link Coupler, pin.....	AT695
Extension Rod Quick Link Coupler, box.....	AT696

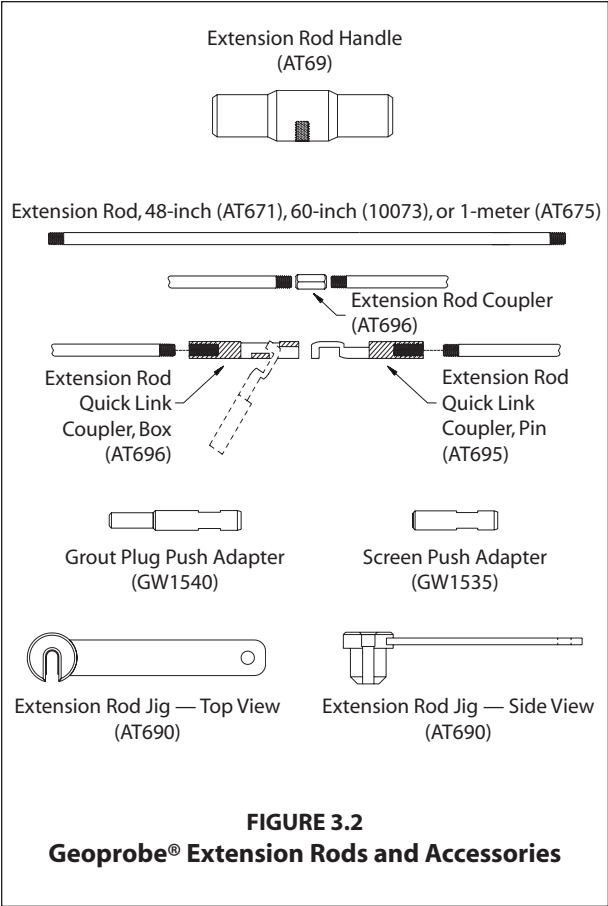
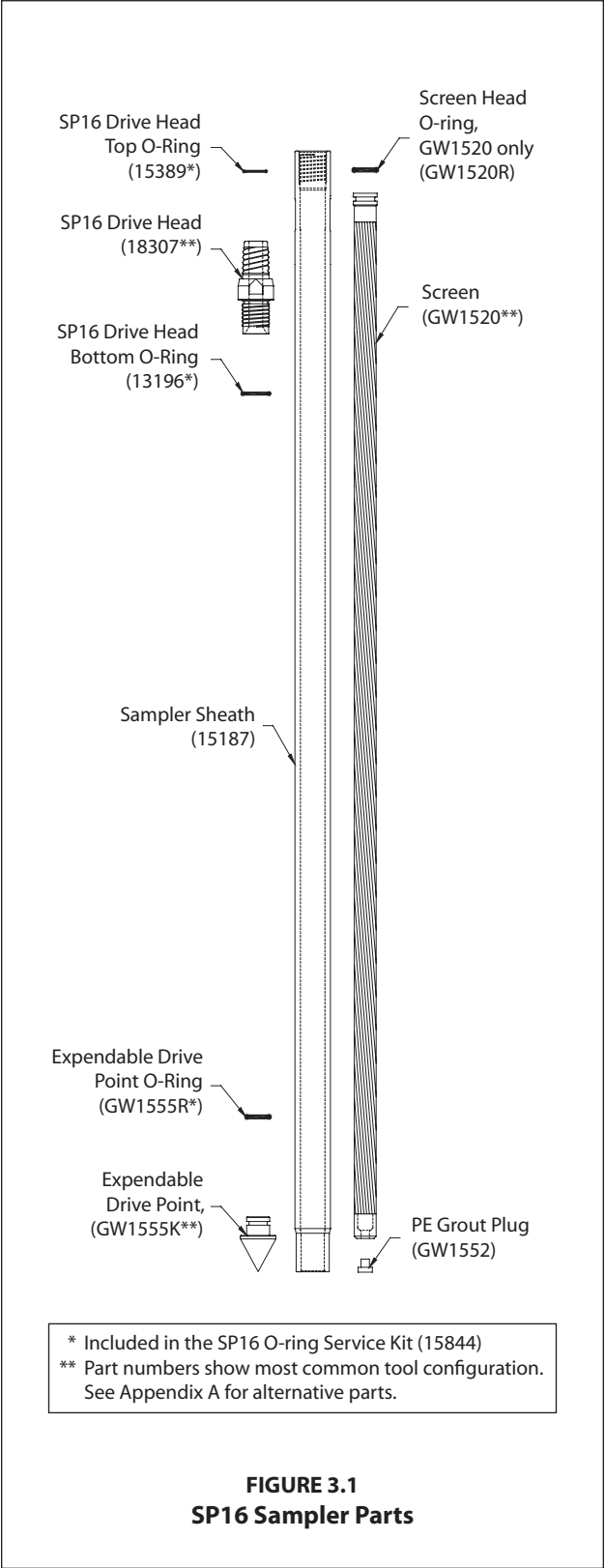
Grout Accessories	Part Number
Grout Nozzle, for 0.375-inch OD tubing	GW1545
High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m).....	11633
Grout Machine, self-contained*	GS1000
Grout System Accessories Package, 1.5-inch rods	GS1015

Groundwater Purging and Sampling Accessories	Part Number
Polyethylene Tubing, 0.375-inch OD, 500 ft. *	TB25L
Check Valve Assembly, 0.375-inch OD Tubing*	GW4210
Water Level Meter, 0.438-inch OD Probe, 100 ft. cable*	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, stainless steel.....	GW41

Additional Tools	Part Number
Adjustable Wrench, 6.0-inch	FA200
Adjustable Wrench, 10.0-inch	FA201
Pipe Wrenches	NA

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



4.0 OPERATION

4.1 Basic Operation

The SP16 sampler utilizes a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

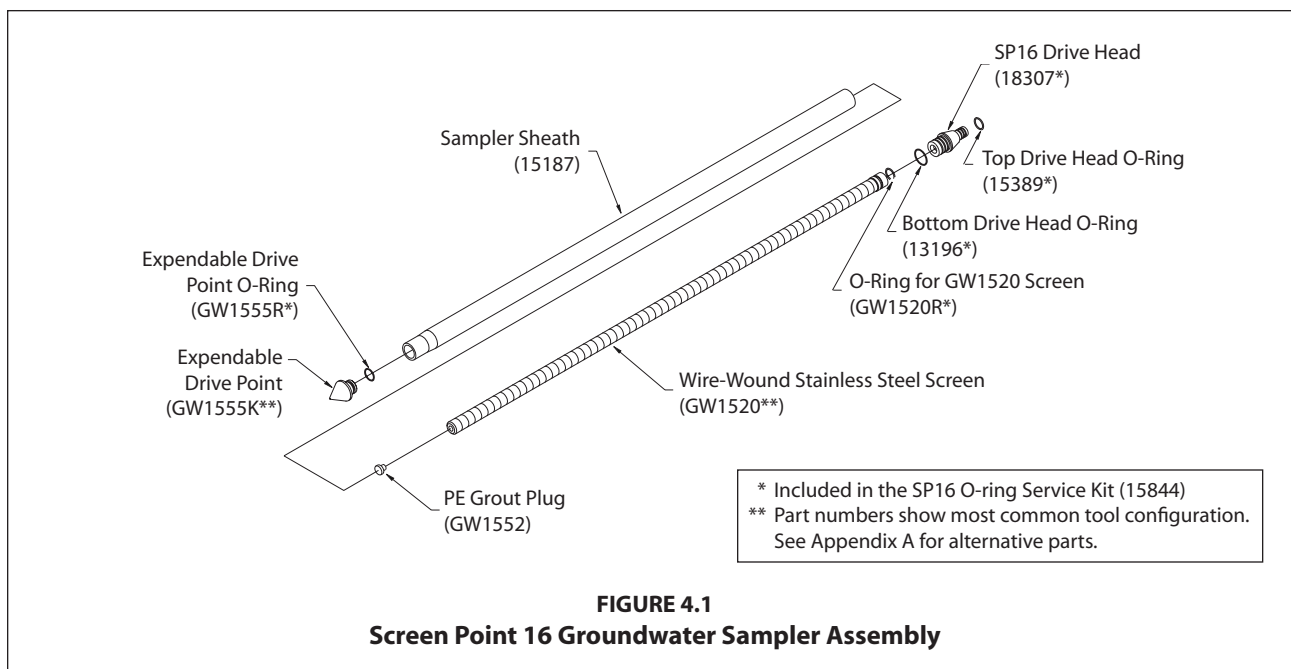
4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).
2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.
3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.
4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

NOTE: The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

Sampler assembly is complete.

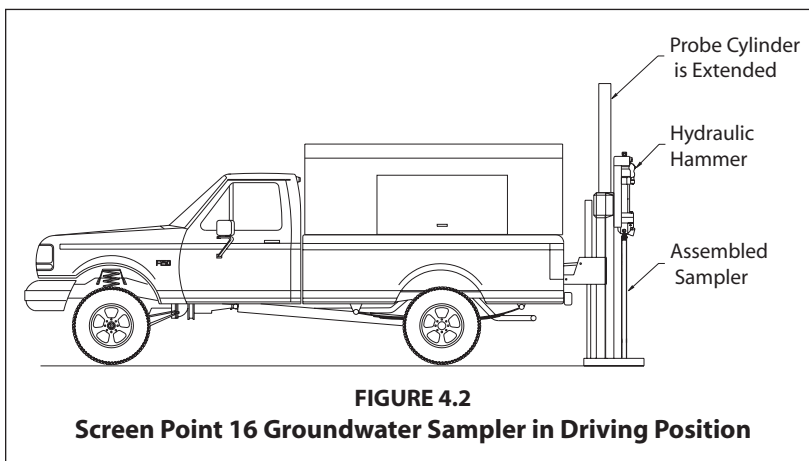


4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.
2. Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.
3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.



4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.
5. Remove the drive cap and retract the probe derrick away from the tool string.

4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.
2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.
3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.
4. Maneuver the probe assembly into position for pulling.
5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

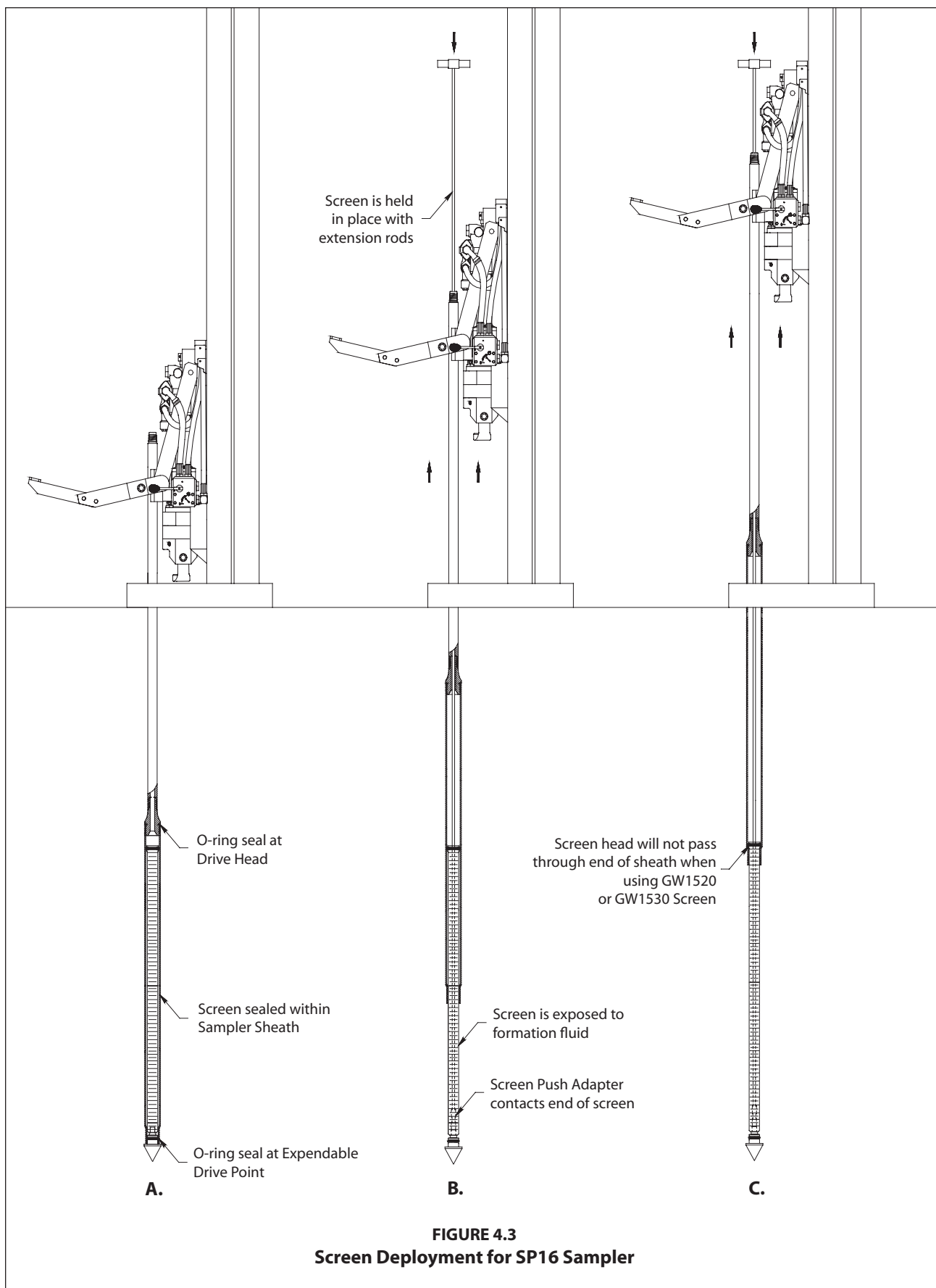
6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.
7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

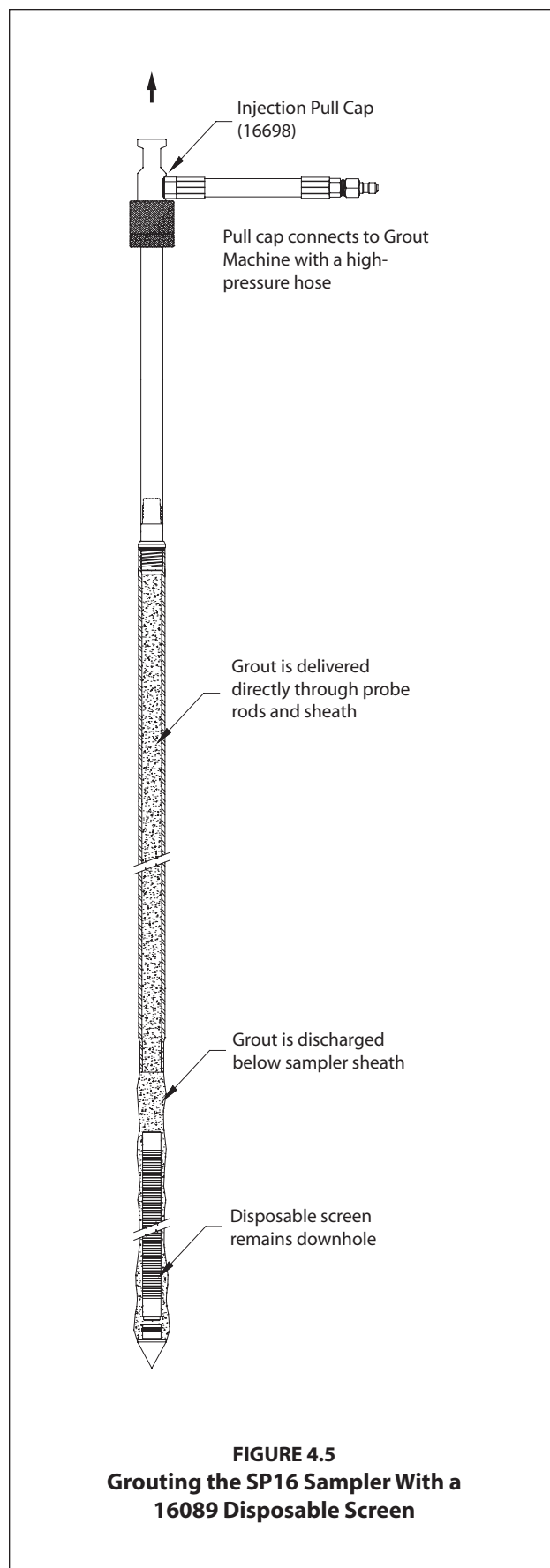
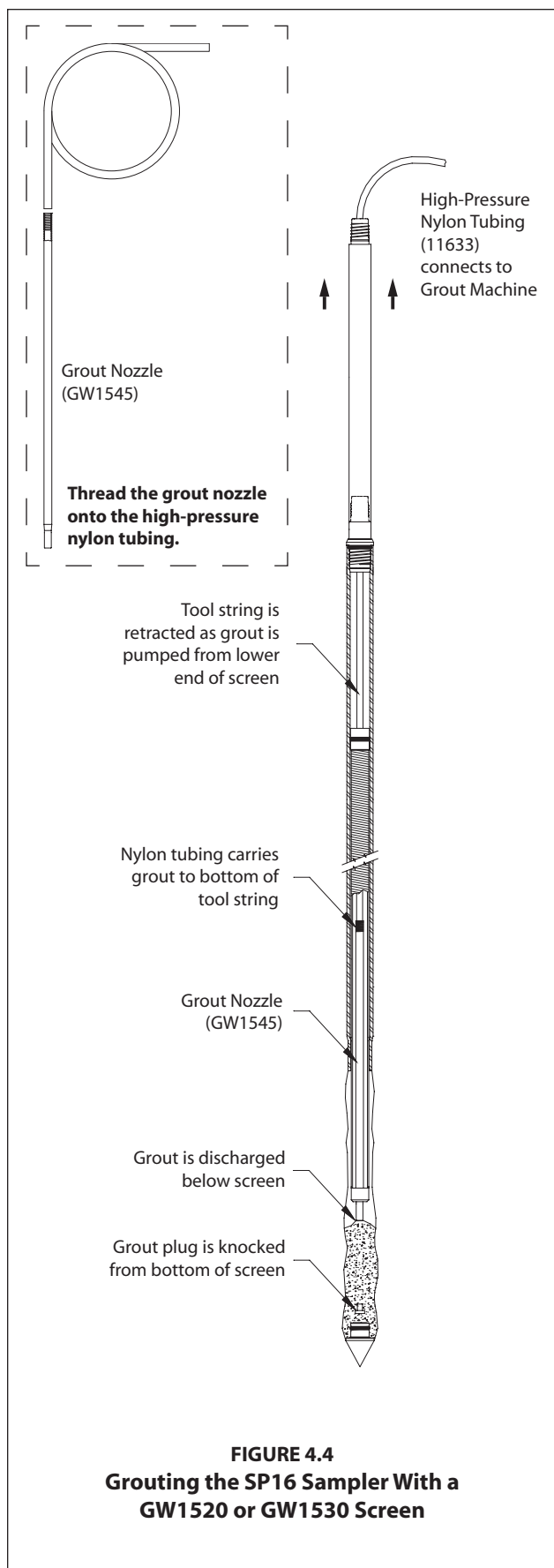
When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.
2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.





3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

Note: When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

Note: All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.
6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.
7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.
2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.
3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.
4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.
6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.
7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

5.0 REFERENCES

- American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshohocken, PA. (www.astm.org)
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- Geoprobe Systems®, 2003, *Tools Catalog, V.6*.
- Geoprobe Systems®, 2006, *Model MB470 Mechanical Bladder Pump Standard Operating Procedure (SOP), Technical Bulletin No. MK3013*.
- Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.
- U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.

Appendix A ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

SP16 Sampler Parts and Accessories.....	Part Number
SP16 Drive Head, 0.625-inch bore, 1.5-inch rods.....	15188
Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25).....	GW1555ALK
Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25).....	17066K
Screen, PVC, 10-Slot	GW1530
Screen, Disposable, PVC, 10-Slot	16089

Groundwater Purging and Sampling Accessories	Part Number
Polyethylene Tubing, 0.25-inch OD, 500 ft.....	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft.....	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft.....	TB50L
Check Valve Assembly, 0.25-inch OD Tubing.....	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200-ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

Grouting Accessories.....	Part Number
Grout Machine, auxiliary-powered	GS500

Probe Rods, Extension Rods, and Accessories	Part Number
Probe Rod, 1.5-inch x 1-meter	17899
Probe Rod, 1.5-inch x 48-inch.....	13359
Drive Cap, 1.5-inch rods (for GH40 Series Hammer)	15590
Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer)	GH1555
Extension Rod, 48-inch.....	AT671
Extension Rod, 1-meter	AT675

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.



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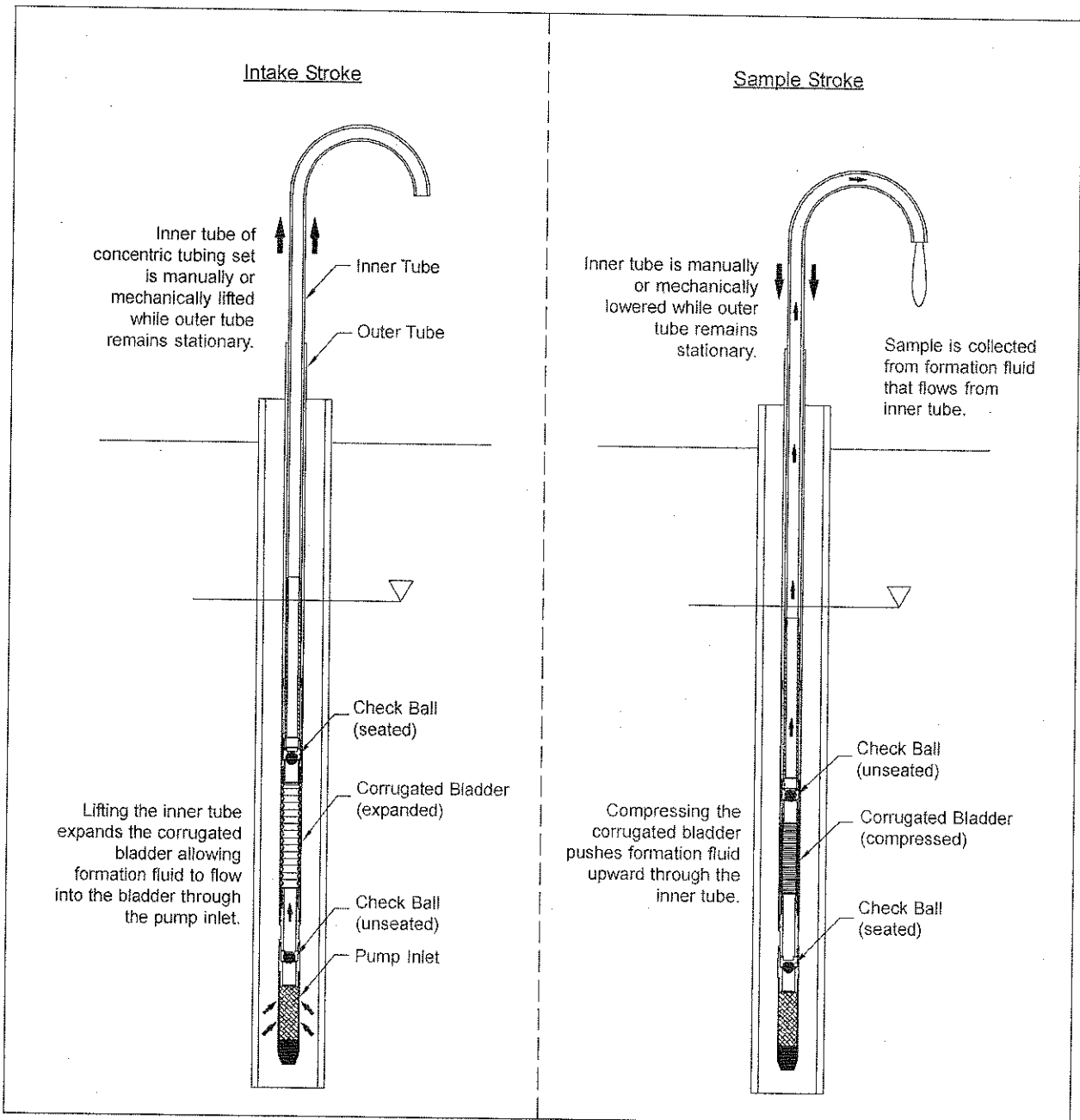
GEOPROBE® MODEL MB470 MECHANICAL BLADDER PUMP

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3013

PREPARED: November, 2003

REVISED: July, 2006



INTAKE AND SAMPLE STROKES OF THE MB470 MECHANICAL BLADDER PUMP



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are Registered Trademarks of Kejr, Inc., Salina, Kansas**

**The Mechanical Bladder Pump is manufactured under
U.S. Patent No. 6,877,965 issued April 12, 2005.**

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1.0 OBJECTIVE

The objective of this document is to provide guidance on how to collect a representative sample of the subsurface formation fluid utilizing the Geoprobe® Model MB470 Mechanical Bladder Pump.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.

**Geoprobe® and Geoprobe Systems® are registered trademarks of Kejr, Inc., Salina, Kansas.*

MB470 Mechanical Bladder Pump (MBP):** A device for obtaining high-quality, low-turbidity samples from groundwater monitoring wells and direct push installed groundwater samplers as small as .5 inches (13 mm) inside diameter (ID). The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

***The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

Within the MB470 pump body, a corrugated Teflon® fluorinated ethylene propylene (FEP) bladder is mechanically compressed and expanded to push groundwater to the surface through a concentric tubing set. Check valves above and below the bladder control flow direction. The outer tube of the concentric tubing set holds the pump body in place while the inner tube is used to actuate the bladder and transmit water to the surface. The pump body and internal components are made of stainless steel with an outside diameter (OD) of .47 inches (12 mm) and an overall length of 26.75 inches (679 mm) with an inlet screen assembly installed.

2.2 MBP System Components

The three basic components of the Model MB470 Mechanical Bladder Pump system are the pump, concentric tubing set, and actuator.

Pump

All pump components (Fig. 2.1) are made of stainless steel material with the exception of the three fluorosilicone O-rings and the Teflon® bladder.

Beginning at the downhole end of the pump, either a Bullet Nose Intake (P/N 20675) or Inlet Screen Assembly (P/N 20725) may be used as determined by project requirements. The screen assembly includes a 60 mesh wire screen with an actual screen length of 6 inches (152 mm). The bullet nose intake is open at the leading end and provides no filtering effect.

Above the intake/inlet, the pump body contains the corrugated bladder and check balls that physically move groundwater to the surface for purging and sampling. As the top of the bladder is extended, the expanding action of the bladder draws groundwater into the bladder through the intake/inlet. Compressing the bladder then pushes the groundwater up through the connected inner tube of the concentric tubing set. Check balls at the Upper and Lower Bladder Adapters (P/N 20679 and 20677) control groundwater flow through the bladder.

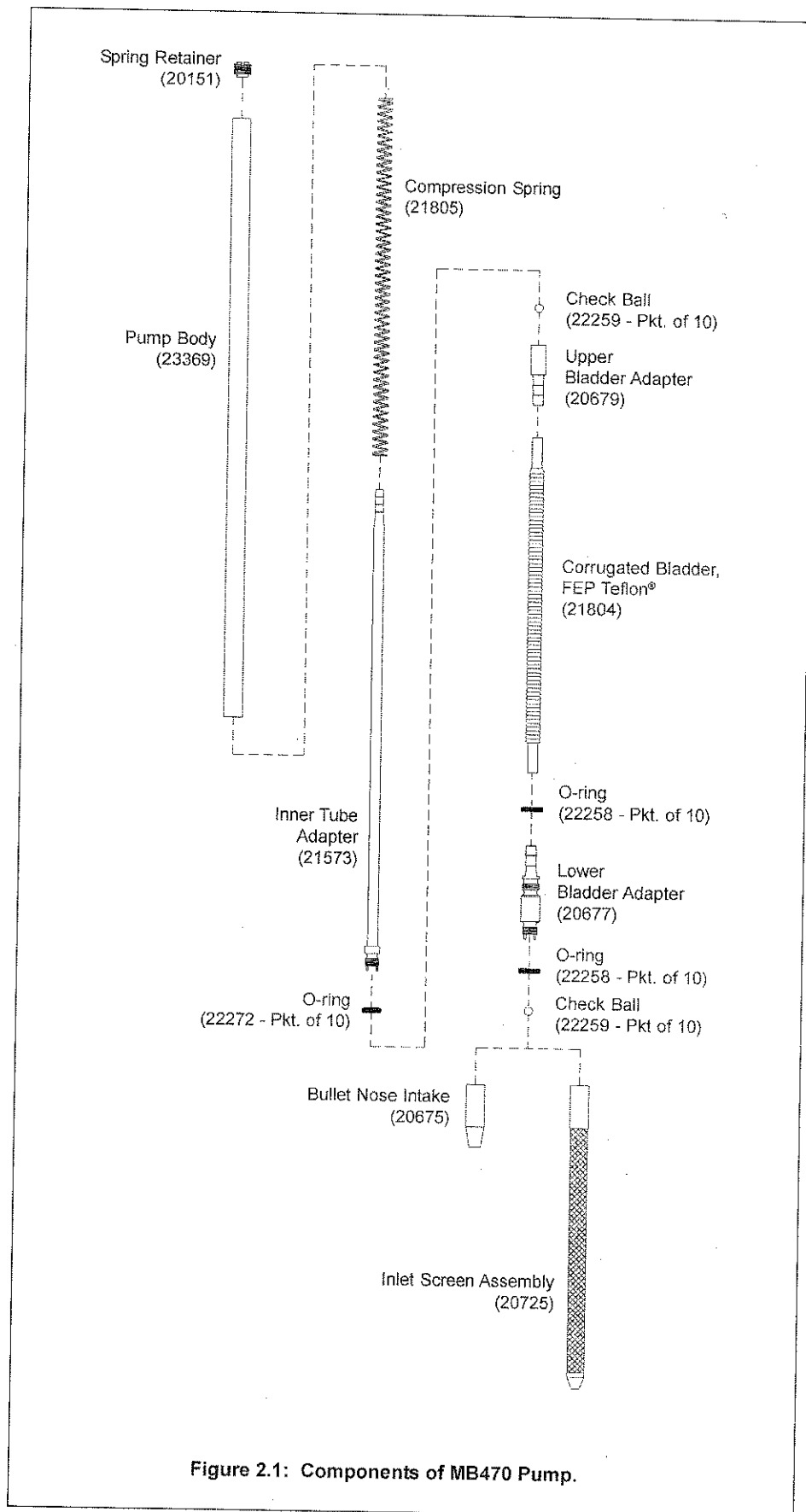


Figure 2.1: Components of MB470 Pump.

The lower end of the corrugated bladder is secured to the pump body by the Lower Bladder Adapter (P/N 20677). The top of the bladder is attached to the inner tube of the concentric tubing set by the Upper Bladder Adapter (P/N 20679) and Inner Tube Adapter (P/N 21573). During operation of the pump, the inner tube is raised and lowered to expand and contract the bladder to move formation fluid to ground surface.

Concentric Tubing Set

A concentric tubing set for the MB470 Mechanical Bladder Pump commonly consists of .19-inch (5 mm) ID / .25-inch (6 mm) OD Teflon® fluorinated ethylene propylene (FEP) tubing surrounded by .31-inch (8 mm) ID / .44-inch (11 mm) OD high-density polyethylene (HDPE) tubing. Where allowed by project requirements, other materials (e.g. low-density polyethylene (LDPE) tubing) may be utilized in place of the Teflon® inner tubing.

Available lengths for the concentric tubing set are 50 and 100 feet (15.2 and 30.5 m). Custom lengths may be assembled from 500-foot rolls of appropriate tubing sizes and materials, some of which are listed on Page 6.

Refer to the magnified view in Figure 2.2. The inner tube of the concentric tubing set is attached to the Inner Tube Adapter (P/N 21573) during assembly of the MB470 pump. The outer tube is then threaded inside the top end of the pump body. Once lowered down the sampler or monitoring well, the outer tube is held stationary either manually or by attachment to a mechanical actuator. The inner tube is raised and lowered by hand or through use of the mechanical actuator to expand and compress the pump bladder. Formation fluid is thus drawn into the pump bladder and then pushed to ground surface.

Actuator

Actuators provide the physical means of holding the outer tube of the concentric tubing set stationary while cycling the inner tube up-and-down. Actuator kits are available for manually or mechanically powering the MB470 pump.

For the manual actuator shown in Figure 2.2, the outer tube of the concentric tubing set is attached to the probe rods using two adapters. The inner tubing is raised and lowered by hand to obtain the groundwater sample. Refer to Section 4.4 for more actuator options.

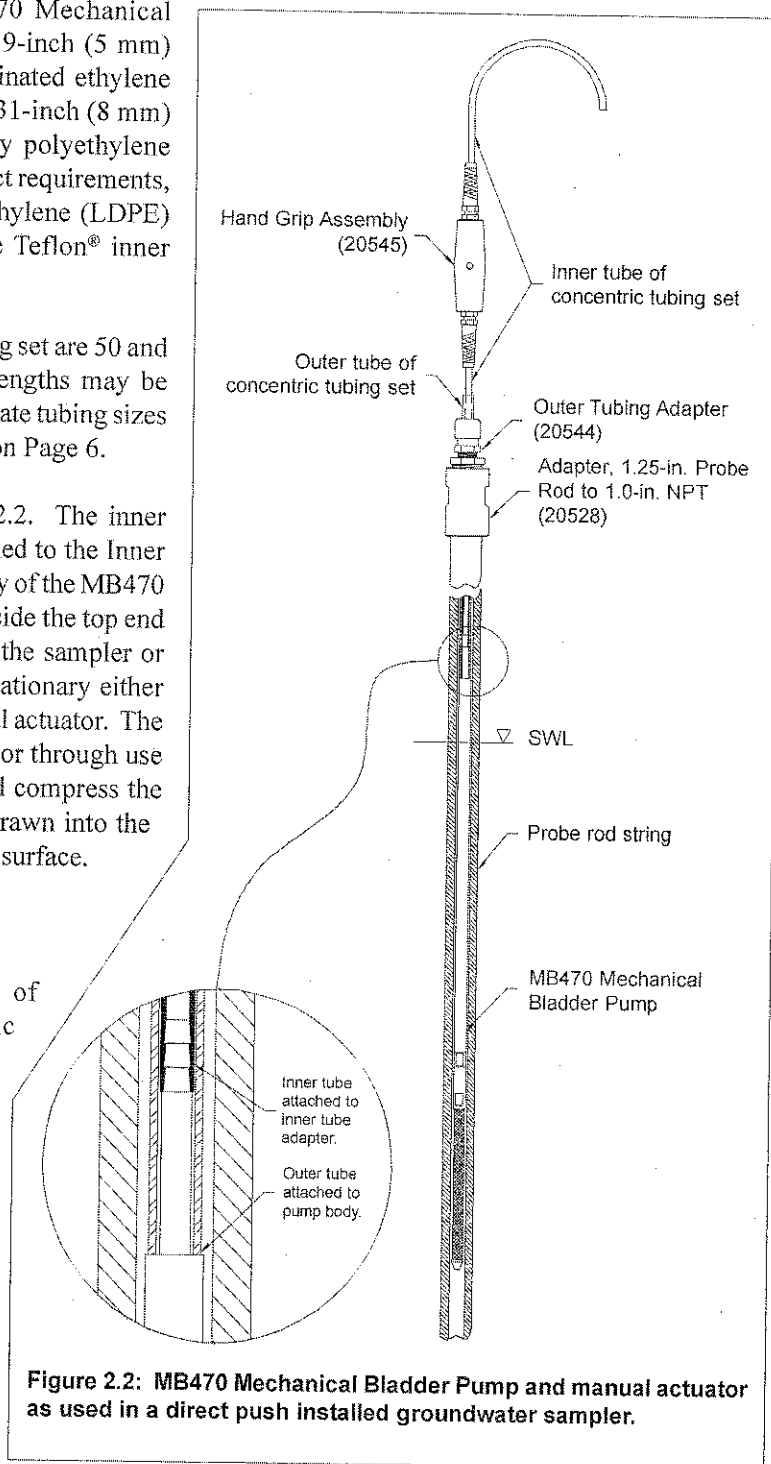


Figure 2.2: MB470 Mechanical Bladder Pump and manual actuator as used in a direct push installed groundwater sampler.

3.0 REQUIRED EQUIPMENT

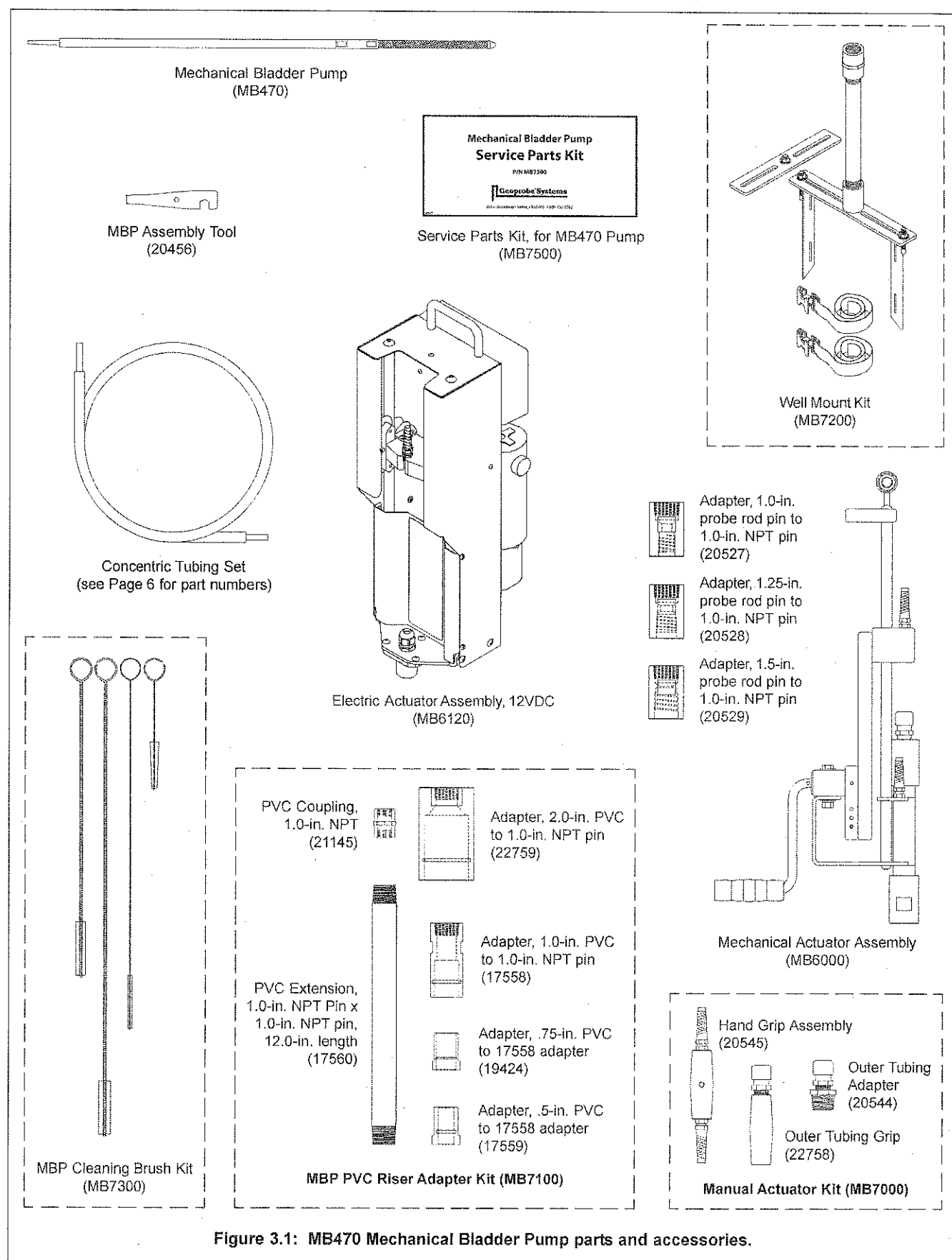
The following equipment is required to collect representative groundwater samples using the Model MB470 Mechanical Bladder Pump. Refer to Figure 3.1 for identification of the specified parts.

Pump Components	Quantity	Part Number
Mechanical Bladder Pump	-1-	MB470
Service Parts Kit, for MB470 Pump	-1-	MB7500
Includes: O-ring Pick	-1-	AT102
Corrugated Bladder, Teflon® FEP	-3-	21804
Compression Spring, Stainless Steel (SS)	-1-	21805
O-rings for Lower Bladder Adapter (#5-585 Fluorosilicone), Pkg. of 10	-1-	22258
O-rings for Inner Tube Adapter (#010 Fluorosilicone), Pkg. of 10	-1-	22272
Check Balls (7/32-in. diameter), SS, Pkg. of 10	-1-	22259
MBP Assembly Tool	-1-	20456
MBP Cleaning Brush Kit	-1-	MB7300
MBP Assembly Tool	-1-	20456

Tubing Options	Quantity	Part Number
Concentric Tubing Set, HDPE (outer)/FEP (inner), .44-in. OD x 50-ft. length	Variable	MB5050
Concentric Tubing Set, HDPE/FEP, .44-in. OD - 100-ft. length	Variable	MB5100
Concentric Tubing Set, HDPE/LDPE, .44-in. OD - 50-ft. length	Variable	MB5051
Concentric Tubing Set, HDPE/LDPE, .44-in. OD - 100-ft. length	Variable	MB5101
Concentric Tubing Set, HDPE/PP, .44-in. OD - 50-ft. length	Variable	MB5052
Concentric Tubing Set, HDPE/PP, .44-in. OD - 100-ft. length	Variable	MB5102
LDPE Tubing, .19-in. ID x .25-in. OD - 100-ft. length	Variable	TB171L
LDPE Tubing, .19-in. ID x .25-in. OD - 500-ft. length	Variable	TB17L
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 50-ft. length	Variable	TB17T
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 100-ft. length	Variable	TB171T
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 500-ft. length	Variable	TB175T
PP Tubing, .17-in. ID x .25-in. OD - 50-ft. length	Variable	TB17P
PP Tubing, .17-in. ID x .25-in. OD - 100-ft. length	Variable	TB171P
HDPE Tubing, .31-in. ID x .44-in. OD - 50-ft. length	Variable	TB31H
HDPE Tubing, .31-in. ID x .44-in. OD - 100-ft. length	Variable	TB311H
HDPE Tubing, .31-in. ID x .44-in. OD - 500-ft. length	Variable	TB315H

Actuator Options	Quantity	Part Number
Manual Actuator Kit	-1-	MB7000
Includes: Hand Grip Assembly	-1-	20545
Outer Tubing Grip	-1-	22758
Outer Tubing Adapter	-1-	20544
Mechanical Actuator Assembly	-1-	MB6000
Electric Actuator Assembly, 12VDC	-1-	MB6120
Electric Actuator Kit, 12VDC	-1	MB6120K
Well Mount Kit (for use with MB6000)	-1-	MB7200

Adapters for Use with Actuators	Quantity	Part Number
MBP PVC Riser Adapter Kit	-1-	MB7100
Includes: PVC Extension, 1.0-in. NPT Pin x 1.0-in. NPT Pin - 12-in. Length	-1-	17560
PVC Coupling, 1.0-in. NPT Box x 1.0-in. NPT Box	-1-	21145
Adapter, 2.0-in. PVC to 1.0-in. NPT Pin	-1-	22759
O-rings for 2.0-in. PVC to 1.0-in. NPT Pin Adapter, pkg. of 25	-1-	22313
Adapter, 1.0-in. PVC to 1.0-in. NPT Pin	-1-	17558
O-rings for 1.0-in. PVC to 1.0-in. NPT Pin Adapter, pkg. of 25	-1-	13942
Adapter, 0.75-in. PVC to 17558 Adapter (0.75-in. PVC requires 2 adapters)	-1-	19424
O-rings for 0.75-in. PVC to 17558 Adapter, pkg. of 25	-1-	13196
Adapter, 0.5-in. PVC to 17558 Adapter (0.5-in. PVC requires 2 adapters)	-1-	17559
O-rings for 0.5-in. PVC to 17558 Adapter, pkg. of 25	-1-	GW1555R
Adapter, Geoprobe® 1.0-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20527
Adapter, Geoprobe® 1.25-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20528
Adapter, Geoprobe® 1.5-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20529



4.0 OPERATION

Use and operation of the MB470 Mechanical Bladder Pump may be divided into five main steps:

- *Assembling the Pump*
- *Selecting and installing the concentric tubing set*
- *Selecting and installing the actuator*
- *Purging and sampling*
- *Decontaminating the Pump*

4.1 Assembling the Pump

This section identifies the procedures for assembling the components of the MB470 Mechanical Bladder Pump and performing a leak check on the corrugated bladder. Refer to Figure 4.1 for parts identification.

1. Ensure that all metal parts are clean and free of burrs that may damage the pump threads or the corrugated bladder during assembly.
2. Install two fluorosilicone O-rings (22258) on the Lower Bladder Adapter (20677). Note that these are the larger of the two sizes of O-rings used with the MB470 pump.
3. Lubricate the O-ring of the lower bladder adapter and inside the Bullet Nose Intake (20675) with DI water. Place a Check Ball (22259) in the bullet nose intake and thread the intake onto the lower bladder adapter.

NOTE: The bullet nose intake is used here to make it easier to leak check the pump later in this procedure. After the leak check has been performed, the bullet nose intake may be replaced with a Screen Inlet Assembly (20725) if desired.

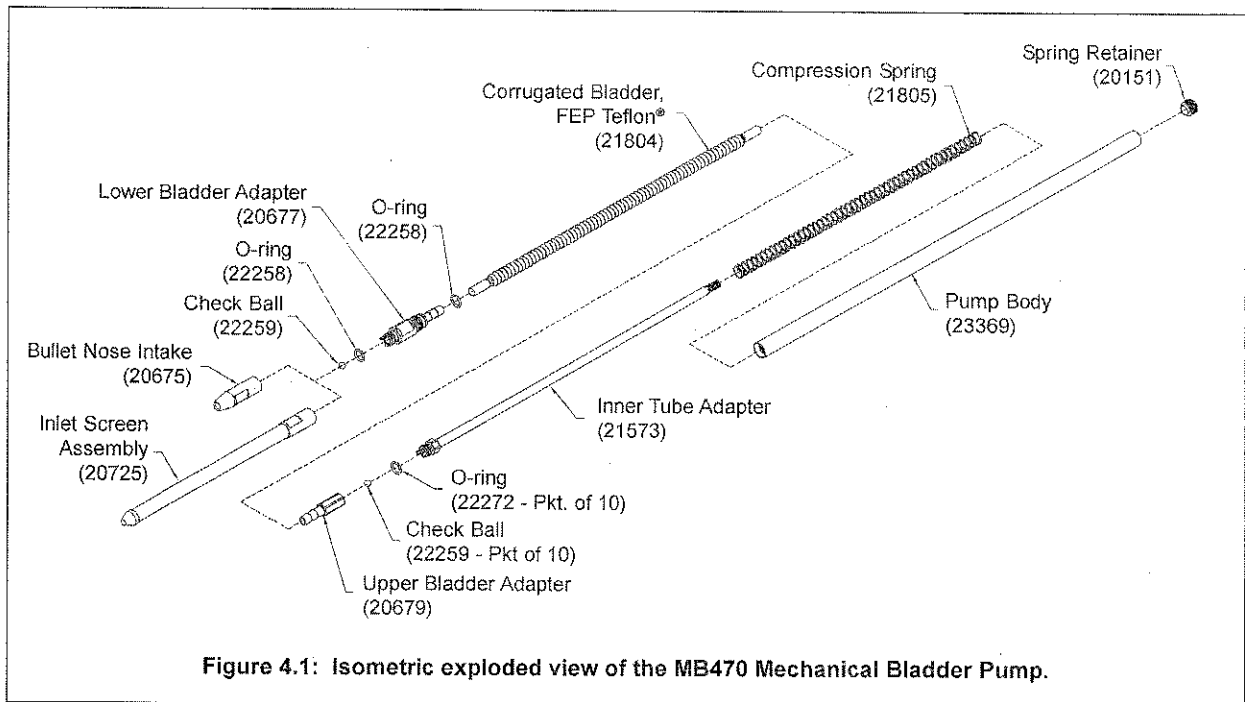
4. Install a fluorosilicone O-ring (22272) on the lower end of the Inner Tube Adapter (21573). Note that this is the smaller of the two sizes of O-rings used with the MB470 pump.
5. Lubricate the O-ring of the inner tube adapter and inside the Upper Bladder Adapter (20679) with DI water. Thread the upper bladder adapter onto the inner tube adapter.

NOTE: A check ball must be installed in the upper bladder adapter after performing the leak check in Step 7.

6. Install the Teflon® FEP Corrugated Bladder (21804):
 - The bladder should be installed with the corrugations pointing “up” (toward the upper bladder adapter/inner tube adapter) as indicated in Figure 4.2.
 - Firmly push and rotate the lower cuff of the bladder over the barbed end of the lower bladder adapter.
 - Firmly push and rotate the upper cuff of the bladder over the barbed end of the upper bladder adapter.
 - Both ends of the bladder should be fully seated on the adapter barbs.

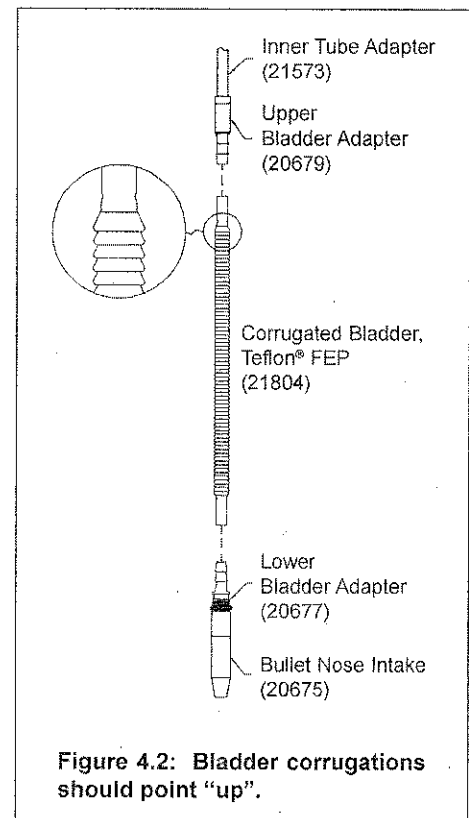
CAUTION: Although firmness is required during installation of the bladder, avoid crushing, kinking, or twisting the bladder corrugations to prevent damage.

7. Perform a leak check on the corrugated bladder before fully assembling the pump components to ensure that the bladder is free of defects. (Leak check procedure is given on opposite page.)



Leak check the corrugated bladder as follows:

- Completely submerge the bladder and lower end of the inner tube adapter in a clean beaker or small bucket of distilled or DI water.
 - Firmly blow into the open end of the inner tube adapter. Leaks in the bladder or assembled parts will be indicated by bubbles.
 - If leaks are found, replace the faulty O-ring(s) or bladder. Retest to ensure that all leakage has stopped.
 - Once the pump has passed the leak test, unthread the upper bladder adapter from the inner tube adapter. Place a Check Ball (22259) in the upper bladder adapter and reinstall it in the inner tube adapter.
 - Replace the bullet nose intake with an Inlet Screen Assembly (20725) if desired. Remember to include the check ball when installing the inlet screen.
8. The Pump Body (23369) is internally threaded at each end. Threads run all the way to the end of the pump body at the upper end, but stop .25 inches (6 mm) from the end at the lower end of the pump body to permit an O-ring seal.



Thread the Spring Retainer (20151) into the top of the pump body. Install the retainer with the slotted end out to allow use of a medium slotted screw driver or the MBP Assembly Tool (20456) to thread or unthread the retainer.

9. Place the Compression Spring (21805) over the top of the inner tube adapter. Slide the spring completely onto the adapter until it contacts the hex fitting.

10. Slide the lower end of the pump body over the top of the inner tube adapter and pump spring. The inner tube adapter will slip through the spring retainer and extend approximately 3 inches (75 mm) from the top of the pump body.
11. The lower bladder adapter is now threaded into the pump body to complete the assembly process.
 - Lubricate the O-ring on the lower bladder adapter and inside the lower end of the pump body with DI water.
 - Grasp the pump body with one hand and the lower bladder adapter with the other hand.
 - Gently compress the spring and bladder into the pump body.
 - Thread the lower bladder adapter into the pump body. Use care to avoid cutting or pinching the O-ring while threading the parts together. The O-ring will no longer be visible when the adapter is fully seated.

Assembly of the MB470 Mechanical Bladder Pump is now complete.

