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

ATTACHMENT B

QUALITY ASSURANCE PROJECT PLAN – REVISION 1
LANE STREET GROUND WATER CONTAMINATION SITE
ELKHART, ELKHART COUNTY, INDIANA

Prepared for
U.S. Environmental Protection Agency
Region 5
77 West Jackson Boulevard
Chicago, IL 60604

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Work Assignment No:	059-RICO-B5LH
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ACRONYMS AND ABBREVIATIONS

%D	Percent difference
%R	Percent recovery
µg/L	Microgram per liter
µg/m^3	Microgram per cubic meter
µm	Micrometer
A	Analytical
AES	Atomic emission spectroscopy
bgs	Below ground surface
CA	Corrective action
CADRE	Computer-aided data review
CAS	Chemical Abstract Services
CCV	Continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Calibration factor
CH_3OH	Methanol
CLP	Contract Laboratory Program
COC	Chain of custody
CRL	Chicago Regional Laboratory
CRQL	Contract-required quantitation limit
DCA	Dichloroethane
DCE	Dichloroethene
DQI	Data quality indicator
ECHD	Elkhart County Health Department
EPA	U.S. Environmental Protection Agency
ESA	Environmental Site Assessment
ESAT	Environmental Services Assistance Team
FID	Flame ionization detector
FS	Feasibility study
FSP	Field Sampling Plan
GC/MS	Gas chromatography/mass spectrometry
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
HCl	Hydrochloric acid

ACRONYMS AND ABBREVIATIONS (CONTINUED)

HDPE	High-density polyethylene
HNO_3	Nitric acid
HRS	Hazard Ranking System
IA	Indoor air
ICP	Inductively coupled plasma
ID	Identification
IDEM	Indiana Department of Environmental Management
IDW	Investigation-derived waste
Lane Street Site	Lane Street Ground Water Contamination Site
LCS	Laboratory control sample
LIMS	Laboratory Information Management System
MCL	Maximum contaminant level
MDL	Method detection limit
mg/kg	Milligram per kilogram
mL	Milliliter
MS	Matrix spike
MSD	Matrix spike duplicate
MW	Monitoring well
NA	Not applicable
$NaHSO_4$	Sodium bisulfate
NC	No criteria
ND	Not detected
NFG	National Functional Guidelines
NPL	National Priorities List
ORP	Oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PAL	Project action level
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene (perchloroethene)
PID	Photo-ionization detector
ppb	Part per billion
ppm	Part per million
PQL	Project Quantitation Limit
PQO	Project quality objective

ACRONYMS AND ABBREVIATIONS (CONTINUED)

PTFE	Polytetrafluoroethylene
PW	Private well
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
QL	Quantitation limit
RAC	Remedial Action Contract
RES	Residential
RI	Remedial investigation
RISC	Risk-Integrated System of Closure
RPD	Relative percent difference
RRF	Relative response factor
RSCC	Regional Sample Control Coordinator
RSD	Relative standard deviation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SI	Site Inspection
SIM	Selected Ion Monitoring
SMO	Sample Management Office
SO	Soil
SOP	Standard operating procedure
SOW	Statement of work
START	Superfund Technical Assessment and Response Team
SVOA	Semivolatile organic analysis
SVOC	Semivolatile organic compound
TAL	Target Analyte List
TBD	To be determined
TCA	Trichloroethane
TCE	Trichloroethene
UFP	Uniform Federal Policy for Implementing Environmental Quality Systems
UST	Underground storage tank
VAS	Vertical aquifer sampling
VOA	Volatile organic analysis
VOC	Volatile organic compound
VRP	Voluntary Remediation Program

ACRONYMS AND ABBREVIATIONS (CONTINUED)

WA	Work Assignment
WACN	Work Assignment Closeout Notification
WACR	Work Assignment Completion Report
WAM	Work Assignment Manager
WESTON	Weston Solutions, Inc.

B1.0 INTRODUCTION

SulTRAC has prepared this Quality Assurance Project Plan (QAPP) as Attachment B of the Sampling and Analysis Plan (SAP) for the Lane Street Ground Water Contamination Site (Lane Street Site) in Elkhart, Elkhart County, Indiana, under the U.S. Environmental Protection Agency (EPA) Remedial Action Contract (RAC) 2 for Region 5, Contract No. EP-S5-06-02, Work Assignment (WA) No. 059-RICO-B5LH. The Lane Street Site is a Superfund site because of the presence of documented hazardous substances and releases, particularly volatile organic compounds (VOC) in groundwater. The SAP consists of the Field Sampling Plan (FSP) (Attachment A) and the 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 2009). This QAPP describes the quality assurance (QA) and the quality control (QC) protocols and objectives, methods, and procedures to be performed by SulTRAC during the field investigation (Phase I) of the remedial investigation/feasibility study (RI/FS) at the Lane Street Site. As outlined in the Lane Street Site Work Plan (SulTRAC 2010), the scope of this QAPP was developed based on interaction with the EPA and review of site-related documents. QAPP activities will focus on the following activities and areas:

- Determine the lateral and vertical extent of the groundwater contamination
- Determine whether other contaminants are also present in the groundwater
- Determine whether there are ecologically sensitive area(s) which may be impacted by the groundwater contamination
- Conduct initial indoor air sampling if analytical results from soil and groundwater sampling warrant

This QAPP discusses only Phase I field sampling activities. Section B2.0 of this QAPP discusses the site description and history, and Section B3.0 discusses the QAPP procedures. The QAPP worksheets are presented after Section B3.0. References used to prepare this QAPP are listed after the worksheets, and figures and tables (not within the text of the report) are presented after the list of References at the end of this QAPP. Appendix B-1 presents the Standard Operating Procedures (SOP) used at the Lane Street Site, and Appendix B-2 presents the Superfund Removal Action Levels.

