# REMEDIAL ACTION CONTRACT 2
# FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME CRITICAL REMOVAL ACTIVITIES IN REGION 5

## ATTACHMENT A

# PHASE I FIELD SAMPLING PLAN
# EAST TROY CONTAMINATED AQUIFER SITE
# TROY, MIAMI COUNTY, OHIO

## (REVISION 3.0)

**Prepared for**
**United States Environmental Protection Agency**
**Region 5**
**77 West Jackson Boulevard**
**Chicago, IL 60604**

| | |
|---|---|
| Date Submitted: | August 11, 2010 |
| EPA Region: | 5 |
| Work Assignment No: | 045-RICO-B5EN |
| Contract No: | EP-S5-06-02 |
| Prepared by: | SulTRAC |
| Project Manager: | Guy Montfort |
| Telephone No: | (513) 564-8350 |
| EPA Work Assignment Manager: | Shari Kolak |
| Telephone No: | (312) 886-6151 |

# CONTENTS

## TABLES

## LIST OF FIGURES

## STANDARD OPERATING PROCEDURES

| | |
|---|---|
| SOP 002 | General Equipment Decontamination, Revision No.3 |
| SOP 003 | Organic Vapor Air Monitoring, Revision No. 2 |
| SOP 005 | Soil Sampling, Revision No. 2 |
| SOP 009 | Surface Water Sampling, Revision No. 4 |
| SOP 014 | Static Water Level, Total Well Depth, and Immiscible Layer Measurement, Revision No. 1 |
| SOP 015 | Groundwater Sample Collection Using Low Flow Sampling Methods, Revision No. 1 |
| SOP 019 | Packaging and Shipping Samples, Revision No. 6 |
| SOP 020 | Monitoring Well Installation, Revision No. 4 |
| SOP 021 | Monitoring Well Development, Revision No. 4 |
| SOP 024 | Recording of Notes in Field Notebook, Revision No. 1 |
| SOP 061 | Field Measurement of Groundwater Indicator Parameters, Revision No. 2 |
| SOP074 | Soil Gas Sampling Methods, Revision No. 2 |

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/L | Micrograms per liter |
| µg/kg | Micrograms per kilogram |
| µm | Micrometer |
| µg/m$^3$ | Micrograms per cubic meter |
| amsl | Above mean sea level |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| bgs | Below ground surface |
| °C | Degrees Celsius |
| CLP | Contract Laboratory Program |
| COC | Chain of custody |
| CRL | Central Regional Laboratory |
| CSM | Conceptual site model |
| DCE | Dichloroethene |
| DGPS | Differential global positioning system |
| DNAPL | Dense-nonaqueous phase liquid |
| DOT | Department of Transportation |
| DPT | Direct-push technology |
| EPA | U.S. Environmental Protection Agency |
| ESI | Expanded site inspection |
| FS | Feasibility study |
| FSP | Field sampling plan |
| ft | Feet |
| FTL | Field team leader |
| GIS | Geographic Information System |
| GPS | Global positioning system |
| HASP | Health and safety plan |
| HHRA | Human health risk assessment |
| ID | Identification |
| IDW | Investigation-derived waste |
| IDEM | Indiana Department of Environmental Management |
| KC | Kimberly-Clark, Inc. |
| MCL | Maximum contaminant level |
| MS | Matrix spike |
| MSD | Matrix spike duplicate |

## ACRONYMS AND ABBREVIATIONS (CONTINUED)

| | |
|---|---|
| ND | None detected |
| NPL | National Priorities List |
| NTU | Nephelometric Turbidity Units |
| ODH | Ohio Department of Health |
| Ohio EPA | Ohio Environmental Protection Agency |
| ORP | Oxidation-reduction potential |
| PCB | Polychlorinated biphenyl |
| PCE | Tetrachloroethene |
| PID | Photoionization detector |
| ppb | Parts per billion |
| POTW | Publicly Owned Treatment Works |
| PPE | Personal protective equipment |
| PTFE | Polytetrafluoroethylene |
| PVC | Polyvinyl chloride |
| QA | Quality assurance |
| QAPP | Quality assurance project plan |
| QC | Quality control |
| RAC | Remedial action contract |
| RI | Remedial investigation |
| SAP | Sampling and analysis plan |
| SARA | Superfund Amendments and Reauthorization Act |
| SLERA | Screening-level ecological risk assessment |
| SMO | Sample Management Office |
| SOP | Standard operating procedure |
| SOW | Statement of work |
| SVOC | Semivolatile organic compound |
| TAL | Target analyte list |
| TCA | Trichloroethane |
| TCE | Trichloroethene |
| TCL | Target compound list |
| TCRA | Time-Critical Removal Action |
| TOC | Top of casing |
| USCS | Unified Soil Classification System |
| UST | Underground storage tanks |

# ACRONYMS AND ABBREVIATIONS (CONTINUED)

| | |
|---|---|
| VAS | Vertical aquifer sampling |
| VOC | Volatile organic compound |
| WA | Work assignment |
| WHPP | Wellhead protection program |

# 1.0 INTRODUCTION

SulTRAC has prepared this Phase I field sampling plan (FSP) as part of the sampling and analysis plan (SAP) for the East Troy Contaminated Aquifer Site (East Troy site) in Troy, Ohio, under the U.S. Environmental Protection Agency (EPA) Remedial Action Contract (RAC) II for Region 5, Contract No. EP-S5-06-02, Work Assignment (WA) No. 045-RICO-B5EN. A Remedial Investigation (RI)/Feasibility Study (FS) will be conducted at the East Troy site. The RI/FS will investigate the nature and extent of contamination in soil, subsurface gas, indoor air, groundwater, sediment, and surface water; and the threat this contamination poses to human health and the environment. The RI/FS will generate sufficient data to allow selection of an approach for site remediation that eliminates, reduces, or controls risks to human health and the environment posed by the site as well as to support a Record of Decision (ROD). The RI/FS is being conducted in two phases. Data gathered during Phase I will be used to develop an approach for the Phase II RI that will address additional field investigations (if needed). Phase I could begin as early as summer 2010, while Phase II will likely begin in the fall of 2010.

This document presents sampling and analytical procedures for all Phase I activities with the exception of sub-slab vapor and indoor monitoring for volatile organic compounds (VOC). The Ohio Environmental Protection Agency (Ohio EPA) has recently developed, and EPA Region 5 is developing, guidance documents that will influence the sampling and analytical methodology that will apply to the East Troy RI/FS. In addition, the specific locations for monitoring will be determined, based in part on the results of groundwater and soil investigations that will comprise the initial activities during Phase I. Based on these considerations and discussions with EPA and Ohio EPA, SulTRAC will prepare and issue a SAP addendum addressing the specific guidance, methodologies and locations for the sub-slab/ indoor air VOC monitoring prior to commencing that portion of the RI. This will allow the initial components of Phase I to commence and generate necessary data for selection of sub-slab and indoor air monitoring locations as guidance is finalized.

The SAP consists of this FSP (Attachment A) and the quality assurance project plan (QAPP) (Attachment B), which are among the site-specific plans to be prepared under the WA in accordance with Task 1 of the EPA statement of work (SOW) (EPA 2009a). Quality assurance (QA) and quality control (QC) protocols associated with sampling and analysis are presented in the QAPP.

The East Troy site consists of groundwater contamination that has been detected in a mixed residential, commercial, and industrial area in the eastern part of the City of Troy, which is located in Miami County, Ohio. Contamination has also been detected in samples of raw water from several of the City of Troy's municipal water supply wells.

The Troy municipal water system serves approximately 28,000 residents and is supplied by groundwater from two wellfields, the East Wellfield and the West Wellfield, located approximately 0.75 mile apart, on the east bank of the Great Miami River (Figures 1 and 2). The municipal wells are installed in the deep portion of a surficial sand and gravel aquifer along the east bank of the Great Miami River. Low concentrations of chlorinated volatile organic compounds (VOC) have been detected in raw water samples collected from production wells in both wellfields (Ohio Environmental Protection Agency [Ohio EPA 2002]; City of Troy [Troy] 2009b). The sources of contamination of each wellfield are currently believed to different.

An area of groundwater contamination has been discovered in the eastern part of the City of Troy, across the Great Miami River from the East Wellfield, and is identified as the East Troy Contaminated Aquifer Site (Figures 2 and 3). The contaminants detected to date in groundwater at the Site are chlorinated VOCs, primarily tetrachloroethene (PCE) and trichloroethene (TCE), with *cis*-1,2-dichloroethene (DCE) and vinyl chloride present as suspected degradation products of PCE and TCE.

Soil and groundwater data collected at the Spinnaker Coatings (Spinnaker) site on Water Street, which was formerly operated by a division of Kimberly Clark Inc., (KC) indicate that the Spinnaker site is one source of groundwater contamination in the plume area (Ohio EPA 2002; Kimberly Clark Inc. [KC] 2009). Several other sites, including Hobart Cabinet Company on Water Street, and several additional entities that no longer exist, are also suspected sources contributing to the contaminant plume(s) and the contamination in the East Wellfield. Overall, the investigations conducted to date indicate that the contamination at the East Troy Site may represent multiple plumes that originated from two or more sources, and may co-mingle in some areas, as described below.

***Residential Area PCE Plume*** **-** One plume, that contains primarily PCE at concentrations as high as approximately 800 ug/L in shallow (less than 30 feet below ground surface [bgs]) groundwater, with lower concentrations of other chlorinated VOCs is located in the predominantly residential area roughly bounded by Walnut Street (northwest/ upgradient side), East Main Street, and Canal Street. The highest PCE concentrations were observed in the vicinity of the intersections of Clay and Crawford Streets with Franklin Street. Only trace levels of PCE have been detected in a deep monitoring well (Troy well MW-Q), screened at a depth of approximately 84 to 94 feet bgs, located in this area. The shallow portion of the plume extends at least as far southeast (downgradient) as Union Street; but appears to decrease significantly in concentration in the block between Crawford and Union.

***Water Street PCE Plume*** - A second area of high PCE concentrations, with lower concentrations of other chlorinated VOCs in groundwater has been found along Water Street, approximately 2 blocks east/northeast of the aforementioned residential area, between Clay Street on the northwest (upgradient) side, and the vicinity of New Street on the southeast (downgradient) side. Data collected by Ohio EPA from 2001-2004 appear to indicate that this plume is separated from the aforementioned residential area PCE plume, based on several "nondetect "concentrations in shallow groundwater samples collected along Main Street, and on Clay Street northeast of Main. The deeper portion of the aquifer was not investigated in this intervening area. This plume appears to extend to the Great Miami River and onto the Spinnaker site property. PCE and other chlorinated VOCs have been detected in shallow soil samples and groundwater samples collected around the perimeter of the Hobart Cabinet building, suggesting the possibility that Hobart Cabinet is a contributing source of contamination to the plume in this area.

***Spinnaker Site Plume*** - Groundwater and soil contamination, including chlorinated VOCs, has been detected in the western part of the Spinnaker property. This area of groundwater contamination appears to contain primarily TCE, cis-1,2-DCE, and vinyl chloride and extends at least to the Great Miami River. The plume also contains PCE at some locations, with the highest PCE levels typically being detected at the locations closer to the western end of the property, near the upgradient boundary, which is also the reported general vicinity of a former dry cleaner that was located in a part of the area now covered by Spinnaker’s parking lot.

Each of these plume areas, and history of related past investigations, are discussed further in Section 2.2, Previous Site Investigations.

SulTRAC will perform various field activities or combinations of activities for data acquisition to support the RI/FS. The primary goals of the Phase I investigation are to (1) determine the nature and extent of contamination in soil, groundwater, sub-slab vapor, surface water, and sediment; (2) identify sources of groundwater contamination; (3) assess the potential vapor intrusion exposure pathway at residences and businesses located within the plume area that were not evaluated during previous studies; (4) evaluate the potential for impacts to the Great Miami River; and (5) collect updated groundwater quality data, including additional information on background water quality. This FSP addresses the following field investigations at the East Troy site that will be performed as part of the Phase I activities:

- Baseline sampling of existing wells – current understanding of the contaminant plume boundaries is based a network of existing monitoring wells, installed by Ohio EPA during previous investigations, and by the City of Troy as part of its wellhead protection program. These wells are summarized in Table 1. SulTRAC will collect groundwater samples and elevation data from these wells as the initial sampling activity in Phase I of the RI. SulTRAC will also collect groundwater elevation data from several Miami Conservancy District (MCD) piezometers recently installed on the levee west of the Great Miami River.. These data will be used to provide a baseline current information regarding the nature and extent of contamination and focus subsequent Phase I investigation activities.

- As part of the RI, EPA will also obtain and review quarterly groundwater monitoring data from the Spinnaker site. KC's consultant conducts quarterly sampling of the existing wells in the western portion of the Spinnaker site. EPA will obtain data from the quarterly sampling event that occurs closest to the timeframe for the baseline sampling. SulTRAC also will split groundwater samples for VOC analysis from up to 5 locations on the Spinnaker site prior to commencement of the baseline sampling event and the split samples will be analyzed through the EPA Contract Laboratory Program (CLP), to provide additional verification of the data for the Spinnaker site.

- Geological Investigation – SulTRAC will conduct geological investigations by drilling 30 soil borings and collecting surface and subsurface soil samples in the area west of the Great Miami River. These borings include background locations and possibly borings along the sanitary sewer alignment (see below).

- Sewer Investigation – SulTRAC will meet with local officials to obtain records, drawings, or maps and confirm the locations of sewers in the vicinity of a known "hot spot" of groundwater contamination in the vicinity of Clay and Franklin Streets. If access is possible, SulTRAC will conduct a robotic sewer investigation to video the length of the sewer pipe in an attempt to identify any cracks, joints, or other damage that may identify a location of past release. If potential release areas are identified, SulTRAC will drill soil borings (for planning purposes SulTRAC estimates drilling up to four of the 30 borings previously discussed adjacent to the sanitary sewer) to a depth slightly below the sewer pipe invert in order to determine if residual soil contamination exists in the area and is an ongoing mechanism for release of VOCs to groundwater.

- SubSlab Vapor Monitoring – SulTRAC will conduct indoor sub-slab vapor monitoring for VOCs at up to 30 locations; locations to be sampled will be selected based on the results of the Phase I soil and groundwater investigations, with emphasis on locations within the defined plume area that were not previously sampled in conjunction with an EPA time-critical removal action completed in 2008. Depending on the results of the Phase I RI activities, some locations may be resampled with concurrent collection of indoor air samples, during Phase II. (Field procedures and monitoring locations for the sub-slab vapor and indoor air monitoring will be presented in an addendum to this SAP.)

- Hydrogeologic Investigations – SulTRAC will collect groundwater samples at the top of the uppermost aquifer at 10 of the soil boring locations; SulTRAC will conduct vertical aquifer sampling (VAS) of the upper aquifer at up to 7 locations (and possibly the upper portion of the lower aquifer at one of these locations) and collect groundwater samples for VOC analysis at various depths; SulTRAC will install up to 12 additional monitoring wells west of the Great Miami River at depths to be determined by the results of the baseline sampling program and VAS program; SulTRAC will install a cluster of shallow and deep monitoring wells east of the Great

Miami River to evaluate whether sources exist east of the river that are contributing to the contamination. Groundwater samples will be collected and analyzed for VOCs, with select locations also being analyzed for full EPA CLP Target Compound List/Target Analyte List (TCL/TAL) parameters.

### TABLE 1
### SUMMARY OF EXISTING OHIO EPA AND CITY OF TROY MONITORING WELLS (TO BE INCLUDED IN RI GROUNDWATER MONITORING PROGRAM)

| Well | Location | ID (in.) | TD (feet) | TOIC EL (feet, amsl) | DTW (8/26/09) (feet) | GW EL (8/26/09) (feet, amsl) |
|---|---|---|---|---|---|---|
| OEPA-1 | SW Corner Crawford and Franklin | 2 | 24.71 | 832.46 | 18.05 | 814.41 |
| OEPA-2 | Crawford and East Main on traffic divider | 1 | 19.7 | 830.89 | 16.45 | 814.44 |
| OEPA-3 | Spinnaker west lot, near NW building corner and levee | 2 | 21.36 | 825.13 | 12.25 | 812.88 |
| OEPA-4 | NE Corner Mulberry and Franklin | 2 | 27.35 | 833.22 | 18.35 | 814.87 |
| OEPA-5 | S side of Franklin, 100 feet SE of Crawford | 2 | 27.22 | 830.29 | 15.97 | 814.32 |
| OEPA-6 | NW side of Crawford, about 60 feet NE of Franklin | 2 | 27.2 | 831.62 | 17.20 | 814.42 |
| OEPA-7 | SE side of Clay, near Franklin | 2 | 26.91 | 833.52 | 18.88 | 814.64 |
| OEPA-8 | Water Street, in front of Spinnaker west end of west lot | 1.5 | 27.22 | 828.58 | 14.47 | 814.11 |
| OEPA-9 | In front of St. Patrick's School, S side of Water St. | 1.5 | 14.47 | 830.43 | 16.00 | 814.43 |
| OEPA-10 | N Side of Water St. in front of private residence between Hobart and Spinnaker | 1.5 | 24.82 | 829.70 | 15.40 | 814.30 |
| OEPA-11 | Walnut, near East Main | 1 | 27.33 | 833.33 | 18.21 | 815.12 |
| OEPA-12 | N Side of Water Street, slightly NW of Crawford | 1 | 27.47 | 831.54 | 16.99 | 814.55 |
| OEPA-13 | NE Corner, Water and Clay | 1 | 27.4 | 833.68 | 18.98 | 814.70 |
| MW-L | East Side GMR, in ballfields east of Market St. | 2 | 25.05 | 825.39 | 10.08 | 815.31 |
| MW-M | Cluster with MW-L | 2 | 81 | 824.61 | 9.93 | 814.68 |
| MW-N | East Side GMR, 300 feet SE of L/M clusterr | 2 | 31.73 | 831.08 | 16.50 | 814.58 |
| MW-O | Franklin and Scott | 2 | 100.11 | 829.31 | 18.14 | 811.17 |
| MW-P | E. Main and Williams | 2 | 94.6 | 827.65 | 16.94 | 810.71 |
| MW-Q | Franklin and Crawford, next to OEPA-1 | 2 | 93.96 | 832.70 | 18.30 | 814.40 |

Notes: "OEPA" - indicates monitoring well installed by Ohio EPA
"MW" - indicates monitoring well installed by City of Troy
in. - inches
AMSL - above mean sea level
GW - groundwater
EL - elevation
TOIC - top of inner casing
DTW - depth to water measured by SulTRAC August 2009
TD - total depth

- Surface Water and Sediment – SulTRAC will collect four surface water and four sediment samples from the Great Miami River. The hydraulic interaction between the river and the aquifer will also be evaluated.

- SulTRAC will complete an elevation survey and location survey of all new monitoring wells, 13 existing Ohio EPA monitoring wells, six existing City of Troy monitoring wells, and select Spinnaker monitoring wells. At least one of the MCD piezometers included in the RI sampling program will also be surveyed to tie the MCD well elevations to the RI survey data. The objective will be to tie all monitoring well top of casing elevations to a common reference datum. The elevations of 2 surface water staff gauges that will be installed during Phase I of the RI will also be included in this survey. Groundwater and surface water elevation data will be collected at these locations.

The groundwater, surface water, sub-slab vapor, and soil samples will be analyzed through EPA's Contract Laboratory Program (CLP) laboratories with the following exception:

- Screening level groundwater samples from the soil borings and the VAS program will be analyzed by a local Troy area laboratory to allow rapid turnaround so that the data can be used to determine the depths at which to install permanent wells.

Phase II will likely involve delineating further the extent of contamination and addressing any data gaps in contamination characterization from Phase I. A Phase II FSP amendment will be prepared describing all Phase II sampling activities.

# 2.0 SITE DESCRIPTION AND HISTORY

The East Troy site is located in the City of Troy, Miami County, Ohio (Figure 1). The East Troy site consists of groundwater contamination that has adversely impacted water quality in the local sand and gravel aquifer. The aquifer is the sole source of drinking water in the area.

The City of Troy operates two water supply wellfields, the West Wellfield and the East Wellfield, located approximately 0.75 mile apart on the east bank of the Great Miami River (Figure 2). Low concentrations of chlorinated VOCs have been detected in samples of raw water from production wells in both wellfields; these include wells 14 and 18 in the East Wellfield, and well 12W in the West Wellfield. However, the concentrations of VOCs in the raw water samples from the east wellfield have not exceeded the U.S. EPA Maximum Contaminant Levels (MCL) established by the Safe Drinking Water Act. It is believed that the groundwater contamination in the East Wellfield and West Wellfield represents two separate plumes based on the absence of detections of VOCs in groundwater samples from City of Troy monitoring wells L, M, and N (see Figure 2), which are located between the two wellfields (Troy 2009a). It is also believed that the sources of contamination of each wellfield differ, based on past investigations by Ohio EPA that suggested the source areas for the West Wellfield contamination were located in the northern portion of Troy, west of the Great Miami River (Ohio EPA 2002; EPA 2008). Groundwater monitoring data from the area east of the Great Miami River are limited; therefore additional investigation is needed to confirm that there are no contributing sources east of the river.

An extensive area of contamination has been identified in the eastern part of the City of Troy, across (west of) the Great Miami River from the East Wellfield. That area, identified as the East Troy Contaminated Aquifer Site (Figures 2 and 3), is the subject of this RI/FS. As previously discussed, data collected to date indicate that this area may be comprised of three currently separate plumes, that may have originated from multiple sources. The contaminants detected to date in the East Troy site plumes are chlorinated VOCs, primarily PCE and TCE, with *cis*-1,2-DCE and vinyl chloride present as suspected degradation products of PCE and TCE (Ohio EPA 2002; EPA 2008; ATSDR 2008).

The subsurface in the area reportedly consists of a thick sequence of sand, gravel, and clay that can generally be divided into three units. The upper and lower units consist primarily of sand and gravel. The middle unit is composed of a silty clay till and fine-grained deposits. However, this unit is not a continuous, laterally extensive unit, but rather consists of numerous irregularly shaped masses and lenses of fine-grained material of varying elevations interspaced with coarser deposits. Flow across the middle unit occurs by leakage though the fine-grained deposits as well as flow through areas where the fine-grained deposits are absent. The production wells in the East Wellfield are screened in the lower aquifer, although the confining unit is absent over a significant portion of the wellfield. Available information also indicates that the till is discontinuous in the area west of the River. The till was not encountered in the boring for City of Troy deep monitoring well MW-Q at the intersection of Franklin and Crawford streets, within the "residential area PCE plume", one of the areas of groundwater contamination that comprise the East Troy site (Malcolm-Pirnie 2007). Clay was not encountered in the boring for Troy well MW-O at Scott and Canal Street, approximately 0.6 mile southeast of well MW-Q. However, significant thicknesses of clay were reported on the log for Troy monitoring well MW-P, which is located between wells MW-Q and MW-O, near the intersection of Williams and Main, approximately 0.3 mile east/southeast of well MW-Q.

The specific source or sources of the chlorinated VOCs in the East Wellfield will be investigated during the RI. It is suspected that the groundwater contamination on the west side of the Great Miami River across from the East Wellfield is migrating to the east/southeast and is the source area for contaminants that have been detected in the East Wellfield. The Great Miami River is hydraulically connected to the sand and gravel deposits in the subsurface. The aquifer system extends to depths much deeper than the current river channel, and groundwater flow modeling completed for the City of Troy East Wellfield indicates that the pumping influence from the East Wellfield extends to the contaminant plume areas on the west side of the river (Malcolm Pirnie 2007). This observation is consistent with the results of pumping tests completed by Ohio EPA that reported groundwater levels in shallow wells on the Spinnaker site (west of the river) responded to variations in pumping rates in East Wellfield production wells (EPA 2008). Based on this observation, and also due to the presence of low concentrations of chlorinated VOCs in East Wellfield production wells #14 and #18, the RI will include sampling activities in the area east of the Great Miami River. C*is*-1,2-DCE is the only chlorinated VOC recently reported as detected in the East Wellfield wells; PCE and TCE have not been detected in the East Wellfield.

Investigations have been completed by various entities since the late 1980s, including private companies and local, state, and federal agencies. These data demonstrate that the East Troy site includes an approximately 20-square-block area where chlorinated VOCs have been identified in groundwater, soil, and indoor air space of residential, public, and commercial properties. This area is bounded approximately by Walnut Street on the west/ northwest (upgradient side) and Canal Street on the south/southwest. The area extends east/northeast to the Great Miami River on the northeast, and is suspected as contributing to the contamination in the East Wellfield. On the west side of the river, the area of contamination extends at least to Union Street on the southeast (Ohio EPA 2002; EPA 2008; ATSDR 2008).

Investigations conducted to date have indicated that the contamination on the west side of the river appears to consist of multiple contaminant plumes that originated from multiple sources and may comingle in some areas. The RI will further investigate these plumes to determine sources of the contamination entering the wellfields, and will investigate whether yet unknown sources east of the river are contributing sources. Some of the specific sources (some or all of which may no longer exist) that contributed to the contamination, where these sources were located, and the transport mechanisms have not been fully characterized. The horizontal and vertical extents of the plumes have not been fully confirmed. The RI/FS investigation will provide data that EPA can use to make such determinations.

## 2.1 Site History

The East Troy site area encompasses a relatively old residential, industrial, and commercial portion of the City of Troy. This area includes a long history of residential use with interspersed commercial and industrial areas. Most of the residences within the 20-block area are more than 60 years old. The former Miami and Erie Canal ran from northwest to southeast along the southwestern portion of the East Troy site area, and a mill race (the Dye Mill Race) ran roughly parallel to the canal. These two features were located in the area between Canal and Race Streets and were filled in some time after the 1920s. Maps prepared in the early 1920s indicating the route of the former canal and mill race show numerous businesses and small industries in the eastern part of Troy, within the area that is now primarily residential (ODNR 2009). It should be noted that the groundwater contaminant concentrations detected to date do not suggest the likelihood that these former features are source areas of VOCs in groundwater at the East Troy site (Ohio EPA 2002; KC 2009).

As previously discussed, the sources of groundwater contamination at the East Troy site include known and unknown or unconfirmed sources. In addition to contamination in soil and groundwater at the Spinnaker site, past investigations have identified several additional possible sources, based primarily on their geographic proximities to the plumes and nature of chemicals typically used in similar operations. Figures 3 and 4 indicate the known boundaries of the area of contamination at the East Troy site outside of the Spinnaker site, and the reported locations of several other possible source areas identified to date. These include a group of businesses that no longer exist including dry cleaners, print shops, and auto repair facilities formerly located throughout the 20-block area. These businesses operated in the area from approximately the 1940s to 1980s. One active industrial facility, Hobart Cabinet on Water Street, a manufacturer of specialty metal cabinetry, has also been suspected of contributing chlorinated VOCs to the contaminant plume, based on detections of chlorinated VOCs in groundwater at locations adjacent to the Hobart property perimeter and in soil samples collected directly adjacent to the Hobart building by Ohio EPA between 2002 and 2004 (Ohio EPA 2002, 2004).

The presence of chlorinated VOCs in on-site soils at another active industrial facility in the area, Spinnaker, has been confirmed, and Spinnaker has been identified as a contributor to the contamination in the East Troy contaminant plume based on past investigations completed on site. The Spinnaker facility on Water Street, directly across the river from the East Wellfield, began operations in the 1920s. Spinnaker is a manufacturer of adhesive-coated papers and related products. Additional information regarding past investigations at Spinnaker is included in Section 2.2.

Low concentrations of chlorinated (less than EPA MCLs) of VOCs have been detected in raw water samples from several wells in the City of Troy's East Wellfield since 1988. The production wells are sampled and analyzed monthly for VOCs. File information indicates that *cis*-1,2-DCE has been detected in Troy wells 14 and 18, which are the two northernmost production wells in the East Wellfield. In recent years, well 18 has been the only well in the East Wellfield in which any chlorinated VOCs have been detected in raw water samples. (Troy 2009b).

The chlorinated VOCs PCE, TCE, and *cis*-1,2-DCE have been detected in production well 12W in Troy's West Wellfield, located approximately 0.75 mile northwest of the East Wellfield, along the Great Miami River (see Figure 2); however, the suspected source areas of these contaminants are believed to differ from those associated with the contaminants affecting the East Wellfield. For this reason, the West Wellfield contaminant plume is not assumed to be within the East Troy site, which consists of the East Troy plume and sources based on EPA and SulTRAC's current understanding; thus, the West Wellfield contaminant plume is not within the scope of this RI/FS. However, well 12W is within the one-year, time-of-travel for East Wellfield wells 14 and 18 (Malcolm Pirnie 2004), and therefore the presence of these contaminants in the West Wellfield may be relevant to the RI/FS with regard to background water quality on the east side of the river. Limited data from existing City of Troy monitoring wells located east of the Great Miami River, between the two wellfields; do not indicate that the West Wellfield plume is migrating to the East Wellfield at this time.

Phase I of the RI will include several critical sampling locations to evaluate the possibilities that (1) sources of contamination in the East Wellfield may be present east of the Great Miami River, or (2) the contaminant plume affecting the West Wellfield is migrating to the East Wellfield along the east side of the river, or to the East Troy Site area in general. These data will be used to evaluate whether expansion of the area of investigation during Phase II of the RI will be necessary.

It should also be noted that Troy may be increasing production on the east side of the river in the near future. Troy is currently evaluating the possibility of adding more production wells. The effects that increased pumping may have on contaminant migration are unknown.

## 2.2 Previous Site Investigations

As previously discussed, chlorinated VOCs were detected in various Troy water production wells beginning in 1988. A series of investigations by Ohio EPA, private entities, and EPA have been completed since the late 1990s. These investigations confirmed the presence of chlorinated VOCs in soils and groundwater at the Spinnaker site, and detected soil and groundwater contamination at locations adjacent to the perimeter of the Hobart Cabinet facility. Additional “hot spots” of chlorinated VOC contamination in groundwater and soil were detected in the area; however, the original sources of these additional areas of contamination have not been confirmed. Industrial or commercial operations prior to the 1980s that have not existed for more than 20 years may have contributed to the contamination, and new construction has covered some areas at the sites of these former operations.

Table 2 summarizes some of the known and additional suspected potential source areas of chlorinated VOCs in groundwater at the East Troy site; the locations of these historical potential sources are shown on Figure 4.

The following sections summarize the scope and relevant results of past investigations of the nature and extent of contamination in the East Troy site vicinity. None of the suspected sources listed in Table 2 appears to be located directly over the area of highest PCE groundwater concentrations identified to date, along and just north of Franklin Street in the vicinity of the Clay/Franklin and Crawford/Franklin intersections, in the “residential PCE plume” area. This issue is discussed in further detail below.

### *Ohio EPA Investigations*

Ohio EPA initiated investigations of the chlorinated VOC plumes beginning in 1999. Figure 3 summarizes key results for PCE from Ohio EPA groundwater sampling from 1999 through 2004. The investigations by Ohio EPA between 1999 and 2004 included investigations of the contamination in both the East and West Wellfield areas. Investigations of the East Wellfield contamination included on-site investigations at Spinnaker as well as off-site areas located throughout the eastern part of Troy. Ohio EPA's investigations of the East Wellfield plume included installation and sampling of 13 groundwater monitoring wells, and collection of groundwater samples from over 60 locations using a direct-push rig. The results of these investigations indicated 3 general areas of groundwater contamination: (1) an on site area at Spinnaker; (2) a plume concentrated along Water Street (referred to herein as the "Water Street PCE plume") and (3) a third plume generally located between Franklin and Main Streets, referred to herein as the "residential area PCE plume".

## TABLE 2
## HISTORICAL BUSINESSES IDENTIFIED AS KNOWN OR POTENTIAL SOURCES OF CHLORINATED VOCs AT THE EAST TROY SITE

| Identified Area | Location | Description |
|---|---|---|
| Troy One-Hour Martinizing | Near Main and Walnut | Dry cleaner, 1960s-70s; current location of addition to the Methodist Church |
| Waltz Cleaners (1) | Near Main and Walnut | Dry cleaner, 1960s-70s |
| Waltz Cleaners (2) | Near Water and New, southwest corner of current Spinnaker property | Dry cleaner(?), 1950s |
| Waltz Cleaners (3) [1] | 432 East Main | Dry cleaner(?), recent |
| Neat Cleaners | North Ferry, near Main | Dry Cleaner, 1950s-1970s |
| Hottle Cleaners | Near Main and Market | Dry Cleaner, dates unknown |
| Cable Cleaners | Near Franklin and Market | Dry Cleaner, dates unknown |
| Pearson’s Laundry | Near E. Canal and Market | Dry Cleaner, dates unknown; a reported UST is located in the paved parking lot behind the buildings that front on Market Street in this area |
| Peters Printing/Genesis Graphics | Near Main and Market | Print shop, dates unknown |
| Aztech Printing and Design | Near Main and Crawford | Print shop, dates unknown |
| Hobart Cabinet | Water Street, east of Clay, west of Spinnaker property | Metal cabinet manufacturing, active |
| Former Junkyard | Near New and Water | No other information available |
| Spinnaker Coatings Facility | Water Street, between Crawford and Counts | Active manufacturing facility with historic solvent and toluene spills |
| Former Auto Service Facility | Near Walnut and Main | Auto repair, no other information available, location is now municipal parking lot. |

Source: KC 2009, Ohio EPA 2010.

Note: [1] Location requires additional research to confirm. This cleaner has been described in various site background documents as either being located near "Main and Union" or 432 East Main.

The Water Street PCE plume and the residential area PCE plume were defined by Ohio EPA through the detection of PCE and several PCE degradation products including TCE, cis-1,2-DCE, and vinyl chloride in groundwater samples at locations throughout a 20-block area south, southwest, and west of the Spinnaker property, immediately east of downtown Troy and west of the Great Miami River. The data indicated that the contamination is roughly divided into the two currently separate plumes by an area of low or “nondetect” VOC concentrations along Main Street and Clay Street, and thus may represent contamination that originated from multiple sources. (Ohio EPA 2002; EPA 2008). These plumes are described in detail below.

The “residential area” PCE plume is concentrated in a mostly older residential area between Main and Franklin Streets, with Walnut Street at or near its upgradient end. This PCE plume extends downgradient (east/southeast) to at least Union Street; however, concentrations appear to decrease significantly in the block between Crawford and Union. Ohio EPA’s data indicated that at least part of this plume originates in the vicinity of the intersection of Main and Walnut streets, where a former “One-Hour Martinizing” dry cleaner had been located. This dry cleaner reportedly burned down, and the site is currently occupied by a relatively recent addition to the neighboring Methodist Church. An automobile service garage and a second dry cleaner (another Waltz Cleaners) were also reportedly located in this area. However, the highest VOC concentrations in groundwater were detected in “hot spot” approximately 3 blocks downgradient/lateral from this area, just to the east/northeast of the intersections of Clay and Crawford Streets with Franklin Street, in an area where no known likely existing or historical VOC sources have been identified to date. It is possible that the sanitary sewer (see Figure 4) may have transported contamination from sources operating in the vicinity of Main and Walnut Streets, and this contamination was released through a joint or break in the sewer lines resulting in a residual source of contaminants such as contaminated soil or dense-nonaqueous phase liquid (DNAPL) in the Clay/Crawford/Franklin area. Data from deep (100 feet deep) City of Troy monitoring well MW-Q, also located in this area does not indicate the presence of significant concentrations of VOCs in the deep part of the aquifer at that location (EPA 2008). No other deep wells have been installed in the residential plume area.

A second plume, also predominantly PCE, is concentrated in the area along and near Water Street, and extends east/southeast from just northwest of Crawford Street at its upgradient end. VOCs were not detected in groundwater samples collected by Ohio EPA along Clay Street, between Water Street and the river, indicating that the source of the PCE contamination along Water Street is, or was formerly, in the area downgradient/southeast from Clay Street. Several Ohio EPA sampling locations along East Main Street were also "nondetect" indicating that this plume is separate from the aforementioned residential areas PCE plume. The highest contaminant concentrations associated with this plume were detected along Water Street near Crawford, in the general vicinity of the Hobart Cabinet Company, St. Patrick’s school, and the west end of the Spinnaker parking lot; and near a former rail spur that served Spinnaker and Hobart. Suspected sources in this portion plume area include Hobart Cabinet and several former dry cleaning operations that were located along Main Street and Water Street. The Water Street PCE plume may merge and become co-mingled with a plume of primarily TCE, cis-1,2-DCE and vinyl chloride contamination on the Spinnaker site, as well as possibly extending to the Great Miami River.

As part of its investigations Ohio EPA completed soil and groundwater sampling in the vicinity of Hobart Cabinet (Figure 4). In 2002 and 2003, Ohio EPA collected groundwater samples from locations on Water Street, near the southeast end of the Hobart building, using a direct push rig. These data indicated the presence of PCE at concentrations up to 78 ug/L in groundwater in front of the Hobart building near the intersection of Crawford and Water Streets. Ohio EPA also collected samples at two locations along a former rail spur parcel that lies between Hobart and the river, but is owned by Spinnaker. Very low concentrations of PCE and TCE were detected along the rail spur. However, one sample collected north of the Hobart building contained vinyl chloride at 6.6 ug/L, and cis-1,2-DCE was reported at 62 ug/L in the second sample, which was collected at the western end of what is now the Spinnaker west parking lot, adjacent to the Hobart property.

In August 2004 Ohio EPA collected soil samples from locations adjacent to the front of the Hobart building. The samples were collected from unpaved areas along the sidewalk on Water Street including one location near a vent hood for Hobart's vapor degreaser. PCE was detected at concentrations of 95 and 138 ug/kg in two of the soil samples that were collected in close proximity to Hobart's vapor degreasing unit. (KC 2009; Ohio EPA 2002, 2004; EPA 2007b; Agency for Toxic Substances and Disease Registry [ATSDR] 2008; SulTRAC 2009a).

The third area of groundwater contamination was defined by Ohio EPA on-site investigations on the Spinnaker site, and additional investigations conducted by KC (see below). This area is located between Water Street and the Great Miami River, and contains primarily TCE with PCE, cis-1,2-DCE, and vinyl chloride also being detected. Ohio EPA completed investigations on the Spinnaker site including soil borings, installation of groundwater monitoring wells, groundwater sampling, and pump tests. Ohio EPA's data, and subsequent data collected by Spinnaker, confirm that on-site sources at Spinnaker released TCE to site soil and groundwater. PCE, *cis*-1,2-DCE, and vinyl chloride have also been detected in soil and groundwater samples collected on-site at Spinnaker. Based on the presence of PCE in some groundwater samples collected from monitoring wells and direct push borings on the west end of the Spinnaker facility and in the former rail spur parcel areas, the Water Street PCE plume may be comingling with the on-site plume at Spinnaker (Mill Creek Environmental Consultants [Mill Creek] 2002; KC 2007, 2009).

Other findings of Ohio EPA's investigations included:

- The highest PCE concentrations detected in groundwater in the area (283 to 800 micrograms per liter [µg/L]) were just northeast of Franklin Street, on Clay and Crawford Streets. These concentrations were found in samples collected in June 2004 from permanent monitoring wells OEPA-1, 5, 6, and 7, approximately 0.25 mile downgradient or crossgradient of the former One-Hour Martinizing location. No known former dry cleaners or other obvious potential sources of chlorinated VOCs have been identified in this immediate area.
- Ohio EPA's June 2004 sampling event included City of Troy deep monitoring well, "MW-Q", located adjacent to shallow Ohio EPA monitoring well OEPA-6, on the northwest corner of Crawford and Franklin Streets. Only trace concentrations (0.71 ug/L) of PCE were detected , indicating that the chlorinated VOC plume is most concentrated in the upper portion of the aquifer in the residential area.
- Based on comparison of data from monitoring wells and/or Geoprobe borings along Water Street, behind the Hobart facility, and on Spinnaker, the composition of the groundwater contaminant plume changes from primarily PCE at the upgradient (west) side of the Spinnaker site to TCE, *cis*-1,2-DCE, and vinyl chloride across the Spinnaker site.
- In the area west of the river, groundwater flow in the upper sand and gravel aquifer is east/southeastward, roughly parallel to and toward the Great Miami River.
- During a pumping test by Ohio EPA that used the East Troy Wellfield wells and shallow monitoring wells at the Spinnaker site, Ohio EPA observed that groundwater levels in shallow wells at Spinnaker responded quickly to variations in pumping rates on the production wells across the river. This observation is consistent with the results of groundwater modeling completed by the City of Troy indicating that (1) the river is not a hydraulic barrier to groundwater flow and (2) the shallow and deep aquifer units are in hydraulic communication. (Mill Creek 2002; Ohio EPA 2002; KC 2007, 2009; EPA 2008).

Ohio EPA compiled the data from the investigations and completed an Expanded Site Inspection (ESI) Report (Ohio EPA 2002). The ESI was used to support the decision for listing on the National Priorities List (NPL) by EPA (EPA 2008).

### *Spinnaker Coatings/ Kimberly Clark Facility Investigations*

Within the East Troy plume, the current or historical presence of chlorinated VOCs in on-site soils and groundwater has been confirmed at the Spinnaker facility on Water Street, directly across the river from the East Wellfield. Spinnaker is a manufacturer of adhesive-coated papers and related products.

The facility started operations in 1928 when Brown-Bridge Industries, Inc., began manufacturing adhesive products. KC acquired Brown-Bridge Industries in 1971 and continued operation of the facility until 1994, when the property was sold to Spinnaker.

Since the 1990s, extensive investigations have been conducted on the Spinnaker property by KC and Ohio EPA to evaluate the presence and sources of contamination in soils and groundwater. The Ohio

EPA investigations were summarized in the preceding section. In addition to the work conducted by Ohio EPA, KC has completed various investigations at the site, as described below.

Environmental assessments were conducted as part of Kimberly-Clark's sale of the property to Spinnaker in 1994. It was determined that the Spinnaker property included a narrow parcel that was formerly used as a rail spur, extending from part of the area now occupied by Spinnaker's west parking area, northwest between Hobart and the Great Miami River, to the main rail line along Clay Street. Spinnaker collected soil samples for analysis for VOCs. Chlorinated VOCs, including PCE and TCE, were detected in several soil samples from this parcel. The highest reported concentration of chlorinated VOCs was 12,000 ug/kg of TCE detected in shallow soil sample SB-4 (2.5 feet depth) from an area adjacent to a municipal sewer and water easement that crosses the parcel, near the western end of the Spinnaker west parking lot. This sample also reportedly contained lower concentrations of PCE; 1,2-DCE; and 1,1,1-TCA, as well as other chlorinated and non-chlorinated VOCs, and semi-volatile organic compounds (SVOC). The highest concentration of PCE (470 ug/kg) was reportedly detected in a sample collected at a depth of 2 feet from boring SB-8, which was collected adjacent to the Hobart facility structure. The maps associated with that report indicate that although boring SB-8 was on the rail spur parcel, the Hobart building encroached onto the rail spur parcel as it was configured at that time. This area is now owned by Hobart.

Also as part of the investigations supporting the sale of the Spinnaker property , soil and groundwater impacted by fuel oil and VOC (primarily toluene) releases were discovered in two small areas on the west side of the facility and two areas on the east side of the facility. An area of soil contaminated with chlorinated solvents, primarily TCE, was later detected near a loading dock in the western portion of the facility.

According to a closure report prepared by KC, remediation of the impacted areas on the Spinnaker property began in April 1995 with removal of impacted soil from the two fuel oil/ toluene spill areas on the west end of the facility and installation of groundwater remediation systems in all four areas impacted by the fuel oil/ toluene releases. Ohio EPA was involved in the development of the cleanup plan, reviewed KC's cleanup goals, and encouraged KC to begin voluntary remediation in accordance with the plan. Analysis of contaminant concentrations in soil samples collected from the walls and floors of the two excavations on the west end of the property indicated that the excavated areas met regulatory soil guidelines for the toluene/ fuel oil related contamination. Groundwater cleanup goals were reportedly achieved on the east end of the facility by January 1998, and the east remediation system was shut down with no further action required. Cleanup goals or background concentrations for groundwater were reportedly achieved on the west end of the facility by December 2000, with regard to the fuel oil/ toluene spills.

Concentrations of chlorinated VOCs continued to be detected in groundwater at the Spinnaker site. Investigations completed by Ohio EPA and KC indicate that the on-site contamination plume at Spinnaker changes in composition from primarily PCE and lower concentrations of degradation products TCE, *cis*-1,2-DCE, and vinyl chloride directly upgradient from the property, to primarily TCE and *cis*-1,2-DCE with lower concentrations of PCE and vinyl chloride at downgradient locations on the Spinnaker site. These observations suggest that the Water Street PCE plume and Spinnaker plume possibly originated from different sources and are co-mingling on the Spinnaker site (Mill Creek 2002, KC 2007, 2009).

In 2002, KC submitted a closure report for the areas of soil contamination at the facility. Table 3 summarizes the maximum concentrations of chlorinated VOCs detected in groundwater presented in the closure report, as well as those detected in the most recent (March 2010) quarterly sampling event. Figure 5 presents a detail map of the Spinnaker west end area, with the monitoring well locations.

### TABLE 3

### MAXIMUM DETECTED CONCENTRATIONS OF CHLORINATED VOCS IN GROUNDWATER AT THE SPINNAKER SITE WEST END (2001 AND 2010)

| VOC DETECTED | 2001 | | 2010 | |
|---|---|---|---|---|
| | CONCENTRATION (µg/L) | MONITORING WELL | CONCENTRATION (µg/L) | MONITORING WELL |
| 1,1-DCA | 1.4 | KMW-8 | ND | NA |
| *cis*-1,2-DCE | 50.7 | PW-3 | 73 | KMW-10 |
| PCE | 60.2 | KMW-7 | 20 | KMW-15 |
| TCA | 8.8 | PW-3 | ND | NA |
| TCE | 10.4 | PW-3 | 6.5 | KMW-15 |
| Vinyl Chloride | 0.6 | KMW-9 | ND | NA |

Notes:

| | |
|---|---|
| µg/L | Micrograms per liter |
| DCE | Dichloroethene |
| DCA | Dichloroethane |
| PCE | Tetrachloroethene |
| TCA | Trichloroethane |
| TCE | Trichloroethene |
| NA | Not Applicable |
| ND | Not Detected |

Source: Mill Creek 2002; 2010

The closure report indicated that because PCE concentrations in groundwater were highest at the upgradient side of the Spinnaker site, PCE may migrate onto the property from an off-site source or sources However, subsequent sampling of soils at the Spinnaker site in 2005 (see below) detected the presence of various chlorinated VOCs in samples collected at depths above the water table, confirming the presence of on-site sources of chlorinated VOCs at Spinnaker.

Ohio EPA subsequently expressed concerns about the source of remaining concentrations of VOCs on the Spinnaker property, the migration and breakdown mechanisms of VOCs coming onto the Spinnaker property, and the risks that remaining groundwater VOC concentrations pose to human health and the environment, including the City of East Troy Wellfield located across the Great Miami River from the Spinnaker property. Consequently, KC continued to operate the groundwater remediation system while conducting additional assessment.

In 2005, KC conducted an investigation of site soils to evaluate the risk from residual concentrations of VOCs, including areas that were not addressed by the previous soil remediation efforts. The investigation involved collection and analysis of 134 subsurface soil samples. Table 4 summarizes the concentrations detected in those samples. As shown in Table 4, chlorinated VOCs, primarily TCE and *cis*-1,2-DCE (with lower concentrations of PCE), were detected in numerous soil samples at the site, many of which were collected from depths above the water table. TCE was detected at concentrations up to 133,000 ug/kg and *cis*-1,2-DCE up to 14,900 ug/kg. These observations, combined with groundwater monitoring data for the site, indicate that on-site releases of chlorinated VOCs to soil and groundwater occurred at the Spinnaker property. (Mill Creek 2002, KC 2007, 2009; EPA 2008).

KC continued to operate the on-site groundwater pump and treat system until May 2009. At that time KC terminated operation of the Spinnaker system as it no longer appeared to be effectively removing significant amounts of contamination or effectively controlling migration of the chlorinated VOC plume.

KC is continuing quarterly groundwater monitoring at the west end of the Spinnaker site to evaluate VOC concentration trends and groundwater flow patterns. All of the monitoring wells in the west end monitor the upper portion of the aquifer.

On behalf of EPA, SulTRAC split groundwater samples from 5 of the monitoring well locations with KC's consultant in December 2009. The split samples were analyzed for VOCs through the EPA Region

5 Central Regional Laboratory (CRL). The data were found to correlate with the data obtained by KC. Additional split sampling may be incorporated into the RI field program in the future.

As indicated on Table 4, data from the most recent sampling event (March 2010) indicated that the highest concentrations of PCE were detected in wells KMW-15 (20 ug/L), located near the levee at the extreme northwest corner of the property, in addition to wells EEIB-4 and GZA-1 (14 ug/L and 16 ug/L, respectively) located near Water Street. Well KMW-15 also contained the highest detected concentration of TCE, at 6.5 ug/L. The highest concentrations of cDCE (73 ug/L and 26 ug/L, respectively) were detected in wells KMW-10 and KMW-11, located on the western side of the Spinnaker parking lot, between wells KMW-15 and EEIB-4. Concentrations of chlorinated VOCs in wells in the center and eastern (downgradient) portions of the lot were lower or nondetect; however, low concentrations of cDCE and TCE were detected in several wells including OEPA -3 and RS-04, located between the Spinnaker building and the Great Miami River.

## TABLE 4

## CHEMICALS DETECTED IN SOIL (2005) SPINNAKER FACILITY

| Sampling Location | Depth (ft bgs) | Date | Hazardous Substance | Concentration (µg/kg) |
|---|---|---|---|---|
| SSB-1 | 1-2 | 5/2/2005 | TCE | 204 |
| SSB-1 | 5-8 | 5/2/2005 | TCE | 105 |
| SSB-1 | 8-10 | 5/2/2005 | TCE | 121 |
| SSB-1 | 12-12.5 | 5/2/2005 | TCE | 2,190 |
| SSB-2 | 2-5 | 5/2/2005 | TCE | 127 |
| SSB-2 | 12.5-13 | 5/2/2005 | TCE | 98.5 |
| SSB-3 | 2-3 | 5/2/2005 | TCE | 6,660 |
| SSB-3 | 8-9.5 | 5/2/2005 | TCE | 386 |
| SSB-4 | 1-5 | 5/2/2005 | TCE | 123 |
| SSB-4 | 6-9 | 5/2/2005 | TCE | 87.1 |
| SSB-4 | 9-10 | 5/2/2005 | TCE | 163 |
| SSB-4 | 11-12.5 | 5/2/2005 | TCE | 308 |
| SSB-4 | 12.5-14 | 5/2/2005 | TCE | 634 |
| SSB-4 | 14-15 | 5/2/2005 | TCE | 193 |
| SSB-5 | 4-5 | 5/2/2005 | TCE | 661 |
| SSB-6 | 3-5 | 5/3/2005 | TCE | 500 |
| SSB-6 | 8-10 | 5/3/2005 | TCE | 114 |
| SSB-7 | 2.5-4 | 5/3/2005 | TCE | 204 |
| SSB-7 | 4-5 | 5/3/2005 | TCE | 158 |
| SSB-7 | 9-10 | 5/3/2005 | TCE | 88.5 |
| SSB-7 | 12-13 | 5/3/2005 | TCE | 178 |

| Sampling Location | Depth (ft bgs) | Date | Hazardous Substance | Concentration (µg/kg) |
|---|---|---|---|---|
| SSB-7 | 13-13.5 | 5/3/2005 | TCE | 182 |
| SSB-8 | 3-5 | 5/3/2005 | TCE | 1,430 |
| SSB-8 | 7.5-10 | 5/3/2005 | TCE | 591 |
| SSB-8 | 12-12.5 | 5/3/2005 | TCE | 198 |
| SSB-8 | 14-15 | 5/3/2005 | TCE | 1,190 |
| SSB-9 | 4.5-5 | 5/3/2005 | TCE | 293 |
| SSB-9 | 5-9 | 5/3/2005 | TCE | 615 E |
| SSB-9 | 9-10 | 5/3/2005 | TCE | 276 |
| SSB-9 | 11.5-12 | 5/3/2005 | TCE | 231 |
| SSB-9 | 12-14 | 5/3/2005 | TCE | 77.2 |
| SSB-9 | 14-15 | 5/3/2005 | TCE | 98.4 |
| SSB-10 | 4.5-5 | 5/3/2005 | TCE | 147 |
| SSB-10 | 5-8 | 5/3/2005 | TCE | 88.5 |
| SSB-10 | 8-10 | 5/3/2005 | TCE | 278 |
| SSB-10 | 12-12.5 | 5/3/2005 | TCE | 451 |
| SSB-10 | 12.5-14 | 5/3/2005 | TCE | 175 |
| SSB-11 | 4-5 | 5/4/2005 | TCE | 72.7 |
| SSB-11 | 8.5-10 | 5/4/2005 | TCE | 212 |
| SSB-11 | 12.5-13 | 5/4/2005 | TCE | 2,250 |
| SSB-12 | 3.5-5 | 5/4/2005 | TCE | 913 |
| SSB-12 | 9-10 | 5/4/2005 | TCE | 2,210 |
| SSB-12 | 12-13 | 5/4/2005 | TCE | 1,530 |
| SSB-12 | 13-15 | 5/4/2005 | TCE | 68.6 |
| SSB-13 | 4-5 | 5/4/2005 | TCE | 1,690 |
| SSB-13 | 8-10 | 5/4/2005 | TCE | 918 |
| SSB-13 | 11.5-12 | 5/4/2005 | TCE | 233 |
| SSB-13 | 12-13 | 5/4/2005 | TCE | 5,890 |
| SSB-13 | 13-15 | 5/4/2005 | TCE | 111 |
| SSB-14 | 4-5 | 5/4/2005 | TCE | 2,050 |
| SSB-14 | 5-9 | 5/4/2005 | TCE | 300 |
| SSB-14 | 12-13 | 5/4/2005 | TCE | 12,800 E |
| SSB-14 | 13-15 | 5/4/2005 | TCE | 1,200 |
| SSB-17 | 4-5 | 5/5/2005 | TCE | 1,650 |
| SSB-17 | 8-9 | 5/5/2005 | TCE | 11,700 E |
| SSB-17 | 9-10 | 5/5/2005 | TCE | 511 |
| SSB-17 | 12-13 | 5/5/2005 | TCE | 1,870 |
| SSB-18 | 4-5 | 5/5/2005 | TCE | 3,510 |
| SSB-18 | 8-9 | 5/5/2005 | TCE | 389 |
| SSB-18 | 9-10 | 5/5/2005 | TCE | 1,240 |
| SSB-18 | 13-14 | 5/5/2005 | TCE | 138 |
| SSB-20 | 4-5 | 5/5/2005 | TCE | 11,800 |
| SSB-20 | 8-10 | 5/5/2005 | TCE | 514 |
| PSB-20 | 2-4 | 4/1/2005 | TCE | 133,000 |
| PSB-22 | 13-14.5 | 3/30/2005 | TCE | 38,400 |
| SSB-1 | 1-2 | 5/2/2005 | PCE | 45.5 |

| Sampling Location | Depth (ft bgs) | Date | Hazardous Substance | Concentration (µg/kg) |
|---|---|---|---|---|
| SSB-1 | 5-8 | 5/2/2005 | PCE | 27 |
| SSB-1 | 8-10’ | 5/2/2005 | PCE | 42.1 |
| SSB-1 | 12-12.5 | 5/2/2005 | PCE | 562 |
| SSB-1 | 12.5-13 | 5/2/2005 | PCE | 116 |
| SSB-2 | 12-12.5 | 5/2/2005 | PCE | 38.8 |
| SSB-2 | 12.5-13 | 5/2/2005 | PCE | 87 |
| SSB-2 | 13-15 | 5/2/2005 | PCE | 52.4 |
| SSB-4 | 14-15 | 5/2/2005 | PCE | 60.7 |
| SSB-5 | 4-5 | 5/2/2005 | PCE | 51.1 |
| SSB-6 | 3-5 | 5/3/2005 | PCE | 98.8 |
| SSB-6 | 5-8 | 5/3/2005 | PCE | 48.3 |
| SSB-6 | 8-10 | 5/3/2005 | PCE | 56.2 |
| SSB-7 | 2.5-4 | 5/3/2005 | PCE | 63.3 |
| SSB-7 | 4-5 | 5/3/2005 | PCE | 146 |
| SSB-7 | 5-9 | 5/3/2005 | PCE | 81.7 |
| SSB-7 | 9-10 | 5/3/2005 | PCE | 244 |
| SSB-7 | 12-13 | 5/3/2005 | PCE | 96.8 |
| SSB-7 | 13-13.5 | 5/3/2005 | PCE | 215 |
| SSB-7 | 13.5-14 | 5/3/2005 | PCE | 71.9 |
| SSB-8 | 3-5 | 5/3/2005 | PCE | 95.2 |
| SSB-8 | 7.5-10 | 5/3/2005 | PCE | 47 |
| SSB-8 | 12-12.5 | 5/3/2005 | PCE | 41.2 |
| SSB-8 | 12.5-14 | 5/3/2005 | PCE | 135 |
| SSB-8 | 14-15 | 5/3/2005 | PCE | 661 |
| SSB-9 | 4.5-5 | 5/3/2005 | PCE | 10.6 |
| SSB-9 | 5-9 | 5/3/2005 | PCE | 19.8 |
| SSB-9 | 9-10 | 5/3/2005 | PCE | 17.3 |
| SSB-9 | 11.5-12 | 5/3/2005 | PCE | 10.4 |
| SSB-9 | 12-14 | 5/3/2005 | PCE | 125 |
| SSB-10 | 8-10 | 5/3/2005 | PCE | 97 |
| SSB-10 | 12-12.5 | 5/3/2005 | PCE | 74.3 |
| SSB-10 | 12.5-14 | 5/3/2005 | PCE | 144 |
| SSB-11 | 4-5 | 5/4/2005 | PCE | 77.2 |
| SSB-11 | 8.5-10 | 5/4/2005 | PCE | 97.4 |
| SSB-11 | 12.5-13 | 5/4/2005 | PCE | 347 |
| SSB-12 | 3.5-5 | 5/42005 | PCE | 39 |
| SSB-12 | 9-10 | 5/42005 | PCE | 59.4 |
| SSB-12 | 12-13 | 5/42005 | PCE | 59.3 |
| SSB-13 | 4-5 | 5/4/2005 | PCE | 127 |
| SSB-13 | 12-13 | 5/4/2005 | PCE | 58.7 |
| SSB-14 | 4-5 | 5/4/2005 | PCE | 108 |
| SSB-14 | 5-9 | 5/4/2005 | PCE | 44.4 |
| SSB-14 | 12-13 | 5/4/2005 | PCE | 158 |
| SSB-14 | 13-15 | 5/4/2005 | PCE | 92.6 |
| SSB-15 | 4-5 | 5/4/2005 | PCE | 733 |

| Sampling Location | Depth (ft bgs) | Date | Hazardous Substance | Concentration (µg/kg) |
|---|---|---|---|---|
| SSB-15 | 5-8 | 5/4/2005 | PCE | 91.7 |
| SSB-15 | 8-10 | 5/4/2005 | PCE | 88.6 |
| SSB-15 | 12-13 | 5/4/2005 | PCE | 73.1 |
| SSB-15 | 13-15 | 5/4/2005 | PCE | 96.4 |
| SSB-17 | 4-5 | 5/5/2005 | PCE | 57.5 |
| SSB-17 | 8-9 | 5/5/2005 | PCE | 931 |
| SSB-17 | 9-10 | 5/5/2005 | PCE | 132 |
| SSB-17 | 12-13 | 5/5/2005 | PCE | 757 |
| SSB-18 | 4-5 | 5/5/2005 | PCE | 75.8 |
| SSB-18 | 9-10 | 5/5/2005 | PCE | 177 |
| SSB-20 | 4-5 | 5/5/2005 | PCE | 134 |
| SSB-4 | 12.5-14 | 5/2/2005 | *cis*-1,2-DCE | 284 |
| SSB-9 | 4.5-5 | 5/3/2005 | *cis*-1,2-DCE | 6.1 |
| SSB-13 | 12-13 | 5/4/2005 | *cis*-1,2-DCE | 1,790 |
| SSB-14 | 12-13 | 5/4/2005 | *cis*-1,2-DCE | 391 |
| SSB-17 | 4-5 | 5/5/2005 | *cis*-1,2-DCE | 240 |
| SSB-18 | 4-5 | 5/5/2005 | *cis*-1,2-DCE | 282 |
| SSB-18 | 8-9 | 5/5/2005 | *cis*-1,2-DCE | 610 |
| SSB-18 | 9-10 | 5/5/2005 | *cis*-1,2-DCE | 882 |
| SSB-18 | 13-14 | 5/5/2005 | *cis*-1,2-DCE | 262 |
| PSB-20 | 2-4 | 4/1/2005 | *cis*-1,2-DCE | 170 |
| PSB-21 | 14-16 | 4/1/2005 | *cis*-1,2-DCE | 405 |
| PSB-22 | 13-14.5 | 3/30/2005 | *cis*-1,2-DCE | 14,900 |

**Notes:**

| | |
|---|---|
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| DCE | Dichloroethene |
| E | Result qualified due to concentration being outside of calibration range |
| µg/kg | Micrograms per kilogram |
| ft bgs | Feet below ground surface |

Source: EPA 2008.