4.2 Selecting and Installing the Concentric Tubing Set

Selecting the Concentric Tubing Material and Length

The outer tube of the concentric tubing set commonly consists of .44-inch OD x .31-inch ID (11.2 mm x 7.9 mm) HDPE material. Inner tube material options are Teflon® FEP, LDPE, or PP. Teflon® FEP and LDPE tubing have dimensions of .25-inch OD x .19-inch ID (6.4 mm x 4.8 mm) while the PP tubing measures .25-inch OD x .17-inch ID (6.4 mm x 4.3 mm).

LDPE inner tubes are the least expensive option. The elasticity of this material may be excessive for deeper wells and in warm ambient conditions (summertime). Teflon® FEP inner tubes are less elastic and provide higher sample quality compared to LDPE due to the chemical properties of the two materials. Teflon® FEP also has a lower coefficient of friction for smoother actuation of the bladder and less resistance to operation, especially at greater depths. The main drawback of Teflon® FEP is its higher cost. PP inner tubes provide a compromise between LDPE and Teflon® FEP in that they are less elastic and provide higher sample quality than LDPE at a lower cost than Teflon® FEP.

While Teflon® FEP exhibits relatively good chemical inertness, it will absorb and desorb some volatile organic contaminants (Parker & Ranney 1998). Because of this, ambient groundwater should be purged through the pump and tubing system for a period of time to achieve equilibrium between the bladder and tubing and sample fluid. The period of time may vary for different volatile organic compounds (VOCs), but if low flow sampling (Puls and Barcelona 1996, ASTM 2003) is conducted, chemical equilibrium may be achieved by the time the monitored water quality parameters (DO, ORP, turbidity, etc.) have stabilized.

Preassembled concentric tubing sets are available from Geoprobe Systems® in lengths of 50 and 100 feet (15.2 and 30.5 m). The user may choose to assemble sets of custom lengths from separate rolls of inner and outer tubing in preparation for the sampling event or while on-site. Be careful to keep the tubing clean while inserting the inner tube into the outer tube.

When long tubing sets are required, it may be wise to use clean PVC riser pipe to protect the tubing during assembly. Simply thread PVC riser sections together, placing them on the shop floor or along the ground surface. Cap one end of the casing to keep dirt and debris out during assembly. Determine the length of the outer tube required and make the PVC casing about the same length. Slide the outer tube into the PVC casing and cut to the desired length. Slide the inner tube into the outer tube. Cut the inner tube three or more feet longer than the outer tube to complete the concentric tubing set.

Keep all tubing stored in clean airtight bags or containers so that dirt, dust, and cross contamination are not a concern or problem. No matter how clean the pump is, sample quality will suffer if the tubing is dirty. Be sure the tubing is of clean, quality material and is not marked with inks that may contribute to cross contamination.

Installing the Concentric Tubing Set on the MB470 Pump

The concentric tubing set is attached to the mechanical bladder pump by pushing the inner tube onto the hose barb on the end of the inner tube adapter and then threading the outer tube into the pump body.

1. Push the inner tube of the concentric tubing set onto the hose barb on the end of the inner tube adapter (Fig. 4.3). Fully seat the tube on the adapter such that the tube engages all three barbs. Take care not to kink or otherwise damage the tubing.
2. Before installing the outer tube, unthread the lower bladder adapter from the pump body and lay the partially disassembled pump on a clean, level surface. This step is recommended so that the bladder is not twisted or damaged as the outer tubing is installed.

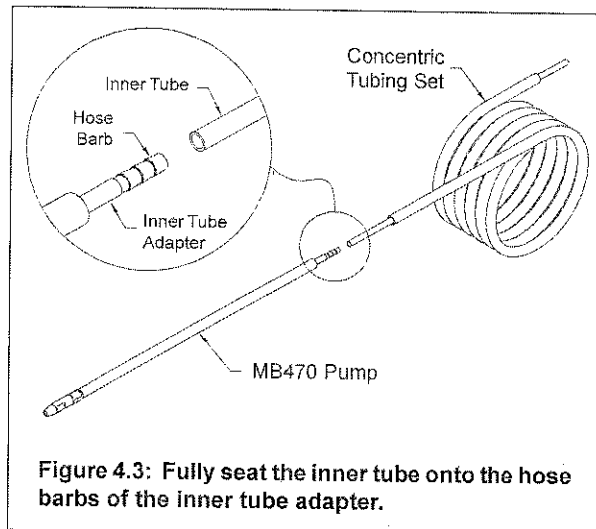


Figure 4.3: Fully seat the inner tube onto the hose barbs of the inner tube adapter.

3. Push and thread the outer tube into the top end of the pump body (Fig. 4.4). The outer tube should be threaded about 0.75 inches (19 mm) into the pump body until it butts against the spring retainer. Remember to take care not to kink or otherwise damage the tubing during installation.
4. Rotate the lower bladder adapter counterclockwise one or two revolutions to minimize torque on the bladder when threading the adapter into the pump body. Now reinstall the lower bladder adapter and inner tube adapter into the lower end of the pump body.

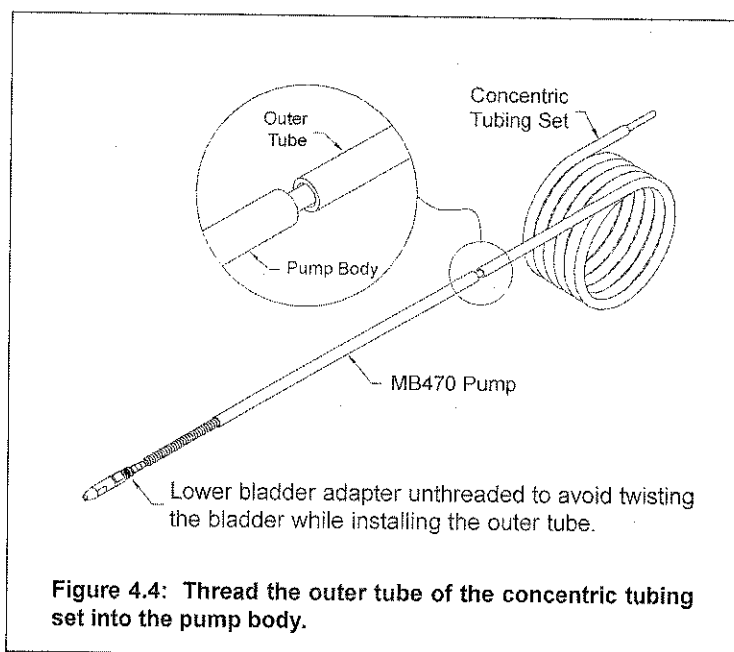


Figure 4.4: Thread the outer tube of the concentric tubing set into the pump body.

The pump and tubing set are now assembled and ready for installation into the monitoring well or sampler.

NOTE: Friction between the inner and outer tubes may make it difficult to attach the pump with the tubing set coiled. To overcome this problem, attach the pump while the concentric tubing is unrolled in the PVC riser sections as described at the bottom of Page 10.

The user may also choose to lower the concentric tubing set partway down the tool string or well, attach the pump to the exposed end of the tubing, retrieve the tubing set, and install the pump for purging or sampling. If this technique is used, **take great care to avoid dropping the tubing set down the well or tool string during attachment of the pump.**

4.3 Selecting and Installing the Actuator

Operating the mechanical bladder pump requires holding the outer tube of the concentric tubing set stationary while moving the inner tube up-and-down. Although this maneuver is possible by simply holding the outer tube in one hand and moving the inner tube with the other hand, an actuator makes operation of the pump significantly easier.

NOTE: The tubing set must be completely unrolled for the inner tube to slide freely within the outer tube.

This section identifies the available actuator options. Methods by which the actuators attach to the concentric tubing set and are installed on the monitoring well or tool string are also addressed.

Handheld Manual Actuator

The handheld actuator option is the first step above simply grasping the inner and outer tube by hand. With this option, a Hand Grip Assembly (20545) and Outer Tubing Grip (22758) are installed on the concentric tubing set (Fig. 4.5). Sampling or purging is accomplished by physically holding the outer tubing grip in one hand while raising and lowering the hand grip assembly with the other hand. A handheld actuator may be used to purge or collect samples through probe rods from a groundwater sampler as well as from a permanent monitoring well.

Installation of the handheld actuator is described below.

1. Determine the depth to which the pump inlet will be installed as measured from the top probe rod or riser pipe with a weighted tape or water level meter.
2. The distance from the pump inlet to the top of the tool string or riser pipe (from Step 1) may now be marked on the outer tube. Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or riser.
3. Leading with the end opposite the compression fitting, slide the outer tubing grip over the top end of the tubing set. It may be necessary to loosen the fitting slightly (Fig. 4.6) to allow installation.
4. Position the grip with the lower end even with, or slightly above the line marked on the outer tube in Step 2. The specific location of the grip should be determined by operator preference. The important thing is that the pump inlet is maintained at the appropriate level during sampling as indicated by the mark on the outer tube.

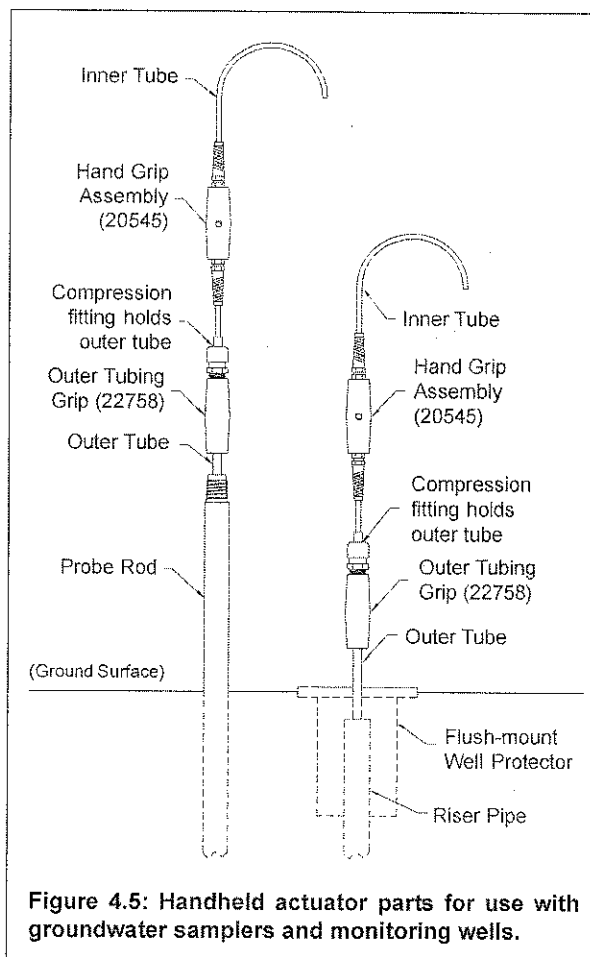


Figure 4.5: Handheld actuator parts for use with groundwater samplers and monitoring wells.

5. Secure the grip to the outer tube by tightening the large nut of the compression fitting (Fig. 4.6) until it is "hand tight". Do not overtighten as this may damage the plastic fitting.
6. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location). Now measure and cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube.
7. Slide the hand grip assembly over the inner tube and position it 1-2 inches (25-51 mm) above the outer tubing grip as shown in Figure 4.6. It may be necessary to first loosen the two compression fittings to allow installation over the inner tube.
8. Secure the hand grip by tightening the two compression fittings. Take care not to overtighten and damage the fittings. Also avoid kinking the inner tube while completing this step.

To operate the mechanical bladder pump with the handheld actuator, simply insert the pump into the probe rod string or monitoring well. Lower the pump and concentric tubing set until the mark on the outer tube (measured and marked previously in Step 2, Page 12) is aligned with the top of the probe rod string or well riser. Initiate pump flow by holding the outer tubing grip stationary with one hand while cycling the hand grip assembly up-and-down with the other hand. A pump stroke of up to approximately 6 inches (150 mm) is recommended.

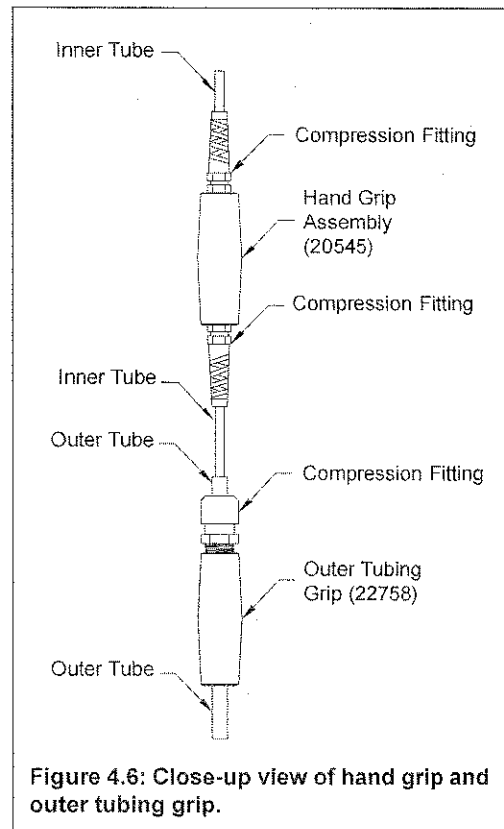


Figure 4.6: Close-up view of hand grip and outer tubing grip.

Anchored Manual Actuator

The anchored actuator option is similar to the handheld actuator in that the mechanical bladder pump is cycled by physically raising and lowering the inner tube using the Hand Grip Assembly (20545). But while the handheld actuator requires a second hand to hold the outer tube, the anchored actuator option utilizes adapters to mechanically secure the outer tubing to the top probe rod or riser pipe as shown in Figure 4.7.

Installation of the mechanical bladder pump with the anchored actuator option is reviewed in this section for both probe rod and well riser applications.

1. The outer tube of the concentric tubing set is connected to the top probe rod or well riser using an Outer Tubing Adapter (20544) plus additional adapters as determined by the size of rod or riser onto which the actuator is to be installed.

Referring to Table 4.1, select the appropriate adapter(s) for your size of probe rod or well riser. Illustrations and complete descriptions of the various adapters are presented in Table 4.2 and Figures 4.8 - 4.10. Note that .5-inch and 0.75-inch riser pipe each require two PVC adapters in addition to the outer tubing adapter.

2. Assemble the adapters by threading the outer tubing adapter into the probe rod or well riser adapter.

As illustrated in Figure 4.8, two adapters are required to attach the outer tubing adapter to .5-inch and .75-inch riser pipe. After threading the outer tubing adapter into the 1.0-inch PVC to 1.0-inch NPT Adapter (17558), either a .5-inch PVC adapter (19424) or .75-inch PVC adapter (17559) is then installed in the remaining end of the 1.0-inch PVC adapter.

3. Determine the depth to which the pump inlet will be installed as measured from the top probe rod or riser pipe with a weighted tape or water level meter.
4. The distance from the pump inlet to the top of the tool string or riser pipe (from Step 3) is now marked on the outer tube:

Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or riser.

5. Slide the assembled adapters (from Step 2) over the top end of the tubing set leading with the end opposite the compression fitting. See Figure 4.7 for adapter orientation. It may be necessary to loosen the compression fitting slightly to allow installation.

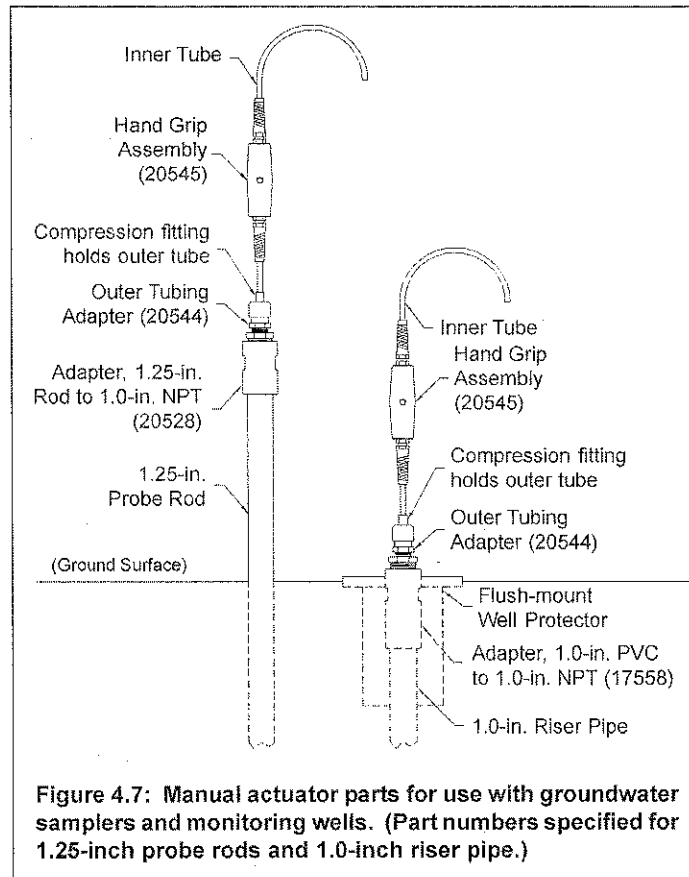


Figure 4.7: Manual actuator parts for use with groundwater samplers and monitoring wells. (Part numbers specified for 1.25-inch probe rods and 1.0-inch riser pipe.)

6. Position the adapters such that the line marked on the outer tube in Step 4 will be even with the top of the probe rod or well riser when the pump is installed on the tool string or riser.
7. Secure the adapters to the outer tube by tightening the large nut of the compression fitting (Fig. 4.7) until it is "hand tight". Do not overtighten as this may damage the plastic fitting.

8. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location). Now measure and cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube.

Size	Probe Rod Adapters	Monitoring Well Riser Adapters
.5-inch	na	17559, 17558, and 20544
.75-inch	na	19424, 17558, and 20544
1.0-inch	20527 and 20544	17558 and 20544
1.25-inch	20528 and 20544	na
1.5-inch	20529 and 20544	na
2.0-inch	na	22759 and 20544

Table 4.1: Part numbers for the adapters required to attach the outer tube to various probe rods and PVC riser pipe.

9. Slide the hand grip assembly over the inner tube and position it 1-2 inches (25-51 mm) above the outer tubing grip as shown previously in Figure 4.6. It may be necessary to first loosen the two compression fittings to allow installation over the inner tube.
10. Secure the hand grip by tightening the two compression fittings until they are hand tight. Do not overtighten the plastic fittings as damage may result.

Illustration	Part Number	Description
	20544	Outer Tubing Adapter
	20527	Adapter, 1.0-in. probe rod pin to 1.0-in. NPT pin
	20528	Adapter, 1.25-in. probe rod pin to 1.0-in. NPT pin
	20529	Adapter, 1.5-in. probe rod pin to 1.0-in. NPT pin
	22759	Adapter, 2.0-in. PVC to 1.0-in. NPT Pin
	17558	Adapter, 1.0-in. PVC to 1.0-in. NPT Pin
	19424	Adapter, .75-in. PVC to 17558 Adapter
	17559	Adapter, .5-in. PVC to 17558 Adapter

Table 4.2: Adapters for attaching the outer tube to probe rods and PVC riser pipe.

11. Lower the mechanical bladder pump down the probe rods or well riser. Secure the outer tubing adapter by threading it onto the top probe rod or sliding it over the top of the well riser.

The mechanical bladder pump is now ready for purging and/or sampling.

Operation of the mechanical bladder pump with a manual actuator is limited to simply raising and lowering the hand grip assembly using a stroke length up to 6 inches (152 mm). This action extends and retracts the pump bladder to push formation fluid to the ground surface through the inner tube of the concentric tubing set. The outer tube is attached to the probe rod string or well riser by adapters and is thus held stationary while the pump is actuated.

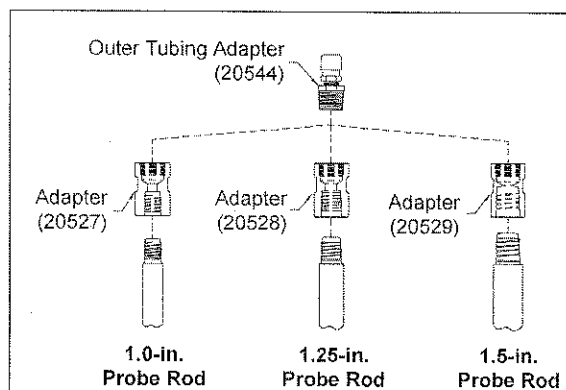


Figure 4.8: Adapters for attaching the outer tube to 1.0-, 1.25-, and 1.5-inch probe rods.

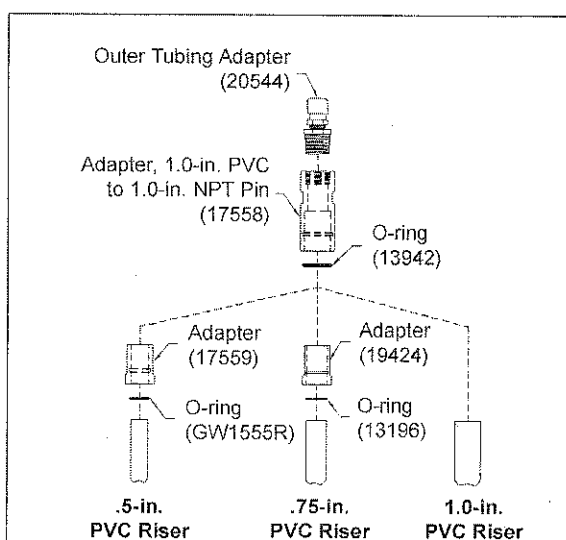


Figure 4.9: Adapters for attaching the outer tube to .5-, .75-, and 1.0-inch PVC riser pipe.

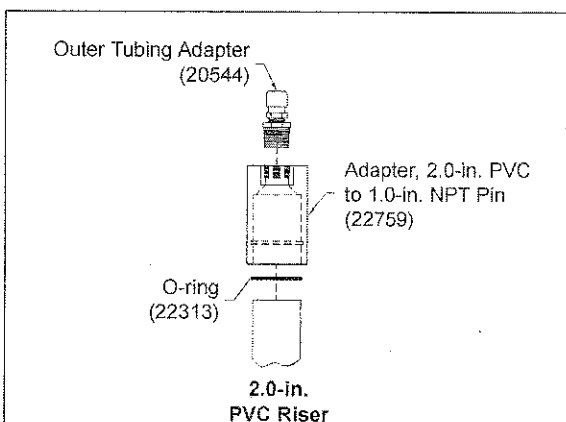


Figure 4.10: Adapters for attaching the outer tube to 2.0-inch PVC riser pipe.

Mechanical Actuator

The third actuator option for the MB470 Mechanical Bladder Pump is a Mechanical Actuator Assembly (MB6000, Figure 4.10). Rather than physically raising and lowering the inner tube to cycle the pump, the operator simply rotates the handle on the side of mechanical actuator. The actuator assembly converts this rotational action to vertical movement of the inner tube which cycles the pump. The operator may also choose to manually raise and lower the inner tube by disconnecting the side handle and utilizing the T-handle at the top of the assembly.

An advantage of the mechanical actuator option is that it requires little physical input to operate the pump. This translates to minimal operator fatigue when purging or sampling from multiple wells during the day.

The mechanical actuator assembly may be installed directly on a probe rod string (Fig. 4.10) or attached to a flush-mount or aboveground well protector using a Well Mount Kit (MB7200) as shown in Figures 4.11 and 4.12. Installation and operation of the mechanical actuator are described below.

1. Determine the depth to which the pump inlet will be installed as measured from the top of the probe rods or well protector with a weighted tape or water level meter.
2. The distance from the pump inlet to the top of the tool string or well protector (from Step 1) may now be marked on the outer tube:

Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or well protector.

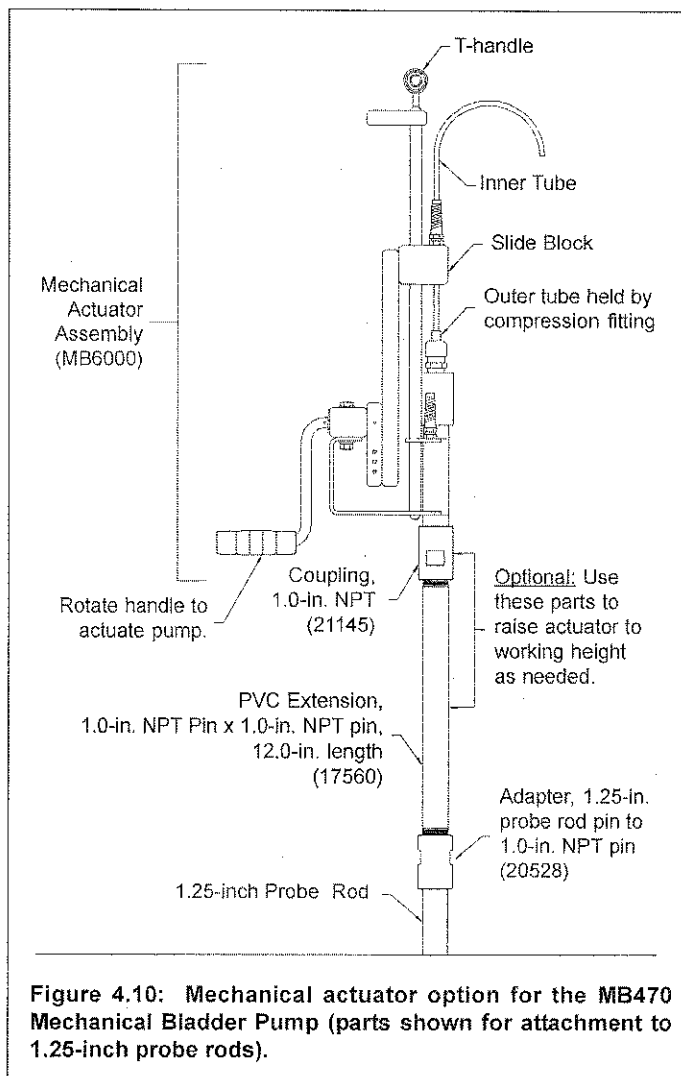
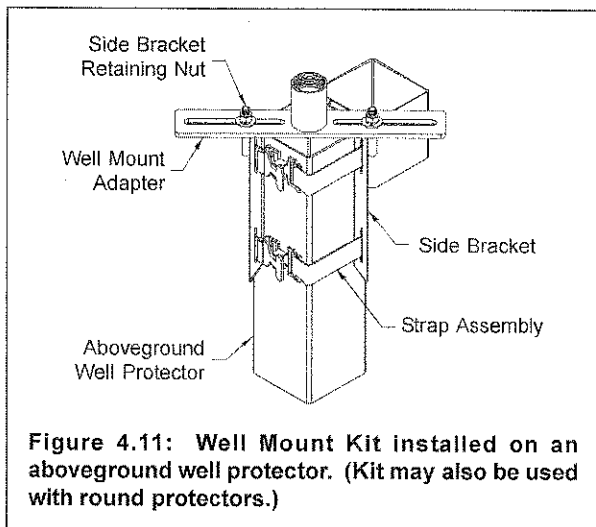


Figure 4.10: Mechanical actuator option for the MB470 Mechanical Bladder Pump (parts shown for attachment to 1.25-inch probe rods).

3. **For monitoring wells only:** Install a Well Mount Kit (MB7200, Figure 3.1) on the well protector. The well mount is strapped onto aboveground well protectors as shown in Figure 4.11 and bolted onto flush-mount well protectors as shown in Figure 4.12. Note that the cross adapter is used for flush-mount protectors that utilize three bolts on the cover (Fig. 4.12) or when the well riser is significantly off center in the protector.
4. Lower the pump and concentric tubing set down the probe rod string or through the well mount into the riser pipe. Stop when the mark on the outer tube (from Step 2) is near the top of the probe rods or well protector.
5. **For probe rods only:** Referring to Table 4.2, select the appropriate Probe Rod Pin to 1.0-inch NPT Pin Adapter (20527, 20528, or 20529) to attach the actuator to the top probe rod. Thread this adapter (and a 12-inch extension if additional height is needed) into the actuator as shown on the completed assembly in Figure 4.10.



6. Insert the top end of the concentric tubing set through the lower end of the mechanical actuator assembly. Feed the tubing set through the actuator and out the compression fitting identified in Figure 4.10.

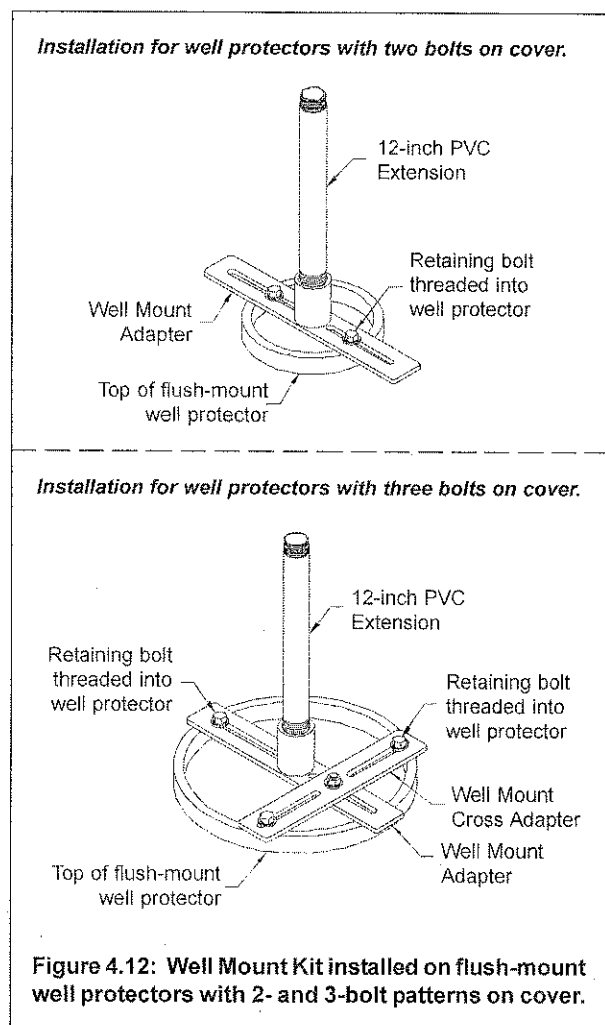
For probe rods only: The mark on the outer tube (Step 2) will not be visible once the actuator is installed on the probe rods. To allow for this, position the tubing within the actuator such that the mark will be at the top of the rods when the actuator is installed. Now mark the outer tube at the compression fitting of the actuator assembly for reference later in the installation procedure.

7. Thread the mechanical actuator onto the top probe rod or well mount until all connections are hand tight.
8. Verify the position of the outer tube by observing the mark placed on the tube in Step 2 or 6. Tighten the compression fitting (hand tight) to secure the tubing. Do not overtighten as this may damage the fitting.
9. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location).
10. Taking care not to kink the inner tube, insert the inner tube up through the compression fitting on the actuator slide block (see Fig. 4.10 for identification of slide block). It may help to raise the slide block during this step.

With the slide block fully lowered, gently pull up on the inner tube to remove slack. Do not pull so far that the pump spring is compressed. Tighten the compression fitting to secure the inner tube. Again, do not overtighten as this may damage the plastic fitting.

11. Cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube. You may choose to insert the end of the inner tube through the top of the compression fitting on the side of the actuator. This will limit movement of the tube outlet while operating the pump

The mechanical bladder pump is ready for operation by rotating the side handle of the mechanical actuator or disconnecting the side handle linkage and manually raising and lowering the T-handle.



4.4 Purging and Sampling

The MB470 Mechanical Bladder pump was designed to provide an economical and efficient method to conduct the low flow sampling protocol (Puls and Barcelona 1996, ASTM 2003), Nielsen and Nielsen 2002). The basis of this protocol is that a sampling flow rate of 500 ml/min or less for 2-inch wells (100 to 200 ml/min for smaller diameter direct push wells) generally provides a sample of higher quality that is more representative than sampling at high flow rates (e.g. several liters or gallons per minute). Higher quality samples for volatile organic compounds are obtained because the water being sampled is subjected to less physical and chemical stress so that loss of these analytes does not occur. Additionally, higher quality samples for inorganic analytes (e.g. lead, hexavalent chromium, etc.) are obtained because the low flow sampling method minimizes turbidity that can cause significant bias for these sensitive analytes.

To obtain the most representative samples, the monitoring well or temporary groundwater sampler should be developed before sampling is conducted. Development may consist of simple surging and purging with an inertial pump for temporary samplers depending on the data quality objectives (Geoprobe® 2002). However, more elaborate methods may be required for some monitoring wells (ASTM 2001).

To meet the full requirements of the low flow sampling protocol, field parameters of the pre-sample purge water (temperature, pH, specific conductance, ORP, DO, and turbidity) should be monitored using an in-line flow cell. Once these parameters have stabilized, the samples are then collected in clean, preserved sample containers appropriate for the analytes of concern. Pre-sample purging may be completed in as little as 10 to 20 minutes in adequately developed small-diameter wells with as little as 5 to 10 liters of water generated. In larger diameter wells that have not been adequately developed, a significantly longer purge time and volume may be required.

4.5 Decontaminating the Pump

Decontamination of the pump may be performed in two general ways. For the highest integrity samples the pump should be fully disassembled for thorough decontamination (decon) and the bladder and O-rings replaced. If the pump is being used as a portable pump for sampling multiple locations daily, the pump may be decontaminated while assembled. Review and understand the sampling and data quality objectives for your project before selecting the appropriate decontamination procedure. (For further information on data quality objectives see EPA 1997, or Geoprobe® 2002). The concentric tubing set should be replaced between each sampling location to minimize the potential for cross contamination. If possible, sample from background or low concentration wells to higher concentration wells to minimize the chance for cross contamination.

Disassemble for Decontamination

Simply reverse the procedures described in Section 4.1 to disassemble the pump and concentric tubing set. Place the disassembled pump in a clean beaker or small bucket of water. Use distilled water for highest level of decon. Add Alconox soap (or similar cleaning agent) to the water. Thoroughly clean and brush all inside and outside surfaces. The MBP Cleaning Brush Kit (MB7300) includes four small-diameter brushes selected specifically to clean inside the various pump components. Double rinse all parts with distilled or deionized (DI) water and allow to air dry. Reassemble the pump using a new bladder and O-rings.

Review ASTM Practice D5088 for further guidance and detail on decon procedures. Additional decontamination may be obtained by drying the disassembled pump in a clean drying oven at about 95°C (203°F). This will provide additional assurance that volatile contaminants are removed from pump surfaces.

Decontamination of Assembled Pump

While this method will not provide the assurance of the highest quality samples it may be preferred when lower sample quality is acceptable (For further information on data quality objectives see EPA 1997, or Geoprobe® 2002). When initial site assessments are conducted it is often desirable to obtain many samples at a reasonably modest cost so as to adequately characterize a site. This decon procedure will help reduce the per sample cost while providing acceptable sample quality for many site assessments.

Remove the concentric tubing set from the pump and discard. Submerge the pump in clean soapy water and pump several volumes of water through the pump. Thoroughly wash the exterior of the pump removing all visible dirt or stains. Rinse and transfer the pump to a container of clean tap water or deionized water. Again pump multiple volumes of water through the pump and wash the pump exterior to remove all soap. A second rinse is recommended. Allow the pump to air dry. Again, drying the fully assembled pump in a clean drying oven at about 95°C (203°F) will further remove any volatiles from pump surfaces.

Rinsate Samples

Regularly collect rinsate samples from the pump following decontamination and submit the samples for analysis for the analytes of concern. This will provide another level of quality control and assurance that samples meet the site-specific data quality objectives. Pump clean distilled water through the pump and collect the fluid in an appropriate preserved container. Store, ship and handle rinsate samples in the same manner as field samples.

5.0 REFERENCES

- American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)
- American Society of Testing and Materials (ASTM), 2001. D-5521 Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers. ASTM, West Conshocken, PA. (www.astm.org)
- American Society of Testing and Materials (ASTM), 1999. D-5088 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites. ASTM, West Conshocken, PA. (www.astm.org)
- U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.
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- Nielsen, David M., and Gillian L. Nielsen, 2002. Technical Guidance on Low-Flow Purging & Sampling and Minimum-Purge Sampling: Second Edition. The Nielsen Environmental Field School, Galena, OH. April.
- Parker, Louise V. and Thomas A. Renney, 1998. Sampling Trace-Level Organic Solutes with Polymeric Tubing, Part 2. Dynamic Studies. Groundwater Monitoring & Remediation (GWMR) Vol. XVIII No. 1, pages 148-155. Winter.
- Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.



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APPENDIX J-G

STANDARD FORMS

PAGE _____ OF _____

DRILLING CONTRACTOR _____
DRILLER _____
SURFACE ELEVATION _____
WEATHER (A.M.) _____
(P.M.) _____

HOLE DESIGNATION _____
DATE/TIME STARTED _____
DATE/TIME COMPLETED _____
DRILLING METHOD _____
CRA SUPERVISOR _____

[illegible]

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.S.)

MAJOR DIVISIONS			GROUP SYMBOL	TYPICAL DESCRIPTION
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS MORE THAN HALF OF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS	GW	WELL GRADED GRAVEL, GRAVEL-SAND MIXTURES, < 5% FINES
			GP	POORLY GRADED GRAVELS AND GRAVEL-SAND MIXTURES, < 5% FINES
		DIRTY GRAVELS	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, > 12% FINES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, > 12% FINES
	SANDS MORE THAN HALF OF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS	SW	WELL GRADED SANDS, GRAVELLY SANDS, < 5% FINES
			SP	POORLY GRADED SANDS, OR GRAVELLY SAND, < 5% FINES
		DIRTY SANDS	SM	SILTY SANDS, SAND-SILT MIXTURES > 12% FINES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES > 12% FINES
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO. 200 SIEVE SIZE)	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLECTIBLE ORGANIC CONTENT		ML	INORGANIC SILTS AND VERY FINE SAND, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY
			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLECTIBLE ORGANIC CONTENT		CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS
			CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	ORGANIC SILTS & ORGANIC CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
			OH	ORGANIC CLAYS OF HIGH PLASTICITY

CONVENTIONAL SOIL DESCRIPTIONS

NON-COHESIVE (GRANULAR) SOIL

RELATIVE DENSITY BLOWS PER FOOT
(N-VALUE)

Very loose less than 5
Loose 5 to 9
Compact 10 to 29
Dense 30 to 50
Very Dense greater than 50

COHESIVE (CLAYEY) SOIL

CONSISTENCY BLOWS PER FOOT
(N-VALUE)

Very Soft 0 to 2
Soft 3 to 4
Firm 5 to 8
Stiff 9 to 15
Very Stiff 16 to 30
Hard greater than 30

GRAIN SIZE CLASSIFICATION

COBBLES Greater than 3 inches (76 mm)
GRAVEL 3 in. to No. 4 (4.76 mm)
 Coarse Gravel 3 in. to 3/4 in.
 Fine Gravel 3/4 in. to No. 4 (4.76 mm)
SAND No. 4 (4.76 mm) to No. 200 (0.074 mm)
 Coarse Sand No. 4 (4.76 mm) to No. 10 (2.0 mm)
 Medium Sand No. 10 (2.0 mm) to No. 40 (0.42 mm)
 Fine Sand No. 40 (0.42 mm) to No. 200 (0.074 mm)
SILT No. 200 (0.074 mm) to 0.002 mm
CLAY Less than 0.002 mm

NOTE: The "No. ____" refers to the standard sieve sizes.

COMPONENT PERCENTAGE DESCRIPTORS

Noun(s) (e.g. SAND and GRAVEL) 35 to 50%
Adjective (e.g. SANDY) 20 to 35%
With 10 to 20%
Trace Less than 10%

SOIL STRUCTURE TERMS

Stratified Blocky
Laminated Lenses/Seams
Fissured Homogeneous

WELL INSTRUMENTATION LOG

PROJECT NAME: _____

HOLE DESIGNATION: _____

PROJECT NO: _____

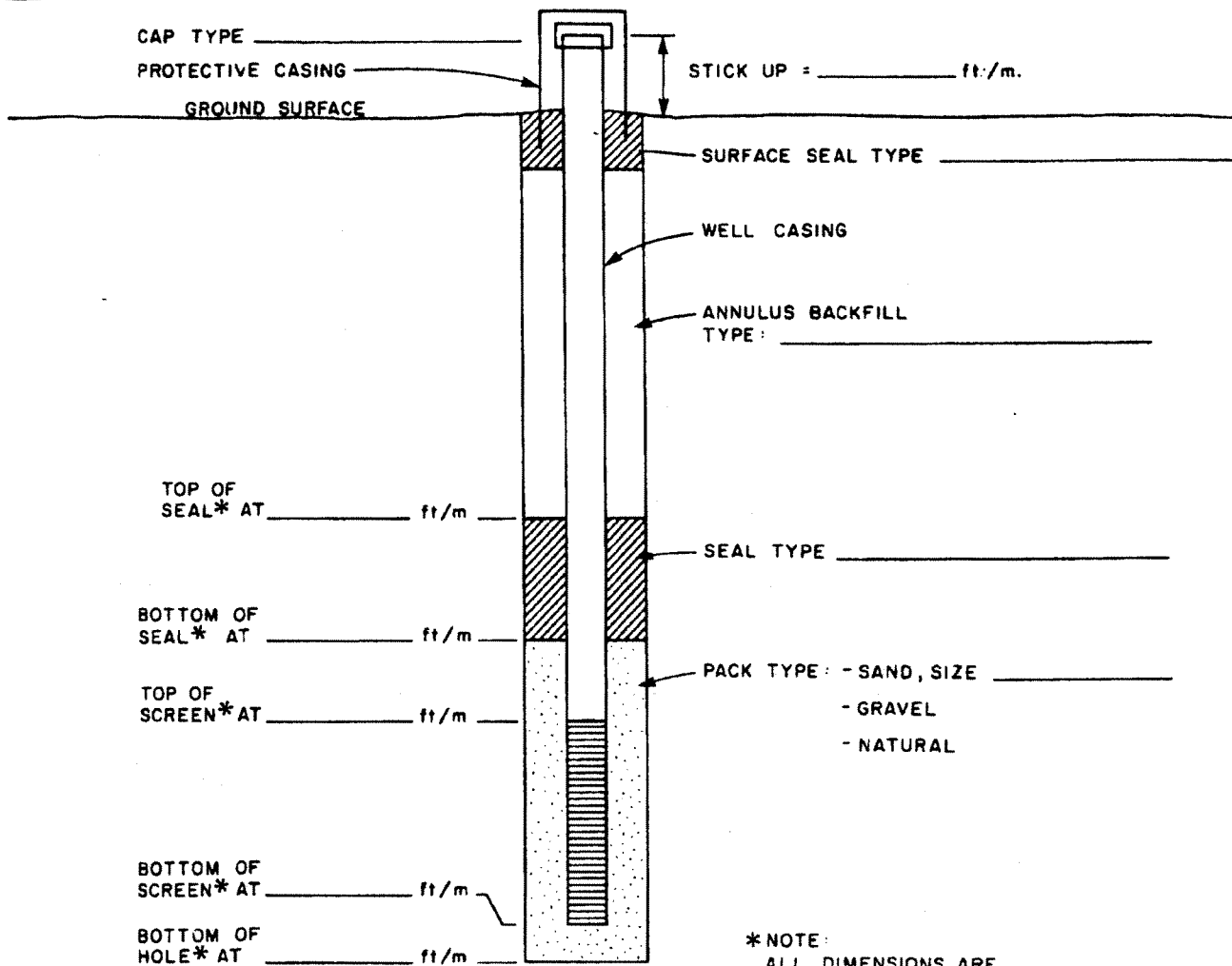
DATE COMPLETED: _____

CLIENT: _____

DRILLING METHOD: _____

LOCATION: _____

CRA SUPERVISOR: _____



*NOTE:
ALL DIMENSIONS ARE
BELOW GROUND SURFACE (BGS)

SCREEN TYPE: ☐ continuous slot ☐ perforated ☐ louvre ☐ other: _____

SCREEN MATERIAL: ☐ stainless steel ☐ plastic ☐ other: _____

SCREEN LENGTH: _____ ft/m SCREEN DIAMETER: _____ in/cm SCREEN SLOT SIZE: _____

WELL CASING MATERIAL: _____ WELL CASING DIAMETER: _____ in/cm

HOLE DIAMETER: _____

DEVELOPMENT: METHOD: _____ DURATION: _____

2/05/85

CRA

WELL DEVELOPMENT AND STABILIZATION FORM

PROJECT NAME _____ PROJECT NO. _____
DATE OF WELL DEVELOPMENT _____
DEVELOPMENT CREW MEMBERS _____
SUPERVISOR _____
PURGING METHOD _____

WELL INFORMATION

WELL NUMBER _____
WELL TYPE (diameter/material) _____
MEASURING POINT ELEVATION _____
STATIC WATER DEPTH _____ ELEVATION _____
BOTTOM DEPTH _____ ELEVATION _____
WATER COLUMN LENGTH _____
SCREENED INTERVAL _____
WELL VOLUME _____

Note: For 2" diameter well, 1 foot = 0.14 gallons (imp) or 0.16 gallons (us).
1 meter = 2 liters.

DEVELOPMENT DATA

					TOT/AVG
VOLUME PURGED (# bails/tot. Volume)					
FIELD pH					
FIELD TEMPERATURE					
FIELD CONDUCTIVITY					
CLARITY					
COLOR					
ODOR					
COMMENTS					

COPIES TO: _____

Project Data:

Date: _____
Personnel: _____

Well No.: _____

Screen Length (ft): _____
 Depth to Pump Intake (ft): _____
 Well Diameter, D (in): _____
 Well Screen Volume, V_s (mL): _____
 Initial Depth to Water (ft): _____

Stabilization Criteria:	±0.1	±3%	±0.005 (<1) ±0.01(>1)	±10	±10%	±10% or (<5)
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APPENDIX J-H

ASTM METHODS

APPENDIX J-H-1

ASTM D1586-08, STANDARD TEST METHOD FOR PENETRATION TEST
AND SPLIT-BARREL SAMPLING OF SOILS



Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils¹

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in

parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,² NDA Drilling Safety Guide,³ drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 ASTM Standards:⁴

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

² Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, <http://www.osha.gov>.

³ Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, <http://www.nda4u.com>.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

¹ This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

(Visual-Manual Procedure)

- D 3550** Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D 3740** Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D 4220** Practices for Preserving and Transporting Soil Samples
- D 4633** Test Method for Energy Measurement for Dynamic Penetrometers
- D 5434** Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5783** Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D 6026** Practice for Using Significant Digits in Geotechnical Data
- D 6066** Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
- D 6151** Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D 6169** Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D 6286** Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6913** Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology **D 653** specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m \pm 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices **D 2487** and **D 2488**) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods **D 854**, **D 2216**, and **D 6913**. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice **D 1587**) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice **D 6151**, and Guide **D 6169**.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice **D 6066** provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method **D 4633**.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

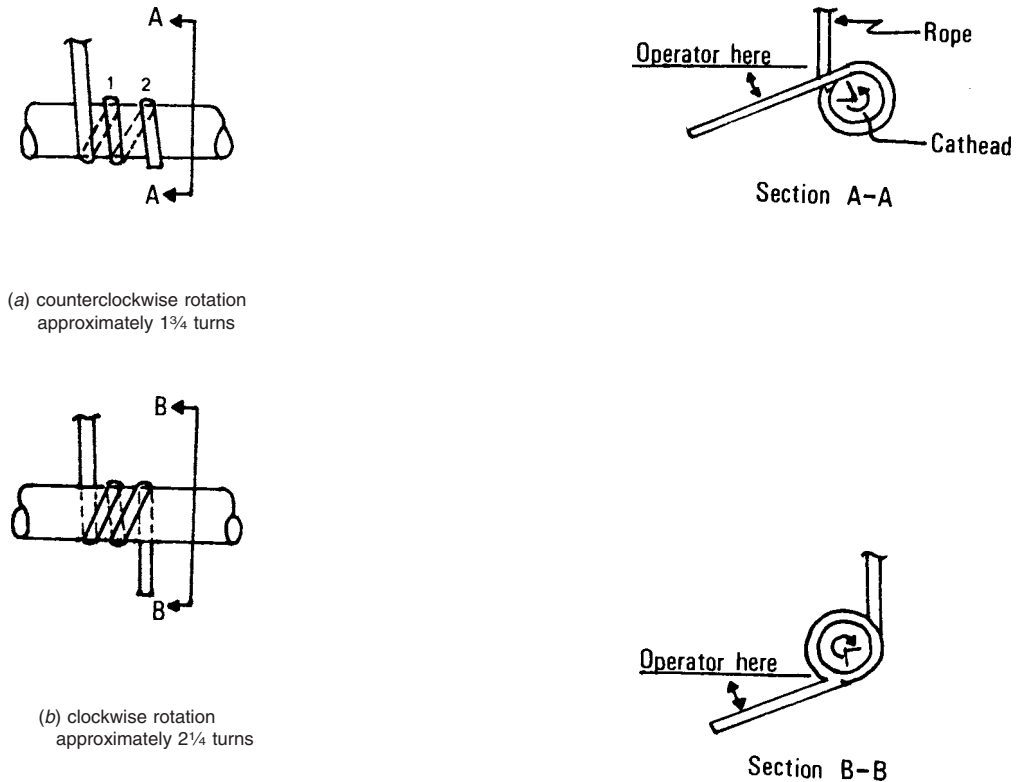


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

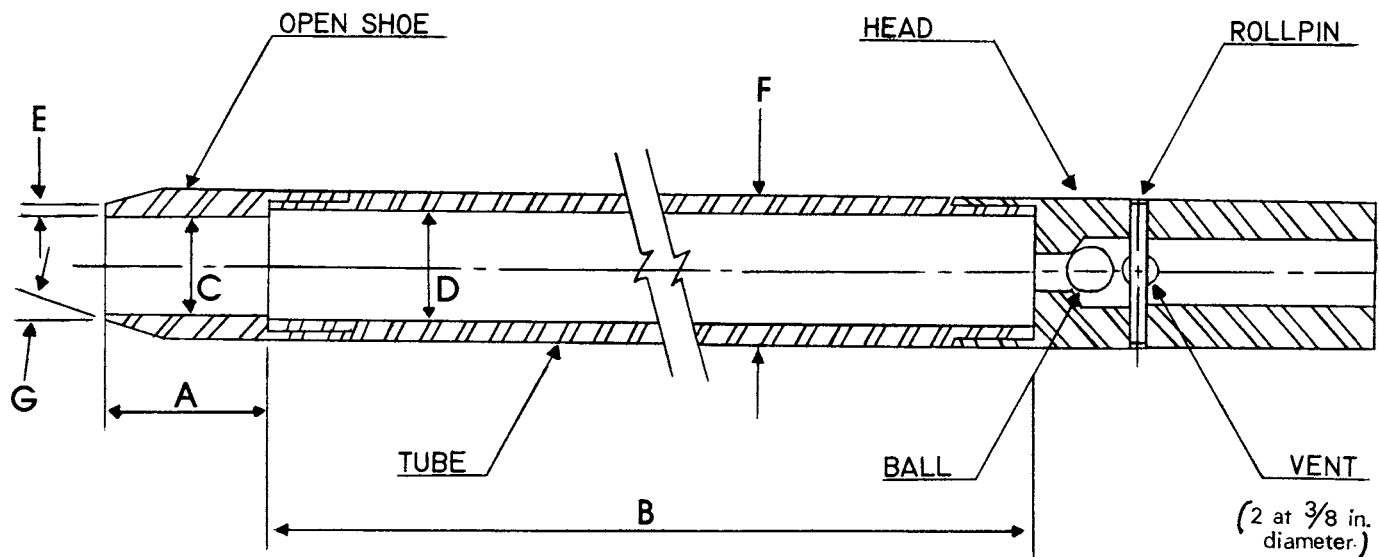
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall “A” rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm)).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



- A = 1.0 to 2.0 in. (25 to 50 mm)
 B = 18.0 to 30.0 in. (0.457 to 0.762 m)
 C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
 D = $1.50 \pm 0.05 - 0.00$ in. ($38.1 \pm 1.3 - 0.0$ mm)
 E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
 F = $2.00 \pm 0.05 - 0.00$ in. ($50.8 \pm 1.3 - 0.0$ mm)
 G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or $1\frac{3}{8}$ -in. (34.9 mm) (see **Note 2**). A 16-gauge liner can be used inside the $1\frac{1}{2}$ -in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice **D 6066**. In North America, it is now common practice to use an upset wall sampler with an inside diameter of $1\frac{1}{2}$ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 Drive-Weight Assembly:

5.4.1 Hammer and Anvil—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. **Fig. 3** shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in **Fig. 3**. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbf (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 Hammer Drop System—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in **Fig. 4** may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 Accessory Equipment—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

- 6.2.1 Open-hole rotary drilling method.
- 6.2.2 Continuous flight hollow-stem auger method.
- 6.2.3 Wash boring method.
- 6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

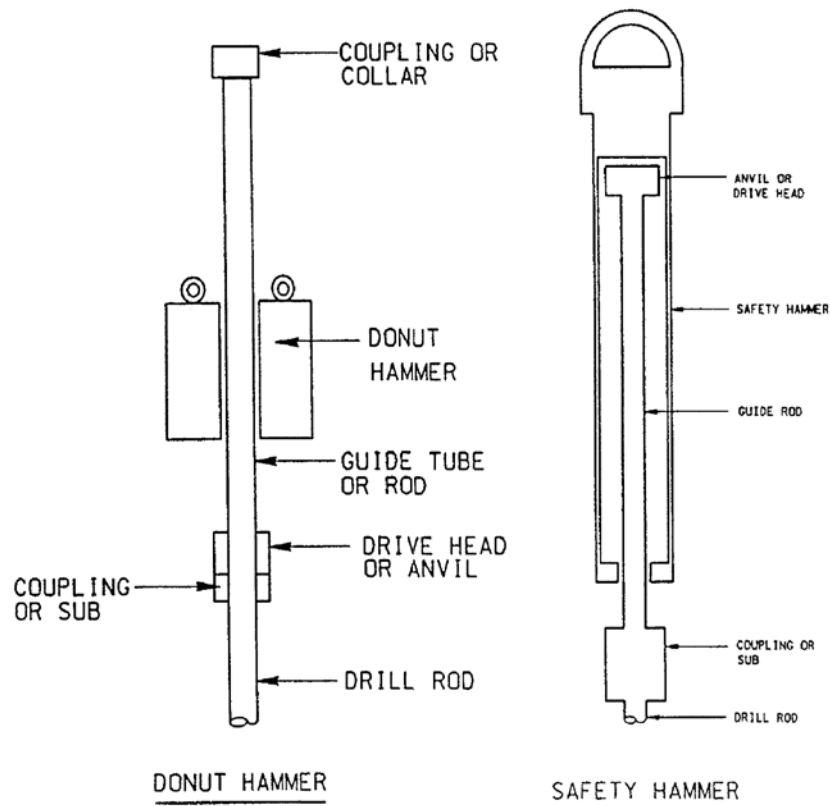


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare

the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

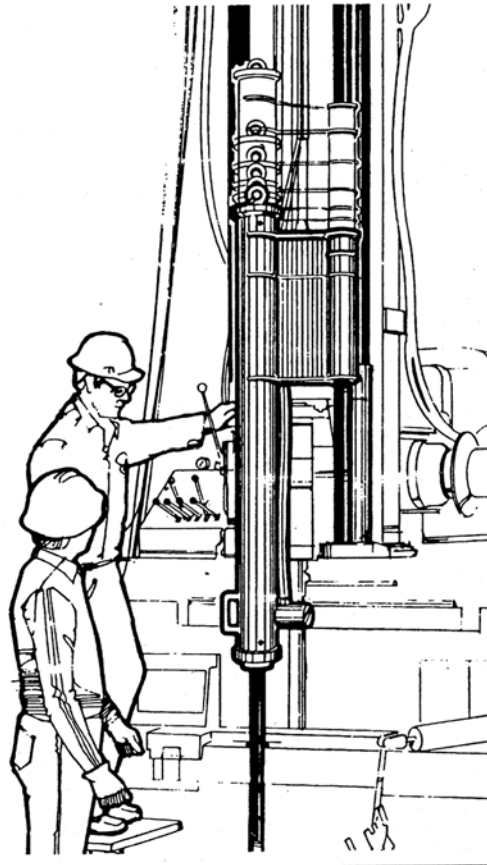


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the “standard penetration resistance,” or the “ N -value.” If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. ($0.76 \text{ m} \pm 0.030 \text{ m}$), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N -value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice **D 6066** provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, *N*₆₀). Practice **D 6066** allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice **D 2488**, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice **D 4220** using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide **D 5434** as required by the exploration program. An example of a sample data sheet is included in **Appendix X1**.