B2.0 SITE DESCRIPTION AND HISTORY

The Lane Street Site, in Elkhart, Elkhart County, Indiana, occupies about 65 acres (Figure B-1). The site is composed of mixed residential, commercial, and industrial areas. Most of the residents and industries within the approximate site boundary do not use private wells. The unknown source of the groundwater plume is presumed to be from the industrial park to the north of Lane Street (EPA 2009). Groundwater at the Lane Street Site is moving primarily south, toward the St. Joseph River. The site consists of a groundwater plume contaminated with VOCs, specifically, trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-DCE, trans-1,2-DCE, and tetrachloroethene (PCE). The VOCs likely originate from a release of chlorinated solvents.

Available information has tentatively defined the plume boundaries based primarily on residential well samples and sampling conducted by the Indiana Department of Environmental Management (IDEM) in April 2008. Based on this delineation, the plume in the residential area of Lane Street is at least 750 feet long and 300 feet wide at its widest extent, although it is not fully defined to the east or west. At present, the site boundaries have been determined to be Barley Street on the south, the eastern property boundary of the private property at [redacted] County Road 106 on the east, and an undeveloped property (Parcel ID 02-26-301-024-026) on the west. North of County Road 106, the eastern boundary widens to include the industrial park bounded by Marina Drive on the east, Ada Drive on the west, County Road 106 in the south, and Cooper Drive on the north (see Figure B-2). The unknown source of the plume is presumed to originate from the industrial park to the north of Lane Street (EPA 2009).

B2.1 SITE HISTORY

A Phase I Environmental Site Assessment (ESA) was conducted for the Geocel facility located at 53280 Marina Road in October 2006. The Phase I ESA and subsequent subsurface investigations indicated that a release of chlorinated solvents from a former PCE underground storage tank (UST) had migrated to the groundwater in the area of the Geocel facility. This prompted an off-site investigation, during which it was learned that the chlorinated solvents had migrated south toward Kershner Street and into a residential area. All of the residents in this area obtained their drinking water from their own private wells; therefore, Geocel sampled the residential wells in the residential area around Kershner Street. Elevated levels of VOCs were detected in the drinking water and carbon filters or bottled water supplied to the residences by Geocel. Geocel notified IDEM and the Elkhart County Health Department (ECHD) of the groundwater contamination and entered into IDEM's Voluntary Remediation Program (VRP). Geocel continued investigations to delineate the groundwater plume and found that the groundwater contamination was bordered by Kershner Street to the west, the Geocel facility to the north, County Road 113 to the east, and Crestwood Street to the south (IDEM 2008).

A resident located at [redacted] Lane Street submitted a sample from her private well to the Water Quality Laboratory at Heidelberg College in Tiffin, Ohio, to be analyzed for VOCs due to the groundwater investigation that was occurring to the east of Lane Street at Kershner Street. On August 22, 2007, the ECHD notified the IDEM that the resident's private-well drinking water was contaminated. The analytical results revealed TCE at a concentration of 1,560 micrograms per liter (µg/L), as well as other breakdown products (IDEM 2008). EPA's maximum contaminant level (MCL) for TCE is 5 µg/L.

On August 23, 2007, IDEM performed a visual site reconnaissance around Lane Street and sampled seven private wells on and north of Lane Street. The results showed that drinking water from four residential wells contained VOC concentrations above MCLs (IDEM 2007).

On August 30, 2007, IDEM returned to Lane Street to conduct a preliminary site assessment and found that 11 residences contained TCE in groundwater at concentrations above the MCL. In September 2007, IDEM provided bottled water to those residences with elevated TCE concentrations in their drinking water. Later, EPA placed filtration units in the homes that had been given bottled water. In November 2008, as part of the EPA removal work, 23 residences on Lane Street, two residences on Barley Street, and one residence on County Road 106 that had private wells were connected to municipal water. Residences south of these were already connected to municipal water.

B2.2 PREVIOUS SITE INVESTIGATIONS

In late August 2007, IDEM conducted a Preliminary Assessment of the Lane Street Site, which consisted of a site reconnaissance of the surrounding properties and sampling drinking water from 32 private water wells for VOC analysis. Sample results indicated that the 11 residential wells and two business wells (north of County Road 106) contained elevated levels of VOCs (IDEM 2007).

IDEM provided bottled water to the residents whose homes contained elevated levels of VOCs in their drinking water and alerted EPA to the exceedance of MCLs in the drinking water at the Lane Street Site (HRS 2009). The EPA, under the Superfund Technical Assessment and Response Team (START) contract, with Weston Solutions, Inc. (WESTON) conducted confirmatory groundwater sampling at the Lane Street Site in September 2007. EPA's sample results confirmed exceedances of MCLs for some VOCs in the residential groundwater.

Additionally, in December 2007, EPA and WESTON conducted 24-hour indoor air sampling in two residences where elevated TCE concentrations in groundwater had been documented. TCE, PCE, and vinyl chloride were not detected in either air sample collected (WESTON 2008).

EPA authorized the installation of carbon filtration water treatment systems for the affected residences as well as one year of maintenance on the systems until a more permanent solution could be effected. The treatment systems were installed in the fall of 2007 and winter of 2008 for 13 residences on Lane Street (WESTON 2008).

In order to list the Lane Street Site on the National Priorities List (NPL), IDEM conducted a Site Inspection from April 14 through April 17, 2008. IDEM collected 132 groundwater samples from private wells and from discrete locations from the industrial park to the north of County Road 106 through direct-push methods. Additionally, nine soil samples were collected from the industrial park in an attempt to identify the source area. It was determined during this investigation that the groundwater is flowing south to southwest. Twelve residential groundwater samples contained detected concentrations of TCE and other VOCs during this sampling event, and many of the direct-push discrete groundwater samples contained elevated concentrations of VOCs, with a maximum TCE concentration of 770 parts per billion (ppb) in a sample collected from the industrial park to the north of Lane Street. No VOCs were detected in the soil samples from IDEM's 2008 Site Inspection (IDEM 2008).