### *EPA Time Critical Removal Action*

Elevated concentrations of VOCs have been detected in sub-slab soil gas and indoor air of structures within an area roughly corresponding to the area of groundwater contamination in the East Troy Site. PCE and other VOCs were detected in indoor air samples collected by the City of Troy from several occupied structures including the Troy police station, a church, and a school in 2005. In 2006, Ohio EPA noted that residences and other occupied structures above and adjacent to the groundwater plumes were at risk for exposure to VOCs through vapor intrusion from soil gas to indoor air. Ohio EPA requested that EPA conduct a time-critical removal action assessment to determine the extent of vapor intrusion contamination and to mitigate levels of VOCs in indoor air that exceed screening levels established by the Agency for Toxic Substances and Disease Registry (ATSDR) and Ohio Department of Health (ODH) (Ohio EPA 2006; EPA 2007c).

EPA conducted sub-slab and indoor air sampling at residences, churches, and schools to evaluate threat to human health. The sampling program was conducted using methods described in EPA's Standard Operating Procedure for the Construction and Installation of Permanent Sub-Slab Soil Gas Wells SOP#2082 (EPA 2004a). Approximately 200 residents were notified to participate in the sampling program. From July 2006 through April 2007, the EPA collected sub-slab and indoor air samples from a total of 85 locations, which included 78 residences, two churches, four schools, and the Troy Police Station during Phase 1 and Phase 2 air sampling activities. VOC concentrations at 17 residences exceeded the screening criteria or 1.2 and 0.4 parts per billion (ppb) for PCE and TCE, respectively, in indoor air (EPA 2007b).

The locations where VOC concentrations exceeded criteria were distributed throughout the approximate same area as the residential area PCE groundwater plume (between East Main and Franklin Streets, most notably along Franklin) and also in the area over the Water Street PCE plume. However, PCE was detected at concentrations above the screening criteria at several locations that appear to be located outside of the currently defined areas of the groundwater plumes (see Table 5). For example, previous groundwater sampling completed from 2001-2004 had not indicated the presence of PCE in groundwater at the intersection of Franklin and Union Streets. However, sub-slab vapor and indoor air samples collected at several locations in the area along Franklin Street southeast (hydraulically downgradient) of Union, between Union and Counts Streets, exceeded screening criteria (see locations EPA-22, -39, -43, -49, and -50 in Table 5). In addition, samples from one residence on Canal Street between Crawford and Union (see location EPA-36 in Table 5) also exceeded screening criteria; however, previous groundwater data from the area to the southwest of Franklin Street had not indicated that the plume extended to Canal Street. TCE was detected above screening criteria at location EPA-18, near the intersection of Water and Mulberry Streets, upgradient from the known boundaries of the Water Street PCE plume (EPA 2007b; ATSDR 2008). These observations suggest that possibly (1) sewers had acted as the initial transport mechanism for PCE resulting in multiple "pockets" of subsurface contamination at locations associated with joints or breaks, with intervening "clean" areas of groundwater; or, (2) by 2007 the plume(s) had migrated beyond the boundaries defined by Ohio EPA's investigations completed in 2004; or, (3) additional contaminant sources are located in the area. For these reasons, the RI scope includes activities to further define the current plume boundaries and migration potential for the PCE in groundwater, sub-slab vapor and indoor air throughout the site and to evaluate the possibility of additional source areas.

The EPA removal action was initiated on May 31, 2007. Vapor abatement mitigation systems were ultimately installed in 16 residences and also at St. Patrick Elementary School, located across Water Street from the Spinnaker and Hobart Cabinet facilities. Follow-up sampling was completed at the location where systems were installed one month after installation. Table 5 summarizes the results of the indoor air sampling, before and after installation of mitigation systems. (Additional sampling of some of these locations will be conducted during the RI.) The EPA removal action was completed on April 17, 2008.

### TABLE 5
### INDOOR AIR SAMPLE RESULTS FOR HOUSES REQUIRING VAPOR ABATEMENT

| Number | EPA ID # | Location | Analyte | Initial Concentration (ppb) | 1-Month After Installation, (ppb) | ODH/ATSDR Screening Level (ppb) |
|---|---|---|---|---|---|---|
| 1 | EPA-03 | Franklin Street | PCE | 7.6 | 1.5 | 1.2 |
| 2 | EPA-06 | Franklin Street | PCE | 22 | 1.7 | 1.2 |
| 3 | EPA-13 | Water Street (School) | PCE | 2.1 | ND | 1.2 |
|  |  |  | TCE | 1.3 | ND | 0.4 |
| 4 | EPA-18 | Water Street | TCE | 1.0 | 1.4 | 0.4 |
| 5 | EPA-22 | E. Franklin St. | PCE | 1.7 | ND | 1.2 |
| 6 | EPA-28 | E. Franklin St. | PCE | 1.3 | 4.6 | 1.2 |
| 7 | EPA-32 | E. Franklin St. | PCE | 4.5 | ND | 1.2 |
| 8 | EPA-39 | E. Franklin St. | PCE | 4.8 | ND | 1.2 |
| 9 | EPA-43 | E. Franklin St. | PCE | 7.2 | ND | 1.2 |
| 10 | EPA-26 | E. Main St. | TCE | 0.51 | 0.60 | 0.4 |
| 11 | EPA-38 | E. Canal St. | TCE | 0.61 | ND | 0.4 |
| 12 | EPA-16 | Franklin Street | PCE | 6.6 | 1.2 | 1.2 |
| 13 | EPA-45 | Union Street | PCE | 2.2 | 0.57 | 1.2 |
| 14 | EPA-49 | E. Franklin St. | PCE | 11 | ND | 1.2 |
| 15 | EPA-50 | E. Franklin St. | PCE | 3.5 | 0.33 | 1.2 |
| 16 | EPA-72 | E. Main Street | PCE | 1.4 | ND | 1.2 |
| 17 | EPA-59 | E. Main Street | PCE | 1.4 | ND | 1.2 |

Notes:

EPA ID #s 28 and 43 had dirt floors; EPA-50 had a partial dirt floor.

| | |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| ODH | Ohio Department of Health |
| ppb | Parts per billion |
| ND | None Detected |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |

Source: ATSDR 2008.

EPA proposed the site for inclusion on the NPL, and the site was listed in September 2008 The EPA initiated negotiations with KC in 2008 for performance of the RI/FS. Negotiations did not result in a settlement; therefore, EPA initiated the investigation in 2009. In February 2009 EPA issued the fund lead RI/FS WA to SulTRAC (EPA 2009a).

***Summary***

In summary, based on the background information reviewed, the following key data gaps were identified with regard to the RI:

- The eastern/ southeastern horizontal limits of the shallow residential area PCE and Water Street PCE contaminant plumes have not been determined.
- Additional data are needed in the area between Main Street and Water Street to confirm the horizontal extent and possible sources of the residential area PCE plume and the Water Street PCE plume.
- Investigation of the vertical distribution of contaminants in the residential area PCE plume has been limited to one location. Data from deep (94 feet deep) City of Troy monitoring well Q, located in the "hot spot" of the residential PCE plume area does not indicate the presence of significant concentrations of VOCs at that depth. However, additional data are needed to ensure that the extent of the contaminant plume does not extend farther at depth..
- Sampling completed at the Spinnaker west end confirmed the presence of chlorinated VOCs, primarily TCE and *cis*-1,2-DCE in soil and groundwater. Detections of these substances at significant concentrations in soil samples collected above the water table indicates on site sources of both of these contaminants at the Spinnaker property. Chlorinated VOCs in shallow groundwater extend downgradient to at least the area between the Spinnaker building and the Great Miami River; however, decrease significantly in concentration in the area between the west side of the parking lot and the east side of the lot. For this reason, the potential for deep plume migration should be evaluated in this area.
- Shallow groundwater contamination detected on Water Street, the Spinnaker property, and on the perimeter of the Hobart property indicate possible comingling of two or more plumes, one primarily composed of PCE, and one primarily composed of cDCE and TCE. Chlorinated VOCs, primarily PCE, may be migrating onto the Spinnaker site from the unknown source plume along Water Street or the Hobart property. For this reason, other potential source areas need to be evaluated.
- The vertical extent and potential for migration of contaminants in the deep portion of the aquifer in the vicinity of Hobart and Spinnaker needs to be evaluated.
- An apparent “hot spot” of groundwater contamination is present in the area bounded by Franklin, Clay, Crawford, and Main streets. The highest VOC concentrations in groundwater were detected just to the east/northeast of the intersections of Clay and Crawford Streets with Franklin Street, in wells screened near the top of the uppermost aquifer (approximately 18 to 28 feet below ground surface). The aforementioned area does not coincide with any known likely existing or historical VOC sources. Possibly, a preferential pathway such as a sewer resulted in a release that has caused a residual source of contaminants such as contaminated soil or dense-nonaqueous phase liquid (DNAPL) in the shallow subsurface and is an ongoing release mechanism and thus should be evaluated.

- Although maps of the Miami and Erie Canal indicate historic businesses and industries in the eastern part of Troy prior to the 1920s, the Franklin Street area is primarily residential; moreover, no historical dry cleaning operations, auto service facilities, or other likely sources of chlorinated VOCs are known to have operated in this immediate area. Based on this consideration, sanitary or storm sewer lines may have provided a mechanism for migration of VOCs from suspected source areas closer to Main and Market Streets. (Figure 4 shows the sanitary sewers in the area.)
- Past investigations of the nature and extent of contamination have been limited to public right-of-ways, parking lots, the Spinnaker property, and the perimeter of Hobart Cabinet. Suspected source areas directly upgradient of the Spinnaker facility, such as interior portions of the Hobart Cabinet property, need to be investigated through on-site sampling of soil and groundwater.
- Groundwater data collected to date are extensive, but were collected by multiple entities using a variety of sampling and analytical methods, some of which were completed with the objective of rapid screening rather than to meet the data quality objectives of an RI. In addition, the data were collected over more than 15 years. For these reasons, a comprehensive set of groundwater data collected from fixed, discrete monitoring locations and depths within a short timeframe and using consistent EPA-approved methodology, is necessary to document current conditions.
- Subsurface soil sampling in the residential area has been extremely limited; it is necessary to try to locate hot spots of residual soil contamination assuming the possibility that the contamination is related to past releases from historical primary sources which no longer exist; an emphasis should be placed on areas near former suspected sources and possible alternate migration pathways (such as sewers).
- Possible interactions between the shallow and deep aquifers, and between the shallow aquifer and the Great Miami River, have not been fully evaluated.
- To date, only limited groundwater data have been collected to the northwest of the East Wellfield to rule out the possibility of contaminant sources on that side of the river or to confirm that the contamination affecting the West Wellfield is not also migrating to the East Wellfield.
- Due to limited public response to EPA's requests, sub-slab and indoor air monitoring were completed at only approximately 20 percent of the residences in the plume area that were invited by EPA to participate in the monitoring program. For this reason, additional sub-slab vapor monitoring is needed to define the extent of contamination and assess human health risk. The locations to be monitored will be selected based in part on groundwater and soil analytical data that become available as Phase I of the RI progresses and will be presented in an Addendum to the SAP.

The chemicals of interest potentially hazardous to human health and the environment at the East Troy Site were identified based on the investigations previously discussed and information obtained by SulTRAC. To date, the plume has been confirmed to contain the chlorinated VOCs PCE, TCE, *cis*-1,2-DCE, and vinyl chloride; therefore, these VOCs are considered the primary chemicals of interest for the RI. However, because the nature and extent of contamination have not been confirmed, other contaminants may be present in the area related to suspected or currently unknown sources. Other contaminants, regardless of source, must be included in evaluating overall human health and ecological risks; for this reason, limited sampling and analysis for semivolatile organic compounds (SVOC), metals, pesticides, and polychlorinated biphenyls (PCB) will also be completed to account for other contaminants that might be present.

The collection of data during the RI will be an iterative process. To ensure that the objectives of the RI are met, if necessary EPA may elect to modify, add or eliminate proposed locations and/or parameters for any of the RI investigative activities as data become available during Phase I of the RI. For this reason, the numbers, locations, and types of samples described herein may be modified at EPA's discretion.

## 3.0 PROJECT OBJECTIVE

This FSP describes the approach that will be used to conduct Phase I of the RI/FS at the East Troy site. Although past investigations have confirmed that releases of hazardous substances to groundwater have occurred, the data suggest that multiple sources may have contributed to the contamination and not all of these sources have been identified. Additional data are needed to determine migration and exposure pathways and complete a conceptual site model (CSM). A secondary source, contaminated groundwater at relatively shallow depth, is releasing VOC vapors that are migrating to local residences. It is unknown if ongoing releases of chlorinated VOCs to groundwater are occurring from other secondary sources that may be present such as contaminated soil, or DNAPL that has migrated from its original disposal location. Phase I encompasses field and other activities to identify potential contamination source areas and further define the nature and extent of contamination. The Phase I investigation will provide the data required to indicate whether the identified properties are potential contamination source areas, whether potential additional contamination source areas exist, the concentrations and depths of contamination in soil, and the impact to shallow and deep groundwater beneath the site. When the Phase I activities are complete, the data will be reviewed. If data gaps or additional data are needed to further delineate the extent of contamination at the site, additional investigations may be required. Otherwise, the FS will proceed. If additional data are deemed necessary, SulTRAC will prepare a subsequent work plan for a Phase II investigation. All SulTRAC field activities will be conducted in accordance with the EPA-approved, site-specific QAPP (Attachment B) and SulTRAC standard operating procedures (SOP) (see SOP attachment). Where the FSP differs from the SOPs, the FSP’s site-specific procedures will take precedence.

## 4.0 FIELD SAMPLING ACTIVITY

Field sampling activities discussed in this section pertain to the Phase I RI, which will focus on identifying potential source areas, delineating the extent of soil and groundwater contamination at the East Troy site, and attempting to determine whether additional source areas are contributing to contamination at the East Troy site. Phase I will also evaluate the potential for impacts to surface water and sediment in the Great Miami River and evaluate the possible nature and extent of contamination in indoor air of structures within the area of the groundwater contaminant plume. As previously discussed, the sub-slab monitoring and indoor air sampling locations and methodologies, some of which are yet to be determined, will be presented in an addendum to this SAP. For this reason, subsequent discussions in this SAP focus on the other activities (soil, groundwater, surface water, and sediment sampling and related activities) that will be completed during Phase I of the RI.

Figures 5-8 show the locations of proposed Phase I sampling and investigation activities. Table 6 lists all samples to be collected, the number of samples, and specific information on collection. A detailed discussion of sample collection procedures is in Section 5.0.

Drilling and well installation in the plume area are problematic due to the age and nature of the neighborhood, which is densely developed residential and commercial, with narrow lots and public right of ways, relatively busy streets, and a high density of underground and overhead utilities. There are relatively few open areas. In addition to work on several private properties, SulTRAC anticipates that project field activities will be conducted in public right-of ways and will be an iterative process, whereby data collected early in Phase I will be used to focus and optimize the efficiency of subsequent Phase I activities. For these reasons, this project will require close coordination with local utility providers and locators, as well as the City of Troy. Procedures for obtaining access to work sites are detailed in the Site Management Plan and Health and Safety Plan for the Phase I RI of the East Troy Site (SulTRAC 2010b, e).

Before intrusive field work begins, several investigations will be conducted to direct intrusive sampling and modify proposed sampling locations as appropriate. Pre-intrusive field activities include a survey of existing monitoring wells, a sewer survey, collection of groundwater elevation data, and groundwater sampling and analyses from existing monitoring wells. Data gathered during these studies will be used to select locations for intrusive soil borings, vertical aquifer profiling, and monitoring well installation.

Following selection of the desired locations for intrusive activities, utilities location and clearance at the actual proposed work sites will be completed.

As discussed with the EPA and as outlined in the East Troy Wellfield Contamination Site work plan (SulTRAC 2009a), SulTRAC will conduct the following Phase I field sampling activities:

- A baseline groundwater sampling event to include 13 existing Ohio EPA monitoring wells and six City of Troy monitoring wells (see Table 1), with collection of groundwater elevations and field parameter data. This task also includes collection of groundwater split samples for VOC analysis at up to 5 locations on the Spinnaker site (completed in December 2009) and ongoing evaluation of the Spinnaker quarterly monitoring data in conjunction with the data to be obtained during the RI.

- Investigation of the sewer lines in the vicinity of Franklin, Clay, and Crawford Streets (if sewer lines are accessible) in order to evaluate the possibility of sewer breaks as a transport/ release mechanism for VOCs.

- Collection of subsurface soil samples from up to 30 locations (including background) in and around the existing contaminant plumes; with collection and analysis of two soil samples per boring; 10 surface soil samples may also be submitted if warranted by site specific conditions

- Collection of groundwater grab samples at the water table at up to 10 of the 30 soil boring locations; analyses will be rapid-turnaround for VOCs using a local laboratory facility with the objective of supporting field decisions regarding well locations.

- VAS of the upper aquifer at seven locations west of the Great Miami River using direct-push techniques; collection of up to six groundwater samples from two of the locations, and up to three groundwater samples from the remaining five locations; analyses will be rapid-turnaround for VOCs using a local laboratory facility with the objective of supporting field decisions regarding well screen depths. The VAS data will be screening level data. These data will also be used to evaluate the need for additional monitoring or VAS locations during Phase II of the RI. The proposed VAS locations are summarized in Table 8 and depicted on Figure 7.

- Installation of at least five new deep monitoring wells using rotosonic techniques west of the Great Miami River. The proposed deep well locations are summarized in Table 8 and depicted on Figure 7. Deep wells are planned to be installed at four of the VAS locations (Hobart, Spinnaker west end, Spinnaker East end, and either at New and Main or on Oak Street). In addition, a deep well will be installed adjacent to existing well OEPA-14 on Walnut, near Main, at the known upgradient end of the residential area PCE plume. Deep wills be paired with new shallow monitoring wells, or placed in proximity to existing shallow wells. Depths for the deep wells will be determined by review of the rapid turnaround VOC data. During Phase II, additional deep wells may be installed.

- Installation of up to 7 new shallow monitoring wells in the area west of the Great Miami River to further evaluate plume boundaries and potential source areas, as indicated on Table 8. Locations include Oak Street between Franklin and East Main; New Street and East Main; Hobart (2 wells);

Crawford Street between East Main and Water Street; and in the vicinity of New Street and Water Street.

- Installation of one additional shallow monitoring well as a permanent "background" location for characterizing groundwater quality as it enters the residential PCE plume area. Past definition of the upgradient plume boundary has been based on samples from temporary wellpoints. This location, and existing Ohio EPA well MW-13, will provide background monitoring data for the residential area PCE plume and Water Street PCE plumes, respectively.

- Repair of several existing Ohio EPA monitoring well surface casings, including MW-13. In addition, wells at locations that are considered significant to the RI and are in need of repair, or are constructed with small diameter casing, may be replaced after the baseline sampling event. Such wells will be replaced if the small casing diameter interferes with efficient collection of samples of sufficient volume or quality in accordance with current EPA approved methods (i.e. low-flow purging and sampling for VOCs).

- Installation of two monitoring wells in a single cluster east of the Great Miami River using Rotosonic techniques, north/northeast of the East Wellfield; these will include one shallow monitoring well screened in the upper aquifer and one deep monitoring well screened in the lower aquifer.

- Installation of two staff gauges in the Great Miami River.

- An elevation survey to tie all new groundwater monitoring locations and staff gauges to a common elevation reference with the existing wells; the elevation data will be used to confirm the groundwater flow direction

- A comprehensive groundwater sampling event of the 19 previously existing wells included in the baseline sampling and 5 Spinnaker wells, plus the 20 new monitoring wells installed during the RI; collection of groundwater elevation data and field parameter data.

- Collection of surface water samples from up to four locations on the Great Miami River (including background).

- Collection of sediment samples from up to four locations on the Great Miami River (including background).

- Collection of indoor sub-slab vapor monitoring samples in the contaminant plume area west of the Great Miami River.

As VOC concentrations in soil vapor and indoor air are anticipated to correlate with soil and groundwater concentrations, it will be preferable to sequence Phase I to allow collection of soil and groundwater data before finalizing the locations that will be selected for sub-slab and indoor air VOC monitoring. In addition, pending and recent guidance from EPA and the Ohio EPA will influence the sampling and analytical methodologies that will apply to the East Troy RI/FS. Based on these considerations and discussions with EPA and Ohio EPA, SulTRAC will prepare and issue a SAP addendum addressing the specific guidance, methodologies and locations for the sub-slab/ indoor air VOC monitoring prior to commencing that portion of the RI.

A summary of sample information is presented below in Table 6.

**TABLE 6**

**SUMMARY SAMPLE INFORMATION FOR EAST TROY CONTAMINATED AQUIFER SITE**

| Number of Sampling Locations | Matrix | Depth (feet) |
|---|---|---|
| 27 locations | Soil[1,2,3] | Will be based on inspection[1] |
| 3 locations (Background soil) | Soil [2,3.4] | 0-2, 8-10[1] |
| 10 Locations | Groundwater[2.3] | Top of uppermost water table |
| 30 Locations (approximate) | Sub-Slab Vapor | 1[6] |
| 24 locations (Existing wells) | Groundwater[2,4, 7] | Various |
| 7 Locations | Groundwater (VAS) [2,3] | Various, maximum of 90 feet or top of aquitard[1] |
| 7 locations (New wells – west of river – includes background) | Groundwater[2,4] | 20[1] |
| 5 locations (New wells – west of river) | Groundwater[2,4] | 60-90 (estimated - will be determined by VAS)[1] |
| 1 location (New well – east of river) | Groundwater[2,4] | 20[1] |
| 1 location (New well – east of river) | Groundwater[2,4] | 120[1] |
| 4 locations (including background) | Surface Water[5] | Surface |
| 4 locations (including background) | Sediment[5] | Surface |

**Notes:**

[1] Sampling depths and locations will be determined based on geologic characteristics, and evidence of contamination (visual, photoionization detector (PID) readings, odors, or analytical data, as applicable)

[2] See Figures 5-8 for sampling locations.

[3] Samples will be collected from direct-push advanced borings.

[4] Samples will be collected from monitoring wells.

[5] Samples will be collected from the Great Miami River (see Figure 8)

[6] Sample locations will be within the boundaries of the chlorinated VOC groundwater plume, and determined based on the results of the Phase I soil and groundwater investigations , past sub-slab VOC monitoring data collected during the EPA TCRA, and consultation with EPA and Ohio EPA. Sampling and analytical methods, numbers and locations of samples will be presented in a SAP addendum to be prepared after initial soil and groundwater analytical data become available At Phase I locations where sub-slab vapor concentrations exceed screening levels, additional sub-slab monitoring and indoor air monitoring may be conducted during Phase II.

[7] Includes 13 Ohio EPA wells, 6 City of Troy wells where split samples will be collected during the baseline event, and which will also be sampled during the comprehensive sampling event; and, 5 wells at the Spinnaker site.

## 4.1 Utilities Location

Due to the size of the area of investigation and density of utilities in the area, utilities location will be completed in phases. SulTRAC will first contact the City of Troy and conduct a visual reconnaissance of the project area to identify obvious locations of buried or overhead utilities related to electrical supply, stormwater conveyance systems, drinking water conveyance systems, sanitary sewer systems, natural gas conveyance systems, telephone lines, and cable television lines. The first field activities will include only groundwater sampling at existing wells, and these data will be used to select the locations for the soil borings, VAS borings, and monitoring well installations. For this reason, field utility clearance activities will be completed after SulTRAC and EPA select and mark the final proposed locations for intrusive (drilling) activities. The local utility providers and location service will be contacted, and SulTRAC will provide oversight of the utilities location. SulTRAC will also document locations using a global positioning system (GPS). All utilities identified will be marked in the field using pin flags or spray paint as appropriate. The GPS locations of all utilities will be stored in a centralized database for future reference and re-locating as needed for additional investigations. If proposed work locations must be adjusted due to utilities, SulTRAC will discuss alternate locations with EPA, field-locate the new locations, and conduct additional clearance before proceeding with work.

## 4.2 Site Surveying and Inspection of Existing Monitoring Wells

Figures 5-8 show the locations of existing monitoring wells that will be sampled as part of the RI. Thirteen shallow groundwater monitoring wells were installed by Ohio EPA prior to 2004. These wells have not been sampled since 2004. Numerous monitoring wells are located on the Spinnaker property and are sampled by KC on a quarterly basis. The City of Troy also has six monitoring wells in the East Troy site area that were installed to support its wellhead protection program.

The existing monitoring wells were installed over a period of years and top of casing elevation data were obtained by surveys completed by multiple entities at different times. During a preliminary site visit conducted in August 2009, the Ohio EPA and Troy wells were located, and depth to groundwater and total well depth were measured (see Table 1). The top of casing elevations for several monitoring wells were rechecked. Several wells were noted to be small (1-inch inside diameter) wells, with several others being 1.5 inches in diameter, and the remainder being 2 inches in diameter. Small diameter wells limit the sampling techniques and equipment that can be practically used to collect samples of documentable quality via low flow purging and sampling; for this reason, some of the 1-inch diameter wells at key locations may be replaced during the RI. Most of the wells appeared to be in good condition, with the exception that several of the inner casings need new locking caps and the flush mount covers need any sheared bolts extracted and replaced to ensure security and integrity of the wells. At one well (OEPA-13), the flush mounted surface casing was loose and needs to be secured. Table 1 summarizes the top of casing elevations, total depth, depth to water and elevation of the piezometric surface of the existing Ohio EPA and Troy monitoring wells.

Following installation of the new monitoring wells and staff gauges, all existing and new wells and staff gauges will be tied to a common survey. SulTRAC will procure the services of an Ohio registered surveyor. The surveyor will determine the horizontal positions of all new wells and staff gauges and each of the 13 Ohio EPA monitoring wells and the six City of Troy monitoring wells and tie the elevations to the network of wells at the Spinnaker site and the MCD piezometers, to ensure that all measurements are from a common datum. The positions will be surveyed to Ohio State Plane coordinates and will also be recorded using a hand-held geographic information system (GIS) device. The top of inner casing elevation of each monitoring well and staff gauge will be determined to an accuracy of +/- 0.01 foot to a common datum; the measurement point will be permanently marked on the casing and used for subsequent water level measurements.

The survey will also establish control points that can be used subsequently to tie additional sampling locations, if needed, during Phase II. Additional site surveying needs will be determined as the RI progresses, depending on the results of the various activities.

During the baseline sampling event (see Section 4.5) the condition of the well interiors at the existing wells will be further evaluated. Those wells in need of minor repair to ensure well integrity will be repaired by the drilling contractor during the well installation phase of the hydrogeologic investigation. If any of the existing wells are found to be unusable, these wells may require abandonment, and possibly replacement (if a data point that is critical to the RI) during Phase I or Phase II. The baseline groundwater sampling event is discussed further in Section 4.5.

## 4.3 Sanitary Sewer Investigation

Based on data collected by Ohio EPA, an apparent “hot spot” of groundwater contamination appears to be present in the area bounded by Franklin, Clay, Crawford, and Main streets. PCE concentrations as high as 800 µg/L were observed in groundwater samples collected from monitoring wells and direct-push borings in this area, with the highest concentrations appearing to be on Clay and Crawford Streets, just to the northeast of Franklin Street (Ohio EPA 2002; EPA 2008). Possibly, a residual source of contaminants such as contaminated soil or DNAPL is present and is an ongoing release mechanism. However, this area is primarily residential and does not coincide with any known or likely historical sources such as dry cleaners.

Information provided by the City of Troy Engineering Department (Troy 2009a) indicates that a 15-inch sanitary sewer line originates in the vicinity of several former locations of dry cleaners and auto service shops in the vicinity of Main and Walnut Streets, runs southwest along Walnut Street, and then runs southeast along Franklin Street (see Figure 4). Laterals flow into this sewer at the major cross streets. The location where the sewer line crosses Clay Street and the railroad tracks coincides with the approximate area of highest observed groundwater contaminant concentrations in this part of the plume. For this reason, it appears possible that the sanitary sewer may have acted as a conduit that transported contaminants from the suspected primary source areas. A break in the sewer line in the vicinity of the Clay Street/rail crossing could have thus caused a release of contaminants to soil and groundwater in this area even though it is several blocks from the point of likely origin of the contaminants.

The sewer investigation will consist of a robotic camera survey if the sewer is accessible. The purpose of this survey is to confirm the presence and drainage route of the sewer, connections to the pipe, and the integrity of the sewer pipe; and to seek locations in the pipe where a release to the subsurface may have occurred at pipe joints or cracks in the pipe.

The robotic camera will be inserted at the point of origin and advanced through accessible lengths of the pipe system. The distance of the advancement will be recorded and simultaneously measured at the ground surface and marked with spray paint or pin flags. Connections to the pipe will also be surveyed to assess whether additional pipe runs are connected to the system and to identify additional pipe run origins and potential contribution of contaminants to the system. The results of the robotic camera survey will also be used in selecting potential soil boring and sampling locations.

Locations of the sewer pipe and any joints or cracks identified by the surveys will be determined using a GPS unit. The data collected will be stored for potential mapping and additional investigations deemed necessary in Phase I.

## 4.4 Source Area Soil Investigations

SulTRAC will conduct geological investigations and collect subsurface soil samples via soil borings following a biased approach. This FSP uses the term "soil boring" to include man-made substrates that have been filled or dumped at the site. Subsurface soil samples collected at the site from soil borings and as grab samples are expected to include both native soil and fill material. All field notebook entries and geologic logs must include one of the substrate designations for each sampled horizon unless no man-made substrates are encountered; in that case, the specific soil type (for example, sand, clay, gravel, etc.) will be identified in both the field notebook and geologic log. Table 7 summarizes information regarding the sample locations.

During the Phase I field investigation, SulTRAC will collect soil samples from advancement of 27 investigative borings and three background soil borings. The primary purposes of sampling are to identify potential contamination source areas, begin delineating the extent of soil contamination at the site, and attempt to determine if additional contamination source areas are contributing contamination at the site.

The proposed boring locations are at or near the locations of existing or former historical possible sources, railroads, and potential contamination conduits, as listed in Table 7. These proposed locations (see Figures 6 and 8) were tentatively selected to identify potential source areas of contamination at the site and to supplement data obtained through prior investigations. Note that actual final soil boring locations will be confirmed with EPA after completion of the baseline sampling event and may be modified from those proposed herein.

The depth to water is typically less than 20 feet throughout most of the East Troy site. Soil borings will be advanced to the top of the water table (or refusal) using direct-push techniques with collection of continuous soil core samples for possible laboratory analysis and logging at each location. Borings will be drilled at each of, but not necessarily limited to, the following areas: (1) various open lots in the area

# TABLE 7
# SOIL BORING LOCATIONS FOR IDENTIFIED AREAS

| Location | Use and Environmental Concern | Number of Soil Borings | Number of Samples* |
|---|---|---|---|
| Vicinity of Walnut and Main Streets | Areas located close to locations where past data have indicated a possible point of origin for the residential area plume; close to former One-Hour Martinizing, Waltz Cleaners, and auto repair locations; area of reported odors in basements of businesses | 4 | 8 |
| Hobart Cabinet | Active facility located on Water Street upgradient from the Spinnaker plume; soil and groundwater data and information gathered by Ohio EPA indicated the presence of chlorinated VOCs on the site perimeter and possible dumping of solvents on site | 4 | 8 |
| Various locations of possible sources within the plume area (Mulberry, Clay, Crawford, Union,Main and Water Streets, also possible UST area near Canal and Race) | Potential additional contributing source areas | 7 | 10 |
| Vicinity of Clay/Franklin and Crawford/ Franklin Intersections | Hot spot of groundwater contamination located in vicinity of these intersections, near rail crossing | 5 | 10 |
| Additional locations along sanitary sewer | Possibility of sewer as historic transport mechanism from original sources (now gone) such as dry cleaners to plume area | 4 | 10 |
| Locations on Franklin between Union and Counts, in vicnity of residences where PCE was detected in sub-slab vapor in 2007 | Possibility of sewer as historic transport mechanism from original sources (now gone) such as dry cleaners to plume area; at least one location will include a groundwater sample | 2 | 6 |
| Spinnaker West Lot - Former Dry Cleaner Location | Potential additional contributing source areas | 1 | 2 |
| Background/off site (west of State Route 55/ Market Street and southwest of Canal Street) | Confirmation of background soil conditions in the area | 3 | 6 |

Notes:

* Number of samples indicated does not include QA/QC samples for each subset. Also, surface soil samples (0 to 2 feet) may also be collected at up to 10 locations if warranted by field observations and site specific conditions.

Groundwater samples will be collected from up to 10 of the 30 soil borings.

between Walnut, Main, Clay, and Franklin Streets where buildings have been demolished since previous investigations, to evaluate the potential presence of residual soil contamination in the suspected source/origin area; (2) the intersections of Franklin Street with Clay and Crawford Streets, with the objective of identifying a soil "hot spot," possibly related to migration of contaminants along sanitary or storm sewer lines (based on the findings of the survey investigation of the sanitary sewer, several of the soil borings may be used to evaluate areas such as breaks or areas where the sewer alignment coincides with areas of significant groundwater contamination); (3) the Hobart Cabinet property, to evaluate that site as a potential source area; and (4) various other locations within the known plume boundaries to determine if areas of significant soil contamination remain and are acting as ongoing release mechanisms to groundwater.

Soil borings will be advanced to the top of the uppermost aquifer using hydraulic push boring methods due to the space limitations and the need to minimize access agreements for private property, which renders working on public right of ways preferable. The horizontal location of each boring will be recorded in the field using a GPS system. Soil recovered during boring advancement will be screened in 2-foot increments using a portable photoionization detector (PID). Samples selected for analysis will be biased within each interval based on the concentration of VOCs detected by the PID. The soil sample with the highest PID reading from each sample will be selected for analysis. If no concentration of VOC is detected by the PID, the sample that exhibits visible evidence of contamination or the sample from the deepest potion of the interval will be selected for analysis. Because the East Troy site is by definition a chlorinated VOC groundwater plume, the analyses will focus on VOCs. Two soil samples from each boring will be submitted for analysis for VOCs. A select number (six) of the soil samples (including samples from at least one background location) will be submitted for analysis for full target compound list (TCL) parameters (includes VOCs, SVOCs, PCBs, and pesticides) and target analyte list (TAL) parameters (includes metals and cyanide). All soil samples will be analyzed through EPA's CLP.

Because areas of significant soil contamination may indicate "hot spots" of residual contamination that are acting as secondary sources of release of VOCs to groundwater, groundwater samples will be collected at the top of the uppermost aquifer at locations where evidence of contamination such as odors, staining, or elevated PID readings indicate the presence of VOCs. These samples will be screening level samples collected with the intent of providing additional data to support decisions regarding monitoring well locations, and will be analyzed for VOCs by a local laboratory using standard EPA methods, but expedited turnaround protocols, to allow timely evaluation and usability of the data during the field program. The data will be evaluated in conjunction with the soil data to focus additional investigative activities.

Samples will be analyzed for these analytical groups using appropriate EPA methods, as identified in Section 6.0 of this FSP. QC samples (field duplicate, matrix spike [MS], and matrix spike duplicate [MSD]) will be collected for soils as described in Section 11.0 of this FSP.

## 4.5 Groundwater

SulTRAC will conduct hydrogeologic investigations that will include (1) an initial baseline sampling of existing monitoring wells, and splitting groundwater samples at the Spinnaker site (2) collection of shallow groundwater samples at up to 10 of the 30 soil boring locations, (3) a VAS program to evaluate the vertical distribution of VOCs in the uppermost aquifer, (4) installation and development of new monitoring wells, and (5) collection of one round of samples at all monitoring wells (previously existing and new wells) and measurement of surface elevations.

Aquifers within this region are sands and gravels within surficial glacial deposits, and the underlying Silurian carbonate bedrock formations. The East Troy site lies in the Great Miami River floodplain at an elevation of approximately 820 to 830 feet above mean sea level (amsl). In the East Troy site area, the Great Miami River flows along the course of a deep bedrock valley filled with sand and gravel deposited as glacial outwash, with interbedded clays and silts. Available information indicates that groundwater flow in the study area is generally southeast, parallel to and in the downstream direction of the Great Miami River. Wells located in the sand and gravel deposits can yield in excess of 1,000 gallons per minute at depths of 95 to 100 feet. A till layer reportedly occurs at a general elevation of 775 feet amsl (approximately 50 to 60 ft bgs) in the area, and separates the sand and gravel deposits into an “upper” and “lower” aquifer at the Site (Ohio EPA 2002; Malcolm Pirnie 2004; EPA 2008); however, the till is not continuous, and hydraulic communication between the upper and lower aquifers occurs. The City of Troy obtains its water supply from five wells in the West Wellfield and five wells in the East Wellfield. Additional productions wells are located in the East Wellfield but are not currently in use. The production wells are screened at depths ranging from approximately 100 to 125 ft bgs and draw water from the “lower” portion of the sand and gravel. The till layer is not present at some locations in the East Wellfield. Piezometric data collected from the Ohio EPA, Troy, and select Spinnaker monitoring wells in August 2009 indicated (1) an increasing horizontal gradient in the upper aquifer in the vicinity of the Spinnaker site and the north end of the East Wellfield; (2) similar groundwater flow patterns in both the shallow and deep aquifers and (3) a downward vertical gradient in the area immediately northwest of the East Wellfield. These factors suggest hydraulic communication between the upper portion of the aquifer and the zone from which the Troy wells draw water.

### 4.5.1 Baseline Sampling

Thirteen shallow groundwater monitoring wells were installed by Ohio EPA prior to 2004. These wells have not been sampled since 2004. The City of Troy also has three monitoring wells east of the Great Miami River and three monitoring wells west of the Great Miami River in the Site area that were installed to support its wellhead protection program. The Ohio EPA and Troy monitoring well locations and specifications are summarized in Table 1; locations are depicted on Figures 6-8. Numerous monitoring wells are located on the Spinnaker site; those at the west end of the facility are sampled by KC on a quarterly basis. Figure 5 is a detailed view of the Spinnaker west end and the monitoring wells at that site.

During a preliminary site visit conducted in August 2009, the 13 Ohio EPA wells were visually located. The depth to water and total well depth were measured at each well. The wells were in generally good condition, with the exception that several of the pads and flush mount surface casings or covers need repairs to secure the wells. Several wells were noted to be small (1-inch diameter) wells, with the remainder being 2 inches in diameter. Small diameter wells limit the sampling techniques and equipment that can be practically used to collect samples of documentable quality via low flow purging and sampling and there some of the 1-inch diameter wells at key locations will be replaced during the RI. During this visit, SulTRAC also located, measured and inspected Troy monitoring wells L, M, N, O, P, and Q, all of which appeared to be in good condition.

SulTRAC will conduct a baseline sampling event encompassing the existing wells, concurrently collecting groundwater samples from all existing Ohio EPA wells and City of Troy wells. Groundwater elevation data will be obtained from these wells, as well as at least 5 wells on the Spinnaker site and 3 MCD piezometers located along the levee on the west side of the river in the site vicinity.

Because the East Troy site is by definition a chlorinated VOC groundwater plume, the analyses will focus on VOCs. However, the potential presence of other contaminants needs to be assessed as these other contaminants could factor into the risk assessment. Fourteen of the samples will be submitted to the EPA Contract Laboratory Program (CLP) for only VOC analysis. Groundwater samples from up to five locations will be analyzed for target analyte list (TAL) metals (including mercury and cyanide), VOCs, semivolatile organic compounds (SVOC), polychlorinated biphenyls (PCB), and pesticides, with the objective of determining if continued monitoring for these additional parameters is warranted during the remainder of the RI. Analysis of these additional parameters at select locations during the baseline sampling event will allow refinement and focusing of the parameter list for subsequent sampling events. Two of the locations at which the additional parameters will be analyzed will be wells OEPA-11 and OEPA-13, which are the two most "upgradient" wells located in the study area, and no VOCs have been detected in OEPA-13. In addition, samples from two wells which have previously contained chlorinated VOCs will be analyzed for the full parameter list (OEPA-7 in the residential PCE plume area and OEPA-9 in the Water Street PCE plume area), and one well located along East Main Street (OEPA-2) will be analyzed for the full parameter suite. SulTRAC will obtain preliminary data from the CLP as quickly as possible following the sampling event, and will use these data to select/confirm the proposed locations for intrusive investigations.

As part of the baseline program, SulTRAC will also split samples from up to five desired wells at the Spinnaker site during at least one quarterly sampling event and will also obtain data for additional wells sampled under that program from KC. (The initial set of split samples were collected in December 2009; additional split samples may be collected as the RI progresses). In addition, groundwater elevation data will be obtained from at least 5 of the Spinnaker wells concurrently with the measurements of the Ohio EPA and Troy wells.

The baseline sampling program will be completed prior to conducting any other intrusive field activities; the data will be used to select optimal locations for VAS and monitoring well installation. SulTRAC will obtain preliminary data from the CLP as quickly as possible following the sampling event and will use these data to select/confirm the proposed locations for intrusive investigations.

The existing City of Troy monitoring wells are 2-inch diameter standard construction (slotted screens with sand filter packs. However, as previously discussed, the Ohio EPA wells range in diameter from 1 to 2 inches and were constructed with either pre-packed external screens or integral porous screens. In the past, Ohio EPA used a variety of techniques to sample these wells, including peristaltic pumps, "Waterra" pumps, and bailers, due to the limitations of the well bore size. Small diameter bladder pumps have since become available and SulTRAC will attempt to sample all of these wells using low-flow purging and sampling techniques. Field measurements of temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductivity will be collected, using a flow-through cell, to ensure that conditions are stable prior to sample collection. However, it is SulTRAC's experience that the small diameter pumps do not work well in all situations due to the small volume of the bladders and small size of the check valve parts, which renders the valves prone to clogging with sediment resulting in loss of water and little to no volumetric flow. For this reason, a contingent sampling method, such as a peristaltic pump (subject to EPA approval), may be necessary for some locations in the event that the low-flow pumps do not allow collection of the samples. EPA will be consulted regarding any proposed changes in sampling procedures prior to collection of the samples. In the event that samples of documentable quality or sufficient volume for all desired parameters are not obtainable at any of the existing wells due to condition or boresize, alternate locations may be selected for analysis for full TCL/TAL parameters and/or sampling deferred until the well can be repaired or replaced, or determined to be unnecessary. In such cases, additional sampling for full TCL/TAL analyses may be incorporated into the full round of sampling to be completed after completion of the well installation activities. These locations will be determined through consultation with the EPA WAM.

SulTRAC completed one round of split sampling at the site in December 2009. Although not anticipated, additional split sampling may be conducted at the discretion of EPA as the RI progresses. Split samples at the Spinnaker site will be collected during routine quarterly sampling events, and thus will be collected using the methods employed by KC’s consultants. If additional sampling of existing Spinnaker wells is completed on the Spinnaker site by SulTRAC personnel, all wells will be sampled using low-flow techniques similar to those used for the other wells sampled during the baseline sampling event.

Following completion of the baseline sampling, SulTRAC will install 14 new groundwater monitoring wells (see Figures 7 and 8) to provide background groundwater quality information, further delineate the extent of groundwater contamination, and further characterize groundwater at the site. The newly installed wells at the East Troy site will be completed and screened at horizons consistent with their intended objectives, as described in the following sections. In addition, existing monitoring wells considered critical to the RI sampling program that are in need of repair to ensure well integrity will be repaired by the drilling subcontractor during the well installation program.

### 4.5.2 VAS and Upper Aquifer Well Installation – West of Great Miami River

In the area west of the Great Miami River, the presence of chlorinated VOC contamination in groundwater at the top of the uppermost aquifer has been confirmed by previous investigations. However, data evaluation has been conducted with only limited consideration of vertical contaminant concentration gradients, and the extent of contamination has thus been based on two-dimensional representations of the plumes. In order to more effectively evaluate the nature and extent of contamination, as well as identify potential sources, a greater understanding of vertical plume geometry is necessary. For this reason additional monitoring wells will be installed to monitor the upper and deeper portions of the upper aquifer. The depths at which the deep wells will be screened will be determined by VAS profiling of the upper aquifer.

Previous investigations provided extensive data on the horizontal extent of the contaminant plumes through a combination of temporary wells/Geoprobe sampling, and permanent monitoring wells. Most of the existing monitoring wells in the Residential and Water Street PCE plume areas, and also the wells at the Spinnaker site, are screened to monitor the uppermost portion of the saturated zone, above 30 feet bgs. Contamination detected in Ohio EPA wells OEPA-1, -5, 6, and 7 indicates the area of highest observed PCE concentrations to date in the upper portion of the aquifer, described herein as the "hot spot" of PCE contamination, extending from the vicinity of Clay and Franklin, southeastward (downgradient) at least to Crawford Street. Data from Union Street, one block farther downgradient, indicate significantly lower concentrations in the shallow zone.

(Note - as previously discussed, sub-slab vapor and indoor air data collected by EPA in 2007 indicated PCE in sub-slab vapor at locations beyond the previously defined boundaries of the residential area groundwater PCE plume. For this reason groundwater samples will be collected from soil borings in these areas to provide additional data regarding the plume boundaries and possibility of additional hot spots of groundwater contamination in these areas. The need for additional monitoring wells in these areas, or moving currently proposed VAS or monitoring well locations, will be determined based on these data evaluated in conjunction with data from the VAS program and baseline sampling as Phase I of the RI progresses. If necessary, locations for VAS and monitoring wells may be altered from those proposed herein and/ or additional locations may be installed during Phase II.)

With regard to the vertical extent of contamination, the City of Troy has one deep monitoring well, "MW-Q", located adjacent to shallow Ohio EPA monitoring well OEPA-1, on the northwest corner of Crawford and Franklin Streets. This area is directly (approximately 250 feet) downgradient of shallow monitoring well OEPA-7 and approximately 100 feet upgradient from Ohio EPA shallow well OEPA-5. During a June 2004 sampling event, PCE was detected in the shallow wells in this vicinity (OEPA-1, 5, 6 and 7) at concentrations ranging from approximately 283 to 800 ug/L. These were the highest detected VOC concentrations of any of the shallow wells sampled during that sampling event. Low /trace concentrations of TCE and 1,2-DCE were also detected in these shallow wells. However, PCE concentrations detected in deep well MW-Q during this same sampling event were only 0.713 ug/L, and no other VOCs were detected.

The boring log for well MW-Q indicates relatively homogenous stratigraphy throughout the saturated zone, and does not indicate the presence of the till layer that reportedly separates the upper aquifer from the lower aquifer in some areas of Troy. Thus, the boring log indicates no obvious hydrostratigraphic features that would prevent downward migration of PCE, or conversely no features that would constitute a preferential flow pathway. Likewise, piezometric data collected by SulTRAC during a preliminary site visit in August of 2009 indicated no measurable vertical gradient at the OEPA-1/MW-Q cluster. These observations, considered in light of the low reported concentrations of PCE in deep well MW-Q, appear to indicate that groundwater contamination is likely to be concentrated in the uppermost part of the aquifer in the residential PCE plume area. Also, VOCs have not been detected in City of Troy monitoring wells MW-O and MW-P, located southeast of the residential and Water Street PCE plume areas.

Based on these considerations, the need for additional wells to monitor deep portions of the aquifer may be limited. However, the data collected in the deep zone to date are limited to only one location within the plume areas. Also, the flow model prepared for the City of Troy's wellhead protection plan and piezometric data collected by SulTRAC in August 2009 suggest a possibility that the deep zone west of the Great Miami River is within the pumping influence of the northern part of the East Wellfield and deep locations may be needed between the residential area PCE plume and the East Wellfield. Based on existing data, supplementing the existing network of water-table monitoring wells during Phase I of the RI and adding monitoring of the deeper portions of the aquifer through VAS and installation of deeper wells at key locations will provide the most accurate means of confirming plume boundaries, potential source areas, vertical gradients, the presence of the till layer (and possible effects on contaminant migration) and vertical contaminant distribution in known source areas.

The VAS program will provide screening level data to evaluate the vertical distribution of contaminants and thus determine the need for an expanded network of wells at depths other than the uppermost water table. The VAS will support the following specific objectives (1) determine if preferential flow pathways exist (2) determine the nature and extent of the plume at depth, especially to see if the plume extends further at depth than it does in the shallow zone (3) differentiate (or not) the residential area PCE plume from the Water Street and Spinnaker plumes and (4) determine if there is plume movement beneath the river toward the city wells. VAS will be conducted at 7 locations. Table 8 summarizes the proposed VAS locations and rationale.

## TABLE 8

## SUMMARY OF PROPOSED VAS AND NEW MONITORING WELL LOCATIONS

| Location | VAS | Deep Well | Shallow Well | Rationale |
|---|---|---|---|---|
| 1 Clay and Franklin, adjacent to monitoring well OEPA-7 | Yes | No | No | "Hot Spot"; possible residual or secondary source area; deep aquifer already monitored by well MW-Q in this general area; shallow aquifer monitored by well Ohio EPA-7 |
| 2 Oak Street, between Main and Franklin | Yes | Contingent (if deep well is not installed at Location 4) | Yes | Track possible migration from Residential PCE Plume toward wellfield; confirm boundaries of deep plume if present; confirm downgradient extent of shallow plume; deep well is contingent on VAS results at locations 2 and 4. |
| 3 Parking lot, west side of Crawford, between Main and Water | Yes | Contingent (phase II) | Yes | Confirm that Residential and Water Street PCE Plumes are separate in the shallow and deep zones; track possible movement of deep plume (if present) from Walnut/Main area toward wellfield; well contingent on results of VAS and would be installed in Phase II if needed. |
| 4 New and Main | Yes | Yes (alternate site would be Location 2) | Yes | Confirm shallow plume boundaries; confirm Residential and Water Street Plumes are separate in the deep zone; track possible movement of deep plume (if present) from Walnut/Main area toward wellfield. Location dependent on access and spatial constraints. Deep well may be installed at Location 2 (Oak Street) depending on VAS data. |
| 5a and 5b Hobart Property, near former rail spur | Yes | Yes (1 well - location 5b) | Yes (2 wells) | Suspected source area; evaluate possibility of shallow and deep contamination; vertical gradients; 2 shallow wells will be installed (location 5a and 5b) |

| Location | VAS | Deep Well | Shallow Well | Rationale |
|---|---|---|---|---|
| 6 Spinnaker West End Parking Area | Yes | Yes | No | Suspected source area; area where plume changes from PCE to TCE and 1,2-DCE and concentrations drop; evaluate possibility of deep contamination and vertical gradients; shallow zone already monitored |
| 7 Adjacent to levee, near Spinnaker east end | Yes | Yes | No | On possible flow path from Residential Area PCE plume, toward Troy wells 14 and 18; due to proximity to wellfield VAS will be terminated if confining layer (till) is encountered |
| 8 Walnut, near Main; near shallow monitoring well Ohio EPA-11 | No | Yes | No | Farthest upgradient end of plume area; evaluate possibility of vertical migration of VOCs at Walnut and Main area or serve as possible deep background well; evaluate vertical gradients; shallow well exists at this location |
| 9 Water Street between New and Counts | No | No | Yes | Confirm boundaries of shallow Water Street PCE plume |
| 10 North of Troy Wells 14 and 18, east of River | No | Yes | Yes | Evaluate possible presence of source areas east of Great Miami River and vertical gradients. VAS will not be conducted due to proximity to wellfield |
| 11 Background, West of Market Street/SR 55 | No | Contingent (Phase II) | Yes | Background location for permanent shallow well; additional deep background well will be installed in Phase II only if deep well at location 8 is found to contain chlorinated VOCs |
| Various | No | No | Contingent (Phase I) | Replace any crucial existing monitoring wells that are found to be in poor condition or not capable of yielding representative samples during the Baseline Sampling. |
| Background Deep - adjacent to OEPA-13 on Clay Street | No | Contingent (Phase II) | No | Background location for permanent deep well to be installed in Phase II contingent on results of Phase I locations 5 (Hobart) and 6 (Spinnaker) |
| Spinnaker, between building and levee, near well RS-06 | Contingent (Phase 2) | Contingent (Phase 2) | No | On possible flow path from Water Street PCE plume, Hobart and Spinnaker toward Troy wells 14 and 18; evaluate vertical gradients; VAS will be contingent on results of Locations 5 (Hobart), 6 (Spinnaker west) and 7; shallow zone is already monitored. Deep well would be installed as far southeast as possible along east side of Spinnaker building; location dependent on access and spatial constraints. |
| Water Street by Ohio EPA-12 | No | Contingent (Phase II) | No | Confirm boundaries and source area of deep Water Street PCE plume if detected at (contingent on) VAS locations 3, 5b and 6 |

| Location | VAS | Deep Well | Shallow Well | Rationale |
|---|---|---|---|---|
| Residental PCE Plume area, southeast (downgradient) of Union Street | No | No | Contingent (Phase II) | Confirm boudnaries of second groundwater "hot spot" if indicated by Phase I results, in area between Union and Counts |
| Area between East Main Street and levee, east of Spinnaker site | No | No | Contingent (Phase II) | Confirm boudnaries of PCE plume if present at location 9 |
| TOTAL | 7 (plus contingent) | 6 (plus contingent) | 8 (plus contingent) | Number of shallow wells to be replaced, if any, will be determined after Baseline Sampling |

Note: See Figures 7 and 8 for locations.