8.2 Drilling information shall be recorded in the field and shall include the following:

- 8.2.1 Name and location of job,
- 8.2.2 Names of crew,
- 8.2.3 Type and make of drilling machine,
- 8.2.4 Weather conditions,
- 8.2.5 Date and time of start and finish of borehole,
- 8.2.6 Boring number and location (station and coordinates, if available and applicable),
- 8.2.7 Surface elevation, if available,
- 8.2.8 Method of advancing and cleaning the borehole,
- 8.2.9 Method of keeping borehole open,
- 8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,
- 8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),
- 8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,
8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See **Fig. 5**.

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

- | | |
|--|--|
| <p>(1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.</p> <p>(2) Scope was completely revised.</p> <p>(3) Referenced Documents updated to include new standards.</p> | <p>(4) Terminology: added section on Definitions.</p> <p>(5) Significance and Use: clarified use of the SPT test.</p> <p>(6) Apparatus: general editorial changes.</p> <p>(7) Sampling and Testing Procedure: general editorial changes.</p> <p>(8) Data Sheets/Forms: general editorial changes.</p> <p>(9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.</p> |
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APPENDIX J-H-2

ASTM D2488-06, STANDARD PRACTICE FOR DESCRIPTION
AND IDENTIFICATION OF SOILS (VISUAL-MANUAL PROCEDURE)



Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)¹

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.*

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may*

be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:*²

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

¹ This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Nov. 1, 2006. Published November 2006. Originally approved in 1966. Last previous edition approved in 2000 as D 2488 – 00.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

3.1.1 *clay*—soil passing a No. 200 (75- μ m) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the “A” line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a $\frac{3}{4}$ -in. (19-mm) sieve.

fine—passes a $\frac{3}{4}$ -in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75- μ m) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425- μ m) sieve.

fine—passes a No. 40 (425- μ m) sieve and is retained on a No. 200 (75- μ m) sieve.

3.1.7 *silt*—soil passing a No. 200 (75- μ m) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the “A” line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

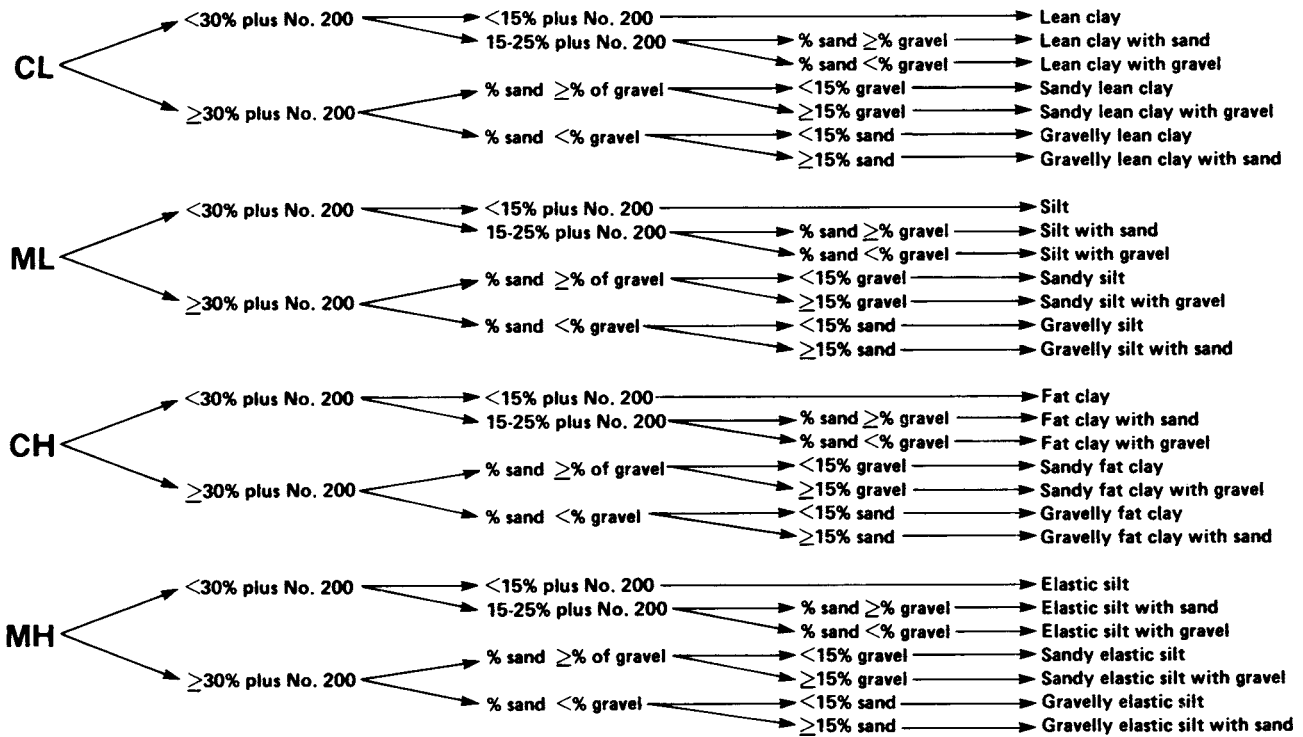
6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

GROUP SYMBOL

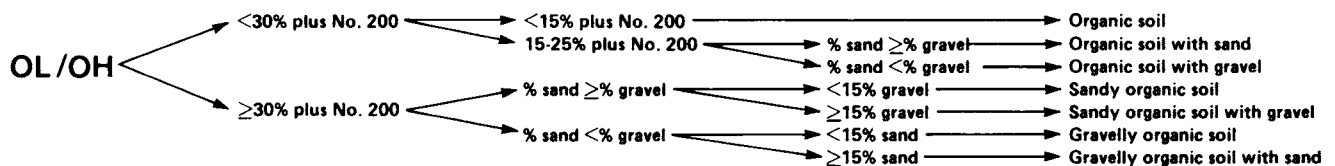
GROUP NAME



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.
FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

GROUP SYMBOL

GROUP NAME



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

6.2.1 Small Test Tube and Stopper (or jar with a lid).

6.2.2 Small Hand Lens.

7. Reagents

7.1 Purity of Water—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 Hydrochloric Acid—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 N) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

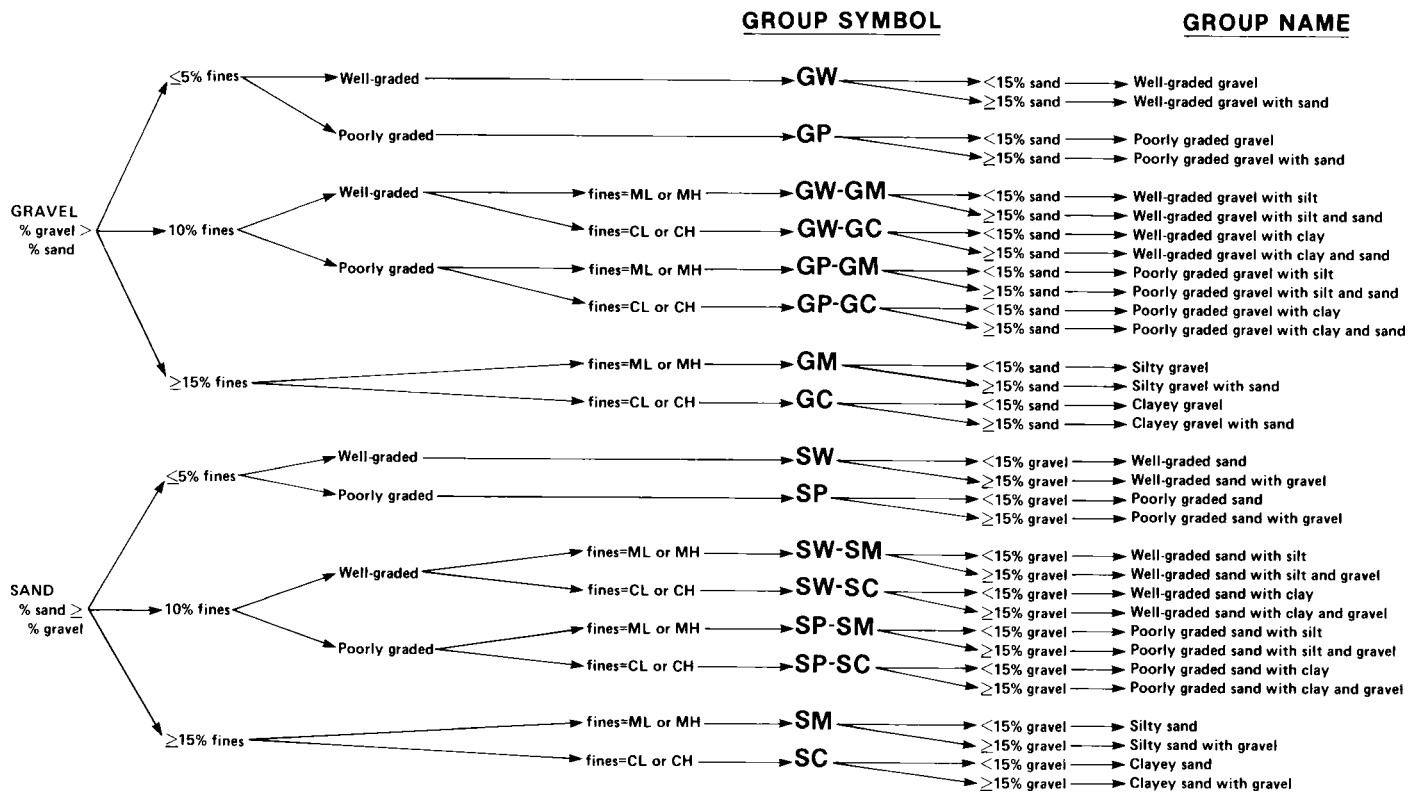
9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (¾ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the criteria in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

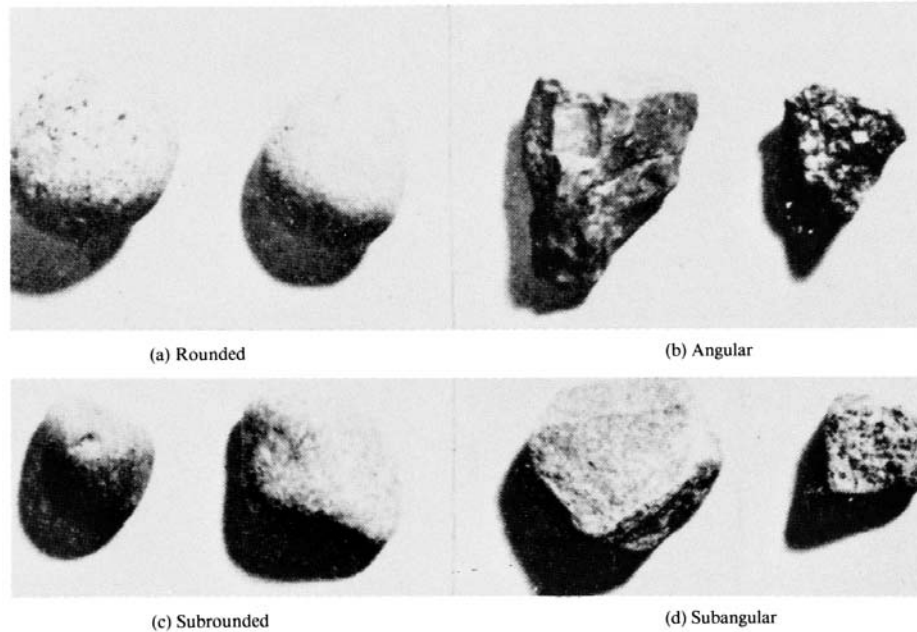


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

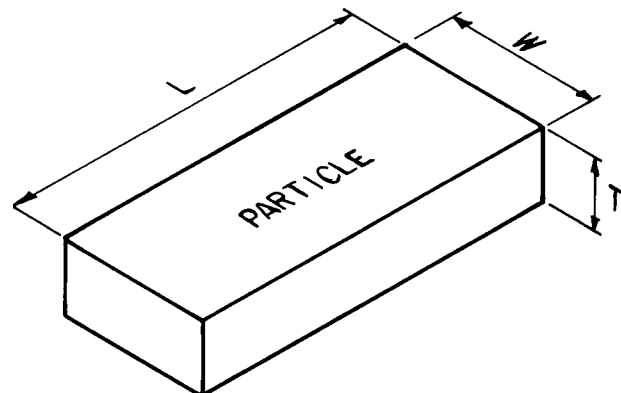
10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

PARTICLE SHAPE

W = WIDTH
T = THICKNESS
L = LENGTH



FLAT: $W/T > 3$
ELONGATED: $L/W > 3$
FLAT AND ELONGATED:
—meets both criteria

FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. “Hard” means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 Identification of Inorganic Fine-Grained Soils:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words “with sand” or “with gravel” (whichever is more predominant) shall be added to the group name. For example: “lean clay with sand, CL” or “silt with gravel, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use “with sand.”

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words “sandy” or “gravelly” shall be added to the group name. Add the word “sandy” if there appears to be more sand than gravel. Add the word “gravelly” if there appears to be more gravel than sand. For example: “sandy lean clay, CL”, “gravelly fat clay, CH”, or “sandy silt, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use “sandy.”

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one

size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM” (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words “with cobbles” or “with cobbles and boulders” shall be added to the group name. For example: “silty gravel with cobbles, GM.”

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—Example: *Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

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

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
Gravel—fine, coarse
Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong
For intact samples:
18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft³; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as “Sandy Lean Clay (CL)”; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; “Poorly Graded Sand with Silt (SP-SM)”; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; “Poorly Graded Gravel with Silt and Sand (GP-GM).”

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; “Poorly Graded Gravel (GP)”; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 Jar Method—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 Visual Method—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present.

The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 Wash Test (for relative percentages of sand and fines)—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:

s = sandy
g = gravelly

Suffix:

s = with sand
g = with gravel
c = with cobbles
b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name

Abbreviated

CL, Sandy lean clay
SP-SM, Poorly graded sand with silt and gravel
GP, poorly graded gravel with sand, cobbles, and boulders
ML, gravelly silt with sand and cobbles

s(CL)
(SP-SM)g
(GP)scb
g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (2000) that may impact the use of this standard.

(1) Revised footnote numbering in Reference Section.

(2) Revised classification example in X2.4.2 and X2.4.3.

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APPENDIX J-H-3

ASTM D6051-96(2001), STANDARD GUIDE FOR COMPOSITE SAMPLING
AND FIELD SUBSAMPLING FOR ENVIRONMENTAL
WASTE MANAGEMENT ACTIVITIES



Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities¹

This standard is issued under the fixed designation D 6051; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 Compositing and subsampling are key links in the chain of sampling and analytical events that must be performed in compliance with project objectives and instructions to ensure that the resulting data are representative. This guide discusses the advantages and appropriate use of composite sampling, field procedures and techniques to mix the composite sample and procedures to collect an unbiased and precise subsample(s) from a larger sample. It discusses the advantages and limitations of using composite samples in designing sampling plans for characterization of wastes (mainly solid) and potentially contaminated media. This guide assumes that an appropriate sampling device is selected to collect an unbiased sample.

1.2 The guide does not address: where samples should be collected (depends on the objectives) (see Guide D 6044), selection of sampling equipment, bias introduced by selection of inappropriate sampling equipment, sample collection procedures or collection of a representative specimen from a sample, or statistical interpretation of resultant data and devices designed to dynamically sample process waste streams. It also does not provide sufficient information to statistically design an optimized sampling plan, or determine the number of samples to collect or calculate the optimum number of samples to composite to achieve specified data quality objectives (see Practice D 5792). Standard procedures for planning waste sampling activities are addressed in Guide D 4687.

1.3 The sample mixing and subsampling procedures described in this guide are considered inappropriate for samples to be analyzed for volatile organic compounds. Volatile organics are typically lost through volatilization during sample collection, handling, shipping and laboratory sample preparation unless specialized procedures are used. The enhanced mixing described in this guide is expected to cause significant losses of volatile constituents. Specialized procedures should be used for compositing samples for determination of volatiles such as combining directly into methanol (see Practice D 4547).

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- C 702 Practice for Reducing Samples of Aggregate to Testing Size
- D 1129 Terminology Relating to Water
- D 4439 Terminology for Geosynthetics
- D 4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds
- D 4687 Guide for General Planning of Waste Sampling
- D 5088 Practices for Decontamination of Field Equipment Used at Waste Sites
- D 5792 Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives
- D 6044 Guide for Representative Sampling for Management of Waste and Contaminated Media
- E 856 Definitions of Terms and Abbreviations Relating to Physical and Chemical Characteristics of Refuse Derived Fuel

3. Terminology

3.1 Definitions:

- 3.1.1 *composite sample, n*—a combination of two or more samples. **D 1129**
- 3.1.2 *sample, n*—a portion of material taken from a larger quantity for the purpose of estimating properties or composition of the larger quantity. **E 856**
- 3.1.3 *specimen, n*—a specific portion of a material or laboratory sample upon which a test is performed or which is taken for that purpose. **D 4439**
- 3.1.4 *subsample, n*—a portion of a sample taken for the purpose of estimating properties or composition of the whole sample.

¹ This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.4.1 *Discussion*—a subsample, by definition, is also a sample.

4. Summary of Guide

4.1 This guide describes how the collection of composite samples, as opposed to individual samples, may be used to: more precisely estimate the mean concentration of a waste analyte in contaminated media, reduce costs, efficiently determine the absence or possible presence of a hot spot (a highly contaminated local area), and, when coupled with retesting schemes, efficiently locate hot spots. Specific procedures for mixing a sample(s) and collecting subsamples for transport to a laboratory are provided.

5. Significance and Use

5.1 This guide provides guidance to persons managing or responsible for designing sampling and analytical plans for determining whether sample compositing may assist in more efficiently meeting study objectives. Samples must be composited properly, or useful information on contamination distribution and sample variance may be lost.

5.2 The procedures described for mixing samples and obtaining a representative subsample are broadly applicable to waste sampling where it is desired to transport a reduced amount of material to the laboratory. The mixing and subsampling sections provide guidance to persons preparing sampling and analytical plans and field personnel.

5.3 While this guide generally focuses on solid materials, the attributes and limitations of composite sampling apply equally to static liquid samples.

6. Attributes of Composite Sampling for Waste Characterization

6.1 In general, the individual samples to be composited should be of the same mass, however, proportional sampling may be appropriate in some cases depending upon the objective. For example, if the objective is to determine the average drum concentration of a contaminant, compositing equals volumes of waste from each drum would be appropriate. If the objective is to determine average contaminant concentration of the waste contained in a group of drums, the volume of each sample to be composited should be proportional to the amount of waste in each drum. Another example of proportional sampling is estimating the contaminant concentration of soil overlying an impermeable zone. Soil cores should be collected from the surface to the impermeable layer, regardless of core length.

6.2 The principal advantages of sample compositing include: reduction in the variance of an estimated average concentration **(1)**,³ increasing the efficiency of locating/identifying hot spots **(2)**, and reduction of sampling and analytical costs **(3)**. These main advantages are discussed in the following paragraphs. However, a principle assumption needed to justify compositing is that analytical costs are high relative to sampling costs. In general, appropriate use of sample compositing can:

6.2.1 Reduce inter-sample variance, that is, improve the precision of the mean estimation while reducing the probability of making an incorrect decision,

6.2.2 Reduce costs for estimating a total or mean value, especially where analytical costs greatly exceed sampling costs (also may be effective when analytical capacity is a limitation),

6.2.3 Efficiently determine the absence or possible presence of hot spots or hot containers and, when combined with retesting schemes, identify hot spots, as long as the probability of hitting a hot spot is low,

6.2.4 Be especially useful for situations, where the nature of contaminant distribution tends to be contiguous and non-random and the majority of analyses are “non-detects” for the contaminant(s) of interest, and

6.2.5 Provide a degree of anonymity where population, rather than individual statistics are needed.

6.3 *Improvement in Sampling Precision*—Samples are always taken to make inferences to a larger volume of material, and a set of composite samples from a heterogeneous population provides a more precise estimate of the mean than a comparable number of discrete samples. This occurs because compositing is a “physical process of averaging.” Averages of samples have greater precision than the individual samples. Likewise, a set of composite samples is always more precise than an equal number of individual samples. Decisions based on a set of composite samples will, for practical purposes, always provide greater statistical confidence than for a comparable set of individual samples.

6.3.1 If an estimated precision of a mean is desired, then more than one composite sample is needed; a standard deviation cannot be calculated from one composite sample. However, the precision of a single composite sample may be estimated when there are data to show the relationship between the precision of the individual samples that comprise the composite sample and that of the composite sample. The precision (standard deviation) of the composite sample is approximately the precision of the individual samples divided by the square root of the number of individual samples in the composite.

6.4 *Example 1*—An example of how a single composite sample can be used for decision-making purposes is given here. Assume a regulatory limit of 1 mg/kg and a standard deviation of 0.5 mg/kg for the individual samples. If the concentration of a site is estimated to be around 0.6 mg/kg, how many individual samples should be composited to have relatively high confidence that the true concentration does not exceed the regulatory limit when only one composite sample is used? Assuming the composite is well mixed, then the precision of a composite is a function of the number of samples as follows:

Number of Individual Samples in Composite	Precision (standard deviation $\div \sqrt{n}$) of One Composite Sample
2	0.35
3	0.29
4	0.25
5	0.22
6	0.20

Thus, if six samples are included in a composite, the composite concentration of 0.6 mg/kg is two standard deviations below the regulatory limit. Therefore, if the composite

³ The boldface numbers in parentheses refer to a list of references at the end of this guide.

concentration is actually observed to be in the neighborhood of 0.6 mg/kg, we can be reasonably confident (approximately 95 %) that the concentration of the site is below the regulatory limit, using only one composite sample.

6.5 *Example 2*—Another example is when the standard deviation of the individual samples in the previous example is relatively small, say 0.1 mg/kg. Then the standard deviation of a composite of 6 individual samples is 0.04 mg/kg (0.1 mg/kg divided by the square root of 6 = 0.04 mg/kg), a very small number relative to the regulatory limit of 1 mg/kg. In this case, simple comparison of the composite concentration to the regulatory limit is often quite adequate for decision-making purposes.

6.5.1 The effectiveness of compositing depends on the relative magnitude of sampling and analytical error. When sampling uncertainty is high relative to analytical error (as is usually assumed to be the case) compositing is very effective in improving precision. If analytical errors are high relative to field errors, sample compositing is much less effective.

6.5.2 Because compositing is a physical averaging process, composite samples tend to be more normally distributed than the individual samples. The normalizing effect is frequently an advantage since calculation of means, standard deviations and confidence intervals generally assume the data are normally distributed. Although environmental residue data are commonly non-normally distributed, compositing often leads to approximate normality and avoids the need to transform the data.

6.5.3 The spatial design of the compositing scheme can be important. Depending upon the locations from which the individual samples are collected and composited, composites can be used to determine spatial variability or improve the precision of the parameter being estimated. Fig. 1 and Fig. 2 represent a site divided into four cells. Composite all samples with the same number together. The sampling approach in Fig. 1 is similar to sample random sampling, except they are now composite samples. Each composite sample in this case is a representative sample of the entire site, eliminates cell-to-cell variability, and leads to increased precision in estimating the mean concentration of the site. If there is a need to estimate the cell-to-cell variability, then the approach in Fig. 2 is suitable. In addition, if the precision of estimating the mean concentration of the cell is needed, multiple composite samples should be collected from that cell.

6.6 *Effect on Cost Reduction*—Because the composite samples yield a more precise mean estimate than the same number of individual samples, there is the potential for substantial cost saving. Given the higher precision associated

1	1	2	2
1	1	2	2
3	3	4	4
3	3	4	4

FIG. 2 Example of Within Cell Compositing

with composite samples, the number of composite samples required to achieve a specified precision is smaller than that required for individual samples. This cost saving opportunity is especially pronounced when the cost of sample analysis is high relative to the cost of sampling, compositing, and analyzing.

6.7 *Hot Container/Hot Spot Identification and Retesting Schemes*—Samples can be combined to determine whether an individual sample exceeds a specified limit as long as the action limit is relatively high compared with the actual detection limit and the average sample concentration. Depending on the difficulty and probability of having to resample, it may be desirable to retain a split of the discrete samples for possible analysis depending on the analytical results from the composite sample.

6.8 *Example 3*—One hundred drums are to be examined to determine whether the concentration of PCBs exceeds 50 mg/kg. Assume the detection limit is 5 mg/kg and most drums have non-detectable levels. Compositing samples from ten drums for analysis would permit determining that none of the drums in the composite exceed 50 mg/kg as long as the concentration of the composite is <5 mg/kg. If the detected concentration is >5 mg/kg, one or more drums may exceed 50 mg/kg and additional analyses of the individual drums are required to identify any hot drum(s). The maximum number of samples that can theoretically be composited and still detect a hot sample is the limit of concern divided by the actual detection limit (for example, 50 mg/kg ÷ 5 mg/kg = 10).

6.9 *Example 4*—Assume background levels of dioxin are non detectable, and the analytical detection limit is 1 µg/kg and the action level is 50 µg/kg. The site is systematically gridded (the most efficient sampling design for detecting randomly distributed hot spots) using an appropriate design, and cores to a depth of 10 cm are collected. Composite samples are collected since analytical costs for dioxin are high. In theory, groups of up to 50 samples could be composited and if the resultant concentration were <1 µg/kg, all samples represented in the composite should be below 50 µg/kg. If the contaminant concentration is >1 µg/kg, one or more spots may exist that exceed 50 µg/kg in the area covered by the composite sample although the precise location and areal extent would not be known without further sampling and analyses. Compositing fewer samples would probably be more practical, however.

6.9.1 The relative efficiency of compositing individual samples to detect a hot spot depends on the probability of a “hot” discrete sample being used to form a composite sample. According to Garner et al. (1), if the probability can be estimated as low, say 1 %, the optimum number of samples to composite is about ten, which would result in a cost saving of

1	2	4	3
4	3	2	1
4	2	1	4
3	1	2	3

FIG. 1 Example of Compositing Across a Site

about 80 % (assuming there is no detection limit problem). When the probability of collecting a sample from a hot spot rises to 10 %, the optimal number of samples to composite is 4, which results in a 40 % cost savings. By the time the probability of sampling a hot spot rises to 40 %, there is no cost benefit to compositing. Other resampling and testing schemes are possible and may lead to somewhat different cost saving potentials.

7. Limitations of Composite Sampling

7.1 The principal limitations of sample compositing involve the loss of the discrete information contained in a single sample and the potential for dilution of the contaminants in a sample with uncontaminated material; however, in that case, the dilution factor can be used to estimate the maximum number of samples that can be composited. The following situations may not lend themselves to cost-effective sample compositing:

7.1.1 When the integrity of individual sample values change because of compositing, for example, chemical interaction occurs between constituents in the samples being combined or volatiles are lost during mixing,

7.1.2 Where the composite sample cannot be properly mixed and subsampled or the whole composite sample cannot be analyzed,

7.1.3 When the goal is to detect hotspots and a large proportion of the samples are expected to test positive for an attribute, compositing and retesting schemes may not be cost effective,

7.1.4 When analytical costs are low relative to sampling costs (for example, in situ field portable X-ray fluorescence takes only 30 s with no sample preparation so analytical costs/sample are very low), and

7.1.5 When regulations specify that a grab sample must be collected (usually a composite sample covering a limited area is still preferred from a technical standpoint).

8. Sample Mixing Procedures

8.1 Prior to sample mixing, project-specific instructions should be followed regarding sample collection, which may include removal of extraneous sample materials such as twigs, grass, rocks, etc. If samples are sieved or large materials are removed, it may be necessary to record the mass of materials removed for later estimation of contaminant concentration in the original sample. According to particulate sampling theory (4,5) the following sample masses are adequate to represent the corresponding maximum size particles in the sample with a relative standard deviation of 15 %.

Sample Mass, g	Maximum Particle Size, cm
5	0.170
50	0.37
100	0.46
500	0.79
1000	1.0
5000	1.7

8.1.1 Frequently it is necessary to mix an individual or composite sample and obtain a representative subsample(s) for transport to the analytical laboratory. This occurs when multiple containers of the identical material are desired (for example, separate sample jars for metals, semivolatile organics, etc. are desired) or when the original sample (or composite

sample) size is greater than accepted by the laboratory. Even when the original sample volume is acceptable, it may be desirable to thoroughly mix the sample prior to transport to an analytical laboratory. However, some samples that have been well mixed in the field may segregate during shipment to the laboratory.

8.1.2 A laboratory typically collects a 0.5 to 30 g specimen (100 g for some extraction tests) from the sample for analysis. Specimens are frequently collected from the surface material in the container or after minimal mixing. Such procedures are inadequate to obtain a small representative specimen from a 100 to 300 g sample. Special mixing and subsampling procedures are necessary to obtain a representative subsample unless the sample is already homogenous. Field mixing should be considered essential unless it is known that the sample in the container is homogeneous or it is known that the laboratory will homogenize the sample and collect a representative specimen. To help ensure that an unbiased and precise specimen is collected, the analytical laboratory should be provided instructions (preferably with the sample shipment) on homogenizing and obtaining a specimen for analysis. Few laboratories follow good sample homogenizing and specimen collection practices. To meet both sampling and analytical objectives, field and analytical personnel, and the end-user of the data must be aware of the laboratories standard practices for handling, mixing, and obtaining a specimen or specify such practices with the sample shipment.

8.1.3 To avoid subsampling it may be possible to collect a small sample (or composite samples) directly into the sample container that is delivered to the laboratory (**Caution:** small sample sizes may result in bias by excluding large particles). While no field mixing and subsampling is needed as long as the laboratory homogenizes the sample, it may be advisable to mix such samples anyway (see 8.1.2).

8.1.4 Soil, sediment, sludge and waste samples collected for purgeable/volatile organic compounds' analyses should *not* be mixed and subsampled using procedures described in this guide but other specialized procedures such as combining samples directly into methanol (see Practice D 4547) may be appropriate.

8.1.5 A significant problem with analyzing very small samples is that the smaller the volume of sample actually extracted or analyzed, the less representative that sample may be unless thoroughly mixed/homogenized and subsampled. Therefore, sample compositing without thorough mixing can nullify the potential benefits of compositing.

8.1.6 Methods that may be applicable to field mixing, depending on the matrix, include hand mixing in a pan, sieving, particle size reduction, kneading, etc. For highly heterogeneous waste such as municipal refuse, field comminution (grinding) may be needed. Some of these methods may be inappropriate if trace levels of contamination are a primary concern. The use of disposable equipment for mixing should be considered to minimize field decontamination problems. Field personnel should use care to ensure that samples do not become contaminated during the sampling, mixing and subsampling process.

8.1.7 Once a sample has been collected, it may have to be split into separate containers for different analyses. A true split of soil, sediment, or sludge samples may be difficult to accomplish under field conditions.

8.1.8 The following are some common methods for mixing soils, sludges, etc. While it is not always possible to determine that a sample is adequately mixed, following standard procedures and observing sample texture, color, and particle distribution are practical methods. While some materials cannot be homogenized, following the subsampling procedures in Section 9 will help ensure that a representative subsample is collected. Under certain conditions, some of the procedures that follow are applicable when trace level contaminants are of concern.

8.1.8.1 *Pan Mixing/Quartering*—One common method of mixing is referred to as quartering. Place the material in a glass or stainless steel sample pan and divide into quarters. Mix each quarter separately, then mix all quarters into the center of the pan. Repeat this procedure several times until the sample is adequately mixed (usually a minimum of three repetitions). If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over.

8.1.8.2 *Mixing Square*—Combine samples through a non-contaminating screen into an appropriate clean mixing container. Mix in the container and pour onto a 1 metre square of non-contaminating material such as plastic for metals analyses or polytetrafluoroethylene for organics. Roll the sample backward and forward on the sheet while alternately lifting and releasing opposite side corners of the sheet. This is appropriate for flowable granular materials (6). If polytetrafluoroethylene sheeting is used, this procedure could be acceptable for trace level contaminants.

8.1.8.3 *Kneading*—Place the sample in a non-contaminating bag and knead as in bread making to mix the sample. This may be appropriate for viscous or clay-like materials. If a non-contaminating bag is used, this approach would be acceptable for trace level contaminants.

8.1.8.4 *Sieving and Mixing*—If a laboratory requires a small specimen (1 to 30 g) or if less than a specific particle size is required, disruption of aggregated particles or sieving, or both, followed by mixing may be needed. Sieving allows only those particles below a desired size to pass through the sieve into a mixing pan for subsequent mixing and subsampling into containers. Sieving works best with relatively dry granular materials. Sieving and the exclusion of large particles can result in very biased results and should only be conducted when designed into a sampling plan.

8.1.8.5 *Particle Size Reduction*—When particle size reduction is appropriate and trace contaminants are of concern, non-contaminating materials compatible with objectives should be used (for example, glass, ceramic, stainless steel). Other materials may be acceptable if trace levels of contaminants are not a concern. The reduction method can be as simple as using a hammer to break apart large pieces into smaller pieces that are either acceptable to the laboratory or that can pass through a sieve. This method of reduction creates a great deal of fine material which may or may not be included in the

sample container, and could introduce bias. More complex reducers, such as ball mills, ceramic plate grinders, etc., are available, but usually require relatively dry samples and thorough decontamination to avoid cross contamination. Such a process may be more appropriately conducted in a laboratory.

8.1.9 With thorough decontamination (see Practice D 5088) of the particle size reducer, sieve and the mixing pan, these procedures could be acceptable for trace level contaminants.

8.1.10 *Other Mixing Equipment*—Riffle splitters, coning and quartering, etc., involve equipment and materials that are difficult to decontaminate, and awkward to use on a routine basis for waste management sampling. Since these procedures are not routinely used, the devices are not considered in this guide. However, procedures for coning and quartering, and the use of riffle splitters are described in Practice C 702 and could be modified for subsampling contaminated media.

9. Field Subsampling Procedures

9.1 If mixing procedures could ensure a truly homogenous sample, subsampling would be simple. Mixing of various particle sizes may, however, cause the particles to segregate according to size, and improper subsampling could introduce bias. Since homogeneity is frequently not achieved, appropriate subsampling procedures should be used by field personnel to provide representative subsamples. The procedures that follow are appropriate for collecting a representative sample from a larger sample. As noted previously, riffle splitters and coning and quartering procedures can also be used for subsampling as well as mixing (see Practice C 702).

9.1.1 *Rectangular Scoop*—As the final step of mixing, the material is arranged in a pile along the long axis of the rectangular pan. A flat bottomed scoop with vertical sides is moved across the entire width of the short axis of the pile to collect a swath of sample (Fig. 3). Multiple evenly-spaced swaths are collected until the subsample container is full. Multiple containers are filled by rearranging the remaining material and collecting swaths as just described.

9.1.2 *Alternate Scoop*—The volume of material required for filling sample containers is compared to the volume of the mixed sample. Scoops of mixed material are placed in the sample container(s) or are discarded, that is, three scoops are discarded for every scoop saved when collecting a 25 % subsample (Fig. 4). Care should be taken that each scoop of material is of the same size and is collected in a consistent manner to minimize bias (5).

9.1.3 *Slab-cake*—The cohesive or clay-like materials as discussed in 8.1.8.3 on kneading. The sample can be flattened, cut into cubes (Fig. 5) and the cubes randomly or systematically combined into subsample(s) (5). The subsample should be re-kneaded before shipment to the laboratory unless it can be ensured that the laboratory will homogenize the subsample before collecting a specimen.

10. Keywords

10.1 composite; compositing; hot spot; particle size reduction; sample; sampling; subsample; subsampling

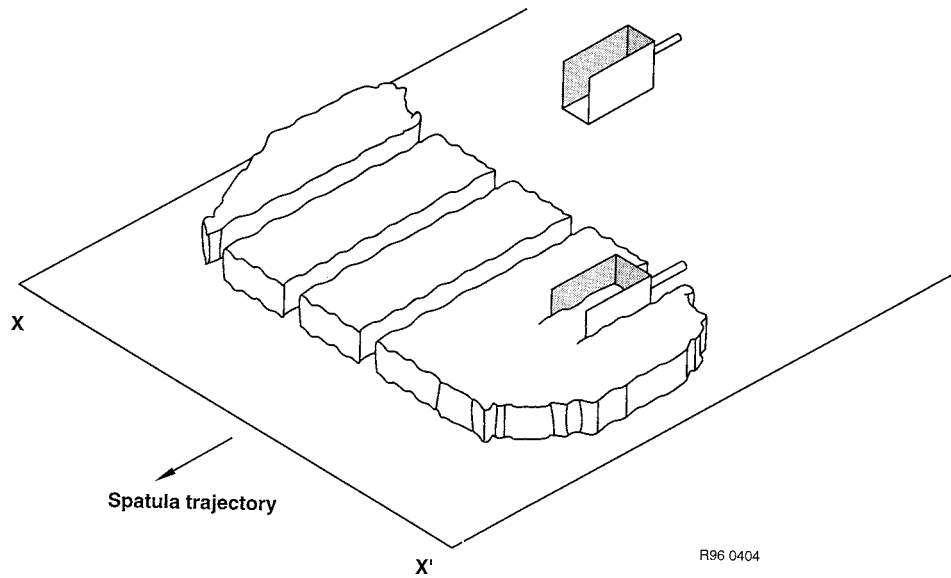


FIG. 3 Rectangular Scoop as Used to Collect Swaths for Subsample

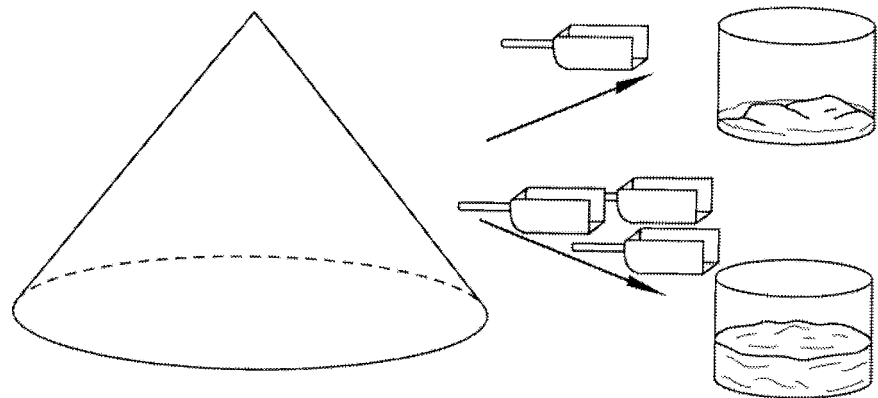


FIG. 4 Alternate Scoop Subsampling Technique

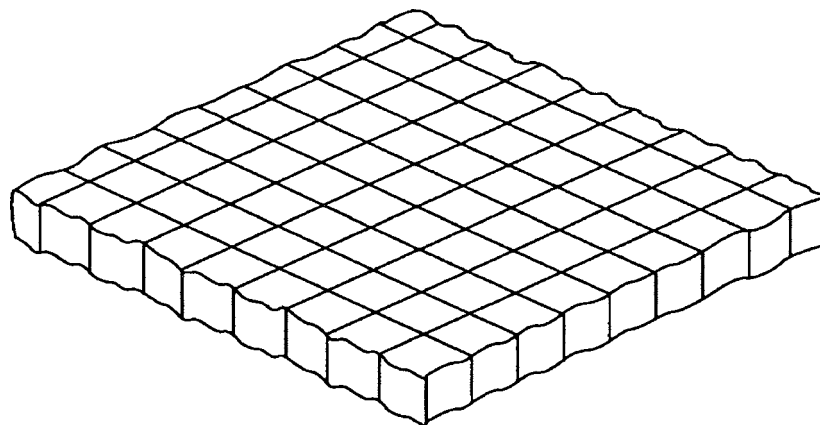


FIG. 5 Slab Cake Subsampling Technique



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APPENDIX J-H-4

ASTM D6724-04, STANDARD GUIDE FOR INSTALLATION OF
DIRECT PUSH GROUND WATER MONITORING WELLS



Standard Guide for Installation of Direct Push Ground Water Monitoring Wells¹

This standard is issued under the fixed designation D 6724; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes various direct push ground water monitoring wells and provides guidance on their selection and installation for obtaining representative ground water samples and monitoring water table elevations. Direct push wells are used extensively for monitoring ground water quality in unconsolidated formations. This guide also includes discussion of some groundwater sampling devices which can be permanently emplaced as monitoring wells.

1.2 This guide does not address the single event sampling of ground water using direct push water samplers as presented in Guide D 6001. The methods in this guide are often used with other tests such as direct push soil sampling (Guide D 6282) and the cone penetrometer test (Guide D 6067). The present guide does not address the installation of monitoring wells by rotary drilling methods such as those presented in Practice D 5092. Techniques for obtaining ground water samples from monitoring wells are covered in Guide D 4448.

1.3 The installation of direct push ground water monitoring wells is limited to unconsolidated soils and sediments including clays, silts, sands, and some gravels and cobbles. Penetration may be limited, or damage may occur to equipment, in certain subsurface conditions; some of which are discussed in 5.5. Information in this guide is limited to ground water monitoring in the saturated zone.

1.4 This guide does not purport to comprehensively address all of the methods and issues associated with monitoring well installation. Users should seek input from qualified professionals for the selection of proper equipment and methods that would be the most successful for their site conditions. Other methods may be available for monitoring well installation, and qualified professionals should have flexibility to exercise judgement concerning alternatives not covered in this guide. The practice described in this guide is current at the time of issue; however, new, alternative, and innovative methods may become available prior to revisions. Therefore, users should consult with manufacturers or producers prior to specifying program requirements.

1.5 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids
- D 4448 Guide for Sampling Ground Water Monitoring Wells
- D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
- D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites
- D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
- D 5254 Practice for Minimum Set of Data Elements
- D 5299 Guide for Decommissioning Monitoring Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 5474 Guide for Selection of Data Elements for Ground Water Investigation

¹ This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

- D 5521 Guide for Development of Ground Water Monitoring Wells in Granular Aquifers
- D 5730 Guide for Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water
- D 6001 Guide for Direct Push Water Sampling for Geoenvironmental Investigations
- D 6067 Guide for Electronic Cone Penetrometer Testing for Environmental Site Characterization
- D 6282 Guide for Direct Push Soil Sampling for Environmental Site Characterization
- D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
- D 6452 Guide for Purging Methods for Wells Used for Groundwater Quality Investigations
- D 6564 Guide for Field Filtration of Ground Water Samples
- D 6634 Guide for the Selection of Purging and Sampling Devices for Ground Water Sampling Wells
- D 6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations

3. Terminology

3.1 Terminology used within this standard is in accordance with D 653.

4. Summary of Guide

4.1 This guide provides information to be used by experienced ground water professionals for investigation of the subsurface and ambient ground water conditions.

4.2 This guide outlines a variety of field methods for installing direct push ground water monitoring wells. Installation methods include: (1) soil probing using combinations of dynamic (percussion or vibratory) driving with, or without, additions of static (constant) force; (2) static force from the surface using hydraulic penetrometer or drilling equipment; and (3) incremental drilling combined with direct push methods. Methods for installation of annular seals and annular grouts are also discussed as well as abandonment grouting.

4.3 This guide addresses considerations for selection and use of direct push well systems and installation techniques that may be classified into two main categories; exposed screen techniques and protected screen techniques. In exposed screen techniques, the screened casing may serve as the drive rod, or may surround a drive rod that is removed following installation. In protected screen techniques, the well may be advanced along with a protective outer casing, or may be lowered into a driven casing that is subsequently removed. Alternatively, the screen, riser, and a retractable shield may be driven simultaneously and all remain in the ground.

4.4 The interval to be tested is determined in advance by prior investigation, or by soil or water sampling during direct push driving. A screen section, either protected or unprotected, is connected to riser pipes and either driven on the outside of, or placed inside of direct push rods. With some monitoring well designs, it may be necessary to add sand pack and seals to isolate the screened test zone as the rods are retracted. The top of the installation is usually completed in a manner consistent with regulatory requirements. The well can be developed to

remove mobile sediments. Water levels can be measured, and water samples are taken as required in the sampling plan.

5. Significance and Use

5.1 The direct push ground method is a rapid and economical procedure for installing ground water monitoring wells to obtain representative ground water samples and location-specific hydrogeologic measurements. Direct push installations may offer an advantage over conventional rotary drilled monitoring wells (Practice D 5092) for ground water investigations in unconsolidated formations because they reduce disturbance to the formation, and eliminate or minimize drill cuttings. At facilities where contaminated soils are present, this can reduce hazard exposure for operators, local personnel, and the environment, and can reduce investigative derived wastes. Additionally, smaller equipment can be used for installation, providing better access to constricted locations.

5.2 Direct push monitoring wells generally do not extend to depths attainable by drilling. They are also typically smaller in diameter than drilled wells, thereby reducing purge water volumes, sampling time, and investigative derived wastes. Practice D 5092 monitoring wells are used when larger diameters and/or sample volumes are required, or at depths to which it is difficult to install direct push wells. Direct push monitoring wells should be viable for monitoring for many years.

5.3 Prior to construction and installation of a direct push well or any other type of ground water well the reader should consult appropriate local and state agencies regarding regulatory requirements for well construction in the state. A regulatory variance may be required for installation of direct push monitoring wells in some states.

5.4 To date, published comparison studies between drilled monitoring wells and direct push monitoring wells have shown comparability (1, 2, 3, 4, 5). However, selection of direct push monitoring wells over conventional rotary drilled wells should be based on several criteria, such as site accessibility and penetrability, stratigraphic structure, depth to groundwater, and aquifer transmissivity.

5.5 Typical penetration depths for installation of ground water monitoring wells with direct push equipment depend on many variables. Some of the variables are the size and type of the driving system, diameter of the drive rods and monitoring well, and the resistance of the earth materials being penetrated. Some direct push systems are capable of installing ground water monitoring wells to depths in excess of 100 feet, and larger direct push equipment, such as the vibratory sonic type drill (Guide D 6286) are capable of reaching much greater depths, sometimes in excess of 400 ft. However, installation depths of 10 to 50 feet are most common. Direct push methods cannot be used to install monitoring wells in consolidated bedrock (for example, granite, limestone, gneiss), but are intended for installation in unconsolidated materials such as clays, silts, sands, and some gravels. Additionally, deposits containing significant cobbles and boulders (for example, some glacial deposits), or strongly cemented materials (for example, caliche) are likely to hinder or prevent penetration to the desired monitoring depth.

5.6 For direct push methods to provide accurate ground water monitoring results, precautions must be taken to ensure

that cross-contamination by “smearing” or “drag-down” (that is, driving shallow contamination to deeper levels) does not occur, and that hydraulic connections between otherwise isolated water bearing strata are not created. Similar precautions as those applied during conventional rotary drilling operations (Guide D 6286) should be followed.

5.7 There have been no conclusive comparisons of effectiveness of sealing between drilled monitoring wells and direct push monitoring wells. As with drilled monitoring wells, sealing methods must be carefully applied to be effective.

5.8 Selection of direct push monitoring wells versus conventional rotary drilled monitoring wells should be based on many issues. The advantages and disadvantages of the many available types of driving equipment and well systems must be considered with regard to the specific site conditions. Specific well systems and components, as well as direct push driving equipment, are described in Section 7.

5.9 *Advantages:*

5.9.1 Minimally intrusive and less disturbance of the natural formation conditions than many conventional drilling techniques.

5.9.2 Rapid and economical.

5.9.3 Smaller equipment with easier access to many locations.

5.9.4 Use of shorter screens can eliminate connections between multiple aquifers providing better vertical definition of water quality than long well screens.

5.9.5 Generates little or potentially no contaminated drill cuttings.

5.9.6 Less labor intensive than most conventional drilling techniques.

5.10 *Disadvantages:*

5.10.1 Cannot be used to install monitoring devices in consolidated bedrock and deposits containing significant cobbles and boulders.

5.10.2 Small diameter risers and screens limit the selection of useable down-hole equipment for purging and sampling.

5.10.3 Difficulty installing sand pack in small annular space if gravity installation of sand pack is used.

5.10.4 Difficulty installing grout in same annular space unless appropriately designed equipment is used.

6. Pre-Installation Considerations

6.1 *Site Characterization*—Successful installation of direct push ground water monitoring wells must be preceded by appropriate site characterization activities. These activities may include reconnaissance, research, conceptual model development, exploratory field investigations, and confirmation and re-evaluation of any existing flow models.

6.2 For the installation to be successful, it is imperative that the target aquifer be located accurately. As with any well installation, the geologic conditions must be understood and the stratigraphy must be known. Although direct push wells can monitor thinner aquifers, with more precision, they may be ineffective if incorrectly placed. In thicker aquifers, and when seeking dense non-aqueous phase liquids, screens may need to be located in the bottom of the water-bearing stratum. Wells placed without determination of nearby geologic conditions can be ineffective and possibly dangerous. Geologic investiga-

tions should look for perched aquifers and use installation methods which will avoid any crosscontamination of the unit.

6.3 Environmental site characterization approaches are described in Guide D 5730. Proper site characterization for monitoring well placement is reviewed in Practice D 5092 on Monitoring Well Design.

6.3.1 *Characterization Tools*—In geologic settings amenable to the use of direct push ground water monitoring wells, other direct push methods and tools can likely also be used to effectively characterize the site. For example, the Cone Penetrometer Test (CPT) (Guide D 6067) is an effective tool for mapping stratigraphy and locating target layers. Other sensors, such as electrical conductivity and optical detectors have been placed on CPT and other direct push systems. Direct push soil sampling (Guide D 6282) and water sampling (Guide D 6001) can be used in advance to locate strata of concern. Direct push characterization experience at a site can guide the user in well design or device selection.