Because of the continued threat to human health, EPA (under the START contract) connected 26 residences, 23 on Lane Street, two on Barley Street, and one on County Road 106, to the City of Elkhart municipal water supply system and abandoned the residential wells at those residences. Even though all 26 residences didn't exhibit elevated levels of VOCs, because the groundwater plume is flowing in a south-southeasterly direction, the downgradient residences were connected to the City of Elkhart municipal water supply to minimize any future threat to the downgradient residences.

Chemicals of interest that have been identified as potentially hazardous to human health and the environment at the Lane Street Site are based on IDEM's investigations discussed above. These chemicals are listed in Table B-1 below.

TABLE B-1
Chemicals of Interest at Lane Street Site

Chemical of Interest	**IDEM's PA and SI Maximum Groundwater Concentration (µg/L) [a]**	**Maximum Contaminant Level (µg/L)**	**EPA Tapwater RSL (µg/L)**	**Superfund Removal Action Level (µg/L) [b]**
1,1,1-Trichloroethane (1,1,1-TCA)	61	200	9,100	1,000
1,1-Dichloroethene (1,1-DCE)	1.3	7	340	70
cis-1,2-Dichloroethene (cis-1,2-DCE)	32	70	370	400
Trichloroethene (TCE)	770	5	2	300
Tetrachloroethene (PCE)	19	5	0.11	70
1,1-Dichloroethane (1,1-DCA)	13	NC	2.4	NC
trans-1,2-Dichloroethene (trans-1,2-DCE)	0.75	100	110	600
Vinyl chloride[c]	ND	2	0.016	2

Notes:

[a] Results are based on groundwater samples collected in 2007 and 2008 (IDEM 2007, IDEM 2008).
[b] Complete list of Superfund Removal Action Levels is included as Appendix B-2.
[c] Vinyl chloride has not been detected in the groundwater at the site; however, vinyl chloride is a degradation product of chlorinated compounds found at the site and may be present in the future.

µg/L	Micrograms per liter
DCA	Dichloroethane
DCE	Dichloroethene
EPA	U.S. Environmental Protection Agency
NC	No criteria
ND	Not detected
PA	Preliminary Assessment
PCE	Tetrachloroethene (perchloroethene)
RSL	Regional Screening Level
SI	Site Inspection
TCA	Trichloroethane
TCE	Trichloroethene

B3.0 QUALITY ASSURANCE PROJECT PLAN PROCEDURE

This QAPP presents procedures that will be used to ensure the quality of data generated for the Lane Street Site. The QAPP provides a framework for procedures to collect environmental data to achieve specific project objectives and describes procedures that will be implemented to obtain data of known and adequate quality. This QAPP was prepared in accordance with EPA's "Uniform Federal Policy for Implementing Environmental Quality Systems" (UFP) (EPA 2005a).

The Lane Street RI will be conducted in two phases. The Phase I investigation will include: groundwater sampling from private wells, vertical aquifer sampling (VAS), collecting soil samples from some of the VAS sampling locations, collecting indoor air samples from three residences, installing nested monitoring wells, and performing two rounds of groundwater sampling from the newly installed monitoring wells. Due to the timing in obtaining access agreements, some Phase I investigation activities may be performed under a new WA. Phase II investigation is presumed to include data-gaps investigation and preparation of the RI/FS report. The second phase will be conducted under a separate, future WA.

SulTRAC will collect groundwater samples from private (residential or industrial) water wells to determine the extent of contamination and to prepare for the future risk assessment (which will be completed under a separate and future WA from EPA). SulTRAC is proposing to collect a sample from the one residence that is presumed to still be using a private well and from the five industrial properties within the Lane Street Site boundary that are currently using private water wells (see Figure B-3). All samples will be analyzed offsite for VOCs at a Contract Laboratory Program (CLP) laboratory. All samples will be collected in accordance with the EPA-approved FSP (SulTRAC 2011).

Following the residential sub-phase, SulTRAC will proceed with an evaluation of the groundwater plume as part of the delineation sub-phase. The objective of delineation will be to refine the understanding regarding the horizontal and vertical extent of groundwater contamination. This investigation will be performed in one field event. VAS is proposed to be performed at 25 locations at 10-foot intervals at each location, from the groundwater surface to approximately 60 feet below ground surface (bgs) (see Figure B-3). A maximum of six groundwater samples will be collected from each VAS location and analyzed for VOCs. Additionally, soil samples will be collected from 10 VAS boring locations to verify soil conditions at the site. The soil samples will be analyzed for VOCs, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) metals. The samples collected will be submitted to a CLP laboratory. All samples will be collected in accordance with the EPA-approved FSP (SulTRAC 2011).

Upon receipt of the VAS sampling results, the site condition will be evaluated to determine the placement of 16 nested monitoring wells to be installed. Each well nest will consist of a shallow well and a deep well to be constructed a few feet away. The VAS sampling results will also be used to determine the approximate depths at which the monitoring wells will be screened and will be discussed with the WAM prior to installation. SulTRAC intends to install the shallow well at the depth interval representing the most contaminated part of the plume. The deep well will be installed in the shallowest interval below the most contaminated portion of the plume, where VOC concentrations from the VAS results are below MCLs. The top of the deep well screen will be set at a minimum of 5 feet below the bottom of the shallow well screen. Although it is not anticipated that the shallow sand and gravel aquifer at the Lane Street Site has a vertical gradient, there will be a minimum of three shallow monitoring wells with 10-foot screens that intersect the water table. Based on current data, the proposed monitoring well locations are shown on Figure B-3.