SulTRAC will conduct VAS of the upper portion of the aquifer system, above the confining layer, which is estimated at an approximate depth of 50 to 60 ft bgs where present. Available evidence suggests that the till may not be present in much of the study area. Locations will include key areas where significant VOC contamination has been detected in the past, including but not limited to such areas as the vicinity of Franklin Street and the Spinnaker property, as well as locations that appear to be on flow paths between the areas of significant contamination and Troy Wells 14 and 18. The purpose will be to select depths within the upper portion of the aquifer at which permanent monitoring wells will be screened.

The proposed locations for VAS and monitoring well installation are tentative and will be confirmed with EPA following completion of the baseline sampling event. This will allow evaluation of the current plume configurations based on a comprehensive, simultaneous sampling of all existing wells, which has not been completed in the past. Note that as the VAS program commences, the screening data will be obtained using rapid turnaround analysis for VOCs, allowing ongoing evaluation and modification of the field program if necessary. Should the VAS data appear to indicate a need for alternate locations or depths for any of the monitoring points, or indicate that some of the monitoring points are not necessary, decisions to modify the number, depths, or locations for VAS and monitoring wells will be made through consultation with, and approval by, EPA. (Note: if the till layer is encountered at locations 5, 6, and 7 at an elevation significantly higher than the elevation of the zone from which the Troy production wells draw water, additional VAS may proceed through the till into the deeper zone, but only after consultation with EPA and the City of Troy, and only if no obvious evidence of significant contamination such as odors, staining or DNAPL is noted in the overlying zone. Any available VOC analytical data for the overlying zone will also be considered in such decisions. Alternatively, additional deeper VAS or well installation may be deferred and conducted after casing off the upper zone; possibly in a second phase.)

As indicated on Table 8, some of the locations for VAS and/or monitoring wells are contingent on the results that will be obtained from other locations, as the VAS program will be an iterative effort with sample data being reviewed daily to allow optimal horizontal placement and vertical screening of the wells. Some of the “contingent” well locations may actually be installed during Phase I, if warranted, whereas others may be deferred to Phase II of the RI.

The overall objective of the VAS program is to provide an extra level of confidence that the monitoring well network is adequate to determine the extent of contamination that is known to be present in the shallow zone but yet unconfirmed in deeper portions of the aquifer. For this reason, "background" VAS data are not necessary and will not be obtained. The tentative locations for monitoring well installation are shown on Figures 7 and 8 include one “background” shallow monitoring well location (Location 11), upgradient of the plume area defined by previous investigations, west of Market Street/SR 55. Past data collected from the upper portion of the aquifer have not indicated that the shallow PCE plume extends northwest of the block between Market and Walnut Streets However, there are no permanent monitoring wells located directly upgradient from the main residential PCE plume area that can be used to document a “clean” boundary.

Deeper portions of the aquifer have not been evaluated in the vicinity of Main and Walnut, which appears to be the source area where at least part of the residential area PCE plume originated. For this reason, one deep well will be installed adjacent to shallow well OEPA-11 (Location 8) The deep well will be installed at the top of the till layer (if encountered) or a depth of 90 feet bgs if the till is not encountered. The location will be installed last, following evaluation of the VAS data from locations within the known plume area. In addition the results of the baseline sampling will be evaluated to provide further data regarding plume configuration before the VAS program is initiated. If, upon review of the data, either the shallow upgradient well west of Market Street or the deep well adjacent to OEPA-11 appear unnecessary, these well will not be installed. However, if the additional wells are installed and samples from either well are found to contain chlorinated VOCs during Phase I of the RI, additional background monitoring of the deep portion of the aquifer may be considered for Phase II of the RI. Conversely, if the deep well is installed at Location 8 and VOCs are not detected in groundwater from this well, this well could serve as a background monitoring point for the deep zone.

Potentiometric groundwater maps created by Ohio EPA and KC, as well as piezometric data collected by SulTRAC in 2009 indicate a general groundwater flow to the southeast (Ohio EPA 2002; EPA 2008; KC 2009). SulTRAC will install 12 (7 shallow, 5 deep) additional groundwater monitoring wells in the area west of the Great Miami River. The monitoring well locations, anticipated types (shallow, deep or both) and rationale are presented in Table 8 and indicated on Figures 7 and 8. SulTRAC has devised a monitoring network that includes one shallow upgradient "background" well (west of SR 55), wells in identified potential source areas, and wells to better define the horizontal and vertical extent of the upper aquifer contaminant plume. Final monitoring well locations and screen depths will be defined based on the results of the baseline sampling, VAS program, and sewer investigation, and also influenced by the limitations of the available work areas given the need to operate on public right of ways and presence of underground and overhead utilities. The wells will be screened at depths where significant contamination is detected during the VAS. The planned depths and locations can only be estimated at this time. If the data do not indicate any significant vertical gradients with regard to contaminant concentrations, it is anticipated that new "shallow" wells will be installed in the uppermost part of the upper aquifer (approximately 15 to 25 feet bgs) and "deep" wells will be installed directly above the underlying till layer (if present), approximately 50 to 60 feet bgs. The wells will be installed using the same mini-sonic rig used for the VAS, given the need to access relatively tightly constrained areas on or adjacent to the right of ways, and will be constructed of polyvinyl chloride (PVC). Ten-foot screens will be used for water table monitoring wells, and 5-foot screens will be used for deeper wells or wells where a more discrete sampling interval suggested by the VAS data. The new wells will be completed as flush-mount wells and will be developed by pumping and surging.

Note that some locations for VAS will be in close proximity to existing Ohio EPA or Spinnaker monitoring well locations. The rationale for these VAS locations is that they are in proximity to suspected source areas or areas of highest chlorinated VOC concentrations detected in groundwater during past investigations, but where no data regarding vertical contaminant distribution over the full saturated thickness of the upper aquifer have been collected. At each of these locations, if the VAS data indicate that the most desirable zone for monitoring includes a horizon already monitored by a nearby Ohio EPA well, other locations in the study area may be considered for additional wells (that is, the locations may be adjusted to provide additional lateral coverage of the plume, if warranted.)

### 4.5.3 Potential Source Investigation – East Side of Great Miami River

The City of Troy currently has a single, shallow groundwater monitoring well (MW-N) approximately 0.25 mile northwest of the East wellfield, and a second well cluster (shallow well MW L and deep well MW-M) located approximately 0.5 mile northwest of the wellfield. Data provided by the City of Troy has indicated that VOCs have not been detected in these wells. No monitoring wells exist, shallow or deep, in the area directly north of the East Wellfield. Data gathered by SulTRAC at the Troy monitoring well L/M cluster in August 2009 indicates a downward vertical gradient, as would be anticipated near a large pumping center.

Additional groundwater data are needed to confirm that the contamination detected in the East Wellfield is originating west of the Great Miami River. SulTRAC will install an additional well cluster to (1) confirm or rule out the possibility of sources east of the river, (2) provide a level of confidence that contamination is not migrating in a manner that could be missed by a single-depth well, and (3) provide data regarding vertical gradients. Available data indicate that the till rich zone is absent in the area of the East Wellfield. The new cluster will consist of one well screened in the upper portion of the aquifer, and one well screened in the lower portion of the aquifer to monitor the same elevation horizon as the Troy municipal wells. The primary objective of these wells is to focus the RI by evaluating the possibility of sources east of the river.

If contamination is detected in the new monitoring wells east of the river, Phase II of the RI may include expansion of the source area investigation to include potential sources east of the river and/or additional sources located in the vicinity of the West Wellfield.

Based on the data evaluation from previous site investigations and the Troy wellhead protection plan (WHPP) (Malcolm Pirnie 2004), the shallow well is anticipated to be approximately 20 to 30 feet deep, and the deep well anticipated to be approximately 120 to 130 feet deep to correspond with the approximate elevations of the screened intervals of Troy Wells 14 and 18. However, it should be noted that the City wells do not draw from a uniform elevation horizon, that is, there is an approximate 30-foot range among the wells. For this reason, the deep monitoring well will be screened as closely as possible to the same horizon monitored by Troy wells 14 and 18, but will also consider subsurface hydrostratigraphic features such as grain size, presence of clay layers, and other features, as well as elevation data.

The wells will be installed using Rotosonic drilling techniques, with collection and inspection of continuous soil cores for geology and field screening with a PID. The well cluster will be located to the north of Well 14, between the wellfield and commercial activities located farther north/northeast. The wells will be developed by pumping and surging.

At this time, no VAS is anticipated for the area east of the river. VAS requires greater lengths of time during the drilling process to allow for purging of the borehole and collection of groundwater samples. Due to the proximity of the East Troy Wellfield, and the currently unknown water quality in the shallow portion of the aquifer east of the river, it will be desirable to complete the wells in as short a timeframe as possible to limit the potential for downward migration of contaminants should they be present. Depending on the results of the Phase I investigation, additional borings, wells, or VAS work may be warranted during Phase II of the RI.

### 4.5.4 Groundwater Sampling and Water Level Measurements

A comprehensive round of groundwater samples will be collected at all monitoring wells (the 19 wells included in the baseline sampling plus the 14 new wells installed during Phase I of the RI). Additional wells at the Spinnaker site may also be sampled depending on the results of the baseline sampling and other Phase I field investigation activities that precede the comprehensive sampling event.

Groundwater elevations and stream surface water elevations will be collected at all wells and staff gauges concurrent with the comprehensive sampling event (and any future groundwater sampling events). In addition, measurements will be collected at several piezometers recently installed by MCD along the levee west of the river.

During the comprehensive sampling event, it is assumed that four samples will be analyzed for filtered and unfiltered TAL metals (including mercury and cyanide), VOCs, SVOCs, PCBs, and pesticides. The remaining samples will be analyzed only for VOCs. The rationale for including four samples for full TCL/TAL parameters is a contingency in the event that (1) the baseline sampling results indicate such a need due to detections of these parameters during the baseline event or uncertainty regarding baseline sample integrity due to well condition; (2) detection of source areas for such contaminants during the VAS, soil boring, and well installation programs. The locations for which the full TCL/TAL analyses will be performed will be determined following completion of the soil boring and VAS programs and, and will include contaminated areas (for instance, Hobart, since SVOCs have been detected in past soil sampling on the Hobart site) and one “background” location.

After the sampling event is complete, analytical data will be evaluated, and the data will be reported to EPA in a graphical or simplified technical memorandum format, indicating the chemicals of interest for each well. Based on the chemicals of interest, specific analyte groups will be selected, and future sampling events and investigations will be limited to the specific chemicals of interest. QC samples (field duplicate, trip blank, MS, and MS/MSD) will be collected for groundwater as described in Section 11.0 of this FSP.

### 4.6 Surface Water and Sediment

Because of the hydraulic connection between the groundwater in the sand and gravel aquifer and the Great Miami River, SulTRAC will collect four surface water samples and four sediment samples from the Great Miami River to evaluate the potential for impacts to the river from discharge of contaminated groundwater. The proposed locations include one background location upstream from the West Wellfield, a location immediately downstream from the West Wellfield, one location adjacent to the western end of the Spinnaker facility, and one sample adjacent to the East Wellfield. The background samples and samples collected adjacent to Spinnaker will be submitted to the EPA CLP for analyses for VOCs, pesticides, and herbicides. It is currently anticipated that the remaining two samples will be analyzed only for VOCs. However, the results of the baseline groundwater sampling event and other sampling activities that precede the surface water and sediment sampling will be evaluated and used to determine if an expanded analyte list is needed. Specifically, if the results of these preceding sampling activities indicate the presence of other, currently unknown contaminants at significant concentrations in soil or groundwater at the Site, the analyte list for surface water and sediment samples may be expanded accordingly.

### 4.7 Sub-slab Vapor and Indoor Air Monitoring

Sub-slab vapor monitoring will be conducted in the residential area, and possibly in some commercial buildings, west of the Great Miami River to assess the potential vapor intrusion exposure pathway. Vapor intrusion is the presence or likely presence of any chemical of concern in the indoor air environment of building structures caused by the release of vapor from contaminated groundwater or soil on the property or within close proximity to the property. The results of past monitoring completed by Ohio EPA and EPA from 2005 to 2008 demonstrated the presence of VOCs in residences located above the groundwater contaminant plume, indicating subsurface vapor transport (vapor intrusion) of VOCs from groundwater into residences at the East Troy site.

Monitoring locations will be selected following receipt of the other data from Phase I of the RI (groundwater, soil, sewer investigation), which will be used to define the extent of the contamination and potential source areas. Sub-slab monitoring will be performed at 1) select locations considered to be at or near potential source areas (such as the former Troy One Hour Martinizing facility); 2) locations not addressed in the EPA Time Critical Removal assessment; and, 3) select locations where vapor abatement systems were installed. The locations will also be determined in part by the willingness of property owners to allow the monitoring.

Once the general areas of interest are determined, SulTRAC will work with EPA to contact specific individual property owners and request permission to conduct the monitoring activities. Recent and pending guidance documents that could influence the sampling and analytical methodology will apply to the East Troy RI/FS. In addition, the specific locations for monitoring will be determined, based in part on the results groundwater and soil investigations that will comprise the initial activities during Phase I. Based on these considerations and discussions with EPA and Ohio EPA, SulTRAC will prepare and issue a SAP addendum addressing the specific guidance, methodologies and locations for the sub-slab/ indoor air VOC monitoring prior to commencing that portion of the RI. This will allow the initial components of Phase I to commence and generate necessary data for selection of sub-slab and indoor air monitoring locations as guidance is finalized.

Because the private structures are uncontrolled, collection of indoor air samples is not anticipated for Phase I but may be warranted during Phase II. At any locations where indoor air sampling is completed during Phase II a second round of sub-slab vapor samples will be collected concurrently to allow correlation between the subsurface VOCs and any VOCs detected in the indoor air.

## 4.8 Ecology and Biology

Ecological risk assessment will rely on analytical results obtained during the Phase I sampling event. The first step in the ecological risk assessment process is to conduct a screening-level ecological risk assessment (SLERA). As part of that process, the available ecological habitats will be identified and characterized. A SulTRAC biologist will visit the site and identify the areas likely to support ecological communities within the areas potentially affected by releases from the site. The quality of the habitats will also be assessed. The biologist will contact the appropriate state agencies to determine if threatened and endangered species are present or suspected to be present at the site or areas adjacent to the site.

The SLERA will use soil (Section 4.4), surface water (Section 4.6), and groundwater (Section 4.5) data to assess the potential impacts on releases from the site to ecological receptors. These data will be compared with appropriate state and federal standards, criteria, and guidelines for the protection of ecological receptors.

## 4.9 Human Health

The human health risk assessment (HHRA) will rely on analytical results associated with Phase I soil, groundwater, surface water, and soil gas samples, as well as historical groundwater and soil samples collected at the site. This section focuses on the Phase I samples of specific relevance to characterizing potential human health exposures both on and off site. These samples are associated with four investigations identified under Task 3 (Field Investigation/Data Acquisition) in the RI/FS work plan. Discussed below is the HHRA-related sampling conducted as part of each of these investigations: geological and storm sewer investigations (Section 4.9.1); hydrogeologic investigations (Section 4.9.2); surface water investigation (Section 4.9.3); and sub-slab vapor monitoring investigation (Section 4.9.4).

### 4.9.1 Geological Investigations

As discussed in Sections 4.3 and 4.5, SulTRAC will collect 60 subsurface soil samples and up to 10 surface soil samples, and 10 groundwater samples, from the plume area west of the Great Miami River, including three background locations (see Figures 6 and 8). The locations are summarized in Table 7. The approximate number of location-specific samples is as follows:

- Open lots in the vicinity of Walnut and Main Street – four locations
- Hobart Cabinet – four locations
- Various potential source locations within plume area (Market, Walnut, Mulberry, Clay, Crawford and Water Streets) – seven locations
- Vicinity of Clay, Crawford and Franklin Streets – five locations
- Additional locations along sanitary sewer – up to five locations
- Additional locations on Franklin between Union and Counts - 2 locations in area where elevated PCE was detected in sub-slab vapor in 2007 downgradient from previously defined groundwater plume boundary

- Background/off site (west of State Route 55/ Market Street and southwest of Canal Street – three locations.

Most of the area is paved. Because the site by definition is a groundwater contaminant plume with no identified sources, the Phase I soil samples will be used primarily to attempt to identify potential source areas. Surface soil samples (0 to 2 ft bgs) will be submitted for analysis only if they exhibit visible staining, odors, or elevated PID readings. For this reason, soil samples for evaluation of potential human exposure for receptors other than construction/utility workers are not anticipated during Phase I. Phase II activities may include more intensive sampling of surficial soils, once source areas are better defined by the Phase I activities. In general, results for the Phase I soil samples will be used to characterize current and future risk for construction/utility workers and future exposure for all other receptors, assuming subsurface soil is brought to the surface as the result of future construction or landscaping. The location and basis for the Phase I subsurface soil samples have been discussed (see Section 4.4). It should be noted that analytical results associated with historical soil samples collected at the site will be used to provide context for interpreting Phase I results.

### 4.9.2 Hydrogeologic Investigations

All groundwater data that will be used to support human health risk assessment will be obtained from fixed monitoring points constructed and sampled in accordance with EPA approved protocols and analyzed through the EPA CLP. (Groundwater data obtained from soil borings and the VAS program will be considered screening level data and will not be used for the risk assessment.)

As discussed in Section 4.5 and shown on Tables 6 and 8, groundwater samples will be collected from 24 existing monitoring wells (including the split sampling locations at Spinnaker) and 14 new monitoring wells (see Figures 5-8) as follows:

- Ohio EPA Monitoring Wells, west of Great Miami River – 13 locations (OEPA-1 though OEPA-13)
- City of Troy Monitoring Wells, east and west of Great Miami River – six monitoring wells
- Spinnaker site – five existing monitoring wells (KMW-5, KMW-10, KMW-15, EEIB-4 and PW-4) were sampled in December 2009 as splits during the routine Spinnaker quarterly sampling. Additional splits may be collected in the future. In addition, two deep monitoring wells (see Table 8) will be installed at either end of the Spinnaker site and will be sampled during Phase I of the RI.

- Hobart site - two new shallow monitoring wells and one deep monitoring well will be installed and sampled
- Residential PCE plume and Water Street PCE Plume areas west of Great Miami River – 8 new wells – 4 shallow upper aquifer wells and four deep upper aquifer wells
- Upgradient, west of Great Miami River and west of SR 55/ Market Street – one new shallow upper aquifer well
- New wells east of Great Miami River –one shallow upper aquifer well and one deep lower aquifer well

All data that will be used to support human health risk assessment for exposure to groundwater will be collected from fixed, permanent monitoring wells of known depth and construction. Final well placement will be influenced by screening level data gathered through collection and analysis of groundwater samples at up to 10 of the soil/source area boring locations. Groundwater data gathered during the VAS program will also be screening level data used solely to provide information regarding the appropriate depths at which to screen permanent monitoring wells. These data will generated through analysis by a local laboratory; because the data will not be generated through EPA CRL or the CLP, the data will not be used to support the human health risk assessment.

Phase I groundwater samples from monitoring wells will be used to characterize and evaluate potential human exposure through direct groundwater-related exposure pathways. The location and basis for the Phase I groundwater samples were discussed in Section 4.5. (Note: analytical results associated with historical groundwater samples collected at the site will be used to provide context for interpreting Phase I results.)

### 4.9.3 Surface Water and Sediment Investigation

As discussed in Section 4.6, four surface water samples and four collocated sediment samples will be collected from the Great Miami River adjacent to the site. The surface water and sediment samples will be used to characterize potential human health exposure through surface water-related exposure pathways.

### 4.9.4 Sub-Slab Vapor and Indoor Air Investigation

Sub-slab soil vapor probes will be installed at residences, and also possibly commercial or public buildings, within the area of the groundwater contaminant plumes west of the Great Miami River. At those locations where VOC concentrations in the sub-slab samples exceed screening criteria, additional followup testing consisting of a combination of indoor air sampling and concurrent subs-slab vapor monitoring, may be completed during Phase II to evaluate human health risk.

As previously discussed recent and pending changes in EPA and Ohio EPA guidance will influence the sampling and analytical methodology that will apply to the East Troy RI/FS. In addition, the specific locations for monitoring will be determined, based in part on the results groundwater and soil investigations that will comprise the initial activities during Phase I. Based on these considerations and discussions with EPA and Ohio EPA, SulTRAC will prepare and issue a SAP addendum addressing the specific guidance, screening levels, methodologies and locations for the sub-slab/ indoor air VOC monitoring prior to commencing that portion of the RI. This will allow the initial components of Phase I to commence and generate necessary data for selection of sub-slab and indoor air monitoring locations as guidance is finalized.

# 5.0 FIELD SAMPLING PROCEDURES

This section describes the procedures to be used to collect the types of samples described in Section 4.0. Specifically, this section details the procedures and methods that will be used to collect soil, groundwater, surface water, sediment, and sub-slab vapor monitoring samples. Additional details regarding sample collection, analytical and data management procedures are provided in SulTRAC's project QAPP and Data Management Plan (SulTRAC 2010a; 2009d). Information in this section is based on procedures and methods specified in standard EPA guidance (EPA 1999, 2002, 2004a, b; 2005 and 2006). All SulTRAC field activities will be conducted in accordance with the procedures described in this section of the FSP and SulTRAC SOPs (see SOP attachment). Where the FSP differs from the SOPs, the FSP's site-specific procedures will take precedence.

## 5.1 Soil

The primary purpose of soil sampling is to identify potential contamination source areas, evaluate whether a soil vapor pathway is present, begin delineating the extent of soil contamination at the East Troy site, and attempt to determine if additional contamination source areas are contributing contamination at the East Troy site. The following subsections describe the sampling collection procedures and methods that will be used during the Phase I field investigation.

During the Phase I field investigation, soil samples will be collected from 30 borings in the area west of the Great Miami River. Before drilling begins, public utility clearance to each work site will be conducted. SulTRAC also anticipates hiring a company to survey the sanitary sewer line in the vicinity of Franklin Street via camera or video along the entire length before any intrusive activities begin in this area.

All soil borings will be advanced using direct-push technology (DPT) methods. Soil cores will be collected continuously from the 30 borings in the potential source areas. The borings will be advanced to the top of the uppermost water bearing zone (about 15 to 20 ft bgs). The 30 soil borings shown in Figures 5 and 8 will be located as follows:

- Open lots in the vicinity of Walnut and Main Street – four locations
- Hobart Cabinet – four locations
- Various possible source locations within the plume area – Market, Mulberry, Clay, Crawford and Water Streets – seven locations,
- Vicinity of Clay, Crawford and Franklin Streets – five locations
- Franklin Street between Union and Counts - three locations
- Additional locations along sanitary sewer – up to five locations
- Background/off site (west of State Route 55/Market Street and southwest of Canal Street) – three locations.

These locations may be modified based on (1) initial data gathered during the baseline groundwater sampling event and sewer inspection, (2) the presence of underground or overhead utilities, (3) access agreements, and (4) information obtained from other soil borings advanced during Phase I activities. SulTRAC will attempt to locate borings in public right of ways to the extent possible; however, some borings likely will be located on private property. SulTRAC assumes that EPA will obtain access permission from private property owners when necessary.

The soil borings will be advanced by DPT methods using a Geoprobe, AMS PowerProbe, or similar direct-push rig. Soil cores will be collected using a MacroCore sampler and Lexan sleeves. Soil cores will be continuously collected from the entire vadose zone. The sleeve will be sealed after the entire sample has been removed from the core rod. The sleeve will be marked with permanent marker, indicating the top and bottom of the boring sample. A measuring tape will be placed along the sleeve to measure sample intervals and recovery. The soil will be divided based on sampling intervals for description, screening, and packaging (see SOP 005). Soil sample screening, containerization, and packaging will be conducted as detailed below.

All sample collections and geologic logging will be conducted by personnel wearing non-powdered nitrile gloves. All soil borings will be logged using the SulTRAC geologic logging forms. The following information must be included on the logging form for each soil boring location: site name, project name, boring number, drilling method, boring diameter, depth to water, date started, date completed, geologist's initials, drilling subcontractor name, and location sketch (with adequate information to find boring location if warranted) with a north directional arrow. During drilling, the time of each interval collected, depth (in 4- or 5-foot divisions, depending on the type of MacroCore barrel used), drive interval, recovered interval, and organic vapor measurements will be recorded on the geologic logging form. The lithologic description will also be recorded for every interval and must include color, texture, and lithology, in accordance with

Unified Soil Classification System (USCS) protocol. If non-native fill material is encountered, this information will be clearly specified on the log sheet and the field notebook. If more than one sheet is used, the information must be repeated, and the sheets consecutively numbered. All soil boring sample identifications (see Table 11) will be entered in the appropriate depth interval on the log, and field QC samples will be clearly identified. All soil boring intervals will be photographed with a tape measure for scale. Photographs will be archived.

A minimum of two and up to three soil samples will be collected for laboratory analysis from each soil boring location. Soil samples will be selected from each boring based on field observations. A surface soil sample (0 to 2 ft bgs) will be collected at each soil boring location but submitted for analysis only if it exhibits evidence of contamination, such as odors or staining, PID screening data, or other factors. As most of the study area is paved, few, if any, surficial soil samples are anticipated. For estimating purposes, this FSP assumes that a total of 10 surface soil samples will be analyzed.

Subsurface soil samples will be collected from depth intervals that appear to exhibit the highest contamination based on field observations and PID screening. Soil samples will be observed for visual coloration changes and screened for organic vapors using a PID. If zones of contamination are observed in soil between 2 and 10 feet bgs, a subsurface soil sample from the interval with the highest PID reading will be sent to the laboratory for analysis and a deeper soil sample (from where field screening indicates “clean” soil is present) will also be submitted to the laboratory to further define the vertical extent of contamination. In the event that field screening and observations do not identify potentially impacted soil, SulTRAC will by default collect a subsurface soil sample for analysis from a depth of 6 to 8 feet bgs, as this depth is within the range applicable to evaluating risk to construction workers. When field observations do not indicate evidence of potentially impacted soil, sampling will be biased toward fine-grained material underlying coarser-grained material—if any exists.

Sample depths may be adjusted in the field and additional samples may be added at an individual boring location based on the observations of the field geologist. For example, if the borings are adjacent to the sewer line, the sampled intervals may be adjusted to coincide with the zone just below the elevation of the sewer pipe and another (depending on the boring location) from just above the water table, if visual observations, odors, or PID readings indicate that the area may be a “hot spot” of significant VOC contamination in the vadose zone.

PID soil sample screening and collection of soil samples for VOC analysis will be conducted using methods described in SOP 003 and SOP 005, respectively, modified as follows. Sample collection for VOC analysis will be completed using disposable plastic syringes rather than using Encore samplers, and samples will not be field preserved with methanol, due to the issues and hazards associated with shipment of flammable liquids via overnight air carriers. The syringes will be used to collect at least 5 grams of soil per depth interval and these samples will be extruded by pushing directly into laboratory supplied VOC vials, capped and placed into iced filled coolers immediately. Field screening of VOC will be performed in the following manner:

- After each MacroCore barrel is retrieved and the sleeve is cut open, a soil sample will be prepared using the disposable syringe as described above, beginning with the 0 to 2 foot interval (or from soil immediately below grass or gravel, if present) for laboratory analysis in the event that it is decided to submit the sample. Sample from each 2-foot interval (to a depth of 10 feet bgs) and additional soil from the corresponding intervals will be placed in resealable bags for headspace; drilling will temporarily stop at this depth until headspace measurements have been made as discussed below
- The soil placed in each resealable plastic bag will be tightly sealed, labeled to identify the sample depth, and vigorously shaken
- After a period of approximately 5 minutes for organic vapors to accumulate, the resealable plastic bag will be shaken again. The PID probe will be inserted through a small opening in the plastic bag and the headspace concentration measured by the PID will be recorded on the borelog form or in the field logbook. After screening, the portion of the sample subjected to headspace screening will be placed with the borehole cuttings for disposal
- Based on the field screening results, subsurface samples will be selected for laboratory analysis or the default sample (6 to 8 feet bgs) will be selected as discussed above
- After all headspace measurements have been made (down to the 8- to 10-foot sample) drilling will resume. If evidence of soil impacts is observed at the 8- to 10-foot interval, this procedure will continue until the water table is encountered (estimated average depth of about 15 feet bgs). If the 8 to 10 foot sample does not show evidence of impacts, the boring will be advanced to the water table for visual characterization only.

All soil samples collected for laboratory analysis will be analyzed for VOCs. In addition, about 10 percent of the soil samples (seven of the 70 investigative samples) will also be analyzed for SVOCs, PCBs, pesticides, and TAL metals (including mercury and cyanide). SulTRAC will collect one soil sample for the full list of parameters from each of the six investigation areas shown on Figure 5. Samples for analysis for VOCs will be collected first, placed directly into the appropriate sample container leaving no headspace, followed by sample collections for TAL metals (including mercury and cyanide), SVOCs, PCBs, and pesticides (see SOP 003, SOP 005 and SOP S019).

At least two, and up to three soil samples will be submitted for laboratory analysis from each soil boring location. Soil samples will be selected from each boring based on field observations. Soil samples will be collected from depth intervals that appear to exhibit the highest contamination based on field observations and PID screening. Soil samples will be screened for visual coloration changes and for organic vapors using a PID. Sampling will be biased toward fine-grained material underlying coarser-grained material—if any exists.

Sample depths may be adjusted in the field and additional samples may be added at an individual boring location based on the observations of the field geologist. For example, if the borings are adjacent to the sewer line, the sampled intervals may be adjusted to coincide with the zone just below the elevation of the sewer pipe and another (depending on the boring location) from just above the water table, if visual observations, odors, or PID readings indicate that the area may be a "hot spot" of significant VOC contamination in the vadose zone.

After soil sampling is completed, grab groundwater samples will be collected from just below the water table at up to 10 of the 30 soil boring locations. Grab groundwater data are considered "screening" level data that will be used solely for the purpose of providing better spatial coverage and potentially selecting shallow monitoring well locations. The samples will be analyzed on a 24-hour turnaround basis, thus allowing real-time field decisions. The groundwater sampling locations will be based on soil observations and PID results, proximity to existing monitoring wells and past Ohio EPA groundwater sampling locations, and overall spatial coverage of the investigation area. Each groundwater sample collected will be analyzed for VOCs. Grab groundwater samples will be collected as follows. Once groundwater is encountered, a Geoprobe manufactured groundwater sampling system (such as the SP 15/16 Groundwater Sampler or the DT 21 Profiler) will be used and a groundwater sample will be collected from just below the water table. The exact sampling system to be used will be selected based on discussions with the drilling subcontractor and compatibility with the drilling systems used. A volume of water equivalent to 3 X the volume of water standing in the casing will be purged prior to collection of the sample.

## 5.2 Groundwater

Groundwater samples will be collected from existing and newly installed wells at the East Troy Site. The following subsections describe the procedures to augment the current monitoring well network, as well as sample collection procedures and methods that will be used during the Phase I field investigation.

SulTRAC will conduct hydrogeologic investigations that will include (1) an initial baseline sampling of existing monitoring wells, (2) collection of 10 groundwater grab samples during borehole drilling as discussed above in Section 5.1, (3) a VAS program to evaluate the vertical distribution of VOCs in the uppermost aquifer, (4) installation and development of new monitoring wells, and (5) collection of one round of samples at all monitoring wells (previously existing and new wells) with surface elevation measurements.

Twenty-four existing groundwater monitoring wells (including split samples at the Spinnaker site) located throughout the East Troy site area are anticipated to be sampled in the Phase I groundwater sampling program. These wells are mostly screened in the upper portion of the uppermost aquifer; however, several deeper wells are maintained by the City of Troy in association with its wellhead protection program. The existing wells that will be included are as follows:

- 13 Ohio EPA monitoring wells in the uppermost water bearing zone, all west of the Great Miami River (wells OEPA-1 through 13)
- Three City of Troy monitoring wells (MW-L, MW-M and MW-N) east of the Great Miami River
- Three City of Troy monitoring wells (MW-O, MW-P and MW-Q) west of the Great Miami River
- Five on-site monitoring wells (various depths within the upper aquifer) at the Spinnaker facility.

SulTRAC will install up to an additional 14 monitoring wells at the site. These will include 7 shallow wells and 5 deep wells located west of the river and, one shallow-deep pair east of the Great Miami River - (see Table 8 and Figures 7 and 8) to delineate the extent of groundwater contamination, continue characterization on site, and identify contaminant source areas. In most instances, shallow and deep wells will be paired together or located near existing wells to allow comparison of contaminant and hydraulic gradients. As Phase I progresses, if it becomes apparent that any locations are not necessary, some of the monitoring wells may be installed at alternative locations to investigate sources or lateral extent of contamination; or, to replace existing monitoring wells if needed.

It is anticipated that shallow wells generally will be installed at the top of the water table, screened from approximately 15 to 25 ft bgs, and deeper wells installed near the top of the underlying till layer, approximately 50 to 60 ft bgs, or a maximum depth of 90 feet bgs. However, these depths may be adjusted based on the VAS results and based on location. East of the river, the pair will include one shallow well screened at the top of the uppermost aquifer, approximately 15 to 25 ft bgs and one deep well screened in the lower aquifer at the same approximate elevation horizon as the Troy production wells, approximately 115 to 125 ft bgs. Alterations to actual proposed monitoring well depths and locations may be implemented by the field team leader (FTL) after actual water table depths are measured.

### 5.2.1 VAS and Monitoring Well Installation

Monitoring wells will be installed using rotosonic methods. All soil borings, VAS borings, and borings completed for well installation purposes will be logged using the SulTRAC geologic logging forms, with the exception of any monitoring well location where lithology has already been determined during completion of a boring, lithologic descriptions will not be recorded, unless the depth of the well goes beyond the depth already logged.

The following information must be included on the logging form for each monitoring well boring location: site name, project name, boring number, drilling method, boring diameter, well casing diameter, depth to water, date started, date completed, geologist's initials, drilling subcontractor name, and location sketch (with adequate information to find boring location if warranted) with a north directional arrow. The time of each interval collected, depth (in 2-foot intervals), drive interval, recovered interval, blow count, and organic vapor measurements will be recorded on the geologic logging form during actual drilling. The lithologic description will also be recorded for every interval and must include color, texture, and lithology in accordance with USCS protocol. If more than one sheet is used, the information must be repeated and the sheets consecutively numbered. All monitoring well boring intervals will be photographed with a tape measure for scale. Photographs will be archived.

The SulTRAC monitoring well completion record form will be filled out by the SulTRAC geologist on site for each monitoring well installation. This record includes time and date of installation, drilling company, drilling method, and specifics regarding the bentonite seal, filter pack, monitoring well, casing, well screen, annual seal, and borehole backfill (if appropriate). Samples will be collected continuously for lithologic logging. For both the shallow and deep wells, it is currently anticipated that the constructed well will be 2-inch-diameter PVC with either a 10-foot-long screen (for shallow wells) or 5-foot screen (deep wells) with 0.010-inch slot size. The proposed screen size and materials are appropriate for the anticipated geologic conditions and types and concentrations of contaminants and may be adjusted in the field.

Monitoring wells will be installed in accordance with SOP 020 with slightly different procedures used for shallow and deep wells. Clean filter pack will consist of coarsely graded sand that will be installed by pouring from the surface through a tremie pipe. The sand will be poured slowly, and the level of the sand will be periodically tested with a weighted steel tape to prevent bridging. For shallow wells, the filter pack sand will be placed from the interval 1 foot below to 1 foot above the well screen. A 2-foot-thick seal of bentonite pellets will be installed at the top of the filter pack. Well screens at these locations will be placed to straddle the water table; for this reason the pellets will require hydration with clean potable water. The annular seal space from the top of the bentonite seal to the surface will be filled with a high-solids all-bentonite grout emplaced with a tremie pipe from the top of the bentonite seal to the surface, as the temporary casing is withdrawn. Portland cement/bentonite grouts will not be used. For deep wells (wells with the entire screen and the bentonite seal placed below the water table), filter pack sand will be placed from the interval 1 foot below to 2 feet above the well screen. Another two feet of fine silica sand will be placed above the filter pack sand and the annular seal space from the top of the fine sand to the surface will be filled with a high-solids all-bentonite grout emplaced with a tremie pipe as the temporary casing is withdrawn.

Surface completion will consist of a concrete pad poured around a flush-mount steel vault with locking lid. Wells will be completed with expandable locking caps and secured with a common keyed all-weather lock (see SOP 020). Sufficient spacing (about one to two inches) will be allowed between the top of the well riser and the bottom of the cap to facilitate well sampling efforts. SOP 020 (Figure 2B) shows a schematic diagram of typical flush-mount well completion details. It should be noted that the protective casings will be set in concrete and the concrete pads will be tapered (sloped) away from the lids to promote drainage away from the well. The flush-mount lids will be completed at the same level as the concrete pad so that the lids are not subject to damage from activities such as snow plowing. After wells are installed, all new wells will be surveyed for ground surface elevation, top of casing (TOC) elevation, and horizontal location by a licensed surveyor. All drill cuttings will be containerized, labeled, and staged with other investigation-derived waste (IDW) at the IDW staging location.

During a site visit in August 2009, SulTRAC noted that several existing wells that will be used as sampling locations during the RI are in need of repair and maintenance. The pad on well OEPA-13 needs to be reset or replaced, and several wells need to have the inner locks and flush mount cover bolts replaced to ensure security. These repairs will be completed by the drilling subcontractor during the well installation program.

### *VAS and Upper Aquifer Well Installation – West of Great Miami River*

SulTRAC will conduct VAS of the upper portion of the aquifer system, above the confining layer, which is estimated to be at a depth of approximately 50 to 60 ft bgs where present. Locations are summarized in Table 8. The VAS data will be "screening" level data used to support selection of depths within the upper portion of the aquifer at which permanent monitoring wells will be screened, and to evaluate the need for additional deep wells.

The samples will be analyzed on a 24-hour turnaround basis, thus allowing real-time decisions regarding well screen depths while the rig is in the area, reducing the amount of access and egress from each site, and minimizing disruption to traffic and local residents. If necessary, work in high-traffic areas may be conducted during times of low traffic volume. SulTRAC will coordinate all activities with the City of Troy Engineering and Police Departments.

Due to anticipated spatial constraints associated with working on the right of way a "Mini-Sonic" rig will be used to advance borings. Borings will extend to the top of the confining layer that separates the upper and lower aquifers (if encountered), or a maximum depth of 90 ft bgs if the confining layer is not encountered. Soil core samples will be collected continuously and inspected for geologic characteristics and evidence of contamination, such as odors, staining, or elevated PID readings.

Two methods may be used to collect groundwater samples during the VAS program:. (1) the "push ahead" sampler or (2) isolation of the target zone using a packer. In either case, a sampling pump will be used to obtain the sample from the target zone. Note that the exact sampling system to be used will be selected based on discussions with the drilling subcontractor and compatibility with the drilling systems used. If water is introduced during drilling, three times the amount of water introduced will be purged prior to sample collection. Samples will be hand delivered to a local laboratory for rapid turnaround analysis for VOCs using standard EPA methods. Measurements of field parameters (dissolved oxygen, specific conductance, pH, ORP, turbidity, and temperature) will be obtained at all sample locations prior to collecting the samples for laboratory analysis.

For sampling in the upper portion of the aquifer, a stainless steel "push ahead" sampling device that is advanced ahead of the casing and bit may be used. This device allows collection of discrete samples from the target depth without a packer as it allows for collection of groundwater samples in advance of the casing materials and added water, thus eliminating the need for a packer. The device is advanced ahead of the casing into the undisturbed target zone, retracted slightly to expose a screen. A sample will be obtained using a submersible pump, after purging the desired volume (in this case 3 X the volume of water in the casing from the target interval). However, this technique requires collection of the groundwater sample prior to collection of the geologic core sample. For this reason, at depths below 50 feet, to ensure that the till layer is not inadvertently penetrated before collection of a groundwater sample can occur, an alternative technique will be used. After the core is retrieved from the target depth, a submersible sampling pump will be placed at the target depth (bottom of the casing) and a packer device will be used to isolate that zone. After isolation, the zone will be pumped and a volume of water equivalent to the 3 X the volume within the area below the packer, plus any volume of water added to advance the casing, will be purged. In either case, pH, specific conductivity, turbidity, temperature, DO, and ORP will be measured using a flow through cell. Groundwater sample will be collected from the pump discharge line at as low a flow rate as possible (<100 ml/minute).

Samples will be collected from up to three depth horizons per location at five locations, and up to six depth horizons at the remaining two locations. The length of the zone to be isolated and the number of intervals per boring will be determined in the field based on inspection of the lithologic cores. Three intervals (one at the top of the aquifer, one at approximately 45 feet below ground surface, and a third from directly above the till layer (if present) or the maximum depth of the boring, will be sampled unless visual inspection and PID data indicate other significant variations in lithology or obvious evidence of contamination. Samples will be hand delivered to a local laboratory for rapid turnaround analysis for VOCs.

SulTRAC will install 12 new groundwater monitoring wells in the area west of the Great Miami River. The wells will be installed using the same sonic rig used for the VAS work. Well construction will be completed as previously described. If the VAS data do not indicate any significant vertical gradients with regard to contaminant concentrations, it is anticipated that at each location, one well will be installed in the uppermost part of the upper aquifer (approximately 15 to 25 ft bgs) and one well will be installed directly above the underlying till layer (if present), approximately 50 to 60 ft bgs or at a depth of 90 feet bgs if the till is not encountered (adjusted by location as previously described).

In addition to the VAS/shallow well installation program, groundwater samples will be obtained during the soil boring program that will be conducted to evaluate suspected source areas, as described in Section 5.1. Grab groundwater samples will be collected from just below the water table at up to 10 of the 30 soil boring locations. The groundwater sampling locations will be based on soil observations and PID results, proximity to existing monitoring wells and past Ohio EPA groundwater sampling locations, and overall spatial coverage of the investigation area. Each groundwater sample collected will be analyzed for VOCs. Geoprobe manufactured groundwater sampling systems (such as the SP 15/16 Groundwater Sampler or the DT 21 Profiler) will be used to isolate target depths and a groundwater sample will be collected from that depth. The exact sampling system to be used will be selected based on discussions with the drilling subcontractor and compatibility with the drilling systems used. Groundwater samples will be collected by using the direct-push rig to advance the screen point beyond the last soil sample depth. Once the screen point is in place, each groundwater sample collected will be retrieved using a mini bladder pump capable of fitting inside the sampling system. If no water is added during drilling, groundwater samples will be collected once stabilization of indicator parameters had been achieved in accordance with SOP 015. However, if water is introduced during drilling, three times the amount of water introduced will be purged prior to taking field measurements of indicator parameters. Sample collection will occur after stabilization of indicator parameters has been achieved as indicated above.

***Additional Source Investigation Wells – East Side of Great Miami River***

Additional groundwater data are needed to confirm that the contamination detected in the East Wellfield is originating solely from locations west of the Great Miami River. East of the Great Miami River, two additional monitoring wells will be installed in a “cluster” with one well screened in the upper portion of the aquifer and one well screened in the lower portion of the aquifer to monitor the same elevation horizon zone as Troy wells. The primary objective of these wells is to focus the RI by evaluating the possibility of sources east of the river. If contamination is detected in the new monitoring wells east of the river, Phase II of the RI may include expansion of the source area investigation to include potential sources east of the river and/or additional sources located in the vicinity of the West Wellfield.

The well cluster will be located to the north of Well 14, between the wellfield, and the Troy Water plant and commercial activities located farther north. The shallow well is anticipated to be approximately 15 to 25 feet deep, and the deep well anticipated to be approximately 115 to 125 feet deep. The wells will be installed using Rotosonic drilling techniques, with collection and inspection of continuous soil cores for geology and field screening with a PID. The wells will be completed as previously described. If observations of the upper aquifer materials in the upper aquifer indicate the presence of significant contamination (odors, staining, or elevated PID readings), consideration will be given to casing off the upper portion of the aquifer with permanent casing before drilling to the lower aquifer.

### 5.2.2 Well Development

The newly installed wells will be developed. The objective of well development is to produce water that is clear and visually free of suspended sediment and yields representative samples of groundwater from the well. Groundwater well development will consist of surging and pumping to remove fine sediments as specified in SulTAC SOP 21 modified for consistency with Ohio EPA's "Technical Guidance for Hydrogeological Investigations and Groundwater Monitoring - TGM-08" (Ohio EPA 2009a). Based on criteria in TGM-08 and SOP 021 (Section 2.3) development will proceed until the following criteria are met:

- Water can enter as readily as hydraulic conditions allow.
- A representative sample can be collected. In general, representative conditions can be assumed when the water is visually clear of sediments.
- As stated in Ohio EPA TGM-08, the goals for well development will be a final turbidity less than 10 NTU, field parameters stable over three consecutive well volumes of pH of 0.2 SUs; 20 mv for ORP; +/- 0.5 degrees C for temperature; 10 percent or +/- 0.2 mg/L for DO, whichever is greater; and, 3 percent for specific conductance.

Typically, turbidity is the last indicator parameter to stabilize during well development. In some instances, collection of a sample with a turbidity of 10 NTU is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met:

- Several procedures have been tried,
- Proper well construction has been verified
- Turbidity has stabilized within 10% over three successive well volumes, and conductivity, and pH have stabilized over at least three successive well volumes. (It should be noted that pH, temperature, and conductivity may not stabilize if water quality has been degraded).
- The sediment thickness remaining in the well is less than 1 percent of the screen length or less than 0.1 feet for screens equal to or less than 10 feet.
- A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus (i.e. filter pack), assuming 30 percent annular porosity) should be removed. In addition to the "three times standing water volume" criteria, further volumetric removal should be considered if fluids were utilized during well drilling and installation.

Development will proceed by use of a well development rig capable of bailing, purging, and pumping groundwater (see SOP 021). All purge water will be containerized, labeled, and staged with other IDW at the IDW staging location. If feasible, purge water will be contained in poly tanks and disposed of at the Troy Municipal Publicly Owned Treatment Works (POTW).

### 5.2.3 Groundwater Monitoring

A baseline sampling of the 19 existing wells will be completed at the start of the Phase I field activities to provide data that will be used to confirm and optimize the proposed sampling locations. Following installation of the new wells, one comprehensive round of groundwater samples will be collected from all existing and newly installed groundwater monitoring wells for the Phase I investigation. During each sampling event during Phase I of the RI, a subset of the groundwater samples (5 samples during the baseline and 4 samples from the comprehensive sampling) will be submitted to the designated EPA CLP laboratory for analyses by EPA Methods CLP SOW SOM01.2 for VOCs, SVOCs, PCBs, and pesticides; and CLP SOW ILM05.4 for total metals and filtered metals (including cyanide and mercury). The criteria that will be used to select these locations will include:

- Proximity to suspected source areas or source areas discovered through the baseline sampling, soil sampling, sewer investigation or VAS
- Well locations in areas where the highest concentrations of VOCs were detected in groundwater samples during past investigations or during the baseline event and VAS program
- At least one “background” location.

The remaining samples will be analyzed for VOCs only. All sampling criteria and sample identifications are listed in Tables 6, 9, 10, and 11. EPA may elect to modify (increase or decrease) the proposed numbers and locations for analysis of additional parameters at any point during the RI as the RI progresses and data from each activity become available. In addition, after the comprehensive sampling event, analytical data will be evaluated, and a brief summary technical memorandum will be submitted to EPA outlining the chemicals of interest for each well. The need to monitor for any other parameters than VOCs during future monitoring events (Phase II) will be determined based on the Phase I data. Based on the chemicals of interest, specific analyte groups will be selected and agreed upon by SulTRAC and EPA for future investigations and sampling events.

Low-flow techniques will be used to obtain groundwater samples from all monitoring wells (see SOP 015). Low flow, also known as micropurging, provides a method of minimizing increased colloid mobilization by removing water from the well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. It is currently anticipated that either a Grundfos submersible pump or Geoprobe portable mechanical bladder pump will be used, depending on the well diameter (some of the existing wells at the site are 1-inch diameter wells). As previously discussed, the small bore and/or condition of some of the wells may necessitate contingent sampling techniques. If such conditions are encountered, sampling of that location will only proceed upon authorization from EPA. The pump will be staged in the saturated portion of the formation, approximately 2 to 3 feet above the bottom of the well screen. Readings of field parameters will be collected at 5-minute intervals. The well water will be considered stabilized after three successive measurements of field parameters at 5-minute intervals fall within the following ranges: ±0.1 for pH, ±0.5 degrees Celsius (°C) for temperature, ±3% for conductivity, ±10 millivolts for ORP, and ±10% for turbidity and dissolved oxygen (see SOP 015). During low-flow sampling, field parameters will be measured using a flow-through cell as described in SOP 061.

The following information will be recorded in the field logbook at each groundwater sampling location: date and time, barometric conditions, temperature and general weather conditions, depth to water measured from the surveyed top of the well casing, and depth to bottom of well measured from the surveyed top of the well casing (see SOP 014) . It should be noted that well depth measurements will be made the first time a particular well is to be sampled (but not sooner than 24 hours before sample collection) and then again on an annual basis if periodic groundwater monitoring is performed. The monitoring well will be opened a sufficient time before taking water level measurements to allow for groundwater in the wells to equilibrate with atmospheric pressure. A complete round of water level measurements (including surface water measurements from staff gauges) will be conducted in as short of a timeframe as feasible to capture a single “snapshot” of water level elevations. Water levels will be measured from a clearly marked reference point on the casing or from the north side of each well if a reference point does not exist.

Sampling will employ the same equipment used for purging. All field measurements will be documented in the field logbook. At each location, groundwater samples will be collected for analysis for VOCs first, followed by sample collection for analyses for metals (including mercury and cyanide), SVOCs, PCBs, and pesticides. Groundwater samples to be collected for dissolved metals analysis will be collected by placing a 0.45 micron in-line disposable filter between the discharge point and the sample container prior to sample collection. Samples will be directly poured into appropriate (glass or high-density polyethylene) containers (see Table 10). Samples will be immediately placed in an iced cooler and maintained at a temperature of 4 ± 2°C without freezing until delivered to the laboratory under standard chain-of-custody (COC) protocol.

## 5.3 Surface Water and Sediment Sampling

Four surface water samples will be collected at the East Troy site. Surface water samples will be collected in accordance with SulTRAC SOP 009. Samples will be collected during base flow conditions, to the extent possible. The Great Miami River in the area is very shallow at most times during the year; specifically, during periods when the stream will be easily accessible for sampling. The river is also prone to rapid flow, and there are dams and other features in the area that make it unsuitable for boats. Before sampling, a YSI water quality meter will be submerged in the river to obtain in-stream water quality parameter measurements of DO, temperature, pH, and specific conductance at the target depth (see SOP 061). After water quality parameters are measured, surface water samples will be collected from the lower third of the water column where possible by directly immersing a hand-held sample container to the desired sampling depth. Once the container is at the desired depth it will then be uncapped and allowed to fill. Samples will be collected by submersing the appropriate (glass or high-density polyethylene) containers (see Table 10) into the river to allow the container to fill slowly. A clean disposable "transfer" bottle will be used to collect surface water and transfer it to the appropriate sample container only in instances where pre-preserved bottles are used (see SOP 009, Section 2.2). The transfer bottles will be sealed with the laboratory-provided lids. The bottles will be immersed to the desired sample collection depth, and then uncapped and allowed to fill. Water in the transfer bottle will then be poured into the appropriate pre-preserved container. Sampling procedures may be impacted by the volume and flow of water, safety concerns and other factors and it may be necessary to use alternative procedures, such as an extending arm dipping device (see SOP 009, Section 2.3). If an extending arm device is used, limitations of this method would require surface water samples to be collected at the river's surface rather than the lower third of the water column .

Immediately following surface water sample collection, collocated sediment samples will be collected at each surface water sampling location. Collocated surface water and sediment samples will be collected at the furthest downstream location first working back in the upstream direction. Sediment samples will be collected when the water levels are as low as possible to allow access to sediments within the stream bed. It is anticipated that sediment samples will be collected using a stainless steel scoop attached to a telescoping arm, from areas of shallow water near the stream banks. Efforts will be made to obtain sediment samples from low-energy depositional areas (if present) and fine-grained sediment will be preferentially collected, where possible. Field notes including a description of the sediment collected will be documented in the field logbook. Sediment will be containerized in the appropriate containers (see soil containers in Table 10) and all samples will be immediately placed in an iced cooler and maintained at a temperature of 4 ± 2°C without freezing until delivered to the laboratory under standard COC protocol.

All field measurements will be documented in the field logbook. Samples will be immediately placed in an iced cooler and maintained at a temperature of 4 ± 2°C without freezing until delivered to the laboratory under standard COC protocol.

All samples will be submitted to the designated EPA CLP laboratory for analysis. The background (farthest upstream) surface water and sediment samples, and the surface water and sediment samples collected adjacent to the north end of the East Wellfield and the area of highest known groundwater contaminant concentrations will be analyzed for full TCL and TAL parameters. The samples from the remaining two locations will be analyzed for VOCs only. A hand-held GIS device will be used to record the location of each sampling site an each site will be photographed to ensure that it may be relocated if necessary.

## 5.4 Sub-Slab Vapor and Indoor Air Sampling

Sub-slab vapor, and possibly indoor air samples will be collected within the area of the shallow groundwater contaminant plumes. The sub-slab vapor sampling locations will be selected based on the results of the soil and groundwater investigations and will be conducted in the latter part of the Phase I field effort. Sub-slab monitoring will be performed at 1) select locations considered to be at or near potential source areas (such as the former Troy One Hour Martinizing facility); 2) locations not addressed in the EPA Time Critical Removal assessment; and, 3) select locations where vapor abatement systems were installed. The locations will also be determined in part by the willingness of the property owner to allow the monitoring.

Once the general areas of interest are determined, SulTRAC will work with EPA to contact specific individual property owners and request permission to conduct the monitoring activities. The soil gas sample analysis will include the full list of analytes listed in EPA Method TO-15 (EPA 1999).