6.3.2 *Sampling During Installation*—Many direct push systems can take soil or water samples as part of the well installation process. For example, two-tube systems described in direct push soil sampling Guide D 6282 can be used to collect soil samples while driving. When the target aquifer is reached, the well screen system can be installed in the casing. Sampling data taken prior to well installation can confirm the target stratum has been reached.

6.3.3 *Sampling Systems*—There is a wide variety of direct push ground water sampling systems which can also be used for ground water monitoring. Direct push water sampling Guide D 6001 describes exposed screen versus protected screen samplers. Guide D 6282 describes the differences in two-tube and single-rod direct push soil sampling systems.

6.4 *Access and Clearances*—The selection of driving equipment should consider the accessibility of the installation site. The site should be surveyed for accessibility. Utility clearances may be required. Certain driving methods are incompatible with nearby hazards (for example, flammables). Also check for overhead utility lines during the site survey.

6.5 *Well Size Selection*—Driving resistance can govern the selection of an appropriate well diameter. Driving resistance can be evaluated by direct push testing on the site prior to well installation. Larger diameter monitoring wells may be easy to install on soft or loose ground sites. Smaller diameter monitoring wells may facilitate deeper installation on sites that are more resistant to penetration, but also present additional considerations for use as discussed below.

6.5.1 The availability of appropriate well development and sampling equipment for use in small-diameter monitoring wells may be limited. Many conventional down-hole pumps for purging and sampling are too large for use in small-diameter screens and risers.

6.5.2 Small diameter monitoring wells, because they are generally less rigid than larger diameter monitoring wells, require special attention during backfilling to maintain vertical alignment. This may include the use of centralizers.

7. Direct Push Wells Systems and Components

7.1 *Drive Rod and Casing*—In some instances the well itself may serve as the drive rod. Otherwise, it either surrounds

the well casing or is contained within it during installation, and is then removed. Direct push drive rod is typically constructed of steel in threaded sections. Lengths of 3.3 ft or 5 ft are common. The diameter selected will depend on the driving resistance of the soil and well size considerations. Consult experienced area contractors or qualified manufacturers to select the appropriate diameters for the site. Drive rods used inside of casings range from 0.5 to 1.25 in. in diameter. Outer drive casings of up to 4.5-in. diameter have been used at relatively soft or loose soil sites allowing installation of 2-in. screen/riser assemblies. The most common casing sizes are 2 to 3 in. Large drive rods can be advanced with large vibratory drills (Guide D 6286). Threaded sections can be outfitted with o-ring seals or PTFE tape to reduce ground water infiltration. Drive casings are equipped with expendable steel or aluminum drive points that are left in the bottom of the well.

7.2 Well Screen and Riser Pipe—Slotted PVC with flush-joint riser pipe is commonly used in the installation of direct push monitoring wells. Sizes range from ½ in. to 2 in. (Schedules 40 and 80). Other riser screen and riser materials such as stainless steel, polyethylene, or PTFE may be used. PVC is preferred due to its low cost and because it is relatively inert. Selection of well material should consider possible material interactions with the contaminant being monitored. While PVC and Stainless steel are commonly used in most monitoring wells without any problem, there are extreme environmental conditions that could lead to failure of these materials. PVC should not be exposed to neat organic solvents (that is, pure products) that are PVC solvents or swelling agents or to extremely high concentrations of these chemicals (approaching a saturated solution) (5, 6, 7, 8, 9, 10). Although there is very little data on the expected life of steel well casings (11), stainless steel is reported to perform well in most environments (11, 12, 13). Stainless steel should be avoided in extremely corrosive conditions, which may include water high in chlorides, low in pH, high in dissolved solids or high in dissolved oxygen (14, 15, 16, 17). As screen and riser pipe may contain chemical residue from manufacturing, the screen and riser should be cleaned prior to installation. Threads of the riser pipe can be sealed with O-rings or by using PTFE tape.

7.2.1 Slotted (PVC) or wire-wrapped (steel) well screen is normally supplied with slot widths of 0.01 or 0.02 in. The screen can be wrapped with stainless steel wire mesh of 0.006 in. opening. The selection of slot size depends on the formation grain size distribution and if a sand pack will be needed to reduce turbidity. Practice D 5092 provides slot size and sand pack selection criteria.

7.2.2 A sediment trap may be specified. If the riser is lifted and needs to be pushed back into place, pointed sediment traps are useful.

7.3 Sand Pack—The use of sand packs assists in reducing turbidity and the amount of well development required to obtain low turbidity samples. Monitoring wells without sand packs will likely yield more turbid water, which may impact the results of some chemical analyses. However, a filter can be as thin as several grain diameters to be effective. Improving well yield is not the purpose of the sand pack; yield is controlled by the formation. For monitoring of metals, filtering

of samples (Guide D 6564) may be required for samples with elevated turbidity levels.

7.3.1 Sand Pack Selection and Size Range—Formations of clean sands and gravels (that is, less than 5 % fines) may not require a sand pack. For soil containing appreciable fines, use of a sand pack should be considered. The gradation requirement depends on the particle size distribution in the target aquifer. Refer to Practice D 5092 for criteria on sand pack design.

7.3.2 Pre-packed Screens—Pre-packed screen systems are intended to ease the installation of sand in direct push cased monitoring wells by carrying it with the casing. The prepack sections use hollow stainless steel screen casings to accommodate the slotted riser. A screen opening of 0.006 in. is typical.

7.4 Seals—In addition to the sand pack, a seal above the screen is needed. Current state regulations and EPA guidance documents (18, 19, 22) require the installation of annular seals and grouting of the well annulus to prevent potential cross contamination along the well bore and the possibility of surface water or chemical spills from contaminating the monitored aquifer(s). Sealing is necessary to prevent infiltration of surface runoff and to maintain the hydraulic integrity of confining layers. The sealing required depends on the formation, well type, and installation technique (Section 8). Several methods can be used to assure a seal above the screened zone. Most completion methods with cased systems use tremie grout placed as the casing is withdrawn. The grout can be bentonite or cement similar to that specified in Guides D 6001, D 6282, and Practice D 5092. A typical well completion diagram is shown on Fig. 1. A grout barrier of fine to medium sand is used to protect the sand pack or screened interval from infiltration of grout, which can change the local water chemistry. Practice D 5092 addresses this subject.

7.4.1 Mechanical techniques can also be used to create an effective seal. For example, Fig. 2 depicts a solid metal sleeve left in the ground, and Fig. 3 shows modular expandable foam

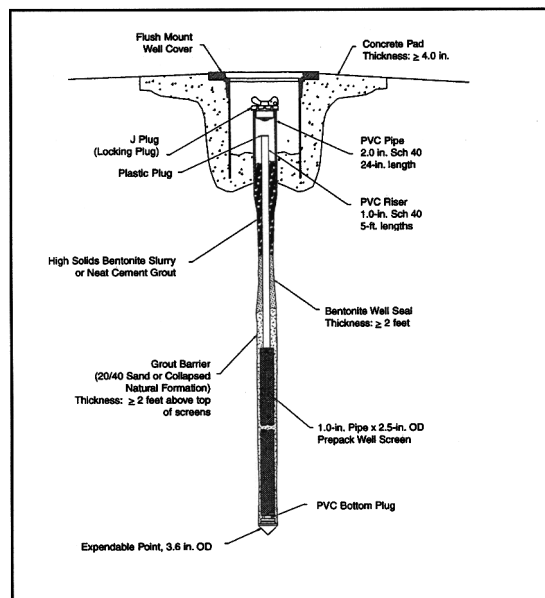


FIG. 1 Example of a Completed Direct Push Monitoring Well (20)

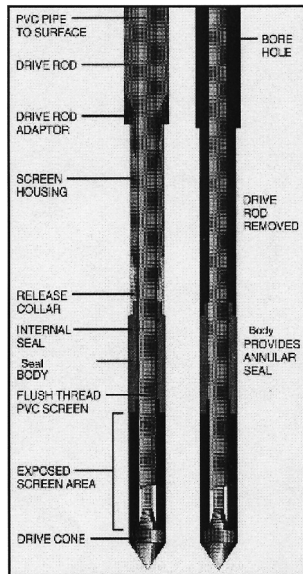


FIG. 2 Example of a Steel Seal Body Above the Screen

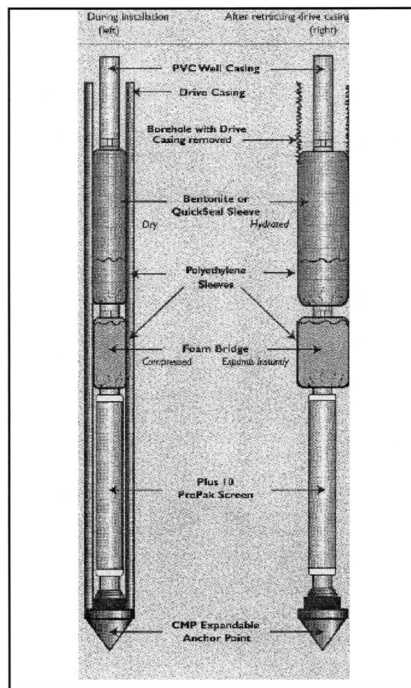


FIG. 3 Direct Push Well with Modular Sealing Components

and bentonite sleeves used above the screened interval. Rubber wiper seal may also be used. Whether this barrier is formed by the addition of fine to medium sand, by collapse of the surrounding formation, or mechanically, the materials employed must be chosen to be compatible with the local groundwater conditions and contaminants of interest.

7.5 Modular Well Systems—The most recent developments have been towards the use of modular components for placing sand pack and seals. Pre-packed screens can be used with most drive systems. The screens are stainless steel wire mesh filled with sand of different gradations. Fig. 3 shows the use of these modular sand packs.

7.6 Other Variations—Numerous innovations have been developed for ground water monitoring through direct push well systems. For example, multiple screened sections can be completed in one installation, and sampling of multiple zones can be performed by using packers or sampling ports for ground water extraction. Another recent development has been the use of everting flexible sock system liners to seal the borehole and isolate a water sampling interval (21).

8. Installation Techniques

8.1 There are several techniques for installing direct push monitoring wells. Techniques can be broadly classified into two categories: exposed screen techniques, and protected screen techniques. Each of the systems described hereafter may require a unique installation procedure. Regardless of the choice of techniques and systems, a written operating procedure should be developed which allows some flexibility in response to field conditions. Project sampling plans and standard operating procedures should be consulted prior to installation.

8.2 Direct Push Driving Equipment—Direct push Guides D 6001 and D 6282 describe typical driving systems. Some systems are manual (slam bar, hand held electric or pneumatic hammers), static weight (cone penetrometers), percussion (hydraulic hammers, air hammers, electric hammers), and vibratory systems. In some cases, direct push monitoring wells may be installed in combination with rotary drilling.

8.3 Exposed Screen Techniques—One method of installing direct push wells is to advance a screen and riser of constant diameter that remain in direct contact with the formation during installation. The riser may be driven either alone or by using a mandrel rod inside the screen and riser (Fig. 4). Because the well screen is exposed to soil during driving, development by surging or jetting will be necessary to remove sediment from the screen slots (see Guide D 5521 for well development methods). When installing exposed screen monitoring wells the slotted screens may become clogged with fine-grained materials if any are present in the penetrated

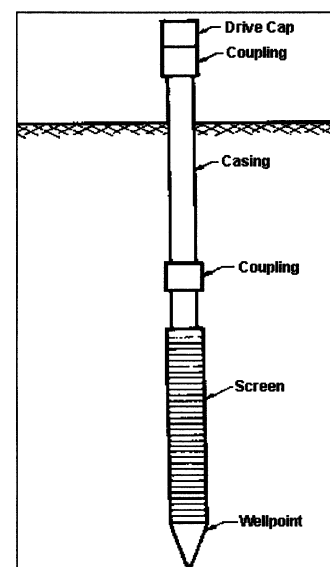


FIG. 4 Example of an Exposed-Screen Driven Well Point (11)

formation. If the zone penetrated with the slotted screens is contaminated the materials trapped in the screens may be contaminated and result in cross contamination of the screened interval. Additional development may be required to remove the material clogged in the screens. Failure to remove such material may bias sample quality.

8.3.1 Driven or Jetted Wellpoints—As is commonly practiced in other hydrology applications (for example, construction site dewatering), well points can be jetted or driven (hammer or vibration) through sands. Fig. 4 shows this simple type of installation. At many saturated sand sites, the well point can be quickly driven using vibrators or vibratory hammers. Well points are generally 2 to 3 in. diameter and constructed of slotted or wire-wrapped steel or stainless steel. Slot widths of 0.01 to 0.02 in. are typical. These monitoring wells perform well in clean, coarse to medium sand deposits, but they do not have a sand pack and will yield sediment in soils containing fines. The use of jetting will reduce effective sealing above the screen. Installation by jetting with water or other fluids is not recommended for environmental water quality monitoring wells, as injection of large volumes of fluids into the local formation will result in significant alteration of the local ground water geochemistry.

8.3.2 Mandrel-Driven Screen and Riser—Fig. 5 shows a section of poly vinyl chloride (PVC) screen and riser that is driven using inner steel CPT rods. A drive tip slightly over-reams the hole to reduce friction on the riser pipes. Through experience, the drive tip diameter can be optimized to assure good sealing above the screen. With this type of installation, rigorous development to remove possible cross-contamination must be performed. A combination of mechanical surging and continuous withdrawal of the well water is effective for this purpose. See Guide D 5521 for well development guidance.

8.4 Protected Screen Techniques—Protected screen techniques do not allow the well screen to come in contact with the formation until the screened section is at the target installation depth. The well is driven inside of a protective outer casing, or lowered down into the casing once it has been driven to the desired depth. A variety of sand pack and sealing approaches

are available, as discussed in subsequent sections. There may be difficulty in installing sand pack or grout in the annular space that is created. However, the use of pre-packed well screens facilitates the quick and accurate placement of the sand pack. Additionally, new grouting technology allows for efficient and accurate placement of seals and grout by the bottom-up tremie method recommended by EPA guidance (11, 18, 19) and most state regulatory agencies.

8.4.1 Single Rod Wells—Guide D 6001 describes rod-driven water samplers which can be driven and left in place as monitoring points without backfilling. Fig. 6 shows a typical rod-driven water sampler. If the drive rod is smaller in diameter than the sampler body, surface infiltration can be prevented by grouting the annular space above the sampler body. Otherwise, the only seal will be between the formation and that portion of sampler body above the screen. If the annulus between the drive rod and soil remains unsealed, such installations are satisfactory only for monitoring the uppermost portions of surficial aquifers, and where potential contamination by infiltration from above is not a concern. Most conventional direct push water samplers of this type are typically not left in the ground for long periods due to equipment expense. However, low-cost versions of these samplers are available and can be used for long-term installations.

8.4.2 Two-Tube Systems—Many protected screen direct push monitoring wells are installed by first advancing the outer tube to the bottom of the desired screen interval. Then the screen(s) and riser are assembled and lowered through the open bore of the probe rods. Following this, the outer tube is retracted while the screen(s) and riser remain in place. The grout barrier, annular seal and grout are then installed by appropriate methods. With non-percussive driving systems the screen and riser may be advanced along with the protective casing without risking damage. Monitoring wells installed using a two-tube system are similar to rotary monitoring wells (Practice D 5092) in that they can contain a sand pack, seal, and annulus sealing to the surface. The well assembly may include a pre-fabricated sand pack or other modular components as illustrated in Fig. 7. By using the protective casing, the well can be installed through multiple aquifers. The well may

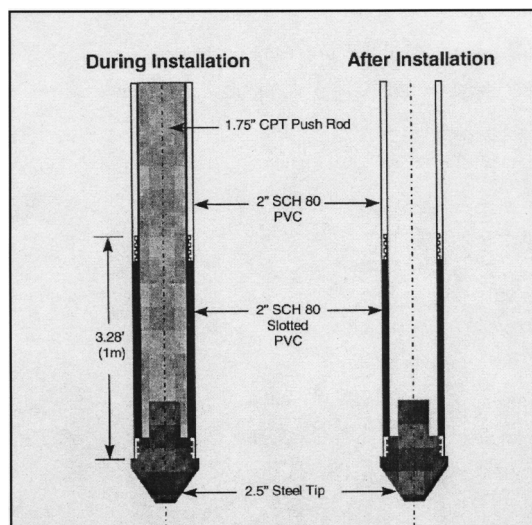


FIG. 5 Mandrel-Pushed Screen and Riser

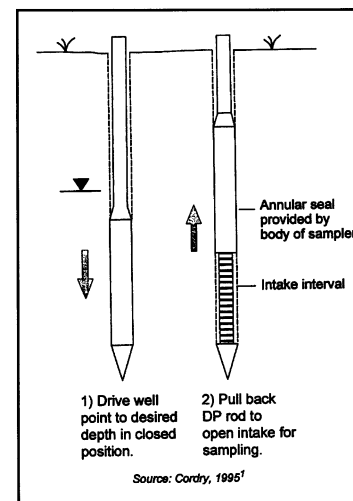


FIG. 6 Typical Rod Driven Water Sampler (23)

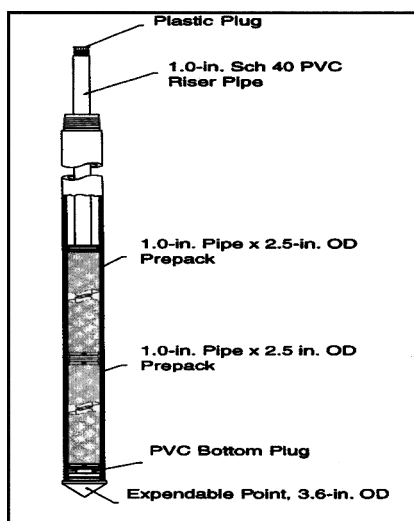


FIG. 7 Example of Prepacked Screens Installed After the Drive Casing is in Position (20)

be lowered down into the casing following driving and prior to casing withdrawal, or the bottom end may be attached to an expendable push point, which remains in the ground upon retraction of the drive rods and acts as an anchor. The casing provides a positive temporary seal and allows for control of sand pack and permanent seal placement as it is retracted. Two-tube systems also allow for soil or ground water sampling along the way. However, they must be checked for standing water in the outer tube which, if not drained, may impact sample quality. Typical well diameters are from one-half to two inches.

8.4.3 Filter Packs and Seals—In a surficial aquifer it may be appropriate to allow the formation to collapse back in against the screen and riser without adding a sand pack. In this case the surface completion method must provide adequate protection against infiltration by surface runoff. Otherwise, sand pack and seals, if not provided by pre-packed or modular construction (7.3.2 and 7.5, respectively), can be placed by tremie or pouring methods, or by pumping.

9. Installation Procedure

9.1 Decontamination of Materials—Well components and installation equipment may require decontamination before and/or after well installation. Consult Practice D 5088 for decontamination procedures. If the well is to be used for water chemistry testing, at least one rinsewater sample of the well material will be required following decontamination and prior to installation.

9.2 Installation—Drive the direct push monitoring well in accordance with the standard operating procedures developed for the push system and/or monitoring well (8.1). Record all assembly lengths and rod or casing lengths, and any unusual driving conditions as the push progresses on the well completion log (Fig. 8). Record water levels if required (see Test Method D 4750). For cased systems in sand below the water table, it may be necessary to fill the casing with clean water to prevent sand heaving. With cased systems, it may be necessary to check for ground water infiltration using a water level meter

CPT WELL INSTALLATION REPORT

Project: _____		Observation Well: _____	
City/State: _____		CPT ID: _____	
Client: _____		Installation Date: _____	
Crew Chief: _____		Location: _____	
File No.: _____			

Ground El. _____	Type of Protective Cover/Lock _____
El. Datum _____	Depth of Top of Roadway Box below Ground Surface _____ ft
Comments: _____	Depth of Top of Riser Pipe below Ground Surface _____ ft
	Type of Protective Casing: _____
	Length _____ ft
	Inside Diameter _____ in
	Depth of Bottom of Roadway Box _____ ft
	Seals: _____
	Type of Riser Pipe: _____
	Inside Diameter of Riser Pipe _____ in
	Type of Backfill around Riser _____
	Diameter of Largest CPT Expander _____ in
	Depth of Top of Wellpoint _____ ft
	Type of Point or Manufacturer: _____
	Screen Gauge or Size of Openings _____
	Diameter of Wellpoint _____ in
	Depth of Bottom of Wellpoint _____ ft
	Silt Trap _____
	Depth of Bottom of Borehole _____ ft
	(Depths refer to ground surface)

Riser length (L1) _____ ft	Screen length (L2) _____ ft	Length of silt trap (L3) _____ ft	Total length _____ ft
----------------------------	-----------------------------	-----------------------------------	-----------------------

FIG. 8 Example of a Direct Push Well Completion Report

prior to detaching the expendable tip. This check is imperative in conditions of contaminated perched water.

9.3 Centralizers—For small diameter casings (less than half the size of the borehole created), the use of centralizers prevents deflections of the riser during backfilling of the annular space. Riser deflection can later interfere with the free passage of bailers and other equipment through the casing. Centralizers may also assist in sealing procedures by keeping the riser in a consistent position within the borehole.

9.4 Sealing—Procedures for sealing direct push monitoring wells are similar to those in Practice D 5092. Direct push sealing considerations and procedures are also addressed in sampling Guides D 6001 and D 6282. Groundwater that has entered the cased system may cause difficulty in placing seal materials by the gravity-pouring method. New grouting equipment allows for efficient and effective installation of well seals and grout (20 to 30 % solids bentonite) by bottom-up tremie methods with tremie tubes as small as 0.25-in. inside diameter. Depth to the top of seal materials can be periodically checked using rods or weighted tape lowered into the annular space.

9.5 Surface Completion—Well capping details vary from simple to detailed, similar to rotary drilled monitoring wells. After the final height of the riser is established, record the elevation of the top of the riser pipe.

9.6 Well Development—Direct-push monitoring wells can be developed using mechanical surging, pumping and backwashing, hydraulic jetting, or inertial lift pumps. The first three methods are described in detail in Guide D 5521. Inertial-lift

pumps (also referred to as tubing check valve pumps) are operated by oscillating a piece of rigid or semi-rigid tubing, with a simple ball check valve on the down-hole end, in the water column within the well screen. The tubing and check valve act like a surge block, alternately forcing water to flow into the well (on the upstroke) and out of the well (on the downstroke), and significantly agitating the water column in the well and the water contained within the filter pack and the adjacent formation materials. The downstroke causes a back-washing action to loosen bridges in the formation and filter pack, and fills the tubing with water and suspended sediment brought into the well during the upstroke. The upstroke pulls dislodged fine-grained material into the well and causes water in the tubing to move upward under inertia, as the tubing is pushed back into the well. This oscillation of the tubing is repeated until water and suspended sediment are discharged from the tubing at the surface; development is complete when the water being discharged is free of suspended sediment. Additional purging with a pumping method that does not surge the well (peristaltic, bladder, etc.) may be needed to achieve low turbidity levels required for some analytes. Information on different monitoring well development and purging devices is available in Guide D 6634. Details on development methods may be found in Practice D 5092, Guide D 5521, EPA 1986, 1991, and Nielsen 1991.

9.6.1 In predominantly fine-grained formation materials (with a high silt and clay content), attempts to develop direct-push wells may not improve well yield and may result in increases in suspended sediment, clogging of the well screen and filter pack, or damage to the screen or filter pack. Pumping the well at a low flow rate, to the point at which pump discharge is free of suspended sediment (using a peristaltic pump, bladder pump, or gas-displacement pump), is often an effective development method for wells installed in fine-grained formations.

9.6.2 Well development should be done either after the well casing, screen and filter pack have been installed and the drive casing has been pulled back to just above the top of the screen (i.e., prior to installation of annular seal materials), or after the entire well has been completed. In the latter case, it is necessary to wait until the annular seal materials have set or cured, typically 48 to 72 hours after well installation.

9.7 *Purging and Sampling*—Purging a direct-push monitoring well is generally required prior to sampling the well. The types of devices appropriate for use in purging and sampling a direct-push monitoring well, and the procedures for using them, are described in detail in Guide D 6634. Because of the smaller inside diameter of most direct-push well, the selection of devices is more limited than it is for wells 2 in. nominal diameter and larger. Bladder pumps, gas-displacement pumps, peristaltic pumps, bailers, and inertial-lift (tubing check valve) pumps may all be used for both purging and sampling. Guide D 6634 should be consulted to determine the conditions and analytes for which each device is appropriate. Additional information on sampling and equipment methods and procedures can be found in Guide D 4448, EPA 1986, 1991, 1992, 1996, and Nielsen 1991. Information on decontamination of sampling equipment is provided in Practice D 5088 and Parker

and Ranney 2000. In wells in which low-flow purging and sampling methods (Practice D 6771) are to be used, or from which low-turbidity samples are required, bailers and inertial-lift pumps are not appropriate devices. Bladder pumps are now available in sizes as small as 1/2 in. diameter and are well suited for low flow sampling. Low flow purging and sampling (Practice D 6771) is highly recommended when sampling for metals in groundwater or other parameters that are affected by elevated turbidity, as well as sampling VOC's.

9.8 *Maintenance*—Monitoring wells that will be used for sufficiently long that biofouling or silt accumulation will be a concern may require periodic maintenance. Maintenance practices might include disinfection, acid treatment, and redevelopment and purging. However, using acid on stainless steel systems is not recommended because of problems with corrosion, and both disinfection and acid treatment are discouraged for environmental water quality monitoring wells as these practices may significantly alter the local chemistry.

9.9 *Abandonment/Decommissioning*—Direct push sampling wells may require removal or closure either at the end of their service life or if an installation attempt is unsuccessful (for example, equipment breakage or failure to reach target depth). The closure and plugging of such wells should be done in accordance with Practice D 5299, relative to techniques for direct push wells. It may be sufficient to fill the screen and riser with an impermeable grout, or if plugging the well is not acceptable, the casing may be removed by rotary over-drilling using a hollow stem auger.

10. Field Report and Project Control

10.1 Record and report information as required in the sampling plan and as noted in Section 8 on the well installation. An example of a well completion report form is shown on Fig. 8.

10.2 Report any subsurface investigation data that are required in the sampling plan and consult Guide D 5434 on logging of subsurface investigations.

10.3 If the well data are to be used in a Geographic Information System, consult Guide D 5254 on minimum data elements for documenting a ground water sampling site.

10.4 Well development events may require a separate report of monitored ground water conditions during development.

10.5 A field notebook should be kept to document all activities relevant to the work plan. Activities include sampling events and conditions that occur during installation, development, and sampling as part of a quality assurance program.

10.6 If samples are obtained during the installation, as with two-tube soil sampling Guide D 6282, record and report the sample intervals and the data that are required.

10.7 If water samples are acquired during the push (Guide D 6001), record the purge water volumes and any monitored water quality indicators.

10.8 Record and report the depth of the push, and details such as effective screen length, effective seal lengths, backfilling and sealing methods. As the well is completed, ensure that all necessary installation information is recorded.

11. Keywords

11.1 direct push; ground water; monitoring well; site investigation

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APPENDIX J-I

SHALLOW GROUNDWATER WORK PLAN



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December 17, 2010

Reference No. 038443-89

Ms. Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Ms. Cibulskis:

Re: Shallow Groundwater Work Plan (Work Plan)
South Dayton Dump and Landfill Site Moraine, Ohio (Site)

As required under the Dispute Resolution Agreement signed by the Respondents and USEPA on December 10, 2010, this Work Plan presents the proposed approach for additional investigation of shallow groundwater conditions at the Site boundary between VAS-09 and VAS-22 and in the vicinity of MW-210 (Shallow Groundwater Investigation). Conestoga-Rovers & Associates (CRA) has prepared this Work Plan on behalf of the Respondents to the Administrative Settlement Agreement and Order on Consent (ASAOC) for Remedial Investigation/Feasibility Study (RI/FS) of the Site, Docket No. V-W-06-C-852 (Respondents).

The work proposed in this Work Plan will be performed in accordance with the United States Environmental Protection Agency- (USEPA-) approved Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Site-Specific Health and Safety Plan (HASP), and associated addenda that are submitted as attachments to this Work Plan.

This Work Plan is presented in the following titled sections:

- 1.0 Background
- 2.0 Shallow Groundwater Investigation
- 3.0 Schedule
- 4.0 Reporting



1.0 BACKGROUND

The Respondents to the ASAOC include Hobart Corporation (Hobart), Kelsey Hayes Company (Kelsey-Hayes), and NCR Corporation (NCR). These three Respondents (the PRP Group) are and have been performing the Work required by the ASAOC under the direction and oversight of the USEPA.

Under the December 10, 2010 Dispute Resolution Agreement, the Respondents agreed to investigate the shallow groundwater along the Site boundary between VAS-09 and VAS-22 and in the vicinity of monitoring well MW-210. This investigation is to identify potential risks to off-Site receptors from volatile organic compounds (VOCs) and naphthalene migrating off-Site in groundwater and into buildings via the vapor intrusion pathway.

Specifically, the Dispute Resolution Agreement requires the Respondents to:

submit a work plan (Shallow Groundwater Work Plan) including FSP and QAPP Addenda, for additional characterization of the top five feet of shallow groundwater in the vicinity of Monitoring Well 210 (MW-210) at the locations in the Respondents' draft MW-210 Shallow Groundwater Investigation Letter Work Plan, dated March 16, 2010, and at locations no greater than 100 feet apart at the Site boundary starting: 1. adjacent to Dryden Road east of VAS-09; 2. continuing south to the Site boundary at the intersection of Dryden Road and East River Road; 3. continuing west along the south side of the access road to Lot 4610, with a sampling point at the northeast corner of Lot 4610; 4. continuing south along the east boundary of Lot 4610 to Lot 3254 (skipping the Site boundary around Lot 3252); and 5. continuing southwest along the East River Road boundary of the Site to a location east of VAS-22 (Shallow Groundwater Investigation Letter Work Plan). See highlighted area on [Figures 1 and 2], attached, for an illustration of the sampling area. The data quality objectives for the groundwater samples will include, but are not limited to, detecting VOCs and naphthalene in shallow groundwater at the Site boundary that pose more than a 1×10^{-6} cancer risk or a hazard index greater than 1.0 through the vapor intrusion pathway to current or potential future receptors. The samples may be collected using direct push technology, and will be collected using low-flow sampling and groundwater stabilization procedures consistent with those developed for the vertical aquifer sampling previously conducted during RI/FS Work at the Site provided the low-flow sampling and groundwater stabilization procedures meet the data quality objectives required for the VI Study. The sampling intake will be set approximately 2.5 feet below the water table. This Shallow Groundwater Work Plan for additional characterization of groundwater shall be submitted by December 17, 2010.



The PRP Group prepared this Letter Work Plan based on requirements of the Dispute Resolution Agreement, previous investigation results and discussions between the PRP Group and USEPA.

2.0 SHALLOW GROUNDWATER INVESTIGATION

The general objective of the Shallow Groundwater Investigation is to identify whether contaminants are present in the upper five feet of shallow groundwater at the Site boundary between VAS-09 and VAS-22 that pose more than a 1×10^{-6} cancer risk or a hazard index (HI) greater than 1 to current or potential future receptors via the vapor intrusion pathway. This will be accomplished by collecting and analyzing groundwater samples from new borings completed in select locations between VAS-09 and VAS-22, as shown on Figure 1.

The Shallow Groundwater Investigation will also include the collection of a groundwater sample from the water supply well located 500 feet downgradient from MW-210. The groundwater sample from the water supply well will be analyzed for VOCs, naphthalene, and metals.

Shallow Groundwater Investigation Data Quality Objectives

There are seven steps in the Data Quality Objective (DQO) process¹. A discussion of the DQO steps for the Shallow Groundwater Investigation is presented below.

Step 1: State the Problem – VOCs and naphthalene are present in shallow groundwater beneath the Site. A data gap exists with respect to whether VOCs and naphthalene contaminants in OU1 shallow groundwater between VAS-09 and VAS-22 are migrating off-Site in this area at concentrations that may pose an unacceptable risk to current or potential future receptors via the vapor intrusion pathway.

Step 2: Identify the goals of the study – Complete a screening level investigation to determine whether contaminants identified in the specified areas are migrating off-Site via shallow groundwater at concentrations that may pose an unacceptable risk to current or potential receptors via the vapor intrusion pathway. Identify areas where off-Site migration is occurring and further investigation, e.g., installation of additional boreholes, permanent monitoring wells or soil gas probes, or remedial activities, is required.

¹ As detailed in the USEPA document *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA QA/G-4, February 2006.



Step 3: Identify information inputs – Complete groundwater investigations using direct push technology and low flow groundwater sampling to determine VOC and naphthalene concentrations in shallow groundwater at discrete locations along the Site boundary.

Step 4: Identify the boundaries of the study – The Study Area for the shallow groundwater investigation is detailed below, and presented on Figure 1.

- In the vicinity of monitoring well MW-210
- At locations no greater than 100 feet (ft) apart at the Site boundary starting
 - Adjacent to Dryden Road, east of VAS-09
 - Continuing south to the Site boundary at the intersection of Dryden Road and East River Road
 - Continuing west along the south side of the access road to Lot 4610, with a sampling point at the northeast corner of Lot 4610
 - Continuing south along the east boundary of Lot 4610 to Lot 3254 (skipping the Site boundary around Lot 3252)
 - Continuing southwest along the East River Road boundary of the Site to a location east of VAS-22

Step 5: Develop the analytic approach – Groundwater samples will be collected using low flow sampling techniques from the top five feet of shallow groundwater in each borehole, following purging and stabilization. The sample intake will be set at 2.5 feet below the water table. Samples will be collected using the sampling methodologies outlined in the FSP and relevant addenda. Groundwater samples will be submitted for analysis of VOCs and naphthalene using the analytical methodologies outlined in the QAPP.

Step 6: Specify Performance or Acceptance Criteria – Performance criteria consist of identifying VOCs and naphthalene that pose more than a 1×10^{-6} cancer risk or a HI greater than 1 to current or potential future receptors via the vapor intrusion pathway. The maximum width of a groundwater plume containing VOCs at concentrations greater than MCLs at the Site boundary that may escape detection during the investigation is 100 feet over most of the Site boundary between VAS-09 and VAS-22 and is 20 feet in the vicinity of MW-210 (see Figure 1).

Step 7: Develop the plan for obtaining data – See Sections 2.1 to 2.3 below, for detailed procedures proposed in order to obtain the required data.

Vapor Intrusion (VI) is the migration of volatile chemicals from the subsurface into overlying buildings. VI is a potential concern at any building, existing or planned, located near soil or



groundwater contaminated with toxic chemicals that can volatilize. USEPA's 2002 draft guidance document, entitled "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (OSWER Draft Guidance), defines "near" as:

volatile or toxic compounds within 100 ft (laterally or vertically) of buildings, unless there is a conduit that intersects the migration route that would allow soil gas to migrate further than 100 ft.

The OSWER Draft Guidance defines a conduit as: *"any passageway that could facilitate flow of soil gas, including porous layers such as sand or gravel, buried utility lines, and animal burrows."*

At the commencement of the Shallow Groundwater Investigation, CRA will visually assess the Site boundary within the Study Area for evidence of conduits that might facilitate the flow of soil gas and will install and sample the groundwater from boreholes located immediately adjacent to any such conduit, in addition to the boreholes discussed above and shown on Figures 1 and 2.

2.1 Chlorinated Solvent Delineation for Shallow Groundwater in the Area of MW-210

The highest TCE concentrations in groundwater from any permanent monitoring well are the samples collected from MW-210. Groundwater impacts at VAS-21 and monitoring wells MW-210, MW-210A, and MW-210B are well defined vertically to 200 feet below ground surface². However, the source and extent of impact present in the shallow groundwater at MW-210 are not well understood and it is not known if contaminants present in shallow groundwater at MW-210 are migrating off-Site. As such, the Respondents propose to complete additional investigation to delineate groundwater impact in this area.

CRA will advance seven boreholes on Site to the south and east of the MW-210 monitoring well nest at an initial distance interval of 20 feet along the southern fence line. To the north of the MW-210 monitoring well nest, CRA will advance four boreholes at an initial distance interval of 40 feet. Boreholes will be advanced to the top five feet of shallow groundwater, to a maximum depth of 40 feet (i.e., to the top of the till layer³). Figure 2 presents the approximate locations of the proposed boreholes around MW-210.

² CRA notes that the full vertical extent of the deeper vinyl chloride contamination (i.e., beyond 200 feet below ground surface) has not been fully delineated. Delineation of the vertical extent of deep groundwater contamination will be completed during the OU2 RI.

³ If the top of the till layer is located at a depth greater than 40 ft, CRA will attempt to advance the boreholes deeper than 40 ft if groundwater is not encountered within the first 40 ft.



2.2 Shallow Boundary Groundwater Investigation

The VOC concentrations in shallow groundwater in the vicinity of VAS-09 may be linked to the VOC concentrations in groundwater samples collected from MW-215A and VAS-15, and concentrations in soil gas samples collected from GP12-09, GP13-09, and GP14-09. The source of the VOC concentrations in shallow groundwater in the vicinity of VAS-09 has not been identified.

CRA collected a soil gas sample from GP09-09 that contained TCE at a concentration of 2,000 µg/m³. This concentration indicates that there may be a source of TCE on Lot 4610. GP09-09 is located approximately 150 feet from a residential property, and approximately 200 feet from a house with a basement foundation. GP09-09 is located at the Site boundary on Lot 4610, the location of the former Mantle Oil Service facility. Between 1971 and 1986 Mantle Oil Service operated a used oil reclamation service on Lot 4610 of the Site including 18 above ground storage tanks.

In order to determine the concentration of shallow groundwater contaminants at the Site boundary within the Study Area, CRA will advance boreholes at distances no greater than 100 feet as shown on Figure 1. CRA will collect a groundwater sample from the top five feet of shallow groundwater at each borehole following the procedures detailed in Section 2.3.

2.3 Borehole Advancement

The proposed groundwater sampling locations are shown on Figures 1 and 2. All borings will be completed using Geoprobe™ direct push drilling techniques. Details regarding Geoprobe™ drilling are provided in Attachment A (addendum to the FSP).

The drill rods, stainless steel screen, and associated drilling equipment will be decontaminated, prior to starting and between each borehole, using a high-pressure, high temperature, hot water cleaner. An off-Site source of potable water, free of contamination such as a fire hydrant will be used. CRA previously collected a sample of the potable water source for analysis of VOCs to verify water quality. In the event of a change in the potable water source, CRA will collect a sample from the new source.

During borehole advancement, continuous soil cores will be retrieved to log soil stratigraphy. Cores will be screened with a photoionization detector (PID) for the presence of volatile organic compounds (VOCs), and screened for the presence of methane, either by using a landfill gas meter (such as a Landtec GEM-500 or MultiRAE 4-Gas monitor) or a flame-ionization detector (FID) calibrated for methane.



Where field screening indicates evidence of contamination, soils will be tested for the presence of NAPL using a Sudan IV® dye test. Field calibration, preventative maintenance, and SOPs for the PID and Sudan IV® dye test are included in the FSP.

Following the field screening and logging of the soil stratigraphy at each borehole, the Geoprobe will be offset approximately 1 foot from the borehole to collect a groundwater sample while preventing drawdown. CRA proposes to use a Geoprobe Screen Point 16 (SP16) Groundwater Sampler. The standard operating procedure (SOP) for the Geoprobe SP16 Groundwater Sampler is included in Attachment A (addendum to the FSP). CRA proposes to use a 32-inch (2.6-ft) stainless steel slotted screen with the Geoprobe SP16 Groundwater Sampler. CRA will collect groundwater samples from the top five feet of shallow groundwater. The sampling intake will be set approximately 2.5 feet below the water table, with the top of the 32-inch stainless steel screen set approximately 1.25 ft below the water table in order for the sampling intake to be set at the midpoint of the screen.

Groundwater samples will be collected through the stainless steel screen using a mechanical bladder pump set at a flow rate of 100 milliliters per minute (mL/min). The SOP for the mechanical bladder pump is included in Attachment A (addendum to the FSP).

The flow rate for purging of groundwater will be dependent on the capacity of the mechanical bladder pump and the transmissivity of the aquifer material. Efforts will be made to maintain low flow during purging (i.e., 100 to 500 mL/min for purging). The minimum required water volume (i.e., three to five screen volumes) will be purged at the lowest sustainable flow rate. During the screen purging, field parameters such as pH, temperature, specific conductance, and turbidity will be monitored to evaluate the stabilization of the purged groundwater. The groundwater will be considered stable after a maximum of five well screen volumes are removed or when three successive readings for pH, specific conductance, and temperature agree within the following limits:

- pH: ± 0.1 pH units
- specific conductance: ± 3 percent (temperature corrected)
- temperature: ± 1.0 °C

pH, and temperature will be monitored using a YSI Model 3560 instrument. Turbidity will be measured using a HF Scientific DRT-15C Turbidimeter. Alternatively, equivalent instruments may be used.

For sampling intervals where the nature of the formation substantially restricts the flow of water during purging, purging will continue for a maximum of two hours. Groundwater



samples will be collected once the parameters have stabilized as detailed in the FSP, or once the maximum purging time has been reached. Groundwater samples will not be collected if attempts to purge and sample indicate the interval does not yield enough water to sample. If this occurs, the borehole location will be resituated, and another attempt to collect a groundwater sample will be made.

All groundwater samples will be analyzed for Target Compound List (TCL) VOCs and naphthalene on a regular (five-day) turnaround time basis.

The groundwater sample from the water supply well located 500 feet downgradient from MW-210 will be analyzed for TCL VOCs, naphthalene, and metals on a regular turnaround time basis.

For QA/QC purposes, CRA will submit one field duplicate for every 10 groundwater samples submitted. Based on the total expected number of groundwater samples to be collected during borehole advancement, CRA will submit three field duplicate groundwater samples. CRA will also submit one trip blank sample per shipment, for VOC analyses to assess the sample handling procedures.

The results of the Shallow Groundwater Investigation will be evaluated to identify locations within the study boundary where concentrations of VOCs or naphthalene in shallow groundwater at the Site boundary exceed the VI pathway 1×10^{-6} cancer risk or a HI of 1 for a residential exposure scenario. Following completion of the Shallow Groundwater Investigation, CRA will recommend any additional temporary boreholes, permanent monitoring wells, soil vapor investigation, or remedial activities required in order to further define or mitigate unacceptable risks posed by contaminants in shallow groundwater at the Site boundary between VAS-09 and VAS-22. Any additional investigation that is deemed necessary based on the results of the Shallow Groundwater Investigation will be completed on an expedited basis outside of the OU2 Remedial Investigation process unless otherwise agreed between the Respondents and USEPA.

3.0 SCHEDULE

Field work will begin within three weeks of receipt of USEPA approval of the Shallow Groundwater and VI Investigation Letter Work Plan, dependant on drilling subcontractor availability, and obtaining access to the various private properties and businesses.



**CONESTOGA-ROVERS
& ASSOCIATES**

December 17, 2010

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Reference No. 038443-89

4.0 REPORTING

CRA will post the validated analytical results to the South Dayton Dump and Landfill file transfer protocol (ftp) site immediately upon validation. Stratigraphic information will also be posted to the ftp site as soon as it is compiled from the field notes. The draft Shallow Groundwater and VI Investigation Report will be submitted to USEPA within 30 days of receipt of the final laboratory data report.

The draft Shallow Groundwater Investigation Report will provide a summary of results from the Shallow Groundwater Investigation and recommendations for further sampling or remedial actions required to identify and address any unacceptable risks to on- or off-Site receptors. The Shallow Groundwater Investigation Report will be finalized following receipt of comments from USEPA. Monthly progress reports submitted to USEPA during the investigative work will include the information required for monthly progress reports in the RI/FS SOW.

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

VC/ca/96

Encl.

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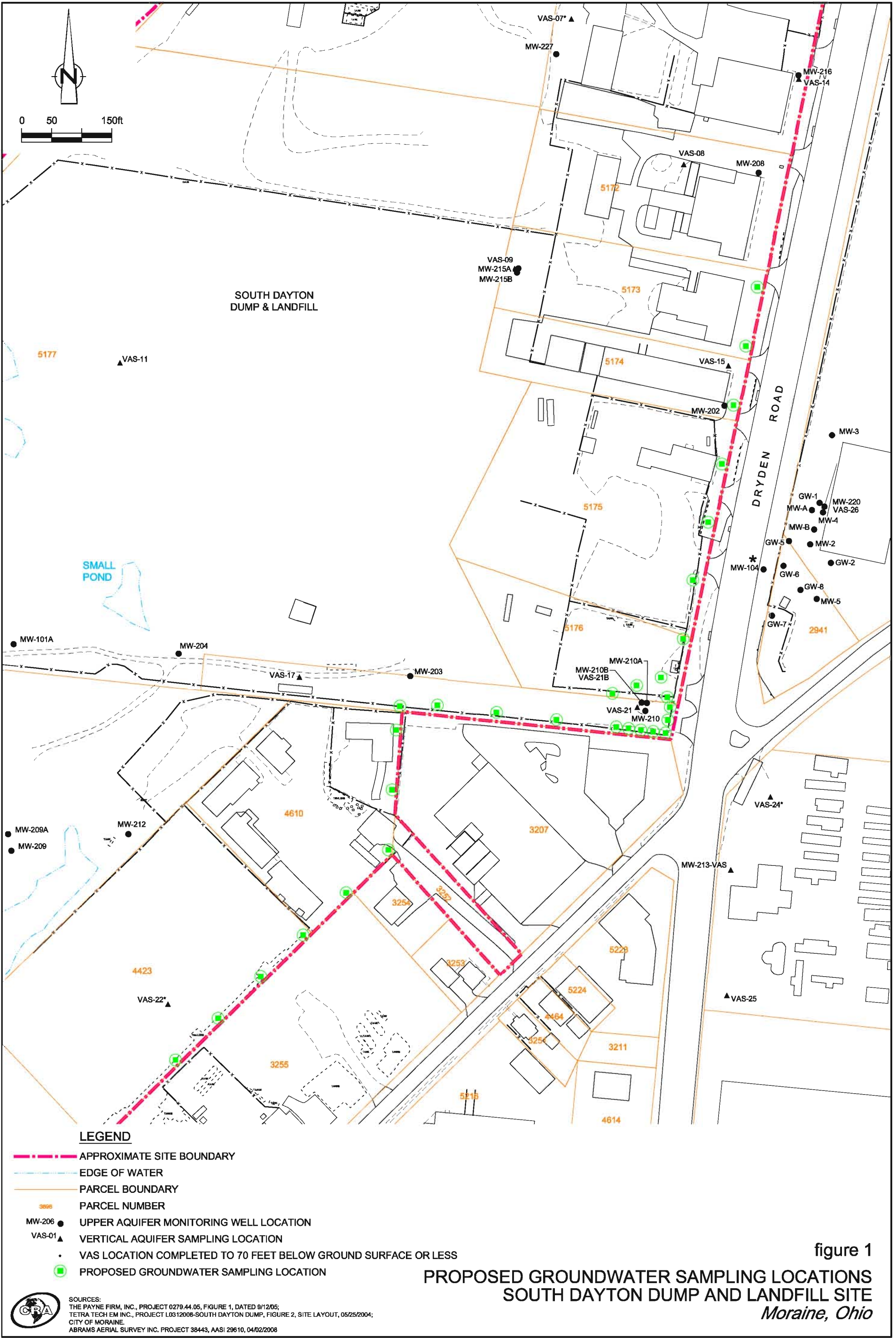
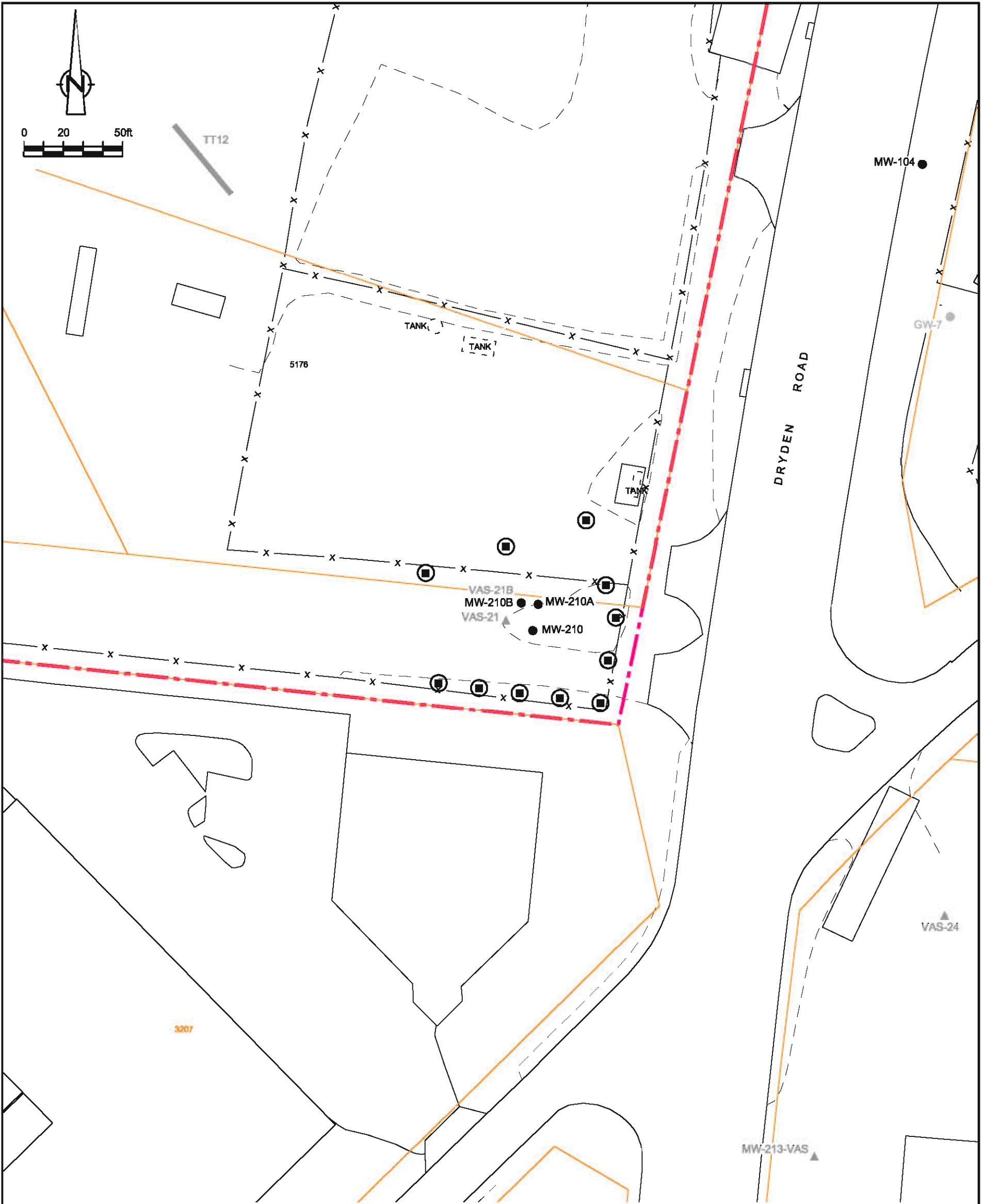


figure 1



LEGEND

- · — · — SITE BOUNDARY (SOW 2006)
- — — — — EDGE OF WATER
- — — — — PARCEL BOUNDARY
- MW-206 MONITORING WELL LOCATION
- MW-1 HISTORIC DP&L MONITORING WELL LOCATION
- TT1 TEST TRENCH LOCATION
- ▲ VAS01 VERTICAL AQUIFER SAMPLING LOCATION
- PROPOSED MEMBRANE INTERFACE PROBE (MIP) BOREHOLE LOCATION
(NOTE THAT ADDITIONAL LOCATIONS MAY BE ADDED BETWEEN THE LOCATIONS SHOWN TO BETTER DELINEATE THE PLUME)

figure 2
PROPOSED MW-210 BOREHOLE LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



SOURCES:
THE PAYNE FIRM, INC., PROJECT 0279.44.05, FIGURE 1, DATED 9/12/05;
TETRA TECH EM INC., PROJECT L0312006-SOUTH DAYTON DUMP, FIGURE 2, SITE LAYOUT, 05/25/2004;
CITY OF MORAINES
ABRAMS AERIAL SURVEY INC. PROJECT 38443, AASI 28810, 04/02/2008

ATTACHMENT A

VERTICAL AQUIFER SAMPLING/TEMPORARY MONITORING
WELL INSTALLATION AND SAMPLING BY GEOPROBE®

ATTACHMENT A

STANDARD OPERATING PROCEDURE FOR VERTICAL AQUIFER SAMPLING /TEMPORARY MONITORING WELL INSTALLATION AND SAMPLING BY GEOPROBE®

1.0 INTRODUCTION

Shallow vertical aquifer sampling (VAS) boreholes and temporary monitoring wells may be installed via direct-push Geoprobe methods.