Following the installation of the monitoring wells, they will be developed in accordance with the Lane Street Site FSP (SulTRAC 2011). Subsequent to well development, two rounds of groundwater sampling will be conducted. Groundwater samples will be collected from each monitoring well and submitted to a CLP laboratory for analysis for VOCs. In addition, four wells will be sampled for semivolatile organic compounds (SVOC), polychlorinated biphenyls (PCB), and filtered Target Analyte List (TAL) metals to verify that other contaminants are not present. All samples will be collected in accordance with the EPA-approved FSP (SulTRAC 2011).

During the Phase I field investigation, three residences will be selected for indoor air sampling. The residences will be selected based on the past groundwater sample results as well as the results from the VAS sampling. It is currently proposed that indoor air sampling be conducted in residences based on groundwater data collected by IDEM during the Site Inspection (IDEM 2008).

Two indoor air samples will be collected from two separate areas within each residential property. One sample will be collected from an area called the "Foundation Area" of the residence. This sample will represent the location where VOC vapors are most likely to infiltrate the residence from beneath the surface (e.g., basement or location where underground utility enters the residence). The second sample will be collected from the "Living Area" of the residence, the location where the residents spend a majority of their time. Samples will be collected using an evacuated 6-liter (L) Summa® canister for integrated 24-hour sample collection. The proposed indoor air sampling locations are shown on Figure B-3. All samples will be analyzed offsite for VOCs at a private laboratory. All samples will be collected in accordance with the EPA-approved FSP (SulTRAC 2011).

SulTRAC will also conduct an ecological investigation during the Phase I investigation. The ecology investigation will include a wetland and habitat delineation/function and value assessment and a screening of databases for endangered species and others of special concern for the Lane Street Site. No ecological samples are anticipated to be collected during Phase I of this RI.

QAPP WORKSHEET #1
TITLE AND APPROVAL PAGE

Quality Assurance Project Plan , Revision 1, for Remedial Investigation/Feasibility Study, Lane Street Ground Water Contamination Site, Elkhart, Elkhart County, Indiana
Document Title

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QAPP WORKSHEET #2
QAPP IDENTIFYING INFORMATION

1. Identify guidance used to prepare QAPP:
"Uniform Federal Policy for Implementing Environmental Quality Systems" (UFP) (EPA 2005a) and "EPA Requirements for Quality Assurance Project Plans" (QA/R-5) EPA/24/B-01/003, March 2001 (reissued May 2006)

2. Identify regulatory program:
CERCLA

3. Identify approval entity: EPA Region 5

4. Indicate whether the QAPP is a generic or project-specific QAPP: Project-specific

5. List dates of scoping sessions that were held: January 19, 2010

6. List dates and titles of QAPP documents written for previous work site, if applicable:

Title	Approval Date
None	

7. List organizational partners (stakeholders) and connection with lead organization:
EPA Region 5, SulTRAC, Indiana Department of Environmental Management (IDEM)

8. List data users: EPA Region 5, SulTRAC, IDEM

9. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusion below: Not applicable

Identify where each required QAPP element is located in the QAPP (provide section, worksheet, table, or figure number) or other project planning documents (provide complete document title, date, section number, page numbers, and location of the information in the document). Circle QAPP elements and required information that are not applicable to the project. Provide an explanation in the QAPP.

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QAPP WORKSHEET #3
DISTRIBUTION LIST

(UFP QAPP Section 2.3.1)

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Cheryl Gorman	Project Manager	SulTRAC	(312) 443-0550, ext. 17	cgorman@onesullivan.com
Richard Baldino	Project QA Manager	SulTRAC	(312) 443-0550, ext. 26	rbaldino@onesullivan.com
John Dirgo	QA/QC Officer	SulTRAC	(312) 201-7765	john.dirgo@ttemi.com
Tracey Koach	Analytical Coordinator	SulTRAC	(312) 443-0550, ext. 11	tkoach@onesullivan.com
David Homer	Ecological Risk Assessor	SulTRAC	(816) 412-1762	david.homer@ttemi.com
Eric Morton	Human Health Risk Assessor	SulTRAC	(312) 201-7797	eric.morton@ttemi.com
Subcontractors	Drillers/Laboratory	TBD [a]	TBD	TBD

Notes:

[a] Staff/subcontractors to be determined (TBD) prior to commencement of each subphase of field work

QAPP WORKSHEET #4
PROJECT PERSONNEL SIGN-OFF SHEET

(UFP QAPP Section 2.3.2)