The specific locations and methods for monitoring will be determined, based in part, on the results groundwater and soil investigations that will comprise the initial activities during Phase I. Based on these considerations and discussions with EPA and Ohio EPA, SulTRAC will prepare and issue a SAP addendum addressing the specific guidance, methodologies and locations for the sub-slab/ indoor air

VOC monitoring prior to commencing that portion of the RI. This will allow the initial components of Phase I to commence and generate necessary data for selection of sub-slab and indoor air monitoring locations as guidance is finalized. Based on these considerations, the specific sub-slab vapor and indoor air monitoring procedures and screening criteria will be addressed in the SAP addendum and are not included in this FSP.

Those locations at which sub-slab vapor concentrations exceed screening criteria will be considered for follow-up sampling to evaluate indoor air. It is anticipated that any such sampling would occur during Phase II of the RI. The sampling regimen would include resampling for sub-slab vapor at the same time indoor air samples are collected, to ensure that VOCs detected in the indoor air space correlate to migration of vapor through the subsurface. Procedures for any such sampling will be presented in the SAP modifications that will be completed prior to Phase II.

## 5.5 Ecology and Biology

As part of the initial phase of the site investigation, no specific field sampling procedures associated with characterizing potential ecological exposures in the various habitats at the East Troy site are required. As noted earlier, the initial ecological evaluation will focus on determining the presence of ecological habitat, the presence or absence of soil, surface water, sediment, or groundwater contamination at the site, and the maximum concentrations of the contaminants consistent with EPA's guidance for conducting a SLERA (EPA 1992). As noted in Section 4.8, the SLERA will use soil, surface water, and groundwater data to assess the potential risks to ecological receptors. The procedures to collect these data have been described in previous sections.

# 6.0 LABORATORY ANALYTICAL METHODS

Table 9 presents the laboratory methods that will be used to analyze the samples collected by SulTRAC. Field investigation samples will be analyzed by the CLP laboratory and the CRL.

**TABLE 9**
**ANALYTICAL METHODS SUMMARY**

| Parameter | Analytical Method |
|---|---|
| **SOIL AND SEDIMENT** | |
| VOCs | CLP SOW SOM01.2 |
| SVOCs | CLP SOW SOM01.2 |
| PCBs | CLP SOW SOM01.2 |
| Pesticides | CLP SOW SOM01.2 |
| TAL metals (including mercury and cyanide) | CLP SOW ILM05.4 |
| **SURFACE WATER** | |
| VOCs | CLP SOW SOM01.2 |
| SVOCs | CLP SOW SOM01.2 |
| PCBs | CLP SOW SOM01.2 |
| Pesticides | CLP SOW SOM01.2 |
| Unfiltered TAL metals (except cyanide) | CLP SOW ILM05.4 |
| Cyanide | CLP SOW ILM05.4 |
| **SOIL GAS** | |
| VOCs | CRL -- TO-15 |
| **GROUNDWATER – VAS AND SOIL BORINGS** | |
| VOCs | EPA 8260 |
| **GROUNDWATER – MONITORING WELLS** | |
| VOCs | CLP SOW SOM01.2 |
| SVOCs | CLP SOW SOM01.2 |
| PCBs | CLP SOW SOM01.2 |
| Pesticides | CLP SOW SOM01.2 |
| Filtered TAL metals (except cyanide) | CLP SOW ILM05.4 |
| Unfiltered TAL metals (except cyanide) | CLP SOW ILM05.4 |
| Cyanide | CLP SOW ILM05.4 |

Notes:

| | |
|---|---|
| CLP | Contract Laboratory Program |
| CRL | Central Regional Laboratory |
| PCB | Polychlorinated biphenyl |
| SVOC | Semivolatile organic compound |
| SOW | Statement of work |
| VOC | Volatile organic compound |
| TAL | Target Analyte List |
| EPA | U.S. Environmental Protection Agency |
| VAS | Vertical Aquifer Sampling – screening level samples to be analyzed by local laboratory using rapid turnaround. |

# 7.0 DECONTAMINATION PROCEDURES

During sampling, SulTRAC will follow decontamination procedures for (1) soil and groundwater sampling and (2) surface water and sediment sampling as outlined below. It is anticipated that potable water to be used for decontaminating equipment will be obtained from the City of Troy municipal well system. Before fieldwork begins, and periodically during field work (once per month), samples will be collected and analyzed for VOCs to ensure that decontamination water is free of VOCs.

## 7.1 Decontamination of Soil and Groundwater Sampling Equipment

All downhole drilling rods and casing for advancement of soil borings and installation of monitoring wells will be decontaminated before work begins and between sampling locations. The equipment will be decontaminated following the general practices in SOP 002. As specified in SOP 002, a portable steam cleaner or pressure washer and an on-site source of potable water will be used for decontamination. All water derived from decontamination will be collected and temporarily stored in Department of Transportation (DOT)-approved, 55-gallon drums or polyethylene tanks on site for characterization.

Downhole equipment used for soil and VAS or grab groundwater sampling will be steam cleaned before work begins and between sampling locations in accordance with Section 2.3 of SOP 002. It should be noted that soil cores will be collected using a MacroCore sampler and disposable Lexan or acetate sleeves; therefore, the MacroCore barrel will not be in direct contact with soil samples and pressure spraying or hand washing may be substituted for steam cleaning. VAS and grab groundwater samples will be collected using Geoprobe manufactured groundwater sampling systems (such as the SP 15/16 Groundwater Sampler or the DT 21 Profiler). The VAS groundwater sampling system will be steam cleaned between sampling locations to prevent cross contamination and decontaminated as described below between samples. Exact decontamination procedures for the push ahead and packer assemblies for the VAS program will be contractor specific but will include cleaning with an alconox-tap water solution followed by a distilled water rinse, Dedicated disposable equipment, such as tubing for groundwater sampling will be used whenever possible to minimize the need for decontamination. All water derived from decontamination will be collected and temporarily stored in DOT-approved, 55-gallon drums or polyethylene tanks on site for characterization.

To prevent cross contamination, measuring and sampling equipment will be decontaminated before sample collection begins and between each two consecutive sampling locations. If stainless steel bowls and spoons will be used, they will be used for one discrete sample and will then require decontamination. Per the "general sampling equipment decontamination" guidelines established in Section 2.5 of SOP 002, stainless steel sampling equipment will be decontaminated using a three tier process including an Alconox or Liquinox wash, a potable water rinse, and a distilled water rinse. SulTRAC does not anticipate the need to use chemical solvents when decontaminating this type of equipment; however, if field conditions indicate that gross contamination is present, solvents may be used as described in SOP 002. All water derived from decontamination will be collected and temporarily stored in DOT-approved, 55-gallon drums or polyethylene tanks on site for characterization. In lieu of stainless steel sampling equipment, disposable sampling equipment may be used to collect individual samples and to minimize the need to decontaminate equipment and generate decontamination water.

Pumps used for low-flow groundwater sampling techniques will be decontaminated by successive washes in, and circulating through, a three tier decontamination process as described in Section 2.6.2 of SOP 002. This process will consist of three 5-gallon buckets containing solutions of (1) Alconox or Liquinox detergent/potable water, (2) potable water, and (3) distilled water, respectively. The pump will be placed in the first bucket and water will be pumped until the detergent/potable water solution is drawn down to the maximum extent possible (approximately 2-3 gallons). Next the pump will be place in the second bucket and potable water will be pumped through until the discharge water appears "visually clear" of detergent. Finally, the pump will be placed in the third bucket (distilled water) and at least 1 gallon will be circulated through the pump. All water derived from decontamination will be collected and temporarily stored in DOT-approved, 55-gallon drums or polyethylene tanks on site for characterization and subsequent disposal.

## 7.2 Decontamination of Surface Water and Sediment Sampling Equipment

SulTRAC will use collect surface water samples by directly submerging the sample container or using disposable transfer bottles when sample containers are pre-preserved. Therefore, decontamination of sampling equipment will not be required except for water quality measurement probes. Water quality meter probes will be decontaminated by wiping or washing the probes and cable (that contact surface water) following the procedures discussed in Section 2.4 of SOP 002.

Non-disposable sediment sampling equipment (scoops, extension arms, etc.) that come into contact with surface water and sediment will be washed following general sampling equipment decontamination procedures described in Section 2.5 of SOP 002. Specifically, per the guidelines established in SOP 002, stainless steel sampling equipment will be decontaminated using a three tier process including an Alconox or Liquinox wash, a potable water rinse, and a distilled water rinse. SulTRAC does not anticipate the need to use chemical solvents when decontaminating this type of equipment; however, if field conditions indicate that gross contamination is present, solvents may be used as described in SOP 002.

SulTRAC will coordinate with the City of Troy Engineer, Water Department, and Sewer Department regarding staging of activities, locations for securing and managing IDW, and decontamination activities. If amenable to the City of Troy and if analytical data do not indicate the presence of significant contamination, water generated from well purging and development may be disposed of at the local POTW, contingent on approval by EPA and Ohio EPA.

# 8.0 SAMPLE HANDLING PROCEDURES

SulTRAC will collect soil, soil gas, groundwater, and surface water samples; prepare the samples for shipment; complete all necessary documentation; and decontaminate non-disposable equipment. Sample containers, preservatives, holding times, identification, documentation, COC, packaging, and shipping are discussed in this section. The SulTRAC QAPP and Data Management Plans (SulTRAC 2010a and 2009d) provide detailed information regarding sample and data management procedures that will be followed during the conduct of the RI.

## 8.1 Sample Container, Preservation, and Holding Times

SulTRAC anticipates collecting soil, soil gas, groundwater, and surface water samples. Sample handling procedures are different for each type of chemical group, analysis, and matrix type. These details are summarized in Table 10.

## 8.2 Sample Identification

Samples will be identified by a unique sample identification number (see Table 11). The identifier will be composed of the following information:

- Matrix
- Sample location (for example, monitoring well identification number, MW-14)
- Area designation
- Sample date
- Sample type (field, field duplicate, or QA/QC).

Except for screening level samples obtained during the VAS and soil boring programs, each sample will also be assigned an identifying number by CLP Forms-II Lite software. Forms-II Lite was developed to expedite sample documentation, track samples from the field to the laboratory, and reduce the most common documentation issues associated with sampling. The user will enter information on the site, project, sampling team, analysis, location, matrix, collection time and date, and sample and tag numbers before or during the sample event. SulTRAC will identify specific sample names after the start of the field campaign, but before intrusive field activities begin, because preliminary activities to be completed before the sampling event may alter sample locations.

# TABLE 10
# SAMPLE CONTAINER, PRESERVATION, AND HOLDING TIMES

| Matrix | Analyte | Sample Container | Preservation Requirements | Maximum Holding Time (preparation/ analysis)[1] |
|---|---|---|---|---|
| Soil | VOCs | Three 40-mL glass containers with PTFE-lined septa and open-top screw caps, pre-weighted and containing magnetic stir bars, and one 2 ounce container of sample filled with no headspace for determination of moisture content. | Iced<br>4 ºC ± 2 ºC | 48 hours to preservation at laboratory/<br>14 days for analysis following preservation |
| Soil | SVOCs | Two 4- or one 8-ounce wide-mouth glass jars | Cool to 4±2°C immediately after collection | 14 days/40 days |
| Soil | PCBs | Two 4- or one 8-ounce wide-mouth glass jars | Cool to 4 ±2°C immediately after collection | 14 days/30 days |
| Soil | Pesticides | Two 4- or one 8-ounce wide-mouth glass jars | Cool to 4±2°C;<br>keep away from light | 14 days/30 days |
| Soil | Metals (including Hg, CN) | Two 4- or one 8-ounce wide-mouth glass jars | Cool to 4°C ± 2°C immediately after collection | NA/6 months (Metals & Hg)<br>14 days/14 days (CN) |
| Water | VOCs | Three 40-mL glass vials with PTFE-lined septa and open-top screw caps | No headspace;<br>cool to 4±2°C;<br>adjust pH to less than 2 with HCl | 7 days/14 days |
| Water | SVOCs | Two 1-liter amber glass bottles fitted with PTFE-lined screw caps | Cool to 4±2°C immediately after collection | 7 days/40 days |
| Water | PCBs | Two 1-liter amber glass bottles, fitted with PTFE-lined screw caps | Cool to 4±2°C immediately after collection | 7 days/40 days |
| Water | Pesticides | Two 1-liter amber glass bottles, fitted with PTFE-lined screw caps | Cool to 4±2°C immediately after collection | 7 days/40 days |
| Water | Total TAL metals (including mercury) | One 1-liter HDPE bottle with polyethylene-lined caps<br>Particulate metals sample: no filter needed | $HNO_3$ to pH < 2 and cool to 4 ˚C (±2 ˚C) immediately after collection | NA |
| Water | Cyanide | One 1-liter HDPE bottle with polyethylene-lined caps | NaOH to pH>12 and cool to 4±2°C immediately after collection | NA/14 days |
| Sub-Slab Vapor/ Soil Gas | VOCs | To be determined - details will be provided in SAP addendum. | - To be determined | To be determined |

## TABLE 10 (CONTINUED)
## SAMPLE CONTAINER, PRESERVATION, AND HOLDING TIMES

Notes:

| | |
|---|---|
| µm | Micrometer |
| °C | Degrees Celsius |
| CLP | Contract Laboratory Program |
| CRL | Central Regional Laboratory (EPA Region 5) |
| CN | Cyanide |
| HCL | Hydrochloric acid |
| HDPE | High-density polyethylene |
| Hg | Mercury |
| $HNO_3$ | Nitric acid |
| MCE | Mixed cellulose ester |
| mL | Milliliter |
| mm | Millimeter |
| NA | Not applicable |
| NaOH | Sodium hydroxide |
| NR | Not required |
| PCB | Polychlorinated biphenyl |
| PTFE | Polytetrafluoroethene |
| SVOC | Semivolatile organic compound |
| TBD | To be determined |
| TCLP | Toxicity characteristic leaching procedure |
| VOC | Volatile organic compound |

[1] Holding time is measured from time of sample collection to the time of sample extraction and analysis (EPA 2004).

# TABLE 11
# GENERALIZED SAMPLE IDENTIFICATION SCHEME

| Matrix | | Location Number | Address or Nearest Street/Location Designation | Depth in Feet | Date | Example Identification | Notes |
|---|---|---|---|---|---|---|---|
| Soil Boring – soil | SB | 013<br>(3 digits) | Example:<br>856 Franklin – 856-FRA<br>etc. | 10 | October 2010 = 1010 | SB013-FRA-10-1010 | All sample locations will have new sample ID, in numerical order. The depth listed is the bottom of the sample interval. |
| Soil Boring – groundwater | BW | 013<br>(3 digits) | Example:<br>856 Franklin – 856-FRA<br>etc. | 20 | October 2010 = 1010 | BW013-FRA-20-1010 | All sample locations will have new sample ID, in numerical order. The depth listed is the bottom of the sample interval. |
| Sub-Slab Vapor | SSV | 003<br>(3 digits) | 856-FRA | NA | November 2010 = 1110 | SSV-003-856-FRA-1110 | All sample locations will have new sample ID, in numerical order. |
| Surface Water | SW | 001<br>(3 digits) | GMR-Great Miami River | NA | October 2010 = 1010 | SW001-GMR-1010 | All sample locations will have new sample ID, in numerical order. |
| Sediment | SD | 001<br>(3 digits) | GMR-Great Miami River | NA | October 2010 = 1010 | SD001-GMR-1010 | All sample locations will have new sample ID, in numerical order |
| Groundwater | MW- | 14<br>(no digit requirement) | OEPA, TROY, SP (Spinnaker) or EPA | S = Shallow<br>D = Deep<br>(if applicable) | October 2010 = 1010 | MW-OEPA-6S-1010<br>MW-EPA-1D-1010<br>etc. | Same sample locations will have same sample location number with different designation and date in sample ID |
| | VAS | 001 | NA | 50 | October 2010 = 1010 | VAS-001-1010 | All sample locations will have new sample ID, in numerical order. |

**Notes:**

| | | | |
|---|---|---|---|
| BW | Soil boring - groundwater | SB | Soil Boring |
| SD | Sediment | SSV | Sub-slab vapor |
| ID | Identification | MW | Monitoring well |
| NA | Not applicable | SW | Surface water |
| VAS | Vertical aquifer sampling | | |

Groundwater samples collected during VAS and soil boring programs will be screening level samples analyzed by a subcontracted laboratory; standard EPA methods will be used and data packages will be prepared in accordance with the requirements specified in the QAPP. These samples will be identified using the nomenclature described in Table 11. However, because these samples will not be analyzed through EPA CRL or the CLP, the CLP Forms-II Lite requirements will not apply to these samples.

## 8.3 Sample Labels

Forms-II Lite generates labels for each sample. A sample label will be affixed to all sample containers. The label will be completed with the following information:

- Project number
- CLP case number
- CLP sample number
- Sample station name (the sample identity [ID] discussed above)
- Sample collection date and time
- Preservative
- Sample collector's initials
- Analysis
- Sample tag number.

After labeling, if required, each sample will be preserved as required (see Table 11).

Groundwater samples collected during the VAS and soil boring programs will be screening level samples analyzed by a subcontracted laboratory. These samples will be identified using the nomenclature described in Table 11. However, because these samples will not be analyzed through EPA CRL or the CLP, the CLP Forms-II Lite requirements will not apply to these samples. For these samples the label will be completed with the following information:

- Project number
- Sample collection date and time
- Preservative
- Sample collector's initials
- Analysis.

After labeling, if required, each sample will be will be preserved as required (see Table 10).

### 8.4 Sample Documentation

Sampling will be documented in a logbook using indelible ink. The header of each page will include the site location name, date, and project number. At the start of each day, the weather, site condition, field staff present, subcontractors present, and any conducted safety meeting or other, shall be noted. The collection time, sample identification number (not CLP ID), sample depth (if appropriate), sample location description, field observations, sampler's name, and time of sample collection will be recorded on field data sheets for each and every sample. Every MS/MSD and duplicate should be clearly designated in the field data sheet. Collection of rinsate samples and preparation of trip blanks will be documented with applicable parameters in the same manner as described above. The sample identification, location, and time will be recorded in the field log book.

Each page of the logbook will be dated, numbered (if appropriate), and signed at the bottom by SulTRAC personnel. Any residual space on the last page of each day's log book will be crossed out with a single line. Each new sampling day will begin on a new page in the log book. Any corrections made during the same day of sampling should be crossed out with one single line, or the term "backnote" can be inserted to account for missed time.

The field team leader ensures that all documentation in the logbook is done appropriately and accordingly, and should check it daily. Any corrections or additions can be made on a subsequent page with appropriate documentation, although this procedure is not recommended, and corrections or additions are at best made on the same day as sampling.

All field logbooks must be kept secure at all times by the field team leader while conducting field work. As possible, all field log books shall be scanned electronically at high resolution, minimum 300 by 300 DPI. If electronic scans cannot be conducted after 1 week of continuous field work, high-resolution hardcopies must be made and kept secure until the logbooks can be scanned. All completed field books and any hardcopies will be stored with the project manager. Field data records will be maintained in accordance with Multi-Media Investigation Manual and Procedures (EPA 1992) and SulTRAC's FSP.

## 8.5 Sample Chain of Custody

SulTRAC will use standard sample custody procedures to maintain and document sample integrity during collection, transportation, storage, and analysis in accordance with the SulTRAC RAC II Contract Level QAPP. A sample will be considered in custody if one of the following statements applies:

- It is in a person's physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

Forms-II Lite generates and prints COC forms, called traffic reports, in Forms II Lite (a laboratory copy and a region copy). The laboratory copy will be sealed inside the lid of the cooler. COC procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. One COC record will be generated for each cooler shipped. The COC record also will be used to document all samples collected and the analysis requested. The following information will be documented on the COC form:

- Project name and number (region copy only)
- CLP case number
- CLP sample numbers
- Sample tag numbers
- Sampling location (station identification)
- Name and signature of sampler
- Destination of samples (laboratory name)
- Sample ID number
- Date and time of collection
- Number and type of containers filled
- Analysis requested
- Preservatives used (if applicable)
- Sample designation (grab or composite)
- Special instructions (e.g., laboratory needs to sub-sample oversized material or perform additional homogenization)
- Signatures of all samplers
- Signatures of individuals involved in custody transfer, including the date and time of transfer
- Airbill number (if applicable)
- Project contact and phone number
- Custody seal number.

Groundwater samples collected during the VAS and soil boring programs will be screening level samples analyzed by a subcontracted local laboratory. These samples will not be analyzed through EPA CRL or the CLP, and therefore the CLP Forms-II Lite requirements will not apply to these samples. For these samples, SulTRAC will use laboratory-provided COC forms that require the same level of information as the EPA Forms-II Lite-generated COC forms, with the exception of the CLP-specific information (CLP case number, CLP sample numbers, and sample tag numbers.

SulTRAC will follow the procedures in the EPA Region 5 CRL "Superfund Amendments and Reauthorization Act (SARA)/Superfund Sample Handling Manual" (EPA 1989) to complete the documentation listed above.

SulTRAC will appoint one of its field technical staff members to serve as the sample custodian. When all required documents have been completed, the sample custodian will sign and date the document and list the time of the sample collection. The custodian will also confirm that all descriptive information is complete on the COC forms, which will be included with each shipping container. Two custody seals will be used: one custody seal will be placed across the latch of the container, and the other affixed on the opposite side of the container lid. The lid will be securely taped shut for shipment. The field sample custodian will send the original copies of the COC region copy to the project manager, who in turn will submit these forms to the Region 5 Sample Management Office (SMO), care of Warren Layne, within 5 working days. The sample custodian will also retain and scan all copies of all COCs (laboratory and region) for the project files.

## 8.6 Sample Packing and Shipping

The following procedures will be implemented when samples collected during this project are shipped:

- All samples jars will be individually wrapped with bubble wrap or other packing material and placed in their own individual Ziploc-type bags. The CLP ID tag for each sample will accompany the sample package.
- Ice will be double bagged in large Ziploc-type bags and placed at the bottom of the cooler. If the cooler has a drain, it will be taped shut both inside and outside of the cooler.
- The cooler will be lined with bubble wrap or other packing material, and all individually packaged samples will be placed into one large plastic bag and tied after all sample jars have been input. Sufficient packing material will be used to prevent sample containers from breaking during shipment.
- Additional ice, double bagged, will be added on top of the tied plastic bag full of samples. Enough ice will be added to maintain a sample temperature of 4 ± 2°C. SulTRAC will prepare, label, and place a temperature blank in each cooler.
- The laboratory should be notified if a sampler suspects that any sample contains anomalously high or low concentrations (handwrite this anomaly directly on the laboratory copy of the COC), or if there may be a sampled substance that would require laboratory personnel to take safety precautions.

- The COC specific to each cooler will be sealed inside a plastic bag and taped to the inside of the cooler lid. Ensure that the COC is signed by all samplers and the custody seal numbers are included on the COC. Include with the COC a return pre-paid air bill so the cooler may be returned to SulTRAC.
- The cooler will be closed and taped shut with strapping tape around both ends.
- Signed and dated custody seals will be placed on the front and side of each cooler. Wide clear tape will be placed over the seals to prevent accidental tearing.
- The air bill, if required, will be completed before the samples are relinquished to the carrier.
- The COC will be transported within the taped sealed cooler. When the cooler is received at the analytical laboratory, laboratory personnel will open the cooler and sign the COCs to document transfer of samples.
- The Superfund SMO will be notified if the laboratory should expect to receive samples on a Saturday. SulTRAC should call its CLP sample coordinator, who in turn will notify the SMO.

All shipping containers will be labeled as required by the DOT. After packaging, the samples will be shipped to the CLP laboratory specified by the EPA Region 5 Regional Sample Control Coordinator.

# 9.0 DISPOSAL OF INVESTIGATION-DERIVED WASTE

IDW is waste generated from an activity related to determining the nature and extent of contamination at the East Troy site. It includes solid and any hazardous waste, media (soil, groundwater, or surface water), and debris that contains "listed" hazardous waste or that exhibits a characteristic of a hazardous waste. It also includes media and debris that are not hazardous, but are contaminated with hazardous constituents.

This investigation will use drilling and sampling techniques that minimize the volume of IDW generated. Drilling techniques will include direct-push and sonic techniques, which displace less soil than augers or rotary methods. Groundwater samples will be collected using low-flow techniques, which reduce the volume of purge water from each well.

IDW generated during the field sampling activities at the East Troy site includes homogenized soil extracted by borings and monitoring well installation; purge water from VAS, well development, and groundwater sampling; and wastewater from decontamination and equipment rinsate procedures. All IDW will be removed from specific work sites and managed at a central, secure location, on property owned and controlled by the City of Troy (SulTRAC 2010b, 2009e).

It is anticipated that soil will be containerized in 55-gallon drums; water from well purging and decontamination activities will be contained in portable tanks or drums. If amenable to the City of Troy and if analytical data do not indicate the presence of significant contamination, water generated from well purging and development may be disposed of at the local POTW, contingent on approval by EPA and Ohio EPA.

Water or soil from locations that appear to have a high potential to contain significant contamination based on source location, odors, staining, or other observations will be drummed and stored separately to minimize the amount of material potentially requiring management as a hazardous waste.

Drummed materials will be clearly marked to indicate the date(s) of collection, its waste contents, and other generator information. A completed "WASTE MATERIAL" label will be affixed to the exterior side of each drum, before DOT classification. This label will include site, address, contents, boring(s) or well depth(s), operation, accumulation date, and consultant phone number information. All information must and will be completed for each drum. Before off-site disposal, the drums will be relabeled with appropriate DOT identification and classification information.

All IDW will be disposed of as required by state and local regulations after results have been received for IDW soil and water analyses. Additional IDW generated as a result of soil and groundwater sampling will include disposable personal protective equipment (PPE) and sampling equipment. Disposable PPE and sampling equipment will be managed according to the level of contamination encountered during field activities. In general, PPE will be managed as nonhazardous solid waste, particularly if little contact occurs with the sampling medium and low levels of contaminants are involved. Therefore, this waste will be double bagged and disposed of with municipal trash.

SulTRAC will coordinate with the City of Troy Engineer, Water Department, and Sewer Department regarding staging of activities, locations for securing and managing IDW, and decontamination activities.

# 10.0 HEALTH AND SAFETY PROCEDURES

All field activities will be conducted in accordance with SulTRAC Health and Safety Plan (HASP), which is among the site-specific plans prepared for the WA (SulTRAC 2009e). Before field activities begin, all SulTRAC field personnel and subcontractors will read and sign the HASP, indicating that they understand the plan and agree to operate in accordance with its requirements. Daily tailgate meetings will be conducted to review daily activities and task-specific hazards. All SulTRAC personnel and subcontractors must have 40-hour hazardous waste and emergency response training, and proof of certification must be filed with the signed HASP. A complete copy of the site-specific plans, including the updated Phase I HASP, will be maintained by the field sampling team at the site.

This project requires special health and safety precautions including work in high-traffic areas and working in close proximity to overhead and underground utilities. SulTRAC will coordinate site activities with appropriate personnel in the City of Troy to minimize potential health and safety concerns for site workers and the public. Additional details regarding coordination with local entities are provided in the SulTRAC Site Management Plan (SulTRAC 2010b)

## 11.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

All QA activities will be conducted in accordance with the SAP. A copy of the SAP will be maintained by the field sampling team for immediate use in resolving any QA issues that might arise during field activities.

For all samples sent to CLP or CRL, QC samples will be collected at the following frequencies:

- Field Duplicate: One per 10 environmental samples will be collected, with a minimum of one per sample matrix.
- Trip Blank Samples: One trip blank will be included in each cooler containing aqueous samples for analysis for VOCs for CLP analysis.
- MS/MSD Samples: One per 20 environmental samples per matrix will be collected.
- Rinsate Blank Samples: One per day of sampling to verify quality of decontamination procedures.

Field duplicate samples consist of two separate samples collected from the same sampling location and depth, using the same equipment and sampling procedures. A trip blank is a clean sample of a matrix that is taken from the laboratory to the sampling site and transported back to the laboratory, without having been exposed to sampling procedures (typically analyzed only for volatile compounds). This sample is not to be labeled or identified as a trip blank for the CLP laboratory. A rinsate blank sample is collected by collecting analyte free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. A rinsate blank sample will be collected daily and analyzed by the CLP for VOCs for each day that VOC samples are collected for CLP analysis. Rinsate blanks for other parameters (SVOCs, PCB, pesticides and metals) will be collected at a lower frequency, but will include at least one rinsate blank for each event sampling task during which aqueous fractions are collected for these additional parameters.

MS/MSD is an environmental sample divided into two separate aliquots, each of which is spiked with known concentrations of target aliquots. The two spiked aliquots, in addition to an unspiked sample aliquot, are analyzed separately and the results are compared to determine the effects of the matrix on the precision and accuracy of the analysis. For groundwater samples, the MS/MSD generally requires collecting triple sample volume (three sets of vials), while for solid matrices, the MS/MSD does not require extra volume collection. All samples should be identified as MS/MSD for the CLP laboratory.

VAS and Geoprobe groundwater sample are intended to be screening level data used to guide the placement of subsequent Phase I RI sampling locations. QC samples associated with VAS and Geoprobe groundwater samples will include field duplicates and rinsate blank samples, and at least one trip blank sample for each sampling activity. These QC samples will be collected in the same manner as described above. One set of field duplicates and one rinsate blank will be analyzed for each task (that is, one field duplicate and rinsate blank for the VAS program, and one field duplicate and a rinsate blank for the Geoprobe program).

# 12.0 REFERENCES

City of Troy, Ohio (Troy). 2009a. Maps of Troy Sanitary Sewer System. Provided by Troy City Engineer's Office. May.

Troy 2009b. Monitoring and Location Data for the Troy Municipal Production and Monitoring Wells. Provided by Tim Ray, Superintendent, Troy Water Department. July.

Kimberly-Clark Inc. (KC). 2007. Comments on Proposed CERCLA Listing East Troy Contaminated Aquifer, FDMS Docket ID NO. EPA-HQ-SFUND-2007-0690. Prepared by Howard L. Sharfstein, Senior Counsel. To U.S. Environmental Protection Agency (EPA) CERCLA Docket Office. December 11.

KC. 2009. Summary of Background Information Regarding the Spinnaker Site and the East Troy Contaminated Aquifer. Compiled by Mill Creek Environmental, Inc. Provided by KC at Meeting with EPA, May 28.

Malcolm Pirnie. 2004. Excerpt Figures from Report – Troy Municipal Wellfield Wellhead Protection Plan (WHPP). Prepared for the City of Troy. January.

Malcolm Pirnie. 2007. Excerpt Figures from Report – Troy Municipal Wellfield Wellhead Expansion. Prepared for the City of Troy.

Mill Creek Environmental Services (Mill Creek). 2002. Closure Report Spinnaker Facility-West End. Prepared for Kimberly-Clark Corporation Roswell, Georgia. April 10.

Mill Creek. 2010. Summary of Groundwater Analytical Data for March 2010 Quarterly Groundwater Monitoring – Spinnaker Facility West End. May.

Ohio Department of Natural Resources (ODNR). 2009. Maps of Former Miami and Erie Canal, Miami County Panels. On-line address: http://www.dnr.state.oh.us/water//meplats/tabid/3298/Default.aspx. April.

Ohio Environmental Protection Agency (Ohio EPA). 2002. Expanded Site Inspection Report – East Troy Contaminated Aquifer Troy, Miami County, Ohio. September 23.

Ohio EPA. 2004. Letter Regarding Results of Soil Sampling Completed adjacent to Hobart Cabinet Company, Troy, Ohio. From Steve Martin, Division of Emergency and Remedial Response. To Charles Hobart,, Hobart Cabinet Company. September 8. (Provided by Jon R. Watterworth, Ohio EPA Site Coordinator, to SulTRAC. October 26, 2009.)

Ohio EPA. 2006. Removal Referral – East Troy Contaminated Aquifer, Miami County, 555-1353. From Kevin Clouse, Manager Emergency Response & Special Investigations Unit. To Mr. Jason El-Zein, Chief Emergency Response Branch U.S. Environmental Protection Agency (EPA). June 30.

Ohio EPA. 2009a. Technical Guidance Manual for Hydrogeological Investigations and Groundwater Monitoring - TGM-08. Division of Drinking and Ground Waters. January.

Ohio EPA. 2009b. GIS Files for Troy Ohio. Provided by Jon. R. Watterworth, Site Coordinator, to SulTRAC. April.

Ohio EPA. 2010. Correspondence (e-mail) Regarding Locations of Former Waltz Cleaners Site # 3. From Jon R. Watterworth, Division of Emergency and Remedial Response. To Shari Kolak, U.S. EPA Region 5. February 25.

SulTRAC. 2009a. Work Plan – Phase I Remedial Investigation/Feasibility Study East Troy Contaminated Aquifer Superfund Site, Troy, Miami County, Ohio. June 23.

SulTRAC. 2010a. Quality Assurance Project Plan – Phase I Remedial Investigation/Feasibility Study East Troy Contaminated Aquifer Superfund Site, Troy, Miami County, Ohio. August 11.

SulTRAC. 2010b. Site Management Plan – Phase I Remedial Investigation/Feasibility Study East Troy Contaminated Aquifer Superfund Site, Troy, Miami County, Ohio. July 14.

SulTRAC. 2010c. Data Management Plan – Phase I Remedial Investigation/Feasibility Study East Troy Contaminated Aquifer Superfund Site, Troy, Miami County, Ohio. July 14.

SulTRAC. 2010d. Site Specific Health and Safety Plan - Phase I Remedial Investigation/Feasibility Study East Troy Contaminated Aquifer Superfund Site, Troy, Miami County, Ohio. July 19.

U.S. Environmental Protection Agency (EPA). 1989. *SARA/Superfund Sample Handling Manual*. October.

EPA. 1992. *Multi-Media Investigation Manual*. EPA-330/9-89-003-R. March.

EPA. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. January.

EPA. 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). November.

EPA. 2004a. Standard Operating Procedure for the Construction and Installation of Permanent Sub-Slab Soil Gas Wells. SOP#2082. March 18.

EPA. 2004b. Contract *Laboratory Program Guidance for Field Samplers*. August.

EPA. 2005. “Superfund Analytical Services/Contract Laboratory Program (CLP), Multi-Media, Multi-Concentration Organic Analysis SOM01.2.” On-line address: http://www.epa.gov/superfund/programs/clp/olm4.htm. May.

EPA. 2006. Multi-Media, Multi-Concentration, Organic Analytical Service for Superfund (SOM01.1). January.

EPA. 2007a. “Superfund Analytical Services/Contract Laboratory Program (CLP), Multi-Media, Multi-Concentration Inorganic Analysis ILM05.3/ILM05.4.” On-line address: http://www.epa.gov/superfund/programs/clp/olm4.htm. March.

EPA. 2007b. Site Assessment Report for Troy VOC Plume Site Troy, Miami County, Ohio. Prepared for Steven L. Renninger On-Scene Coordinator Emergency Response Branch EPA Region 5 by Weston Inc. May 14.

EPA. 2007c. Action Memorandum, Request for a Time Critical Removal Action at the East Troy Contaminated Aquifer Site (aka Troy VOC Plume), Troy, Miami County, Ohio (Site ID #B5EN). From Steven L. Renninger, On-Scene Coordinator Emergency Response Branch-Section 1. To Richard C. Karl, Director Superfund Division. May 16.

EPA. 2008. Hazard Ranking System Documentation Record for the East Troy Contaminated Aquifer Site. September.

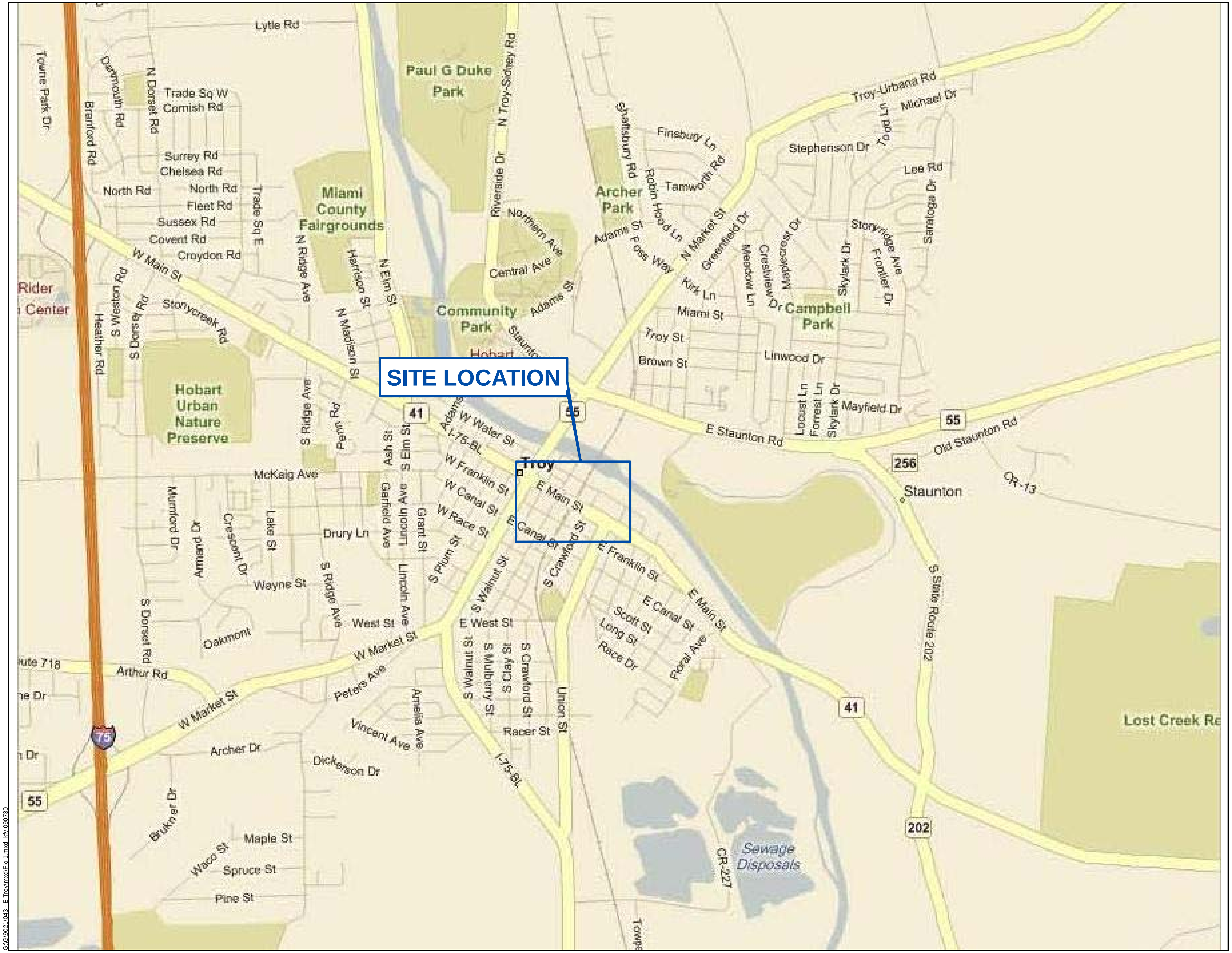
EPA. 2009a. Statement of Work for RI/FS of the East Troy Contaminated Aquifer Site. Issued by EPA Region 5. Contract EP-S5-06-02 Work Assignment 045-RICO-B5EN. February 26.

EPA. 2009b. National Risk Based Concentration Standards. Obtained from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. May 19.

U.S. Department of Health and Human Services – Public Health Service - Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Health Consultation – East Troy Contaminated Aquifer Site (Vapor Intrusion). July 29.

## FIGURES

(Eight Sheets)



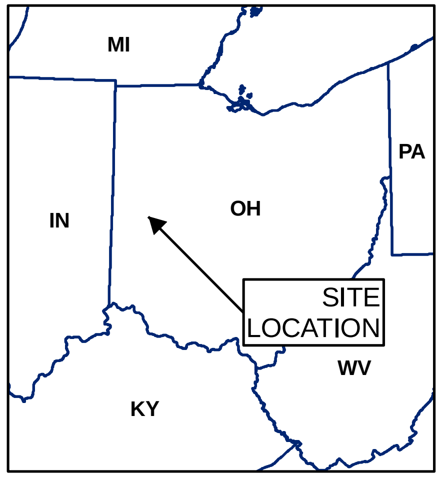
G:\G\9021\043 - E Troy\mxd\Fig 1.mxd kfv 090730

N
W
E
S

**LEGEND**

▭ SITE LOCATION

0 2,625 5,250 10,500
Feet



SOURCE: © 2009 Navteq © 2009 Microsoft

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE I**
**TROY, OHIO**

FIGURE 1
SITE LOCATION MAP

ST SulTRAC

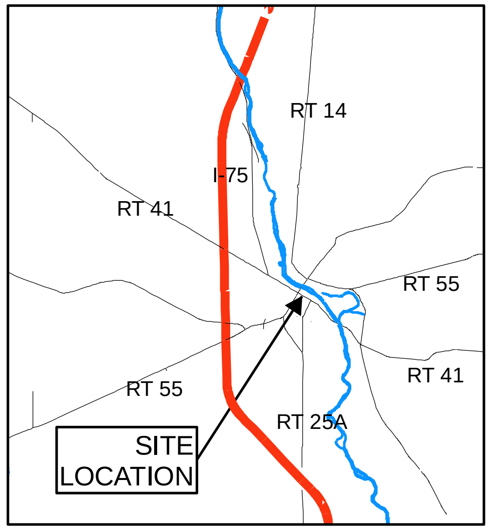
## LEGEND

- 🟢 Troy Production Well
- ⊙ Troy Monitoring Well
- ▲ Ohio EPA Well

N
W E
S

0 800 1,600 Feet

SOURCE: Modified From Ohio EPA 2009



**East Troy Contaminated Aquifer Site**
**RI/FS Phase I**
**Troy, Ohio**

FIGURE 2
Site Layout

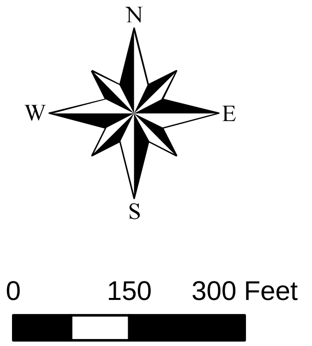
ST SulTRAC

2010-01-14 g:\g\9021\045 - e troy\mxd\fig 3.mxd TtEMI-CH kurt.voigts

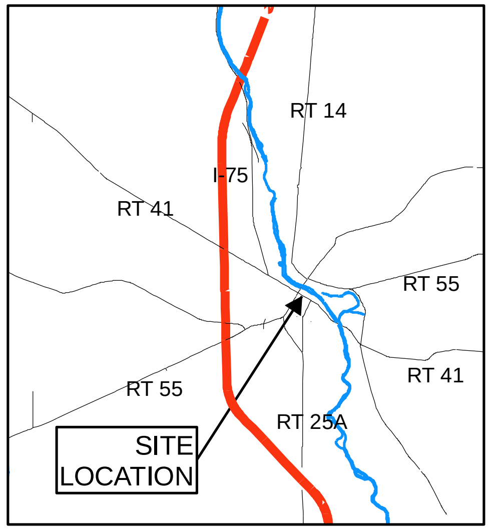
**LEGEND**

- ◯ Direct Push Geoprobe (2002)
- ● Geoprobe (2003)
- ● Geoprobe (2004)
- ⬠ Monitoring Well

Note:
All Values in Micrograms Per Liter or Parts Per Billion
ND-Not Detectable



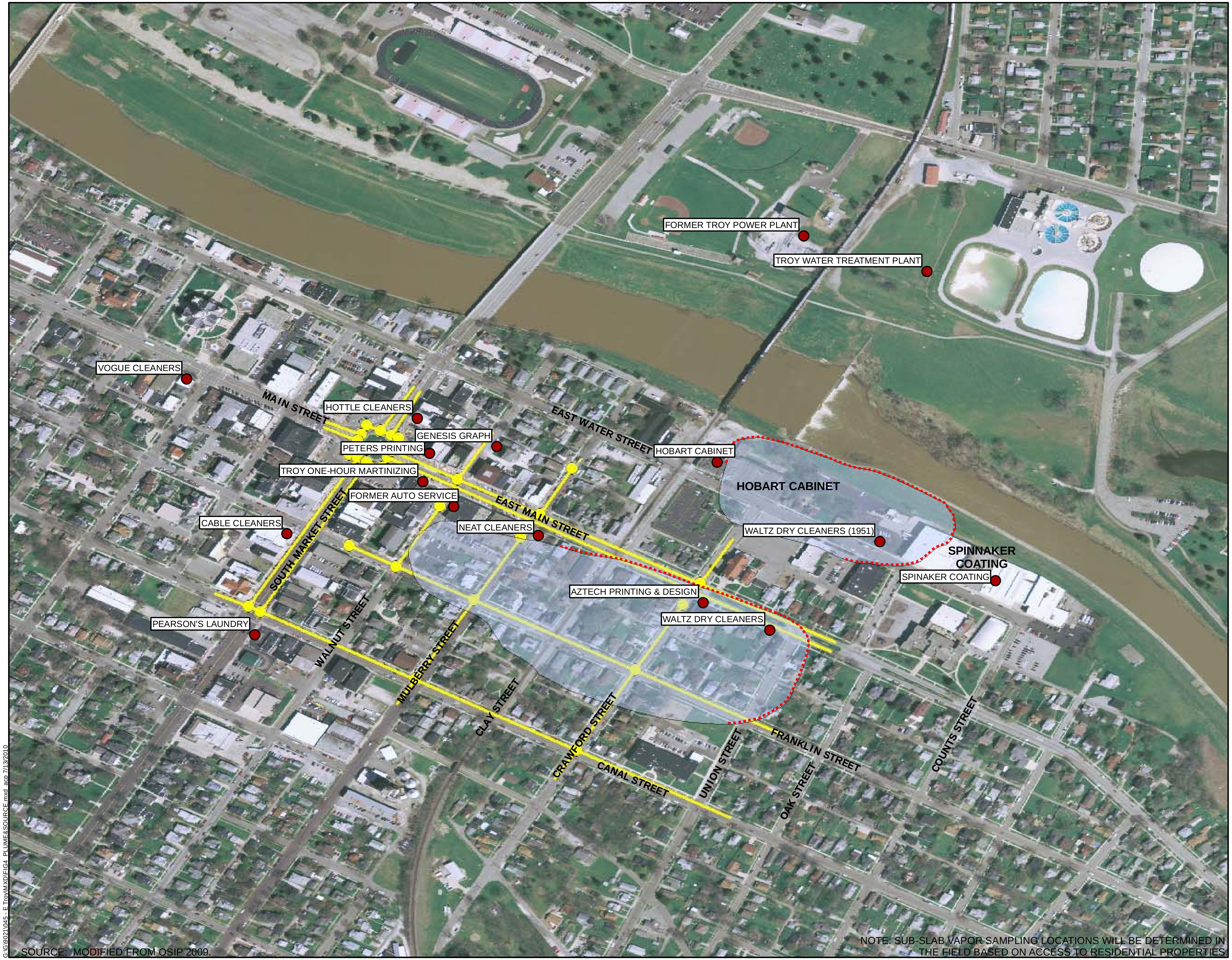
SOURCE: Modified From Ohio EPA 2009



## East Troy Contaminated Aquifer Site
## RI/FS Phase I
## Troy, Ohio

FIGURE 3
Summary of Ohio EPA Groundwater Sampling Results for PCE

ST SulTRAC



SOURCE: MODIFIED FROM OSIP 2009.

NOTE: SUB-SLAB VAPOR SAMPLING LOCATIONS WILL BE DETERMINED IN THE FIELD BASED ON ACCESS TO RESIDENTIAL PROPERTIES.

G:\G\9021\045 - E Troy\MXD\FIG4_PLUME&SOURCE.mxd acp 7/13/2010

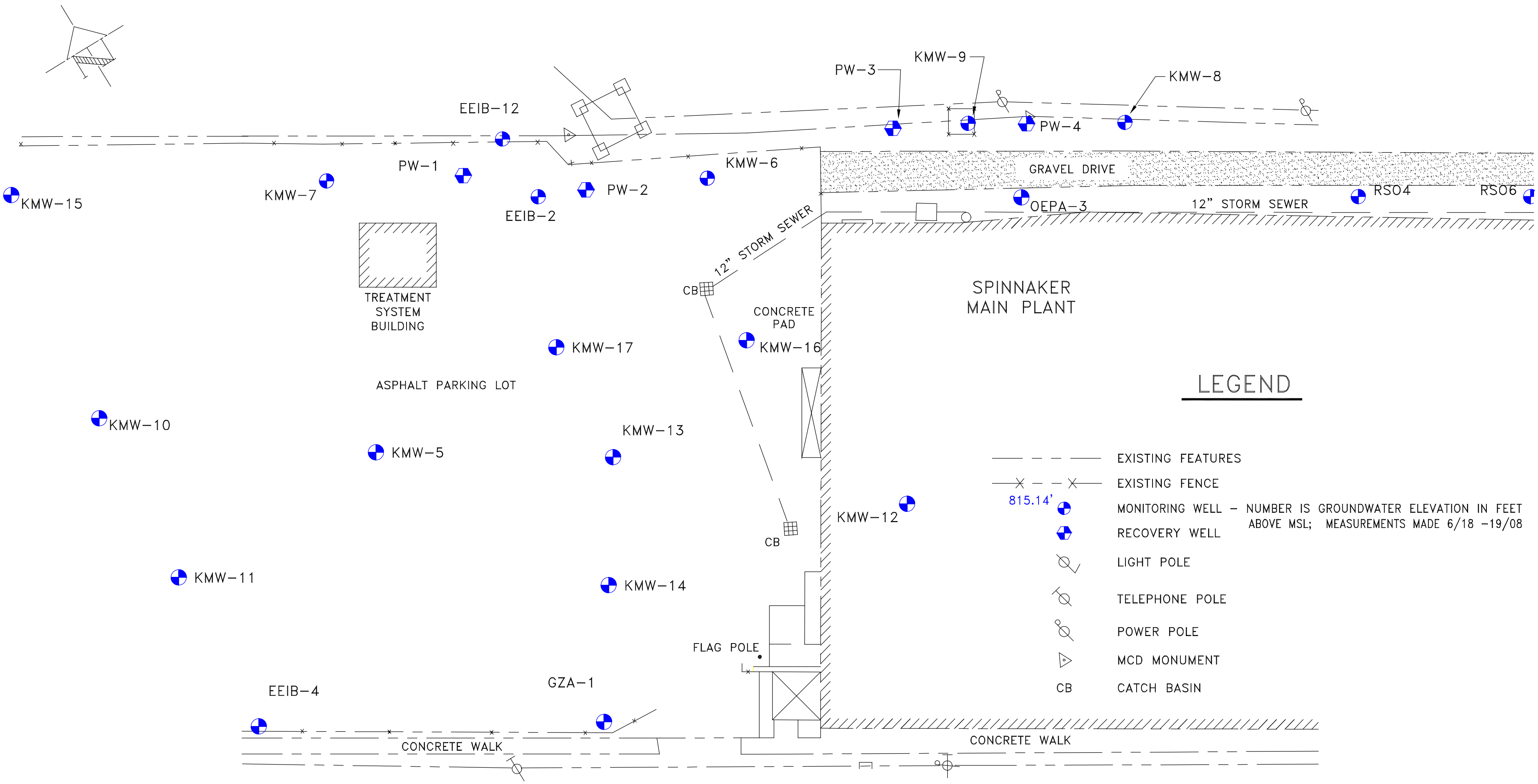
**LEGEND**

| | |
|---|---|
| ● | POTENTIAL HISTORIC VOC SOURCES |
| ○ | MANHOLE |
| ········ | PLUME BOUNDARY UNKNOWN |
| — | SANITARY SEWER |
| ▭ | VOC PLUME BASED ON OHIO EPA PCE DATA 1999-2004 |

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE I**
**TROY, OHIO**

FIGURE 4
APPROXIMATE CHLORINATED VOC PLUME AREA AND HISTORIC POTENTIAL VOC SOURCE AREA

ST SulTRAC



Source: Mill Creek Environmental Services June 2008

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE 1**
**TROY, OHIO**

FIGURE 5
SPINNAKER COATINGS - WEST END
MONITORING WELLS

**ST SulTRAC**

NOTE: SUB-SLAB VAPOR SAMPLING LOCATIONS WILL BE DETERMINED IN THE FIELD BASED ON ACCESS TO RESIDENTIAL PROPERTIES.

SOURCE: MODIFIED FROM OSIP 2009.

**LEGEND**

| | |
|---|---|
| ⊗ | PROPOSED SOIL BORING |
| ⊙ | EXISTING CITY OF TROY MONITORING WELL |
| ▲ | OEPA MONITORING WELL |
| ● | MANHOLE |
| — | SANITARY SEWER |
| ········ | PLUME BOUNDARY UNKNOWN |
| ▭ | VOC PLUME BASED ON OHIO EPA PCE DATA 1999-2004 |

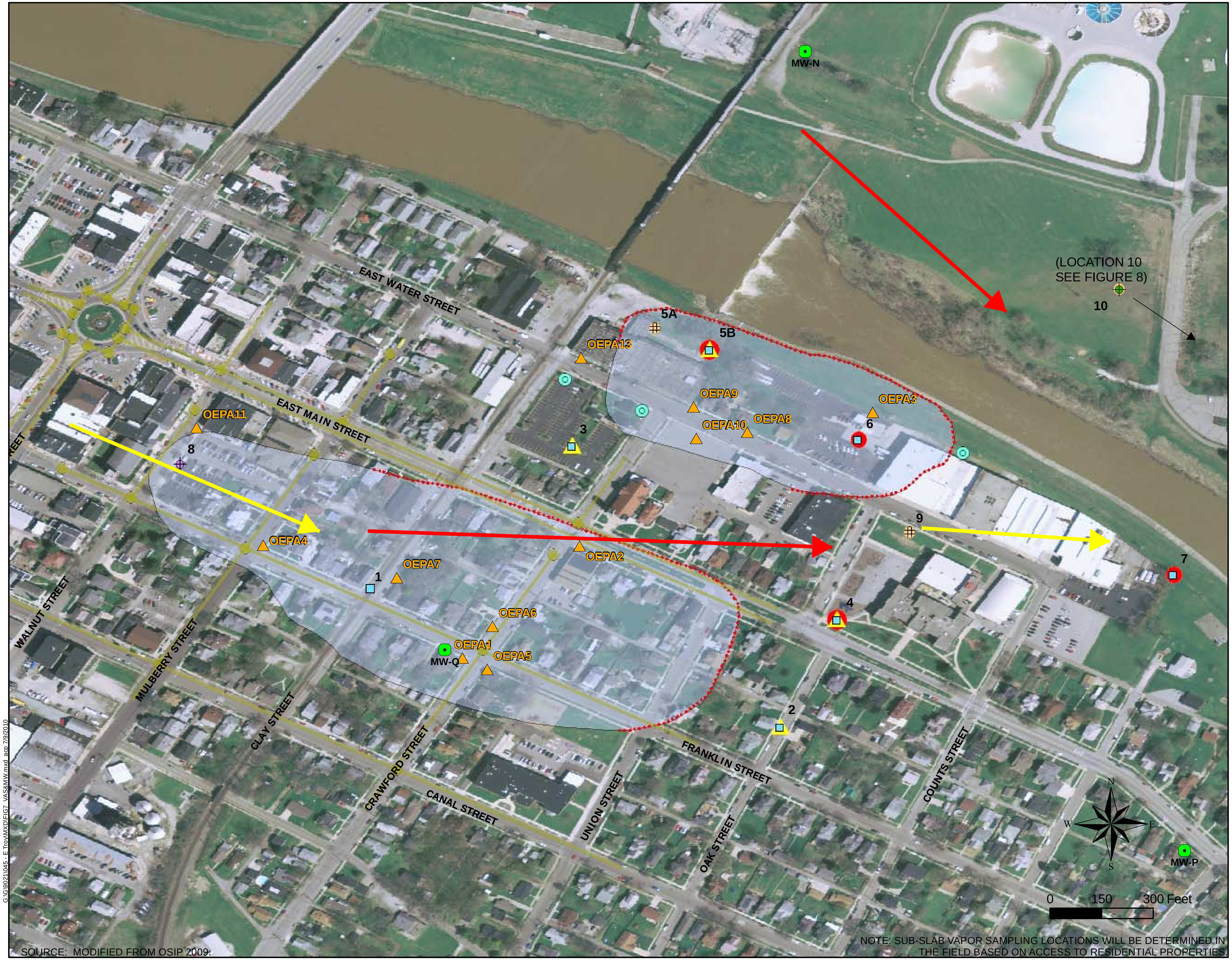
N
W E
S

0 150 300 Feet

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE I**
**TROY, OHIO**

FIGURE 6
BASELINE GROUNDWATER SAMPLING
AND SOIL BORING LOCATIONS-
WEST OF RIVER

ST SulTRAC



SOURCE: MODIFIED FROM OSIP 2009.