Direct-push (a.k.a., Geoprobe) refers to the sampler being "pushed" into the soil material without the use of drilling to remove the soil. This method relies on the drill unit static weight, combined with rapid hammer percussion, to advance the tool string. Discrete soil samples are continuously obtained. It is important that the direct-push drilling method (i.e., Geoprobe) used minimizes the disturbance of subsurface materials.

This method is used extensively for initial site screening to establish site geology and delineate vertical and horizontal plume presence.

Standard Penetration Test (SPT) blow count values cannot be obtained when sampling with a direct-push discrete soil sampler.

The direct-push method is popular due to the limited volume of cuttings produced and the speed of the sampling process, which can be much faster than the sample description and sample preparation process.

Discrete continuous soil samples are collected in tube samplers (various lengths) affixed with a cutting shoe and internal liner [polyvinyl chloride (PVC), Teflon, or acetate are available]. The soil sampler may be operated in "open-mode" (when borehole collapse is not a concern), or in "closed-mode" (when minimization of sample "slough" is desired). Closed-mode operation involves placement of a temporary drill-point in the cutting shoe and driving the assembled sampler to depth. At the required depth, the temporary drill-point is released (via internal threading) and the sampler is driven to the desired soil interval. The drill-point slides inside the sample liner, riding above the collected soil column. Once driven to depth, the sampler is retrieved to the ground surface and the sample liner, with soil, is removed for examination. Extra care must be taken when cutting open the sample tube; no open blade cutting tools may be used in the process, you must have an appropriate stabilizer/holder for the tube, and cut resistant hand protection must be included as part of the overall PPE.

The Geoprobe drilling method should not contaminate the subsurface soils and groundwater. It is extremely important that drilling does not create a hydraulic link or conduit between different hydrostratigraphic units. Groundwater in monitoring and extraction wells must not be contaminated by drilling fluids or the borehole advancement process. Geoprobe drilling equipment will be decontaminated before use and between locations to prevent cross-contamination between VAS boreholes or temporary monitoring well locations and sites. Geoprobe drilling equipment will be decontaminated between well locations regardless of whether or not contaminants are suspected. Section 7.0 in the FSP specifies the required decontamination procedures. At a minimum, decontamination procedures detailed in Section 7.0 of the FSP should be used during monitoring well design and construction.

A Geoprobe SP16 will be used for shallow VAS and temporary monitoring well activities. The SOP for the Geoprobe SP16 Groundwater Sampler is included in Attachment A (addendum to the FSP). The Geoprobe SP16 is a direct push groundwater sampling device that consists of a well screen inside a steel sheath that is driven to the desired sample depth using standard Geoprobe rods. The Geoprobe SP16 is then deployed by retracting the steel sheath and exposing the well screen directly to the formation. The maximum well screen length of the Geoprobe SP16 is 32 inches. Generally, the full 32-inch well screen will be used for VAS and temporary monitoring well activities. Groundwater samples will be collected through the stainless steel screen using a mechanical bladder pump set at a flow rate of 100 milliliters per minute (mL/min) (a peristaltic pump may also be use). The SOP for the mechanical bladder pump is included in Attachment A (addendum to the FSP). The VAS or temporary monitoring well location will then be abandoned using grouting.

Finally, if a permanent monitoring well is required, pre-cleaned construction materials are used in order to prevent the potential introduction of contaminants into a hydrostratigraphic unit. Permanent monitoring well installation is discussed in Section 2.7 of the FSP.

2.0 PLANNING AND PREPARATION

Prior to undertaking shallow VAS or temporary groundwater monitoring well installation and sampling utilizing a Geoprobe the following procedures will be followed:

1. Review the appropriate Work Plan and Site-Specific Health and Safety Plan (HASp), project documents, all available geologic and hydrogeologic mapping and reports, water well records, and historic site reports to become familiar with

the geologic and hydrogeologic framework of the site and surrounding area. Review and become familiar with the health and safety requirements, and discuss the work activities with the Project Coordinator.

2. Assemble all required equipment, materials, log books, and forms.
3. Obtain a site plan and previous stratigraphic logs. Determine the exact number, location, and depth of wells to be installed.
4. If not performed as part of borehole advancement, complete a Property Access/Utility Clearance Data Sheet. In most instances, the utility clearances and property access will have been completed as part of the well drilling and advancements.
5. Determine notification requirements with the Project Coordinator. Have all regulatory groups, the client, landowner, drilling contractor, and CRA personnel been informed of the well design and installation program?
6. Determine the methods for handling and disposal of cuttings, purged groundwater, and decontamination fluids. Generally, this is dealt with as part of the well advancement activities.

In addition to the above, the following may be required when conducting VAS or temporary monitoring well installation and sampling activities:

1. Establish a water source for well installation and decontamination. Pre-plan the methods of handling and disposal of well installation and decontamination fluids.
2. Arrange with the drilling contractor/client to provide a means of containment and disposal of fluids.

3.0 EQUIPMENT DECONTAMINATION

Prior to use and between each borehole location, drilling and sampling equipment must be decontaminated in accordance with Section 7.0 of the FSP.

4.0 LOCATION AND MARKING OF VAS/TEMPORARY MONITORING WELL SITES/FINAL VISUAL CHECK

The proposed investigative locations marked on the site plan are located and staked in the field. This should be completed several days prior to the drill rig arriving on site. Investigative locations are required for the completion of utility locates. Generally, VAS

or temporary monitoring well locations are strategically placed to assess site hydrogeologic conditions.

Once the final VAS or temporary monitoring well location has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds to confirm the locations of adjacent utilities (subsurface or overhead) and verify adequate clearance. If gravity sewers or conduits exist in the area, access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

When possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to confirm that there are no buried utilities or pipelines. This is particularly important in limited space sites where wells are being installed close to buried utilities. Alternatively, a Hydrovac truck can vacuum a large diameter hole to check for utilities, although soils collected this way may require containment on site. This procedure generally clears the area to the full diameter of the drilling equipment which will follow.

Caution: *Do not assume that site plan details regarding pipe alignment/position are correct. Visually inspect pipe alignment when advancing boreholes near sewers. Be prepared to find additional piping if outdated plans are being used. If possible confirm pipe locations with on-site employees or a client representative.*

Investigative locations are selected primarily to provide a good geographical distribution across the site. Most often, the VAS or temporary monitoring well locations specified in the Work Plan are not pre-verified to confirm clearance from underground or overhead utilities, or to consider site-specific physical characteristics (e.g., traffic patterns, drainage patterns). Consequently, it is the Field Supervisor's responsibility to perform the following:

1. Select the exact location of each well consistent with the site and project requirements.
2. If a VAS or temporary monitoring well location must be relocated more than 20 feet (5.7 m) from the initially identified location, confirm the new location's suitability with the Project Coordinator.
3. Ensure all utilities have been cleared prior to initiating borehole advancement activities.

To the extent practical, wells should be located adjacent to permanent structures (e.g., fences, buildings) that offer some form of protection and a reference point for

future identification. Wells located in high traffic areas or road allowances or low-lying wet areas are undesirable, but may be unavoidable.

5.0 **PROCEDURES FOR VERTICAL AQUIFER SAMPLING/TEMPORARY MONITORING WELL INSTALLATION AND SAMPLING BY GEOPROBE**

The direct push procedure will use the Geoprobe, as follows:

1. The direct push drill rig will advance the borehole using methods consistent with ASTM Standard D6724-04 (Appendix J-H-4 of the FSP).
2. The direct push borehole will be advanced from ground surface to the top five feet of shallow groundwater. Soil cores will be collected using Geoprobe® MacroCore® sampling techniques or equivalent. Soil cores will be collected throughout the entire length of the borehole.
3. Representative samples will be logged immediately after opening the acetate liner. Field measurements of undifferentiated VOCs will be conducted by placing representative soil samples into a closed sample container and allowing them to equilibrate. The VOCs in the headspace will then be measured by placing the wand of the PID into the headspace. Field calibration, preventative maintenance, and SOPs for the PID are contained in Section 6.0 of the FSP.
4. The soil core will be logged by CRA personnel and soils will be classified using the USCS in accordance with ASTM Method D-2488-06 (Appendix J-H-2). Soil stratigraphy will be described on an Overburden Stratigraphy Log, an example of which is in Appendix J-G of the FSP.
5. Following the field screening and logging of the soil stratigraphy at each borehole, the Geoprobe will be offset approximately 1 foot from the borehole in order to collect a groundwater sample while preventing drawdown.
6. VAS will be conducted beginning no deeper than 5 feet below the water table unless otherwise specified in the Work Plan. Temporary monitoring well sampling will be conducted within the top 5 feet of the water table unless otherwise specified in the Work Plan.
7. A pre-cleaned Geoprobe® SP16 groundwater sampler will be assembled as per manufacturer's operational procedure. A description of the Geoprobe® SP16 is provided in Section 1.0 of this SOP.
8. New 1/4-inch diameter tubing will be installed and attached to a peristaltic or bladder pump. Groundwater will be purged from the Geoprobe® SP16 groundwater sampler using the pump. A minimum of three to five screen point well volumes will be purged at the same rate as the low flow sampling prior to commencing stabilization monitoring. Field measurements of pH, conductivity,

turbidity, and temperature will be collected at approximate 5-minute intervals. If it is apparent that stabilization will not be achieved quickly, stabilization parameter measurements may be made at a greater time interval. Stabilization monitoring will be performed using a flow-through-cell. All field measurements will be recorded in the field book.

The groundwater will be considered stable after a maximum of five well volumes are removed or when three successive readings for pH, specific conductance, turbidity, and temperature agree within the following limits:

- pH: ± 0.1 pH unit
 - Specific conductance: $\pm 3\%$ (temperature corrected)
 - Temperature: ± 1.0 °C
 - Turbidity: or < 5 NTU
9. Once field parameters have stabilized, groundwater samples will be collected directly from the discharge line in laboratory-supplied, analyte-specific sample containers and preserved according to laboratory requirements. Groundwater samples collected for VOC analysis will be collected from the tubing before it reaches the pump head, by crimping the tubing, detaching it from the pump, and pouring the water into the vial.
 10. VAS and temporary monitoring well samples will be analyzed for parameters detailed in the Work Plan. The Geoprobe® SP16 groundwater sampler will be decontaminated between samples following the procedures in Section 7.0 of the FSP.
 11. Upon reaching the total depth of the VAS or temporary monitoring well location, the downhole equipment will be removed from the borehole and the borehole will be backfilled with pure bentonite slurry grout.
 12. All downhole equipment such as drill rods and sample tools will be decontaminated as discussed in Section 7.0 of the FSP.
 13. Drill cuttings and decontamination water will be managed as discussed in Section 8.0 of the FSP.

6.0 SOIL SAMPLE COLLECTION FROM GEOPROBE DRILLING CORES

When borehole drilling, the core sample retrieved from the borehole is considered a discrete grab sample that has been taken from one sampling location, as long as both the stratigraphy of the entire sample and the level of contamination are consistent over the length of the core sample. If a single core sample contains soils from two different

stratigraphic units, the soils from each of these stratigraphic units are considered separate discrete grab samples.

If a single core sample contains soils from a single stratigraphic unit, but visual observation indicated that some of the soil was heavily impacted with contaminants, while the rest of the soil was only lightly impacted, then the soils representing each of the two levels of contamination are considered two separate discrete grab samples.

If required, representative soil samples will be collected from the drilling cores in accordance with the following procedures.

- i. Once removed to the ground surface, open the discrete soil sampler by removing the cutting shoe, and extract the soil liner (with recovered soil) from the sampler body.
- ii. Place the soil liner into a holder and cut lengthwise (using a liner knife) to expose the collected soil core.
- iii. Perform PID screening for organic vapors and record readings.
- iv. Measure length of sample and record as the recovered length.
- v. Representative soil samples will be collected from Geoprobe drilling cores using a pre-cleaned stainless steel trowel or other appropriate tool (e.g., spoons or push tube).
- vi. Use a new pair of disposable gloves for each sample.
- vii. Prior to use, for each sample, decontaminate all sampling tools as specified in the Work Plan or as described in Section J.7 of the FSP.
- viii. Use a pre-cleaned sampling tool to remove the sample from the layer of exposed soil. For clayey or cohesive soils,
 - a. Discard upper and lower ends of sample core (3 inches) if near the area to be sampled.
 - b. Use a pre-cleaned stainless steel knife.
 - c. Cut the portion of the core to be sampled longitudinally.
 - d. With a sample spoon, remove soil from the center portion of the core and place in a pre-cleaned stainless steel bowl.
 - e. Remove large stones and natural vegetative debris.
 - f. Homogenize the soil and place directly into sample jars.

For sandy or non-cohesive soils, as sandy soils have less cohesion than clayey soils, it is not easy to cut the core longitudinally to remove the center of the sample. Therefore, with a stainless steel spoon, scrape away surface soils which have likely contacted the sampler and then sample the center portion of the soil core.

Note: Samples for VOC analysis must not be homogenized. Collect soil samples for VOC analysis in En Core™ Samplers (refer to Appendix J-F-24 of the FSP). Completely fill the container. No air space (headspace) should remain in the sample container.

- ix. Place the collected soil directly into a clean, pre-labeled sample jar and seal with a Teflon-lined cap. If a sample is to be split for duplicate analyses, first homogenize the soil in a pre-cleaned stainless steel bowl (with the exception of samples for VOC analysis, which shall be placed directly in the sample jar and not homogenized in order to prevent volatilization of the VOCs).

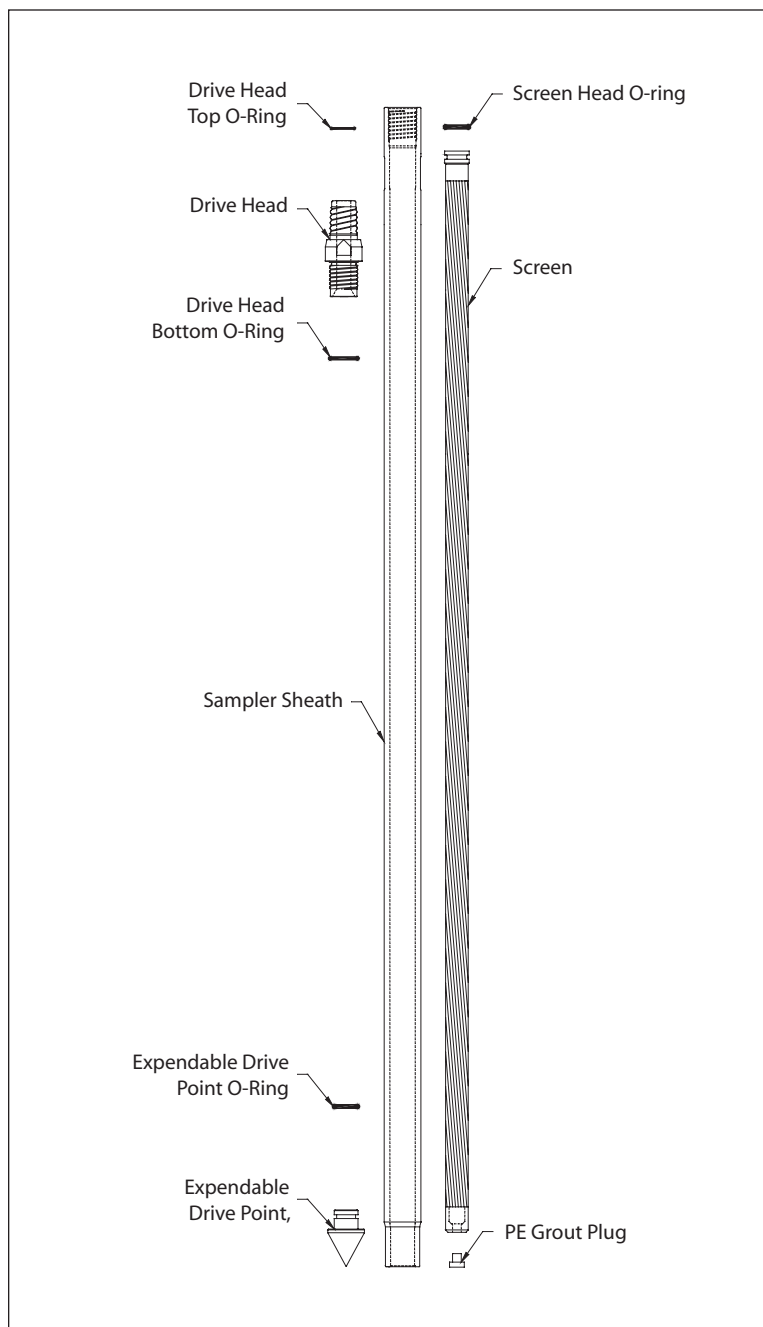
Note: Place all soil samples collected for chemical analysis immediately into a cooler with ice.

GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3142

PREPARED: November, 2006



GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS



**Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image® are
Registered Trademarks of Kejr, Inc., Salina, Kansas**

**Screen Point 16 Groundwater Sampler is manufactured
under U.S. Patent 5,612,498**

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ing from Kejr, Inc.

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 16 (SP16) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may chose to use this sampler in soils where driving is difficult.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of the these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

(continued on following page)

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

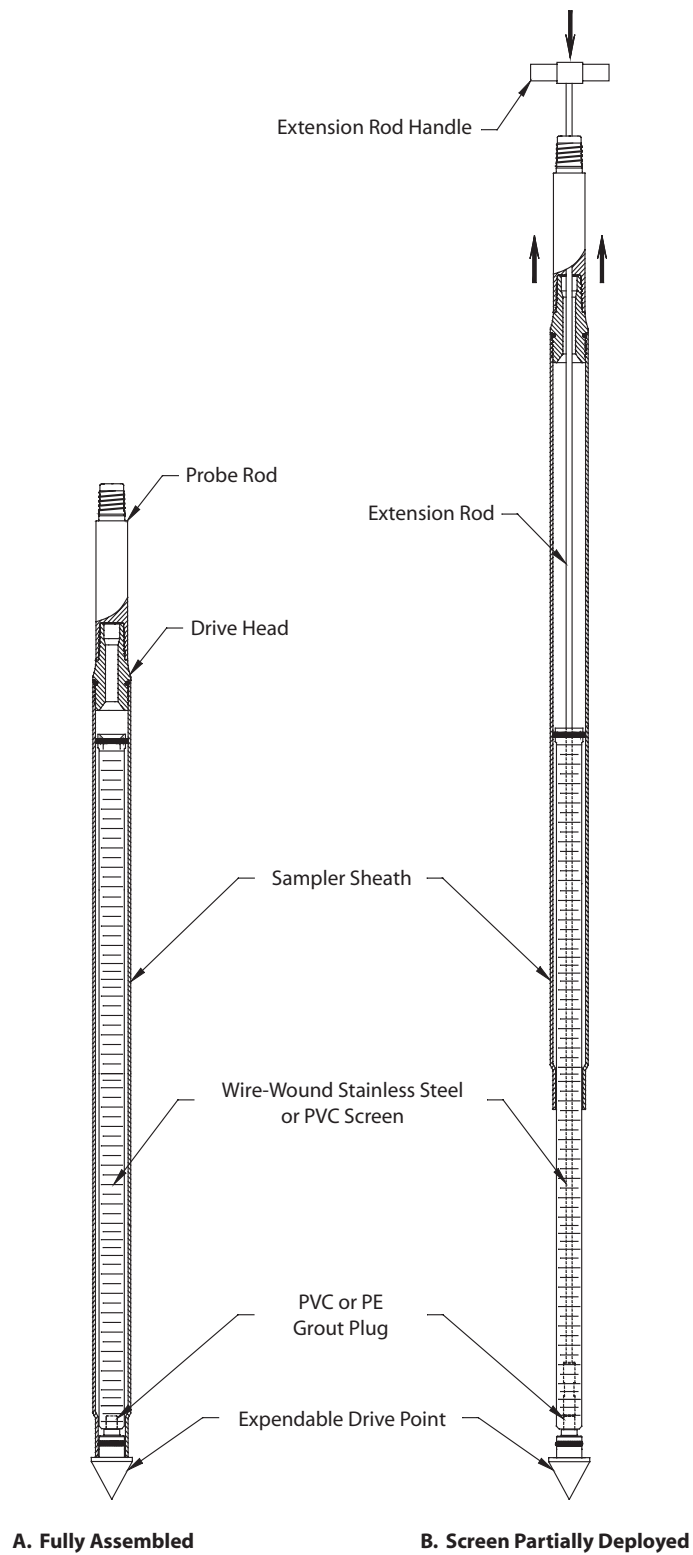


FIGURE 2.1
Screen Point 16 Groundwater Sampler

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

SP16 Sampler Parts	Part Number
SP16 Sampler Sheath.....	15187
SP16 Drive Head, 0.5-inch bore, 1.5-inch rods*	18307
SP16 O-ring Service Kit, 1.5-inch rods (<i>includes 4 each of the O-ring packets below</i>)	15844
<i>O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)</i>	15389
<i>O-rings for Bottom of SP16 Drive Head (Pkt. of 25)</i>	13196
<i>O-rings for GW1520 Screen Head (Pkt. of 25)</i>	GW1520R
<i>O-rings for SP16 Expendable Drive Point (Pkt. of 25)</i>	GW1555R
Screen, Wire-Wound Stainless Steel, 4-Slot*	GW1520
Grout Plugs, PE (Pkg. of 25)	GW1552K
Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)*	GW1555K
Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods (<i>includes 1 each of:</i> 15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K)	15770

Probe Rods and Probe Rod Accessories	Part Number
Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer)	12787
Pull Cap, 1.5-inch probe rods	15090
Probe Rod, 1.5-inch x 60-inch*	11121

Extension Rods and Extension Rod Accessories	Part Number
Screen Push Adapter.....	GW1535
Grout Plug Push Adapter.....	GW1540
Extension Rod, 60-inch*	10073
Extension Rod Coupler.....	AT68
Extension Rod Handle	AT69
Extension Rod Jig.....	AT690
Extension Rod Quick Link Coupler, pin.....	AT695
Extension Rod Quick Link Coupler, box.....	AT696

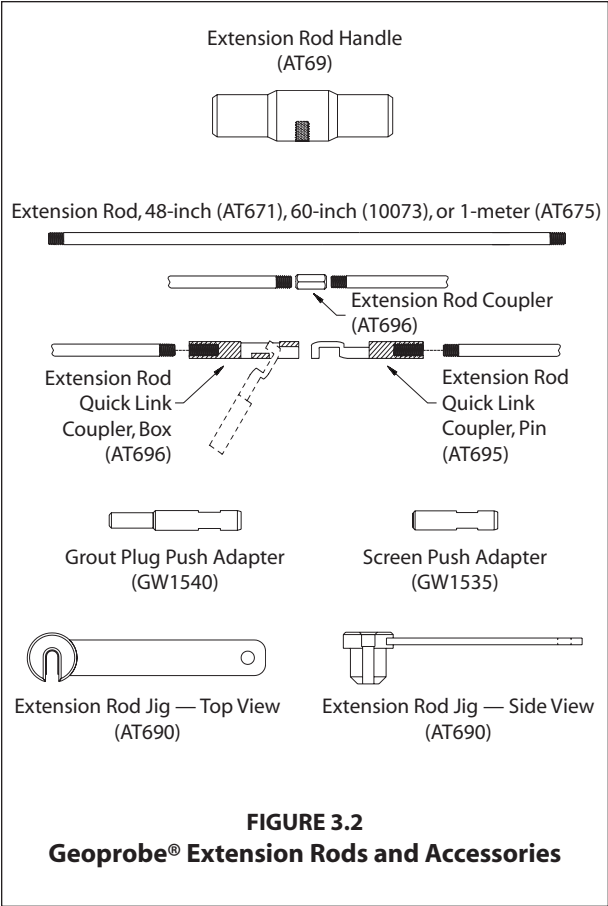
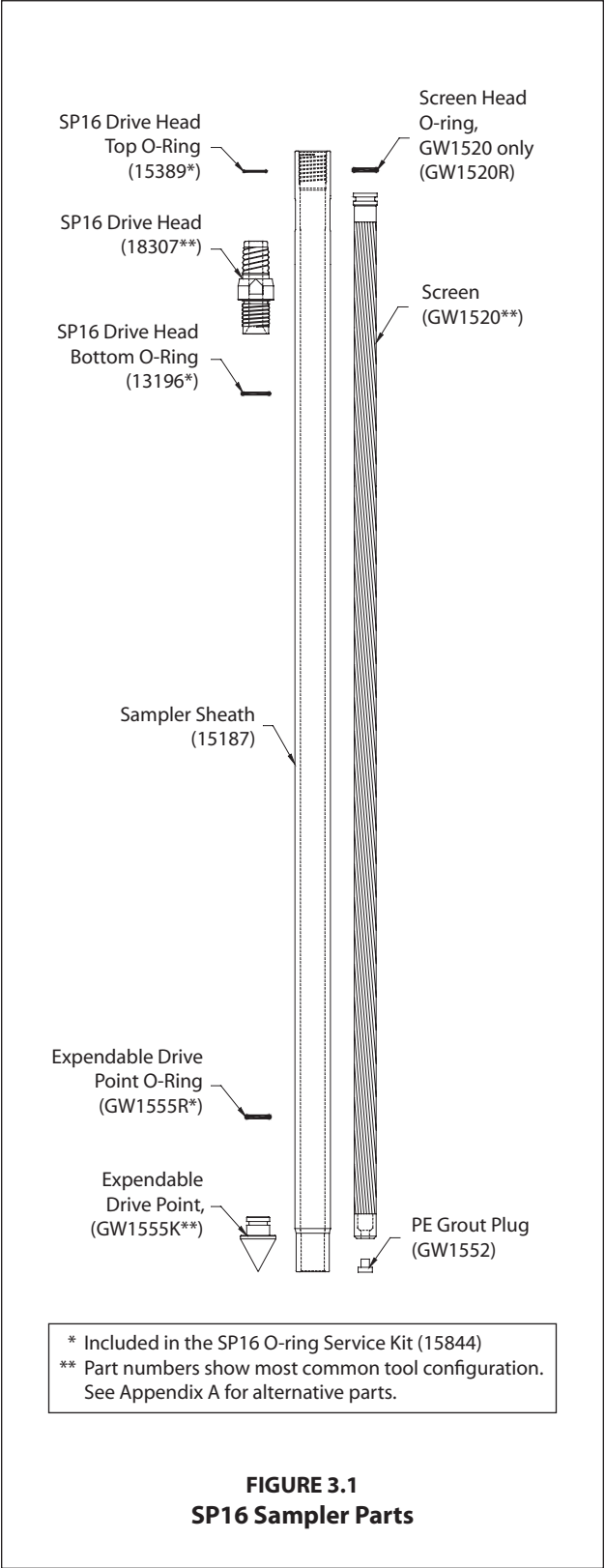
Grout Accessories	Part Number
Grout Nozzle, for 0.375-inch OD tubing	GW1545
High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m).....	11633
Grout Machine, self-contained*	GS1000
Grout System Accessories Package, 1.5-inch rods	GS1015

Groundwater Purging and Sampling Accessories	Part Number
Polyethylene Tubing, 0.375-inch OD, 500 ft. *	TB25L
Check Valve Assembly, 0.375-inch OD Tubing*	GW4210
Water Level Meter, 0.438-inch OD Probe, 100 ft. cable*	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, stainless steel.....	GW41

Additional Tools	Part Number
Adjustable Wrench, 6.0-inch	FA200
Adjustable Wrench, 10.0-inch	FA201
Pipe Wrenches	NA

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



4.0 OPERATION

4.1 Basic Operation

The SP16 sampler utilizes a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

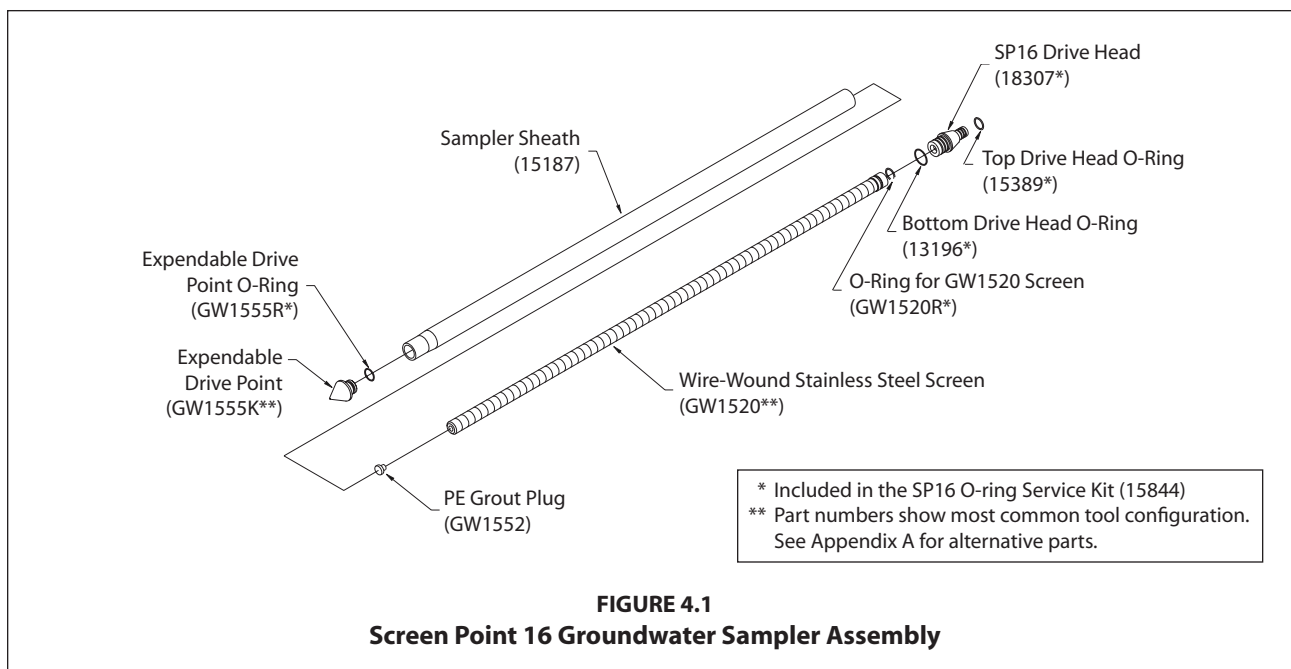
4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).
2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.
3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.
4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

NOTE: The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

Sampler assembly is complete.

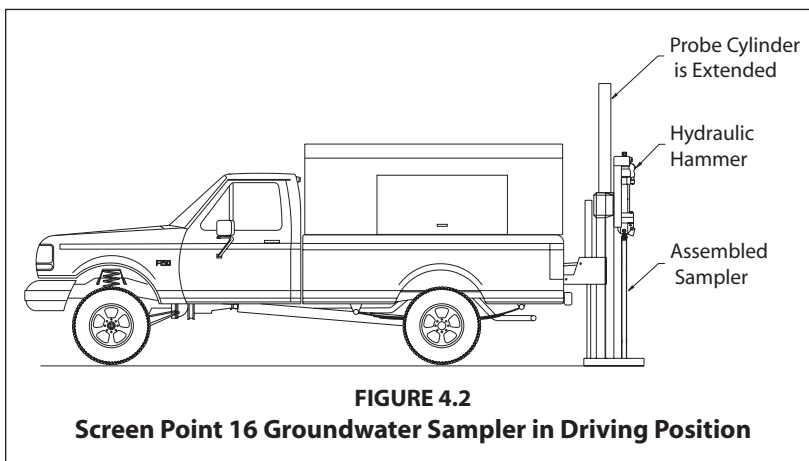


4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.
2. Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.
3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.



4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.
5. Remove the drive cap and retract the probe derrick away from the tool string.

4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.
2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.
3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.
4. Maneuver the probe assembly into position for pulling.
5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

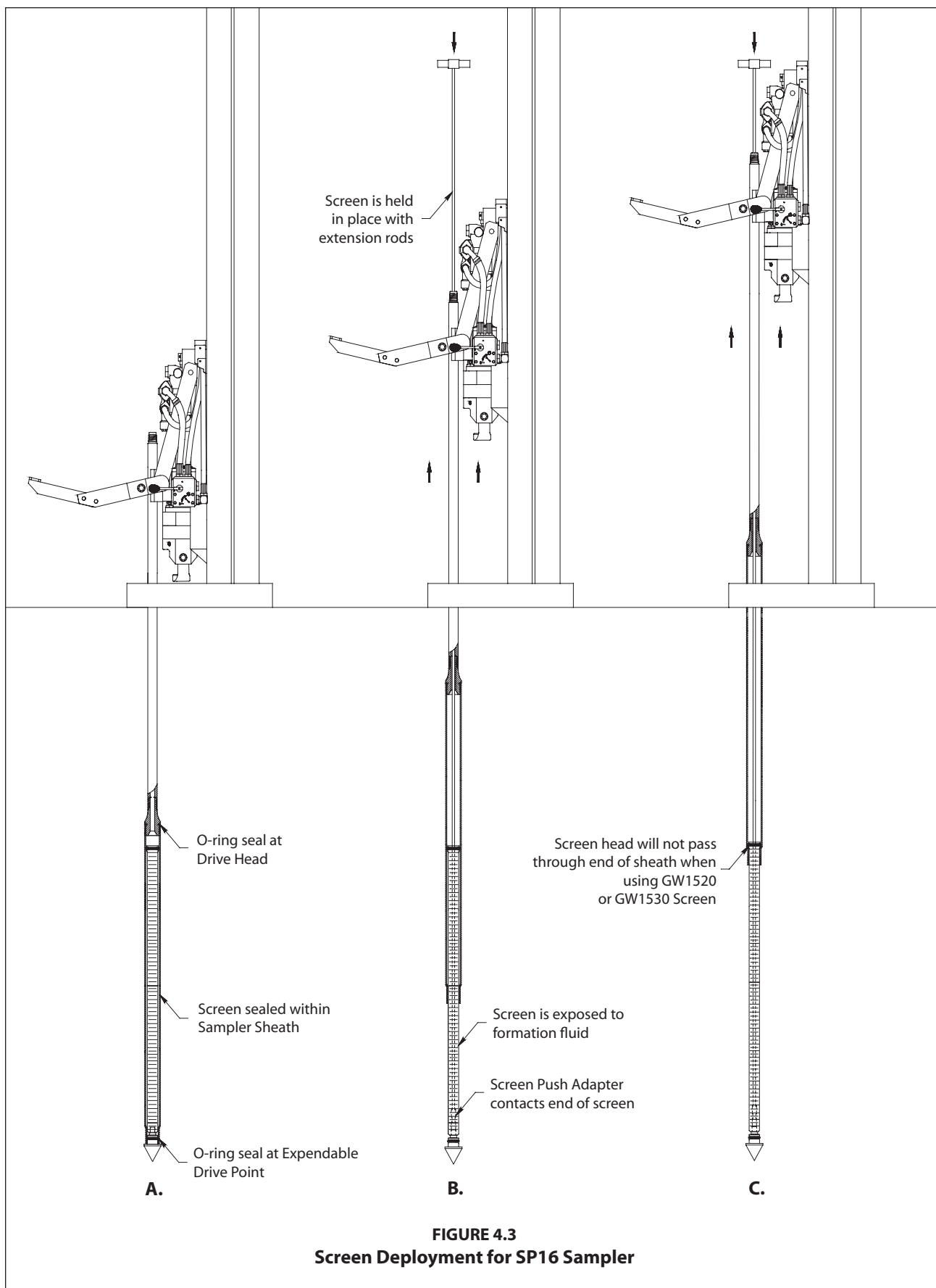
6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.
7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

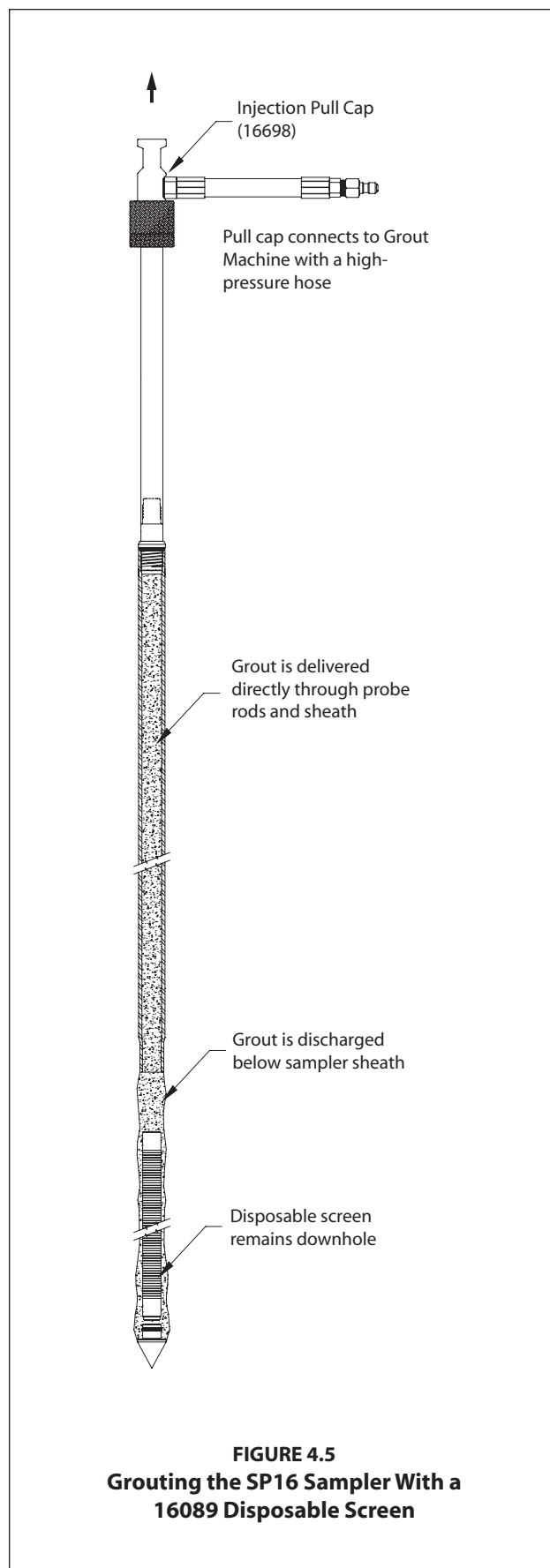
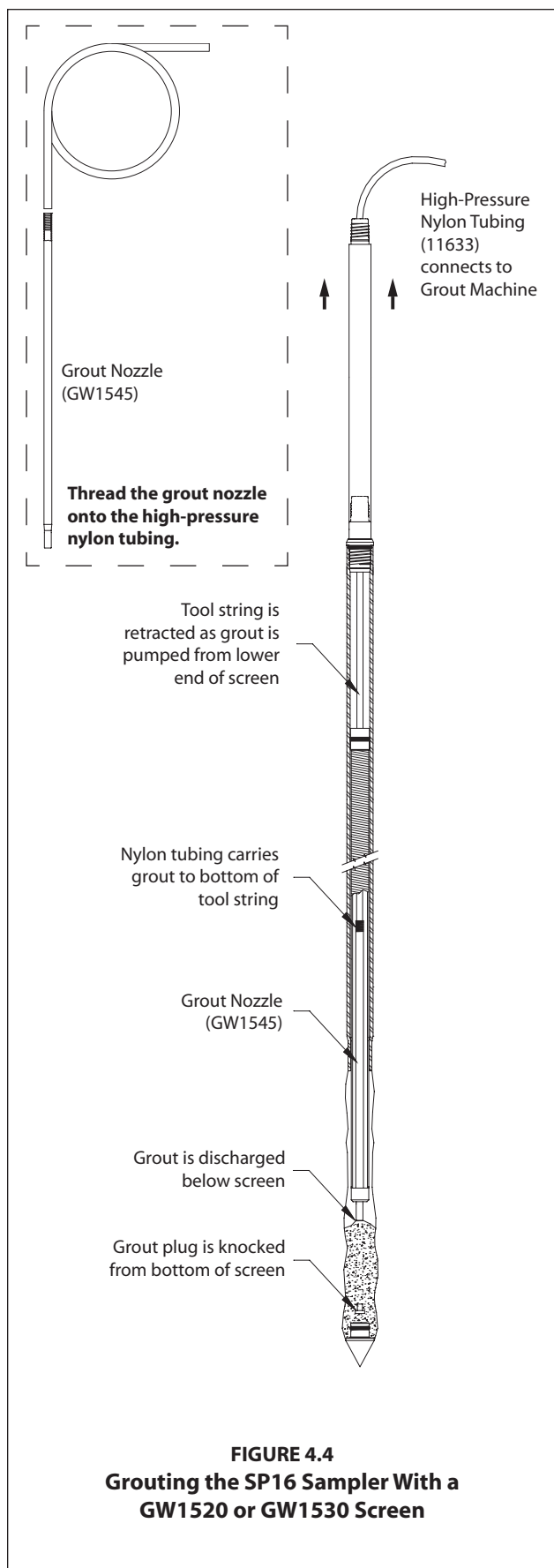
When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.
2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.





3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

Note: When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

Note: All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.
6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.
7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.
2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.
3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.
4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.
6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.
7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

5.0 REFERENCES

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- American Society of Testing and Materials (ASTM), 1993. ASTM 5299 *Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities*. ASTM West Conshohocken, PA. (www.astm.org)
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- Geoprobe Systems®, 2006, *Model MB470 Mechanical Bladder Pump Standard Operating Procedure (SOP), Technical Bulletin No. MK3013*.
- Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.
- U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.

Appendix A ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

SP16 Sampler Parts and Accessories.....	Part Number
SP16 Drive Head, 0.625-inch bore, 1.5-inch rods.....	15188
Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25).....	GW1555ALK
Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25).....	17066K
Screen, PVC, 10-Slot	GW1530
Screen, Disposable, PVC, 10-Slot	16089

Groundwater Purging and Sampling Accessories	Part Number
Polyethylene Tubing, 0.25-inch OD, 500 ft.....	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft.....	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft.....	TB50L
Check Valve Assembly, 0.25-inch OD Tubing.....	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200-ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

Grouting Accessories.....	Part Number
Grout Machine, auxiliary-powered	GS500

Probe Rods, Extension Rods, and Accessories	Part Number
Probe Rod, 1.5-inch x 1-meter	17899
Probe Rod, 1.5-inch x 48-inch.....	13359
Drive Cap, 1.5-inch rods (for GH40 Series Hammer)	15590
Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer)	GH1555
Extension Rod, 48-inch.....	AT671
Extension Rod, 1-meter	AT675

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.



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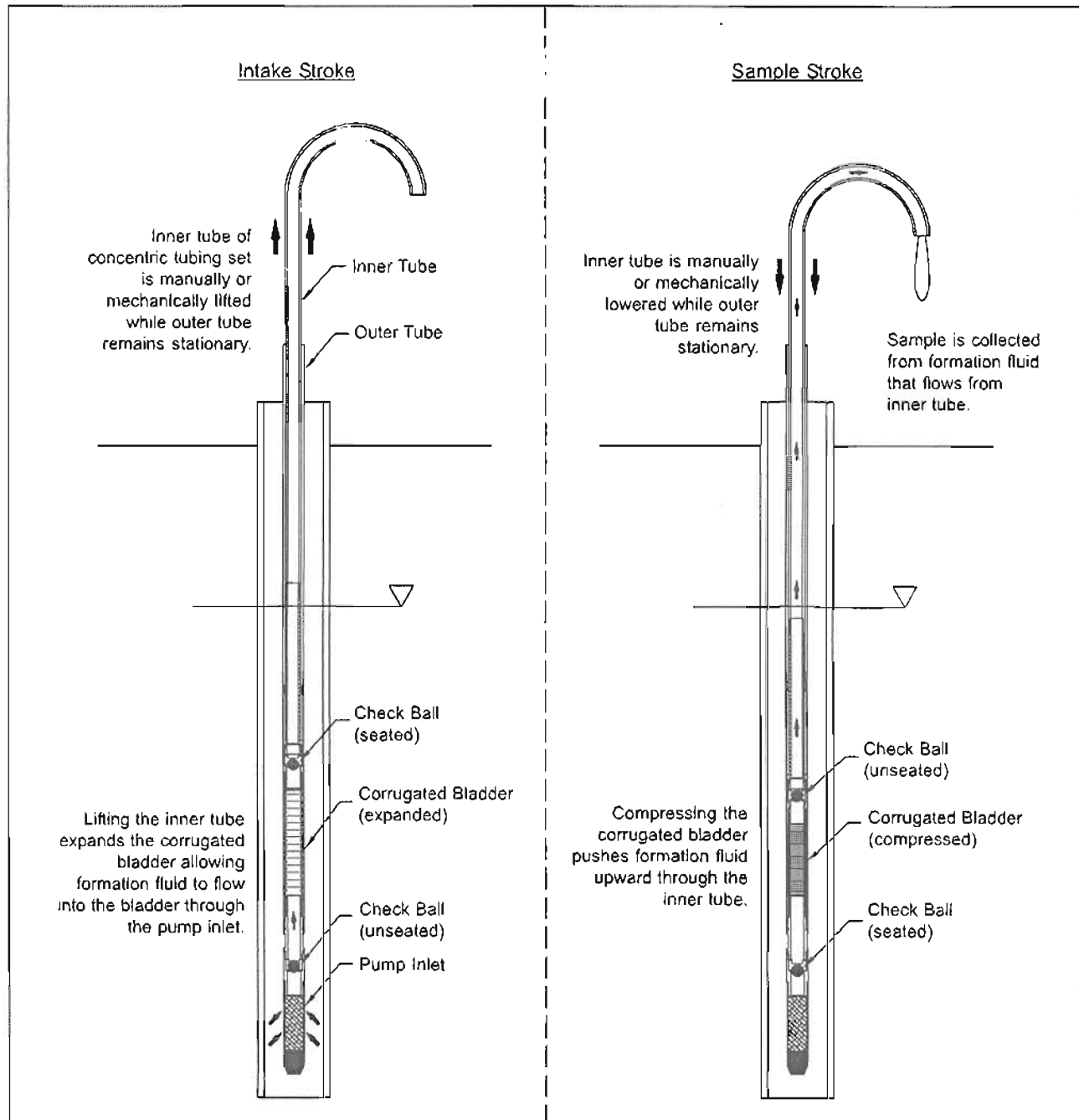
GEOPROBE® MODEL MB470 MECHANICAL BLADDER PUMP

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3013

PREPARED: November, 2003

REVISED: July, 2006



INTAKE AND SAMPLE STROKES OF THE MB470 MECHANICAL BLADDER PUMP



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are Registered Trademarks of Kejr, Inc., Salina, Kansas**

**The Mechanical Bladder Pump is manufactured under
U.S. Patent No. 6,877,965 issued April 12, 2005.**

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1.0 OBJECTIVE

The objective of this document is to provide guidance on how to collect a representative sample of the subsurface formation fluid utilizing the Geoprobe® Model MB470 Mechanical Bladder Pump.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.

**Geoprobe® and Geoprobe Systems® are registered trademarks of Kejr, Inc., Salina, Kansas.*

MB470 Mechanical Bladder Pump (MBP)**: A device for obtaining high-quality, low-turbidity samples from groundwater monitoring wells and direct push installed groundwater samplers as small as .5 inches (13 mm) inside diameter (ID). The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

***The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

Within the MB470 pump body, a corrugated Teflon® fluorinated ethylene propylene (FEP) bladder is mechanically compressed and expanded to push groundwater to the surface through a concentric tubing set. Check valves above and below the bladder control flow direction. The outer tube of the concentric tubing set holds the pump body in place while the inner tube is used to actuate the bladder and transmit water to the surface. The pump body and internal components are made of stainless steel with an outside diameter (OD) of .47 inches (12 mm) and an overall length of 26.75 inches (679 mm) with an inlet screen assembly installed.

2.2 MBP System Components

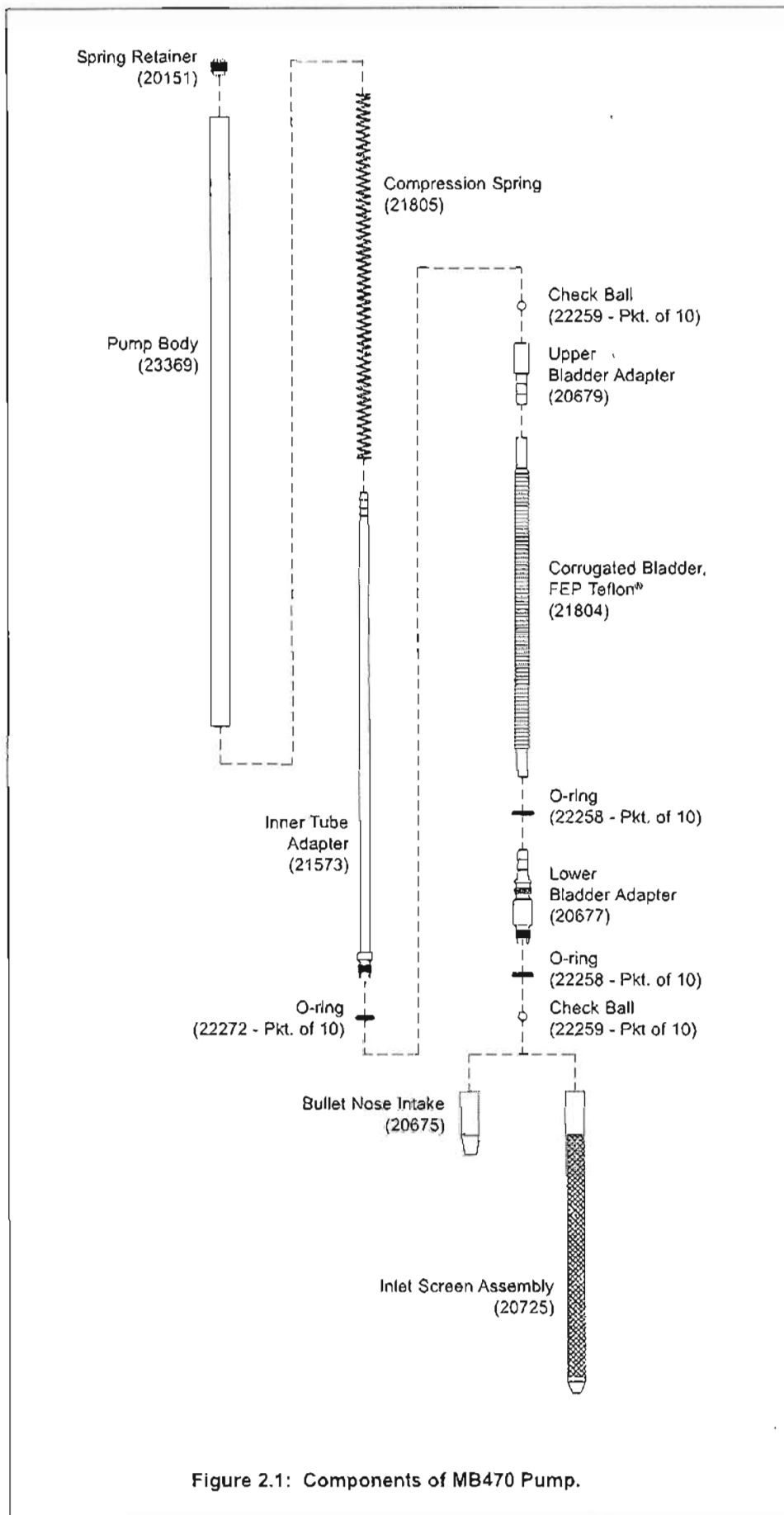
The three basic components of the Model MB470 Mechanical Bladder Pump system are the pump, concentric tubing set, and actuator.

Pump

All pump components (Fig. 2.1) are made of stainless steel material with the exception of the three fluorosilicone O-rings and the Teflon® bladder.

Beginning at the downhole end of the pump, either a Bullet Nose Intake (P/N 20675) or Inlet Screen Assembly (P/N 20725) may be used as determined by project requirements. The screen assembly includes a 60 mesh wire screen with an actual screen length of 6 inches (152 mm). The bullet nose intake is open at the leading end and provides no filtering effect.

Above the intake/inlet, the pump body contains the corrugated bladder and check balls that physically move groundwater to the surface for purging and sampling. As the top of the bladder is extended, the expanding action of the bladder draws groundwater into the bladder through the intake/inlet. Compressing the bladder then pushes the groundwater up through the connected inner tube of the concentric tubing set. Check balls at the Upper and Lower Bladder Adapters (P/N 20679 and 20677) control groundwater flow through the bladder.



The lower end of the corrugated bladder is secured to the pump body by the Lower Bladder Adapter (P/N 20677). The top of the bladder is attached to the inner tube of the concentric tubing set by the Upper Bladder Adapter (P/N 20679) and Inner Tube Adapter (P/N 21573). During operation of the pump, the inner tube is raised and lowered to expand and contract the bladder to move formation fluid to ground surface.