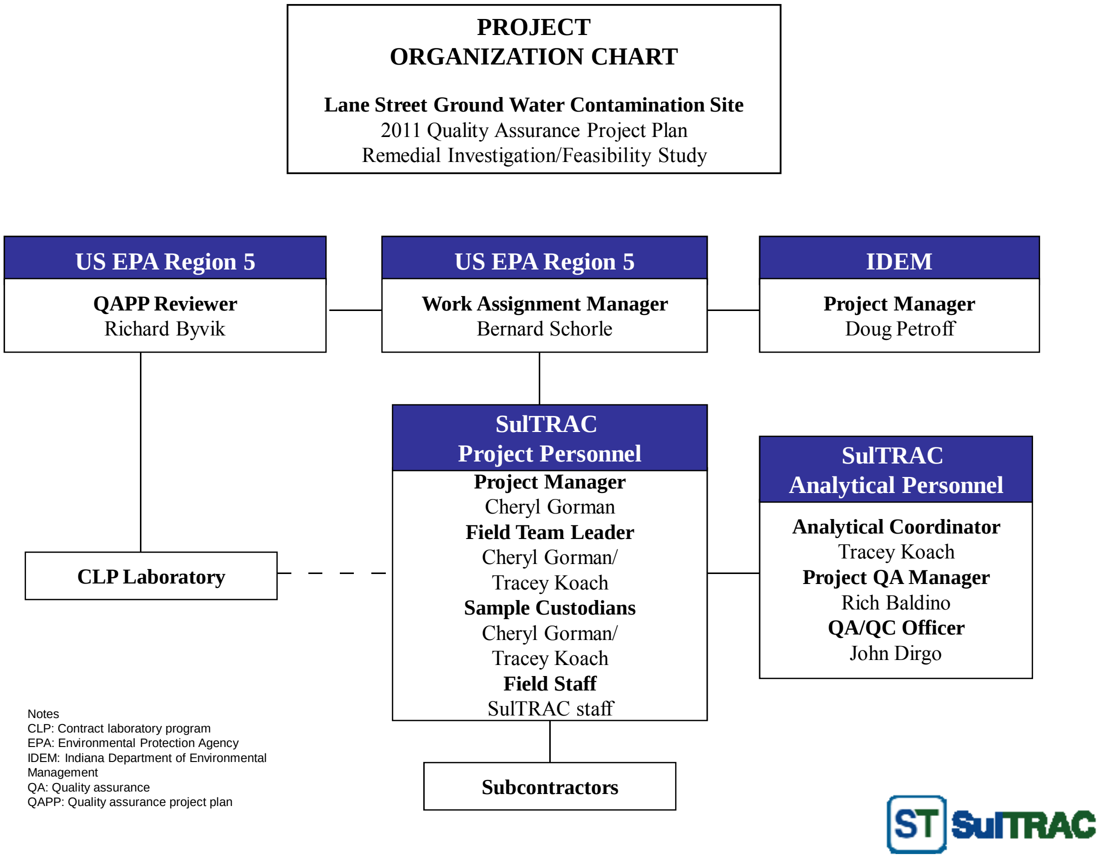
Project Personnel	Organization	Title	Telephone No.	Signature	Date QAPP Read
Richard Byvik	EPA Region 5	QAPP Reviewer	(312) 353-3114		
Cheryl Gorman	SulTRAC	Project Manager	(312) 443-0550, ext. 17		
Richard Baldino	SulTRAC	Project QA Manager	(312) 443-0550, ext. 26		
John Dirgo	SulTRAC	QA/QC Officer	(312) 201-7765		
Tracey Koach	SulTRAC	Analytical Coordinator	(312) 443-0550, ext. 11		
Cheryl Gorman / Tracey Koach	SulTRAC	Field Team Leader [a]	(312) 443-0550, ext. 17 / (312) 443-0550, ext. 11		
Cheryl Gorman / Tracey Koach	SulTRAC	Sample Custodian [a]	(312) 443-0550, ext. 17 / (312) 443-0550, ext. 11		
David Homer	SulTRAC	Ecological Risk Assessor	(816) 412-1762		
Eric Morton	SulTRAC	Human Health Risk Assessor	(312) 201-7797		
Drilling Subcontractor	TBD [a]	TBD [a]	TBD		
Laboratory Subcontractor	TBD [a]	TBD [a]	TBD		

Notes:

[a] Staff/subcontractors to be determined and/or confirmed prior to commencement of each subphase of field work

QAPP WORKSHEET #5
PROJECT ORGANIZATION CHART

(UFP QAPP Section 2.4.1)



Notes
CLP: Contract laboratory program
EPA: Environmental Protection Agency
IDEM: Indiana Department of Environmental Management
QA: Quality assurance
QAPP: Quality assurance project plan

QAPP WORKSHEET #6
COMMUNICATION PATHWAYS

(UFP QAPP Section 2.4.2)

Communication Drivers	Responsible Entity	Name	Telephone No.	Procedure (Timing, Pathways, etc.)
Point of contact with EPA WAM	Project Manager	Cheryl Gorman	(312) 443-0550, ext. 17	Cheryl Gorman will forward all materials and information about the project to Bernard Schorle.
Manage all project phases	Project Manager	Cheryl Gorman	(312) 443-0550, ext. 17	Communicate information to project team (including subcontractors) on a timely basis. Notify EPA WAM by telephone or e-mail of any significant issues. Direct field team and facilitate communication with analytical coordinator. Delivery of all CLP data packages to project QA manager for final review of validation.
Daily field progress report	Field Team Leader(s)	Cheryl Gorman Tracey Koach [a]	(312) 443-0550, ext. 17 (312) 443-0550, ext. 11 [a]	Conduct specific field investigation tasks, direct field activities of subcontractors, and provide daily communication with project manager and sample custodian.
Manage field sample organization and delivery to CLP laboratory	Sample Custodian(s)	Cheryl Gorman Tracey Koach [a]	(312) 443-0550, ext. 17 (312) 443-0550, ext. 11[a]	Ensure that field staff is collecting samples in proper containers, observing holding times, and properly packaging and preparing samples for shipment. Coordinate daily with analytical coordinator concerning sample quantities and delivery locations and dates. Communicate daily with field staff and project manager regarding any issues and developments.
Point of contact with EPA Region 5 Regional Sample Control Coordinator (RSCC)	Analytical Coordinator	Tracey Koach	(312) 442-0550, ext. 11	Contact the RSCC before each sampling event to schedule CLP laboratory services. Notify sample custodian and project manager of any CLP issues or developments. Track all CLP data deliveries. Notify project manager and forward data to her.
Release of Analytical Data	SulTRAC Project QA Manager	Richard Baldino	(312) 443-0550, ext.26	No analytical data can be released until validation is completed and Richard Baldino has reviewed and approved the release.

QAPP WORKSHEET #6 (CONTINUED)
COMMUNICATION PATHWAYS

Communication Drivers	Responsible Entity	Name	Telephone No.	Procedure (Timing, Pathways, etc.)
Report of laboratory data quality issues	Laboratory QA Officer	TBD [a]	TBD [a]	All QA/QC issues with project field samples will be reported by the laboratory QA officer to the RSCC.

Note:

[a] Due to the length of the field component of this project, personnel in this role may change.