NOTE: SUB-SLAB VAPOR SAMPLING LOCATIONS WILL BE DETERMINED IN THE FIELD BASED ON ACCESS TO RESIDENTIAL PROPERTIES.

G:\G\9021\1045 - E Troy\MXD\FIG7_VAS&MW.mxd_acp 7/9/2010

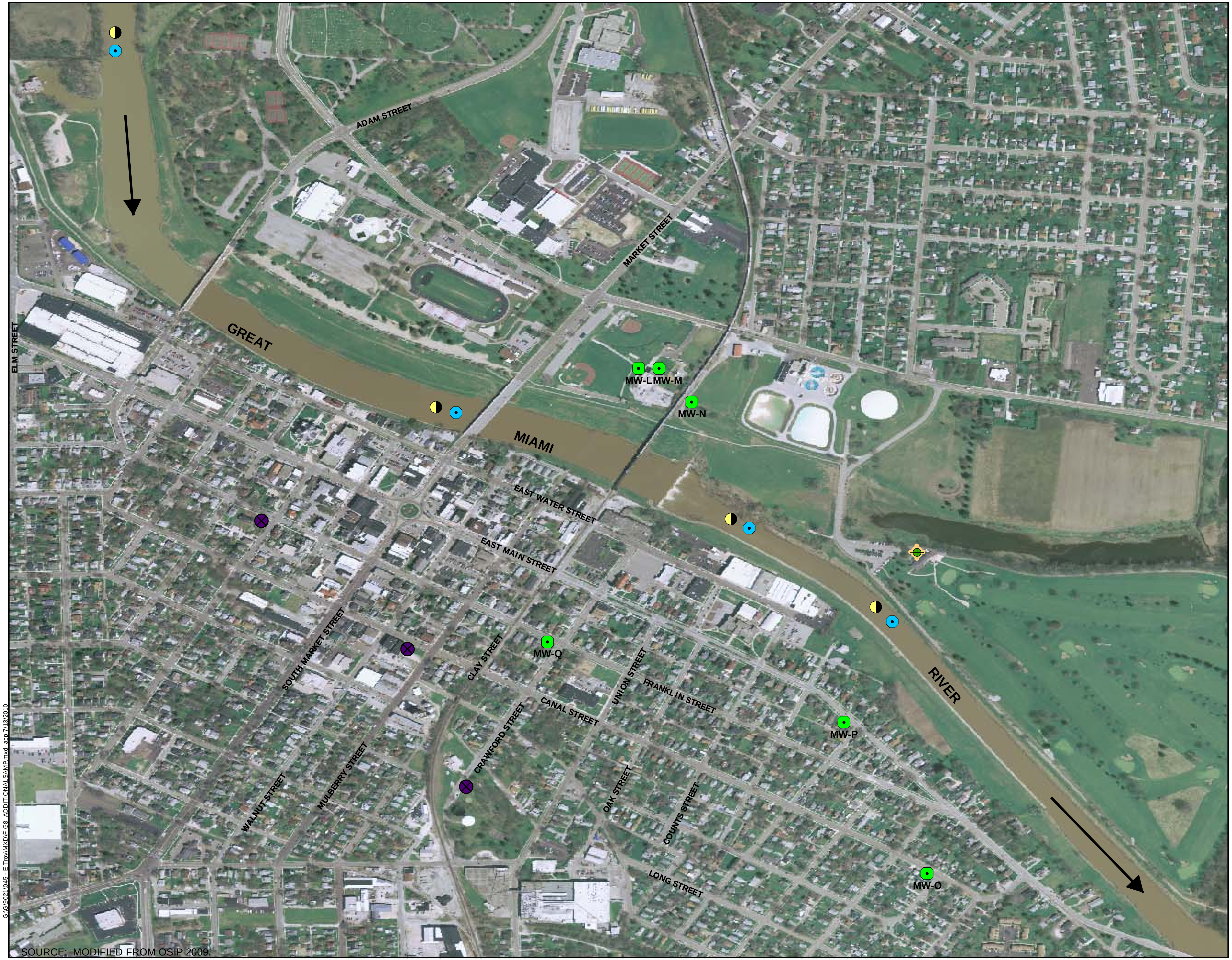
**LEGEND**

| | |
|---|---|
| 🟩 | EXISTING CITY OF TROY MONITORING WELL |
| ▲ | OEPA MONITORING WELL |
| ⊕ | SHALLOW AND DEEP WELL PAIR |
| ■ | PROPOSED VAS ONLY |
| ◎ | CONTINGENT (PHASE II) DEEP WELL |
| ⊕ | PROPOSED SHALLOW WELL |
| ⊕ | PROPOSED DEEP WELL |
| ▲ | PROPOSED VAS AND SHALLOW WELL |
| ● | PROPOSED VAS AND DEEP WELL |
| ● | PROPOSED VAS AND SHALLOW AND DEEP WELL |
| ● | MANHOLE |
| — | SANITARY SEWER |
| ⋯ | PLUME BOUNDARY UNKNOWN |
| ▭ | VOC PLUME BASED ON OHIO EPA PCE DATA 1999-2004 |
| → | APPARENT FLOW DIRECTION, SHALLOW AQUIFER |
| → | APPARENT FLOW DIRECTION, DEEP AQUIFER |

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE I**
**TROY, OHIO**

FIGURE 7
VAS AND MONITORING WELL LOCATIONS

ST SulTRAC



SOURCE: MODIFIED FROM OSIP 2009.

G:\G\9021\045 - E Troy\MXD\FIG8 ADDITIONALSAMP.mxd acp 7/13/2010

**LEGEND**

- ⊗ BACKGROUND SOIL SAMPLING LOCATION
- ◐ SEDIMENT SAMPLING LOCATION
- ⊙ SURFACE WATER SAMPLING LOCATION
- ⊡ EXISTING CITY OF TROY MONITORING WELL
- ⊕ EAST SIDE UPPER/LOWER AQUIFER MONITORING WELL CLUSTER

NOTE: ALL LOCATIONS ARE SUBJECT TO FIELD CONDITIONS OF ACCESS AND AVAILABILITY. LOCATIONS MAY BE ADJUSTED AS NEEDED. STAFF GAUGES TO BE PLACED NEAR FARTHES TWO DOWNSTREAM SURFACE WATER AND SEDIMENT LOCATIONS.

N
W E
S

0 500 1,000 Feet

**EAST TROY CONTAMINATED AQUIFER SITE**
**RI/FS PHASE I**
**TROY, OHIO**

FIGURE 8
ADDITIONAL SAMPLING LOCATIONS

ST SulTRAC

# STANDARD OPERATING PROCEDURES

# STANDARD OPERATING PROCEDURES

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# GENERAL EQUIPMENT DECONTAMINATION

## SOP NO. 002

## REVISION NO. 2

Last Reviewed: December 1999

RRiesing

Quality Assurance Approved

*February 2, 1993*

Date

## 1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

### 1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

### 1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

### 1.3 DEFINITIONS

**Alconox:** Nonphosphate soap

### 1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992. “RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste. Washington, DC. EPA/530-R-93-001. November.

EPA. 1994. “Sampling Equipment Decontamination.” Environmental Response Team SOP #2006 (Rev. #0.0, 08/11/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

### 1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles

- Alconox
- Tap water
- Distilled water
- Plastic sheeting
- Aluminum foil
- Methanol or hexane
- Dilute (0.1 N) nitric acid

## 2.0 PROCEDURE

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water level measurement equipment, and general sampling equipment.

### 2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off-site or to clean areas. All used disposable protective clothing, such as Tyvek coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.

2. Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.

3. Remove Tyvek or coveralls. Containerize Tyvek for disposal and place coveralls in plastic bag for reuse.

4. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.

5. Remove disposable gloves and place them in plastic bag for disposal.

6. Thoroughly wash hands and face in clean water and soap.

## 2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on-site before drilling operations begin, between borings, and at completion of the project.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

## 2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.

5. Decontaminate all pipe placed down the hole as described for drilling equipment.

## 2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.
2. Rinse with deionized organic-free water.

## 2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of protection as was used for sampling.
3. To decontaminate a piece of equipment, use an Alconox wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
5. Containerize all water and rinsate.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

## ORGANIC VAPOR AIR MONITORING

### SOP NO. 003

### REVISION NO. 2

Last Reviewed: December 1999

KRiesing

Quality Assurance Approved

*April 8, 1994*

Date

## 1.0 BACKGROUND

Exposure to airborne organic contaminants can present a significant threat to worker health and safety. Identifying and quantifying these contaminants through air monitoring is essential for reconnaissance activities. Reliable measurements of airborne organic contaminants are necessary for selecting personal protective equipment, delineating areas where protection is needed, assessing the potential health effects of exposure, and determining the need for specific medical monitoring.

### 1.1 PURPOSE

This standard operating procedure (SOP) discusses factors to consider when conducting organic vapor air monitoring.

### 1.2 SCOPE

This SOP discusses procedures, instruments, and variables affecting outdoor monitoring for assessing airborne organic vapor contamination. The instrument manuals, which outline the procedures for using an HNu® photoionization detectors (PID), Foxboro® organic vapor analyzer (OVA) flame ionization detectors (FID), and Photovac MicroTIP™ PIDs, are included with the equipment.

### 1.3 DEFINITIONS

**Flame Ionization:** A process by which a sample gas is ionized with a flame allowing a count of carbon atoms to determine organic vapor concentration

**Flame Ionization Detector (FID):** A portable instrument used to detect, measure, and provide a direct reading of organic vapor concentrations in a gas sample that is ionized with a flame

**Ionization Potential:** The amount of energy needed to strip an electron from the orbit of its resident molecule, expressed in electron volts

**Organic Vapor:** Airborne compounds composed of carbon, hydrogen, and other elements with chain or ring structures

**Organic Vapor Analyzer (OVA):** A portable instrument used to detect, measure, and provide a direct reading of the concentration of a variety of trace organic gases in the atmosphere through flame ionization

**Photoionization:** A process involving the absorption of ultraviolet light by a gaseous molecule, leading to ionization

**Photoionization Detector (PID):** A portable instrument used to detect, measure, and provide a direct reading of the concentrations of a variety of trace organic gases in the atmosphere through photoionization

## 1.4 REFERENCES

NIOSH/OSHA/USCG/EPA. 1985. "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities." U.S. Government Printing Office. Washington, DC.

EPA. 1994. "Photoionization Detector (PID) HNu." Environmental Response Team SOP #2114 (Rev. #0.0, 10/06/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

The equipment used to conduct direct monitoring of airborne organic compounds includes the HNu® PID and the Foxboro® OVA FID. Other equipment, such as a Photovac MicroTIP™ PID, is available to conduct similar air monitoring. Calibration gas is also required.

# 2.0 PROCEDURES

The following subsections present a detailed discussion of direct-reading instrument constraints, accurate recording and interpretation of instrument readings, and general information on the HNu® PID and the Foxboro® OVA FID.

## 2.1 DIRECT-READING INSTRUMENT CONSTRAINTS

All direct-reading instruments have inherent constraints in their ability to detect gaseous organic compounds. They usually detect and/or measure only specific classes of chemicals. Generally, they are not designed to measure and/or detect airborne concentrations below 1 part per million (ppm). Finally, many direct reading instruments that have been designed to detect one particular substance also detect other substances, causing interference and possibly resulting in false readings.

## 2.2 ACCURATE RECORDING AND INTERPRETATION

Direct-reading instruments must be operated and the data interpreted by individuals who understand the operating principles and limitations of the instruments. At hazardous waste sites where unknown and multiple contaminants are frequently encountered, instrument readings should be interpreted conservatively.

The following guidelines promote accurate recording and interpretation:

- Calibrate instruments in accordance with the manufacturer’s instructions before and after every use.
- The instrument’s readings have limited reliability when specific organic contaminants are unknown. When recording readings of unknown contaminants, report them as “X” instrument units or as a “positive response” rather than in specific concentrations in measured units such as ppm.
- Conduct additional monitoring at any location where a positive response occurs.
- Report a reading of zero as nondetectable “ND” rather than as “clean.” Quantities of chemicals may be present but at concentrations that are not detectable by the instrument.
- Repeat the air monitoring survey using other detection devices.

## 2.3 HNu® PHOTOIONIZATION DETECTOR

The following subsections discuss the procedures for use, application, detection method, limitations, general care and maintenance, and typical operating time of the HNu® PID.

### 2.3.1 Procedures for Use

The procedures for calibrating and using the HNu® PID, which vary for each model number, are presented in the instruction manual included with the instrument.

### 2.3.2 Application

The HNu® PID can be used to detect total concentrations of many organic and some inorganic gases and vapors. It can also be used in conjunction with other detection devices such as colorimetric indicator detector tubes to identify specific compounds (see SOP No. 065, Colorimetric Indicator Detectors [Dräeger Tubes]).

### 2.3.3 Detection Method

The HNu® PID ionizes molecules using ultraviolet (UV) radiation. The radiation strips electrons from the molecules, producing ions that produce a current proportional to the number of ions generated. The HNu® PID is more sensitive to aromatics and unsaturated compounds than the Foxboro® OVA FID. The PID is nonspecific for gas and vapor detection for organics and some inorganics. The PID is also sensitive to 0.1 ppm of benzene. Sensitivity is related to the ionization potential of the compound being monitored.

### 2.3.4 Limitations

The HNu® PID cannot be used to:

- Detect methane
- Detect a compound that has a lower energy level than the ionization potential of the PID light source
- Respond accurately to a mixture of gases or vapors
- Respond accurately in high humidity or very cold weather
- Respond accurately when interference from other sources is present

### 2.3.5 General Care and Maintenance

The HNu® PID needs to be recharged every 10 hours or have its battery replaced. The lamp window in the probe must be cleaned regularly. The instrument and its accessories must also be regularly cleaned and maintained.

### 2.3.6 Typical Operating Time

The HNu® PID can run continuously on a charged battery for 10 hours alone or for 5 hours with a strip chart recorder. The battery needs to be recharged for 14 hours; therefore, additional batteries are recommended when conducting field work.

## 2.4 FOXBORO® ORGANIC VAPOR ANALYZER FLAME IONIZATION DETECTOR

The following subsections discuss the procedures for use, application, detection method, limitations, general care and maintenance, and typical operating time of the Foxboro® OVA FID.

### 2.4.1 Procedures for Use

The procedures for calibrating and using the Foxboro® OVA FID are presented in the instruction manual included with the instrument.

### 2.4.2 Application

When set in the survey mode, the OVA FID can detect the total concentration of many organic gases and vapors. In the gas chromatography (GC) mode, the OVA FID can identify and measure the concentrations of specific compounds. In the survey mode, all organic compounds are ionized and detected at the same time. In the GC mode, volatile species are ionized and detected separately.

### 2.4.3 Detection Method

Organic gases and vapors are flame-ionized in the OVA FID. The ions produce a current that is proportional to the number of carbon atoms present. The current is interpreted by a deflection on the instrument's meter. In the survey mode, the OVA FID functions as a nonspecific total hydrocarbon analyzer. In the GC mode, the OVA FID can provide a tentative qualitative and quantitative identification of gases and vapors. The OVA FID is most sensitive to saturated hydrocarbons (alkanes), unsaturated hydrocarbons (alkenes), and aromatic hydrocarbons. The OVA FID is not suitable for inorganic gases such as chloride, hydrogen cyanide, and ammonia. The OVA FID is also less sensitive to aromatics and unsaturated compounds than the HNu® PID. However, the OVA FID is less sensitive to high humidity than the HNu® PID. Gases and vapors that contain substituted function groups such as hydroxide (OH-) reduce the detector's sensitivity. Finally, if the operator monitors for a specific gas or vapor, the operator should use a calibration standard and GC column for that particular gas or vapor.

### 2.4.4 Limitations

The OVA FID cannot be used to:

- Detect organic vapors at temperatures below 40 °F (4 °C)
- Identify specific organic vapors when operated in the survey mode; results must be reported relative to the calibration standard used (for example, as methane equivalents)
- Detect inorganic gases and vapors; the instrument also gives a lower response to oxygen-containing organic compounds (such as alcohols, ethers, and aldehydes) and nitrogen-containing organic compounds (such as amines, amides, and nitriles)
- Detect high organic contaminant concentrations or in oxygen-deficient atmospheres; operation in these conditions requires system modification

### 2.4.5 General Care and Maintenance

The hydrogen fuel level must be monitored during use to maintain an adequate supply. Also, the OVA FID user should perform routine maintenance procedures described in the instruction manual included with the equipment and routinely check the OVA FID for leaks.

### 2.4.6 Typical Operating Time

The OVA FID can typically run continuously on a fully charged battery for 8 hours alone or for 3 hours with a strip chart recorder. The OVA FID battery must be recharged every 8 hours or replaced, as needed.

## 3.0 VARIABLES AFFECTING OUTDOOR AIR MONITORING

Complex environments containing many substances such as those associated with hazardous waste sites pose significant challenges to accurately and safely assess airborne contaminants. Several independent and uncontrollable variables (most notably temperature and weather conditions) can affect airborne concentrations. These factors must be considered when conducting air monitoring and interpreting data. The following environmental variables must be considered:

- **Temperature:** An increase in temperature increases the vapor pressure of most chemicals.
- **Wind Speed:** An increase in wind speed can affect vapor concentration near a free-standing liquid surface. Dust and particulate-bound contaminants are also affected.
- **Rainfall:** Water from rainfall can essentially cap or plug vapor emission routes from open or closed containers, saturated soil, or lagoons, thereby reducing airborne emissions of certain substances.
- **Moisture:** Dusts, including finely divided hazardous solids, are highly sensitive to moisture. Moisture can vary significantly with respect to location and time and can also affect the accuracy of many sampling results.
- **Vapor Emissions:** The physical displacement of saturated vapors can produce short-term, relatively high vapor concentrations. Continuing evaporation and/or diffusion may produce long-term vapor concentrations and may involve large areas.
- **Work Activities:** Work activities often require the mechanical disturbance of contaminated materials, which may change the concentration and composition of airborne contaminants and contribute to airborne emissions. Organic air emissions at a work site can also occur from operation of gasoline or diesel engines.

These conditions should be reported with organic vapor readings to provide a more accurate interpretation of monitoring results.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# SOIL SAMPLING

## SOP NO. 005

## REVISION NO. 1

Last Reviewed: December 1999

RRiesing

Quality Assurance Approved

*March 23, 1992*

Date

# 1.0 BACKGROUND

Soil sampling is conducted for three main reasons. First, samples can be obtained for laboratory chemical analysis. Second, samples can be obtained for laboratory physical analysis. Third, samples can be obtained for visual classification and field screening. These three sampling objectives can be achieved separately or in combination with each other. Sampling locations are typically chosen to provide chemical, physical, or visual information in both the horizontal and vertical directions. A sampling and analysis plan is used to outline sampling methods and provide preliminary rationale for sampling locations. Sampling locations may be adjusted in the field based on the screening methods being used and the physical features of the area.

## 1.1 PURPOSE

Soil sampling is conducted to determine the chemical, physical, and visual characteristics of surface and subsurface soils.

## 1.2 SCOPE

This standard operating procedure (SOP) describes procedures for soil sampling in different areas using various implements. It includes procedures for test pit, surface soil, and subsurface soil sampling, and describes eight devices.

## 1.3 DEFINITIONS

**Hand auger:** Instrument attached to the bottom of a length of pipe that has a crossarm or “T” handle at the top. The auger can be closed-spiral or open-spiral.

**Bucket auger:** A type of auger that consists of a cylindrical bucket 10 to 72 inches in diameter with teeth arranged at the bottom.

**Core sampler:** Thin-wall cylindrical metal tube with diameter of 0.5 to 3 inches, a tapered nosepiece, a "T" handle to facilitate sampler deployment and retrieval, and a check valve (flutter valve) in the headpiece.

**Spatulas or Spoons:** Stainless steel instruments for collecting loose unconsolidated material.

**Trier:** Tube cut in half lengthwise with a sharpened tip that allows for collection of sticky solids or loosening of cohesive soils.

**Trowel:** Tool with a scooped blade 4 to 8 inches long and 2 to 3 inches wide with a handle.

**Split-Spoon (or Split-Barrel) Sampler:** Thick-walled steel tube that is split lengthwise. A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to drill rods.

**Thin-Wall Tube Sampler:** Steel tube (1 to 3 millimeters thick) with tapered bottom edge for cutting. The upper end is fastened to a check valve that is attached to drill rods.

## 1.4 REFERENCES

Barth, D.S., and B.J. Mason. 1984. "Soil Sampling Quality Assurance Users Guide." EPA 600/4-84-043.

DeVara, E.R., B.P. Simmons, R.D. Stephens, and D.L. Storm. 1980. "Samplers and Sampling Procedures for Hazardous Waste Streams." EPA 600/2-80-018. January.

Mason, B.J. 1983. "Preparation of Soil Sampling Protocol: Techniques and Strategies." EPA 600/4-83-020.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." OSWER Directive 9355.0-14 (EPA/540/P-87/001).

EPA. 1991. "Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells." March. EPA/600/4-89/034.

EPA. 1994. "Soil Sampling." Environmental Response Team SOP #2012 (Rev. #0.0, 11/16/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

Soil sampling requires that one or more of the following types of equipment be used:

| Sampling Equipment | Other Required Equipment |
|---|---|
| Spoons and spatulas | Sample containers, labels, and chain-of-custody forms |
| Trowel | Logbook |
| Shovel or spade | Tape for measuring recovery |
| Trier | Soil classification information |
| Core sampler | Wax for sealing ends of thin-wall tube |
| Hand auger | Plastic sheeting |
| Bucket auger | Decontamination equipment |
| Split-spoon | Drilling equipment |
| Thin-wall tube | Backhoe |
| | Health and safety equipment |

## 2.0 PROCEDURES

This SOP presents procedures for conducting test pit, surface soil, and subsurface soil sampling. The site sampling plan will specify which of the following procedures will be used.

Soil samples for chemical analysis should be collected in the following order: (1) volatile organics, (2) semivolatile organics, and (3) metals. Once the chemical samples have been containerized, samples for physical analyses can be containerized. Typical physical analyses conducted include (1) grain size distribution, (2) moisture content, (3) saturated permeability, (4) unsaturated permeability, and (5) Atterberg limits. Additionally, visual descriptions of samples, using the Unified Soil Classification System (USCS), should be recorded. Field tests such as head space analyses can also be conducted.

Soil samples for chemical analyses can be collected either as grab samples or composite samples. A grab sample is collected from a discrete location or depth. A composite sample consists of soil combined from more than one discrete location. Typically, composite samples consist of soil obtained from several locations and homogenized in a stainless steel or Teflon® pan or tray. Samples for volatile organic analysis (VOA) should not be composited.

## 2.1 TEST PIT SOIL SAMPLING

Test pit soil sampling is conducted when a complete soil profile is required or as a means of locating visually detectable contamination. This type of sampling provides a detailed description of the soil profile and allows for multiple samples to be collected from specific soil horizons. Prior to conducting any test pit or trench excavation with a backhoe, the sampling team should ensure that the sampling area is clear of utility lines, subsurface pipes, and poles.

A test pit or trench is excavated by incrementally removing soil material with a backhoe bucket. The excavated soil is placed on plastic sheeting well away from the edge of the test pit. A test pit should not be excavated to depths greater than 4 feet unless its walls are properly stabilized.

Personnel entering the test pit may be exposed to toxic or explosive gases and oxygen deficient environments. Air monitoring is required before entering the test pit and the use of appropriate respiratory gear and protective clothing is mandatory. At least two persons must be present at the test pit before sampling personnel enter the excavation and begin soil sampling.

Test pits are not practical for depths greater than 15 feet. If soil samples are required from depths greater than 15 feet, samples should be obtained using test borings instead of test pits. Test pits are also usually limited to a few feet below the water table. In some cases, a pumping system may be required to control the water level within the pits.

Access to open test pits should be restricted by use of flagging, tape, or fencing. If a fence is used, it should be erected at least 6 feet from the perimeter of the test pit. The test pit should be backfilled as soon as possible after sampling is completed.

Soil samples can be collected from the walls or bottom of a test pit using various equipment. A hand auger, bucket auger, or core sampler can be used to obtain samples from various depths. A trier, trowel, or spoons can be used to obtain samples from the walls or pit bottom surface.

## 2.2 SURFACE SOIL SAMPLING

The surface soil sampling equipment presented in this SOP is best suited for sampling to depths of 0 to 6 feet below ground surface (bgs). The sample depth, sample analyses, soil type, and soil moisture will also dictate the best suited sampling equipment. Prior to sample collection, the sampling locations should be cleared of any surface debris such as twigs, rocks, and litter. The following table presents various surface soil sampling equipment and their effective depth ranges, operating means (manual or power), and sample types collected (disturbed or undisturbed).

| Sampling Equipment | Effective Depth Range (feet bgs) | Operating Means | Sample Type |
|---|---|---|---|
| Hand Auger | 0 to 6 | Manual | Disturbed |
| Bucket Auger | 0 to 4 | Power | Disturbed |
| Core Sampler | 0 to 4 | Manual or Power | Undisturbed |
| Shovel | 0 to 6 | Manual | Disturbed |
| Trier | 0 to 1 | Manual | Disturbed |
| Trowel | 0 to 1 | Manual | Disturbed |
| Spoon/Spatula | 0 to 0.5 | Manual | Disturbed |

The procedures for using these various types of sampling equipment are discussed below.

### 2.2.1 Hand Auger

A hand auger equipped with extensions and a “T” handle is used to obtain samples from a depth of up to 6 feet. If necessary, a shovel may be used to excavate the topsoil to reach the desired subsoil level. If topsoil is removed, its thickness should be recorded. Samples obtained using a hand auger are disturbed in their collection; determining the exact depth at which samples are obtained is difficult.

The hand auger is screwed into the soil at an angle of 45 to 90 degrees from horizontal. When the entire auger blade has penetrated soil, the auger is removed from the soil by lifting it straight up without turning it, if possible. If the desired sampling depth has not been reached, the soil is removed from the auger and deposited onto plastic sheeting. This procedure is repeated until the desired depth is reached and the soil sample is obtained. The auger is then removed from the boring and the soil sample is collected directly from the auger into an appropriate sample container.

### 2.2.2 Bucket Auger

A bucket auger, equipped similarly as the hand auger, is used to obtain disturbed samples from a depth of up to 4 feet. A bucket auger should be used when sampling stony or dense soil that prohibits the use of a hand-operated core or screw auger. A bucket auger with closed blades is used in soil that cannot generally be penetrated or retrieved by a core sampler.

The bucket auger is rotated while downward pressure is exerted until the bucket is full. The bucket is then removed from the boring, the collected soil is placed on plastic sheeting, and this procedure is repeated until the appropriate depth is reached and a sample is obtained. The bucket is then removed from the boring and the soil sample is transferred from the bucket to an appropriate sample container.

### 2.2.3 Core Sampler

A hand-operated core sampler (Figure 1), similarly equipped as the hand auger, is used to obtain samples from a depth of up to 4 feet in uncompacted soil. The core sampler is capable of retrieving undisturbed soil samples and is appropriate when low concentrations of metals or organics are of concern. The core sampler should be constructed of stainless steel. A polypropylene core sampler is generally not suitable for sampling dense soils or sampling at an appreciable depth.

The core sampler is pressed into the soil at an angle of 45 to 90 degrees from horizontal and is rotated when the desired depth is reached. The core is then removed, and the sample is placed into an appropriate sample container.

### 2.2.4 Shovel

A shovel may be used to obtain large quantities of soil that are not readily obtained with a trowel. A shovel is used when soil samples from a depth of up to 6 feet are to be collected by hand excavation; a tiling spade (sharpshooter) is recommended for excavation and sampling. A standard steel shovel may be used for excavation; either a stainless steel or polypropylene shovel may be used for sampling. Soil excavated from above the desired sampling depth should be stockpiled on plastic sheeting. Soil samples should be collected from the shovel and placed into the sample container using a stainless-steel scoop, plastic spoon, or other appropriate tool.

### 2.2.5 Trier

A trier (Figure 2) is used to sample soil from a depth of up to 1 foot. A trier should be made of stainless steel or polypropylene. A chrome-plated steel trier may be suitable when samples are to be analyzed for organics and heavy metal content is not a concern.

Samples are obtained by inserting the trier into soil at an angle of up to 45 degrees from horizontal. The trier is rotated to cut a core and is then pulled from the soil being sampled. The sample is then transferred to an appropriate sample container.

### 2.2.6 Trowel

A trowel is used to obtain surface soil samples that do not require excavation beyond a depth of 1 foot. A trowel may also be used to collect soil subsamples from profiles exposed in test pits. Use of a trowel is practical when sample volumes of approximately 1 pint (0.5 liter) or less are to be obtained. Excess soil should be placed on plastic sheeting until sampling is completed. A trowel should be made of stainless steel or galvanized steel. It can be purchased from a hardware or garden store. Soil samples to be analyzed for organics should be collected using a stainless steel trowel. Samples may be placed directly from the trowel into sample containers.

## 2.3 SUBSURFACE SOIL SAMPLING

Subsurface soil sampling, in conjunction with borehole drilling, is required for soil sampling from depths greater than approximately 6 feet. Subsurface soil sampling is frequently coupled with exploratory boreholes or monitoring well installation. Refer to SOP Nos. 045, 046, and 047 (borehole drilling SOPs) and SOP No. 020 (Monitoring Well Installation).

Subsurface soil sampling may be conducted using a drilling rig or power auger. Selection of sampling equipment depends upon geologic conditions and the scope of the sampling program. Two types of samplers used with machine-driven augers—the split-spoon sampler and the thin-wall tube sampler—are discussed below. All sampling tools should be cleaned before and after each use in accordance with SOP No. 002 (General Equipment Decontamination). Both the split-spoon sampler and the thin-wall tube sampler can be used to collect undisturbed samples from unconsolidated soils. The procedures for using the split-spoon and thin-wall tube samplers are presented below.

### 2.3.1 Split-Spoon Sampler

Split-spoon samplers are available in a variety of types and sizes. Site conditions and project needs such as large sample volume for multiple analyses determine the specific type of split-spoon sampler to be used. Figure 3 shows a generic split-spoon sampler.

The split-spoon sampler is advanced into the undisturbed soil beneath the bottom of the casing or borehole using a weighted hammer and a drill rod. The relationship between hammer weight, hammer drop, and number of blows required to advance the split-spoon sampler in 6-inch increments indicates the density or consistency of the subsurface soil. After the split-spoon sampler has been driven to its intended depth, it should be removed carefully to avoid loss of sample material. In noncohesive or saturated soil, a catcher or basket should be used to help retain the sample.

After the split-spoon sampler is removed from the casing, it is detached from the drill rod and opened. If VOA samples are to be collected, VOA vials should be filled with soil taken directly from the split-spoon sampler. Samples for other specific chemical analyses should be taken as soon as the VOA sample has been collected. The remainder of the recovered soil can then be used for visual classification of the sample and containerized for physical analysis. The entire sample (except for the top several inches of possibly disturbed material) is retained for analysis or disposal.

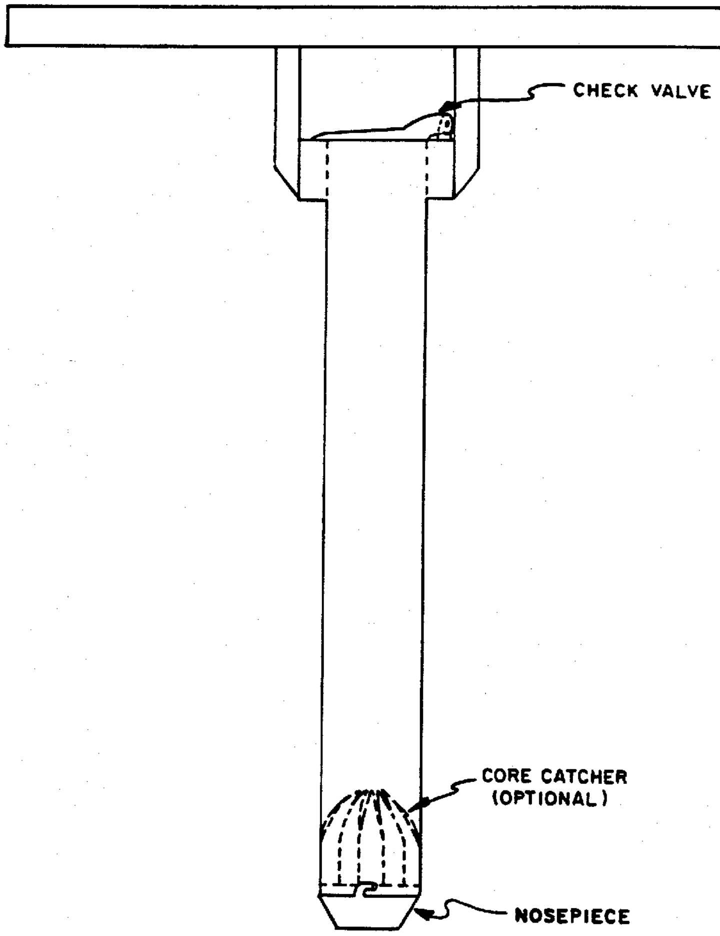
### 2.3.2 Thin-Wall Tube Sampler

A thin-wall tube sampler, sometimes called the Shelby tube (Figure 4), may be pressed or driven into soil inside a hollow-stem auger flight, wash bore casing, or uncased borehole. The tube sampler is pressed into the soil without rotation to the desired depth or until refusal. If the tube cannot be advanced by pushing, it may be necessary to drive it into the soil without rotation using a hammer and drill rod. The tube sampler is then rotated to collect the sample from the soil and removed from the borehole.

After removal of the tube sampler from the drilling equipment, the tube sampler should be inspected for adequate sample recovery. The sampling procedure should be repeated until an adequate soil core is obtained (if sample material can be retained by the tube sampler). The soil core obtained should be documented in the logbook. Any disturbed soil is removed from each end of the tube sampler. If chemical analysis is required, VOA samples must be collected immediately after the tube sampler is withdrawn. Before use, and during storage and transport, the tube sampler should be capped with a nonreactive material. For physical sampling parameters, the tube sampler should be sealed by pouring three 0.25-inch layers of sealing liquid (such as wax) in each end, allowing each layer to solidify before applying the next. The remaining space at each end of the tube is filled with Ottawa sand or other, similar sand, which is allowed to settle and compact. Plastic caps are then taped over the ends of the tube. The top and bottom of the tube sampler should be labeled and the tube sampler should be stored accordingly.

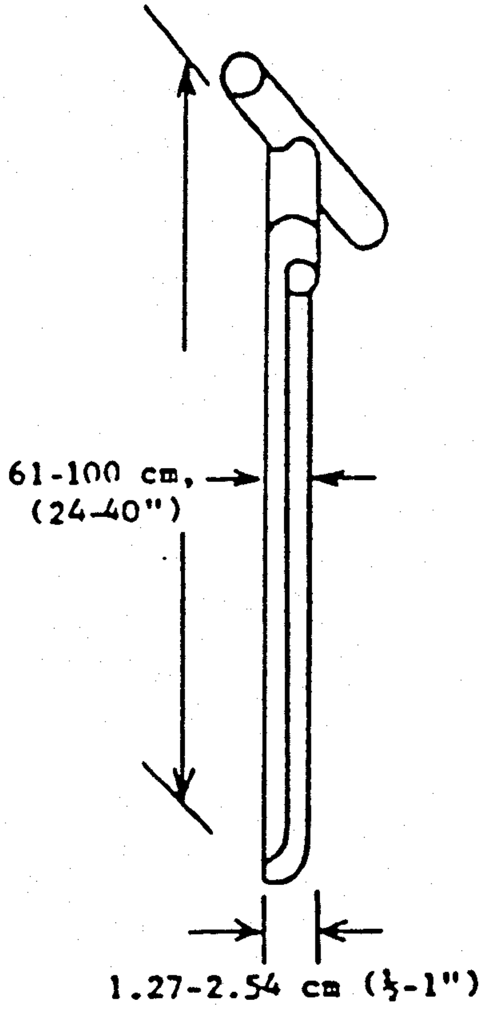
## FIGURE 1

## HAND-OPERATED CORE SAMPLER



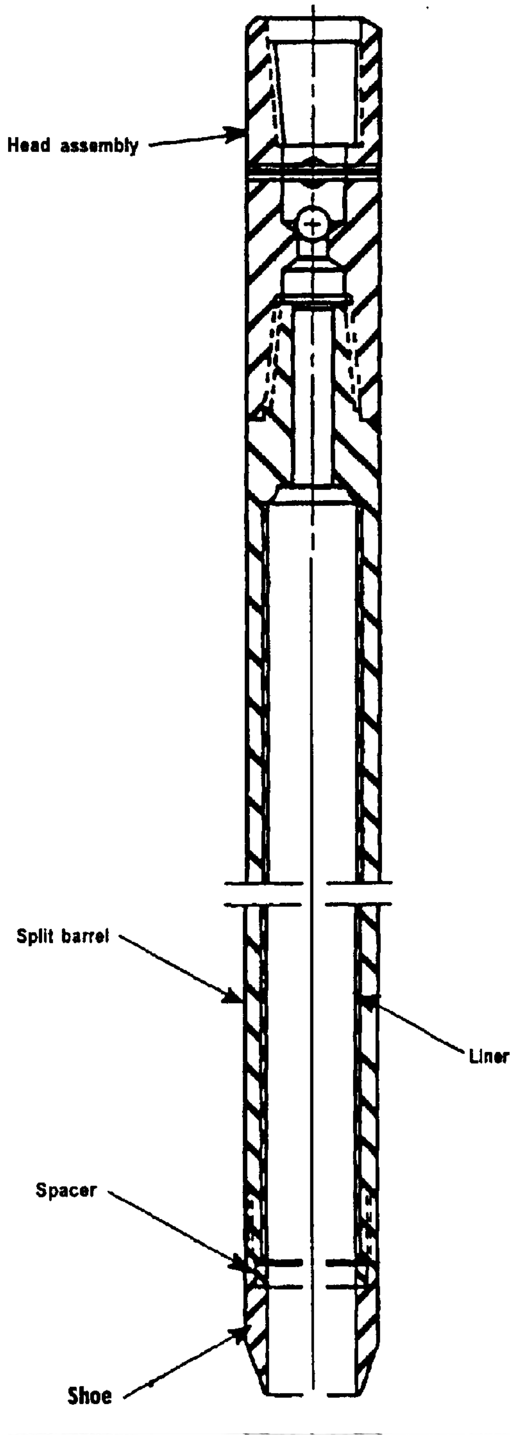
## FIGURE 2

## TRIER



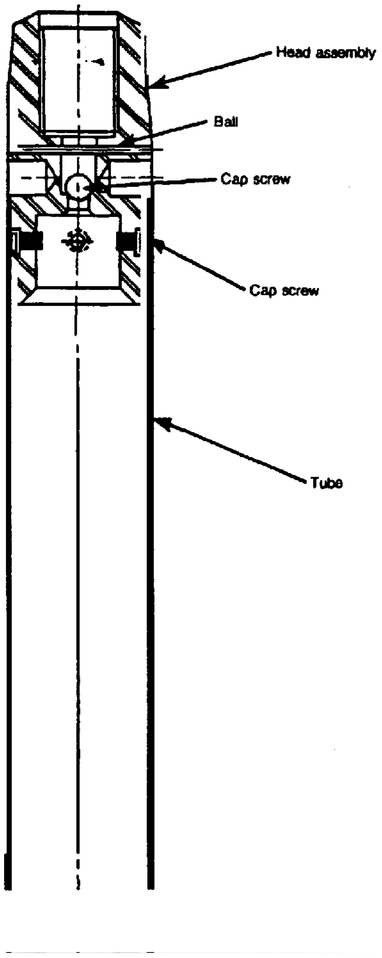
## FIGURE 3

## GENERIC SPLIT-SPOON SAMPLER



## FIGURE 4

## THIN-WALL TUBE SAMPLER



# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

## SURFACE WATER SAMPLING

**SOP NO. 009**

**REVISION NO. 3**

Last Reviewed: December 1999

K Riesing

Quality Assurance Approved

*May 19, 1993*

Date

## 1.0 BACKGROUND

Surface water sampling is conducted to determine the quality of surface water entering, leaving, or affected by a site. Surface water bodies that can be sampled include streams, rivers, lakes, ponds, lagoons, and surface impoundments. This standard operating procedure (SOP) discusses common methods of collecting grab samples that represent water quality in a water body at a particular point in time.

A series of grab samples also can be composited to represent water quality over a longer period of time. Composite samples can be flow proportional or time proportional. The details of compositing water samples are not included in this SOP.

### 1.1 PURPOSE

This SOP establishes the requirements and procedures for surface water sampling.

### 1.2 SCOPE

This SOP applies to surface water sampling and the instruments and methods used to collect the samples.

### 1.3 DEFINITIONS

**Kemmerer Sampler:** A messenger-activated water sampling device. Water flows through the device until the release mechanism is triggered to close the container.

**Peristaltic Pump:** A rotary, positive-displacement pumping device characterized by its low suction and rhythmic nature, and by the fact that the pump does not come into direct contact with the water being sampled.

**Pond Sampler:** A sampling device fabricated by using an adjustable beaker clamp to attach a beaker to a telescoping, heavy-duty aluminum pole.

## 1.4 REFERENCES

deVera, E.R., and others. 1980. “Samplers and Sampling Procedures for Hazardous Waste Streams.” EPA-600/2-80-018. January.

U.S. Environmental Protection Agency (EPA). 1977. “Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities.” EPA-530/SW-611. August.

EPA. 1984. “Characterization of Hazardous Waste Sites — A Methods Manual, Volume II. Available Sampling Methods.” Second Edition. EPA-600/4-84-076. December.

EPA. 1994. “Surface Water Sampling.” Environmental Response Team SOP #2013 (Rev. #0.0, 11/17/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

Surface water sampling requires a variety of procedures and instruments. The choice of procedure should be determined by site-specific conditions, such as the type of surface water body, the sampling depth, and the sample location’s distance from shore.

Samples can be collected from shallow depths by submerging the sample container. An intermediary disposable collection container or one constructed of a nonreactive material also may be used. A pond sampler, a peristaltic pump, or a Kemmerer sampler may be used to provide extended reach. The following equipment may be required to sample surface water:

- Decontamination materials
- Sample containers and labels
- Point-source bailer
- Dipper
- Boat
- Pond sampler
- Peristaltic pump with batteries or power source
- Silicone tubing
- Heavy-wall Teflon® tubing
- Kemmerer sampler
- Logbook or field sheets

- Chain-of-custody documentation
- Shipping materials

## 2.0 PROCEDURES

Safe access, handling, and other physical limitations should be influential factors during surface water sampling. A site-specific sampling plan should delineate which of the procedures described below will be used. Any deviations from the sampling plan should be recorded in the site-specific field logbook.

The following subsections provide detailed procedures for surface water sampling using specific instruments and methods. In all cases, select a sampling location where the water quality will best represent the water chemistry of the water body. Avoid stagnant or fast-moving areas. Do not sample immediately downstream of incoming tributaries, because of the likelihood of incomplete mixing.

### 2.1 SURFACE WATER SAMPLING BY SUBMERGING SAMPLE CONTAINER

Samples from shallow depths should be collected by submerging the sample container. This method is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This method should not be used for sampling lagoons or surface impoundments where contact with contaminants is a potential concern.

The following procedure can be used for sampling surface water by submerging the sample container:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements in SOP No. 017 (Sample Collection Container Requirements).

2. If required by the project, measure the temperature, pH, and specific conductance of the surface water body before collecting the sample using procedures in SOPs No. 11 (Field Measurement of Water Temperature), No. 12 (Field Measurement of pH in Water), and No. 13 (Field Measurement of Specific Conductance), respectively. Record this information on the field sheet or in the logbook.

3. For stream sampling, sample the location farthest downstream first. Orient the mouth of the sample container upstream while standing downstream so as not to stir up any sediment that would contaminate the sample.

4. For a larger body of surface water, such as a lake, collect samples near the shore, unless boats are feasible and permitted. Collect samples from shallow depths by submerging the sample container.

5. Collect surface water samples at each location before collecting sediment samples to avoid contaminating the water samples with excess suspended particles generated during sediment sampling.

6. Continue delivery of the sample until the container is almost full. If sampling for volatile organic compounds (VOC), the container must be completely filled leaving no head space.

7. Preserve the sample in accordance with requirements in SOP No. 16 (Sample Preservation and Maximum Holding Times). Ensure that a Teflon® liner is present in the cap of the sample container if required. Secure the cap tightly and affix a completed sample label to the container.

8. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

## 2.2 SURFACE WATER SAMPLING WITH TRANSFER DEVICE

A dipper, bailer, or other device made of inert material, such as stainless steel or Teflon®, can be used to transfer liquid samples from their source to a sample container. This prevents contamination of the outside of the sample container as a result of direct immersion in surface water. Depending on the sampling application, the transfer device may be either disposed of or reused. If reused, the device should be thoroughly rinsed and decontaminated prior to sampling a different source.

A transfer device can be used in most sampling situations. However, direct collection by submerging the sample container is the preferred method when (1) aeration of the sample must be avoided (as in sampling surface water for VOCs) or (2) a significant amount of the sample may be lost due to adhesion to the transfer device.

The following procedure can be used for sampling surface water with a dipper, bailer, or other transfer device:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements in SOP No. 017 (Sample Collection Container Requirements).

2. If required by the project, measure the temperature, pH, and specific conductance of the surface water body before collecting the sample using procedures in SOPs No. 11 (Field Measurement of Water Temperature), No. 12 (Field Measurement of pH in Water), and No. 13 (Field Measurement of Specific Conductance), respectively. Record this information on the field sheet or in the logbook.

3. With minimal surface water disturbance, submerge a precleaned dipper, bailer, or other transfer device.

4. Allow the device to fill slowly and continuously.

5. Retrieve the device from the surface water with minimal disturbance.

6. Remove the cap from the sample container. Slightly tilt the mouth of the container below the edge of the transfer device.

7. Empty the device slowly, allowing the sample to flow gently down the inside of the container with minimal entry turbulence. Continue delivery of the sample until the container is almost full. If sampling for VOCs, the container must be completely filled leaving no head space.

8. Preserve the sample in accordance with requirements in SOP No. 16 (Sample Preservation and Maximum Holding Times). Ensure that a Teflon® liner is present in the cap of the sample container if required. Secure the cap tightly and affix a completed sample label to the container.

9. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

10. Decontaminate the transfer device prior to reuse or storage using the procedures in SOP No. 002, General Equipment Decontamination.

### 2.3 SURFACE WATER SAMPLING WITH POND SAMPLER

A pond sampler may be used to collect liquid samples from ponds, pits, and lagoons (see Figure 1). A pond sampler is easily and inexpensively fabricated. To construct a pond sampler, use an adjustable clamp to attach a sampling beaker to the end of a two- or three-piece telescoping aluminum tube. The telescoping tube serves as the handle. Nondisposable equipment should be cleaned before and after each use.

The following procedure can be used for sampling surface water with a pond sampler:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements in SOP No. 017 (Sample Collection Container Requirements).

2. If required by the project, measure the temperature, pH, and specific conductance of the surface water body before collecting the sample using procedures in SOPs No. 11 (Field Measurement of Water Temperature), No. 12 (Field Measurement of pH in Water), and No. 13 (Field Measurement of Specific Conductance), respectively. Record this information on the field sheet or in the logbook.

3. Assemble the pond sampler. Ensure that the sampling beaker, bolts, and nuts securing the clamp to the pole are tightened properly.

4. Collect the sample by slowly submerging the precleaned beaker with minimal surface water disturbance.

5. Retrieve the pond sampler from the surface water with minimal disturbance.

6. Remove the cap from the sample container. Slightly tilt the mouth of the container below the edge of the beaker.

7. Empty the beaker slowly, allowing the sample to flow gently down the inside of the container with minimal entry turbulence. Continue delivery until the container is almost full. If sampling for VOCs, the container must be completely filled leaving no head space.

8. Preserve the sample in accordance with requirements in SOP No. 16 (Sample Preservation and Maximum Holding Times). Ensure that a Teflon® liner is present in the cap of the sample container if required. Secure the cap tightly and affix a completed sample label to the container.

9. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

10. Decontaminate the pond sampler prior to reuse or storage using the procedures in SOP No. 002, General Equipment Decontamination.

## 2.4 SURFACE WATER SAMPLING WITH PERISTALTIC PUMP

To extend reach in sampling efforts, a small peristaltic pump can be used (see Figure 2). A peristaltic pump draws the sample through heavy-wall Teflon® tubing and pumps it directly into the sample container. Use of a peristaltic pump allows the operator to reach out into a liquid body, to sample from a depth or to sweep the width of a narrow stream. A battery-powered pump is preferable because it eliminates the need for a direct current generator or an alternating current inverter.

If medical-grade silicone tubing is used in the peristaltic pump, it is suitable for sampling almost any parameter, including most organics. However, some VOC stripping may occur and some sample material may adhere to the tubing. Teflon® tubing may be used in place of silicon tubing on the intake side of the pump to minimize the amount of sample adherence to the tubing. If tubing is to be reused, it should be cleaned before and after each use. Depending on project requirements, it may be necessary to replace the Teflon® intake tubing and the pump silicon tubing between sampling locations to prevent cross contamination.

Procedures for sampling surface water with a peristaltic pump are summarized below:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements in SOP No. 017 (Sample Collection Container Requirements).

2. If required by the project, measure the temperature, pH, and specific conductance of the surface water body before collecting the sample using procedures in SOPs No. 11 (Field Measurement of Water Temperature), No. 12 (Field Measurement of pH in Water), and No. 13 (Field Measurement of Specific Conductance), respectively. Record this information on the field sheet or in the logbook.

3. Install clean, medical-grade silicone tubing in the pump head according to the manufacturer’s instructions. Allow enough tubing on the discharge side to facilitate delivery of liquid into the sample container. Allow only enough tubing on the suction end for attachment to the intake line. This will minimize sample contact with the tubing.

4. Select the length of intake tubing needed to reach the required sample location. Attach it to the intake side of the pump tubing. Heavy-wall Teflon® tubing of a diameter equal to that of the required pump tubing suits most applications. A heavier tubing wall will allow slightly greater lateral reach.

5. If possible, allow several liters of surface water to pass through the pump before collecting the sample. Collect this purge volume. Return it to the source after the samples have been withdrawn.

6. Fill the sample container by allowing the pump discharge to flow gently down the inside of the bottle with minimal entry turbulence. Continue delivery of the sample until the container is almost full. If sampling for VOCs, the container must be completely filled leaving no head space.

7. Preserve the sample in accordance with requirements in SOP No. 16 (Sample Preservation and Maximum Holding Times). Ensure that a Teflon® liner is present in the cap of the sample container if required. Secure the cap tightly and affix a completed sample label to the container.

8. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

9. Allow the pump to drain, and then disassemble it. Decontaminate the tubing before reuse using the procedures in SOP No. 002 (General Equipment Decontamination) or dispose of it.

## 2.5 SURFACE WATER SAMPLING WITH KEMMERER SAMPLER

The Kemmerer sampler (see Figure 3) is used to collect surface water samples when the required sample depth is greater than that which can be sampled with a pump. A Kemmerer sampler may be constructed of various materials to be compatible with the required analytical technique. The sampler should be cleaned before and after each use.

Procedures for sampling surface water with a Kemmerer sampler are summarized below:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements in SOP No. 017 (Sample Collection Container Requirements).

2. If required by the project, measure the temperature, pH, and specific conductance of the surface water body before collecting the sample using procedures in SOPs No. 11 (Field Measurement of Water Temperature), No. 12 (Field Measurement of pH in Water), and No. 13 (Field Measurement of Specific Conductance), respectively. Record this information on the field sheet or in the logbook.

3. Inspect the body of the Kemmerer sampler to ensure that the drain line valve is closed, as appropriate. Measure and mark the sample line (cable) at the desired sampling depth.

4. Open the sampler by lifting the upper stopper-trip head assembly.

5. Gradually lower the sampler into the surface water until the sample liquid reaches the sample line.

6. Place a messenger on the sample line and release it, closing the sampler.

7. Retrieve the sampler. Prevent accidental opening of the lower stopper by holding the center rod of the sampler.

8. Rinse or wipe off the exterior of the sampler. Recover the sample by grasping the lower stopper and sampler body with one hand. Transfer the sample by lifting the upper stopper with the other hand and carefully pouring the contents into the sample container. If a drain line valve is present, hold the valve over the sample container, and open the valve slowly to release the sample.

9. Transfer the sample slowly, allowing it to flow gently down the inside of the container with minimal entry turbulence. Continue delivery until the container is almost full. If sampling for VOCs, the container must be completely filled leaving no head space.

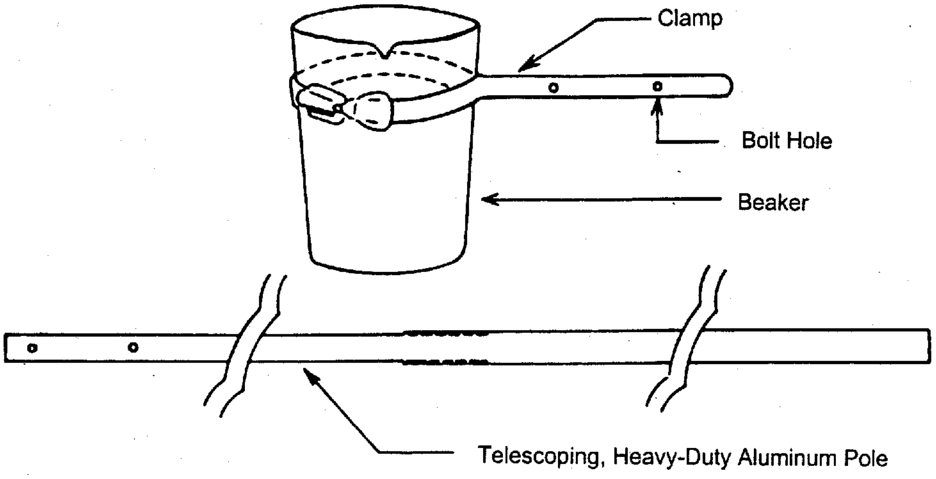
10. Preserve the sample in accordance with requirements in SOP No. 16 (Sample Preservation and Maximum Holding Times). Ensure that a Teflon® liner is present in the cap of the sample container if required. Secure the cap tightly and affix a completed sample label to the container.

11. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

12. Decontaminate the Kemmerer sampler prior to reuse or storage using the procedures in SOP No. 002, General Equipment Decontamination.