Concentric Tubing Set

A concentric tubing set for the MB470 Mechanical Bladder Pump commonly consists of .19-inch (5 mm) ID / .25-inch (6 mm) OD Teflon[®] fluorinated ethylene propylene (FEP) tubing surrounded by .31-inch (8 mm) ID / .44-inch (11 mm) OD high-density polyethylene (HDPE) tubing. Where allowed by project requirements, other materials (e.g. low-density polyethylene (LDPE) tubing) may be utilized in place of the Teflon[®] inner tubing.

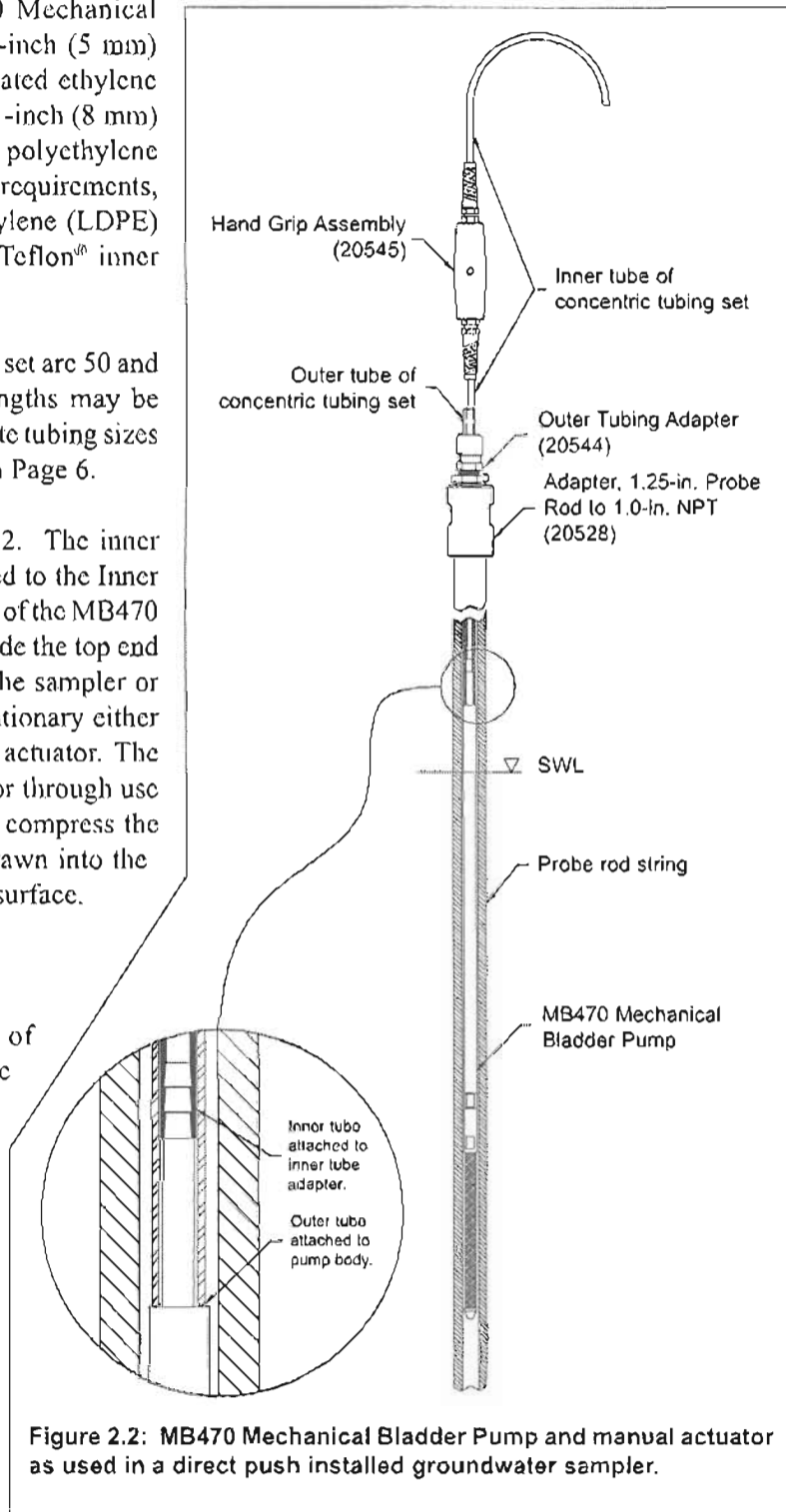
Available lengths for the concentric tubing set are 50 and 100 feet (15.2 and 30.5 m). Custom lengths may be assembled from 500-foot rolls of appropriate tubing sizes and materials, some of which are listed on Page 6.

Refer to the magnified view in Figure 2.2. The inner tube of the concentric tubing set is attached to the Inner Tube Adapter (P/N 21573) during assembly of the MB470 pump. The outer tube is then threaded inside the top end of the pump body. Once lowered down the sampler or monitoring well, the outer tube is held stationary either manually or by attachment to a mechanical actuator. The inner tube is raised and lowered by hand or through use of the mechanical actuator to expand and compress the pump bladder. Formation fluid is thus drawn into the pump bladder and then pushed to ground surface.

Actuator

Actuators provide the physical means of holding the outer tube of the concentric tubing set stationary while cycling the inner tube up-and-down. Actuator kits are available for manually or mechanically powering the MB470 pump.

For the manual actuator shown in Figure 2.2, the outer tube of the concentric tubing set is attached to the probe rods using two adapters. The inner tubing is raised and lowered by hand to obtain the groundwater sample. Refer to Section 4.4 for more actuator options.



3.0 REQUIRED EQUIPMENT

The following equipment is required to collect representative groundwater samples using the Model MB470 Mechanical Bladder Pump. Refer to Figure 3.1 for identification of the specified parts.

<u>Pump Components</u>	<u>Quantity</u>	<u>Part Number</u>
Mechanical Bladder Pump	-1-	MB470
Service Parts Kit, for MB470 Pump	-1-	MB7500
Includes: O-ring Pick	-1-	AT102
Corrugated Bladder, Teflon® FEP	-3-	21804
Compression Spring, Stainless Steel (SS)	-1-	21805
O-rings for Lower Bladder Adapter (#5-585 Fluorosilicone), Pkg. of 10	-1-	22258
O-rings for Inner Tube Adapter (#010 Fluorosilicone), Pkg. of 10	-1-	22272
Check Balls (7/32-in. diameter), SS, Pkg. of 10	-1-	22259
MBP Assembly Tool	-1-	20456
MBP Cleaning Brush Kit	-1-	MB7300
MBP Assembly Tool	-1-	20456

<u>Tubing Options</u>	<u>Quantity</u>	<u>Part Number</u>
Concentric Tubing Set, HDPE (outer)/FEP (inner), .44-in. OD x 50-ft. length	Variable	MB5050
Concentric Tubing Set, HDPE/FEP, .44-in. OD - 100-ft. length	Variable	MB5100
Concentric Tubing Set, HDPE/LDPE, .44-in. OD - 50-ft. length	Variable	MB5051
Concentric Tubing Set, HDPE/LDPE, .44-in. OD - 100-ft. length	Variable	MB5101
Concentric Tubing Set, HDPE/PP, .44-in. OD - 50-ft. length	Variable	MB5052
Concentric Tubing Set, HDPE/PP, .44-in. OD - 100-ft. length	Variable	MB5102
LDPE Tubing, .19-in. ID x .25-in. OD - 100-ft. length	Variable	TB171L
LDPE Tubing, .19-in. ID x .25-in. OD - 500-ft. length	Variable	TB17L
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 50-ft. length	Variable	TB17T
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 100-ft. length	Variable	TB171T
Teflon® FEP Tubing, .19-in. ID x .25-in. OD - 500-ft. length	Variable	TB175T
PP Tubing, .17-in. ID x .25-in. OD - 50-ft. length	Variable	TB17P
PP Tubing, .17-in. ID x .25-in. OD - 100-ft. length	Variable	TB171P
HDPE Tubing, .31-in. ID x .44-in. OD - 50-ft. length	Variable	TB31H
HDPE Tubing, .31-in. ID x .44-in. OD - 100-ft. length	Variable	TB311H
HDPE Tubing, .31-in. ID x .44-in. OD - 500-ft. length	Variable	TB315H

<u>Actuator Options</u>	<u>Quantity</u>	<u>Part Number</u>
Manual Actuator Kit	-1-	MB7000
Includes: Hand Grip Assembly	-1-	20545
Outer Tubing Grip	-1-	22758
Outer Tubing Adapter	-1-	20544
Mechanical Actuator Assembly	-1-	MB6000
Electric Actuator Assembly, 12VDC	-1-	MB6120
Electric Actuator Kit, 12VDC	-1-	MB6120K
Well Mount Kit (for use with MB6000)	-1-	MB7200

<u>Adapters for Use with Actuators</u>	<u>Quantity</u>	<u>Part Number</u>
MBP PVC Riser Adapter Kit	-1-	MB7100
Includes: PVC Extension, 1.0-in. NPT Pin x 1.0-in. NPT Pin - 12-in. Length	-1-	17560
PVC Coupling, 1.0-in. NPT Box x 1.0-in. NPT Box	-1-	21145
Adapter, 2.0-in. PVC to 1.0-in. NPT Pin	-1-	22759
O-rings for 2.0-in. PVC to 1.0-in. NPT Pin Adapter, pkg. of 25	-1-	22313
Adapter, 1.0-in. PVC to 1.0-in. NPT Pin	-1-	17558
O-rings for 1.0-in. PVC to 1.0-in. NPT Pin Adapter, pkg. of 25	-1-	13942
Adapter, 0.75-in. PVC to 17558 Adapter (0.75-in. PVC requires 2 adapters)	-1-	19424
O-rings for 0.75-in. PVC to 17558 Adapter, pkg. of 25	-1-	13196
Adapter, 0.5-in. PVC to 17558 Adapter (0.5-in. PVC requires 2 adapters)	-1-	17559
O-rings for 0.5-in. PVC to 17558 Adapter, pkg. of 25	-1-	GW1555R
Adapter, Geoprobe® 1.0-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20527
Adapter, Geoprobe® 1.25-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20528
Adapter, Geoprobe® 1.5-in. Probe Rod Pin to 1.0-in. NPT Pin	-1-	20529

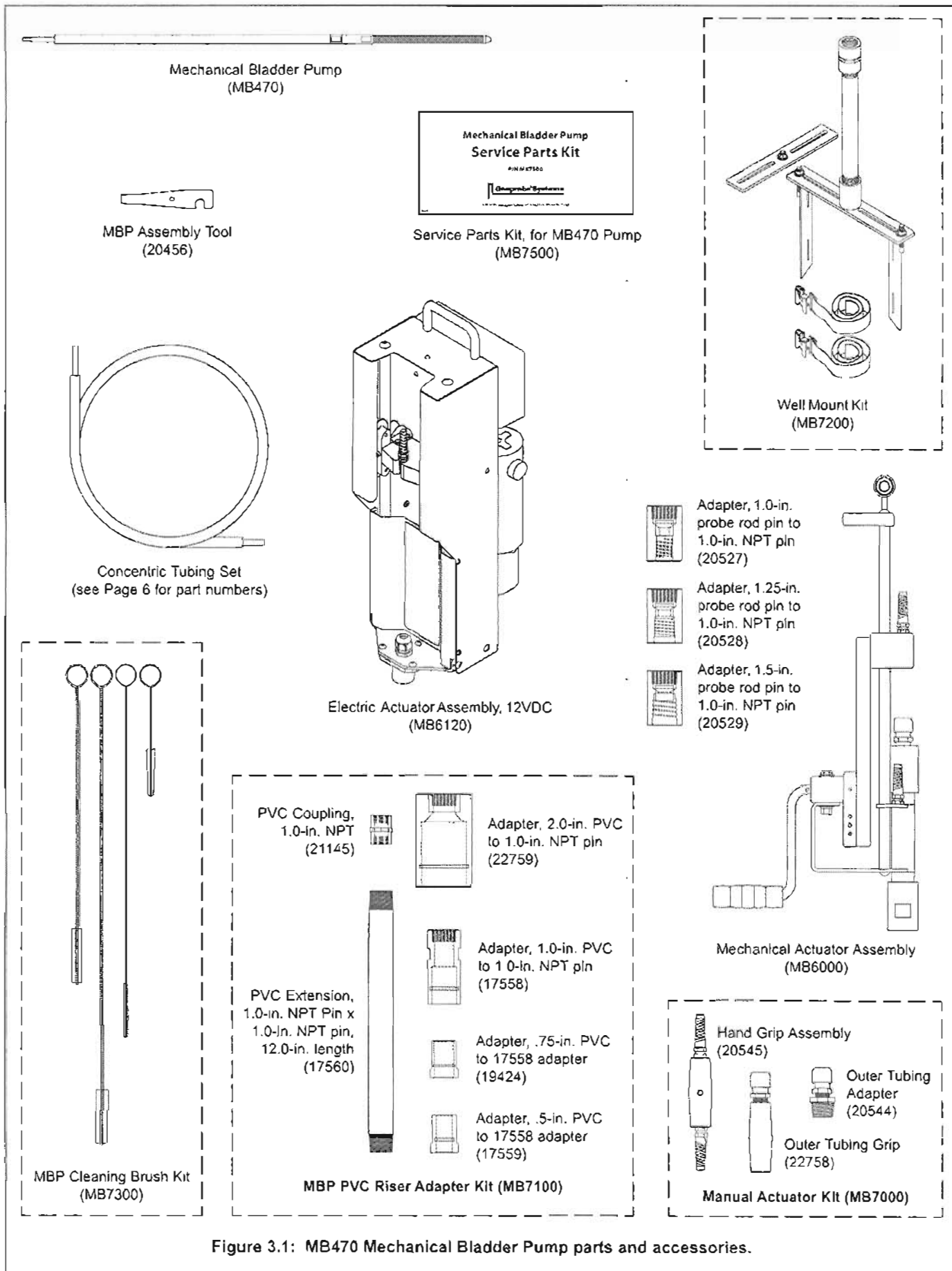


Figure 3.1: MB470 Mechanical Bladder Pump parts and accessories.

4.0 OPERATION

Use and operation of the MB470 Mechanical Bladder Pump may be divided into five main steps:

- *Assembling the Pump*
- *Selecting and installing the concentric tubing set*
- *Selecting and installing the actuator*
- *Purging and sampling*
- *Decontaminating the Pump*

4.1 Assembling the Pump

This section identifies the procedures for assembling the components of the MB470 Mechanical Bladder Pump and performing a leak check on the corrugated bladder. Refer to Figure 4.1 for parts identification.

1. Ensure that all metal parts are clean and free of burrs that may damage the pump threads or the corrugated bladder during assembly.
2. Install two fluorosilicone O-rings (22258) on the Lower Bladder Adapter (20677). Note that these are the larger of the two sizes of O-rings used with the MB470 pump.
3. Lubricate the O-ring of the lower bladder adapter and inside the Bullet Nose Intake (20675) with DI water. Place a Check Ball (22259) in the bullet nose intake and thread the intake onto the lower bladder adapter.

NOTE: The bullet nose intake is used here to make it easier to leak check the pump later in this procedure. After the leak check has been performed, the bullet nose intake may be replaced with a Screen Inlet Assembly (20725) if desired.

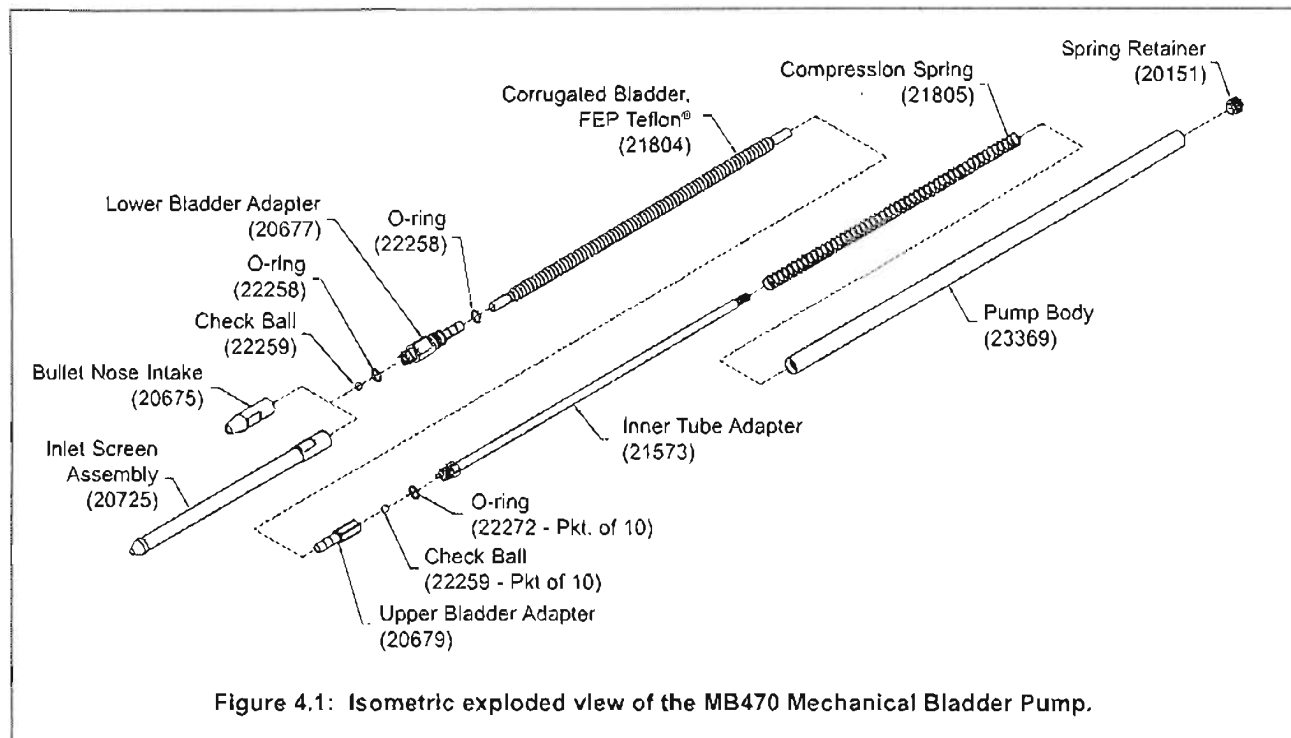
4. Install a fluorosilicone O-ring (22272) on the lower end of the Inner Tube Adapter (21573). Note that this is the smaller of the two sizes of O-rings used with the MB470 pump.
5. Lubricate the O-ring of the inner tube adapter and inside the Upper Bladder Adapter (20679) with DI water. Thread the upper bladder adapter onto the inner tube adapter.

NOTE: A check ball must be installed in the upper bladder adapter after performing the leak check in Step 7.

6. Install the Teflon® FEP Corrugated Bladder (21804):
 - The bladder should be installed with the corrugations pointing “up” (toward the upper bladder adapter/ inner tube adapter) as indicated in Figure 4.2.
 - Firmly push and rotate the lower cuff of the bladder over the barbed end of the lower bladder adapter.
 - Firmly push and rotate the upper cuff of the bladder over the barbed end of the upper bladder adapter.
 - Both ends of the bladder should be fully seated on the adapter barbs.

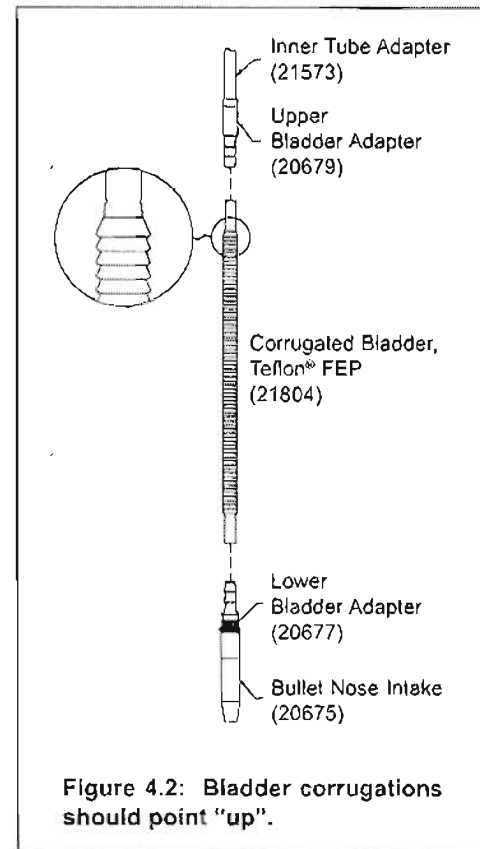
CAUTION: Although firmness is required during installation of the bladder, avoid crushing, kinking, or twisting the bladder corrugations to prevent damage.

7. Perform a leak check on the corrugated bladder before fully assembling the pump components to ensure that the bladder is free of defects. (Leak check procedure is given on opposite page.)



Leak check the corrugated bladder as follows:

- Completely submerge the bladder and lower end of the inner tube adapter in a clean beaker or small bucket of distilled or DI water.
 - Firmly blow into the open end of the inner tube adapter. Leaks in the bladder or assembled parts will be indicated by bubbles.
 - If leaks are found, replace the faulty O-ring(s) or bladder. Retest to ensure that all leakage has stopped.
 - Once the pump has passed the leak test, unthread the upper bladder adapter from the inner tube adapter. Place a Check Ball (22259) in the upper bladder adapter and reinstall it in the inner tube adapter.
 - Replace the bullet nose intake with an Inlet Screen Assembly (20725) if desired. Remember to include the check ball when installing the inlet screen.
8. The Pump Body (23369) is internally threaded at each end. Threads run all the way to the end of the pump body at the upper end, but stop .25 inches (6 mm) from the end at the lower end of the pump body to permit an O-ring seal.



Thread the Spring Retainer (20151) into the top of the pump body. Install the retainer with the slotted end out to allow use of a medium slotted screw driver or the MBP Assembly Tool (20456) to thread or unthread the retainer.

9. Place the Compression Spring (21805) over the top of the inner tube adapter. Slide the spring completely onto the adapter until it contacts the hex fitting.

10. Slide the lower end of the pump body over the top of the inner tube adapter and pump spring. The inner tube adapter will slip through the spring retainer and extend approximately 3 inches (75 mm) from the top of the pump body.
11. The lower bladder adapter is now threaded into the pump body to complete the assembly process.
 - Lubricate the O-ring on the lower bladder adapter and inside the lower end of the pump body with DI water.
 - Grasp the pump body with one hand and the lower bladder adapter with the other hand.
 - Gently compress the spring and bladder into the pump body.
 - Thread the lower bladder adapter into the pump body. Use care to avoid cutting or pinching the O-ring while threading the parts together. The O-ring will no longer be visible when the adapter is fully seated.

Assembly of the MB470 Mechanical Bladder Pump is now complete.

4.2 Selecting and Installing the Concentric Tubing Set

Selecting the Concentric Tubing Material and Length

The outer tube of the concentric tubing set commonly consists of .44-inch OD x .31-inch ID (11.2 mm x 7.9 mm) HDPE material. Inner tube material options are Teflon® FEP, LDPE, or PP. Teflon® FEP and LDPE tubing have dimensions of .25-inch OD x .19-inch ID (6.4 mm x 4.8 mm) while the PP tubing measures .25-inch OD x .17-inch ID (6.4 mm x 4.3 mm).

LDPE inner tubes are the least expensive option. The elasticity of this material may be excessive for deeper wells and in warm ambient conditions (summertime). Teflon® FEP inner tubes are less elastic and provide higher sample quality compared to LDPE due to the chemical properties of the two materials. Teflon® FEP also has a lower coefficient of friction for smoother actuation of the bladder and less resistance to operation, especially at greater depths. The main drawback of Teflon® FEP is its higher cost. PP inner tubes provide a compromise between LDPE and Teflon® FEP in that they are less elastic and provide higher sample quality than LDPE at a lower cost than Teflon® FEP.

While Teflon® FEP exhibits relatively good chemical inertness, it will absorb and desorb some volatile organic contaminants (Parker & Ranney 1998). Because of this, ambient groundwater should be purged through the pump and tubing system for a period of time to achieve equilibrium between the bladder and tubing and sample fluid. The period of time may vary for different volatile organic compounds (VOCs), but if low flow sampling (Puls and Barcelona 1996, ASTM 2003) is conducted, chemical equilibrium may be achieved by the time the monitored water quality parameters (DO, ORP, turbidity, etc.) have stabilized.

Preassembled concentric tubing sets are available from Geoprobe Systems® in lengths of 50 and 100 feet (15.2 and 30.5 m). The user may choose to assemble sets of custom lengths from separate rolls of inner and outer tubing in preparation for the sampling event or while on-site. Be careful to keep the tubing clean while inserting the inner tube into the outer tube.

When long tubing sets are required, it may be wise to use clean PVC riser pipe to protect the tubing during assembly. Simply thread PVC riser sections together, placing them on the shop floor or along the ground surface. Cap one end of the casing to keep dirt and debris out during assembly. Determine the length of the outer tube required and make the PVC casing about the same length. Slide the outer tube into the PVC casing and cut to the desired length. Slide the inner tube into the outer tube. Cut the inner tube three or more feet longer than the outer tube to complete the concentric tubing set.

Keep all tubing stored in clean airtight bags or containers so that dirt, dust, and cross contamination are not a concern or problem. No matter how clean the pump is, sample quality will suffer if the tubing is dirty. Be sure the tubing is of clean, quality material and is not marked with inks that may contribute to cross contamination.

Installing the Concentric Tubing Set on the MB470 Pump

The concentric tubing set is attached to the mechanical bladder pump by pushing the inner tube onto the hose barb on the end of the inner tube adapter and then threading the outer tube into the pump body.

1. Push the inner tube of the concentric tubing set onto the hose barb on the end of the inner tube adapter (Fig. 4.3). Fully seat the tube on the adapter such that the tube engages all three barbs. Take care not to kink or otherwise damage the tubing.
2. Before installing the outer tube, unthread the lower bladder adapter from the pump body and lay the partially disassembled pump on a clean, level surface. This step is recommended so that the bladder is not twisted or damaged as the outer tubing is installed.

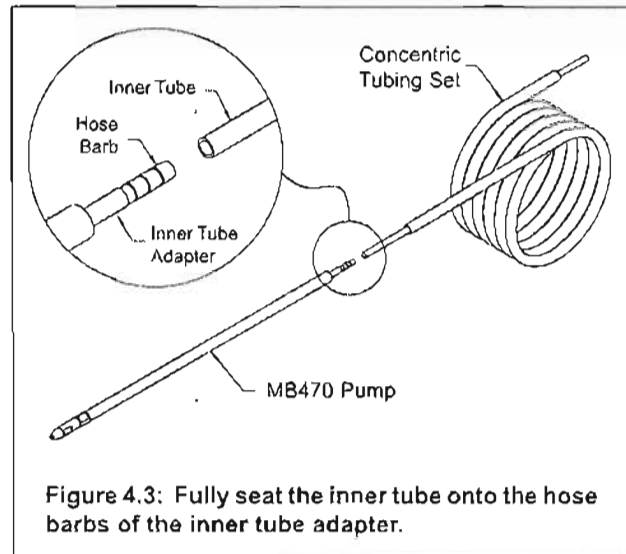


Figure 4.3: Fully seat the inner tube onto the hose barbs of the inner tube adapter.

3. Push and thread the outer tube into the top end of the pump body (Fig. 4.4). The outer tube should be threaded about 0.75 inches (19 mm) into the pump body until it butts against the spring retainer. Remember to take care not to kink or otherwise damage the tubing during installation.
4. Rotate the lower bladder adapter counterclockwise one or two revolutions to minimize torque on the bladder when threading the adapter into the pump body. Now reinstall the lower bladder adapter and inner tube adapter into the lower end of the pump body.

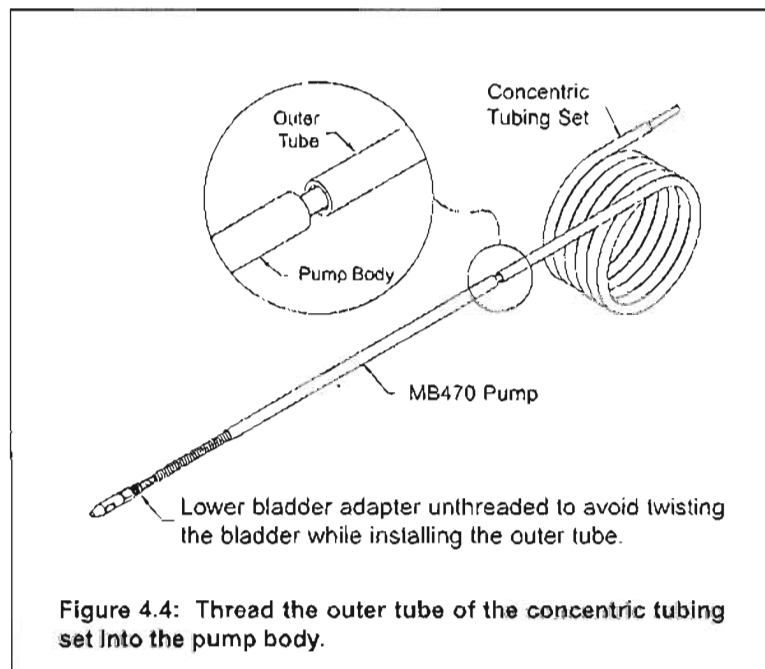


Figure 4.4: Thread the outer tube of the concentric tubing set into the pump body.

The pump and tubing set are now assembled and ready for installation into the monitoring well or sampler.

NOTE: Friction between the inner and outer tubes may make it difficult to attach the pump with the tubing set coiled. To overcome this problem, attach the pump while the concentric tubing is unrolled in the PVC riser sections as described at the bottom of Page 10.

The user may also choose to lower the concentric tubing set partway down the tool string or well, attach the pump to the exposed end of the tubing, retrieve the tubing set, and install the pump for purging or sampling. If this technique is used, **take great care to avoid dropping the tubing set down the well or tool string during attachment of the pump.**

4.3 Selecting and Installing the Actuator

Operating the mechanical bladder pump requires holding the outer tube of the concentric tubing set stationary while moving the inner tube up-and-down. Although this maneuver is possible by simply holding the outer tube in one hand and moving the inner tube with the other hand, an actuator makes operation of the pump significantly easier.

NOTE: The tubing set must be completely unrolled for the inner tube to slide freely within the outer tube.

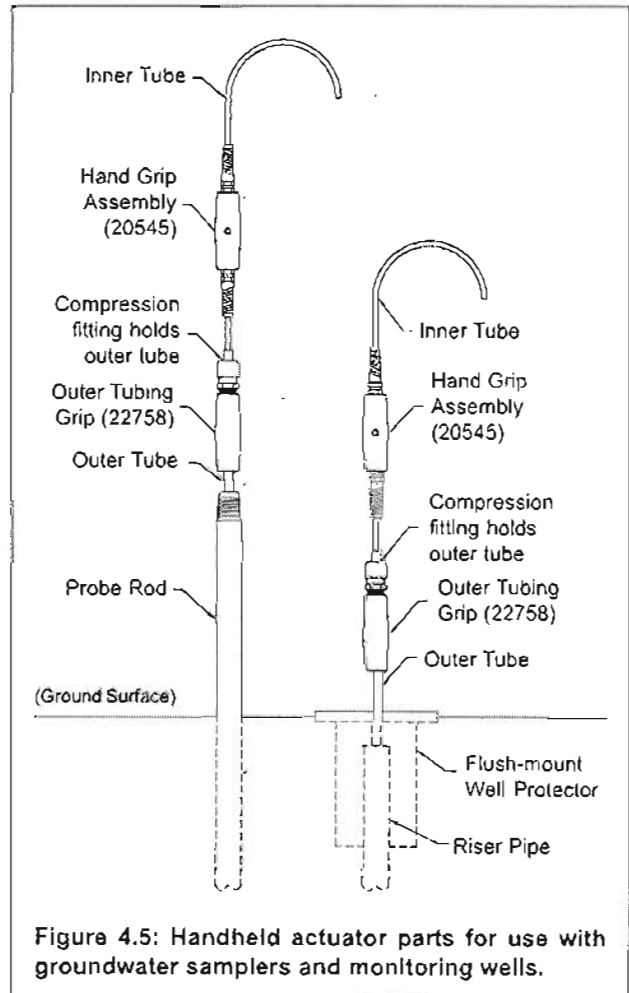
This section identifies the available actuator options. Methods by which the actuators attach to the concentric tubing set and are installed on the monitoring well or tool string are also addressed.

Handheld Manual Actuator

The handheld actuator option is the first step above simply grasping the inner and outer tube by hand. With this option, a Hand Grip Assembly (20545) and Outer Tubing Grip (22758) are installed on the concentric tubing set (Fig. 4.5). Sampling or purging is accomplished by physically holding the outer tubing grip in one hand while raising and lowering the hand grip assembly with the other hand. A handheld actuator may be used to purge or collect samples through probe rods from a groundwater sampler as well as from a permanent monitoring well.

Installation of the handheld actuator is described below.

1. Determine the depth to which the pump inlet will be installed as measured from the top probe rod or riser pipe with a weighted tape or water level meter.
2. The distance from the pump inlet to the top of the tool string or riser pipe (from Step 1) may now be marked on the outer tube. Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or riser.
3. Leading with the end opposite the compression fitting, slide the outer tubing grip over the top end of the tubing set. It may be necessary to loosen the fitting slightly (Fig. 4.6) to allow installation.
4. Position the grip with the lower end even with, or slightly above the line marked on the outer tube in Step 2. The specific location of the grip should be determined by operator preference. The important thing is that the pump inlet is maintained at the appropriate level during sampling as indicated by the mark on the outer tube.



5. Secure the grip to the outer tube by tightening the large nut of the compression fitting (Fig. 4.6) until it is "hand tight". Do not overtighten as this may damage the plastic fitting.
6. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location). Now measure and cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube.
7. Slide the hand grip assembly over the inner tube and position it 1-2 inches (25-51 mm) above the outer tubing grip as shown in Figure 4.6. It may be necessary to first loosen the two compression fittings to allow installation over the inner tube.
8. Secure the hand grip by tightening the two compression fittings. Take care not to overtighten and damage the fittings. Also avoid kinking the inner tube while completing this step.

To operate the mechanical bladder pump with the handheld actuator, simply insert the pump into the probe rod string or monitoring well. Lower the pump and concentric tubing set until the mark on the outer tube (measured and marked previously in Step 2, Page 12) is aligned with the top of the probe rod string or well riser. Initiate pump flow by holding the outer tubing grip stationary with one hand while cycling the hand grip assembly up-and-down with the other hand. A pump stroke of up to approximately 6 inches (150 mm) is recommended.

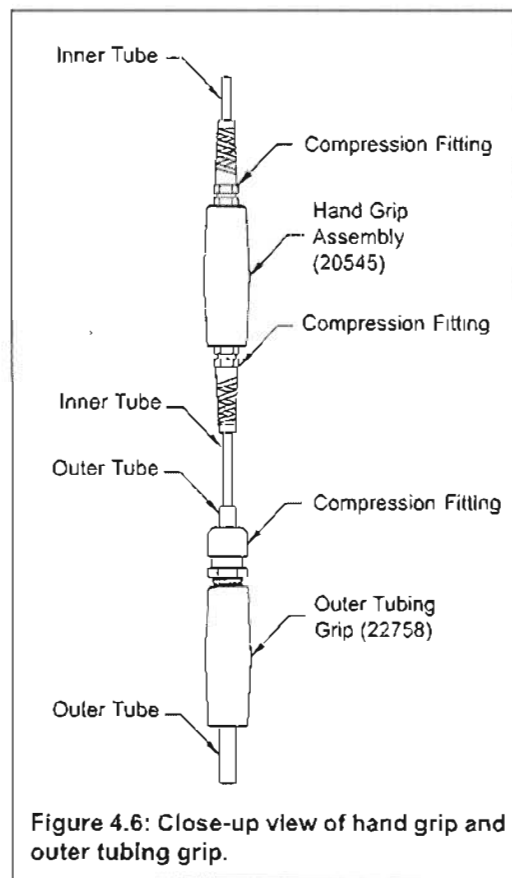


Figure 4.6: Close-up view of hand grip and outer tubing grip.

Anchored Manual Actuator

The anchored actuator option is similar to the handheld actuator in that the mechanical bladder pump is cycled by physically raising and lowering the inner tube using the Hand Grip Assembly (20545). But while the handheld actuator requires a second hand to hold the outer tube, the anchored actuator option utilizes adapters to mechanically secure the outer tubing to the top probe rod or riser pipe as shown in Figure 4.7.

Installation of the mechanical bladder pump with the anchored actuator option is reviewed in this section for both probe rod and well riser applications.

1. The outer tube of the concentric tubing set is connected to the top probe rod or well riser using an Outer Tubing Adapter (20544) plus additional adapters as determined by the size of rod or riser onto which the actuator is to be installed.

Referring to Table 4.1, select the appropriate adapter(s) for your size of probe rod or well riser. Illustrations and complete descriptions of the various adapters are presented in Table 4.2 and Figures 4.8 - 4.10. Note that .5-inch and 0.75-inch riser pipe each require two PVC adapters in addition to the outer tubing adapter.

2. Assemble the adapters by threading the outer tubing adapter into the probe rod or well riser adapter.

As illustrated in Figure 4.8, two adapters are required to attach the outer tubing adapter to .5-inch and .75-inch riser pipe. After threading the outer tubing adapter into the 1.0-inch PVC to 1.0-inch NPT Adapter (17558), either a .5-inch PVC adapter (19424) or .75-inch PVC adapter (17559) is then installed in the remaining end of the 1.0-inch PVC adapter.

3. Determine the depth to which the pump inlet will be installed as measured from the top probe rod or riser pipe with a weighted tape or water level meter.
4. The distance from the pump inlet to the top of the tool string or riser pipe (from Step 3) is now marked on the outer tube:

Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or riser.

5. Slide the assembled adapters (from Step 2) over the top end of the tubing set leading with the end opposite the compression fitting. See Figure 4.7 for adapter orientation. It may be necessary to loosen the compression fitting slightly to allow installation.

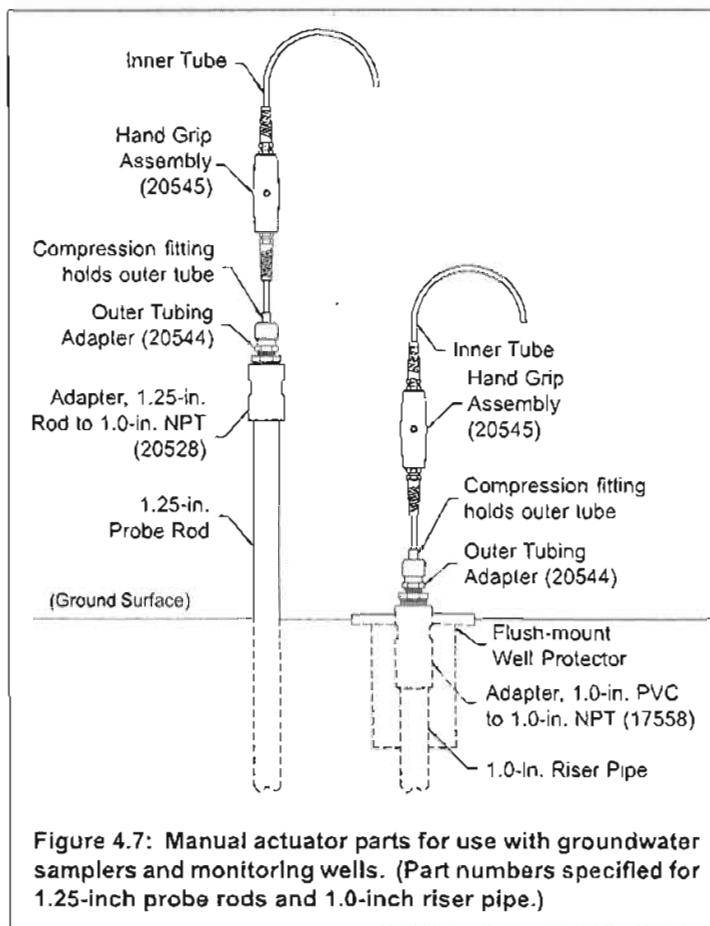


Figure 4.7: Manual actuator parts for use with groundwater samplers and monitoring wells. (Part numbers specified for 1.25-inch probe rods and 1.0-inch riser pipe.)

6. Position the adapters such that the line marked on the outer tube in Step 4 will be even with the top of the probe rod or well riser when the pump is installed on the tool string or riser.
7. Secure the adapters to the outer tube by tightening the large nut of the compression fitting (Fig. 4.7) until it is "hand tight". Do not overtighten as this may damage the plastic fitting.

8. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location). Now measure and cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube.

Size	Probe Rod Adapters	Monitoring Well Riser Adapters
.5-inch	na	17559, 17558, and 20544
.75-inch	na	19424, 17558, and 20544
1.0-inch	20527 and 20544	17558 and 20544
1.25-inch	20528 and 20544	na
1.5-inch	20529 and 20544	na
2.0-inch	na	22759 and 20544

Table 4.1: Part numbers for the adapters required to attach the outer tube to various probe rods and PVC riser pipe.

9. Slide the hand grip assembly over the inner tube and position it 1-2 inches (25-51 mm) above the outer tubing grip as shown previously in Figure 4.6. It may be necessary to first loosen the two compression fittings to allow installation over the inner tube.
10. Secure the hand grip by tightening the two compression fittings until they are hand tight. Do not overtighten the plastic fittings as damage may result.





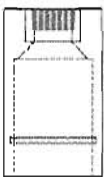



Illustration	Part Number	Description
	20544	Outer Tubing Adapter
	20527	Adapter, 1.0-in. probe rod pin to 1.0-in. NPT pin
	20528	Adapter, 1.25-in. probe rod pin to 1.0-in. NPT pin
	20529	Adapter, 1.5-in. probe rod pin to 1.0-in. NPT pin
	22759	Adapter, 2.0-in. PVC to 1.0-in. NPT Pin
	17558	Adapter, 1.0-in. PVC to 1.0-in. NPT Pin
	19424	Adapter, .75-in. PVC to 17558 Adapter
	17559	Adapter, .5-in. PVC to 17558 Adapter

Table 4.2: Adapters for attaching the outer tube to probe rods and PVC riser pipe.

11. Lower the mechanical bladder pump down the probe rods or well riser. Secure the outer tubing adapter by threading it onto the top probe rod or sliding it over the top of the well riser.

The mechanical bladder pump is now ready for purging and/or sampling.

Operation of the mechanical bladder pump with a manual actuator is limited to simply raising and lowering the hand grip assembly using a stroke length up to 6 inches (152 mm). This action extends and retracts the pump bladder to push formation fluid to the ground surface through the inner tube of the concentric tubing set. The outer tube is attached to the probe rod string or well riser by adapters and is thus held stationary while the pump is actuated.

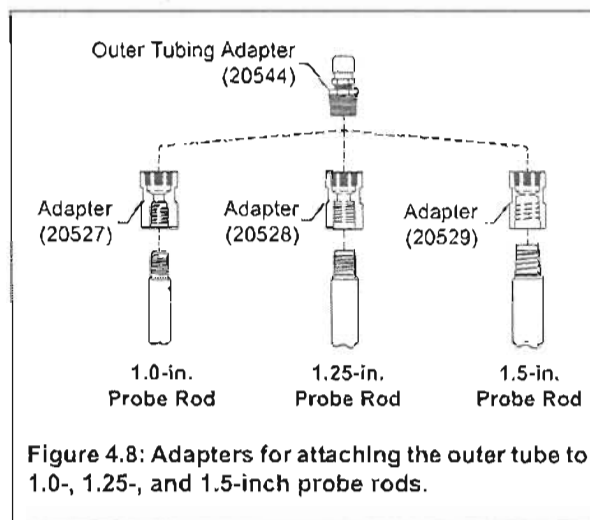


Figure 4.8: Adapters for attaching the outer tube to 1.0-, 1.25-, and 1.5-inch probe rods.

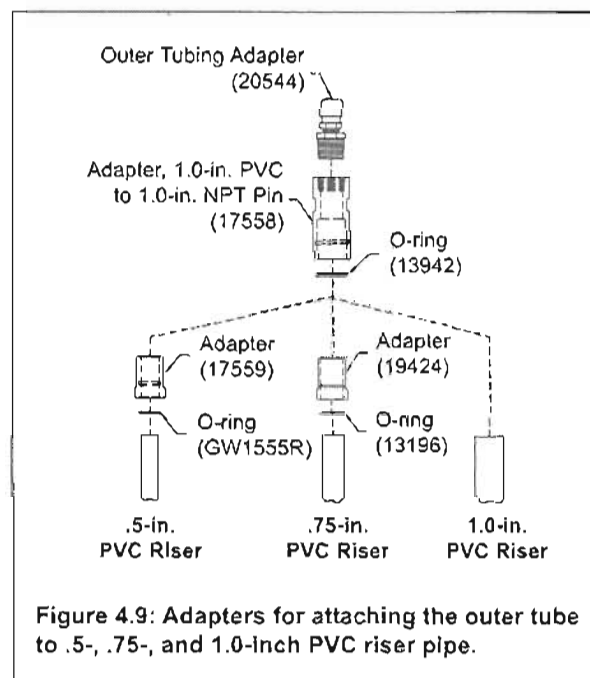


Figure 4.9: Adapters for attaching the outer tube to .5-, .75-, and 1.0-inch PVC riser pipe.

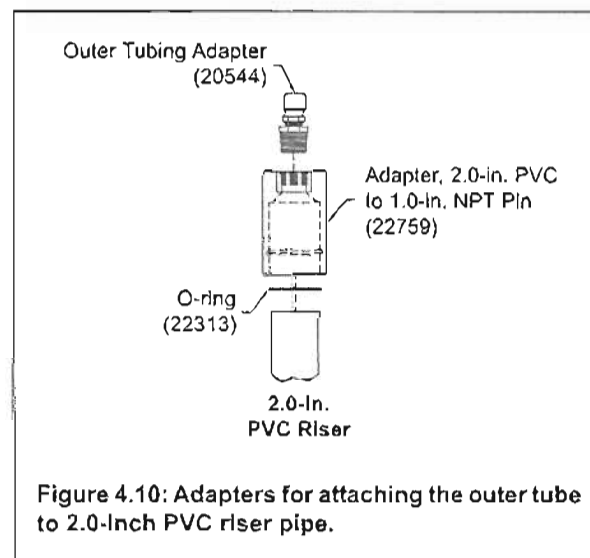


Figure 4.10: Adapters for attaching the outer tube to 2.0-Inch PVC riser pipe.

Mechanical Actuator

The third actuator option for the MB470 Mechanical Bladder Pump is a Mechanical Actuator Assembly (MB6000, Figure 4.10). Rather than physically raising and lowering the inner tube to cycle the pump, the operator simply rotates the handle on the side of mechanical actuator. The actuator assembly converts this rotational action to vertical movement of the inner tube which cycles the pump. The operator may also choose to manually raise and lower the inner tube by disconnecting the side handle and utilizing the T-handle at the top of the assembly.

An advantage of the mechanical actuator option is that it requires little physical input to operate the pump. This translates to minimal operator fatigue when purging or sampling from multiple wells during the day.

The mechanical actuator assembly may be installed directly on a probe rod string (Fig. 4.10) or attached to a flush-mount or aboveground well protector using a Well Mount Kit (MB7200) as shown in Figures 4.11 and 4.12. Installation and operation of the mechanical actuator are described below.

1. Determine the depth to which the pump inlet will be installed as measured from the top of the probe rods or well protector with a weighted tape or water level meter.
2. The distance from the pump inlet to the top of the tool string or well protector (from Step 1) may now be marked on the outer tube:

Obtain an assembled MB470 Mechanical Bladder Pump (Section 4.1) with a concentric tubing set installed as instructed in Section 4.2. Beginning from the pump inlet, measure the appropriate distance along the outer tube and mark it with electrical tape or a suitable marker. The tubing set will be installed such that this mark is aligned with the top of the probe rods or well protector.

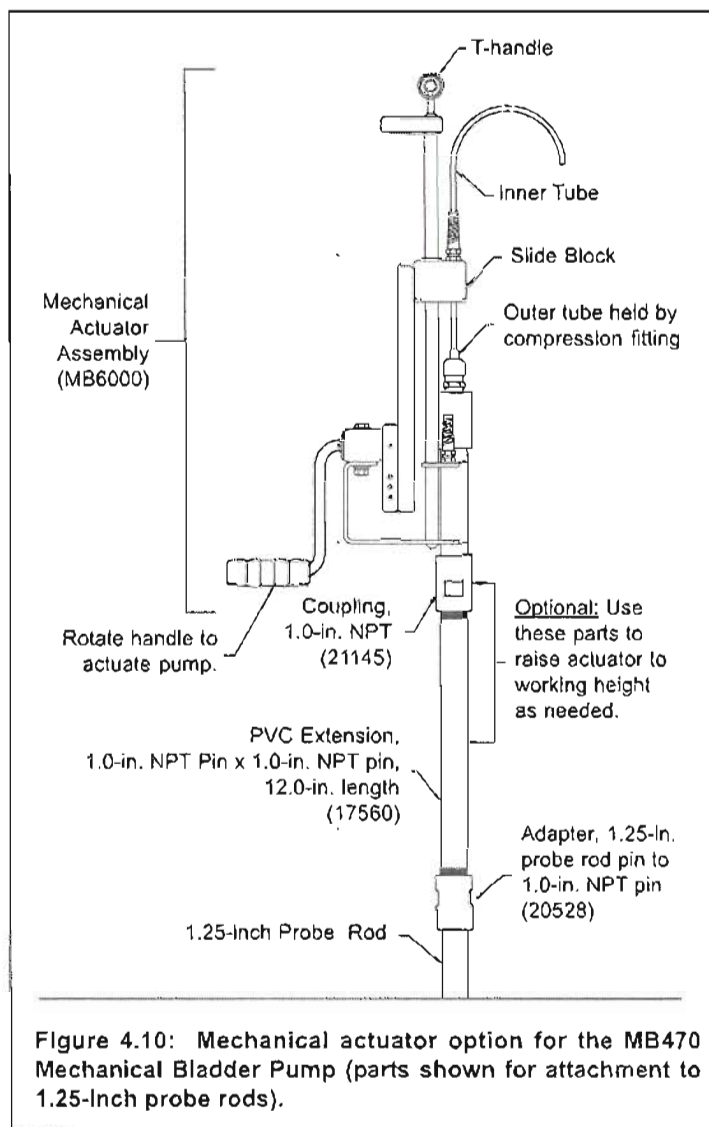
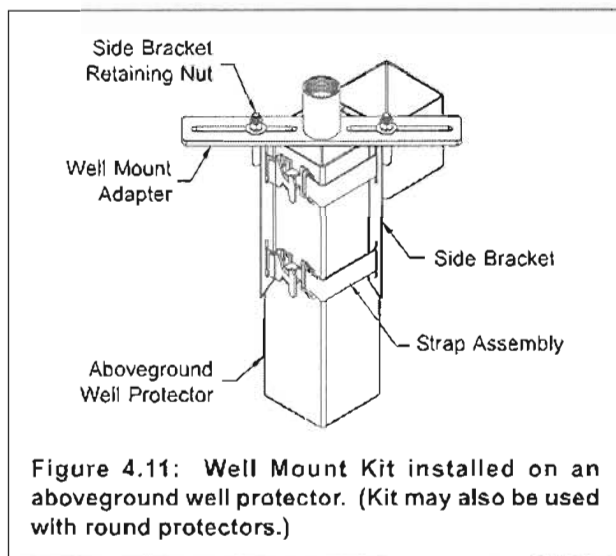


Figure 4.10: Mechanical actuator option for the MB470 Mechanical Bladder Pump (parts shown for attachment to 1.25-inch probe rods).

3. **For monitoring wells only:** Install a Well Mount Kit (MB7200, Figure 3.1) on the well protector. The well mount is strapped onto aboveground well protectors as shown in Figure 4.11 and bolted onto flush-mount well protectors as shown in Figure 4.12. Note that the cross adapter is used for flush-mount protectors that utilize three bolts on the cover (Fig. 4.12) or when the well riser is significantly off center in the protector.
4. Lower the pump and concentric tubing set down the probe rod string or through the well mount into the riser pipe. Stop when the mark on the outer tube (from Step 2) is near the top of the probe rods or well protector.
5. **For probe rods only:** Referring to Table 4.2, select the appropriate Probe Rod Pin to 1.0-inch NPT Pin Adapter (20527, 20528, or 20529) to attach the actuator to the top probe rod. Thread this adapter (and a 12-inch extension if additional height is needed) into the actuator as shown on the completed assembly in Figure 4.10.



6. Insert the top end of the concentric tubing set through the lower end of the mechanical actuator assembly. Feed the tubing set through the actuator and out the compression fitting identified in Figure 4.10.