QAPP WORKSHEET #7
PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS TABLE

(UFP QAPP Section 2.4.3)

Name	Title	Organization/ Affiliation	Responsibilities	Education and Experience Qualifications
Cheryl Gorman	Project Manager	SulTRAC	Manages project; coordinates between lead agency and subcontractor; coordinates CLP lab data deliverables from analytical coordinator to project QA manager; manages field staff	B.S. Earth & Environmental Science, 4 years of experience
Cheryl Gorman [a]	Field Team Leader	SulTRAC	Supervises field sampling and coordinates all field activities; daily reporting to project manager while conducting field activities; implements field plan; verifies sample processing, packaging, and shipping	B.S. Earth & Environmental Science, 4 years of experience
Tracey Koach [a]				B.A. Environmental Studies, 17 years of experience
Cheryl Gorman [a]	Sample Custodian	SulTRAC	Verifies sample processing, packaging, and shipping	B.S. Earth & Environmental Science, 4 years of experience
Tracey Koach [a]				B.A. Environmental Studies, 17 years of experience
Richard Baldino	Project QA Manager	SulTRAC	QA/QC oversight	M.S. Water Chemistry, Senior Chemist, 17 years of experience
John Dirgo	QA/QC Officer	SulTRAC	QA/QC oversight	Sc.D. Environmental Science and Physiology, 28 years of experience
Tracey Koach	Analytical Coordinator	SulTRAC	Coordinates sample scheduling; verifies sample chain of custody; reviews computer-aided data review (CADRE) results and data from subcontracted laboratories; notifies sample custodian and project manager of any issues or developments	B.A. Environmental Studies, 17 years of experience

QAPP WORKSHEET #7 (CONTINUED)
PERSONNEL RESPONSIBILITIES AND QUALIFICATIONS TABLE

Name	Title	Organization/ Affiliation	Responsibilities	Education and Experience Qualifications
Matt Nied[a]	Field Staff	SulTRAC	Implements field plan	B.A Geology and Environmental Geosciences, 7 years of experience
Robert Kondreck	Field Staff	SulTRAC	Implements field plan	B.S. Geology, 5 years of experience
TBD	Drillers	TBD Subcontractor	Provides subsurface drilling and sampling	TBD
TBD	Subcontracted Laboratories	TBD Subcontractor(s)	Performs investigation-derived waste (IDW) disposal parameters and Indoor Air Sampling	TBD

Note:

[a] Due to the length of the field component of this project, personnel in this role may change.

QAPP WORKSHEET #8
SPECIAL PERSONNEL TRAINING REQUIREMENTS TABLE

(UFP QAPP Section 2.4.4)

Project Function	**Specialized Training – Title or Description of Course**	**Training Provider**	**Training Date**	**Personnel/Groups Receiving Training**	**Personnel Titles/ Organizational Affiliation**	**Location of Training Records/Certificates [1]**
Field Staff	40-hour or 8-hour refresher - OSHA HAZWOPER training	Various	Various	SulTRAC	SulTRAC	Corporate human resources office
Drillers	40-hour OSHA HAZWOPER training	TBD	TBD	Drillers/Geoprobers	TBD	As noted in subcontract agreement – corporate Human Resources office

Notes:

[1] Certificates will be issued to each field staff member in accordance with the respective employer's policies. Copies of necessary training certificates will be kept on file by the Project Manager at the Chicago office.

HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
OSHA	Occupational Safety and Health Administration
TBD	To be determined

QAPP WORKSHEET #9
PROJECT SCOPING SESSION PARTICIPANTS SHEET

(UFP QAPP Section 2.5.1)

Project Name	RI/FS for Lane St Site	Site Name	Lane Street Ground Water Contamination Site
Projected Date(s) of Sampling	May 2010 through June 2011	Site Location	Elkhart County, Indiana
Project Manager	Cheryl Gorman		
Date of Session	January 19, 2010		
Scoping Session Purpose:	Define scope of project		

Name	Title	Affiliation	Phone #	E-Mail Address	Project Role
Bernard Schorle	WAM	EPA Region 5	(312) 886-4746	schorle.bernard@epa.gov	WAM
Cheryl Gorman	Project Manager	SulTRAC	(312) 443-0550 ext. 17	cgorman@onesullivan.com	Project Manager
Ron Riesing	Program Manager	SulTRAC	(312) 201-7460	ronald.riesing@tetratech.com	Program Manager
Ed Quigley	Project Officer	EPA Region 5	(312) 886-7726	Quigley.Edward@epa.gov	Project Officer

Comments/Decisions: The kickoff meeting was held to clarify any questions that SulTRAC had regarding the SOW. SulTRAC questioned whether EPA or SulTRAC will be responsible for researching and obtaining access agreements, and it was decided that the EPA WAM would clarify whether SulTRAC or EPA would get access agreements. Because the Lane Street Site RI will be conducted in phases, SulTRAC wanted to clarify if air samples, pump test, and evaluation of treatability studies as indicated in Task 3 of the SOW should be conducted during Phase II of the project. EPA clarified that air sampling should be conducted in at least two residential homes during the Phase I investigation; however, the pump test and evaluation of treatability studies will be conducted during the second phase of the project. WAM also indicated that some groundwater samples should be collected for SVOCs and inorganics as well as VOCs. SulTRAC requested clarification on whether an ecological investigation would be necessary and whether SulTRAC should expect to collect any building samples as indicated in Task 3 of the SOW. The WAM indicated that a quick field observation would suffice for the ecological investigation and no building samples will need to be collected.