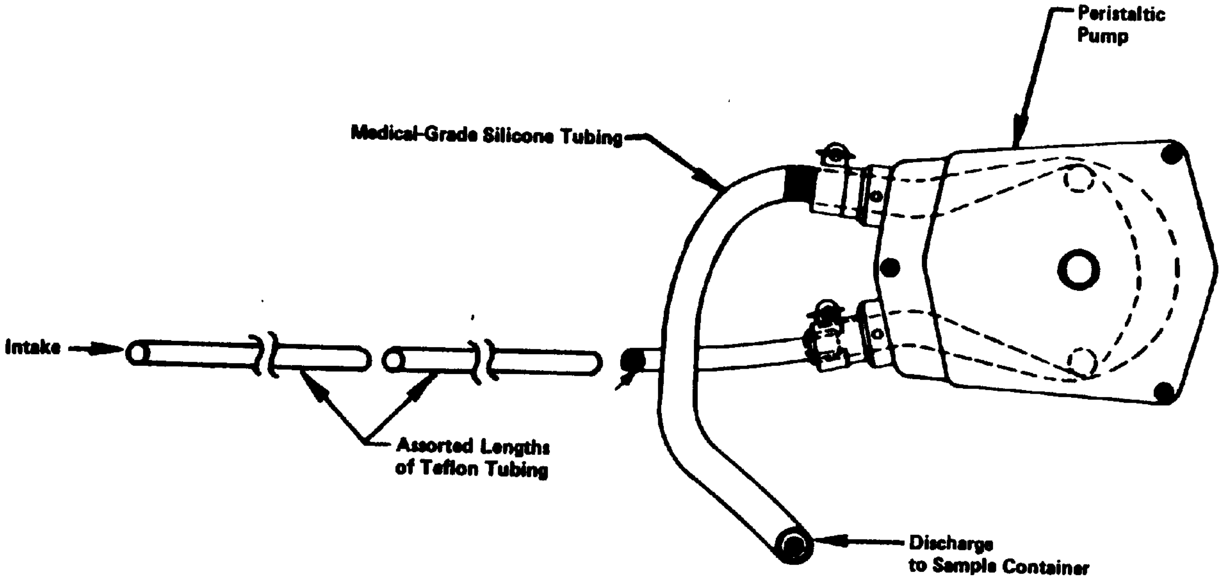
**FIGURE 1**

**POND SAMPLER**



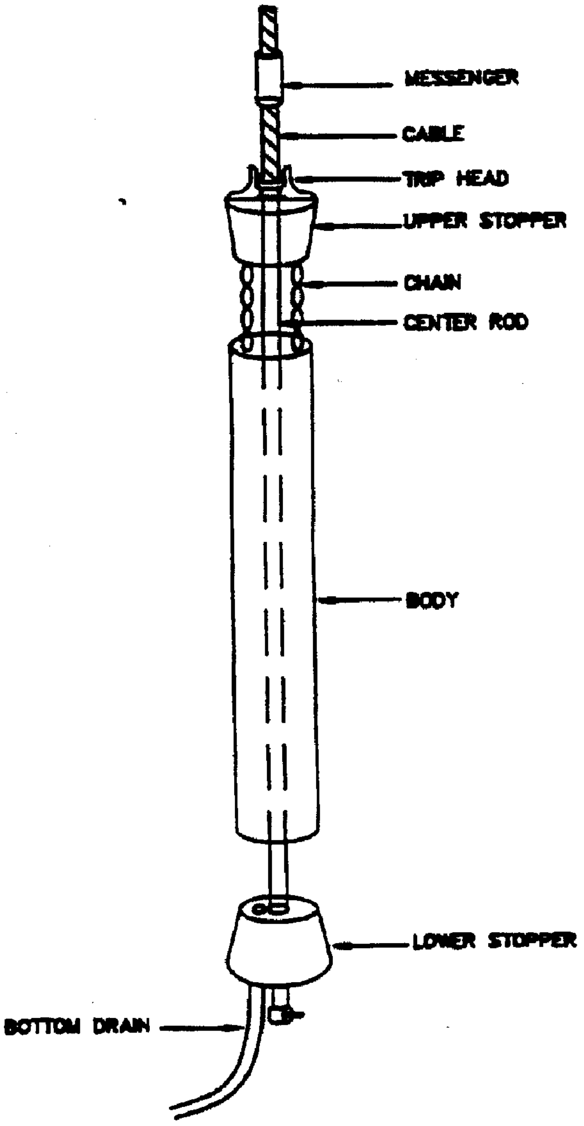
## FIGURE 2

## PERISTALTIC PUMP FOR LIQUID SAMPLING



## FIGURE 3

## KEMMERER SAMPLER



# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# STATIC WATER LEVEL, TOTAL WELL DEPTH, AND IMMISCIBLE LAYER MEASUREMENT

## SOP NO. 014

## REVISION NO. 0

Last Reviewed: December 1999

KRiesing

Quality Assurance Approved

*July 20, 1994*

Date

## 1.0 BACKGROUND

Measurement of static water level, total well depth, and any immiscible layers is necessary before a well can be sampled and groundwater flow direction can be determined. If an immiscible layer is present, its depth and thickness must be determined. In addition, the static water level and total depth of a monitoring well are needed to determine a purging volume.

### 1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidelines for field personnel measuring static water levels and total water depths of monitoring wells or piezometers. This SOP also provides guidelines for measuring immiscible layers in such wells.

### 1.2 SCOPE

This SOP describes the methodologies for measuring static water level, total well depth, and immiscible layer depth and thickness.

### 1.3 DEFINITIONS

To clarify the methodologies presented in this SOP, the following definitions are presented:

**Electrical Water Level Indicator:** An electrical probe used to determine the depth to fluid. The probe has a light or sound alarm connected to an open circuit. The circuit is closed and the alarm is activated when the probe contacts a conducting fluid such as water.

**Immiscible Layer:** A liquid phase that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink in water; light immiscible phases float on water.

**Interface Probe:** An electrical probe used to determine the thicknesses of light or dense immiscible layers in the water column of a monitoring well.

**Ionization Detector:** A photoionization detector (PID) or a flame ionization detector (FID) is used to measure the level of volatile organic compounds in the gaseous phase. These units are generally not compound-specific and thus measure only total volatile organic compounds. The PID generally cannot detect as complete a range of compounds as the FID. This difference is the result of the relative ionization energies of the two detectors. Most PIDs cannot detect methane, but FIDs can. The HNu and Microtip are examples of PIDs; the Foxboro organic vapor analyzer (OVA) is an example of an FID.

**Static Water Level:** The level of water in a monitoring well or piezometer. This level can be measured as the depth to water or as the elevation of water relative to a reference mark or datum.

**Total Well Depth:** The distance from the ground surface to the bottom of a monitoring well or piezometer

## 1.4 REFERENCES

SOP No. 002, General Equipment Decontamination

U.S. Environmental Protection Agency. 1994. “Water Level Measurement.” Environmental Response Team SOP #2043 (Rev. #0.0, 10/03/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

The equipment required for measuring static water levels, total well depths, and immiscible layers is as follows:

- Electrical water level indicator
- Interface probe
- PID or FID

## 2.0 PROCEDURES

This section provides general guidance followed by specific procedures for static water level, total well depth, and immiscible layer measurement.

Techniques for measuring depth to water and depth to the bottom of a monitoring well should be identified in the planning stage of field work. Also at this stage, measuring devices should be chosen, and an individual should be assigned to take and record measurements.

All measurement instruments should be decontaminated before and after use and between measurement locations. Refer to SOP No. 002, General Equipment Decontamination.

Before initiating any measuring activities, the ambient air at a monitoring well head should be monitored for possible emissions of volatile organic compounds. To accomplish this monitoring, a PID or an FID should be used. The health and safety plan for on-site activities should provide action levels and the rationale for selection of either detector.

Appropriate respiratory protection equipment should be worn by the sampling team. Wells should be approached from the upwind side. When opening the monitoring well, the sampling team should systematically survey the inside of the well casing, the area from the casing to the ground, the area from above the well casing to the breathing zone, and the area around the well. Readings for comparison to action levels should be taken not within the well casing but in the breathing zone. If PID or FID readings of volatile organic compounds are above action levels, the sampling team should retreat to a safe area and put on appropriate safety gear. The site-specific health and safety plan should be consulted for action levels.

### 2.1 STATIC WATER LEVEL MEASUREMENT

The procedure described below should be followed to measure the static water level in a monitoring well or piezometer.

An electric water level indicator is typically used for static water level measurement. The electrical probe of the indicator should be lowered into the monitoring well until the light or sound alarm is activated, indicating that the probe has touched the water surface. The static water level should then be read directly from the indicator to the 0.01-foot fraction. If the monitoring well top is not flush with the ground surface, the distance between the static water level and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth to static water below ground surface. If surveyed elevations are available, they should be used to establish the water level elevation. To ensure measurement accuracy, the probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the values should be averaged. The measurement date and time, individual readings, and the average of the readings should be recorded in a field logbook.

## 2.2 TOTAL WELL DEPTH MEASUREMENT

The procedure described below should be followed to measure total well depth in a monitoring well or piezometer.

Total well depth measurement can be performed also using an electric water level indicator. The electrical probe of the indicator should be lowered into the monitoring well until resistance is met, indicating that the probe has reached the bottom of the well. The total well depth should then be read directly from the indicator to the 0.01-foot fraction. If the monitoring well top is not flush with the ground surface, the distance between the bottom of the well and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth from ground surface to the bottom of the well. To ensure measurement accuracy, the probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the values should be averaged. The measurement date and time, individual readings, and the average of the readings should be recorded in a field logbook.

## 2.3 IMMISCIBLE LAYER DETECTION AND MEASUREMENT

The procedure described below should be followed to detect and measure an immiscible layer in a monitoring well.

A light immiscible layer in a monitoring well can be detected by slowly lowering an interface probe to the surface of the water in the well. When the audible alarm sounds, the depth of the probe should be recorded. If the alarm is continuous, a light immiscible layer has been detected. To measure the thickness of this layer, the probe should then be lowered until the alarm changes to an oscillating signal. The oscillating alarm indicates that the probe has reached a water layer. The probe depth at the time the alarm begins oscillating should be recorded as the depth to water. The thickness of the light immiscible layer should then be determined by subtracting the depth at which a continuous alarm occurred from the depth at which the alarm began to oscillate. To ensure measurement accuracy, the interface probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the depths and thicknesses measured should be averaged. The measurement date and time, individual readings for depth and thickness, and average values for depth and thickness should be recorded in a field logbook.

To determine whether a dense immiscible layer is present, the interface probe should be lowered further into the monitoring well. If the alarm changes from an oscillating to a continuous signal, a heavier immiscible layer has been detected, and the probe depth should be recorded at that point. Total well depth obtained in Section 2.2 should be used for calculating the thickness of the dense layer. The dense layer should be calculated by subtracting the depth at which the alarm became continuous from the total well depth. This procedure provides an estimate of the thickness of the dense layer in the monitoring well. To ensure measurement accuracy, the interface probe should be left hanging above the water surface in the monitoring well; a series of three readings should be taken, and the depths and thicknesses measured should be averaged. The measurement date and time, individual readings for depth and thickness, and average values for depth and thickness should be recorded in a field logbook.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

## GROUNDWATER SAMPLE COLLECTION USING MICROPURGE TECHNOLOGY

**SOP NO. 015**

**REVISION NO. 0**

Last Reviewed: January 2000

KRiesing

Quality Assurance Approved

*April 7, 1998*

Date

## 1.0 BACKGROUND

Groundwater sample collection is an integral part of site characterization at many contaminant release investigation sites. Often, a requirement of groundwater contaminant investigation is to evaluate contaminant concentrations in the aquifer. Since data quality objectives of most investigations require a laboratory setting for chemical analysis, samples must be collected from the aquifer and submitted to a laboratory for analysis. Therefore, sample collection and handling must be conducted in a manner that minimizes alteration of chemical characteristics of the groundwater.

In the past, most sample collection techniques followed federal and state guidance. Acceptable protocol included removal of water in the casing of a monitoring well (purging), followed by sample collection. The water in the casing was removed so groundwater from the formation could flow into the casing and be available for sample collection. Sample collection was commonly completed with a bailer, bladder pump, controlled flow impeller pump, or peristaltic pump. Samples were preserved during collection. Often, samples to be analyzed for metals contamination were filtered through a 0.45-micron filter prior to preservation and placement into the sample container.

Research conducted by several investigators has demonstrated that a significant component of contaminant transport occurs while the contaminant is sorbed onto colloid particles. Colloid mobility in an aquifer is a complex, aquifer-specific transport issue, and its description is beyond the scope of this Standard Operating Procedure (SOP). However, concentrations of suspended colloids have been measured during steady state conditions and during purging activities. Investigation results indicate standard purging procedures can cause a significant increase in colloid concentrations, which in turn may bias analytical results.

Micropurge sample collection provides a method of minimizing increased colloid mobilization by removing water from the well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. During micropurge sampling, groundwater is discharged from the aquifer at a rate that the aquifer will yield without creating a cone of depression around the sampled well. Research indicates that colloid mobilization will not increase above steady-state conditions during low-flow discharge. Therefore, the collected sample is more likely to represent steady-state groundwater chemistry.

## 1.1 PURPOSE

The purpose of this SOP is to describe the procedures to be used to collect a groundwater sample from a well using the micropurge technology. The following sections describe the equipment to be used and the methods to be followed to promote uniform sample collection techniques by field personnel that are experienced in sample collection and handling for environmental investigations.

## 1.2 SCOPE

This SOP applies to groundwater sampling using the micropurge technology. It is intended to be used as an alternate SOP to the general "Groundwater Sampling" SOP (SOP No. 10) that provides guidance for the general aspects of groundwater sampling.

## 1.3 DEFINITIONS

**Colloid:** Suspended particles that range in diameter from 5 nanometers to 0.2 micrometers.

**Dissolved oxygen:** The ratio of the concentration or mass of oxygen in water relative to the partial pressure of gaseous oxygen above the liquid which is a function of temperature, pressure, and concentration of other solutes.

**Flow-through cell:** A device connected to the discharge line of a groundwater purge pump that allows regular or continuous measurement of selected parameters of the water and minimizes contact between the water and air.

**pH:** The negative base-10 log of the hydrogen-ion activity in moles per liter.

**Reduction and oxidation potential:** A numerical index of the intensity of oxidizing or reducing conditions within a system, with the hydrogen-electrode potential serving as a reference point of zero volts.

**Specific conductance:** The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of aqueous solution at a specified temperature.

**Turbidity:** A measurement of the suspended particles in a liquid that have the ability to reflect or refract part of the visible portion of the light spectrum.

## 1.4 REFERENCES

Puls, R. W. and M. J. Barcelona. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. U.S. Environmental Protection Agency. Office of Research and Development. EPA/540/S-95/504. April.

## 1.5 REQUIREMENTS AND RESOURCES

The following equipment is required to complete micropurge sample collection :

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, or impeller)
- Discharge flow controller
- Flow-through cell
- pH probe
- Dissolved oxygen (DO) probe
- Turbidity meter
- Oxidation and reduction (Redox or Eh) probe
- Specific conductance (SC) probe (optional)
- Temperature probe (optional)
- Meter to display data for the probes
- Calibration solutions for pH, SC, turbidity, and DO probes, as necessary
- Container of known volume for flow measurement or calibrated flow meter
- Data recording and management system

## 2.0 PROCEDURE

The following procedures and criteria were modified from the U. S. Environmental Protection Agency guidance titled “Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures” (Puls and Barcelona 1996). This reference may be consulted for a more detailed description of micropurge sampling theory.

Micropurging is most commonly accomplished with low-discharge rate pumps, such as bladder pumps, piston pumps, controlled velocity impeller pumps, or peristaltic pumps. Bailers and high capacity submersible pumps are not considered acceptable micropurge sample collection devices. The purged water is monitored (in a flow-through cell or other constituent monitoring device) for chemical and optical parameters that indicate steady state flow conditions between the sample extraction point and the aquifer. Samples are collected when steady state conditions are indicated.

Groundwater discharge equipment may be permanently installed in the monitoring well as a dedicated system, or it can be installed in each well as needed. Most investigators agree that dedicated systems will provide the best opportunity for collecting samples most representative of steady state aquifer conditions, but the scope of a particular investigation and available investigation funds will dictate equipment selection.

### 2.1 EQUIPMENT CALIBRATION

Prior to sample collection, the monitoring equipment used to measure pH, Eh, DO, turbidity, and SC should be calibrated or checked according to manufacturer’s directions. Typically, calibration activities are completed at the field office at the beginning of sampling activities each day. The pH meter calibration should bracket the pH range of the wells to be sampled (acidic to neutral pH range [4.00 to 7.00] or neutral to basic pH range [7.00 to 10.00]). The DO meter should be calibrated to one point (air-saturated water) or two points (air-saturated water and water devoid of all oxygen). The SC meter cannot be calibrated in the field. It is checked against a known standard (typical standards are 1, 10, and 50 millimhos per centimeter at 25 EC). The offset of the measured value of the calibration standard can be used as a correction value. Similarly, the Eh probe cannot be calibrated in the field, but is checked against a known standard, such as Zobell solution. The instrument should display a millivolt (mv) value that falls within the range set by the manufacturer. Because Eh is temperature dependent, the measured value should be corrected for site-specific variance from standard temperature (25 EC). The Eh probe should be replaced if the reading is not within the manufacturer's specified range. All calibration data should be recorded on the Micropurging Groundwater Sampling Data Sheet attached to this SOP or in a logbook.

## 2.2 WELL PURGING

The well to be sampled should be opened and groundwater in the well allowed to equilibrate to atmospheric pressure. Equilibration should be determined by measuring depth to water below the marked reference on the wellhead (typically the top of the well casing) over two or more 5-minute intervals. Equilibrium conditions exist when the measured depth to water varies by less than 0.01 foot over two consecutive readings. Total depth of well measurement should be made following sample collection, unless the datum is required to place nondedicated sample collection equipment. Depth to water and total well depth measurements should be made in accordance with procedures outlined in SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement).

If the well does not have a dedicated sample collection device, a new or previously decontaminated portable sample collection device should be placed within the well. The intake of the device should be positioned at the midpoint of the well screen interval. The device should be installed slowly to minimize turbulence within the water in the casing and mixing of stagnant water above the screened interval with water in the screened interval. Following installation, the flow controller should be connected to the sample collection device and the flow-through cell connected to the outlet of the sample collection device. The calibrated groundwater chemistry monitoring probes should be installed in the flow-through cell. If a flow meter is used, it should be installed ahead of the flow-through cell.

If the well has a dedicated sample collection device, the controller for the sample collection device should be connected to the sample collection device. The flow meter and flow-through cell should be connected in line to the discharge tube, and the probes installed in the flow-through cell.

The controller should be activated and groundwater extracted (purged) from the well. The purge rate should be monitored, and should not exceed the capacity of the well. The well capacity is defined as the maximum discharge rate that can be obtained with less than 0.1 meter (0.3 foot) drawdown. Typically, the discharge rate will be less than 0.5 liters per minute (L/min) (0.13 gallons per minute). The maximum purge rate should not exceed 1 L/min (0.25 gallons per minute), and should be adjusted to achieve minimal drawdown.

Water levels, effluent chemistry, and effluent flow rate should be continuously monitored while purging the well. Purging should continue until the measured chemical and optical parameters are stable. Stable parameters are defined as monitored chemistry values that do not fluctuate by more than the following ranges over three successive readings at 3-minute intervals: ±0.1 pH unit; ±3 percent for SC; ±10 mv for Eh; and ±10 percent for turbidity and DO. Purging will continue until these stabilization criteria have been met or three well casing volumes have been purged. If three casing volumes of water have been purged and the stabilization criteria have not been met, a comment should be made on the data sheet that sample collection began after three well casing volumes were purged. The final pH, SC, Eh, turbidity, and DO values will be recorded. All data should be recorded on the Micropurging Groundwater Sampling Data Sheet attached to this SOP or in a logbook.

## 2.3 SAMPLE COLLECTION

Following purging, the flow through cell shall be disconnected, and groundwater samples collected directly from the discharge line. Discharge rates should be adjusted so that groundwater is dispensed into the sample container with minimal aeration of the sample. Samples collected for volatile organic compound analysis should be dispensed into the sample container at a flow rate equal to or less than 100 milliliters per minute. Samples should be preserved and handled as described in the investigation field sampling plan or quality assurance project plan.

Tetra Tech EM Inc.

# MICROPURGING GROUNDWATER SAMPLING DATA SHEET

Page ______ of ______
Date ____________

**Well Name** ____________________
Project ____________________
Project No. ____________________
Well Location ____________________
**Sample Date** ____________________
Sampling Personnel ____________________
____________________
____________________
**Sample ID** ____________________
**Duplicate ID** ____________________

Screen Interval ____________________
Station Elevation ________ GND ____ TOC ______
Static Water Level (from TOC) ____________
Well Stick Up ____________________
Static Elevation ____________________
Well Depth __________ MEAS ____ RPTD ______
Feet of Water ____________________
Gallons/Foot ____________________
Casing Volume ____________________

Immiscible Phases Present ☐ Yes ☐ No
Type ____________________
Measured with ____________________
PID Readings (background) ____________
PID Reading (TOC) ____________________
Wells Installed by ____________________
Installation Date ____________________
Development Date(s) ____________________

**FIELD CHEMISTRY CALIBRATIONS**

Date/Time ____________________ Spec. Conductance: Standard ________ µmhos/cm at 25EC Reading ________ µmhos/cm at _____EC
pH: pH 4.00 - _______ at ________ EC pH 7.00 - _______ at ________ EC pH 10.00 - ______ at _______ EC Slope ______________
Dissolved Oxygen: D.O. Meter _______ mg/L at _______EC PID: Calibration Gas __________ PPM ______ Span ______ Reading __________

**PURGING**

| Time | Discharge Rate (mL/min) | Dissolved Oxygen (mg/L) | pH | Eh/ORP (mV) | Temp. (EC) | Specific Conduct. (µmhos/cm at EC) | Turbidity (NTU) | Cumulative Volume of Water Removed (Purged) |  | PID/OVA Reading |  | Depth to Water (ft) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  | Gallons | Casing Vol. | Location | Value |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**SAMPLE PARAMETERS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Condition of well: ________________________________________

Remarks: ________________________________________

**FIELD EQUIPMENT**

pH Meter ____________________ Serial Number ____________________
Spec. Cond. Meter ____________________ Serial Number ____________________
Pump ____________________ Serial Number ____________________
Water Level Meter ____________________ Serial Number ____________________
D.O. Meter ____________________ Serial Number ____________________
Filter Apparatus ____________________ Filters ____________________
Temperature Measure ________________________________________
Interface Probe ____________________ Serial Number ____________________
PID/OVA ____________________ Serial Number ____________________

**Field Chemistry Calibrations**

Fractions ____________________
____________________
____________________
Number of Bottles ____________________
Sample Depth ____________________
Field Notebook ____________________
Sample Method ____________________
____________________
Discharge Water Containerized ☐ Yes ☐ No

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# PACKAGING AND SHIPPING SAMPLES

## SOP NO. 019

## REVISION NO. 5

Last Reviewed: January 2000

RRiesing

Quality Assurance Approved

*January 28, 2000*

Date

## 1.0 BACKGROUND

In any sampling program, the integrity of a sample must be ensured from its point of collection to its final disposition. Procedures for classifying, packaging, and shipping samples are described below. Steps in the procedures should be followed to ensure sample integrity and to protect the welfare of persons involved in shipping and receiving samples. When hazardous substances and dangerous goods are sent by common carrier, their packaging, labeling, and shipping are regulated by the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR, *Code of Federal Regulations*, Title 49 [49 CFR] Parts 106 through 180) and the International Air Transportation Association (IATA) Dangerous Goods Regulations (DGR).

### 1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for packaging and shipping samples. It has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) "Sampler's Guide to the Contract Laboratory Program (CLP)," the DGR, and the HMR. Sample packaging and shipping procedures described in this SOP should be followed for all sample packaging and shipping. Deviations from the procedures in this SOP must be documented in a field logbook. This SOP assumes that samples are already collected in the appropriate sample jars and that the sample jars are labeled and tagged appropriately.

### 1.2 SCOPE

This SOP applies to sample classification, packaging, and shipping.

### 1.3 DEFINITIONS

**Custody seal:** A custody seal is a tape-like seal. Placement of the custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been packaged for shipping.

**Dangerous goods:** Dangerous goods are articles or substances that can pose a significant risk to health, safety, or property when transported by air; they are classified as defined in Section 3 of the DGR (IATA 1999).

**Environmental samples:** Environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, and biological specimens. Environmental samples typically contain low concentrations of contaminants and when handled require only limited precautionary procedures.

**Hazardous Materials Regulations:** The HMR are DOT regulations for the shipment of hazardous materials by air, water, and land; they are located in 49 CFR 106 through 180.

**Hazardous samples:** Hazardous samples include dangerous goods and hazardous substances. Hazardous samples shipped by air should be packaged and labeled in accordance with procedures specified by the DGR; ground shipments should be packaged and labeled in accordance with the HMR.

**Hazardous substance:** A hazardous substance is any material, including its mixtures and solutions, that is listed in Appendix A of 49 CFR 172.101 and its quantity, in one package, equals or exceeds the reportable quantity (RQ) listed in the appendix.

**IATA Dangerous Goods Regulations:** The DGR are regulations that govern the international transport of dangerous goods by air. The DGR are based on the International Civil Aviation Organization (ICAO) Technical Instructions. The DGR contain all of the requirements of the ICAO Technical Instructions and are more restrictive in some instances.

**Nonhazardous samples:** Nonhazardous samples are those samples that do not meet the definition of a hazardous sample and **do not** need to be packaged and shipped in accordance with the DGR or HMR.

**Overpack:** An enclosure used by a single shipper to contain one or more packages and to form one handling unit (IATA 1999). For example, a cardboard box may be used to contain three fiberboard boxes to make handling easier and to save on shipping costs.

## 1.4 REFERENCES

U.S. Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico (DOT and others). 1996. “1996 North American Emergency Response Guidebook.”

International Air Transport Association (IATA). 1997. “Guidelines for Instructors of Dangerous Courses.”

IATA. 1999. “Dangerous Goods Regulations.” 40th Edition.

U.S. Environmental Protection Agency. 1996. “Sampler’s Guide to the Contract Laboratory Program.” Office of Solid Waste and Emergency Response. Washington, DC. EPA/540/R-96/032. On-Line Address: http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm#sample

## 1.5 REQUIREMENTS AND RESOURCES

The procedures for packaging and shipping **nonhazardous** samples require the following:

- Coolers
- Ice
- Vermiculite, bubble wrap, or similar cushioning material
- Chain-of-custody forms and seals
- Airbills
- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)

The procedures for packaging and shipping **hazardous** samples require the following:

- Ice
- Vermiculite or other non-combustible, absorbent packing material
- Chain-of-custody forms and seals
- Appropriate dangerous goods airbills and emergency response information to attach to the airbill

- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)
- Appropriate shipping containers as specified in the DGR
- Labels that apply to the shipment such as hazard labels, address labels, "Cargo Aircraft Only" labels, and package orientation labels (up arrows)

## 2.0 PROCEDURES

The following procedures apply to packaging and shipping nonhazardous and hazardous samples.

### 2.1 SAMPLE CLASSIFICATION

Prior to sample shipment, it must be determined whether the sample is subject to the DGR. Samples subject to these regulations shall be referred to as hazardous samples. If the hazardous sample is to be shipped by air, then the DGR should be followed. Any airline, including FedEx, belonging to IATA must follow the DGR. As a result, FedEx **may not** accept a shipment that is packaged and labeled in accordance with the HMR (although in most cases, the packaging and labeling would be the same for either set of regulations). The HMR states that a hazardous material may be transported by aircraft in accordance with the ICAO Technical Instruction (49 CFR 171.11) upon which the DGR is based. Therefore, the use of the DGR for samples to be shipped by air complies with the HMR, but not vice versa.

Most environmental samples are not hazardous samples and do not need to be packaged in accordance with any regulations. Hazardous samples are those samples that can be classified as specified in Section 3 of the DGR, can be found in the List of Dangerous Goods in the DGR in bold type, are considered a hazardous substance (see definition), or are mentioned in "Section 2 - Limitations" of the DGR for countries of transport or airlines (such as FedEx). The hazard classifications specified in the DGR (and the HMR) are as follows:

Class 1 - Explosives

Division 1.1 - Articles and substances having a mass explosion hazard

Division 1.2 - Articles and substances having a projection hazard but not a mass explosion hazard
Division 1.3 - Articles and substances having a fire hazard, a minor blast hazard and/or a minor projection hazard but not a mass explosion hazard
Division 1.4 - Articles and substances presenting no significant hazard
Division 1.5 - Very sensitive substances mass explosion hazard
Division 1.6 - Extremely insensitive articles which do not have a mass explosion hazard

Class 2 - Gases

Division 2.1 - Flammable gas
Division 2.2 - Non-flammable, non-toxic gas
Division 2.3 - Toxic gas

Class 3 - Flammable Liquids

Class 4 - Flammable Solids; Substances Liable to Spontaneous Combustion; Substances, which, in Contact with Water, Emit Flammable Gases

Division 4.1 - Flammable solids.
Division 4.2 - Substances liable to spontaneous combustion.
Division 4.3 - Substances, which, in contact with water, emit flammable gases.

Class 5 - Oxidizing Substances and Organic Peroxide

Division 5.1 - Oxidizers.
Division 5.2 - Organic peroxides.

Class 6 - Toxic and Infectious Substances

Division 6.1 - Toxic substances.
Division 6.2 - Infectious substances.

Class 7 - Radioactive Material

Class 8 - Corrosives

Class 9 - Miscellaneous Dangerous Goods

The criteria for each of the first eight classes are very specific and are outlined in Section 3 of the DGR and 49 CFR 173 of the HMR. Some classes and divisions are further divided into packing groups based on their level of danger. Packing group I indicates a great danger, packing group II indicates a medium danger, and packing group III indicates a minor danger. Class 2, gases, includes any compressed gas being

shipped and any noncompressed gas that is either flammable or toxic. A compressed gas is defined as having a pressure over 40 pounds per square inch (psi) absolute (25 psi gauge). Most air samples and empty cylinders that did not contain a flammable or toxic gas are exempt from the regulations. An empty hydrogen cylinder, as in a flame ionization detector (FID), is considered a dangerous good unless it is properly purged with nitrogen in accordance with the HMR. A landfill gas sample is usually considered a flammable gas because it may contain a high percentage of methane. Class 3, flammable liquids, are based on the boiling point and flash point of a substance. Most class 3 samples include solvents, oil, gas, or paint-related material collected from drums, tanks, or pits. Division 6.1, toxic substances, is based on oral toxicity ($LD_{50}$ [lethal dose that kills 50 percent of the test animals]), dermal toxicity ($LD_{50}$ values), and inhalation toxicity ($LC_{50}$ [lethal concentration that kills 50 percent of the test animals] values).
Division 6.1 substances include pesticides and cyanide. Class 7, radioactive material, is defined as any article or substance with a specific activity greater than 70 kiloBecquerels (kBq/kg) (0.002 [microCuries per gram [µCi/g]). If the specific activity exceeds this level, the sample should be shipped in accordance with Section 10 of the DGR. Class 8, corrosives, are based on the rate at which a substance destroys skin tissue or corrodes steel; they are not based on pH. Class 8 materials include the concentrated acids used to preserve water samples. Preserved water samples are not considered class 8 substances and should be packaged as nonhazardous samples. Class 9, miscellaneous dangerous goods, are substances that present a danger but are not covered by any other hazard class. Examples of class 9 substances include asbestos, polychlorinated biphenyls (PCB), and dry ice.

Unlike the DGR, the HMR includes combustible liquids in hazard class 3. The definition of a combustible liquid is specified in 49 CFR 173.120 of the HMR. The HMR has an additional class, ORM-D, that is not specified in the DGR. "ORM-D material" refers to a material such as a consumer commodity, that although otherwise subject to the HMR, presents a limited hazard during transport due to its form, quantity, and packaging. It must be a material for which exceptions are provided in the table of 49 CFR 172.101. The DGR lists consumer commodities as a class 9 material.

In most instances, the hazard of a material sampled is unknown because no laboratory testing has been conducted. A determination as to the suspected hazard of the sample must be made using knowledge of the site, field observations, field tests, and other available information.

According to 40 CFR 261.4(d) and (e), samples transported to a laboratory for testing or treatability studies, including samples of hazardous wastes, are **not** hazardous wastes. FedEx will not accept a shipment of hazardous waste.

## 2.2 PACKAGING NONHAZARDOUS SAMPLES

Nonhazardous samples, after being appropriately containerized, labeled, and tagged, should be packaged in the following manner. Note that these are general instructions; samplers should be aware of any client-specific requirements concerning the placement of custody seals or other packaging provisions.

1. Place the sample in a resealable plastic bag.
2. Place the bagged sample in a cooler and pack it to prevent breakage.
3. Prevent breakage of bottles during shipment by either wrapping the sample container in bubble wrap, or lining the cooler with a noncombustible material such as vermiculite. Vermiculite is especially recommended because it will absorb any free liquids inside the cooler. It is recommended that the cooler be lined with a large plastic garbage bag before samples, ice, and absorbent packing material are placed in the cooler.
4. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C. Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. As an option, a temperature blank (a sample bottle filled with distilled water) can be included with the cooler.
5. Seal the completed chain-of-custody forms in a plastic bag and tape the plastic bag to the inside of the cooler lid.
6. Tape any instructions for returning the cooler to the inside of the lid.
7. Close the lid of the cooler and tape it shut by wrapping strapping tape around both ends and hinges of the cooler at least once. Tape shut any drain plugs on the cooler.
8. Place two signed custody seals on the cooler, ensuring that each one covers the cooler lid and side of the cooler. Place clear plastic tape over the custody seals.
9. Place address labels on the outside of the cooler.
10. Ship samples overnight by a commercial carrier such as FedEx.

## 2.3 PACKAGING HAZARDOUS SAMPLES

The procedures for packaging hazardous samples are summarized below. Note that according to the DGR, all spellings must be exactly as they appear in the List of Dangerous Goods, and only approved abbreviations are acceptable. The corresponding HMR regulations are provided in parentheses following any DGR referrals. The HMR must be followed only if shipping hazardous samples by ground transport.

1. Determine the proper shipping name for the material to be shipped. All proper shipping names are listed in column B of the List of Dangerous Goods table in Section 4 of the DGR (or column 2 of the Hazardous Materials Table in 49 CFR 172.101). In most instances, a generic name based on the hazard class of the material is appropriate. For example, a sample of an oily liquid collected from a drum with a high photoionization detector (PID) reading should be packaged as a flammable liquid. The proper shipping name chosen for this sample would be "flammable liquid, n.o.s." The abbreviation "n.o.s." stands for "not otherwise specified" and is used for generic shipping names. Typically, a specific name, such as acetone, should be inserted in parentheses after most n.o.s. descriptions. However, a technical name is not required when shipping a sample for testing purposes and the components are not known. If shipping a hazardous substance (see definition), then the letters "RQ" must appear in front of the proper shipping name.

2. Determine the United Nations (UN) identification number, class or division, subsidiary risk if any, required hazard labels, packing group, and either passenger aircraft or cargo aircraft packing instructions based on the quantity of material being shipped in one package. This information is provided in the List of Dangerous Goods (or Hazardous Materials Table in 49 CFR 172.101) under the appropriate proper shipping name. A "Y" in front of a packing instruction indicates a limited quantity packing instruction. If shipping dry ice or a limited quantity of a material, then UN specification shipping containers do not need to be used.

3. Determine the proper packaging required for shipping the samples. Except for limited quantity shipments and dry ice, these are UN specification packages that have been tested to meet the packing group of the material being shipped. Specific testing requirements of the packages is listed in Section 6 of the DGR (or 49 CFR 178 of the HMR). All UN packages are stamped with the appropriate UN specification marking. Prior planning is required to have the appropriate packages on hand during a sampling event where hazardous samples are anticipated. Most samples can be shipped in either a 4G fiberboard box, a 1A2 steel drum, or a 1H2 plastic drum. Drums can be purchased in 5- and 20-gallon sizes and are ideal for shipping multiple hazardous samples. When FedEx is used to ship samples containing PCBs, the samples must be shipped in an inner metal packaging (paint can) inside a 1A2 outer steel drum. This method of packaging PCB samples is in accordance with FedEx variation FX-06, listed in Section 2 of the DGR.

4. Place each sample jar in a separate resealable plastic bag. Some UN specification packagings contain the sample jar and plastic bag to be used when shipping the sample.

5. Place each sealed bag inside the approved UN specification container (or other appropriate container if a limited quantity or dry ice) and pack with enough noncombustible, absorbent, cushioning material (such as vermiculite) to prevent breakage and to absorp liquid.

6. Place chain-of-custody forms in a resealable plastic bag and either attach it to the inside lid of the container or place it on top inside the container. Place instructions for returning the container to the shipper on the inside lid of the container as appropriate. Close and seal the shipping container in the manner appropriate for the type of container being used.

7. Label and mark each package appropriately. All irrelevant markings and labels need to be removed or obliterated. All outer packagings must be marked with proper shipping name, UN identification number, and name and address of the shipper and the recipient. For carbon dioxide, solid (dry ice), the net weight of the dry ice within the package needs to be marked on the outer package. For limited quantity shipments, the words "limited quantity" or "LTD. QTY." must be marked on the outer package. Affix the appropriate hazard label to the outer package. If the material being shipped contains a subsidiary hazard, then a subsidiary hazard label must also be affixed to the outer package. The subsidiary hazard label is identical to the primary hazard label except that the class or division number is not present. It is acceptable to obliterate the class or division marking on a primary hazard label and use it as the subsidiary hazard label. If using cargo aircraft only packing instructions, then the "Cargo Aircraft Only" label must be used. Package orientation labels (up arrows) must be placed on opposite sides of the outer package. Figure 1 depicts a properly marked and labeled package.

8. If using an overpack (see definition), mark and label the overpack and each outer packaging within the overpack as described in step 7. In addition, the statement "INNER PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS" must be marked on the overpack.

9. Attach custody seals, and fill out the appropriate shipping papers as described in Section 2.4.

## 2.4 SHIPPING PAPERS FOR HAZARDOUS SAMPLES

A "Shippers Declaration for Dangerous Goods" and "Air Waybill" must be completed for each shipment of hazardous samples. FedEx supplies a Dangerous Goods Airbill to its customers; the airbill combines both the declaration and the waybill. An example of a completed Dangerous Goods Airbill is depicted in Figure 2. A shipper's declaration must contain the following:

- Name and address of shipper and recipient
- Air waybill number (not applicable to the HMR)
- Page ___ of ___
- Deletion of either "Passenger and Cargo Aircraft" or "Cargo Aircraft Only," whichever does not apply
- Airport or city of departure
- Airport or city of destination
- Deletion of either "Non-Radioactive" or "Radioactive," which ever does not apply
- The nature and quantity of dangerous goods. This includes the following information in the following order (obtained from the List of Dangerous Goods in the DGR): proper shipping name, class or division number, UN identification number, packing group number, subsidiary risk, quantity in liters or kilograms (kg), type of packaging used, packing instructions, authorizations, and additional handling information. Authorizations include the words "limited quantity" or "LTD. QTY." if shipping a limited quantity, any special provision numbers listed in the List of Dangerous Goods in the DGR, and the variation "USG-14" when a technical name is required after the proper shipping name but not entered because it is unknown.
- Signature for the certification statement
- Name and title of signatory
- Place and date of signing certification
- A 24-hour emergency response telephone number for use in the event of an incident involving the dangerous good
- Emergency response information attached to the shipper's declaration. This information can be in the form of a material safety data sheet or the applicable North American Emergency Response Guidebook (NAERG; DOT 1996) pages. Figure 3 depicts the appropriate NAERG emergency response information for "Flammable liquids, n.o.s." as an example.

Note that dry ice does not require an attached shipper's declaration. However, the air waybill must include the following on it: "Dry ice, 9, UN1845, ____ x ____ kg." The blanks must include the number of packages and the quantity in kg in each package. If using FedEx to ship dry ice, the air waybill includes a box specifically for dry ice. Simply check the appropriate box and enter in the number of packages and quantity in each package.

The HMR requirements for shipping papers are located in 49 CFR 172 Subpart C.

## 3.0 POTENTIAL PROBLEMS

The following potential problems may occur during sample shipment:

- Leaking package. If a package leaks, the carrier may open the package, return the package, and if a dangerous good, inform the Federal Aviation Administration (FAA), which can result in fines.

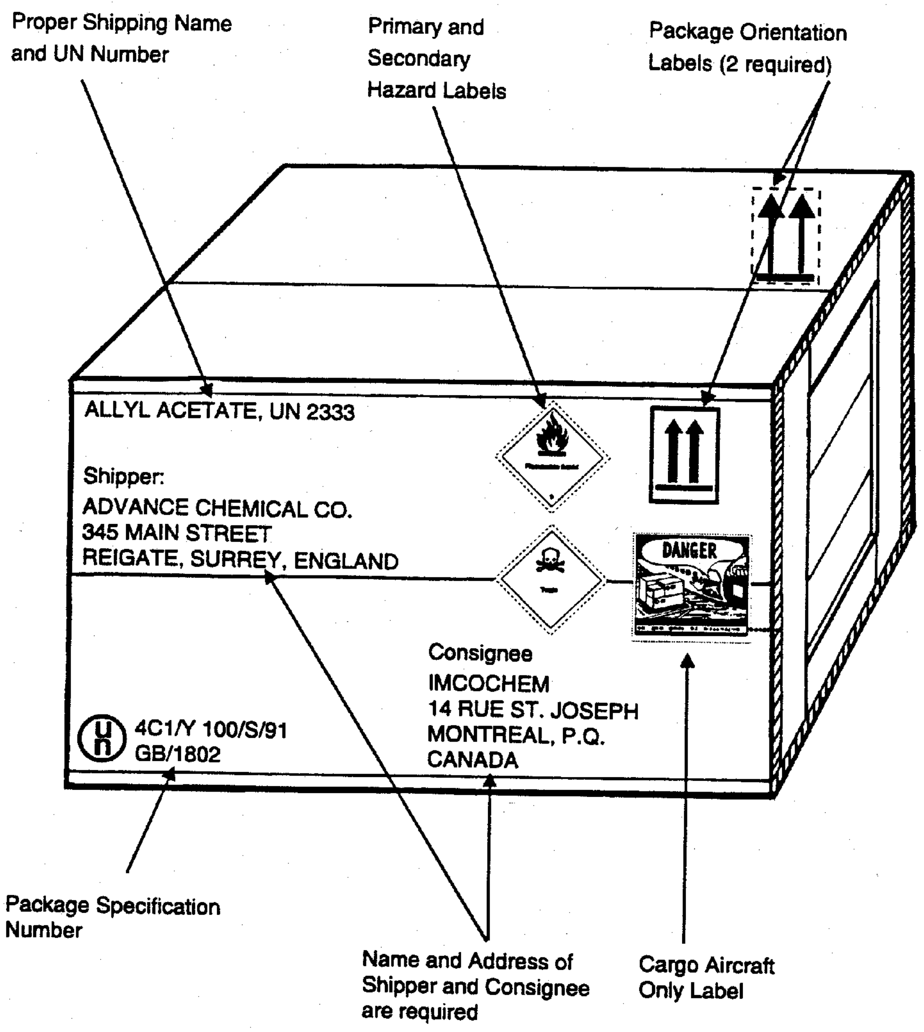
- Improper labeling and marking of package. If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment.

- Improper, misspelled, or missing information on the shipper's declaration. The carrier will most likely notice this as well and return the package to the shipper.

Contact FedEx with questions about dangerous goods shipments by calling 1-800-463-3339 and asking for a dangerous goods expert.

## FIGURE 1

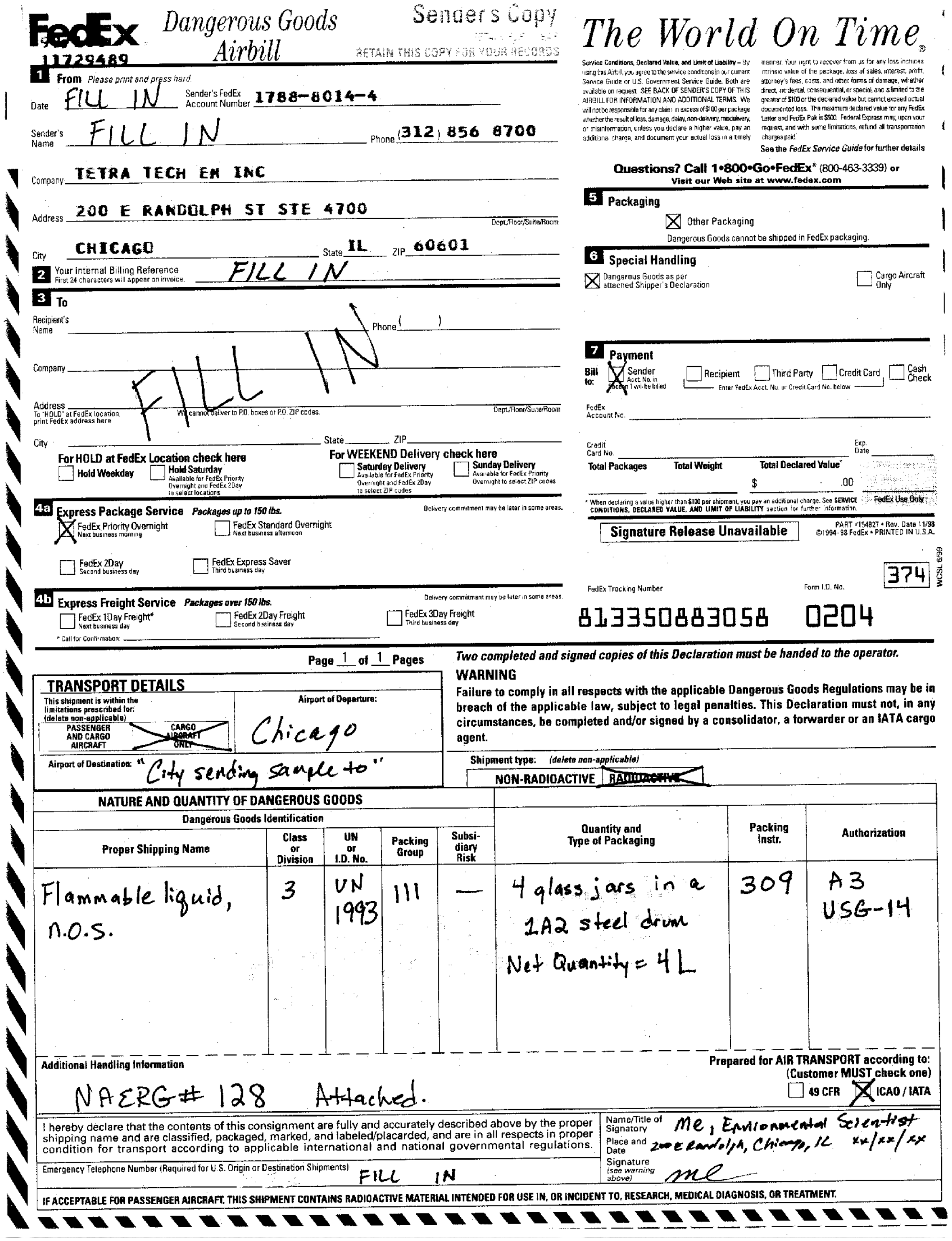
## EXAMPLE OF A CORRECTLY MARKED AND LABELED DANGEROUS GOODS PACKAGE



Source: International Air Transport Association (IATA). 1997.

## FIGURE 2

## EXAMPLE OF A DANGEROUS GOODS AIRBILL



**FedEx** *Dangerous Goods Airbill*

11729489

Senders Copy
RETAIN THIS COPY FOR YOUR RECORDS

**1 From** *Please print and press hard.*

Date FILL IN Sender's FedEx Account Number 1788-8014-4
Sender's Name FILL IN Phone (312) 856 8700
Company TETRA TECH EM INC
Address 200 E RANDOLPH ST STE 4700 Dept./Floor/Suite/Room
City CHICAGO State IL ZIP 60601

**2** Your Internal Billing Reference FILL IN
First 24 characters will appear on invoice.

**3 To**

FILL IN

Recipient's Name Phone (    )
Company
Address
To "HOLD" at FedEx location, print FedEx address here
We cannot deliver to P.O. boxes or P.O. ZIP codes. Dept./Floor/Suite/Room
City State ZIP

**For HOLD at FedEx Location check here**
☐ **Hold Weekday**
☐ **Hold Saturday** Available for FedEx Priority Overnight and FedEx 2Day to select locations

**For WEEKEND Delivery check here**
☐ **Saturday Delivery** Available for FedEx Priority Overnight and FedEx 2Day to select ZIP codes
☐ **Sunday Delivery** Available for FedEx Priority Overnight to select ZIP codes

**4a Express Package Service** ***Packages up to 150 lbs.*** Delivery commitment may be later in some areas.
☒ FedEx Priority Overnight Next business morning
☐ FedEx Standard Overnight Next business afternoon
☐ FedEx 2Day Second business day
☐ FedEx Express Saver Third business day

**4b Express Freight Service** ***Packages over 150 lbs.*** Delivery commitment may be later in some areas.
☐ FedEx 1Day Freight* Next business day
☐ FedEx 2Day Freight Second business day
☐ FedEx 3Day Freight Third business day
* Call for Confirmation:

*The World On Time*®

**Service Conditions, Declared Value, and Limit of Liability** – By using this Airbill, you agree to the service conditions in our current Service Guide or U.S. Government Service Guide. Both are available on request. SEE BACK OF SENDER'S COPY OF THIS AIRBILL FOR INFORMATION AND ADDITIONAL TERMS. We will not be responsible for any claim in excess of $100 per package whether the result of loss, damage, delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss in a timely manner. Your right to recover from us for any loss includes intrinsic value of the package, loss of sales, interest, profit, attorney's fees, costs, and other forms of damage, whether direct, incidental, consequential, or special, and is limited to the greater of $100 or the declared value but cannot exceed actual documented loss. The maximum declared value for any FedEx Letter and FedEx Pak is $500. Federal Express may, upon your request, and with some limitations, refund all transportation charges paid.
See the *FedEx Service Guide* for further details

**Questions? Call 1•800•Go•FedEx**® (800-463-3339) **or**
**Visit our Web site at www.fedex.com**

**5 Packaging**
☒ Other Packaging
Dangerous Goods cannot be shipped in FedEx packaging.

**6 Special Handling**
☒ Dangerous Goods as per attached Shipper's Declaration
☐ Cargo Aircraft Only

**7 Payment**
**Bill to:** ☒ Sender Acct. No. in Section 1 will be billed ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash Check
Enter FedEx Acct. No. or Credit Card No. below
FedEx Account No.
Credit Card No. Exp. Date

| **Total Packages** | **Total Weight** | **Total Declared Value*** | FedEx Use Only |
|---|---|---|---|
| | | $ .00 | |

* When declaring a value higher than $100 per shipment, you pay an additional charge. See **SERVICE CONDITIONS, DECLARED VALUE, AND LIMIT OF LIABILITY** section for further information.

**Signature Release Unavailable**

PART #154827 • Rev. Date 11/98
©1994-98 FedEx • PRINTED IN U.S.A.

374
WCSL 6/99

FedEx Tracking Number 813350883058
Form I.D. No. 0204

**Page** 1 **of** 1 **Pages**

***Two completed and signed copies of this Declaration must be handed to the operator.***

**WARNING**
**Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.**

**TRANSPORT DETAILS**

**This shipment is within the limitations prescribed for:** (delete non-applicable)
**PASSENGER AND CARGO AIRCRAFT** ~~**CARGO AIRCRAFT ONLY**~~

**Airport of Departure:** Chicago

**Airport of Destination:** "City sending sample to"

**Shipment type:** *(delete non-applicable)*
**NON-RADIOACTIVE** ~~**RADIOACTIVE**~~

**NATURE AND QUANTITY OF DANGEROUS GOODS**

| Proper Shipping Name | Class or Division | UN or I.D. No. | Packing Group | Subsidiary Risk | Quantity and Type of Packaging | Packing Instr. | Authorization |
|---|---|---|---|---|---|---|---|
| Flammable liquid, n.o.s. | 3 | UN 1993 | III | — | 4 glass jars in a 1A2 steel drum<br>Net Quantity = 4 L | 309 | A3<br>USG-14 |

**Additional Handling Information**
NAERG# 128 Attached.

**Prepared for AIR TRANSPORT according to:**
**(Customer MUST check one)**
☐ **49 CFR** ☒ **ICAO / IATA**

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

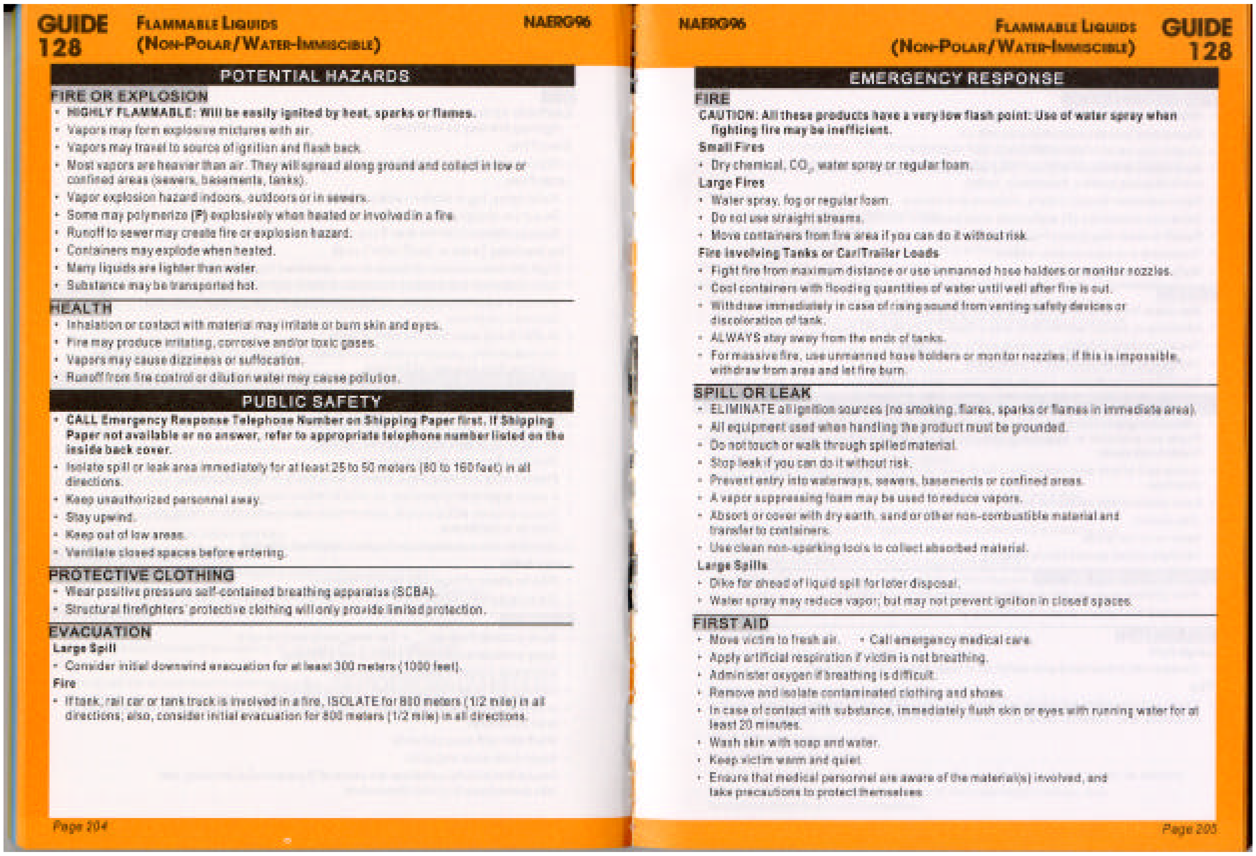
Emergency Telephone Number (Required for U.S. Origin or Destination Shipments) FILL IN

Name/Title of Signatory Me, Environmental Scientist
Place and Date 200 E Randolph, Chicago, IL xx/xx/xx
Signature (see warning above) me

**IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.**

## FIGURE 3

## NAERG EMERGENCY RESPONSE INFORMATION FOR FLAMMABLE LIQUIDS, N.O.S.



**GUIDE 128** FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE) NAERG96

### POTENTIAL HAZARDS

#### FIRE OR EXPLOSION

- **HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames.**
- Vapors may form explosive mixtures with air.
- Vapors may travel to source of ignition and flash back.
- Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Vapor explosion hazard indoors, outdoors or in sewers.
- Some may polymerize (P) explosively when heated or involved in a fire.
- Runoff to sewer may create fire or explosion hazard.
- Containers may explode when heated.
- Many liquids are lighter than water.
- Substance may be transported hot.

#### HEALTH

- Inhalation or contact with material may irritate or burn skin and eyes.
- Fire may produce irritating, corrosive and/or toxic gases.
- Vapors may cause dizziness or suffocation.
- Runoff from fire control or dilution water may cause pollution.

### PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate closed spaces before entering.

#### PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.

#### EVACUATION

**Large Spill**

- Consider initial downwind evacuation for at least 300 meters (1000 feet).