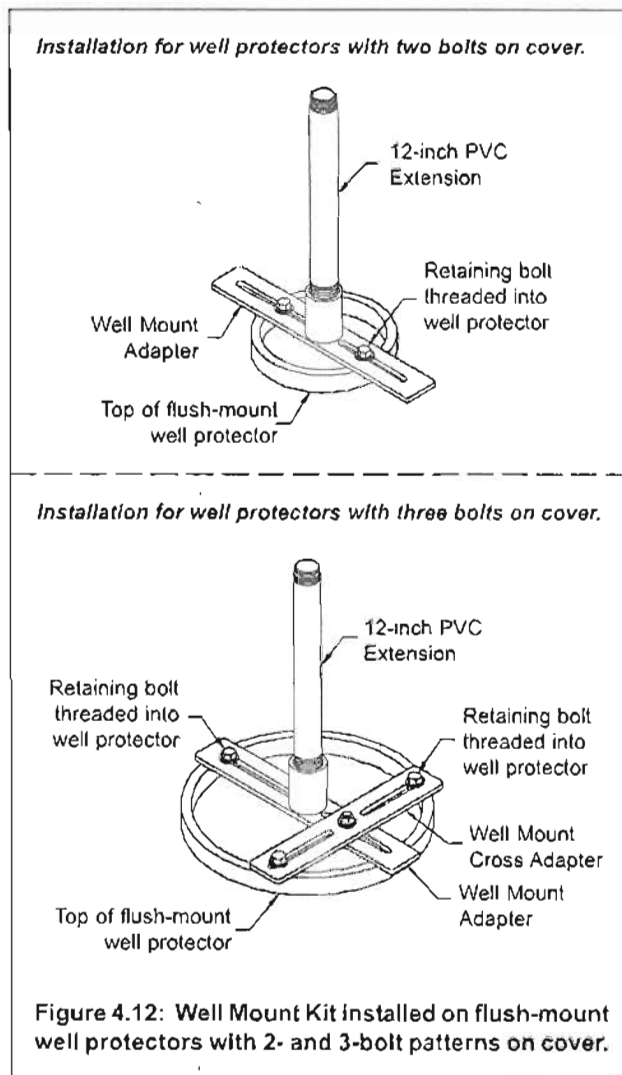
For probe rods only: The mark on the outer tube (Step 2) will not be visible once the actuator is installed on the probe rods. To allow for this, position the tubing within the actuator such that the mark will be at the top of the rods when the actuator is installed. Now mark the outer tube at the compression fitting of the actuator assembly for reference later in the installation procedure.

7. Thread the mechanical actuator onto the top probe rod or well mount until all connections are hand tight.
8. Verify the position of the outer tube by observing the mark placed on the tube in Step 2 or 6. Tighten the compression fitting (hand tight) to secure the tubing. Do not overtighten as this may damage the fitting.
9. Carefully cut off the excess outer tube leaving approximately .25 inches (6 mm) above the compression fitting. (Note that the inner tube is not cut at this location).
10. Taking care not to kink the inner tube, insert the inner tube up through the compression fitting on the actuator slide block (see Fig. 4.10 for identification of slide block). It may help to raise the slide block during this step.

With the slide block fully lowered, gently pull up on the inner tube to remove slack. Do not pull so far that the pump spring is compressed. Tighten the compression fitting to secure the inner tube. Again, do not overtighten as this may damage the plastic fitting.

11. Cut the inner tube leaving it approximately 3 feet (1 m) longer than the outer tube. You may choose to insert the end of the inner tube through the top of the compression fitting on the side of the actuator. This will limit movement of the tube outlet while operating the pump

The mechanical bladder pump is ready for operation by rotating the side handle of the mechanical actuator or disconnecting the side handle linkage and manually raising and lowering the T-handle.



4.4 Purging and Sampling

The MB470 Mechanical Bladder pump was designed to provide an economical and efficient method to conduct the low flow sampling protocol (Puls and Barcelona 1996, ASTM 2003), Nielsen and Nielsen 2002). The basis of this protocol is that a sampling flow rate of 500 ml/min or less for 2-inch wells (100 to 200 ml/min for smaller diameter direct push wells) generally provides a sample of higher quality that is more representative than sampling at high flow rates (e.g. several liters or gallons per minute). Higher quality samples for volatile organic compounds are obtained because the water being sampled is subjected to less physical and chemical stress so that loss of these analytes does not occur. Additionally, higher quality samples for inorganic analytes (e.g. lead, hexavalent chromium, etc.) are obtained because the low flow sampling method minimizes turbidity that can cause significant bias for these sensitive analytes.

To obtain the most representative samples, the monitoring well or temporary groundwater sampler should be developed before sampling is conducted. Development may consist of simple surging and purging with an inertial pump for temporary samplers depending on the data quality objectives (Geoprobe® 2002). However, more elaborate methods may be required for some monitoring wells (ASTM 2001).

To meet the full requirements of the low flow sampling protocol, field parameters of the pre-sample purge water (temperature, pH, specific conductance, ORP, DO, and turbidity) should be monitored using an in-line flow cell. Once these parameters have stabilized, the samples are then collected in clean, preserved sample containers appropriate for the analytes of concern. Pre-sample purging may be completed in as little as 10 to 20 minutes in adequately developed small-diameter wells with as little as 5 to 10 liters of water generated. In larger diameter wells that have not been adequately developed, a significantly longer purge time and volume may be required.

4.5 Decontaminating the Pump

Decontamination of the pump may be performed in two general ways. For the highest integrity samples the pump should be fully disassembled for thorough decontamination (decon) and the bladder and O-rings replaced. If the pump is being used as a portable pump for sampling multiple locations daily, the pump may be decontaminated while assembled. Review and understand the sampling and data quality objectives for your project before selecting the appropriate decontamination procedure. (For further information on data quality objectives see EPA 1997, or Geoprobe® 2002). The concentric tubing set should be replaced between each sampling location to minimize the potential for cross contamination. If possible, sample from background or low concentration wells to higher concentration wells to minimize the chance for cross contamination.

Disassemble for Decontamination

Simply reverse the procedures described in Section 4.1 to disassemble the pump and concentric tubing set. Place the disassembled pump in a clean beaker or small bucket of water. Use distilled water for highest level of decon. Add Alconox soap (or similar cleaning agent) to the water. Thoroughly clean and brush all inside and outside surfaces. The MBP Cleaning Brush Kit (MB7300) includes four small-diameter brushes selected specifically to clean inside the various pump components. Double rinse all parts with distilled or deionized (DI) water and allow to air dry. Reassemble the pump using a new bladder and O-rings.

Review ASTM Practice D5088 for further guidance and detail on decon procedures. Additional decontamination may be obtained by drying the disassembled pump in a clean drying oven at about 95°C (203°F). This will provide additional assurance that volatile contaminants are removed from pump surfaces.

Decontamination of Assembled Pump

While this method will not provide the assurance of the highest quality samples it may be preferred when lower sample quality is acceptable (For further information on data quality objectives see EPA 1997, or Geoprobe® 2002). When initial site assessments are conducted it is often desirable to obtain many samples at a reasonably modest cost so as to adequately characterize a site. This decon procedure will help reduce the per sample cost while providing acceptable sample quality for many site assessments.

Remove the concentric tubing set from the pump and discard. Submerge the pump in clean soapy water and pump several volumes of water through the pump. Thoroughly wash the exterior of the pump removing all visible dirt or stains. Rinse and transfer the pump to a container of clean tap water or deionized water. Again pump multiple volumes of water through the pump and wash the pump exterior to remove all soap. A second rinse is recommended. Allow the pump to air dry. Again, drying the fully assembled pump in a clean drying oven at about 95°C (203°F) will further remove any volatiles from pump surfaces.

Rinsate Samples

Regularly collect rinsate samples from the pump following decontamination and submit the samples for analysis for the analytes of concern. This will provide another level of quality control and assurance that samples meet the site-specific data quality objectives. Pump clean distilled water through the pump and collect the fluid in an appropriate preserved container. Store, ship and handle rinsate samples in the same manner as field samples.

5.0 REFERENCES

- American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)
- American Society of Testing and Materials (ASTM), 2001. D-5521 Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers. ASTM, West Conshocken, PA. (www.astm.org)
- American Society of Testing and Materials (ASTM), 1999. D-5088 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites. ASTM, West Conshocken, PA. (www.astm.org)
- U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.
- U.S. Environmental Protection Agency (EPA), 1997. Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators. Office of Solid Waste and Emergency Response. EPA 510-B-97-001. March.
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- Nielsen, David M., and Gillian L. Nielsen, 2002. Technical Guidance on Low-Flow Purging & Sampling and Minimum-Purge Sampling: Second Edition. The Nielsen Environmental Field School, Galena, OH. April.
- Parker, Louise V. and Thomas A. Renney. 1998. Sampling Trace-Level Organic Solutes with Polymeric Tubing, Part 2. Dynamic Studies. Groundwater Monitoring & Remediation (GWMR) Vol. XVIII No. 1, pages 148-155. Winter.
- Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.



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APPENDIX J-J

VAPOR INTRUSION INVESTIGATION WORK PLAN



**CONESTOGA-ROVERS
& ASSOCIATES**

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December 17, 2010

Reference No. 038443-89

Ms. Karen Cibulskis
Remedial Project Manager
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Mail Code SR-6J
Chicago, IL 60604

Dear Ms. Cibulskis:

Re: Vapor Intrusion (VI) Investigation Work Plan (Work Plan)
South Dayton Dump and Landfill Site Moraine, Ohio (Site)

As required under the Dispute Resolution Agreement signed by the Respondents and USEPA on December 10, 2010, this Work Plan presents the proposed approach for a VI Study to investigate sub-slab soil vapor conditions beneath buildings on particular Site parcels and adjacent to the Site. The VI Study will be completed as an interim response action pursuant to Paragraph 37(c) of the Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study (RI/FS) of the Site, Docket No. V-W-06-C-852 (ASAO). Conestoga-Rovers & Associates (CRA) has prepared this Work Plan on behalf of the Respondents to the ASAO (Respondents).

The work proposed in this Work Plan will be performed in accordance with the United States Environmental Protection Agency- (USEPA-) approved Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Site-Specific Health and Safety Plan (HASP), and associated addenda that are submitted as attachments to this Work Plan.

This Work Plan is presented in the following titled sections:

- 1.0 Background
- 2.0 VI Study
- 3.0 Schedule
- 4.0 Reporting



1.0 BACKGROUND

The Respondents to the ASAOC include Hobart Corporation (Hobart), Kelsey Hayes Company (Kelsey-Hayes), and NCR Corporation (NCR). These three Respondents (the PRP Group) are and have been performing the Work required by the ASAOC under the direction and oversight of the USEPA.

The investigation of the Site has documented elevated concentrations of methane, naphthalene, and volatile organic compounds (VOCs) in landfill gas. There are a number of operating businesses located on the Site, above or immediately adjacent to fill material and in close proximity to the soil gas probe locations where elevated levels of VOCs and methane were detected. By a letter dated October 5, 2010, USEPA had directed Respondents to submit a work plan for a VI Study to address the risks from VI to residents and businesses in buildings on and adjacent to the Site.

VI is the migration of volatile chemicals from the subsurface into overlying buildings. VI is a potential concern at any building, existing or planned, located near soil or groundwater contaminated with toxic chemicals that can volatilize.

Under the December 10, 2010 Dispute Resolution Agreement the Respondents and USEPA agreed that the Respondents will complete the VI Study to assess the potential for methane, VOCs, and naphthalene in soil vapor to result in potential risks to receptors in buildings on and adjacent to the Site.

Specifically, the Dispute Resolution Agreement states:

[T]he Respondents shall conduct the VI Study, as required by EPA, pursuant to Paragraph 37 (c) of the ASAOC, as an interim response action. EPA has given the Group a copy of the newly issued EPA Region 5 Vapor Intrusion Guidebook (Guidebook) and the Parties have agreed that the Respondents will prepare their VI Work Plan, which will include Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) Addenda, in accordance with this new guidance and other relevant guidance (e.g., FSP and QAPP guidance). The Parties agree that the Work Plan will provide for sub-slab sampling, on an expedited schedule of any of the following structures which are of slab-on-grade construction or have basements or enclosed crawl spaces (see highlighted structures on Figure [1], attached, for an illustration of the structures for which sub-slab sampling is anticipated):



A. Structures On Site West of Dryden Road:

- 3 building structures on Lot 5054*
- 3 building structures on Lot 5171*
- 2 building structures on Lot 5172*
- 1 building structure on Lot 5174*
- 1 building structure on Lot 5175, and*

B. Structures On Site or Adjacent to Site Along East River Road:

- 4 building structures on Lot 4610 (Barnett; on-Site)*
- 2 building structures on Lot 3207*
- 1 residence on Lot 3253; and*
- 1 building structure on Lot 3254.*

Any additional structures on the Site that are, or may be, occupied will be evaluated to determine the need for VI sampling.

The Parties agree that if any structure on or adjacent to the Site that is or may be occupied has no slab (e.g., dirt or gravel floor) that Respondents will take indoor air samples (see Section 6.6 of Guidebook).

The Parties agree that the Respondents shall submit a Work Plan for the VI Study required by EPA by December 17, 2010. The Parties agree that if identified contaminant concentrations pose more than a 1×10^{-4} cancer risk or a hazard index greater than 1.0 through the VI pathway to current or potential future receptors, or if VI sampling results show an exceedance of 10% of the Lower Explosive Limit, EPA may require actions to mitigate those risks.

The PRP Group has prepared this Work Plan based on requirements of the Dispute Resolution Agreement, previous investigation results and discussions between the PRP Group and USEPA.

2.0 VI STUDY

CRA will complete a sub-slab soil vapor quality investigation beneath the existing on-Site structures and certain structures adjacent to the Site as described in Section 1.0 above. CRA will install and sample the sub-slab soil vapor probes in accordance with CRA's SOPs for installing sub-slab probes and collecting sub-slab soil vapor samples presented in Attachment A, which is an addendum to the FSP.

For any of the structures listed above and any additional structures evaluated that are or may be occupied but do not have a concrete slab floor (e.g., dirt or gravel floor), CRA will collect indoor air samples within the structure. The standard operating procedure (SOP) for the Indoor



Air Sampling is provided in Attachment B (addendum to the FSP). For any location where an indoor air sample is collected, CRA will also install a soil vapor probe screened between 3 and 5 feet below ground surface in accordance with CRA's SOP (Appendix J-F-11 of the FSP) in order to attempt to correlate indoor air concentrations to concentrations of contaminants in soil vapor near the structure. The soil vapor probes will be installed immediately adjacent to the side of the building closest to the most likely source of any soil vapor impacts. CRA will agree on the proposed soil vapor probe locations with USEPA prior to their installation. CRA will collect a soil vapor sample from any newly installed soil vapor probe, and submit the sample(s) for analysis of VOCs by USEPA's TO-15 methodology¹. In addition, where indoor air samples are collected, CRA will also collect ambient air samples immediately adjacent to the structure as per CRA's SOP. Sub-slab soil vapor and indoor air sampling activities are summarized in Attachment C (addendum to the QAPP).

CRA has prepared this scope of work for the sub-slab soil vapor sampling in accordance with the following vapor intrusion guidance documents:

- Office of Solid Waste and Emergency Response (OSWER) - Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002 (USEPA, 2002)
- Interstate Technology Regulatory Council (ITRC) - Vapor Intrusion Pathway: A Practical Guide, January 2007 (ITRC, 2007)
- United States Environmental Protection Agency (USEPA) - Region 5 - Vapor Intrusion Guidebook, October 2010 (USEPA, 2010)

The purpose of the VI Investigation is to collect additional data to determine if compounds are volatilizing into soil vapor beneath the building foundations and floor slabs at concentrations that are sufficiently high that contaminants could potentially migrate into the indoor air of the Site buildings at concentrations that pose an unacceptable risk to building occupants.

A simplified discussion of the DQO steps for the VI investigation is presented below.

Step 1: State the Problem – Soil vapor samples collected from soil gas probes adjacent to three on-Site buildings, and 50 feet from a fourth building, contained VOC concentrations greater than 1×10^{-4} and/or $HI=1$ industrial risk-based levels. As detailed in the Dispute Resolution Agreement,

¹ Samples will be submitted for USEPA TO-15 GC/MS analysis operated in either select ion monitoring (SIM) or scanning (SCAN) mode, as needed in order to meet required detection limits.



There are a number of operating businesses located on the Site, above or immediately adjacent to fill material and in close proximity to the gas probe locations where elevated levels of VOC and methane were detected.

In addition, there is at least one residential building located in close proximity to soil vapor probe GP09-09, where elevated concentrations of VOCs were detected.

It is not known whether concentrations of contaminants in soil vapor and shallow groundwater pose an unacceptable risk, via the vapor intrusion pathway, to occupants of structures on, or immediately adjacent to, the Site.

Step 2: Identify the goals of the study – Determine whether contaminant concentrations pose more than a 1×10^{-4} cancer risk or a HI greater than 1.0 through the VI pathway to current or potential future receptors. Further, determine whether concentrations of combustible gases within a structure exceed 10 percent of the Lower Explosive Limit (LEL) for methane. Identify buildings where indoor air sampling is required based on the sub-slab sample results.

Step 3: Identify information inputs – Conduct sub-slab soil vapor or, where a structure does not have a concrete slab, indoor air sampling to determine VOC concentrations, through the installation and sampling of sub-slab soil vapor probes and, where appropriate, the collection of indoor air samples.

Step 4: Identify the boundaries of the study – The buildings included in the VI Study are detailed in Section 1.0 above, and presented on Figure 1.

Step 5: Develop the analytic approach – Sub-slab soil vapor samples will be collected from the sub-slab soil vapor probes, following purging in accordance with the FSP. Sub-slab soil vapor and indoor air samples will be submitted for analysis of VOCs in accordance with the requirements of the QAPP and USEPA Method TO-15.

Step 6: Specify Performance or Acceptance Criteria – performance criteria consist of identifying VOC concentrations within existing structures that pose more than a 1×10^{-4} cancer risk or a HI greater than 1 to current or potential future receptors via the vapor intrusion pathway, or an exceedance of 10 percent of the LEL. Additional data quality performance and acceptance criteria are outlined in the QAPP.

Step 7: Develop the plan for obtaining data – see Sections 3.1 to 3.2 below, for detailed procedures proposed in order to obtain the required data.

The sub-slab soil vapor investigation is discussed in further detail below.



2.1 Installation of Sub-Slab Soil Vapor Probes

CRA will assess the potential for vapor intrusion by installing and sampling permanent sub-slab soil vapor probes within the on-Site buildings. The proposed sample locations are presented on Figure 1.

Prior to conducting the sampling, CRA will visually inspect the Lots in question and document the number and type of buildings present on each Lot in order to ensure that all buildings that are or may be occupied are included in the sampling program. Lean-tos, car ports, kennels (unless contained within a larger building), open-sided buildings, etc. will not be included in the sampling program. For buildings where explosive gases might accumulate but exposure times, with respect to specific contaminants would typically be small (i.e., small sheds and outbuildings that do not permit long term exposure), CRA will measure the concentration of explosive gas within the building but will not install a sub-slab soil vapor probe or collect an indoor air sample.

Prior to installing the sub-slab probes, a survey will be conducted of each building, to identify potential preferential pathways for vapor migration under the building. The survey will evaluate the presence of underground utilities, floor slab condition, foundation footings, and vadose zone soil conditions known from nearby monitoring well installations. As building-specific conditions dictate, the probes will be installed in the lowest point of the building, at the approximate middle of the building floor slab. The actual locations will be finalized and documented in the field based on the conditions encountered, the presence of underground utilities, potential preferential vapor migration pathways, and detected groundwater concentrations in the vicinity of each building. The final sub-slab probe locations will be selected with a bias to providing the highest anticipated sub-slab soil vapor concentrations determined based on the weight of the available data collected during the building surveys.

USEPA, 2010 recommends the collection of at least one sample per property and that multiple sub-slab probes be installed in a minimum of 10 percent of the buildings included in the investigation. Therefore, CRA will initially install one sub-slab soil vapor probe per building for eighteen (18) of the twenty (20) buildings included in the investigation. For the remaining two buildings, two sub-slab probes will be installed. These two buildings will be selected based on results of the building survey, the potential presence of multiple preferential exposure pathways, and proximity to elevated groundwater concentrations. In each of the two buildings, one probe will be located at the approximate middle of the building, and the second probe will be located where the greatest degree of variability in sub-slab soil vapor concentrations may be expected based on the weight of the available data collected during the building surveys. If the owners of the residence on Lot 3253 grant permission, and should construction considerations



allow (i.e., underground utilities, floor materials and floor condition), two sub-slab probes will be installed in the residence on Lot 3253, as residents are considered a more sensitive receptor to exposure via the VI pathway.

CRA will complete the sub-slab soil vapor sampling in accordance with CRA's SOPs for collecting sub-slab soil vapor samples (Attachment A, addendum to the FSP). Based on the analytical results of the initial sampling round, CRA will assess the need to install additional sub-slab soil vapor probes to delineate the lateral extent of impact and to identify the maximum sub-slab soil vapor concentrations in the affected building.

As described in detail in CRA's SOP for sub-slab soil vapor probe installation (Attachment A, addendum to the FSP), CRA will use a concrete corer to drill a "shallow" (approximately 1-inch deep) outer hole (approximately 7/8 inches in diameter) that partially penetrates the floor slab. CRA will then use an electric hammer to drill a smaller diameter inner hole (approximately 3/8 inches diameter) into the center of the outer hole, through the floor material and approximately 3 inches into the sub-slab bedding material to create an open cavity.

CRA will clean cuttings from the outer and inner holes using a towel moistened with distilled water or a small portable vacuum cleaner.

To construct the probes, CRA will cut chromatography grade 316 stainless steel or brass tubing (approximately 1/4-inch in diameter) to a length that allows the probe to float within the slab thickness to avoid obstruction of the probe with sub-slab bedding material. CRA will construct the probes prior to drilling to minimize exposure time, or venting, of the sub-slab bedding material through the open hole.

CRA will place the sub-slab soil vapor probe in the hole so that the top of the probe is flush with the top of the floor. The top of the probe will have a recessed stainless steel or brass plug. CRA will push or inject quick drying Portland cement slurry into the annular space between the probe and the outer hole. The cement will be allowed to dry for at least 24 hours prior to sampling.

2.2 Sub-Slab Soil Vapor Probe Sampling

As detailed in the Interstate Technology & Regulatory Council (ITRC) January 2007 document entitled "Vapor Intrusion Pathway: A Practical Guideline":

Precipitation can affect vapor intrusion rates and possible soil gas concentrations. Percolation of water through the soil can displace soil gas and lead to a short-term spike in vapor intrusion. The increased soil moisture after a rain event can reduce vapor



*transport through the soil due to reduced effective porosity and permeability.
Measurements made during or immediately after a significant rain event (e.g., >1 inch)
may not be representative of long-term average conditions.*

As per CRA's SOP in Attachment A, sub-slab vapor sampling will not be performed during or within 48 hours of a significant rainfall event (e.g., greater than 0.5 inches of total precipitation).

CRA will collect and submit the sub-slab soil vapor samples for analysis of benzene, toluene, ethylbenzene, and xylenes, along with chlorinated volatile organic compounds (CVOCs) including perchloroethylene (PCE), trichloroethylene (TCE), cis/trans-1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and VC in accordance with the USEPA Toxic Organics-15 (TO-15) parameter list. CRA's SOP for sub-slab vapor probe sampling is described in detail in Attachment A (addendum to the FSP), and is summarized below.

Prior to sampling, CRA will purge the sub-slab soil vapor probes using a personal sampling pump at a flow rate of less than 200 mL/min. This ensures that the sub-slab soil vapor sample is representative of actual vapor concentrations within the sub-slab bedding material. Prior to purging, CRA will complete a vacuum or tightness test on the sampling assembly to test for leaks (details provided below). CRA will purge two to three purge volumes from the probe assembly prior to collecting the samples from each probe using 6-liter Summa canisters.

The OSWER, ITRC and Region 5 VI guidance documents do not mandate a required minimum number of sampling events to confirm the results. As such, CRA will collect a minimum of two samples from each location and determine the need for additional sampling events based on the initial two sample results. CRA will resample all of the sub-slab soil vapor probe or indoor air sample locations within no less than three months of the collection of the initial sample to account for seasonal changes. Locations selected for sampling on a second occasion will be sampled at least once during the winter when the surrounding ground is frozen and vapor intrusion is expected to be highest.

Where contaminants are detected in a sub-slab soil vapor or indoor air sample at concentrations that represent an excess lifetime cancer risk above 1×10^{-4} or a non-cancer HI greater than 1, CRA will collect a confirmatory sample as soon as reasonably practicable following receipt of the sample results. Where contaminants are detected in both the original and confirmatory sub-slab soil vapor samples at concentrations that exceed an excess lifetime cancer risk above 1×10^{-4} or a non-cancer HI greater than 1, CRA will collect two indoor air samples (in two discrete sampling events) to determine whether the contaminants detected in the sub-slab samples are migrating to indoor air at concentrations that pose an unacceptable risk to receptors. The indoor air samples will be collected following the procedures described above and in accordance with the relevant requirements of the FSP and QAPP.



2.2.1 Leak Testing

Prior to purging, CRA will complete a vacuum test on the sampling assembly as the first of two leak-testing steps. During the first leak-testing step, CRA will open the valve to the personal sampling pump leaving the valves to the Summa™ canister and the soil gas probe closed. CRA will then operate the pump to ensure that no ambient air enters the sampling assembly (i.e., the pump should create a negative pressure within the sampling assembly).

During the second leak-testing step, CRA will release a tracer compound to the ground surface immediately around the sub-slab probe surface casing. The tracer test will test for ambient air leakage through the probe assembly. The tracer compound is either monitored for in the field using a meter connected in-line to sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the soil gas samples (e.g., isopropanol). CRA will complete leak testing during sample collection by injecting helium into a shroud covering the sub-slab probe, and monitoring for the presence of helium in the sampling line both before and after sample collection.

Attachment A (addendum to the FSP) details the protocol for leak testing.

2.2.2 QA/QC

For QA/QC purposes, CRA will submit one field duplicate for every 10 samples submitted. Based on the total expected sub-slab soil vapor samples during the initial sampling round, CRA will submit two field duplicate samples. CRA will also submit one trip blank sample for analysis to assess the sample handling procedures, and one background outdoor air sample per day to assess the background concentrations at the time of sampling. Where sampling occurs in more than one area of the Site on a single day, CRA will collect one background outdoor air sample from each area to ensure that local-scale ambient air concentrations of contaminants are characterized. All Summa canisters used in the sampling program will be individually certified by the laboratory to ensure that they are free of contamination prior to collection of the samples. Results of this certification will be included in the VI Investigation Report.

3.0 SCHEDULE

Field work will begin within thirty days of receipt of USEPA approval of the VI Investigation Work Plan, dependant on subcontractor availability, and obtaining access to the various private properties, businesses and residences. Follow-up sampling will be completed within 90 to 120 days of the original sampling event.



**CONESTOGA-ROVERS
& ASSOCIATES**

December 17, 2010

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Reference No. 038443-89

4.0 REPORTING

CRA will post the validated analytical results to the South Dayton Dump and Landfill file transfer protocol (ftp) site immediately upon completion of validation. CRA will notify USEPA immediately of any analytical results that demonstrate a potential excess lifetime cancer risk above 1×10^{-4} or a non-cancer HI greater than 1.

The draft VI Investigation Report will be submitted to USEPA within thirty days of receipt of the final laboratory data report from the second sampling event. The draft VI Investigation Report will provide a summary of results from the sub-slab soil vapor and indoor sampling and recommendations for further sampling or remedial actions required to address any unacceptable risks to on- or off-Site receptors. The VI Report will be finalized following receipt of comments from USEPA. Monthly progress reports submitted to USEPA during the investigative work will include the information required for monthly progress reports in the RI/FS SOW.

Should you have any questions on the above, please do not hesitate to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Stephen M. Quigley

VC/ca/98

Encl.

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Chris Athmer, Terran
Bryan Heath, NCR

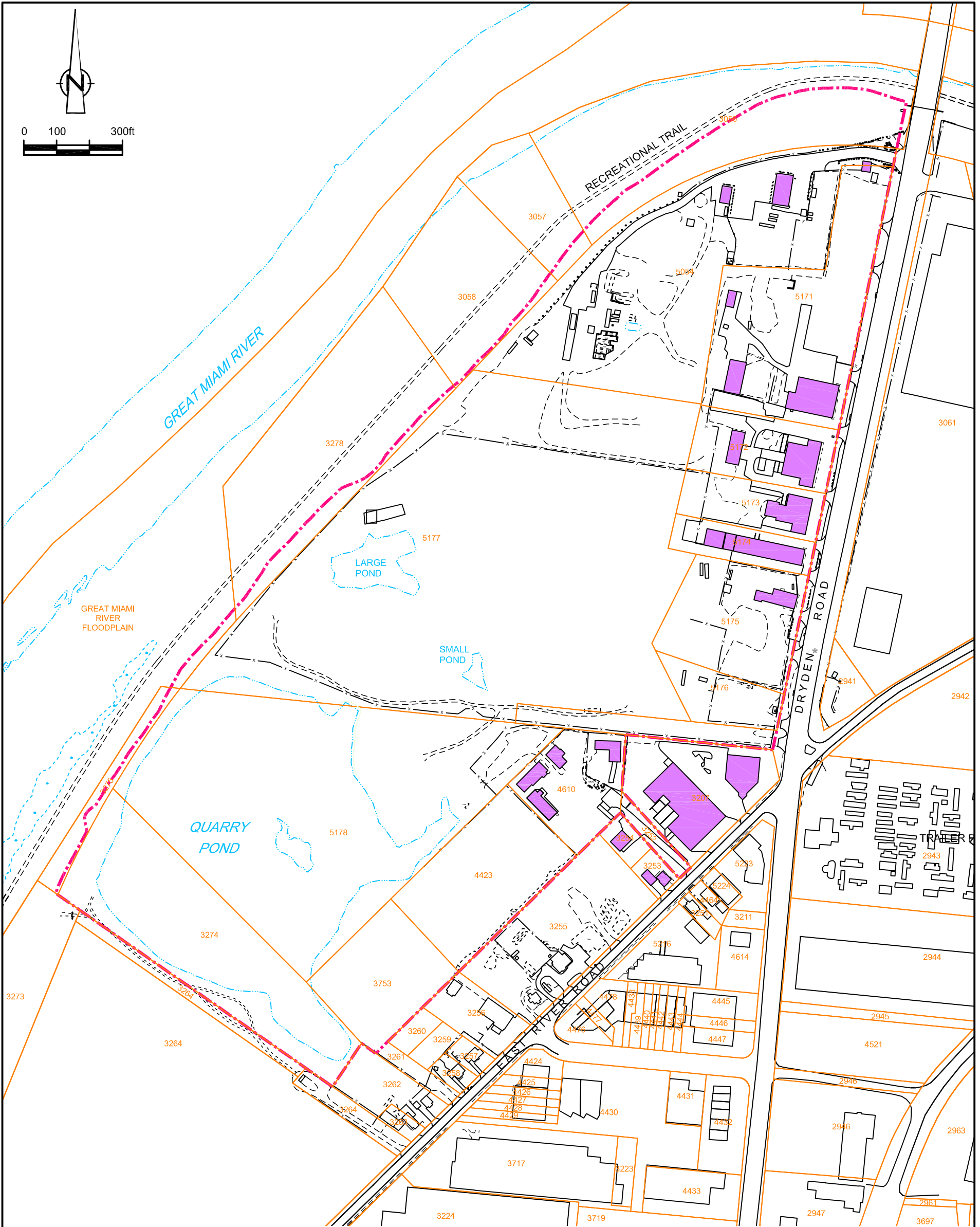


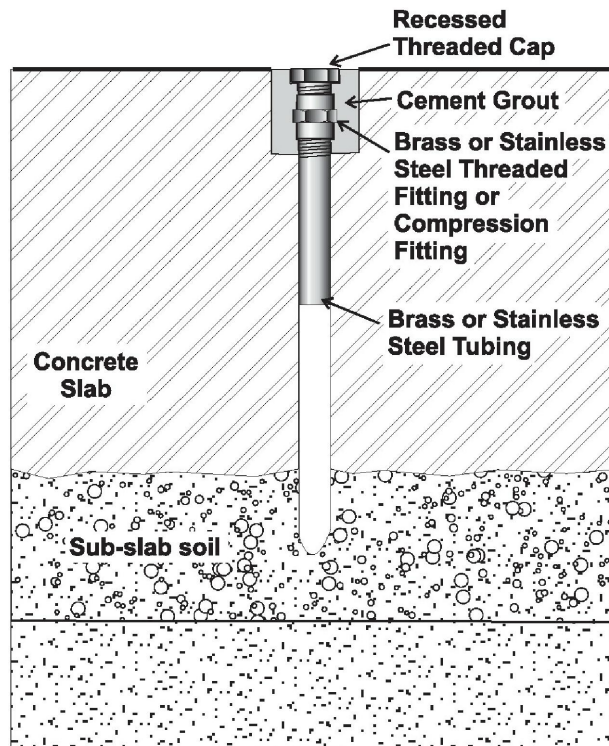
figure 1
SUB SLAB SAMPLING LOCATIONS
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



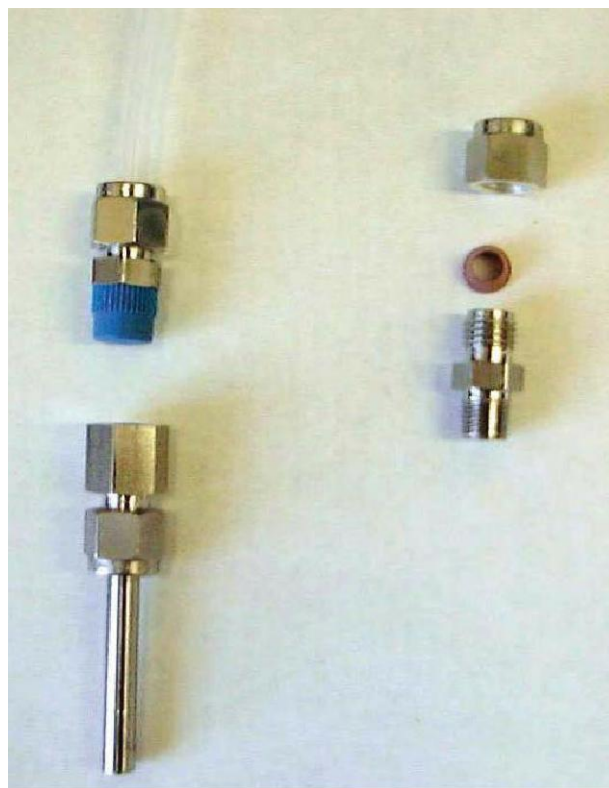
SOURCES:
THE PAYNE FIRM, INC., PROJECT 0279.44.05, FIGURE 1, DATED 9/12/05;
TETRA TECH EM INC., PROJECT L0312006-SOUTH DAYTON DUMP, FIGURE 2, SITE LAYOUT, 05/25/2004;
CITY OF MORaine.
ABRAMS AERIAL SURVEY INC. PROJECT 38443, AASI 29610, 04/02/2008

ATTACHMENT A

STANDARD OPERATING PROCEDURE
FOR SUB-SLAB SOIL GAS PROBES



SCHEMATIC OF TYPICAL SUB-SLAB SOIL GAS PROBE



FITTINGS USED FOR SUB-SLAB SOIL GAS PROBE ASSEMBLY

figure A.1

SOURCE: U.S. EPA (2006)

TYPICAL SUB-SLAB SOIL GAS COMPLETION DETAIL
SOUTH DAYTON DUMP AND LANDFILL SITE
Moraine, Ohio



STANDARD OPERATING PROCEDURE FOR SUB-SLAB SOIL GAS PROBES

1.0 PRIOR PLANNING AND PREPARATION

Prior to installing a sub-slab gas probe:

1. Review the Work Plan and HASP with the Project Coordinator. Understand the existing site geologic/hydrogeologic conditions such as the type of soil, level of water table or perched groundwater table, and properties of refuse (if installing a probe in a landfill) such as depth, leachate levels or perched leachate levels. Know the seasonally high and low water table and leachate elevations, and know if perched conditions exist.
2. Assemble all required equipment, materials, log books, and forms.
3. Coordinate with a drilling/coring contractor (if one is retained) to ensure the work can be completed and to provide them with all relevant information to complete the job prior to arriving on site.
4. Obtain information on the probes to be installed to ensure a complete understanding of the task to be performed. Required information for installation includes knowing the type of gas probe construction materials that are to be used, including knowing the diameter of the probe, depth of probe (length of riser), type and amount of packing material, type of probe material, and planned location for each probe. Also determine if multilevel probes are required.
5. Determine the type of analyses that are required from the probes after installation, and the type of gas monitoring that is required during the drilling and installation of the probe.
6. Arrange access to the site, especially if the property owner is not our client. Obtain all necessary keys. Also consider site conditions (e.g., is snow removal required?).
7. Determine excess soil or refuse disposal procedures before commencing drilling/coring activities.
8. Determine drilling or property access notification requirements with the Project Coordinator. Notify the client, landowner, and appropriate regulatory agencies and complete utility clearance activities in accordance with the FSP.
9. Understand and review the potential health and safety hazards associated with the task and with the site.

These considerations should have been incorporated during development of the Work Plan and should be discussed with the Project Coordinator.

2.0 EQUIPMENT DECONTAMINATION

Prior to use between gas probe locations, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the Quality Assurance Project Plan (QAPP), or the methods presented in the following section.

The minimal procedures for decontamination of drilling or excavating equipment are:

1. Hot water and detergent wash (brushing as necessary to remove particulate matter).
2. Potable, hot water rinse.

Cover clean equipment with clean plastic sheeting to prevent contact with foreign materials.

On environmental sites, soil sampling equipment (e.g., split-spoons, trowels, spoons, shovels, and bowls) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with potable water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

3.0 INSTALLATION PROCEDURES - SUB-SLAB GAS PROBES

Sub-slab soil gas probes allow for collection of sub-slab soil gas samples from directly beneath the slab of a building. Note that sub-slab soil gas probes are not recommended when groundwater is present directly below the slab, as drilling through the slab could allow groundwater to enter the building. A summary of the steps involved in the installation of sub-slab soil gas probes is presented below:

1. Prior to drilling holes into the building floor, the location of utilities coming into the building (e.g., gas, electrical, water, and sewer lines, etc.) will be identified. Avoid installing sub-slab soil gas probes near where utilities penetrate the slab as these may be entry points for downward ambient air migration through the slab during sub-slab soil gas sampling.
2. A rotary hammer drill or equivalent equipment will be used to drill a "shallow" [approximately 1-inch (2.5-cm) deep] outer hole [approximately 7/8 inches (2.2 cm) in diameter] that partially penetrates the floor slab. Cuttings may be removed using a towel moistened with distilled water or small portable vacuum cleaner.
3. The rotary hammer drill or equivalent equipment will be used to drill a smaller diameter inner hole, within the center of the outer hole, approximately 3/8 inch (9.5 mm) in diameter through the floor material and approximately 3 inches (7.6 cm) into the sub-slab bedding material to create an open cavity. The outer hole will be cleaned with a towel moistened with distilled water.
4. Chromatography grade 316 stainless steel or brass tubing will be cut to a length that allows the probe to float within the slab thickness to avoid obstruction of the probe with sub-slab bedding material. The tubing will be approximately 1/4 inch (6.4 mm) in diameter. Where necessary, the compression fittings will be stainless steel or brass (approximately 1/4 inch O.D. and 1/8-inch NPT) Swagelok® female thread connectors. Whenever possible, the probes will

be constructed prior to drilling to minimize exposure time, or venting, of the sub-slab bedding material through the open hole.

5. The sub-slab soil gas probe will be placed in the holes so that the top of the probe is flush with the top of the floor. The top of the probe will have a recessed stainless steel or brass plug. A quick-drying, Portland cement slurry will be injected or pushed into the annular space between the probe and the outer hole. The cement will be allowed to dry for at least 24 hours prior to sampling.

3.1 INSTALLATION DOCUMENTATION

Details of each sub-slab soil gas probe installation should be recorded on CRA's standard Stratigraphic Log Overburden, or recorded within a standard CRA field book. The Well Instrumentation Log is provided for recording the overburden well instrumentation details, and can be used for sub-slab soil vapor probe installations. This figure must note:

- borehole depth;
- slab thickness;
- probe perforation intervals;
- plug intervals;
- surface cap detail;
- sub-slab soil gas probe material;
- sub-slab soil gas probe instrumentation (i.e., probe length);
- sub-slab soil gas probe diameter;
- cement slurry seal detail;
- stickup/flush-mount detail; and
- date installed.

Each sub-slab soil gas probe installed must have accurate field ties to the center of the sub-slab soil gas probe from three adjacent permanent features of the structure within which the probe is installed, each located in a different direction from the installation.

Each sub-slab soil gas probe must be permanently marked to identify the sub-slab soil gas probe number designation.

4.0 RESPIRATORY PROTECTION

The HASP must be followed with regard to respiratory protection.

5.0 FOLLOW-UP ACTIVITIES

Once the sub-slab soil gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes.
2. All logs will be submitted to CRA's hydrogeology department who will be responsible for the generation of the final well log.
3. Arrange surveyor to obtain accurate horizontal and vertical control.
4. Gas probe/boring locations will be accurately plotted on the site plan, since boring locations may change in the field due to utility interferences or other conditions.
5. Tabulate sub-slab gas probe details.
6. A summary write-up on field activities including, but not necessarily limited to such items as drilling method(s), construction material, etc.
7. Field book will be kept at the appropriate CRA office.

6.0 FIELD INSTRUMENTATION CALIBRATION

Sampling or monitoring equipment used in the sub-slab soil gas and outdoor air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. Field calibration of the personal sampling pump and PID meter will be carried out prior to sampling activities.

The vacuum gauge used to measure canister vacuum will be calibrated and provided by the laboratory. The vacuum gauge will be returned to the laboratory for the laboratory to obtain vacuum measurements prior to sample analysis (checking canister integrity was maintained during shipment). Using a common vacuum gauge will avoid variations in vacuum measurements that can arise due to using different vacuum gauges.

7.0 SUB-SLAB SOIL GAS SAMPLING PROTOCOL

The following sections describe the protocol for sub-slab soil gas sampling from permanent sub-slab soil gas probes. For evaluating vapor intrusion, permanent sub-slab soil gas probes are preferable to allow for multiple sub-slab soil gas sampling events. More than one sub-slab soil gas sampling event is often required when assessing vapor intrusion to address seasonal variations and temporal variability commonly observed in sub-slab soil gas concentrations.

Sub-slab soil gas sampling should commence a minimum of 24 hours following installation of the sub-slab soil gas probes, to allow time for disturbances created by drilling to dissipate and allow the formation to return to an equilibrium condition. In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for equilibrium conditions to become re-established (e.g., 72 hours). Sub-slab soil gas sampling will not be performed during or within 48 hours of a

significant rainfall event [e.g., >0.5 inches after Cal EPA (2003)]. This will avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen sub-slab soil gas concentrations, or possibly prevent sub-slab soil gas sample collection (i.e., such as in cases where the sub-slab soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for rainfall events to dissipate. The potential influence of rainfall events on sub-slab soil gas concentrations is less of concern in cases where the sub-slab soil gas probes are located beneath impervious ground cover (e.g., pavement or building foundation).

A summary of the steps involved in sub-slab soil gas sampling is presented below:

- i) Sub-slab soil gas samples for assessing the vapor intrusion pathway will be collected using certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for sub-slab soil gas sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability. Consideration should be given to using smaller capacity canisters to reduce sample volume and increase confidence that the sub-slab soil gas sample is drawn from the formation immediately surrounding the probe screen during sampling. Larger volume samples can promote drawing ambient air down the annulus of the sub-slab soil gas probe which can dilute the sub-slab soil gas sample. The use of the smaller canister sizes becomes more critical in fine-grained soil conditions where the formation may not give up significant sub-slab soil gas volumes (in this case, ambient air infiltration down the sub-slab soil gas probe annulus can be more problematic).
- ii) The Summa™ canisters will be fitted with a laboratory calibrated critical orifice flow regulation device sized to restrict the maximum sub-slab soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum sub-slab soil gas sampling flow rate recommended by Cal EPA (2003) of 100 to 200 mL/min. The 100 mL/min maximum flow rate translates to sample collection times of 10, 17, or 60 minutes, respectively, for of 1-, 1.7-, or 6-liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the sub-slab soil gas probe annulus that would dilute the sub-slab soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the sub-slab soil gas sample is drawn from immediately surrounding the screened interval.
- iii) A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory. Using the same vacuum gauge throughout the entire sampling process will eliminate discrepancies between vacuum measurements that can arise from using different gauges with a potentially different sensitivity and/or calibration.
- iv) The canister will be connected to the sub-slab soil gas probe valve at the surface casing using the sampling assembly that is depicted on Figure 15.5. The sampling assembly is connected using short lengths [e.g., 1-foot (0.3 m)] 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and air-tight stainless steel or brass tee-connectors and tee-valves

(e.g., Swagelok® type). The canister will be connected to the sub-slab soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of sub-slab soil gas probe, vacuum gauge, pump, and canister). A tee-valve will be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing will be used for each sample.

- v) Prior to collecting a sub-slab soil gas sample, the stagnant air in the sampling assembly tubes and sub-slab soil gas probe casing/sand pack must be removed. The sub-slab soil gas probes will be purged prior to sampling using the personal sampling pump at a flow rate of less than 200 mL/min. This ensures that the collected sub-slab soil gas sample is representative of actual sub-slab soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.
- vi) Prior to purging, a vacuum, or tightness, test will be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 15.2.4. Briefly, this first leak-testing step (the vacuum test) will consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the sub-slab soil gas probe closed. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. Further details of the vacuum test are described below.
- vii) Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps will be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the sub-slab soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the sub-slab soil gas probe and into the sub-slab soil gas sample. The tracer compound is either monitored for in the field using a meter connected in-line to sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the sub-slab soil gas samples (e.g., isopropanol). The set-up requirements of the tracer compound leak-testing step are described below.
- viii) Following the vacuum test, and the set-up for the tracer compound leak-testing step, the sub-slab soil gas probe purging will commence by opening the valve to the sub-slab soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™ canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas will be monitored using a portable photoionization detector (PID) meter. The PID meter will be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary from approximately 300 mL/min to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump likely will increase the purging flow rate temporarily until a reading from the PID meter is obtained. PID readings will be recorded and entered in the field logbook and chain of custody form. The PID readings will provide the laboratory with an indication of whether a sample could require dilution before analysis.

- ix) Following purging, the valve to the personal sampling pump will be closed, and the valves to the sub-slab soil gas probe and Summa™ canister will be opened to draw the sub-slab soil gas sample into the canister concurrent with continuing to apply the leak-testing tracer compound. The vacuum gauge reading will be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10-inches mercury (Hg) for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the sub-slab soil gas probe does not produce sufficient sub-slab soil gas to permit sample collection.
- x) To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain of custody procedures.
- xi) The vacuum gauge provided by laboratory will be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.
- xii) If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they will be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi.
- xiii) The canisters will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all sub-slab soil gas sampling data.
- xiv) The canisters will be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The sub-slab soil gas samples will be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. Quality control/quality assurance (QA/QC) measures implemented during the sub-slab soil gas sampling event will include the two-step leak testing procedure (see Section 15.2.4), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample.

8.0 SUB-SLAB SOIL GAS PROBE LEAK TESTING

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the sub-slab soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing will be conducted in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air tight; and
- Step 2 - Tracer Test: used to ensure that ambient air during sub-slab soil gas sample collection is not drawn down the sub-slab soil gas probe annulus through an incomplete seal between the formation and the sub-slab soil gas probe casing.

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly will be connected to the sub-slab soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the sub-slab soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of sub-slab soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test will consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the sub-slab soil gas probe. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.
- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure will be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the sub-slab soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the sub-slab soil gas probe and into

the sub-slab soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) will be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in the dilute solution of isopropanol will be wrapped around the sub-slab soil gas probe surface casing and ground surface immediately surrounding the surface casing. Sub-slab soil gas probe surface casing then will be covered over using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface will be accomplished using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the sub-slab soil gas probe purging, remove the paper towels from the solution wringing out the towels so they are very damp, but not dripping, before placed them around the vapor probe and sealing them in place using the plastic sheeting.
- The isopropanol solution will be kept fresh, with new solution being made every hour. The solution will be mixed at a central location away from the sampling activities. The isopropanol will be kept tightly capped and kept away from all sampling equipment. The solution will be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel will wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.
- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapors emitted from dilute isopropanol solution will not be considered reliable and representative of sub-slab soil gas concentrations within the formation (ITRC, 2007). The starting concentration will be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly will be monitored during purging and sub-slab soil gas sample collection using a helium meter installed in-line with the sampling assembly just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.

- A containment unit is constructed to cover the sub-slab soil gas probe surface casing. The containment unit will consist of an over-turned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the sub-slab soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to sub-slab soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the containment unit will be confirmed using the helium meter and recorded in the field logbook. Helium will continue to be introduced to the containment unit during sub-slab soil gas probe purging and sampling, but care will be taken not to increase the pressure within the containment unit beyond that of atmospheric pressure.
- During sub-slab soil gas probe purging and sampling, the helium meter will be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the containment unit), the sub-slab soil gas probe will be judged to permit significant leakage such that the collected sub-slab soil gas sample will not be considered reliable and representative of sub-slab soil gas concentrations within the formation (ITRC, 2007).
- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

REFERENCES

- Cal EPA, 2003. Advisory – Active Sub-slab soil gas Investigations, Department of Toxic Substances Control, January 28.
- Cal EPA, 2005. Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion in Indoor Air. Department of Toxic Substances Control, (revised February 7).
- ITRC, 2007. Vapor Intrusion Pathway: A Practical Guide, January.
- U.S. EPA, 1988. The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis, May.
- USEPA, 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air Second Edition, EPA/625/R-96/010b, January 1999.
- U.S. EPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, March 2006. EPA/600/R-05/147.

ATTACHMENT B

SOP FOR THE INDOOR AIR SAMPLING

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LIST OF FORMS
(Following Text)

FORM 1	BUILDING PHYSICAL SURVEY QUESTIONNAIRE
FORM 2	INDOOR AIR SAMPLING FIELD DATA SHEET
FORM 3	INDOOR AIR SAMPLING INSTRUCTIONS TO BUILDING OCCUPANTS

1.0 INTRODUCTION

This Attachment presents the indoor air sampling protocol employed by Conestoga-Rovers & Associates to evaluate the potential presence of volatile organic compounds (VOCs) in indoor air due to subsurface soil and/or groundwater impacts. The protocol presented herein consists of conducting a physical survey of the building to be sampled in conjunction with interviewing building occupants, followed by collection of indoor air samples using 6-liter Summa™ canisters. This indoor air sampling protocol has been developed in consideration of the sampling procedures recommended in the following regulatory guidance documents:

- *“Indoor Air Sampling and Evaluation Guide”* dated April 2002 and prepared by the Massachusetts Department of Environmental Protection (MDEP) (MDEP, 2002)
- *“Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion – Interim Final”* dated December 15, 2004 (and revised February 7, 2005) and prepared by the California Environmental Protection Agency (Cal EPA) (Cal EPA, 2004)
- *“Draft Vapor Intrusion Pilot Program Guidance”* dated April 26, 2006 and prepared by the Indiana Department of Environmental Management (IDEM) (IDEM, 2006)
- United States Environmental Protection Agency (USEPA) – Region 5 - *Vapor Intrusion Guidebook*, October 2010 (USEPA, 2010)

Section 2.0 presents the physical building survey to be conducted that will enable a qualitative assessment of factors that potentially could influence indoor air quality. Section 3.0 presents the indoor air sample collection procedure, including quality assurance/quality control (QA/QC) measures and laboratory analytical methodology to be applied in the sample analysis.

2.0 PHYSICAL BUILDING SURVEY

A physical survey will be conducted of the buildings to be sampled. The physical survey will be conducted in conjunction with interviewing the occupants of the buildings. The purpose of the physical survey is to obtain data that will allow a qualitative assessment of factors that potentially could influence indoor air quality. The physical survey includes collecting data on aspects of the building configuration such as building layout, attached garages, utility entrances into the building, ventilation system design, foundation conditions, presence of foundation sump, building material types (e.g., recent carpeting/linoleum and/or painting), location of laundry facilities, etc. The physical survey also includes collecting data related to occupant lifestyle choices that could potentially influence indoor air quality such as use of cleaning products, dry-cleaner use, indoor storage of paints and/or petroleum hydrocarbon products, use of aerosol consumer products, smoking, etc.

The physical survey will be documented by completing the attached Form 1 - Building Physical Survey Questionnaire.

3.0 INDOOR AIR SAMPLE COLLECTION PROCEDURE

Indoor air samples will be collected from the buildings which are or may be occupied that have no slab (e.g., dirt or gravel floor). The indoor air sample will be collected from the lowest floor of the building. An outdoor ambient air sample will be collected concurrently with the indoor air sample from an upwind location on the building property. The indoor and ambient air samples will be collected using a Summa™ canister (6-litre capacity) equipped with a critical orifice flow regulation device sized to allow the collection of an air sample over an 8-hour sampling period. The critical orifice flow regulation device will be supplied and calibrated by the laboratory selected to conduct the sample analysis.