QAPP WORKSHEET #10
PROBLEM DEFINITION

(UFP QAPP Section 2.5.2)

The problem to be addressed by the project: Previous groundwater investigations at the Lane Street Site show VOC contamination in the groundwater. The VOCs detected are primarily PCE, TCE, cis-1,2-DCE, 1,1-DCA, trans-1,2-DCE, 1,1-DCE, and 1,1,1-TCA. This project intends to fully characterize the extent of VOC contamination and to determine the type and extent of other contaminants in groundwater within the Lane Street Site boundaries.
The environmental questions being asked: What is the extent of contamination at the Lane Street Site?
Observations from any site reconnaissance reports: During the 2007 IDEM investigation, groundwater concentrations exceeding the federal MCLs for VOCs were reported in 13 residential wells at the Lane Street Site. During the 2008 IDEM investigation, 12 residential wells and many of the direct-push discrete groundwater samples contained elevated levels of VOCs. The chemicals of concern have been identified as potentially hazardous to human health and safety.
A synopsis of secondary data or information from site reports: See Worksheet #13.
The possible classes of contaminants and the affected matrices: Groundwater samples from private wells, monitoring wells, and VAS sampling will be analyzed for VOCs. Soil samples collected during the VAS sampling will be analyzed for VOCs, SVOCs, PCBs, and TAL metals. In addition, four monitoring wells during the first round of groundwater sampling will be analyzed for VOCs, SVOCs, PCBs, and TAL metals (including mercury) to verify that other contaminants are not present. VAS location samples will be analyzed by a CLP laboratory for VOCs. As stated in the FSP, soil samples will be collected and analyzed by a CLP laboratory for VOCs, SVOCs, PCBs, and TAL metals (including mercury). Three residences will be selected for indoor air sampling and analyzed offsite through a subcontract laboratory for VOCs only. No other matrices will be sampled during the Phase I investigation.
Project decision conditions ("If…, then…" statements): If the RI/FS results reveal that contamination at the Lane Street Site poses an unacceptable risk to human health and/or the environment, then a remedial action will be implemented.

QAPP WORKSHEET #11
PROJECT QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS STATEMENTS

(UFP QAPP Section 2.6.1)

Who will use the data: EPA Region 5 and SulTRAC will use the data.

What will the data be used for? During the Phase I field investigation, the data will be used to characterize the extent of contamination, as well as potential source areas of contamination. Data from the Phase I investigation will be used to conduct a risk assessment for the Lane Street Site and to evaluate remedial alternatives as part of the FS.

What type of data are needed (target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques)? Groundwater (VAS, private well, monitoring well), soil, and air samples will be collected from the Lane Street Site. Groundwater samples will be collected from existing private drinking water wells, VAS locations, and newly installed groundwater monitoring wells. Field screening instruments will include (1) a photo-ionization detector (PID) to screen all groundwater and soil boring samples, and (2) a water quality meter to monitor all groundwater parameters during sampling. All groundwater samples will be sent to a CLP laboratory to be analyzed for VOCs. Groundwater from four monitoring wells (two from the industrial area and two from the residential area) will be analyzed for SVOCs, PCBs, and filtered TAL metals at a CLP laboratory. Soil samples will be collected during the VAS from 10 locations based on visual and field screening techniques. Soil samples will be analyzed at a CLP laboratory for VOCs, SVOCs, PCBs, and TAL metals. Air samples will be collected from residences and sent to a subcontractor laboratory to be analyzed for VOCs.

How "good" do the data need to be in order to support the environmental decision? Ultimately, the data need to allow full assessment of the nature and extent of contamination in the water, soil, and air samples collected by SulTRAC. The data also need to be validated and used to support risk assessment and the evaluation of remedial alternatives.

How much data are needed (number of samples for each analytical group, matrix, and concentration)? SulTRAC will collect 6 private well groundwater samples; 150 groundwater samples from 25 vertical aquifer sample locations (25 locations, samples at 10-foot depth intervals from groundwater table to a total depth of 60 ft bgs); and 64 groundwater samples from 32 newly installed Phase I monitoring wells. Soil samples will be collected from 10 locations during the VAS sampling event. SulTRAC will also collect 2 indoor air samples from three residences for a total of 6 indoor air samples.

In addition, QC samples will be collected and analyzed, including duplicates, matrix spikes (MS), matrix spike duplicates (MSD), trip blanks, and field blanks.

QAPP WORKSHEET #11 (CONTINUED)
PROJECT QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS STATEMENTS

Where, when, and how should the data be collected/generated? Phase I sampling activities will take place during fall/winter 2010/11 and spring 2011 at the Lane Street Site. Twenty-five VAS locations will be advanced, with samples being collected at 10-foot intervals from the water table to a maximum depth of 60 ft bgs. Based on the VAS sampling results, the site condition will be evaluated in order to determine the placement of nested monitoring wells to be installed. One shallow well, approximately 30 ft bgs, and one deep well, approximately 60 ft bgs, will be installed. Well depths and screen locations will be finalized after evaluation of the VAS sampling results and prior to installation.

Soil samples will be collected during the VAS when contamination is observed and at several pre-determined locations as detailed in the FSP (SulTRAC 2011). 10 soil samples will be collected at various VAS locations. All drilling will be conducted using either a hollow stem auger drill rig or a direct-push drill rig. All intrusive work will be performed by subcontractors under the supervision of a SulTRAC geologist.

SulTRAC anticipates hiring subcontractors to perform VAS and monitoring well installation.

Who will collect and generate the data? SulTRAC will collect the samples discussed herein. VAS samples will be sent to an EPA CLP laboratory. A laboratory from the EPA CLP will analyze soil and groundwater samples for VOCs, SVOCs, PCBs, and TAL metals (including mercury). Sample results for specific analytes detailed in worksheet #15 will be reported at the method detection limit (MDL) concentration in order to be less than the project action levels (PAL). Reporting specific analytes at the MDL will be submitted as a modified analyses request and will be submitted 3 weeks in advance of sampling to the EPA Sample Management Office (SMO).

How will the data be reported? Data will be reported by the CLP laboratory using standard CLP data reporting techniques. Data will be reported in electronic and hard-copy form. Subcontracted laboratory data will be reported by the subcontracted laboratory using standard data reporting techniques.