**Fire**

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

Page 204

NAERG96 FLAMMABLE LIQUIDS (NON-POLAR/WATER-IMMISCIBLE) **GUIDE 128**

### EMERGENCY RESPONSE

#### FIRE

**CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient.**

**Small Fires**

- Dry chemical, $CO_2$, water spray or regular foam.

**Large Fires**

- Water spray, fog or regular foam.
- Do not use straight streams.
- Move containers from fire area if you can do it without risk.

**Fire involving Tanks or Car/Trailer Loads**

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from the ends of tanks.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

#### SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- Prevent entry into waterways, sewers, basements or confined areas.
- A vapor suppressing foam may be used to reduce vapors.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
- Use clean non-sparking tools to collect absorbed material.

**Large Spills**

- Dike far ahead of liquid spill for later disposal.
- Water spray may reduce vapor; but may not prevent ignition in closed spaces.

#### FIRST AID

- Move victim to fresh air. • Call emergency medical care.
- Apply artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Wash skin with soap and water.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

Page 205

Source: DOT and others. 1996.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# MONITORING WELL INSTALLATION

## SOP NO. 020

## REVISION NO. 3

Last Reviewed: December 2000

KRiesing

Quality Assurance Approved

*December 19, 2000*

Date

## 1.0 BACKGROUND

Groundwater monitoring wells are designed and installed for a variety of reasons including: (1) detecting the presence or absence of contaminants, (2) collecting groundwater samples representative of in situ aquifer chemical characteristics, or (3) measuring water levels for determining groundwater potentiometric head and groundwater flow direction.

Although detailed specifications for well installation may vary in response to site-specific conditions, some elements of well installation are common to most situations. This standard operating procedure (SOP) discusses common methods and minimum standards for monitoring well installation for Tetra Tech EM Inc. (Tetra Tech) projects. The SOP is based on widely recognized methods described by the U.S. Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM). However, well type, well construction, and well installation methods will vary with drilling method, intended well use, subsurface characteristics, and other site-specific criteria. In addition, monitoring wells should be constructed and installed in a manner consistent with all local and state regulations. Detailed specifications for well installation should be identified within a site-specific work plan, sampling plan, or quality assurance project plan (QAPP).

General specifications and installation procedures for the following monitoring well components are included in this SOP:

- Monitoring well materials
    - Casing materials
    - Well screen materials
    - Filter pack materials
    - Annular sealant (bentonite pellets or chips)
    - Grouting materials
    - Tremie pipe
    - Surface completion and protective casing materials
    - Concrete surface pad and bumper posts
    - Uncontaminated water
- Monitoring well installation procedures
    - Well screen and riser placement
    - Filter pack placement
    - Temporary casing retrieval

  - Annular seal placement
  - Grouting
  - Surface completion and protective casing (aboveground and flush-mount)
  - Concrete surface pad and bumper posts
  - Permanent and multiple casing well installation

- Recordkeeping procedures
  - Surveying
  - Permits and well construction records
  - Monitoring well identification

Well installation methods will depend to some extent on the boring method. Specific boring or drilling protocols are detailed in other SOPs. The boring method, in turn, will depend on site-specific geology and hydrogeology and project requirements. Boring methods commonly used for well installation include:

- Hollow-stem augering
- Cable tool drilling
- Mud rotary drilling
- Air rotary drilling
- Rock coring

The hollow-stem auger method is preferred in areas where subsurface materials are unconsolidated or loosely consolidated and where the depth of the boring will be less than 100 feet. This maximum effective depth for hollow-stem augering depends on the diameter of the augers, the formation characteristics, and the strength and durability of the drilling equipment. This method is preferred because under the right conditions it is cost effective, addition of water into the subsurface is limited, continuous soil samples can easily be collected, and monitoring wells can easily be constructed within the hollow augers.

Cable tool drilling is a preferred method when the subsurface contains boulders, coarse gravels, or flowing sands, or when the operational depth of the hollow-stem auger is exceeded. However, this method is slow.

Rotary methods are generally used when other methods cannot be used. The use of drilling fluids or large amounts of water to maintain an open borehole, and the difficulty in obtaining representative samples limit the utility of rotary methods. However, rotary methods can be used to quickly and effectively drill deep wells through consolidated or unconsolidated materials. Modifications to this method such as dual-tube drilling procedures, drill-through casing hammers, or eccentric-type drill systems, can reduce the amount of fluids introduced into the well borehole.

Rock coring is an effective method when drilling in competent consolidated rock. Intact, continuous cores can be obtained, and limited amounts of fluid are required if the formations are not fractured.

### 1.1 PURPOSE

This SOP establishes the requirements and procedures for monitoring well installation. Monitoring wells should be designed to function properly throughout the duration of the monitoring program. The performance objectives for monitoring well installation are as follows:

- Ensure that the monitoring well will provide water samples representative of in situ aquifer conditions.
- Ensure that the monitoring well construction will last for duration of the project.
- Ensure that the monitoring well will not serve as a conduit for vertical migration of contaminants, particularly vertical migration between discrete aquifers.
- Ensure that the well diameter is adequate for all anticipated downhole monitoring and sampling equipment.

### 1.2 SCOPE

This SOP applies to the installation of monitoring wells. Although some of the procedures may apply to the installation of water supply wells, this SOP is not intended to cover the design and construction of such wells. The SOP identifies several well drilling methods related to monitoring well installation, but the scope of this SOP does not include drilling methods.

Other relevant SOPs include SOP 002 for decontamination of drilling and well installation equipment, SOP 005 for soil sampling, SOP 021 for monitoring well development, SOPs 010 and 015 for groundwater sampling from monitoring wells, and SOP 014 for measuring static water levels within monitoring wells.

## 1.3 DEFINITIONS

**Annulus:** The space between the monitoring well casing and the wall of the well boring.

**Bentonite seal:** A colloidal clay seal separating the sand pack from the annular grout seal.

**Centralizer:** A stainless-steel or plastic spacer that keeps the well screen and casing centered in the borehole.

**Filter pack:** A clean, uniform sand or gravel placed between the borehole wall and the well screen to prevent formation material from entering the screen.

**Grout seal:** A fluid mixture of (1) bentonite and water, (2) cement, bentonite, and water, or (3) cement and water placed above the bentonite seal between the casing and the borehole wall to secure the casing in place and keep water from entering the borehole.

**Tremie pipe:** A rigid pipe used to place the well filter pack, bentonite seal, or grout seal. The tremie pipe is lowered to the bottom of the well or area to be filled and pulled up ahead of the material being placed.

**Well casing:** A solid piece of pipe, typically polyvinyl chloride (PVC) or stainless steel, used to keep a well open in either unconsolidated material or unstable rock.

**Well screen:** A PVC or stainless steel pipe with openings of a uniform width, orientation, and spacing used to keep materials other than water from entering the well and to stabilize the surrounding formation.

## 1.4 REFERENCES

American Society for Testing and Materials. 1995. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers. D5092-90. West Conshohocken, Pennsylvania.

California Department of Toxic Substances Control. 1994. Monitoring Well Design and Construction for Hydrogeologic Characterization. Guidance for Groundwater Investigations. August.

Driscoll, F.G. 1986. *Groundwater and Wells (Second Edition).* Johnson Division, UOP, Inc. St. Paul, Minnesota.

U.S. Environmental Protection Agency (EPA). 1986. RCRA Ground Water Monitoring Technical Enforcement Guidance Document. Office of Solid Waste and Emergency Response. Washington, DC. OSWER-9950-1. September.

EPA. 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. Office of Research and Development, Environmental Monitoring Systems Laboratory. Washington, DC. EPA/600-4-89/034. March. On-Line Address: http://www.epa.gov/swerust1/cat/wwelldct.pdf

EPA. 1994. Monitor Well Installation. Environmental Response Team SOP #2048 (Rev. #0.0, 03/18/96). On-Line Address: http://www.ert.org/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

Well installation requires a completed boring with stable or supported walls. The type of drilling rig needed to complete the boring and the well construction materials required for monitoring well installation will depend on the drilling method used, the geologic formations present, and chemicals of concern in groundwater. The rig and support equipment used to drill the borehole is usually used to install the well. Under most conditions, the following items are also required for the proper installation of monitoring wells:

- Tremie pipe and funnel
- Bentonite pellets or chips
- Grouting supplies
- Casing materials
- Well screen materials
- Filter pack materials
- Surface completion materials (protective casing, lockable and watertight well cover, padlock)
- Electronic water level sounding device for water level measurement
- Measuring tape with weight for measuring the depth of the well and determining the placement of filter pack materials
- Decontamination equipment and supplies

- Site-specific work plan, field sampling plan, health and safety plan, and QAPP
- Monitoring Well Completion Record (see Figure 1)

## 2.0 MONITORING WELL INSTALLATION PROCEDURES

This section presents standard procedures for monitoring well installation and is divided into three subsections. Section 2.1 addresses monitoring well construction materials, while Section 2.2 describes typical monitoring well installation procedures. Section 2.3 addresses recordkeeping requirements associated with monitoring well installation. Monitoring well installation procedures described in work plans, sampling plans, and QAPPs should be fully consistent with the procedures outlined in this SOP as well as any applicable local and state regulations and guidelines.

### 2.1 MONITORING WELL CONSTRUCTION MATERIALS

Monitoring well construction materials should be specified in the site-specific work plan as well as in the statement of work for any subcontractors assisting in the well installation. Well construction materials that come in contact with groundwater should not measurably alter the chemical quality of groundwater samples with regard to the constituents being examined. The riser, well screen, and filter pack and annular sealant placement equipment should be steam cleaned or high-pressure water cleaned immediately prior to well installation. Alternatively, these materials can be certified by the manufacturer as clean and delivered to the site in protective wrapping. Samples of the filter pack, annular seal, and mixed grout should be retained as a quality control measure until at least one round of groundwater sampling and analysis is completed.

This section discusses material specifications for the following well construction components: casing, well screen, filter pack, annular sealant (bentonite pellets or chips), grout, tremie pipes, surface completion components (protective casing, lockable and water tight cap, and padlock), concrete surface pad, and uncontaminated water. Figure 2 shows the construction details of a typical monitoring well.

### 2.1.1 Casing Materials

The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. If the casing has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the casing should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002). The ends of each casing section should be either flush-threaded or beveled for welding.

Schedule 40 or Schedule 80 PVC casing is typically used for monitoring well installation. Either type of casing is appropriate for monitoring wells with depths less than 100 feet below ground surface (bgs). If the well is deeper than 100 feet bgs, Schedule 80 PVC should be used.

Stainless steel used for well casing is typically Type 304 and is of 11-gauge thickness.

### 2.1.2 Well Screen Materials

Well screens should be new, machine-slotted or continuous wrapped wire-wound, and composed of materials most suited for the monitoring environment based on site characterization findings. Well screens are generally constructed of the same materials used for well casing (PVC or stainless steel). The screen should be plugged at the bottom with the same material as the well screen. Alternatively, a short (1- to 2-foot) section of casing material with a bottom (sump) should be attached below the screen. This assembly must be able to withstand installation and development stresses without becoming dislodged or damaged. The length of the slotted area should reflect the interval to be monitored.

If the well screen has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the screen should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002).

The minimum internal diameter of the well screen should be chosen based on the particular application. A minimum diameter of 2 inches is usually needed to allow for the introduction and withdrawal of sampling devices. Typical monitoring well screen diameters are 2 inches and 4 inches.

The slot size of the well screen should be determined relative to (1) the grain size of particles in the aquifer to be monitored and (2) the gradation of the filter pack material.

Screen length and monitoring well diameter will depend on site-specific considerations such as intended well use, contaminants of concern, and hydrogeology. Some specific considerations include the following:

- Water table wells should have screens of sufficient length and diameter to monitor the water table and provide sufficient sample volume under high and low water table conditions.
- Wells with low recharge should have screens of sufficient length and diameter so that adequate sample volume can be collected.
- Wells should be screened over sufficiently short intervals to allow for monitoring of discrete migration pathways.
- Where light nonaqueous-phase liquids (LNAPL) or contaminants in the upper portion of a hydraulic unit are being monitored, the screen should be set so that the upper portion of the water-bearing zone is below the top of the screen.
- Where dense nonaqueous-phase liquids (DNAPL) are being monitored, the screen should be set within the lower portion of the water-bearing zone, just above a relatively impermeable lithologic unit.
- The screened interval should not extend across an aquiclude or aquitard.
- If contamination is known to be concentrated within a portion of a saturated zone, the screen should be constructed in a manner that minimizes the potential for cross-contamination within the aquifer.
- If downhole geophysical surveys are to be conducted, the casing and screen must be of sufficient diameter and constructed of the appropriate material to allow for effective use of the geophysical survey tools.
- If aquifer tests are to be conducted in a monitoring well, the slot size must allow sufficient flux to produce the required drawdown and recovery. The diameter of the well must be sufficient to house the pump and monitoring equipment, and allow sufficient water flux (in combination with the screen slot size) to produce the required drawdown or recovery.

### 2.1.3 Filter Pack Materials

The primary filter pack consists of a granular material of known chemistry and selected grain size and gradation. The filter pack is installed in the annulus between the well screen and the borehole wall. The grain size and gradation of the filter pack are selected to stabilize the hydrologic unit adjacent to the screen and to prevent formation material from entering the well during development. After development, a properly filtered monitoring well is relatively free of turbidity.

A secondary filter pack is a layer of material placed in the annulus directly above the primary filter pack and separates the filter pack from the annular sealant. The secondary filter pack should be uniformly graded fine sand, with 100 percent by weight passing through a No. 30 U.S. Standard sieve, and less than 2 percent by weight passing through a No. 200 U.S. Standard sieve.

### 2.1.4 Annular Sealant (Bentonite Pellets or Chips)

The materials used to seal the annulus may be prepared as a slurry or used as dry pellets, granules, or chips. Sealants should be compatible with ambient geologic, hydrogeologic, and climatic conditions and any man-induced conditions anticipated to occur during the life of the well.

Bentonite (sodium montmorillonite) is the most commonly used annular sealant and is furnished in sacks or buckets in powder, granular, pelletized, or chip form. Bentonite should be obtained from a commercial source and should be free of impurities that may adversely impact the water quality in the well. Pellets are compressed bentonite powder in roughly spherical or disk shapes. Chips are large, coarse, irregularly shaped units of bentonite. The diameter of the pellets or chips should be less than one-fifth the width of the annular space into which they will be placed in order to reduce the potential for bridging. Granules consist of coarse particles of unaltered bentonite, typically smaller than 0.2 inch in diameter. Bentonite slurry is prepared by mixing powdered or granular bentonite with water from a source of known chemistry.

### 2.1.5 Grouting Materials

The grout backfill that is placed above the bentonite annular seal is ordinarily liquid slurry consisting of either (1) a bentonite (powder, granules, or both) base and water, (2) a bentonite and Portland cement base and water, or (3) a Portland cement base and water. Often, bentonite-based grouts are used when flexibility is desired during the life of the well installation (for example, to accommodate freeze-thaw cycles). Cement- or bentonite-based grouts are often used when cracks in the surrounding geologic material must be filled or when adherence to rock units, or a rigid setting is desired.

Each type of grout mixture has slightly different characteristics that may be appropriate under various physical and chemical conditions. However, quick-setting cements containing additives are not recommended for use in monitoring well installation because additives may leach from the cement and influence the chemistry of water samples collected from the well.

### 2.1.6 Tremie Pipe

A tremie pipe is used to place the filter pack, annular sealant, and grouting materials into the borehole. The tremie pipe should be rigid, have a minimum internal diameter of 1.0 inch, and be made of PVC or steel. The length of the tremie pipe should be sufficient to extend to the full depth of the monitoring well.

### 2.1.7 Surface Completion and Protective Casing Materials

Protective casings that extend above the ground surface should be made of aluminum, steel, stainless steel, cast iron, or a structural plastic. The protective casing should have a lid with a locking device to prevent vandalism. Sufficient clearance, usually 6 inches, should be maintained between the top of the riser and the top of protective casing. A water-tight well cap should be placed on the top of the riser to seal the well from surface water infiltration in the event of a flood. A weep hole should be drilled in the casing a minimum of 6 inches above the ground surface to enable water to drain out of the annular space.

Flush-mounted monitoring wells (wells that do not extend above ground surface) require a water-tight protective cover of sufficient strength to withstand heavy traffic. The well riser should be fitted with a locking water-tight cap.

### 2.1.8 Concrete Surface Pad and Bumper Posts

A concrete surface pad should be installed around each well when the outer protective casing is installed. The surface pad should be formed around the well casing. Concrete should be placed into the formed pad and into the borehole (on top of the grout), typically to a depth of 1 to 3 feet bgs (depending on state, federal, and local regulations). The protective casing is then installed into the concrete. As a general guideline, if the well casing is 2 inches in diameter, the concrete pad should be 3 feet square and 4 inches thick. If the well casing is 4 inches in diameter, the pad should be 4 feet square and 6 inches thick. Round concrete pads are also acceptable.

The finished pad should be sloped so that drainage flows away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed around the pad to protect the well. Bumper posts, consisting of steel pipes 3 to 4 inches in diameter and at least 5 feet long, should be installed in a radial pattern around the protective casing, beyond the edges of the cement pad. The base of the bumper posts should be installed 2 feet bgs in a concrete footing; the top of the post should be capped or filled with concrete.

### 2.1.9 Uncontaminated Water

Water used in the drilling process, to prepare grout mixtures, and to decontaminate the well screen, riser, and annular sealant injection equipment, should be obtained from a source of known chemistry. The water should not contain constituents that could compromise the integrity of the monitoring well installation.

## 2.2 MONITORING WELL INSTALLATION PROCEDURES

This section describes the procedures used to install a single-cased monitoring well, with either temporary casing or hollow-stem augers to support the walls of the boring in unconsolidated formations. The procedures are described in the order in which they are conducted, and include: (1) placement of well screen and riser pipe, (2) placement of filter pack, (3) progressive retrieval of temporary casing, (4) placement of annular seal, (5) grouting, (6) surface completion and installation of protective casing, and (7) installation of concrete pad and bumper posts.

The additional steps necessary to install a well with permanent or multiple casing strings are described at the end of this section.

### 2.2.1 Well Screen and Riser Placement

After the total depth of the boring is confirmed and the well screen depth interval and the height of the aboveground completion are determined, the screen and riser is assembled from the bottom up as it is lowered down the hole. The following procedures should be followed:

1. Measure the total depth of the boring using a weighted tape.
2. Determine the length of screen and casing materials required to construct the well.
3. Assemble the well parts from the bottom up, starting with the well sump or cap, well screen, and then riser pipe. Progressively lower the assembled length of pipe.
4. The length of the assembled pipe should not extend above the top of the installation rig.

The well sump or cap, well screen, and riser should be certified clean by the manufacturer or should be decontaminated before assembly and installation. No grease, oil, or other contaminants should contact any portion of the assembly. Flush joints should be tightened, and welds should be water tight and of good quality. The riser should extend above grade and be capped temporarily to prevent entrance of foreign materials during the remaining well completion procedures.

When the well screen and riser assembly is lowered to the predetermined level, it may float and require a method to hold it in place. For borings drilled using cable tool or air rotary drilling methods, centralizers should be attached to the riser at intervals of between 20 and 40 feet.

### 2.2.2 Filter Pack Placement

The filter pack is placed after the well screen and riser assembly has been lowered into the borehole. The steps below should be followed:

1. Determine the volume of the annular space in the filter pack interval. The filter pack should extend from the bottom of the borehole to at least 2 feet above the top of the well screen.
2. Assemble the required material (sand pack and tremie pipe).
3. Lower a clean or decontaminated tremie pipe down the annulus to within 1 foot of the base of the hole.
4. Pour the sand down the tremie pipe using a funnel; pour only the quantity estimated to fill the first foot.
5. Check the depth of sand in the hole using a weighted tape.
6. Pull the drill casing up ahead of the sand to keep the sand from bridging.
7. Continue with this process (steps 4 through 6) until the filter pack is at the appropriate depth.

If bridging of the filter pack occurs, break out the bridge prior to adding additional filter pack material. For wells less than 30 feet deep installed inside hollow-stem augers, the sand may be poured in 1-foot lifts without a tremie pipe.

Sufficient measurements of the depth to the filter pack material and the depth of the bottom of the temporary casing should be made to ensure that the casing bottom is always above the filter pack. The filter pack should extend 2 feet above the well screen (or more if required by state or local regulations). However, the filter pack should not extend across separate hydrogeologic units. The final depth interval, volume, and type of filter pack should be recorded on the Monitoring Well Completion Record (Figure 1).

A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack. A measured volume of secondary filter material should be added to extend 1 to 2 feet above the primary filter pack. As with the primary filter pack, a secondary filter pack must not extend into an overlying hydrologic unit. An on-site geologist should evaluate the need for a secondary filter pack by considering the gradation of the primary filter pack, the hydraulic head difference between adjacent units, and the potential for grout intrusion into the primary filter pack.

The secondary filter material is poured into the annular space through tremie pipe as described above. Water from a source of known chemistry may be added to help place the filter pack into its proper location.

The tremie pipe or a weighed line inserted through the tremie pipe can be used to measure the top of the secondary filter pack as work progresses. The amount and type of secondary filter pack used should be recorded on the Monitoring Well Completion Record (Figure 1).

### 2.2.3 Temporary Casing Retrieval

The temporary casing or hollow-stem auger should be withdrawn in increments. Care should be taken to minimize lifting the well screen and riser assembly during withdrawal of the temporary casing or auger. It may be necessary to place the top head of the rig on the riser to hold it down. To limit borehole collapse in formations consisting of unconsolidated materials, the temporary casing or hollow-stem auger is usually withdrawn until the lowest point of the casing or auger is at least 2 feet, but no more than 5 feet, above the filter pack. When the geologic formation consists of consolidated materials, the lowest point of the casing or auger should be at least 5 feet, but no more than 10 feet, above the filter pack. In highly unstable formations, withdrawal intervals may be much less. After each increment, the depth to the primary filter pack should be measured to check that the borehole has not collapsed or that bridging has not occurred.

### 2.2.4 Annular Seal Placement

A bentonite pellet, chip, or slurry seal should be placed between the borehole and the riser on top of the primary or secondary filter pack. This seal retards the movement of grout into the filter pack. The thickness of the bentonite seal will depend on state and local regulations, but the seal should generally be between 3 and 5 feet thick.

The bentonite seal should be installed using a tremie pipe, lowered to the top of the filter pack and slowly raised as the bentonite pellets or slurry fill the space. Care must be taken so that bentonite pellets or chips do not bridge in the augers or tremie pipe. The depth of the seal should be checked with a weighted tape or the tremie pipe.

If a bentonite pellet or chip seal is installed above the water level, water from a known source should be added to allow proper hydration of the bentonite. Sufficient time should be allowed for the bentonite seal to hydrate. The volume and thickness of the bentonite seal should be recorded on the Monitoring Well Completion Record (Figure 1).

### 2.2.5 Grouting

Grouting procedures vary with the type of well design. The volume of grout needed to backfill the remaining annular space should be calculated and recorded on the Monitoring Well Completion Record (Figure 1). The use of alternate grout materials, including grouts containing gravel, may be necessary to control zones of high grout loss. Bentonite grouts should not be used in arid regions because of their propensity to desiccate. Typical grout mixtures include the following:

- Bentonite grout: about 1 to 1.25 pounds of bentonite mixed with 1 gallon of water
- Cement-bentonite grout: about 5 pounds of bentonite and one 94-pound bag of cement mixed with 7 to 8 gallons of water
- Cement grout: one 94-pound bag of cement mixed with 6 to 7 gallons of water

The grout should be installed by gravity feed through a tremie pipe. The grout should be mixed in batches in accordance with the appropriate requirements and then pumped into the annular space until full-strength grout flows out at the ground surface without evidence of drill cuttings or fluid. The tremie pipe should then be removed to allow the grout to cure.

The riser should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser. For bentonite grouts, curing times are typically around 24 hours; curing times for cement grouts are typically 48 to 72 hours. However, the curing time required will vary with grout content and climatic conditions. The curing time should be documented in the Monitoring Well Completion Record (Figure 1).

### 2.2.6 Surface Completion and Protective Casing

Aboveground completion of the monitoring well should begin once the grout has set (no sooner than 24 hours after the grout was placed). The protective casing is lowered over the riser and set into the cured grout. The protective casing should extend below the ground surface to a depth below the frost line (typically 3 to 5 feet, depending on local conditions). The protective casing is then cemented in place. A minimum of 6 inches of clearance should be maintained between the top of the riser and the protective casing. A 0.5-inch diameter drainage or weep hole should be drilled in the protective casing approximately

6 inches above the ground surface to enable water to drain out of the annular space between the casing and riser. A water-tight cap should be placed on top of the riser to seal the well from surface water infiltration in the event of a flood. A lock should be placed on the protective casing to prevent vandalism.

For flush-mounted monitoring wells, the well cover should be raised above grade and the surrounding concrete pad sloped so that water drains away from the cover. The flush-mount completion should be installed in accordance with applicable state and local regulations.

### 2.2.7 Concrete Surface Pad and Bumper Posts

The concrete pad installed around the monitoring well should be sloped so that the drainage will flow away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed in a radial pattern around the protective casing, outside the cement pad. Specifications for concrete surface pads and bumper posts are described in Section 2.1.8.

### 2.2.8 Permanent and Multiple Casing Well Installation

When wells are installed through multiple saturated zones, special well construction methods should be used to assure well integrity and limit the potential for cross-contamination between geologic zones. Generally, these types of wells are necessary if relatively impermeable layers separate hydraulic units. Two procedures that may be used are described below.

In the first procedure, the borehole is advanced to the base of the first saturated zone. Casing is then anchored in the underlying impermeable layer (aquitard) by advancing the casing at least 1 foot into the aquitard and grouting to the surface. After the grout has cured, a smaller diameter borehole is drilled through the grout. This procedure is repeated until the zone of interest is reached. After the zone is reached, a conventional well screen and riser are set. A typical well constructed in this manner is shown on Figure 3.

A second acceptable procedure involves driving a casing through several saturated layers while drilling ahead of the casing. However, this method is not acceptable when the driven casing may structurally damage a competent aquitard or aquiclude and result in cross-contamination of the two saturated layers. This method should also be avoided when highly contaminated groundwater or nonaqueous-phase contamination may be dragged down into underlying uncontaminated hydrologic units.

## 2.3 RECORDKEEPING PROCEDURES

Recordkeeping procedures associated with monitoring well installation are described in the following sections. These include procedures for surveying, obtaining permits, completing well construction records, and identifying monitoring wells.

### 2.3.1 Surveying

Latitude, longitude, and elevation at the top of the riser should be determined for each monitoring well. A permanent notch or black mark should be made on the north side of the riser. The top of the riser and ground surface should be surveyed.

### 2.3.2 Permits and Well Construction Records

Local and state regulations should be reviewed prior to monitoring well installation, and any required well permits should be in-hand before the driller is scheduled.

Monitoring well installation activities should be documented in both the field logbook and on the Monitoring Well Completion Record (Figure 1). Geologic logs should be completed and, if necessary, filed with the appropriate regulatory agency within the appropriate time frame.

### 2.3.3 Monitoring Well Identification

Each monitoring well should have an individual well identification number or name. The well identification may be stamped in the metal surface upon completion or permanently marked by using another method. Current state and local regulations should be checked for identification requirements (such as township, range, section, or other identifiers in the well name).

# FIGURE 1

# MONITORING WELL COMPLETION RECORD

TETRATECH EM INC

## MONITORING WELL COMPLETION RECORD

### MONITORING WELL

MONITORING WELL NO.:
PROJECT:
SITE:
BOREHOLE NO.:
WELL PERMIT NO.:
TOC TO BOTTOM OF WELL:

### DRILLING INFORMATION

DRILLING BEGAN:
DATE: TIME:
WELL INSTALLATION BEGAN:
DATE: TIME:
WELL INSTALLATION FINISHED:
DATE: TIME:
DRILLING CO.:
DRILLER:
LICENSE:
DRILL RIG:
DRILLING METHOD:
- ☐ HOLLOW-STEM AUGER
- ☐ AIR ROTARY
- ☐ OTHER:

DIAMETER OF AUGERS:
ID: OD:

### WELL CASING

☐ SCHEDULE 40 PVC
☐ OTHER:
PRODUCT:
MFG. BY:
CASING DIAMETER:
ID: OD:
LENGTH OF CASING:

### WELL SCREEN

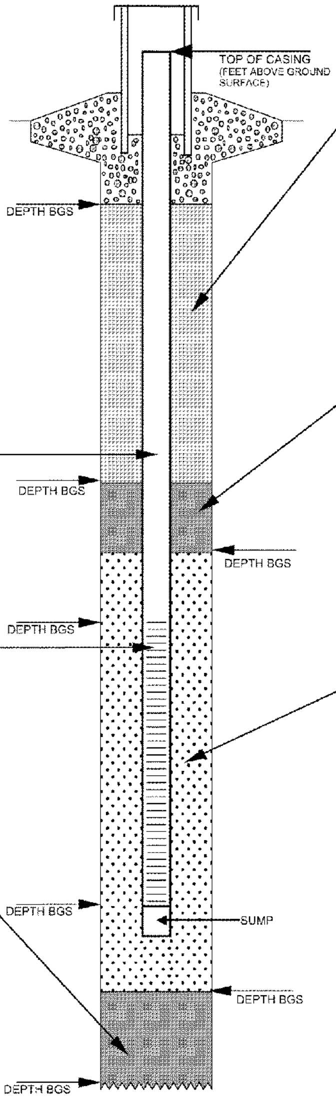
☐ SCHEDULE 40 PVC
☐ OTHER:
PRODUCT:
MFG. BY:
CASING DIAMETER:
ID: OD:
SLOT SIZE:
LENGTH OF SCREEN:

### BOREHOLE BACKFILL

AMOUNT CALCULATED:
AMOUNT USED:
☐ BENTONITE CHIPS, SIZE:
☐ BENTONITE PELLETS, SIZE:
☐ SLURRY:
☐ FORMATION COLLAPSE:
☐ OTHER:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:

### SURFACE COMPLETION

☐ FLUSH MOUNT
☐ ABOVE GROUND WITH BUMPER POST
☐ CONCRETE ☐ ASPHALT



### SURVEY INFORMATION

TOC ELEVATION:
GROUND SURFACE ELEVATION:
NORTHING:
EASTING:
DATE SURVEYED:
SURVEY CO.:

### ANNULAR SEAL

VOLUME CALCULATED:
AMOUNT USED:
☐ GROUT FORMULA (PERCENTAGES)
PORTLAND CEMENT:
BENTONITE:
WATER:
☐ PREPARED MIX
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:

### BENTONITE SEAL

VOLUME CALCULATED:
AMOUNT USED:
☐ PELLETS, SIZE:
☐ CHIPS, SIZE:
☐ OTHER:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:
AMOUNT OF WATER USED:

### FILTER PACK

☐ PREPACKED FILTER
VOLUME CALCULATED:
AMOUNT USED:
☐ SAND, SIZE:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:
WATER LEVEL:
(BTOC AFTER WELL INSTALLATION)

### CENTRALIZERS USED?

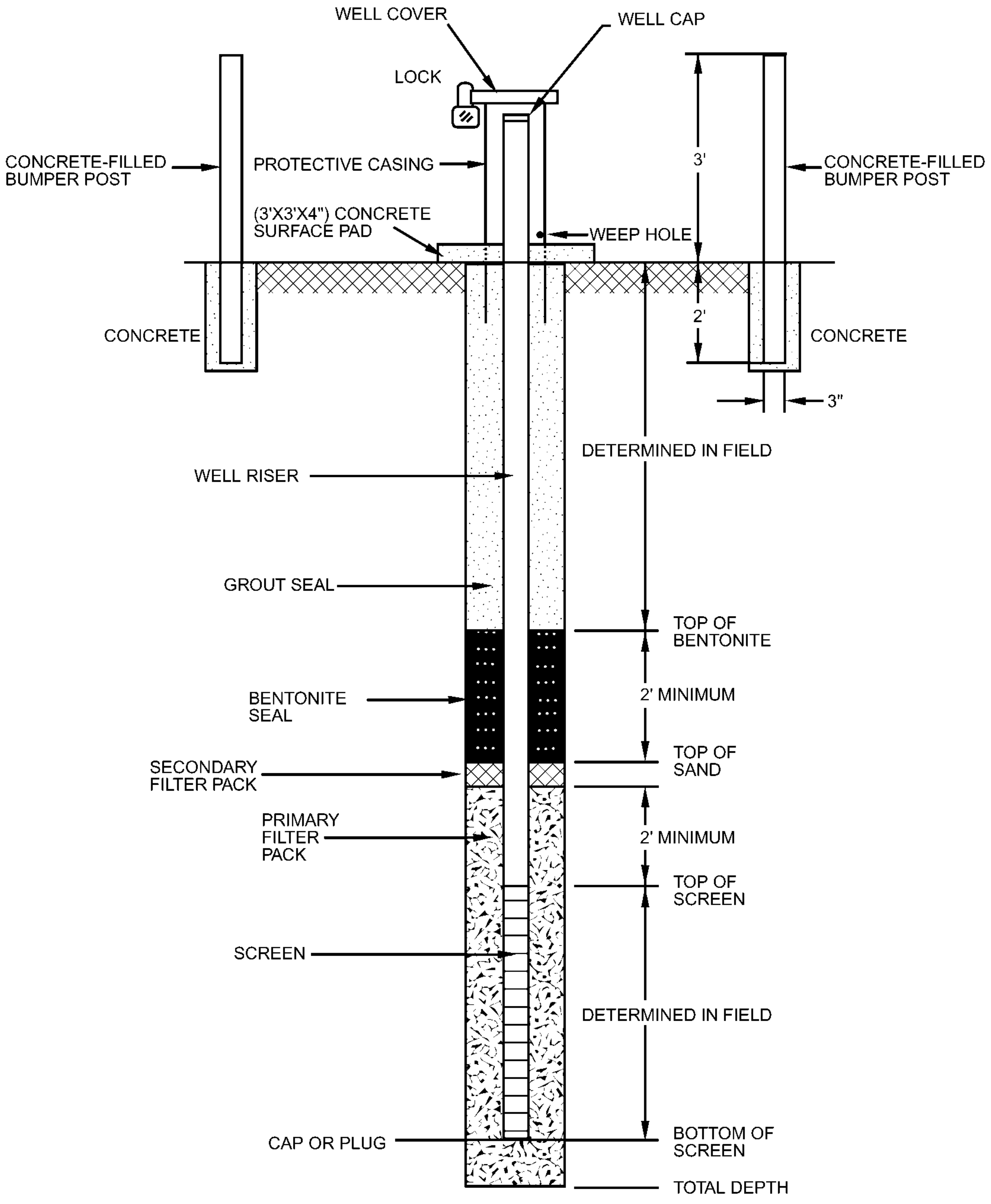
☐ YES ☐ NO;
CENTRALIZER DEPTHS:

**LEGEND**

BGS = BELOW GROUND SURFACE
BTOC = BELOW TOP OF CASING
N/A = NOT APPLICABLE
NR = NOT RECORDED
TOC = TOP OF CASING
ID = INSIDE DIAMETER
OD = OUTSIDE DIAMETER

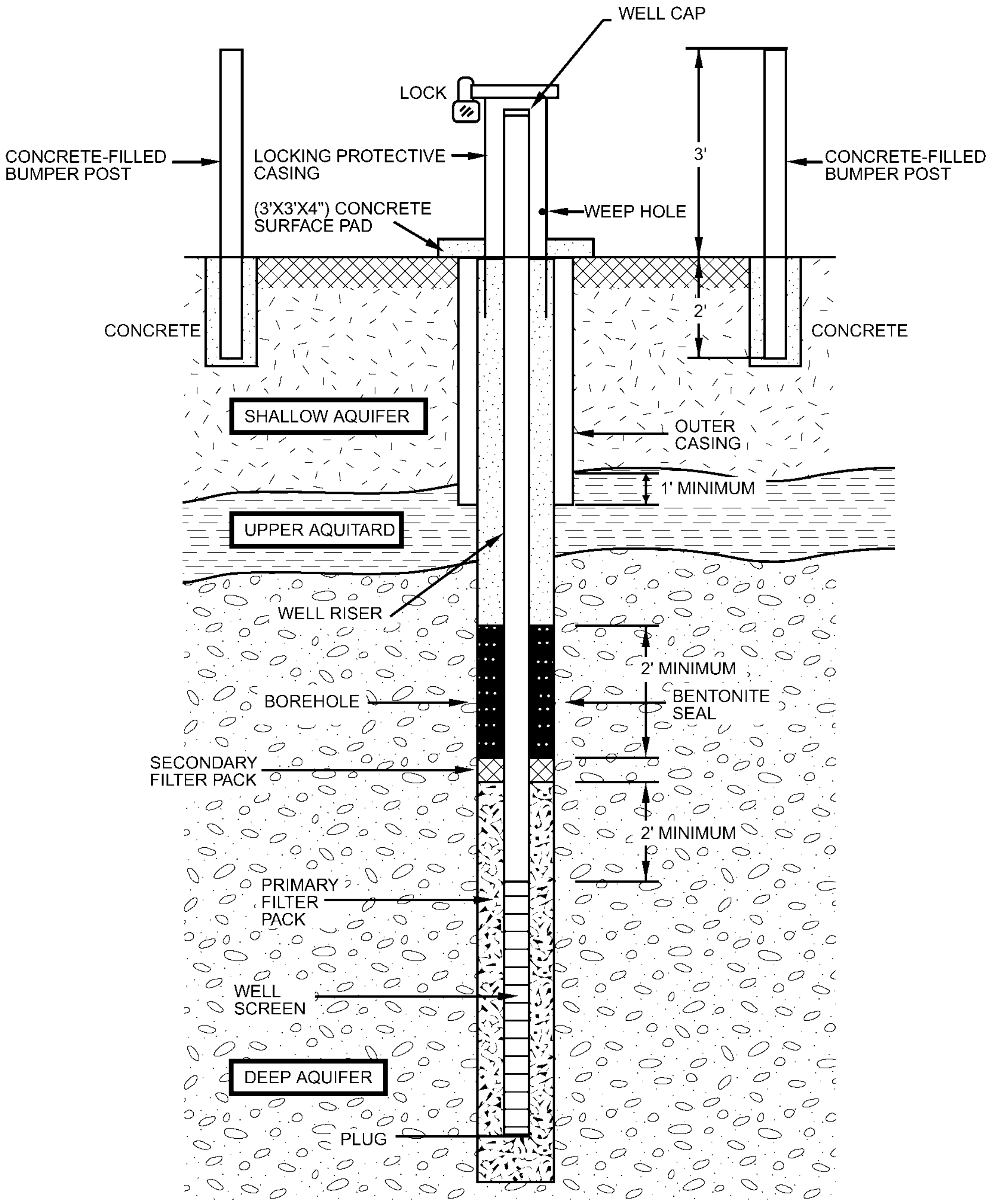
# FIGURE 2

# MONITORING WELL CONSTRUCTION DIAGRAM



## FIGURE 3

## MULTIPLE CASING WELL CONSTRUCTION DIAGRAM



## SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# MONITORING WELL DEVELOPMENT

## SOP NO. 021

## REVISION NO. 3

Last Reviewed: October 2000

RRiesing

Quality Assurance Approved

*October 5, 2000*

Date

## 1.0 BACKGROUND

All drilling methods impair the ability of an aquifer to transmit water to a drilled hole. This impairment is typically a result of disturbance of soil grains (smearing) or the invasion of drilling fluids or solids into the aquifer during the drilling process. The impact to the hydrologic unit surrounding the borehole must be remediated so that the well hydraulics and samples collected from the monitoring well are representative of the aquifer.

Well development should be conducted as an integral step of monitoring well installation to remove the finer-grained material, typically clay and silt, from the geologic formation near the well screen and filter pack. (Monitoring well installation is discussed in standard operating procedure [SOP] No. 020.) The fine-grained particles may interfere with water quality analyses and alter the hydraulic characteristics of the filter pack and the hydraulic unit adjacent to the well screen. Well development improves the hydraulic connection between water in the well and water in the formation. The most common well development methods are surging, jetting, overpumping, and bailing.

The health and safety plan for the site should be followed to avoid exposure to chemicals of concern. Water, sediment, and other waste removed from a monitoring well should be disposed of in accordance with applicable federal, state, and local requirements.

### 1.1 PURPOSE

This SOP establishes the requirements and procedure for monitoring well development. Well development improves the hydraulic characteristics of the filter pack and borehole wall by performing the following functions:

- Reducing the compaction and the intermixing of grain sizes produced during drilling by removing fine material from the pore spaces.
- Removing the filter cake or drilling fluid film that coats the borehole as well as much or all of the drilling fluid and natural formation solids that have invaded the formation.
- Creating a graded zone of sediment around the screen, thereby stabilizing the formation so that the well can yield sediment-free water.

## 1.2 SCOPE

This SOP applies to the development of newly installed monitoring wells. The SOP identifies the most commonly used well development methods; these methods can be used individually or in combination to achieve the most effective well development. Selection of a particular method will depend on site conditions, equipment limitations, and other factors. The method selected and the rationale for selection should be documented in a field logbook or appropriate project reports.

## 1.3 DEFINITIONS

**Aquifer:** A geologic formation, group of formations, or part of a formation that is saturated and capable of storing and transmitting water.

**Aquitard:** a geologic formation, group of formations, or part of a formation through which virtually no water moves.

**Bailer:** A cylindrical sampling device with valves on either end, used to extract water from a well or borehole.

**Bentonite seal:** A colloidal (extremely fine particle that will not settle out of solution) clay seal separating the sand pack from the surface seal.

**Drilling fluid:** A fluid (liquid or gas) that may be used in drilling operations to remove cuttings from the borehole, to clean and cool the drill bit, and to maintain the integrity of the borehole during drilling.

**Filter pack:** A clean, uniform sand or gravel placed between the borehole wall and the well screen to prevent formation material from entering the screen.

**Grout seal:** A fluid mixture of (1) cement and water or (2) cement, bentonite, and water that is placed above the bentonite seal between the casing and the borehole wall to secure the casing in place and keep water from entering the borehole.

**Hydraulic conductivity:** A measure of the ease with which water moves through a geologic formation. Hydraulic conductivity, K, is typically measured in units of distance per time in the direction of groundwater flow.

**Hydrologic units:** Geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units.

**Oil air filter:** A filter or series of filters placed in the airflow line from an air compressor to reduce the oil content of the air.

**Oil trap:** A device used to remove oil from the compressed air discharged from an air compressor.

**Riser:** The pipe extending from the well screen to or above the ground surface.

**Specific conductance:** A measure of the ability of the water to conduct an electric current. Specific conductance is related to the total concentration of ionizable solids in the water and is inversely proportional to electrical resistance.

**Static water level:** The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumpage.

**Transmissivity:** The volume of water transmitted per unit width of an aquifer over the entire thickness of the aquifer flow, under a unit hydraulic gradient.

**Well screen:** A cylindrical pipe with openings of a uniform width, orientation, and spacing used to keep materials other than water from entering the well and to stabilize the surrounding formation.

**Well screen jetting (hydraulic jetting):** A jetting method used for development; nozzles and a high pressure pump are used to force water outwardly through the screen, the filter pack, and sometimes into the adjacent geologic unit.

## 1.4 REFERENCES

American Society for Testing and Materials. 1990. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers. D5092-90. West Conshohocken, Pennsylvania.

California Department of Toxic Substances Control. 1994. Monitoring Well Design and Construction for Hydrogeologic Characterization. Guidance for Groundwater Investigations. August.

Driscoll, F.G. 1986. *Groundwater and Wells (Second Edition).* Johnson Division, UOP, Inc. St. Paul, Minnesota.

U.S. Environmental Protection Agency (EPA). 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. Office of Research and Development, Environmental Monitoring Systems Laboratory. Washington, DC. EPA/600-4-89/034. March. On-Line Address: http://www.epa.gov/swerust1/cat/wwelldct.pdf

EPA. 1994. Well Development. Environmental Response Team SOP #2044 (Rev. #0.0, 10/03/94). On-Line Address: http://www.ert.org/media_resrcs/media_resrcs.asp?Child1=

## 1.5 REQUIREMENTS AND RESOURCES

The type of equipment used for well development will depend on the well development method. Well development methods and the equipment required are discussed in Section 2.1 of this SOP. In general, monitoring wells should be developed shortly after they are installed but no sooner than 24 hours after the placement of the grout seal, depending on the grout cure rate and well development method. Most drilling or well development rigs have pumps, air compressors, bailers, surge blocks, and other equipment that can be used to develop a monitoring well.

All downhole equipment should be properly decontaminated before and after each well is developed. See SOP No. 002 (General Equipment Decontamination) for details.

# 2.0 WELL DEVELOPMENT PROCEDURES

This section describes common well development methods, factors to be considered in selecting a well development method, procedures for initiating well development, well development duration, and calculations typically made during well development. In addition to this, procedures described in any work plans for well development should be fully consistent with local and state regulations and guidelines.

## 2.1 WELL DEVELOPMENT METHODS

Well development methods vary with the physical characterization of hydrologic units in which the monitoring well is screened and the drilling method used. The most common methods include mechanical surging, overpumping, air lift pumping, backwashing, surge bailing, and well jetting. These methods may be effective alone or may need to be combined (for example, overpumping combined with backwashing). Factors such as well design and hydrogeologic conditions will determine which well development method will be most practical and cost-effective. Commonly used well development methods are described in Sections 2.1.1 through 2.1.6.

The use of chemicals for monitoring well development should be avoided as much as possible. Introduction of chemicals may significantly alter groundwater chemistry in and around the well.

### 2.1.1 Mechanical Surging

The mechanical surging method forces water to flow in and out of the well screen by operating a plunger (or surge block) in the casing, similar to a piston in a cylinder. A typical surge block is shown in Figure 1. The surge block should fit snugly in the well casing to increase the surging action. The surge block is attached to a drill rod or drill stem and is of sufficient weight to cause the block to drop rapidly on the down stroke, forcing water contained in the borehole into the aquifer surrounding the well. In the recovery stroke or upstroke, water is lifted by the surge block, allowing water and fine sediments to flow back into the well from the aquifer. Down strokes and recovery strokes are usually 3 to 5 feet in length.

The surge block should be lowered into the water column above the well screen. The water column will effectively transmit the action of the block to the filter pack and hydrologic unit adjacent to the well screen. Development should begin above the screen and move progressively downward to prevent the surge block from becoming sand locked in the well. The initial surging action should be relatively gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. As water begins to move easily both in and out of the screen, the surge block is usually lowered in increments to a level just above the screen. As the block is lowered, the force of the surging movement should be increased. In wells equipped with long screens, it may be more effective to operate the surge block in the screen to concentrate its actions at various levels.

A pump or bailer should be used periodically to remove dislodged sediment that may have accumulated at the bottom of the well during the surging process. The pump or bailer should be moved up and down at the bottom of the well to suspend and collect as much sediment as possible.

The accumulation of material developed from a specific screen interval can be measured by sounding the total depth of the well before and after surging. Continue surging until little or no sand accumulates.

#### 2.1.2 Overpumping

Overpumping involves pumping the well at a rate substantially higher than it will be pumped during well purging and groundwater sampling. This method is most effective on coarse-grained formations and is usually conducted in conjunction with mechanical surging or backwashing. Overpumping is commonly implemented using a submersible pump. In cases were the water table is less than 30 feet from the top of the casing, it is possible to overpump the well with a centrifugal pump. The intake pipe is lowered into the water column at a depth sufficient to ensure that the water in the well is not drawn down to the pump intake level. The inflow of water at the well screen is not dependent on the location of the pump intake as long as it remains submerged.

Overpumping will induce a high velocity water flow, resulting in the flow of sand, silt, and clay into the well, opening clogged screen slots and cleaning formation voids and fractures. The movement of these particles at high flow rates should eliminate particle movement at the lower flow rates used during well purging and sampling. The bridging of particles against the screen because of the flow rate and direction created by overpumping may be overcome by using mechanical surging or backwashing in conjunction with this method.

### 2.1.3 Air Lift Pumping

Air lift pumping uses a two-pipe system consisting of an air injection pipe and a discharge pipe. In this well development method, an air lift pump is operated by cycling the air pressure on and off for short periods of time. This operation provides a surging action that can dislodge fine-grained particles in the vicinity of the well screen. Subsequently applying a steady low pressure removes the fines drawn into the well by the surging action.

The bottom of the air lift should be at least 10 feet above the top of the well screen. Air is injected through an inner pipe at sufficient pressure to bubble out directly into the surrounding discharge pipe. The bubbles formed by the injected air cause the column of water in the discharge pipe to be lifted upward and allow water from the aquifer to flow into the well. This arrangement prevents injected air from entering the well screen. Pumping air through the well screen and into the filter pack and adjacent hydrologic unit should be avoided because it can cause air entrainment, inhibiting future sampling efforts and possibly altering groundwater chemistry.

The air injected into the well should be filtered using an oil/air filter and oil trap to remove any compressor lubricant entrained in the air. Air pressures required for this well development method are relatively low; an air pressure of 14.8 pounds per square inch should move a 30-foot column of water. For small-diameter, shallow wells where the amount of development water is likely to be limited, tanks of inert gas (such as nitrogen) can be used as an alternative to compressed air.

### 2.1.4 Backwashing

Effective development procedures should cause flow reversals through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Backwashing overcomes the bridging that results from overpumping by allowing the water that is pumped to the top of the well to flow back through the submersible pump and out through the well screen. The backflow portion of the backwashing cycle breaks down bridging, and the inflow then moves the fine material toward the screen and into the well.

Some wells respond satisfactorily to backwashing techniques, but the surging effect is not vigorous enough to obtain maximum results in many cases.

A variation of backwashing may be effective in low-permeability formations. After the filter pack is installed on a monitoring well, clean water is circulated down the well casing, out through the well screen and filter pack, and up through the open borehole before the grout or bentonite seal is placed in the annulus. Flow rates should be controlled to prevent floating the filter pack. Because of the low hydraulic conductivity of the formation, negligible amounts of water will infiltrate into the formation. Immediately after this procedure, the bentonite seal should be installed, and the nonformation water should be pumped out of the well and filter pack.

### 2.1.5 Surge Bailing

Surge bailing can be an effective well development method in relatively clean, permeable formations where water flows freely into the borehole. A bailer made of stainless steel or polyvinyl chloride and slightly smaller than the well casing diameter is allowed to fall freely through the borehole until it strikes the groundwater surface. The contact of the bailer produces a downward force and causes water to flow outward through the well screen, breaking up bridging that has developed around the screen. As the bailer fills and is rapidly withdrawn from the well, the drawdown created causes fine particles to flow through the well screen and into the well. Subsequent bailing can remove these particles from the well. Lowering the bailer to the bottom of the well and using rapid short strokes to agitate and suspend solids that have settled to the well bottom can enhance removal of sand and fine particles. Bailing should continue until the water is free of suspended particles.

### 2.1.6 Well Jetting

Well jetting can be used to develop monitoring wells in both unconsolidated and consolidated formations. Water jetting can open fractures and remove drilling mud that has penetrated the aquifer. The discharge force of the jetting tool is concentrated over a small area of the well screen. As a result, the tool must be rotated constantly while it is raised and lowered in a very small increments to be sure that all portions of the screen are exposed to the jetting action.

Jetting is relatively ineffective on the fine screens typically used in monitoring wells (slot sizes from 0.01 to 0.02 inch). In addition, jetting requires the introduction of external water into the well and surrounding formation. This water should be obtained from a source of known chemistry. Water introduced for development should be completely removed from the aquifer immediately after development.

The use of compressed air as a jetting agent should not be employed for development of monitoring wells. Compressed air could entrain air in the formation, introduce oil into the formation, and damage the well screen.

## 2.2 FACTORS TO CONSIDER WHEN SELECTING A WELL DEVELOPMENT METHOD

It is important to check federal, state, and local regulatory requirements for monitoring well development requirements. This SOP may be changed to accommodate applicable regulations, site conditions, or equipment limitations.

The type of geologic material, the design and completion of the well, and the type of drilling method used are all factors to be considered during the development of a monitoring well.

Monitoring well development should usually be started slowly and gently and then performed with increasing vigor as the well is developed. Most well development methods require the application of sufficient energy to disturb the filter pack, thereby freeing fine particles and allowing them to be drawn into the well. The coarser particles then settle around and stabilize the screen.

Development procedures for wells completed in fine sand and silt strata should involve methods that are relatively gentle so that strata material will not be incorporated into the filter pack. Vigorous surging for development can produce mixing of the fine strata and filter pack and produce turbid samples from the formation. In addition, development methods should be carefully selected based upon the potential contaminants present, the quantity of wastewater generated, and requirements for containerization or treatment of wastewater.

For small diameter and small volume wells, a development bailer can be used in place of a submersible pump in the pumping method. Similarly, a bailer can be used in much the same fashion as a surge block in small diameter wells.

Any time an air compressor is used for well development, it should be equipped with an oil air filter or oil trap to minimize the introduction of oil into the screened area. The presence of oil could impact the organic constituent concentrations of the water samples collected from the well.

The presence of light nonaqueous phase liquid (LNAPL) can impact monitoring well development. Water jetting or vacuum-enhanced well development may assist in breaking down the smear zone in the LNAPL. Normal development procedures are conducted in the water-saturated zone and do not affect the LNAPL zone.

## 2.3 INITIATING WELL DEVELOPMENT

Newly completed monitoring wells should be developed as soon as practical, but no sooner than 24 hours after grouting is completed if rigorous well development methods are used. Development may be initiated shortly after well installation if the development method does not interfere with the grout seal. State and local regulations should be checked for guidance. The following general well development steps can be used with any of the methods described in Section 2.1.

1. Assemble the necessary equipment on a plastic sheet around the well. This may include a water level meter (or oil/water interface probe if LNAPL or dense nonaqueous phase liquid is present); personal protective equipment; pH, conductivity, temperature, and turbidity meters; air monitoring equipment; Well Development Data Sheets (see Figure 2); a watch; and a field logbook.

2. Open the well and take air monitoring readings at the top of the well casing and in the breathing zone. See SOP No. 003 (Organic Vapor Air Monitoring) for additional guidance.

3. Measure the depth to water and the total depth of the monitoring well. See SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement) for additional guidance.

4. Measure the initial pH, temperature, turbidity, and specific conductance of the groundwater from the first groundwater that comes out of the well. Note the time, initial color, clarity, and odor of the water. Record the results on a Well Development Data Sheet (see Figure 2) or in a field logbook. See SOPs No. 011 (Field Measurement of Water Temperature), 012 (Field Measurement of pH), 013 (Field Measurement of Specific Conductance), and 088 (Field Measurement of Water Turbidity) for additional guidance.

5. Develop the well using one or more of the methods described in Section 2.1 until the well is free of sediments and the groundwater turbidity has reached acceptable levels. Record the development method and other pertinent information on a Well Development Data Sheet see Figure 2) or in a field logbook.

6. Containerize any groundwater produced during well development if groundwater contamination is suspected. The containerized water should be sampled and analyzed to determine an appropriate disposal method.

7. Do not add water to assist in well development unless the water is from a source of known chemical quality and the addition has been approved by the project manager. If water is added, five times the amount of water introduced should be removed during development.

8. Continue to develop the well, repeating the water quality measurements for each borehole volume. Development should continue until each water quality parameter is stable to within 10 percent. Development should also continue until all the water added during development (if any) is removed or the water has a turbidity of less than 50 nephelometric turbidity units. This level may only be attainable after allowing the well to settle and testing at low flow sampling rates.

9. At the completion of well development, measure the final pH, temperature, turbidity, and specific conductance of the groundwater. Note the color, clarity, and odor of the water. Record the results on a Well Development Data Sheet (see Figure 2) or in a field logbook. In addition to the final water quality parameters, the following data should be noted on the Well Development Data Sheet: well identification, date(s) of well installation, date(s) and time of well development, static water level before and after development, quantity of water removed and time of removal, type and capacity of pump or bailer used, and well development technique.

All contaminated water produced during development should be containerized in drums or storage vessels properly labeled with the date collected, generating address, well identification, and consultant contact number.

## 2.4 DURATION OF WELL DEVELOPMENT

Well development should continue until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. When pH, temperature, turbidity, and specific conductance readings stabilize and the water is visually clear of suspended solids, the water is representative of formation water. The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes, whereas bailing the well may require several hours of continuous effort to obtain a clear sample.