To the extent possible, the indoor air samples will be collected with windows and doors closed to represent appropriately conservative conditions during sampling. If possible, windows and doors should be kept closed for a period of at least 24 hours prior to sample collection. During summer months, air conditioners typically would be operating under closed windows/doors conditions, and the operation of an air conditioner can be allowed during sample collection. This would be representative of season-specific ventilation conditions, and with the expected pattern of operation of the building. Care will be taken to deploy the Summa™ canisters away from the direct influence of any forced air emanating from an air conditioning unit or central air conditioning vents.

The indoor air sampling procedure is described as follows:

- Samples will be collected from an occupied building and as close as practical to the center of the area, but away from high traffic areas to minimize the potential for disturbances during sample collection. Typically, sample canisters will be located between 1 to 1.5 meters above floor level.
- For each ambient air sample, a suitable upwind location (selected to minimize the potential for disturbances during sample collection) will be selected. The ambient air sample will be collected a minimum of 1 meter above grade (if possible) and located to minimize the potential for disturbance of the canister while providing protection from weather effects.
- Air sample canisters will be labeled with a unique sample designation number. Both the sample number and the sample location information will be recorded on the attached Form 2 – Indoor Air Sampling Field Data Sheet.
- The Summa™ canister vacuum will be measured immediately prior to canister deployment and recorded on Form 2 – Indoor Air Sampling Field Data Sheet.

- The critical orifice flow controller will be installed, as supplied by the laboratory, on the canister and the canister will be opened fully at the beginning of sample collection period and start time recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- At the start and the end of the 8-hour sample period, a portable photoionization detector (PID) will be used to screen for VOC presence in the sample area. Results of the PID monitoring were recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- Other data recorded on Form 2 – Indoor Air Sampling Field Data Sheet will include: outside and interior temperatures both at the start and end of the sample period, equipment serial numbers, sampler name, and any comments.
- Following equipment setup, the building occupant will be given the list of instructions to follow while the Summa™ canister sample is being taken in the building. The instructions are listed in the attached Form 3 - Indoor Air Sampling Instructions to Building Occupants. The date and completion time of the 8-hour sample period will be written on Form 3 and the occupant will be instructed that the sampling team would be back to pick up the canister after approximately 8 hours.
- The canister valve will be closed fully at the end of the sample period (after 8 hours) and the end time recorded on the field data sheet. If there is evidence of canister disturbance during the sample collection, this will be recorded on Form 2 – Indoor Air Sampling Field Data Sheet.
- The Summa™ canister vacuum will be measured immediately after canister retrieval at the end of the 8-hour sample period and recorded on the field data sheet. Any samples where the canister reached atmospheric pressure will be rejected and the canisters returned for cleaning. The minimum vacuum required to be considered a valid sample will be 1 to 2 inch Hg vacuum. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under CRA chain of custody procedures. The requirement for residual vacuum retained in the canister following sample collection is to ensure that a driving force was maintained to collect a steady flow rate until the end of the sampling event.
- The Summa™ canister vacuum will be measured by the laboratory immediately prior to sample analysis and recorded on the analytical data report.
- All canisters will be cleaned in accordance with United States Environmental Protection Agency (USEPA) Method TO-15 and documentation of the cleaning activities will be obtained from the laboratory.

3.1 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) samples will be collected during the indoor air sampling. QA/QC samples will include:

- the ambient air sample
- one duplicate

3.2 ANALYTICAL METHOD/LABORATORY

The soil vapor samples will be analyzed by a certified laboratory using the USEPA TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology.

3.3 DATA VALIDATION

A data validation for the air sample result will be conducted by CRA.

3.4 CANISTER CLEANING

Canister cleaning was completed in accordance with the applicable sections of Method TO-15.

4.0 REFERENCES

- Cal EPA, 2004. Guidance on the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air - Interim Final, Department of Toxic Substances Control, California Environmental Protection Agency, December 15 (revised February 7, 2005).
- IDEM, 2006. Draft Vapor Intrusion Pilot Program Guidance. Indiana Department of Environmental Management, April 26.
- MDEP, 2003. Indoor Air Sampling and Evaluation Guide, WSC Policy #02-430, Office of Research and Standards, Massachusetts Department of Environmental Protection, April.
- USEPA, 2010. Region 5 - Vapor Intrusion Guidebook, United States Environmental Protection Agency .

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

Address: _____

Building Owner: _____

Occupant Name: _____

Date: _____ Time: _____ Inspector: _____ Sample No.: _____

Contact Name: _____ Phone Number: _____

How long have you lived/worked in this home/building? _____

Occupation: _____

Number of Occupants Adults: _____

Children: _____

BUILDING TYPE: One story _____ Two storey _____ Brick _____ Siding _____ Stucco _____

DESCRIBE BUILDING: _____ **YEAR CONSTRUCTED:** _____

WEATHER SEALS: General Condition: Good _____ Fair _____ Poor _____

BASEMENT:	None	<input type="checkbox"/>	Finished	Unfinished	Depth below reference point (meters)
Partial	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	
Full	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	
Crawl space	<input type="checkbox"/>	na	na	_____	

Number of floors at or above grade: _____

Depth of basement below grade: _____ ft. Basement Size: _____ ft²

Foundation construction: Poured concrete ☐ Cinder block ☐ Stone ☐

Any visual evidence of leakage through basement walls or floor ☐

Floor Construction: Poured concrete ☐ Wood ☐ Earth ☐ Brick ☐ Other: _____

Floor condition (cracks, drains): _____

Condition at floor/wall joint (if visible): _____

Any exterior openings from the basement:

☐ Vents

☐ Fans

☐ Windows

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

- ☐ Wall openings
☐ Utility pipe penetrations
☐ Other: _____

Type of ground cover outside of building: grass / concrete / asphalt / other (specify): _____

Sub-slab vapor/moisture barrier in place? Yes / No / Don't know

Type of barrier: _____

Do you have a sump?: Yes ☐ No ☐

Where: _____

If yes, sealed ☐ open ☐ NA ☐

If yes, is there water in the sump?: Yes ☐ No ☐

Is this building serviced with municipal water? Yes ☐ No ☐

Do you have a water well?: Yes ☐ No ☐ Don't know ☐

Well location: _____

Do you drink the water obtained from the well? _____

What do you use the well for?: _____

Do you have a cistern?: Yes ☐ No ☐

If yes, describe its location: _____

Do you have a septic system?: Yes ☐ No ☐

If yes, describe its location: _____

If yes, describe how septic system is cleaned: _____

Have there ever been a fire in the building?: Yes ☐ No ☐

If yes, describe its location and extent: _____

Is there a laundry room located inside the house/building?: Yes ☐ No ☐

If yes, describe its location: _____

FURNACE: Location: _____

Type:	gas	<input type="checkbox"/>	Forced air	<input type="checkbox"/>
	oil	<input type="checkbox"/>	hot water	<input type="checkbox"/>
	electric	<input type="checkbox"/>	other	_____

Does furnace have outside combustion air vent? _____

Do you have a fireplace? Yes ☐ No ☐

Does the fireplace have an outside combustion air vent? Yes ☐ No ☐

Do you use kerosene space heaters? Yes ☐ No ☐

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

AIR CONDITIONER: None _____ Central _____ Room _____
(If yes, which rooms and capacities?) _____

RADON SYSTEM: ☐ Yes ☐ No

GARAGE: Do you have an attached garage? ☐ Yes ☐ No

1. When was the last time dry-cleaned clothes were brought into the house/building?
☐ 0 to 5 days ago ☐ 6 to 10 days ago ☐ More than 10 days ago ☐ Don't dry-clean
2. When was your carpet installed?
☐ In the last six months ☐ More than six months ago ☐ No Carpet
3. When was the last time your carpet was cleaned?
☐ In the last six months ☐ More than six months ago ☐ Never
4. Do you have any spot removers in the house?
☐ Yes ☐ No Details: _____
5. Do your hobbies include model building, arts and crafts, model railroading, or others that require paints, thinners, or glue?
☐ Yes ☐ No Details: _____
6. Do you perform automotive or other vehicle maintenance or repair at home?
☐ Yes ☐ No Details: _____
7. Please review the following list and check items you know are in your home
 - ☐ Latex caulk
 - ☐ Latex paint
 - ☐ Vinyl cove molding
 - ☐ Linoleum tile
 - ☐ Black rubber molding
 - ☐ Vinyl edge molding
 - ☐ Polystyrene foam insulation
 - ☐ Adhesive removers

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

- ☐ Aerosol spray paints
- ☐ Other paints
- ☐ Air fresheners
- ☐ Degreasers
- ☐ Deodorants
- ☐ Disinfectants
- ☐ Furniture Polish
- ☐ Solvents
- ☐ Caulking

8. Do you have pesticides in your home/building?

- ☐ Yes ☐ No ☐ Unsure

9. Do you have any spray insecticides in your home/building?

- ☐ Yes ☐ No ☐ Unsure

10a. Have you painted any area of the interior of your home/building in the last 12 months?

- ☐ Yes ☐ No

10b. If yes, please indicate what paint you used

- ☐ Enamel
- ☐ Vinyl
- ☐ Latex
- ☐ Other

11a. Have you painted the exterior of your building in the last 12 months? ☐ Yes ☐ No

11b. If yes, please indicate what paint you used

- ☐ Enamel
- ☐ Vinyl
- ☐ Latex
- ☐ Other

FORM 1: BUILDING PHYSICAL SURVEY QUESTIONNAIRE

12. Where do you store your paint, thinner, pesticides, insecticides?

	<i>Paint</i>	<i>Thinner</i>	<i>Pesticides</i>	<i>Insecticides</i>
Garage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Basement	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storage shed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ I don't store these items at home

13. Have you purchased one of the following items in the last 12 months?

- | | | |
|---|-----------------------------------|-----------------------------------|
| <input type="checkbox"/> Rubberized door mat | <input type="checkbox"/> Computer | <input type="checkbox"/> Wiring |
| <input type="checkbox"/> Plastic shower curtain | <input type="checkbox"/> Printer | <input type="checkbox"/> Linoleum |
| <input type="checkbox"/> Wood stains or paint | <input type="checkbox"/> VCR | |

14. Do you have a computer printer in your home/building?

☐ Yes ☐ No

15. Do you have a VCR in your home/building?

☐ Yes ☐ No

16. Do you use cleaners to maintain your VCR/building?

☐ Yes ☐ No

If yes, what type? _____

17. Do you have pets residing in this building?

☐ Yes ☐ No

If yes, what type? _____

If yes, number _____

18. Does anyone in the building smoke? ☐ Yes ☐ No

19. Questions asked by Occupant that require follow-up.

FORM 2: INDOOR AIR SAMPLING FIELD DATA SHEET

A) General Information

Sample Identification Number: _____

Site Address: _____

Sample Canister Location: _____

Sample source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sample Date: _____ Sampler: _____

Sample Time: _____ Start: _____ Stop: _____

Shipping Date: _____

Canister Type: 400 mL - 1.0 L Summa Canister/6 L Summa Canister/Other (specify): _____

Canister Serial No.: _____

Flow Controller Serial No.: _____

Were "Instructions for Occupants" followed?

☐ Yes ☐ No

B) Sampling Information

	Start		Stop	
	Ambient	Interior	Ambient	Interior
Temperature	_____	_____	_____	_____

	Start	Stop
Canister Pressure Gauge Reading:	_____	_____
Time:	_____	_____
PID Reading (ppm):	_____	_____
Basement Depth (ft below grade):	_____	_____
Window Marked:	Yes/No	_____

Was there significant precipitation within 12 hours prior to (or during) the sampling event?

☐ Yes ☐ No

Describe the general weather conditions: _____

FORM 2: INDOOR AIR SAMPLING FIELD DATA SHEET

Provide Drawing of Sample Location(s) in Building



C) Comments

1. The duration of this test is approximately 8 hours.
2. The canister is made of clean stainless steel. It does not contain any moving parts or chemicals.
3. Do not handle or move a canister during testing.
4. Do not smoke around the canister.
5. To the extent possible, leave doors and windows closed during testing.
6. To the extent possible, do not use paint, solvents, glues, and spray cans during testing.
7. If possible, do not bring dry cleaning into the building during the testing.
8. We will be back tomorrow to pick up the canister about this time.

Canister pick up: Day_____

Time_____

Thank you for your cooperation.

ATTACHMENT C

SUB-SLAB SOIL VAPOR AND
INDOOR AIR SAMPLING ACTIVITIES

SUB-SLAB SOIL VAPOR AND INDOOR AIR SAMPLING ACTIVITIES

The objectives of the sub-slab soil gas sampling are as follows:

- Determine whether contaminant concentrations pose more than a 1×10^{-4} cancer risk or a hazard index (HI) greater than 1.0 through the vapor intrusion (VI) pathway to current or potential future receptors
- Determine whether concentrations of combustible gases within a structure exceed 10 percent of the lower Explosive Limit (LEL) for methane)
- Identify buildings where indoor air sampling is required based on the sub-slab sample results

Sub-slab soil vapor probes will be installed in accordance with the Vapor Intrusion Investigation Work Plan, dated December 17, 2010. Sub-slab soil vapor probes will be installed beneath the following existing on-Site structures:

- A. *Structures On Site West of Dryden Road:*
 - 3 building structures on Lot 5054*
 - 3 building structures on Lot 5171*
 - 2 building structures on Lot 5172*
 - 1 building structure on Lot 5174*
 - 1 building structure on Lot 5175, and*
- B. *Structures On Site or Adjacent to Site Along East River Road:*
 - 4 building structures on Lot 4610 (Barnett; on-Site)*
 - 2 building structures on Lot 3207*
 - 1 residence on Lot 3253; and*
 - 1 building structure on Lot 3254.*

Prior to conducting the sub-slab soil vapor sampling, CRA will visually inspect of the Lots in question and document the number and type of buildings present on each Lot in order to ensure that all buildings that are or may be occupied are included in the sampling program.

Prior to installing the sub-slab soil vapor probes, a survey will be conducted of each building, to identify potential preferential pathways for vapor migration under the building. Details of the building survey are included in the Vapor Intrusion Investigation Work Plan. If any structure on or adjacent to the Site that is or may be occupied has no slab (e.g., dirt or gravel floor), indoor air samples will be collected. For any location where an indoor air sample is collected, CRA will also install a soil vapor probe screened between 3 and 5 feet below ground

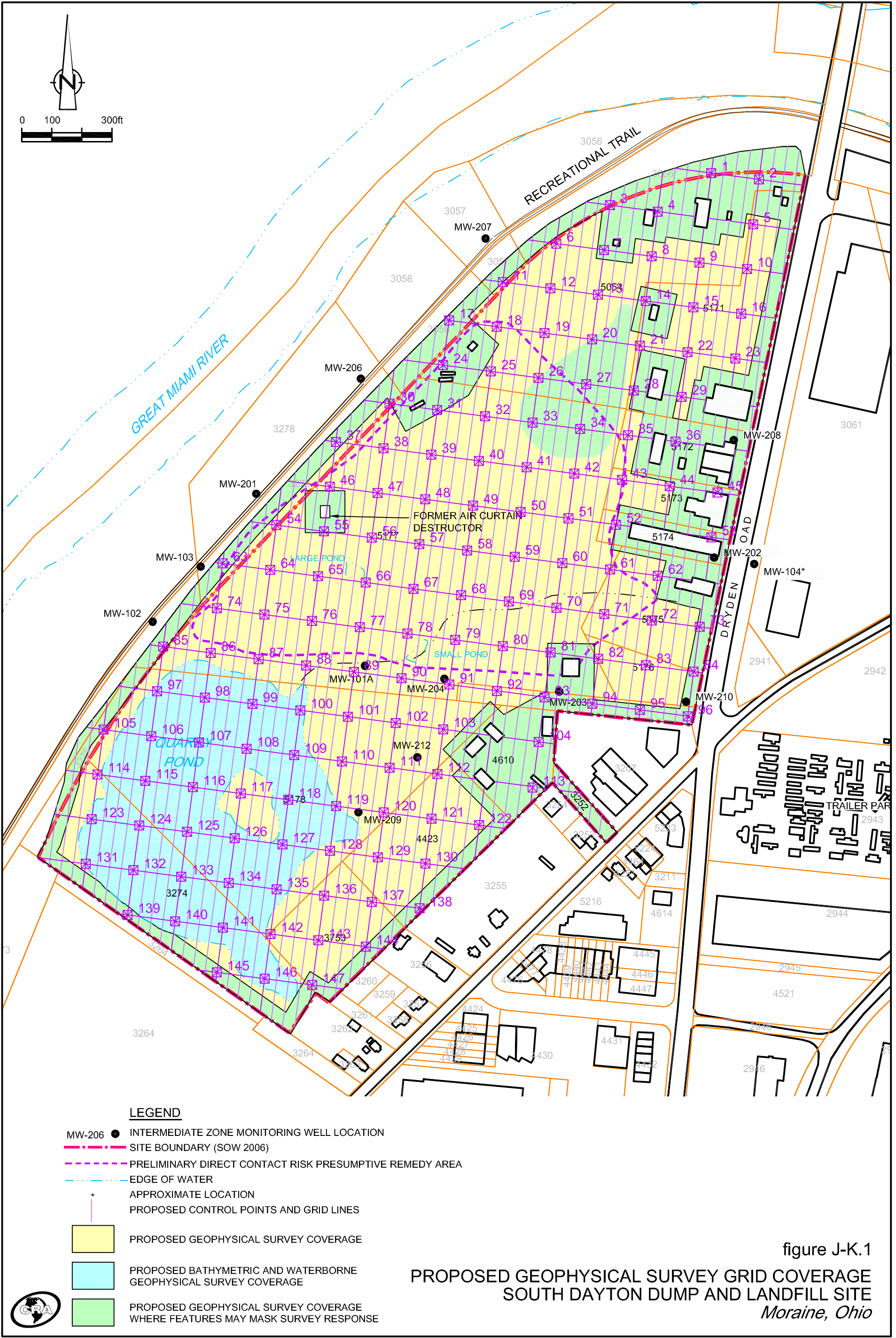
surface in accordance with CRA's SOP [Appendix J-F-11 of the Field Sampling Plan (FSP)] in order to attempt to correlate indoor air concentrations to concentrations of contaminants in soil vapor near the structure. The soil vapor probes will be installed immediately adjacent to the side of the building closest to the most likely source of any soil vapor impacts. In addition, where indoor air samples are collected, CRA will also collect ambient air samples immediately adjacent to the structure as per CRA's SOP.

CRA's standard operating procedure (SOP) for installing sub-slab probes and collecting sub-slab vapor samples are in Attachment A to the Vapor Intrusion Investigation Letter Work Plan (addendum to the FSP). CRA's SOP for indoor air sampling is in Attachment B to the Vapor Intrusion Letter Work Plan (addendum to the FSP).

If collected, sub-slab soil gas samples will be analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), along with chlorinated VOCs including perchloroethylene (PCE), trichloroethylene (TCE), cis/trans-1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and VC in accordance with the USEPA Toxic Organics-15 (TO-15) parameter list.

APPENDIX J-K

FIELD MODIFICATIONS



From Loney, Adam **Date** Monday, August 24, 2009 3:07:00 PM
To 'Cibulskis.Karen@epamail.epa.gov'
Cc 'kbrown@itw.com'; 'Brett.Fishwild@CH2M.com'; 'Osaguona.Ogbebor@CH2M.com';
'vanderpool.luanne@epa.gov'; 'murawski.ronald@epa.gov'; Close, Jason; 'jrc@e-emi.com'; Quigley,
Steve
Subject 38443-60: Landfill Gas Probe Screen Intervals
Karen,

The fill material that CRA has identified at the locations in question is inert fill material, mainly various types of sands, rather than putrescible landfill materials. CRA has not identified any odors typical of VOCs, petroleum, or waste degradation and has not detected elevated PID readings (I should note that the moisture content of the soils results in condensation which is interfering with the PID; however, high readings would still be detectable). In the absence of putrescible landfill material or evidence of VOC or petroleum contamination, CRA has been installing the screen in the most permeable strata. This is consistent with the intent of the Letter Work Plan which was to identify the most likely pathway for landfill gas or soil vapour migration and in which we state that the "screened interval of the gas probes will be installed in soil strata with a notably higher permeability than the surrounding geologic strata." CRA has also been discussing the screen intervals and the rationale for them with CH2M staff at each location.

In the case of location GP04-08, I agree that a second probe with a screened interval between 3 and 4 ft bgs is appropriate to ensure that we have data from above the moist interval. According to our field staff the interval was moist rather than wet or saturated; however, to the extent there is any possibility that the increased moisture might impede the migration of landfill gas or soil vapour, a second probe is a reasonable precaution.

Please call me if you wish to discuss the screen intervals.

Regards, Adam

From: Cibulskis.Karen@epamail.epa.gov [mailto:Cibulskis.Karen@epamail.epa.gov]
Sent: August 24, 2009 11:30 AM
To: Loney, Adam; kbrown@itw.com
Cc: Brett.Fishwild@CH2M.com; Osaguona.Ogbebor@CH2M.com; vanderpool.luanne@epa.gov;
murawski.ronald@epa.gov
Subject: Landfill Gas Probes Not Installed According to Work Plan

Adam/Ken:

It's just come to my attention that the screened intervals for gas probe locations located in fill material are not being installed in accordance with the Landfill Gas Letter Work Plan. As indicated on pages 3 and 4 of the work plan:

LFG and soil vapor will not preferentially migrate through discrete intervals of fill material at the site unless impermeable layers are present between the discrete intervals of fill material....Further, LFG and soil vapor migration to ambient air or into a building will occur from the shallow soil horizon.

...The proposed gas probe locations wil alos address LFG/soil vapor concentrations at locations near potential receptors.

The screened interval will be selected based on field observations that will identify the presence of landfill materials....Where landfill materials are present, the screen will be placed at a depth immediately above the landfilled materials. If the landfilled material extends to

within three feet of the surface and it is, therefore, not possible to set the screen above the landfilled material, the screen will be placed within the landfilled mater, with the screened interval set as close to the top of the landfilled materials as possible but deep enough to minimize the breakthrough of ambient air from the surface (i.e., 3 to 5 ft. bgs).

Based on the field reports I am got from CH2M, the following gas probes have not been properly installed:

GP05-8

0-12 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as: 8 ft. bgs

GP02-08

0-17 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as: 8 ft. bgs

GP03-08

0-15 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as: 8 ft. bgs

GP04-08

0-20 ft. fill

0-5 ft. dry

5-9.5 ft. wet

9.5-19.5 ft. dry

Screened interval should be 3-4 ft. bgs with a second screened interval just below the 5-9.5 ft. wet interval.

Actual screened interval reported as: 13 ft. bgs.

GP11-08

0-10 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 9 ft.bgs

GP09-08

0-9 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 9 ft. bgs

GP14-08

0-8 ft. fill

0-5 ft. dry

7.5-8.5 ft. wet

8.5-20 ft. dry

Screened interval should be 3-4 ft. or 4-5 ft. bgs with a second screened interval just below the 7.5-8.5 ft. wet interval.

Actual screened interval reported as 7 ft. bgs.

GP12-08

0-7.5 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 6 ft. bgs

GP13-08

0-19 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 7 ft. bgs

GP15-08

0-10 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 10 ft. bgs

GP16-08

0-12.5 ft. fill

Screened interval should be 3-4 ft. or 4-5 ft. bgs

Actual screened interval reported as 13 ft. bgs

Since the screened interval for these probes were not installed at depths "immediately above the landfilled materials" or "as close to the top of the landfilled materials as possible but deep enough to minimize the breakthrough of ambient air from the surface (i.e., 3 to 5 ft. bgs)" any LFG or soil vapor contaminants detected during the sampling may not be as representative of LFG/soil vapor concentrations closer to the surface and potential receptors.

EPA is not requiring CRA to reinstall the screened intervals for the purposes of completing the RI/FS; however, this uncertainty must be taken into consideration when the data is evaluated, and may need to be addressed more thoroughly during RD/RA.

I am out of the office today but will be back in tomorrow if you want to have a call to discuss this further.

Karen.

From: Cibulskis.Karen@epamail.epa.gov [<mailto:Cibulskis.Karen@epamail.epa.gov>]
Sent: Tuesday, December 09, 2008 2:46 PM
To: Robert.Frank2@CH2M.com
Cc: Brett.Fishwild@CH2M.com; David.Boehnker@ch2m.com; Osaguona.Ogbebor@CH2M.com; matt.justice@epa.state.oh.us; Loney, Adam

Subject: South Dayton Dump 12/8/08 Call

Thanks Rob. I don't know if CH2M was in on yesterday's call or not but here is what was discussed/agreed:

Since the purpose of the VAS is to collect data to be used for the FS, and existing groundwater and preliminary VAS data already indicate groundwater impacts above drinking water standards in both the deep and shallower parts of the aquifer, EPA agreed that:

1. VAS-10 may be eliminated.
2. Vertical aquifer sampling at locations VAS-2, VAS-6, VAS-7, VAS 19 or 22 (based on data), VAS-20 and VAS 24 may be conducted down to the first interval below the first low permeability layer encountered or to a depth of 50 ft-bgs, whichever is greater. If a low permeability layer is not encountered in the first 50 ft-bgs, the VAS will be extended to 60 ft-bgs.
3. VAS will continue using two 5-foot intervals sampled within one 10-foot screen in shallow and deep VAS locations. EPA did not agree to reduce the sampling interval to 10-foot intervals at deep borings.
4. Purging will be conducted consistent with CRA's field modification sent out by Adam Loney on 12/04/08.
5. EPA may agree that VAS -16 and VAS-18 do not need to be drilled based on VAS-17 results which should come in the next day or two. This will be discussed at next call scheduled for 4:30 eastern/3:30 central on Thursday, December 11th.

Please let me know if you have any questions.

Thanks! Karen.

From: Vanderpool.Luanne@epamail.epa.gov [<mailto:Vanderpool.Luanne@epamail.epa.gov>]
Sent: Thursday, December 04, 2008 3:39 PM
To: Loney, Adam
Cc: brett.fishwild@ch2m.com; Paul Jack; jrc@e-emi.com; Cibulskis.Karen@epamail.epa.gov; KBrown@ITW.com; Vander Meulen, Ken; Almeida, Luis; Mankowski.Matthew@epamail.epa.gov; matt.justice@epa.state.oh.us; roger.mccready@ncr.com; Quigley, Steve

Subject: Re: FW: 38443: Revised VAS Procedure

The changes agree with my recollection of the discussions yesterday.
You are good to go with these changes.

Luanne Vanderpool
U. S. Environmental Protection Agency
Region 5, Superfund
77 W. Jackson, Chicago, IL 60604
Phone: 312-353-9296
FAX: 312-886-4071
vanderpool.luanne@epa.gov

From: Loney, Adam

Sent: Thursday, December 04, 2008 1:23 PM

To: Vanderpool.Luanne@epamail.epa.gov; Cibulskis.Karen@epamail.epa.gov

Cc: brett.fishwild@ch2m.com; KBrown@ITW.com; Vander Meulen, Ken; Mankowski.Matthew@epamail.epa.gov; matt.justice@epa.state.oh.us; Quigley, Steve; roger.mccready@ncr.com; Paul Jack; jrc@e-emi.com; Almeida, Luis

Subject: FW: 38443: Revised VAS Procedure

Hello Luanne,

As agreed, I have prepared this email to document the decision reached on the conference call of December 3, 2008 regarding changes to the vertical aquifer sampling (VAS) program at the South Dayton Dump & Landfill.

The specific changes agreed to on the call relate to the purging of groundwater prior to sampling. The purging procedure in the Rotosonic SOP from the Field Sampling Plan would be modified as shown below:

3. In order to collect representative water samples, the amount of water added during the during the preceding 10-foot advancement of the outer casing will be measured and twice that volume will be removed prior to purging. When using a 10-foot temporary well screen the purging will be conducted with the pump intake set 2.5 feet below the top of the well screen. When using a 5-foot temporary well screen, the purging will be conducted with the pump intake set at the middle of the well screen. This pre-purge may be done at higher flow rates than the regular purging and a further three to five well volumes will be removed prior to sample collection (one well volume equals the number of feet of water within the screen ~~and riser pipe~~ times 0.161 gallons per foot). The regular purging of the well will be done at the same rate as the low flow rate sampling. The water level will be measured within the 2-inch diameter riser pipe using a water level tape (Solinst Model 101 or equivalent) in order to determine well volume and monitor drawdown. The depth to the bottom of the screen is known.

To ensure that the groundwater removed during purging and sampling is representative of the water in the formation, i.e., standing water in the riser pipe is not drawn into the sample, the drawdown in the riser pipe will be monitored and maintained within 20 percent of the original water level following insertion of the well screen. During purging, the water level will be checked after each purge volume is removed to ensure that it is stable.

Where a 10-foot temporary well screen is used, the submersible pump will then be lowered to a depth of 7.5 feet below the top of the temporary 10-foot screen and a second groundwater sample will be collected following the procedures provided in C3, C4, and C5 of this SOP. In cases where a 5-foot temporary well screen is used the second groundwater sample will not be collected.

In all cases, except as detailed below, water samples will only be collected after well stabilization is achieved (i.e., a minimum 3 to a maximum of 5 well volumes are purged with monitoring of stabilization parameters) as presented in C4 below. For sampling intervals where the nature of the

formation restricts the flow of water during purging significantly, purging will continue for a maximum of two hours. After this time, a sample will be collected regardless of the volume of water removed. The volume of water removed and the fact that this volume was lower than that required by the scope of work will be documented in the field notes. For intervals where water is added to the formation during drilling, an additional two hours will be added to the total purge time in an effort to recover all water added during drilling. Therefore, purging will continue for a maximum of two hours for locations where no water is added during drilling and four hours where a pre-purge is necessary to remove water added during drilling.

Please let me know if this accurately reflects the agreement reached on the call yesterday and if we can proceed with the modified sampling strategy.

Regards, Adam

From Loney, Adam **Date** Tuesday, December 02, 2008 6:44:56 PM
To 'Cibulskis.Karen@epamail.epa.gov'; 'Vanderpool.Luanne@epamail.epa.gov'
Cc 'brett.fishwild@ch2m.com'; 'KBrown@ITW.com'; Vander Meulen, Ken;
'Mankowski.Matthew@epamail.epa.gov'; 'matt.justice@epa.state.oh.us'; Quigley, Steve;
'roger.mccready@ncr.com'; 'Paul Jack'; 'jrc@e-emi.com'; Almeida, Luis
Subject 38443: Draft Revised VAS Groundwater Investigation Scope of Work

 [038443Cibu-52.doc](#) (99 KB [HTML](#))

Karen and Luanne,

Please find attached a draft letter proposing modifications to the Vertical Aquifer Sampling (VAS) program. The proposed modifications attempt to strike a balance between the need to obtain the data necessary to complete the Feasibility Study while still completing the VAS Investigation within a reasonable time frame and budget.

We wanted to provide you with the draft letter in advance of tomorrow's call in order to provide you with the opportunity to consider the proposed modifications before we discuss them on the call.

Please do not hesitate to call me if you wish to discuss the proposed modifications.

Regards, Adam

Adam Loney
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From: Cibulskis.Karen@epamail.epa.gov [mailto:Cibulskis.Karen@epamail.epa.gov]
Sent: Thu 11/6/2008 4:59 PM
To: Almeida, Luis
Subject: Re: 38443 - VAS 4 Update

Thanks Luis, I was hoping they were more above the water table. I let my guys know we were leaving it up to CRA as to whether you would case and continue sampling or leave characterizing the deeper parts of the aquifer similar to VAS-21 (or the depth of groundwater contamination from VAS-4 NAPL) as an RD/RA data gap. Just let us know what CRA decides. Karen.

-----"Almeida, Luis" <lalmeida@craworld.com> wrote: -----

To: Karen Cibulskis/R5/USEPA/US@EPA, LUANNE VANDERPOOL/R5/USEPA/US@EPA
From: "Almeida, Luis" <lalmeida@craworld.com>
Date: 11/06/2008 03:37PM
cc: <brett.fishwild@ch2m.com>, <KBrown@ITW.com>, "Vander Meulen, Ken" <kvandermeulen@craworld.com>, "Quigley, Steve" <squigley@craworld.com>, <roger.mccready@ncr.com>, "Paul Jack" <cbay3@verizon.net>, <jrc@e-emi.com>, "Loney, Adam" <aloney@craworld.com>, "Filing" <Filing@craworld.com>
Subject: 38443 - VAS 4 Update

Karen

This email documents our telephone conversation regarding the today's field observation at sample location VAS 4. VAS 4 is located in the northeast corner of the Site on the Valley Asphalt property (approximately 50 feet west of Dryden Road along the property boundary between Valley Asphalt and B&K Trucking). CRA oversight staff encountered a high PID reading when screening the soil core at the sample depth corresponding to 24-25 feet bgs. The PID reading from the core was 235 ppm. The corresponding head space reading was 600 ppm. CRA field staff performed a Sudan IV test on the soil and observed the red color development indicating the presence of NAPL. Saturated soils were encountered at 27 ft bgs at VAS 4. The temporary well was screened from 25 to 30 feet bgs. The static water level at the top of the temporary well was observed to be 25 feet bgs. There was a notable sheen in the development water being purged from the well and strong odor was also noted. One groundwater sampled was collected from the temporary well and VAS 4 was abandoned. A soil sample has been collected from the interval with the high PID reading for submission to the laboratory for analysis of VOCs. Additional soil sample volume is also being submitted to the laboratory for potential additional analyses.

Please call or email me if you have comments or questions.

Regards

Luis Almeida
Conestoga-Rovers & Associates
651 Colby Drive
Waterloo, Ontario
N2V 1C2

From Loney, Adam **Date** Friday, October 31, 2008 11:47:00 AM
To 'Cibulskis.Karen@epamail.epa.gov'; 'brett.fishwild@ch2m.com';
 'Vanderpool.Luanne@epamail.epa.gov'; 'Paul Jack'; 'jrc@e-emi.com'; 'KBrown@ITW.com';
 'matt.justice@epa.state.oh.us'; 'roger.mccready@ncr.com'; 'Osaguona.Ogbebor@CH2M.com'
Cc Almeida, Luis; Quigley, Steve; Vander Meulen, Ken
Subject RE: 38443: October 30, 2008 VAS Update Call and Schedule - Telephone Number: 1-800-503-2899
 Access Code: 3581489

Karen,

I wanted to send this email to document what we identified in the borehole at VAS-21 this morning. Last night we advanced to 64-69' bgs and purged the water added during drilling. When we measured the water level in the borehole this morning prior to starting the purging, we detected a 0.25" layer of separate phase material with the oil/water interface probe. The separate phase layer was present on the surface of the water at 23' bgs, i.e., well above the top of the well screen. There was no odor to the water and no sheen. We suspect that the separate phase layer is likely the vegetable-oil based drilling lubricant used on the threads of the drill rods. The field observations and data collected today support this determination. We do not believe that the separate phase material is due to contamination present in the formation and did conduct Sudan IV dye tests on the soil from the core in question to confirm this. No NAPL was detected using the Sudan IV dye tests. We have purged the groundwater and collected our sample at this interval in accordance with the Letter Work Plan and Field Sampling Plan (FSP), so we will have groundwater data at this location to verify the assumption.

Based on these results, we will continue to advance the borehole at this location. In order to confirm that no NAPL is present we will conduct headspace VOC screening and Sudan IV tests on the soil at the top of the next core sample. If any evidence of NAPL is discovered, the borehole will immediately be discontinued at this point and abandoned in accordance with the FSP.

Please call me if you wish to discuss and I will send a follow-up email to let everyone know what we identify in the next core sample.

Regards, Adam

From: Loney, Adam
Sent: Thursday, October 30, 2008 5:04 PM
To: 'Cibulskis.Karen@epamail.epa.gov'; 'brett.fishwild@ch2m.com'; 'Vanderpool.Luanne@epamail.epa.gov'; 'Paul Jack'; 'jrc@e-emi.com'; 'KBrown@ITW.com'; 'matt.justice@epa.state.oh.us'; 'roger.mccready@ncr.com'; 'Osaguona.Ogbebor@CH2M.com'
Cc: Almeida, Luis; Quigley, Steve; Vander Meulen, Ken
Subject: 38443: October 30, 2008 VAS Update Call and Schedule - Telephone Number: 1-800-503-2899 Access Code: 3581489

Hello everyone,

For those not on the call this afternoon, I wanted to provide a brief summary of what we have encountered thus far and what was discussed on the call. Drilling is proceeding at VAS-21. To date, the drill rig has advanced 70' bgs. Groundwater was encountered at 24' bgs. The stratigraphy encountered thus far is as follows:

- o 0-8' SW-GW Sand and Gravel (Fill)
- o 8-9.3' SM Silty Sand (Fill)
- o 9.3-30 SW-GW Sand and Gravel, water at 24 to 30'
- o 30-44 CL Clay, dry (Till)
- o 44-49' SC Clayey Sand, very moist to wet

- o 49'-... SW-GW Sand & Gravel, wet

The highest PID reading encountered thus far during screening of the soil core was 2.9 ppm at the base of the 64-69' interval. A headspace sample of this portion of the core was collected and a PID reading of approximately 40 ppm was recorded. One piece of information that I neglected to relay on the call was that we did perform a Sudan IV dye test on the sample with the elevated PID reading in order to confirm whether NAPL was present. No NAPL was detected.

The highest PID reading recorded during the remainder of the soil core screening was 0.3 ppm at 25' bgs.

We have encountered heaving sands below the 30-44' bgs clay till layer, which is slowing progress down as we need to add significant amounts of water to equalize the pressure (between 40 and 65 gallons per sample). We then need to remove twice the volume of water during the pre-purge before purging and sampling the well.

We will continue to monitor the progress of the VAS drilling and will suggest changes if warranted based on the rate of progress and the stratigraphy encountered. As discussed on the conference call, we will do full headspace screening on the final core sample from each borehole to determine whether contamination exists at that depth.

The next call will be on Monday at 4:30 p.m. For convenience, all of the calls for the VAS updates will use the call in number and access code in the subject line above.

Please call me if you have any questions regarding the above.

Regards, Adam

Adam Loney
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Tel.: 519-884-0510 ext. 2287
cell: 519-502-2897
Fax: 519-884-0525
email: aloney@craworld.com

From: Loney, Adam
Sent: Tuesday, October 28, 2008 8:59 AM
To: 'Cibulskis.Karen@epamail.epa.gov'
Cc: 'brett.fishwild@ch2m.com'; 'KBrown@ITW.com'; Vander Meulen, Ken; Almeida, Luis; 'Vanderpool.Luanne@epamail.epa.gov'; 'matt.justice@epa.state.oh.us'; Quigley, Steve; 'roger.mccready@ncr.com'; 'Paul Jack'; 'jrc@e-emi.com'
Subject: 38443: VAS Update Call and Schedule

Hello Karen,

For the conference call this afternoon, please use the following call in information:

Telephone Number: 1-800-503-2899
Access Code: 3581489

I have attached a preliminary schedule for the VAS investigation at the South Dayton Dump & Landfill.

<<38443 VAS Schedule.xls>>

The schedule assumes the following:

- One rig commences drilling today (October 28, 2008) and the second rig commences drilling November 4, 2008;
- The first two weeks of drilling will be completed on a five days on, two days off schedule as discussed;
- The remainder of the drilling will be completed on a ten days on, four days off schedule - some adjustment may be required to accommodate the Thanksgiving holiday; and
- Each VAS location requires two days to complete and the borehole location requires one day to complete.

One additional note, due to the heavy truck traffic and limited space on the Valley Asphalt site, it appears we will need to move VAS-4 approximately 30 feet to the south, to the northeast corner of the B&G Equipment Property (Lot 5171). As B&G needs to move some equipment to accommodate the drilling equipment, VAS-4 will be installed on Monday November 3, 2008 rather than this week as originally planned.

I have posted additional analytical data for the test pits and test trenches to the ftp site. If anyone would like a copy of the data emailed to them, please let me know.

Please let me know if you have any questions or concerns regarding the schedule and we can discuss further on the call this afternoon.

Regards, Adam

Adam Loney
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cell: 519-502-2897
Fax: 519-884-0525
email: aloney@craworld.com

From: Cibulskis.Karen@epamail.epa.gov [mailto:Cibulskis.Karen@epamail.epa.gov]
Sent: Tuesday, October 28, 2008 8:44 PM
To: Loney, Adam
Cc: brett.fishwild@ch2m.com; KBrown@ITW.com; Vander Meulen, Ken; Almeida, Luis; Vanderpool.Luanne@epamail.epa.gov; matt.justice@epa.state.oh.us; Quigley, Steve; roger.mccready@ncr.com; Paul Jack; jrc@e-emi.com; Osaguona.Ogbebor@CH2M.com; David.Boehnker@ch2m.com
Subject: Field Modifications

Hi Adam. Go ahead and make the field modifications we discussed including using a different packer and collecting PID readings with the bag open.

However, please document these changes in a formal letter and note these changes in subsequent reports.

Also, since PID readings with the bag open may significantly underestimate VOC concentrations, a lack of any readings or low readings cannot be used to rule out the presence of a potential hot spot at these locations.

I think the call today was very helpful and EPA will be on the next call scheduled for Thursday.

Thanks, Karen.

From Loney, Adam **Date** Tuesday, October 14, 2008 11:34:19 AM
To Cibulskis.Karen@epamail.epa.gov
Cc brett.fishwild@ch2m.com; KBrown@ITW.com; Vander Meulen, Ken; Almeida, Luis;
matt.justice@epa.state.oh.us; Quigley, Steve; Mankowski.Matthew@epamail.epa.gov;
Vanderpool.Luanne@epamail.epa.gov
Subject 38443: Valley Asphalt Drum Area

Karen,

By way of background for everyone on the distribution list, on Wednesday afternoon (October 8, 2008), CRA excavated test trench TT-21, which was located at the edge of the area where drums were removed from the Valley Asphalt property in 2000. Fill, consisting of sand, gravel, brick, and concrete debris, was encountered throughout the majority of the test trench. At the end of the trench, close to the existing shed on the property, a layer of clay was encountered. CRA encountered a single drum in the clay layer. The mostly intact drum was filled with a solid sandy material. Sustained PID readings of approximately 35 ppm were recorded in the area immediately above the soil (not in the workers' breathing zones), which necessitated a transition to Level B PPE for the soil sampling and backfilling activities. The drum was sampled for bulk analysis as well as waste characterization analysis before being placed in an overpack drum.

Given the proximity of the shed in this area of the Valley Asphalt property, it is not possible to extend the trench much further now. CRA proposes to complete the geophysical survey in this area (the area will be completed as soon as possible and the data processed immediately). Once the results of the soil analysis and the geophysical survey are received, the Group, in consultation with EPA and Ohio EPA, will propose additional investigation, if necessary, to characterize the Site and complete the FS. The additional investigation, if required, could involve additional test pits, soil borings, or both.

Please let me know if you have any questions or concerns with this approach.

Regards, Adam

From: Cibulskis.Karen@epamail.epa.gov [mailto:Cibulskis.Karen@epamail.epa.gov]
Sent: Thursday, October 09, 2008 2:37 PM
To: Loney, Adam
Cc: brett.fishwild@ch2m.com; Winterink, Jeroen; KBrown@ITW.com; Vander Meulen, Ken; Almeida, Luis;
matt.justice@epa.state.oh.us; Quigley, Steve; Mankowski.Matthew@epamail.epa.gov;
Vanderpool.Luanne@epamail.epa.gov
Subject: Valley Asphalt Drum Area

Hi Adam. I heard about the sludge-filled drum excavated near the Valley Asphalt 2000 drum removal area yesterday that was overpacked and triggered a Level B HASP upgrade that resulted in ending the trench.

Is CRA planning any additional excavations or other work to delineate this area further? Please let EPA, CH2M and OEPA know what CRA's initial thoughts are concerning this area and how CRA would like to proceed in terms of the current investigation, as well as for the purpose of completing the FS.

Thanks! Karen.

From Cibulskis.Karen@epamail.epa.gov **Date** Thursday, October 02, 2008 5:53:21 PM
To Loney, Adam
Cc brett.fishwild@ch2m.com; Paul Jack; jrc@e-emi.com; KBrown@ITW.com;
Mankowski.Matthew@epamail.epa.gov; matt.justice@epa.state.oh.us; roger.mccready@ncr.com;
Vanderpool.Luanne@epamail.epa.gov; Quigley, Steve; Almeida, Luis; Chan, Valerie; Filing
Subject Re: 38443: EPA Questions Regarding Test Pit/Test Trench Investigation

Thanks Adam, I didn't know CRA doesn't have access to excavate the lots along Dryden Road on the other side of the fence line or on Lot 4610; and the Work Plan did not indicate less intrusive methods would be used in these areas. We can talk more about where to go from here next week.

For TT-16 I was thinking CRA would also excavate away from the Quarry Pond toward Lot 4610, but based on the other trenches, borings and air photos it seems like this area is pretty much all fill anyway.

Also, based on the trenches and air photos, it does seem like there was irregular excavation and filling along the TT-1, TT-15, MW-101A, TT-14, MW-204, TT-13, MW-203 and MW-210 line.

Karen.

-----"Loney, Adam" <aloney@craworld.com> wrote: -----

To: Karen Cibulskis/R5/USEPA/US@EPA
From: "Loney, Adam" <aloney@craworld.com>
Date: 10/02/2008 03:20PM
cc: <brett.fishwild@ch2m.com>, "Paul Jack" <cbay3@verizon.net>, <jrc@e-emi.com>, <KBrown@ITW.com>, MATTHEW MANKOWSKI/R5/USEPA/US@EPA, <matt.justice@epa.state.oh.us>, <roger.mccready@ncr.com>, LUANNE VANDERPOOL/R5/USEPA/US@EPA, "Quigley, Steve" <squigley@craworld.com>, "Almeida, Luis" <lalmeida@craworld.com>, "Chan, Valerie" <vchan@craworld.com>, "Filing" <Filing@craworld.com>
Subject: 38443: EPA Questions Regarding Test Pit/Test Trench Investigation

Karen,

A number of the test trenches have not been excavated to the limits of fill for a couple of reasons which are detailed below.

For test trenches TT-13 and TT-8 through TT-12 along Dryden Road we have excavated or will be excavating to the fenced boundary of the Site. In the case of TT-13, a thin layer of fill material (less than 3 feet thick) was encountered up to the fence. In the case of TT-8 through TT-12, the expectation, based on visual observations of the Site surface following clearing, is that fill material extends beyond the fenced boundary on to the properties along Dryden Road. The fence actually appears to run through parcels 5172, 5173, 5174, and 5175 as all of the surveyed test trench locations based on the figure in the Test Pit/Test Trench Investigation Letter Work Plan are within the fence. To confirm that the fill material extends to the fence, we will excavate as close to the fence as is possible (there are some power lines in the area, which we need to maintain a safe distance from). Should native material be encountered along the fenceline at any of TT-8 through TT-12, we will excavate back towards the known areas of fill until we reach the fill material. For TT-13 and, assuming fill material extends beyond the eastern fence line, for TT-8 through TT-12, we will then need to obtain access to the adjacent properties to continue the excavation or investigate the limits through other less intrusive means such as boreholes.

At TT-16, we extended the test trench to the edge of the Quarry Pond. Fill material was encountered along the edge of the Quarry Pond and it was, therefore, not possible to extend TT-16 any further.

At TT-17 and TT-18, we extended the test trenches to lengths of approximately 45 feet. During the excavation of TT-17 and TT-18, it became apparent that fill material has been placed throughout the area in which the trenches are located, possibly to bring the area up to grade with the front of the property along East River Road, but that is merely speculation. The decision was made, in consultation with EPA's oversight personnel, to stop excavation at these locations as further extension of the trench was impractical, and in the case of one of the trenches unsafe due to the stability of the sidewalls. Further investigation, either through additional test pits or boreholes, will be necessary in this area (Lots 4423 and 3753) to determine the extent of the fill material.

Regarding your earlier question concerning why TT-13 and TT-15 were not excavated to the water table, the sampling crew, in consultation with EPA's oversight personnel, determined that they had reached native material and stopped the excavation at that point. We have asked them to resume the excavation at both locations to the water table or the limit of the excavator's reach. TT-13 was completed yesterday and the sand and gravel material remained consistent to the final depth of the excavation. TT-15 is being completed this morning. CRA staff and, to my understanding EPA oversight staff, made the observation that the material was native as it was consistent with material lying outside the edges of the fill material in other locations and contained no evidence that it had ever been disturbed, i.e., waste material, organic material from mixing with surface soils, etc. The material was also not sorted as would be expected with Quarry spoils.

Please do not hesitate to call me if you have any questions or concerns regarding this approach.

Regards, Adam

From: Cibulskis.Karen@epamail.epa.gov [mailto:Cibulskis.Karen@epamail.epa.gov]
Sent: Thursday, October 02, 2008 10:41 AM
To: Loney, Adam
Cc: brett.fishwild@ch2m.com; Paul Jack; jrc@e-emi.com; KBrown@ITW.com; Mankowski.Matthew@epamail.epa.gov; matt.justice@epa.state.oh.us; roger.mccready@ncr.com; Vanderpool.Luanne@epamail.epa.gov; Quigley, Steve; Almeida, Luis; Chan, Valerie
Subject: Please Discuss Why CRA is Not Excavating Trenches to Visual Limits of Fill Per Work Plan

Hi Adam.

EPA is wondering why CRA is not excavating the test trenches to the visual limits of fill per the approved Work Plan. TT-13, TT-16, TT-17 and TT-18 were not excavated to the visual limits of fill, and EPA's understanding is that TT-12 and the other test trenches on the eastern edge of the PRP's presumptive remedy area will be excavated at the staked locations and then jump to somewhere along Dryden Road once the utilities are staked out. Is this correct?

Per the Work Plan, if fill is encountered in a trench, CRA is supposed to continue to trench away from the presumptive remedy area or to "step out" away from the presumptive remedy area - not stop (as with TT-13, TT-16, TT-17 and TT-18), and not jump all the way to the Site boundary (as with TT-12 and other locations).

Please discuss. Since CRA is doing this investigation, it seems like it would be

especially good to know more about any landfilled materials as close to the on-Site buildings as possible, which could be different than any landfilled materials along the Dryden Road boundary of the Site.

Also, will we be getting an agenda and any materials for our on-Site Monday/Tuesday meeting next week soon?

Thanks, Karen.

From Loney, Adam **Date** Wednesday, September 24, 2008 3:18:00 PM
To Cibulskis.Karen@epamail.epa.gov
Cc brett.fishwild@ch2m.com; Winterink, Jeroen; KBrown@ITW.com; Vander Meulen, Ken; Almeida, Luis; matt.justice@epa.state.oh.us; Quigley, Steve; Mankowski.Matthew@epamail.epa.gov; Vanderpool.Luanne@epamail.epa.gov; Osaguona.Ogbebor@CH2M.com
Subject 38443: Test Pit/Test Trench Investigation - Documentation of Field Change of Sept. 23, 2008

Karen,

As a follow up to our conversation yesterday, I wanted to send this email to provide documentation of the clarification in the Test Pit/Test Trench Investigation Scope that we agreed to.

CRA will collect soil samples for field screening from each distinct layer of soil or waste encountered in the test pits and test trenches (provided that the layer is of sufficient thickness to permit sampling) rather than one sample from each sidewall and the excavation floor as documented in the May 9, 2008 Test Pit/Test Trench Investigation Letter Work Plan (Letter Work Plan). This will ensure that each distinct layer of fill and/or native material is assessed in the field.

As per the Letter Work Plan, CRA will submit a minimum of one soil sample from each test pit and two soil samples from each test trench for laboratory analysis. Where distinct layers with potentially different contaminants (based on field screening, e.g., high PID reading in one layer and visible staining in another layer, etc.) are identified, additional samples may be submitted in consultation with USEPA oversight personnel.

Please let me know if you have any concerns with this approach.

Thanks, Adam

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From: Cibulskis.Karen@epamail.epa.gov [<mailto:Cibulskis.Karen@epamail.epa.gov>]
Sent: Tuesday, September 09, 2008 3:49 PM
To: Loney, Adam; Winterink, Jeroen; Almeida, Luis; Lewis, Greg
Cc: vanderpool.luanne@epa.gov; mankowski.matthew@epa.gov; brett.fishwild@ch2m.com; matt.justice@epa.state.oh.us; KBrown@ITW.com; Quigley, Steve

Subject: MW-209

Hi. I understand CRA had to redevelop MW-209 but the FSP doesn't address how long to let redeveloped wells stabilize before purging. EPA recommends waiting at least 48 hours after redeveloping MW-209 before starting purging for stabilization criteria. The one analytical sample for metals analysis from MW-209 contained lead at 100 ug/L, which is above the MCL action level of 15 ug/L. EPA agrees CRA does not need to wait 2 weeks to begin purging since MW-209 is not a new well and has already been redeveloped; however, the longer CRA waits the longer

MW-209 will have to stabilize.

If you have any questions or would like to discuss this further please let me know.

Thanks, Karen.