An on-site project geologist should make the final decision as to whether well development is complete. This decision should be documented on a Well Development Data Sheet (see Figure 2) or in a field logbook.

## 2.5 CALCULATIONS

It is necessary to calculate the volume of water in the well. Monitoring well diameters are typically 2, 3, 4, or 6 inches. The height of water column (in feet) in the well can be multiplied by the following conversion factors to calculate the volume of water in the well casing.

| Well Diameter (inches) | Volume (gallon per foot) |
|---|---|
| 2 | 0.1631 |
| 3 | 0.3670 |
| 4 | 0.6524 |
| 6 | 1.4680 |

## 3.0 POTENTIAL PROBLEMS

The following potential problems can occur during development of monitoring wells:

- In some wells the pH, temperature, and specific conductance may stabilize but the water remains turbid. When this occurs, the well may still contain construction materials (such as drilling mud in the form of a mud cake) and formation soils that have not been washed out of the borehole. Excessive or thick drilling muds cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete well development. If the well is completed in a silty zone, it may be necessary to sample with low flow methods or filtering.

- Mechanical surging and well jetting disturb the formation and filter pack more than other well development methods. In formations with high clay and silt contents, surging and jetting can cause the well screen to become clogged with fines. If an excessive amount of fines is produced, sand locking of the surge block may result. Well development with these methods should be initiated gently to minimize disturbance of the filter pack and to prevent damage to the well screen.

- Effective overpumping may involve the discharge of large amounts of groundwater. This method is not recommended when groundwater extracted during well development is contaminated with hazardous constituents. If the hazardous constituents are organic compounds, this problem can be partially overcome by passing the groundwater through an activated carbon filter.

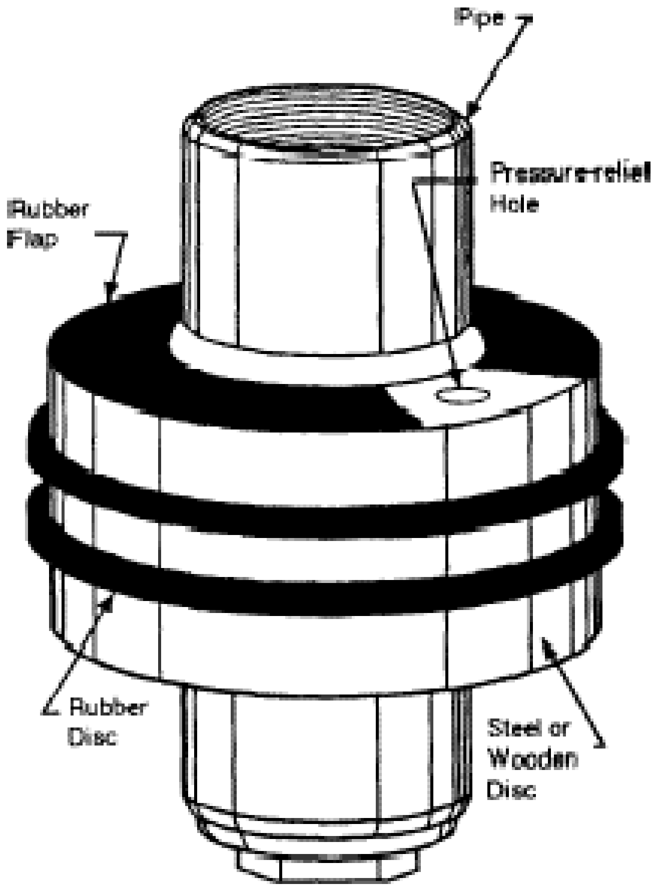
- When a well is developed by mechanical surging or bailing, rapid withdrawal of the surge block or bailer can result in a large external pressure outside of the well. If the withdrawal is too rapid and this pressure is too great, the well casing or screen can collapse.

- A major disadvantage of well jetting is that an external supply of water is needed. The water added during well jetting may alter the hydrochemistry of the aquifer; therefore, the water added in this development procedure should be obtained from a source of known chemistry. In addition, the amount of water added during well development and the amount lost to the formation should be recorded.

- The use of air in well development can chemically alter the groundwater, either directly through chemical reaction or indirectly as a result of impurities introduced through the air stream. In addition, air entrainment within the formation can interfere with the flow of groundwater into the monitoring well. Consequently, air should not be injected in the immediate vicinity of the well screen.

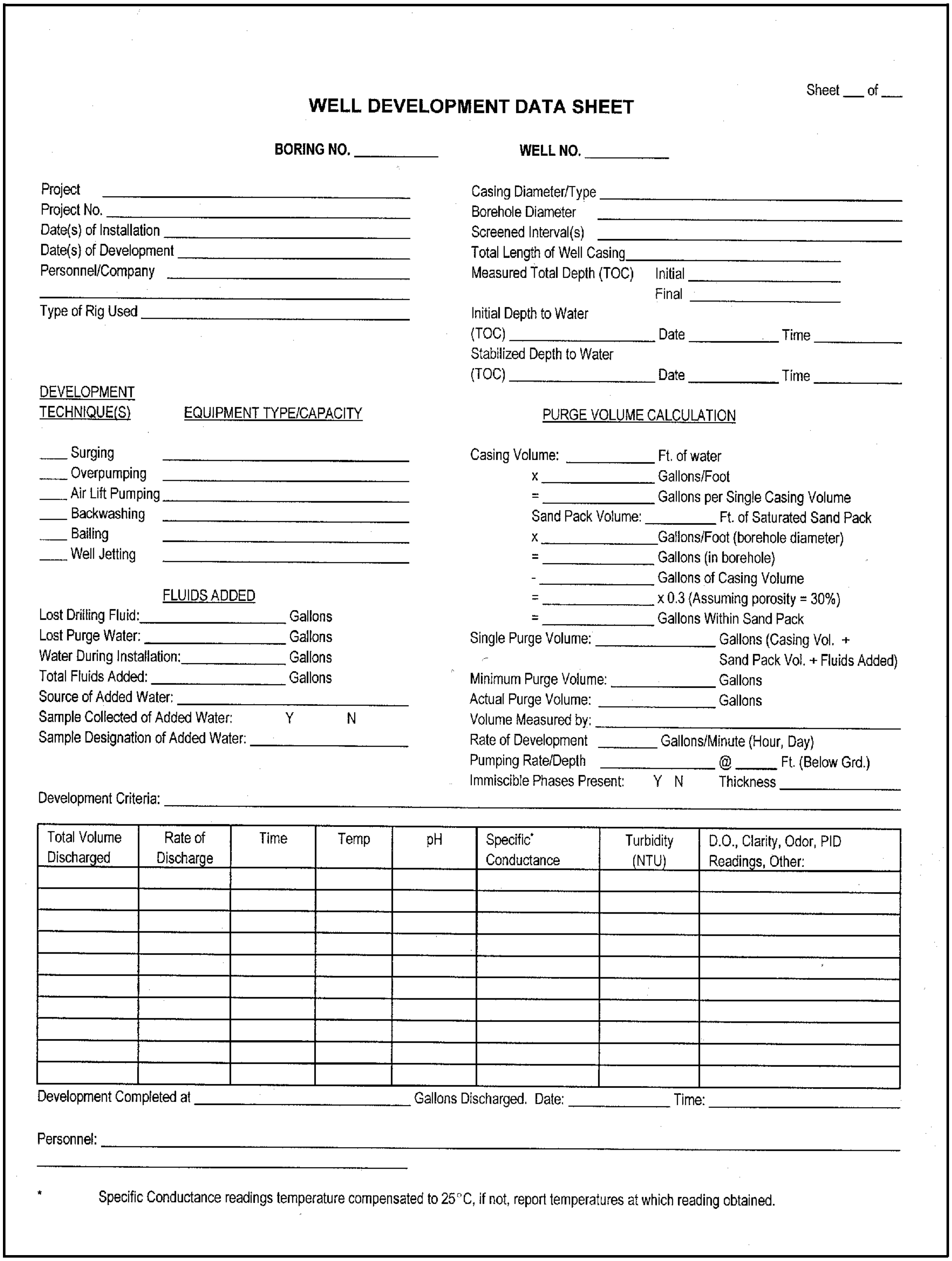
## FIGURE 1

## SCHEMATIC DRAWING OF A SURGE BLOCK



## FIGURE 2

## WELL DEVELOPMENT DATA SHEET



Sheet ___ of ___

**WELL DEVELOPMENT DATA SHEET**

**BORING NO.** ___________ **WELL NO.** ___________

Project ______________________________
Project No. ______________________________
Date(s) of Installation ______________________________
Date(s) of Development ______________________________
Personnel/Company ______________________________
______________________________
Type of Rig Used ______________________________

Casing Diameter/Type ______________________________
Borehole Diameter ______________________________
Screened Interval(s) ______________________________
Total Length of Well Casing ______________________________
Measured Total Depth (TOC) Initial ______________
Final ______________
Initial Depth to Water
(TOC) ______________ Date ___________ Time ___________
Stabilized Depth to Water
(TOC) ______________ Date ___________ Time ___________

DEVELOPMENT TECHNIQUE(S) EQUIPMENT TYPE/CAPACITY

____ Surging ______________________________
____ Overpumping ______________________________
____ Air Lift Pumping ______________________________
____ Backwashing ______________________________
____ Bailing ______________________________
____ Well Jetting ______________________________

FLUIDS ADDED

Lost Drilling Fluid: ______________ Gallons
Lost Purge Water: ______________ Gallons
Water During Installation: ______________ Gallons
Total Fluids Added: ______________ Gallons
Source of Added Water: ______________________________
Sample Collected of Added Water: Y N
Sample Designation of Added Water: ______________

PURGE VOLUME CALCULATION

Casing Volume: ___________ Ft. of water
x ______________ Gallons/Foot
= ______________ Gallons per Single Casing Volume
Sand Pack Volume: _________ Ft. of Saturated Sand Pack
x ______________ Gallons/Foot (borehole diameter)
= ______________ Gallons (in borehole)
- ______________ Gallons of Casing Volume
= ______________ x 0.3 (Assuming porosity = 30%)
= ______________ Gallons Within Sand Pack
Single Purge Volume: ______________ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: ______________ Gallons
Actual Purge Volume: ______________ Gallons
Volume Measured by: ______________________________
Rate of Development _______ Gallons/Minute (Hour, Day)
Pumping Rate/Depth ______________ @ _____ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness ______________

Development Criteria: ______________________________________________________________

| Total Volume Discharged | Rate of Discharge | Time | Temp | pH | Specific* Conductance | Turbidity (NTU) | D.O., Clarity, Odor, PID Readings, Other: |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Development Completed at ______________________ Gallons Discharged. Date: ___________ Time: ______________

Personnel: ______________________________________________________________
______________________________

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

## RECORDING OF NOTES IN FIELD LOGBOOK

## SOP NO. 024

## REVISION NO. 1

Last Reviewed: November 1999

KRiesing

Quality Assurance Approved

*May 18, 1993*

Date

## 1.0 BACKGROUND

The field logbook should contain detailed records of all the field activities, interviews of people, and observations of conditions at a site. Entries should be described in as much detail as possible, so that personnel can accurately reconstruct the activities and events which have taken place during field assignments. Field logbooks are considered accountable documents in enforcement proceedings and may be subject to review. Therefore, the entries in the logbook must be accurate, detailed, and reflect the importance of the field events.

### 1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide guidance to ensure that logbook documentation for any field activity is correct, complete, and adequate. Logbooks are used for identifying, locating, labeling, and tracking samples. A logbook should document any deviations from the project approach, work plans, quality assurance project plans, health and safety plans, sampling plans, and any changes in project personnel. They also serve as documentation of any photographs taken during the course of the project. In addition, the data recorded in the logbook may assist in the interpretation of analytical results. A complete and accurate logbook also aids in maintaining good quality control. Quality control is enhanced by the proper documentation of all observations, activities, and decisions.

### 1.2 SCOPE

This SOP establishes the general requirements and procedures for recording notes in the field logbook.

### 1.3 DEFINITIONS

None

### 1.4 REFERENCES

Compton, R.R. 1985. *Geology in the Field*. John Wiley and Sons. New York, N.Y.

## 1.5 REQUIREMENTS AND RESOURCES

The following items are required for field notation:

- Field logbooks
- Ballpoint pens with permanent ink
- 6-inch ruler (optional)

Field logbooks should be bound (sewn) with water resistant and acid-proof covers; they should have preprinted lines and wide columns. They should be approximately 7 1/2 by 4 1/2 inches or 8 1/2 by 11 inches in size. Loose-leaf sheets are not acceptable for field notes. If notes are taken on loose paper, they must be transcribed as soon as possible into a regular field logbook by the same person who took the notes.

Logbooks can be obtained through the Document Control Administrator (DCA) for each office. The DCA will have assigned each logbook an identification number. The DCA will make sure the pages in the logbooks are preprinted with consecutive numbers or are consecutively numbered by hand. If the numbers are written by hand, then numbers should be circled so that they are not confused with data.

# 2.0 PROCEDURES

The following subsections provide general guidelines and formatting requirements for field logbooks and detailed procedures for completing field logbooks.

## 2.1 GENERAL GUIDELINES

- A separate field logbook must be maintained for each project. If a site consists of multiple subsites, designate a separate logbook for each subsite. For special tasks, such as periodic well water-level measurements, data from multiple subsites may be entered into one logbook which contains only one type of information.

- All logbooks must be bound and contain consecutively numbered pages.

- No pages can be removed from the logbook for any purpose.

- All field activities, meetings, photographs, and names of personnel must be recorded in the site logbook.

- All logbooks pertaining to a site or subsite should be assigned a serial number based on the date the logbook is issued to the project manager. The first logbook should be assigned number 1, the next logbook issued assigned number 2, and so on. The project manager is to maintain a record of all logbooks issued under the project.

- All information must be entered with a ballpoint pen with waterproof ink. Do not use pens with "wet ink," because the ink may wash out if the paper gets wet. Pencils are not permissible for field notes because information can be erased. The entries should be written dark enough so that the logbook can be easily photocopied.

- Do not enter information in the logbook that is not related to the project. The language used in the logbook should be factual and objective.

- Begin a new page for each day's notes.

- Write notes on every line of the logbook. If a subject changes and an additional blank space is necessary to make the new subject title standout, skip one line before beginning the new subject. Do not skip any pages or parts of pages unless a day's activity ends in the middle of a page.

- Draw a diagonal line on any blank spaces of four lines or more to prevent unauthorized entries.

## 2.2 LOGBOOK FORMAT

The layout and organization of each field logbook should be consistent with other field logbooks. Guidelines for the cover, spine, and internal pagination are discussed below.

### 2.2.1 FORMAT OF FIELD LOGBOOK COVER AND SPINE

Write the following information in clear capital letters on the front cover of each logbook.

- Logbook identification number (assigned by the DCA)

- The serial number of the logbook (assigned by the project manager)

- Name of the site, city, and state

- Name of subsite if applicable
- Type of activity
- Beginning and ending dates of activities entered into the logbook
- “Tetra Tech EM Inc.” City and State
- “REWARD IF FOUND”

Some of the information listed above, such as the list of activities and ending dates, should be entered after the entire logbook has been filled or after it has been decided that the remaining blank pages in the logbook will not be filled.

The spine of the logbook should contain an abbreviated version of the information on the cover. For example: “1, Col. Ave., Hastings, 5/88 - 8/88.”

### 2.2.2 First Page of the Field Logbook

Spaces are usually provided on the inside front cover (or the opening page in some logbooks), for the company name (“Tetra Tech EM Inc.”), address, and telephone number. If preprinted spaces for this information are not provided in the logbook, write the information on the first available page.

## 2.3 ENTERING INFORMATION IN THE LOGBOOK

Enter the following information at the beginning of each day or whenever warranted during the course of a day:

- Date
- Starting time
- Specific location
- General weather conditions and approximate temperature

- Names of personnel present at the site. Note the affiliation(s) and designation(s) of all personnel.
- Equipment calibration and equipment models used.
- Changes in instructions or activities at the site.
- Levels of personal protective clothing and equipment.
- A general title of the first task undertaken (for example, well installation at MW-11, decon at borehole BH-11, groundwater sampling at MW-11).
- Provide an approximate scale for all diagrams. If this can't be done, write "not to scale" on the diagram. Indicate the north direction on all maps and cross-sections. Label features on each diagram.
- Corrections should be made by drawing a single line through the entry being corrected. Initial and date any corrections made in the logbook.
- The person recording notes is to initial each page after the last entry. No information will be entered in the area following these initials.
- At the end of the day, the person recording notes is to sign and date the bottom of the last page. Indicate the end of the work day by writing "Left site at (time)." A diagonal line will be drawn across any blank space to the bottom of the page.

The following information should be recorded in the logbook after taking a photograph:

- Time, date, location, direction, and if appropriate, weather conditions
- Description of the subject photographed and the reason for taking the picture
- Sequential number of the photograph and the film roll number (if applicable)
- Name of the photographer

The following information should be entered into the logbook when taking samples:

- Location description
- Names of samplers
- Collection time
- Designation of samples as a grab or composite sample
- Type of sample (water, sediment, soil gas, etc.)

- On-site measurement data (pH, temperature, specific conductivity)
- Field observations (odors, colors, weather, etc.)
- Preliminary sample description
- Type of preservative used
- Instrument readings

## 2.4 PRECAUTIONS

Custody of field logbooks must be maintained at all times. Field personnel must keep the logbooks in a secure place (locked car, trailer, or field office) when the logbook is not in personal possession. Logbooks are official project documents and must be treated as such.

# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

# FIELD MEASUREMENT OF GROUNDWATER pH, SPECIFIC CONDUCTANCE, AND TEMPERATURE USING THE YSI MODEL 3560

## SOP NO. 061

## REVISION NO. 1

Last Reviewed: January 2000

KRiesing

Quality Assurance Approved

*February 19, 1993*

Date

## 1.0 BACKGROUND

The YSI Model 3560 water quality monitoring system can be used for determining groundwater pH, specific conductance, and temperature. The system is designed to be used in the field with a pump but can also be used with a bailer. As water is pumped through the system, temperature, temperature-compensated pH, and temperature-compensated specific conductance can be monitored simultaneously. Stable readings of the groundwater running through the sample chamber can be obtained in as little as two minutes. The continuous monitoring of these parameters helps determine when a representative sample of the groundwater has been obtained. The system is designed for simple assembly and disassembly to facilitate frequent calibration and maintenance.

The YSI 3560 consists of a water quality monitor, a temperature probe, a flow-through conductivity cell, a pH electrode assembly, an oxidation-reduction potential electrode assembly, and a sample chamber assembly. The measurement of oxidation-reduction potential is not discussed in this standard operating procedure (SOP).

### 1.1 PURPOSE

This SOP establishes the requirements and procedures for using the YSI Model 3560 water quality monitoring system for determining groundwater pH, specific conductance, and temperature in the field.

This instrument allows the user to visually monitor three parameters simultaneously by means of three LCD displays. The unit operates on six alkaline “D” cell batteries that will provide a minimum of 1,400 operating hours. An on/off switch controls power to the instrument. A second function switch controls each of the three ranges of specific conductance indicated on the middle display. Temperature is read out constantly in °C on the top display, and temperature-compensated specific conductance, automatically corrected to 25 °C, can be monitored. A third function switch controls the bottom display, which shows temperature-compensated pH in either pH units or millivolts (mV).

## 1.2 SCOPE

This SOP applies to monitoring temperature, temperature-compensated pH, and temperature-compensated specific conductance simultaneously while using the YSI 3560 water quality monitoring system in the field.

The temperature probe can be used independently as a temperature probe or in conjunction with the specific conductance or pH probe for temperature-compensated readings when attached properly to the water quality monitor. It is usable over a range of -5 °C to 50 °C with an accuracy of ±0.2 °C.

## 1.3 DEFINITIONS

**Flow-Through Conductivity Cell:** The flow-through conductivity cell is constructed of polyvinyl chloride. A 3-foot jacketed cable is attached to the cell body. Two electrodes measure specific conductance. The cell response time is 10 seconds for 95 percent reading of specific conductance changes. Accurate measurement can be made with a flow rate up to 1.5 gallons per minute. The conductivity cell constant is K = 5.0 millimhos/cm (mmhos/cm).

**ph Electrode Assembly:** The pH electrode is a 5.5-inch-long polymer body consisting of a silver/silver chloride reference electrode and a silver working electrode sealed in 4-molar potassium chloride gel. This gel eliminates the need to add filling solution.

**Sample Chamber Assembly:** The sample chamber assembly is an integral part of the YSI water quality monitoring system. It is designed to be attached to a water pump outlet but can be used as a non-flowing sample chamber. The chamber is designed to provide good mixing of fluid, so residual sample is not a problem. The sample chamber holds approximately 1 liter of sample.

## 1.4 REFERENCE

YSI, Inc., “YSI Model 3560 Water Quality Monitoring System Instructions, Operator’s Manual.”

## 1.5 REQUIREMENTS AND RESOURCES

The following are required to measure groundwater pH, specific conductance, and temperature using this SOP:

- YSI Model 3560 water quality measuring system
- YSI 3167, 3168, and 3169 specific conductance calibration solutions
- Buffer solutions of pH 4, 7, and 10 for pH calibration
- Distilled or deionized water
- Rinse bottle
- 50-milliliter (mL) sample cups or beakers
- Sample tubing and connectors (described in Section 2.2.1)
- Waste container to collect purge water
- Logbook or field data sheets
- Ohmmeter for testing the temperature probe (optional)

# 2.0 PROCEDURES

The procedures outlined in this SOP apply to using the YSI Model 3560 water quality monitoring system to measure groundwater pH, specific conductance, and temperature in the field. Procedures for testing and calibrating the YSI Model 3560 are presented first, followed by procedures for operating the instrument and making field measurements.

## 2.1 TESTING AND CALIBRATION PROCEDURES

This section outlines procedures for testing and calibrating the YSI Model 3560 water quality monitoring system. The instrument contains no user serviceable adjustments. If testing and calibration measurements are out of tolerance, the instrument must be serviced or repaired.

### 2.1.1 Calibrating the pH Electrode

The calibration frequency of the pH electrode depends on the electrode, the pH monitor and the characteristics of the water to which the electrode is exposed. Since normal life of a pH electrode is only 3 to 6 months, it is advisable to calibrate the pH system before sampling at each site. The pH electrode should be tested for background noise and appropriately offset on a daily basis.

Before connecting the pH electrode, zero the electronics with the shorting cap attached to the water quality monitor. Turn on the water quality monitor and set the pH function switch to pH. Next, connect the shorting cap to the pH input jack and set the manual temperature compensation knob to 25 °C. Then 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.

Once it has been established that the electrode offset is functioning properly, a two-point calibration should be performed. Use pH buffers of 7.00 and 4.00 or of 7.00 and 10.00, whichever two are closer to the expected sample value. Proceed as follows to make a two-point calibration.

Rinse the pH electrode and temperature probe with pH 7.00 buffer to remove any contaminants. Connect the pH electrode to the pH input jack and the temperature probe to the TEMP input jack. Pour the pH 7.00 buffer into a 50-mL sample cup, then immerse both sensors into the buffer. Allow the sensors to equilibrate in the buffer until a stable reading is obtained. Read the temperature and manually adjust the pH temperature-compensation knob to the same value. Adjust the CAL control knob for 7.00 ± 0.01 pH units on the display and discard the buffer. Rinse the sensors with deionized or distilled water, followed by a rinse of the next desired buffer (pH 4.00 or 10.00). 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. If the temperatures of the two buffers differ by more than ±0.1 °C, the temperature should be allowed to stabilize. Adjust the SLOPE control until the display is within 0.01 pH units of the buffer's stated value. Discard the buffer and rinse the sensors with distilled or deionized water. The pH system is now calibrated and ready for use.

### 2.1.2 Calibrating the pH Electrode with Temperature Compensation

Follow the pH instructions in Section 2.1.1; however, the calibration procedure should be modified as indicated. Set the pH function switch to pH ATC. Connect the temperature probe to the pH ATC input jack. While the temperature probe can be used in either location, the pH ATC function will not work unless the temperature probe is connected to the pH ATC input. It is recommended that a second temperature probe be used for this operation. Manual temperature compensation is not necessary since temperature compensation is performed automatically in this mode.

### 2.1.3 Calibrating the Specific Conductance Probe

The designed cell constant of the flow-through conductivity cell is K = 5 mmhos/cm. The stainless steel electrodes provide different accuracies in different ranges. The cell constant can be affected by electrode fouling or mechanical shock. Therefore, it is wise to redetermine the cell constant routinely. When testing the calibration of the system, be sure to check the accuracy of the test against system specifications.

To check the cell constant, YSI 3167, 3168, 3169, or similar specific conductance calibration solutions may be used. The YSI calibration solutions are packaged eight to a box in 1-pint unbreakable plastic bottles designed for field use. The solutions are manufactured to nominal values of 1, 10, or 50 mmhos/cm at 25°C, with a ±1 percent accuracy of the stated value. A chart for uncompensated values at temperatures other than 25 °C is included with each box.

Connect the flow-through conductivity cell and temperature probe to the water quality monitor, 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 of the contents of the calibration solution bottle. Place both sensors into the remaining solution in the bottle, and allow them to come to temperature equilibrium. Make sure that the flow-through conductivity cell body is immersed so that the solution level is at least 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 within specification, the measured error can be used to improve the accuracy of the system by providing a correction factor for further readings. This is done as follows:

$$\text{Corrected Sample Value} = \frac{\text{Calibration Value}}{\text{Displayed Value}} \times \text{Sample Value}$$

Calibration Value = 1.000 mmhos/cm

Displayed Value = 0.978 mmhos/cm

Sample Value = 0.634 mmhos/cm

0.648 mmhos/cm = [(1.000 mmhos/cm)/(0.978 mmhos/cm )] x 0.634 mmhos/cm

Discard the calibration solution once the accuracy of the system has been determined. It has been contaminated and should not be reused. If system accuracy is out of specification, see Warranty and Shipping Information for repair instructions.

### 2.1.4 Testing the Temperature Probe (Optional)

The temperature probe is assembled with a thermistor and may be tested using an ohmmeter. With the sheath of the probe submerged in a 0.0 °C ± 1 °C ice bath, thermistor resistance can be compared to the following values:

Across pins A and B = 94.98 K ± 482 ohms
Across pins B and C = 15.59 K ± 103 ohms
Across pins A and C = 114.6 K ± 585 ohms
Across pins B and D = 0 K ± 1 ohms

If any measurement is out of tolerance, the temperature probe should be repaired or replaced.

## 2.2 OPERATING PROCEDURES

Operation of the YSI 3560 is discussed below, including hooking up the pump and measuring groundwater temperature, specific conductance (with and without automatic temperature compensation), and pH (with and without automatic temperature compensation).

### 2.2.1 Hooking up the Pump

The YSI 3560 water quality monitoring system may be connected to the pump outlet at any time during the purging-pumping process as long as the flow rate does not exceed 1.5 gallons per minute. The system is normally connected prior to starting the pump so that constant parameter monitoring may be achieved and the point for logging the representative sample values can be determined. Because of sample chamber construction, it is very important that a 1.5-gallon-per-minute sample flow not be exceeded; otherwise, leakage may occur. Small hose clamps or rubber bands may be used, as appropriate, to tighten seals and avoid leakage that sometimes may occur after properly hooking up the pump.

The outlet from the pump must first be prepared for the sample chamber input. Inlet and outlet lines for the sample chamber assembly are cut to the length desired from the 10-foot-long plastic tubing supplied. Insert a tube-hose stem adapter into each end of the inlet tubing. This section connects the pump outlet to the sample chamber inlet. Insert a third tube-hose stem adapter into one end of the outlet tubing. This goes from the sample chamber to a waste container.

Next, the sample chamber assembly is connected to a 1/2-inch or 3/8-inch outer diameter (OD) pump outlet by using the appropriate straight union connector supplied. For a 1/2-inch-OD pump outlet, use the straight-union connector with two 1/2-inch-ID ports. For a 3/8-inch-OD pump outlet, use the straight-union connector that has one 3/8-inch-ID port and one 1/2-inch-ID port. Hand-tighten the appropriate port of the straight union connector at the pump outlet. Insert one end of the previously constructed sample chamber inlet tubing into the opposite port of the straight-union connector at the pump outlet and hand-tighten it.

Insert the other end of the constructed inlet tubing into an elbow until it stops. Then insert the elbow into the top of the flow-through conductivity cell and push down until it stops. Two internal O-rings in the cell serve as water seals.

The constructed end of the outlet tubing with the inserted tube-hose stem adapter is then pushed into another elbow until it stops. Then the elbow is inserted into the outlet port of the sensor mounting plate of the sample chamber and pushed down until it stops. There is a double O-ring seal here too.

Install the sensors that will be used into the sensor mounting plate in their respective ports. The sensor ports not in use must have plugs (provided with the YSI 3560 system) installed to close off the sample chamber. The input jacks are marked for proper placement of each connector. The temperature, conductivity, pH, automatic temperature-compensation probe inputs, and the recorder output have male connectors. The pH electrode comes with a connector that has a very low water integrity and so its “boot” should be installed over its connector. With the sensors attached to the water quality monitor, place all the cables from the sample chamber into the black cable harness provided with the YSI 3560 system. The harness is slotted for easy cable installation. The system is now ready for operation.

With the system connected to the pump, begin pumping according to the pump manufacturer’s instructions. Turn on the water quality monitor. Before recording any values, make sure the sample chamber is full, that all air is voided, and that all of the displayed values are stable.

### 2.2.2 Measuring pH

To measure pH, connect the pH electrode to the water quality monitor, and set the pH function switch to pH. Install the electrode into its port in the sample chamber assembly. Though the instrument and electrode have been calibrated at one temperature, they can be used at other temperatures as long as the manual temperature knob is reset to the new sample temperature before final pH values are determined. Be sure to reset the dial to the temperature indicated by the top display. Though pH is temperature dependent, it is not customarily corrected to 25 °C, as specific conductance often is; pH changes with temperature at the rate of 0.355 percent/1 °C from the calibration point.

When measuring pH with no electrode connected to the mV input, the shorting cap attached to the water quality monitor should be on the mV input jack.

### 2.2.3 Measuring Automatically Temperature-Compensated pH

To measure automatically temperature-compensated pH, a temperature probe and the pH electrode must be connected to the water quality monitor.  As long as the pH ATC mode is being used, the temperature probe must remain connected to the pH ATC input jack or else the pH display will show an underrange negative value, or an overrange value greater than 14.00; both values are outside of the pH range of 0.00 to 14.00 and cannot be adjusted into the measurable pH range.

Install the electrode into the sample chamber assembly in its appropriate port, and the temperature probe into the pH ATC port.  Though the instrument and sensors have been calibrated at one temperature, they can be used at other temperatures, since temperature changes from the calibration point will be automatically corrected to the new value.  When measuring pH with no electrode connected to the mV input, the shorting cap attached to the water quality monitor should be on the mV input jack.

### 2.2.4 Measuring Specific Conductance

To measure specific conductance, connect the flow-through conductivity cell to the water quality measurement.  Set the conductivity function switch to 2 and observe the displayed value after the reading is stable.  The display reads out in mmhos/cm.  If no cell or a dry cell is attached to the water quality monitor, the display will read 000 (±002) with the appropriate decimal point.

If the overrange signal (1.___) is displayed, the specific conductance of the water being tested 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, the specific conductance is greater than 100.0 mmhos/cm and the water quality monitor cannot be used for specific conductance determination.

### 2.2.5 Measuring Automatically Temperature-Compensated Specific Conductance

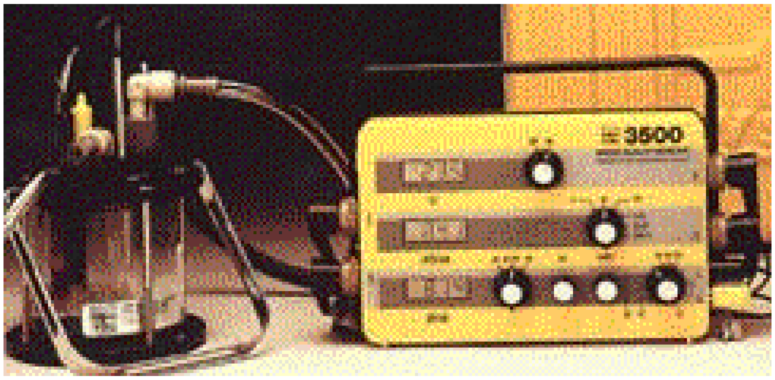
To measure automatically temperature-compensated specific conductance, connect the temperature probe and the flow-through conductivity cell to the water quality monitor, and set the conductivity function switch to the correct automatic temperature-compensated specific conductance range. Readings are automatically compensated by 2 percent/1 °C to 25 °C. The temperature probe must be located in the sample being tested for the automatic compensation to work correctly. If no temperature probe is connected to the monitor, the display will show the overrange signal (1.___).

### 2.2.6 Measuring Temperature

To measure temperature, connect the temperature probe to the water quality monitor. Temperature is measured in °C and is shown continuously on the top display. With no probe attached, the water quality monitor display will read -34.0 ± 0.2 °C.

## FIGURE 1

## THE YSI 3560 WATER QUALITY MONITORING SYSTEM



# SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

## SOIL GAS SAMPLING METHODS

**SOP NO. 074**

**REVISION NO. 1**

Last Reviewed: November 1999

KRiesing

Quality Assurance Approved

*May 21, 1993*

Date

## 1.0 BACKGROUND

Soil gas samples can be collected using several methods. This standard operating procedure (SOP) presents sample collection procedures for collecting soil gas samples in Tedlar® bags, glass sampling bulbs, and stainless-steel canisters. Tedlar® bags and glass sampling bulbs are best suited for on-site or near-site chemical analysis, whereas steel canisters are best suited for shipping samples to a full service laboratory.

### 1.1 PURPOSE

The purpose of this SOP is to provide guidance for the use of Tedlar® bags, glass sampling bulbs, and stainless-steel canisters for soil gas sample collection. Soil gas samples collected by these methods may be analyzed for volatile organic compounds such as trichloroethene, benzene, and toluene and for inorganic parameters such as nitrogen, oxygen, and carbon dioxide.

### 1.2 SCOPE

This SOP applies to all personnel collecting soil gas samples in Tedlar® bags, glass sampling bulbs, or stainless-steel canisters. The site-specific work plan and sampling plan should be followed during soil gas sampling activities.

### 1.3 DEFINITIONS

**Soil Gas -** The gases or atmosphere filling the void spaces in soils and unconsolidated sediments. These gases may all be of natural origin, but manmade contaminants or by-products may be present in detectable quantities.

### 1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1984. *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods*. Second Edition. EPA-600/4-84-076. December.

EPA. 1988. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. Method TO-14. Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC. 600/4-89/017. June.

EPA. 1990. "General Precautions in the Use of Canister Sampling for Measuring VOCs in Ambient Air." *Office of Solid Waste Emergency Response (OSWER). Bulletin Board.*

## 1.5 REQUIREMENTS AND RESOURCES

When using the Tedlar® bag collection method, the following items are needed:

- A sampling port and attached sampling line, ready for sampling
- A pump (SKC universal flow pump or equivalent), capable of pumping at least 3 liters per minute to allow purging of the sample point prior to collection of soil gas samples
- Sampling lines (dedicated, 0.375-inch outer diameter Tygon tubing) to connect all field equipment
- Y-branched plastic (Teflon®-lined if available) sampling hose for duplicate collection
- 500-cubic-centimeter (cc) Tedlar® bags, with metal fittings
- Vacuum chamber

When using glass sampling bulbs to collect soil gas, the following items are needed:

- A supply of clean 250- or 500-milliliter (mL) glass gas sampling bulbs with stopcock valves
- Tygon tubing or equivalent of appropriate size to connect the sampling bulb to the sample port and vacuum system
- A vacuum pump to purge the sampling system and allow for sample collection. A vacuum/volume system capable of measuring purge volumes is desirable.
- A sampling system with an inline pressure gauge
- A source of heated air to purge and decontaminate the reusable glass sampling bulbs prior to initial use and between each subsequent use. This may consist of a simple hand-held hair drier.

When using steel canisters to collect soil gas, the following items are needed:

- A supply of clean, evacuated stainless-steel canisters (SUMMA canisters) with a pressure gauge to verify internal pressure
- A vacuum pump (SKC universal flow pump or equivalent) to allow purging of the sample point prior to collection of soil gas samples
- Tygon tubing or equivalent of appropriate size for connecting the sampling port to pump (during gas point purging) and the sampling port to stainless steel canister (during sample collection)
- Y-branched tubing (plastic, Teflon®-lined if available) for duplicate collection

## 2.0 PROCEDURES

This section describes selection of soil gas sampling locations and general preparation of the sampling system to be used. This section also provides detailed procedures for collecting samples using Tedlar® bags, glass bulbs, and stainless-steel canisters. Finally, this section discusses additional considerations that affect soil gas sampling, including duplicate and equipment blank sample collection, decontamination, and sample transfer, and summarizes the advantages and disadvantages of each sampling method.

### 2.1 SAMPLING LOCATION SELECTION

Sampling locations should be selected and prepared for sampling as described in a site-specific quality assurance project plan and field sampling plan. Soil gas samples may be collected from depths as shallow as 3 feet or as great as 50 feet, depending on the objectives of the project, the site soil conditions, and the specific equipment used to penetrate to depth. The horizontal spacing of soil gas sampling points (grid size) may be only a few feet or more than 500 feet. Again, this is a function of project-specific objectives and site conditions.

## 2.2 SAMPLING SYSTEM PREPARATION

The sample probe assemblies may consist of three types: (1) a hand-driven soil gas probe 4 feet in length, (2) a drill rig-driven soil gas probe 2 feet in length, (3) a hydraulic-driven soil gas probe 3 feet in length. The probes may be assembled in series to reach the desired sampling depth. The probes will be driven to or emplaced at the desired sample collection depth, and then fitted with the Tygon sampling line.

Once fitted with the sampling line, the ambient air within the sampling system is purged. Usually, three system volumes are purged prior to sample collection. If the sampling system purge volume cannot be measured, then a standard purge time of 3 to 5 minutes should be used.

After the system is purged of ambient air but before the pump is turned off, approximately 2 inches of the sampling line closest to the entrance port of the pump should be folded over itself and the tubing should be clamped to keep ambient air from reentering the system. This is not necessary when sampling with glass bulbs because the bulbs are already connected to the sampling line. After the system is purged and sealed to ambient air, the pump should be turned off. Sample collection can now proceed using a Tedlar® bag, a glass bulb, or a stainless-steel canister.

## 2.3 SAMPLE COLLECTION USING TEDLAR® BAGS

Soil gas can be collected for chemical analysis in a 500-cc Tedlar® gas sampling bag. This can be accomplished by using an SKC pump to induce a vacuum on the exterior of the bag. This will cause the Tedlar® bag to be inflated with soil gas. The following procedure should be used:

1. Connect the free end of the Tygon tubing (previously inserted through the top of the vacuum chamber) to the Tedlar® gas sampling bag. Open the valve on the gas sampling bag and place the tubing into the body of the vacuum chamber.
2. Place the top on the vacuum chamber.
3. Connect the free end of the evacuation tube to the SKC pump.
4. Turn on the pump. This should create a vacuum in the chamber, and the Tedlar® bag should fill at a rate of approximately 2 liters per minute. The rate at which the Tedlar® gas sampling bag fills will depend on the porosity and permeability of the soil.

5. The minimum amount of soil gas needed for analysis is approximately 0.25 liter.

6. If less than 0.25 liter is collected after 4 minutes of sampling, raise the soil gas probe 0.5 foot (if possible). Continue to evacuate the vacuum chamber for another minute. If the minimum required soil gas is not collected, repeat the procedure again. If the minimum required volume of soil gas is still not collected, abandon the collection process. All steps conducted are to be accurately recorded in the field logbook.

7. Remove the top of the vacuum chamber after the soil gas sample is collected in the Tedlar® bag.

8. Close the valve on the Tedlar® gas sampling bag, clamp the Tygon tubing, and remove the Tedlar® gas sampling bag.

9. Turn off the pump.

10. Label the Tedlar® bag and its corresponding field datasheet (Figure 1) with the sample number.

11. Fill out the rest of the field datasheet. An alternative documentation procedure is to enter the requisite information in the field logbook.

## 2.4 SAMPLE COLLECTION USING GLASS BULBS

Soil gas also can be collected for chemical analysis in a glass bulb. When this sampling method is used, the glass bulb must be connected to the sampling system and purged of ambient air along with the sampling line before the sample is collected. The system is purged and the sample is collected using the following procedure:

1. Connect one end of the glass bulb to the sample line and the other end of the glass bulb to the vacuum pump using Tygon tubing, and then open both stopcocks on the bulb.

2. Turn on the vacuum pump and purge the sampling system as discussed in Section 2.2.

3. Turn off the vacuum pump.

4. Observe the inline pressure gauge to determine when the vacuum in the bulb has been filled with soil gas. This may require several minutes, particularly in soils with low porosity and permeability. If the vacuum in the bulb has not dropped after 4 minutes of sampling, raise the soil gas probe in 0.5-foot increments in an attempt to find a more permeable zone. If the soil gas probe is moved, guard against leakage of ambient air into the system and repurge if necessary.

5. Once the vacuum in the gas sampling bulb has been filled, close off the upstream stopcock on the bulb, then the downstream stopcock and disconnect the bulb from the sample line.
6. Label the glass bulb and its corresponding field datasheet with the sample number.
7. Fill out the rest of the field datasheet. An alternative documentation procedure is to enter the requisite information in the field logbook.

## 2.5 SAMPLE COLLECTION USING STAINLESS-STEEL CANISTERS

Soil gas also can be collected for chemical analysis in a stainless-steel, evacuated canister. Usually, these expensive canisters are used to collect duplicate samples for off-site analysis from locations that are being sampled for field screening analysis using Tedlar® bags or glass bulbs.

When this method is used, the canister is connected directly to the purged Tygon sampling tube. To prevent ambient air from entering the canister during sample collection, all connections must be airtight. To collect soil gas samples using this method, the following procedure is used:

1. Measure the canister pressure reading, ambient air temperature, and ambient air pressure, and record the readings in the field logbook prior to sample collection.
2. Open the canister pressure valve, which will allow the evacuated stainless-steel canister to draw in soil gas until the canister reaches ambient pressure. When the sampling valve on the canister shows that ambient pressure has been reached, close the sampling valve and remove the canister from the sampling line.
3. Measure and record the post-sampling pressure reading on the canister pressure valve.
4. Label the canister and its corresponding field datasheet with the sample number.
5. Fill out the rest of the field datasheet. An alternative documentation procedure is to enter the requisite information in the field logbook.

## 2.6 DUPLICATE AND EQUIPMENT BLANK COLLECTION

Duplicate soil gas samples will be collected at each site as required in the site-specific sampling plan and quality assurance project plan. Generally, 1 duplicate sample will be collected for every 10 samples collected. Each duplicate is collected in conjunction with a corresponding environmental sample.

To collect duplicate samples, a Y-branched sampling hose will be connected to the vacuum chamber or pump. Two Tedlar® bags, glass bulbs, or stainless-steel canisters will be attached, one to each end of the Y-branched hose. Sample collection will proceed as described above. After collection, one sample will be labeled as the environmental sample and one as the duplicate.

Equipment blanks also will be collected at each site as required in the site-specific sampling plan and quality assurance project plan. Generally, 1 blank will be collected for every 10 samples collected. Blanks will be collected by running ambient air through the sampling system immediately after it has been decontaminated, and by collecting the ambient air in a Tedlar® bag, glass bulb, or stainless-steel canister using the same procedures used to collect environmental samples. Blank sample collection is conducted upwind of any observed interference, and the location of the sampling should be recorded in the field logbook. Equipment blanks are collected to ensure that field equipment decontamination procedures are adequate.

## 2.7 DECONTAMINATION

Sampling probes should be decontaminated before the first sample is collected and between sampling points. Probes that are grossly contaminated should be decontaminated using a high pressure steam cleaner. Probes that are not grossly contaminated can be decontaminated by brushing off loose soil particles, then heating the probes until they are warm to the touch to drive off any volatile contaminants. Heating times of 7 to 10 minutes are generally sufficient for this purpose. This brushing and heating method greatly reduces the generation of decontamination fluids.

Glass sampling bulbs also must be decontaminated between each use. This may be accomplished by purging heated air through the bulbs using a hand-held hair drier and the vacuum pump. Highly contaminated bulbs may require decontamination using either a methanol or soapy water wash and a deionized water rinse.

If Y-branched tubing or any other sampling equipment is to be reused, it must also be decontaminated between sampling locations.

### 2.8 SAMPLE TRANSFER

After collection, each sample container will be transported to the designated laboratory for analysis. In many cases, samples will be analyzed on site in a mobile laboratory.

### 2.9 ADVANTAGES AND DISADVANTAGES OF EACH SAMPLING METHOD

Tedlar® bags are relatively inexpensive to use but can only be used once and then must be disposed of. If the soil formation being sampled has a low porosity and permeability, such as clay or silty clay, it may not be possible to inflate the Tedlar® bag with soil gas.

Glass bulbs are more expensive than Tedlar® bags but they can be reused indefinitely, as long as they are not broken. However, bulbs must be decontaminated between each use, and periodic equipment blanks must be analyzed to verify that the decontamination procedures used are effective.

Stainless-steel canisters are very expensive and, therefore, are not cost-effective when conducting on-site analysis. The advantage of this type of sampler is that confirmation samples may be collected and shipped off-site for analysis with excellent assurance of sample integrity.

## 3.0 CAUTIONS

Both Tedlar® bags and glass bulbs are transparent to light, and many volatile compounds are subject to degradation in sunlight. Because of this, samples should be stored in a dark place, such as a cooler, and analyzed as quickly as possible. In general, samples collected in Tedlar® bags or glass bulbs should be analyzed within 24 hours after collection, at a maximum. This will ensure sample integrity and minimize contaminant loss by degradation processes or absorption onto surfaces.

The concentration of volatile organic contaminants in the vapor phase in soil gas is a function of many complex and dynamic variables. Because of this, soil gas results do not usually show a direct correlation to groundwater contamination. However, soil gas may show a good relation to groundwater conditions and is therefore a very powerful tool for quickly and inexpensively locating sources of volatile organic contamination in groundwater.

While sampling, each sampling location should be screened with a flame ionization detector (FID) or photoionization detector (PID) following sample collection. The result of the FID or PID screening should be recorded on the sample container and field sheet so that the chemist analyzing the sample can determine whether sample dilutions or smaller sample volumes are required for analysis.

## FIGURE 1

## FIELD DATASHEET FOR SOIL GAS SAMPLING METHODS

Date: ____________________________________ Site/Facility Name: ________________________

Time: ____________________________________ Project No.: ______________________________

Sample Container: _______ Tedlar® Bag: ______ Glass Bulb: _______ SUMMA® canister: ________

Sampling location and depth: ________________________________________________________________

Description of location: ____________________________________________________________________

____________________________________________________________________________________________

Sample location purged: Yes ________________ FID or PID (circle one) Reading: __________________

Sample relinquished by: ___________________________ Date/Time: _________________

Sample received by: _______________________________ Date/Time: _________________

Attach field copy of sample label or write in sample number:

Notes:

# SLUG TESTS

SOP#: 2046
DATE: 10/03/94
REV. #: 0.0

## 1.0 SCOPE AND APPLICABILITY

This procedure is applicable to determine the horizontal hydraulic conductivity of distinct geologic horizons under in-situ conditions. The hydraulic conductivity (K) is an important parameter for modeling the flow of groundwater in an aquifer.

These are standard (i.e. typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limimtations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

## 2.0 METHOD SUMMARY

A slug test involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder of known volume. This is accomplished by displacing a known volume of water from a well and measuring the artificial fluctuation of the groundwater level.

The primary advantages of using slug tests to estimate hydraulic conductivities are numerous. First, estimates can be made in-situ, thereby avoiding errors incurred in laboratory testing of disturbed soil samples. Second, tests can be performed quickly at relatively low costs because pumping and observation wells are not required. And lastly, the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay).

## 3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this standard operating procedure (SOP).

## 4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Limitations of slug testing include: 1) only the hydraulic conductivity of the area immediately surrounding the well is estimated which may not be representative of the average hydraulic conductivity of the area, and 2) the storage coefficient, S, usually cannot be determined by this method.

## 5.0 EQUIPMENT/APPARATUS

The following equipment is needed to perform slug tests. All equipment which comes in contact with the well should be decontaminated and tested prior to commencing field activities.

- Tape measure (subdivided into tenths of feet)
- Water pressure transducer
- Electric water level indicator
- Weighted tapes
- Steel tape (subdivided into tenths of feet)
- Electronic data-logger (if transducer method is used)
- Stainless steel slug of a known volume
- Watch or stopwatch with second hand
- Semi-log graph paper (if required)
- Water proof ink pen and logbook
- Thermometer
- Appropriate references and calculator
- Electrical tape
- 21X micrologger
- Compact portable computer or equivalent with Grapher installed on the hard disk

## 6.0 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solvents may be necessary. If decontamination of the slug or equipment is required, refer to the Sampling Equipment Decontamination SOP and the site specific work plan.

## 7.0 PROCEDURES

### 7.1 Field Procedures

The following general procedures may be used to collect and report slug test data. These procedures may be modified to reflect site specific conditions:

1. When the slug test is performed using an electronic data-logger and pressure transducer, all data will be stored internally or on computer diskettes or tape. The information will be transferred directly to the main computer and analyzed. A computer printout of the data shall be maintained in the files as documentation.

   If the slug test data is collected and recorded manually, the slug test data form (Figure 1, Appendix A) will be used to record observations. The slug test data form shall be completed as follows:

   C Site ID - Identification number assigned to the site.
   C Location ID - Identification of location being tested.
   C Date - The date when the test data was collected in this order: year, month, day (e.g., 900131 for January 31, 1990).
   C Slug volume (ft$^3$) - Manufacturers specification for the known volume or displacement of the slug device.
   C Logger - identifies the company or person responsible for performing the field measurements.
   C Test method - The slug device is either injected or lowered into the well or withdrawn or pulled-out from the monitor well. Check the method that is applicable to the test situation being run.
   C Comments - Appropriate observations or information for which no other blanks are provided.
   C Elapsed time (min) - Cumulative time readings from beginning of test to end of test, in minutes.
   C Depth to water (ft) - Depth to water recorded in tenths of feet.

2. Decontaminate the transducer and cable.

3. Make initial water level measurements on monitor wells in an upgradient to downgradient sequence, if possible.

4. Before beginning the slug test, information will be recorded and entered into the electronic data-logger. The type of information may vary depending on the model used. When using different models, consult the operator's manual for the proper data entry sequence to be used.

5. Test wells from least contaminated to most contaminated, if possible.

6. Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings.

7. Cover sharp edges of the well casing with duct tape to protect the transducer cables.

8. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test but at least two feet from the bottom of the well. Be sure the depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at a constant depth.

9. Connect the transducer cable to the electronic data-logger.

10. Enter the initial water level and transducer design range into the recording device according to manufacturers instructions (the transducer design range will be stamped on the side of the transducer). Record the initial water level on the recording device.

11. "Instantaneously" introduce or remove a

known volume or slug of water to the well. Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.

12. At the moment of volume addition or removal assigned time zero, measure and record the depth to water and the time at each reading. Depths should be measured to the nearest 0.01 foot. The number of depth-time measurements necessary to complete the test are variable. It is critical to make as many measurements as possible in the early part of the test. The number and intervals between measurements will be determined from earlier previous aquifer tests or evaluations.

13. Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth.

14. Retrieve slug (if applicable).

    Note: The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

    If the well is to be used as a monitoring well, precautions should be taken that the wells are not contaminated by material introduced into the well. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers or measuring devices should be cleaned prior to the test. If tests are performed on more than one monitor well, care must be taken to avoid cross contamination of the wells.

    Slug tests shall be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the water level prior to sampling. At least one week should elapse between the drilling of a well and the performance of a slug test.

## 7.2 Post Operation Procedures

When using an electronic data-logger use the following procedure:

1. Stop logging sequence.

2. Print data.

3. Send data to computer by telephone.

4. Save memory and disconnect battery at the end of the day's activities.

5. Review field forms for completeness.

# 8.0 CALCULATIONS

The simplest interpretation of piezometer recovery is that of Hvorslev (1951). The analysis assumes a homogenous, isotropic medium in which soil and water are incompressible. Hvorslev's expression for hydraulic conductivity (K) is:

$$K = \frac{r^2 \ln (L/R)}{2 L T_0} \quad \text{for } L/R > 8$$

where:

$K$ = hydraulic conductivity [ft/sec]
$r$ = casing radius [ft]
$L$ = length of open screen (or borehole) [ft]
$R$ = filter pack (borehole) radius [ft]
$T_0$ = Basic Time Lag [sec]; value of t on semi-logarithmic plot of $H\text{-}h/H\text{-}H_0$ vs. t, where $H\text{-}h/H\text{-}H_0 = 0.37$
$H$ = initial water level prior to removal of slug
$H_0$ = water level at $t = 0$
$h$ = recorded water level at $t > 0$

(Hvorslev, 1951; Freeze and Cherry, 1979)

The Bower and Rice method is also commonly used for K calculations. However, it is much more time consuming than the Hvorslev method. Refer to Freeze and Cherry or Applied Hydrogeology (Fetter) for a discussion of these methods.

## 9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

1. All data must be documented on standard Chain of Custody records, field data sheets, or within personal/site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activity will apply:

1. Each well should be tested at least twice in order to compare results.

## 10.0 DATA VALIDATION

This section is not applicable to this SOP.

## 11.0 HEALTH AND SAFETY

When working with potential hazardouse materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

## 12.0 REFERENCES

Bower, H., 1978. Groundwater Hydrology, McGraw-Hill Book Company, New York, New York.

Bower, H., and R.C. Rice, 1980. "A Slug Test for Determining the Hydraulic Properties of Tight Formations", Water Resources Research, Vol. 16, No. 1 pp. 233-238.

Cooper, Jr. H.H., J.D., Bredehoeft, and S.S. Papadopulos, 1967. "Response of a Finite-Diameter Well to an Instantaneous Charge of Water", Water Resources Research, Vol. 13, No. 1.

DOI (U.S. Department of the Interior), Ground Water Manual, U.S. Government Printing Office, New York, New York, Washington, D.C.

Earlougher, R.C., 1977. Advances in Well Test Analysis, Society of Petroleum Engineers of AIME.

Ferris, J.G., and D.B., Knowles, 1954. "The Slug Test for Estimating Transmissivity", U.S. Geological Survey Ground Water Note 26.

Freeze, R. Allen and John A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Hvorslev, 1951. "Time Lag and Soil Permeability in Ground Water Observations", Bulletin No. 36, U.S. Army Corps of Engineers p. 50.

Johnson Division, UOP, Inc., 1966. Ground Water and Wells, Johnson Division, UOP, Inc., St. Paul, Minnesota.

Lohman, S.W., 1982. "Ground Water Hydraulics", U.S. Geological Survey, Paper 708, p. 70.

Neuman, S.P., 1972. "Theory of Flow in Unconfined Aquifers Considering Delayed Response of the Water Table", Water Resources Research, Vol. 8, No. 4, p. 1031.

Papadopulos, S.S., J.D., Bredehoeft, H.H., Cooper, Jr., 1973. "On the Analysis of Slug Test Data", Water Resources Research, Vol. 9, No. 4.

Todd, David K., 1980. Ground Water Hydrology, 2nd ed. John Wiley & Sons.

# APPENDIX A

## Slug Test Data Form

Page __ of __

FIGURE 1. Slug Test Data Form

DATE: ____________________________

SITE ID: ____________________________ SLUG VOLUME ($ft^3$): ____________________

LOCATION ID: ______________________ LOGGER: ______________________________

TEST METHOD: __ SLUG INJECTION __ SLUG WITHDRAWAL

COMMENTS: ______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Time Beginning of Test #1 __________ Time Beginning of Test #2 _______________

Time End of Test #1 __________ Time End of Test #2 ________________

| ELAPSED TIME (MIN) | DEPTH TO WATER (FT) | ELAPSED TIME (MIN) | DEPTH TO WATER (FT) |
|---|---|---|---|