How will the data be archived? Electronic and hard copies of CLP analytical data will be archived by the CLP laboratory. Electronic and hard copies of subcontracted laboratory data will be archived by the SulTRAC analytical coordinator. Field data (notebooks, sampling sheets, etc.) will be maintained at SulTRAC's Chicago office. SulTRAC will also provide 10-year data storage.

QAPP WORKSHEET #12
MEASUREMENT PERFORMANCE CRITERIA TABLE

(UFP QAPP Section 2.6.2)

Matrix	Soil/Solid^s
Analytical Group [1]	Volatile Organic Analysis (VOA)/CLP
Concentration Level	Low concentration

Sampling Procedure [2]	**Analytical Method SOP** [3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-1	Precision	RPD ≤ 70%	Field duplicate	S & A
S-1	A-1	Accuracy/ Bias-Contamination	VOC < QL	Trip blank	S & A
S-1	A-1	Accuracy/ Bias-Contamination	VOC < QL	Rinsate blank	S & A
S-1	A-1	Accuracy/Bias	1,1-Dichloroethene: 59-172 %R TCE: 62-137 %R Benzene: 66-142 %R Toluene: 59-139 %R Chlorobenzene: 60-133 %R	MS/MSD	S & A
S-1	A-1	Precision	1,1-Dichloroethene: 22% RPD TCE: 24% RPD Benzene: 21% RPD Toluene: 21% RPD Chlorobenzene: 21% RPD	MS/MSD	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Soil/Solid[s]
Analytical Group[1]	Volatile Organic Analysis (VOA)/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP[3]**	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-1	Accuracy	Vinyl chloride-d_3: 68-122 %R Chloroethane-d_5: 61-130 %R 1,1-Dichloroethene-d_2: 45-132 %R 2-Butanone-d_5: 20-182 %R Chloroform-d: 72-123 %R 1,2-Dichloroethane-d_4: 79-122 %R Benzene-d_6: 80-121 %R 1,2-Dichloropropane-d_6: 74-124 %R Toluene-d_8: 78-121 %R 1,1,2,2-Tetrachloroethane-d_2: 56-161 %R Trans-1,3-Dichloropropene-d_4: 72-130 %R 2-Hexanone-d_5: 17-184 %R 1,4-Dioxane-d_8: 50-150 %R 1,2-Dichlorobenzene-d_4: 70-131 %R	Deuterated monitoring compounds	A
S-1	A-1	Accuracy/ Bias-Contamination	VOC < QL	Method blank	A
S-1	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Soil/Solids
Analytical Group[1]	Semivolatile Organic Analysis (SVOA)/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-1	Precision	RPD ≤ 70%	Field duplicate	S & A
S-1	A-1	Accuracy/ Bias-Contamination	SVOC < QL	Rinsate blank	S & A
S-1	A-1	Accuracy/Bias	Phenol-d_5: 26-90 %R 2-Chlorophenol: 25-102 %R N-Nitroso-di-n-propylamine: 41-126 %R 4-Chloro-3-methylphenol: 26-103 %R Acenaphthene: 31-137 %R 4-Nitrophenol: 11-114 %R 2,4-Dinitrotoluene: 28-89 %R Pentachlorophenol: 17-109 %R Pyrene: 35-142 %R	MS/MSD	S & A
S-1	A-1	Precision	Phenol: 35% RPD 2-Chlorophenol: 50% RPD N-Nitroso-di-n-propylamine: 38% RPD 4-Chloro-3-methylphenol: 33% RPD Acenaphthene: 19% RPD 4-Nitrophenol: 50% RPD 2,4-Dinitrotoluene: 47% RPD Pentachlorophenol: 47% RPD Pyrene: 36% RPD	MS/MSD	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Soil/Solids
Analytical Group[1]	Semivolatile Organic Analysis (SVOA)/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-1	Accuracy	Phenol-d_5: 17-103 %R Bis(2-Chloroethyl)ether-d_8: 12-98 %R 2-Chlorophenol-d_4: 13-101 %R 4-Methylphenol-d_8: 8-100 %R Nitrobenzene-d_5: 16-103 %R 2-Nitrophenol-d_4: 16-104 %R 2,4-Dichlorophenol-d_3: 23-104 %R 4-Chloroaniline-d_4: 1-145 %R Dimethylphthalate-d_6: 43-111 %R Acenaphthylene-d_8: 20-97 %R 4-Nitrophenol-d_4: 16-166 %R Fluorene-d_{10}: 40-108 %R 4,6-Dinitro-2-methylphenol-d_2: 1-121 %R Anthracene-d_{10}: 22-98 %R Pyrene-d_{10}: 51-120 %R Benzo(a)pyrene-d_{12}: 43-111 %R	Deuterated monitoring compounds	A
S-1	A-1	Accuracy/Bias-Contamination	SVOC < QL	Method blank	A
S-1	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S&A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Soil/Solids
Analytical Group[1]	PCB/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-1	Precision	RPD ≤ 70%	Field duplicate	S & A
S-1	A-1	Accuracy/ Bias-Contamination	PCB < QL	Rinsate blank	S & A
S-1	A-1	Accuracy/Bias	Aroclor-1016: 29-135 %R Aroclor-1260: 29-135 %R	MS/MSD	S & A
S-1	A-1	Precision	Aroclor-1016: 15% RPD Aroclor-1260: 20% RPD	MS/MSD	S & A
S-1	A-1	Accuracy	Decachlorobiphenyl: 30-150 %R	Surrogate spike	A
S-1	A-1	Accuracy	Aroclor-1016: 50-150 %R Aroclor-1260: 50-150 %R	Laboratory Control Sample	A
S-1	A-1	Accuracy/ Bias-Contamination	PCB < QL	Method blank	A
S-1	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Soil/Solids
Analytical Group[1]	TAL Metals and Mercury /CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-1	A-2	Precision	RPD ≤ 70%	Field duplicate	S & A
S-1	A-2	Accuracy/ Bias-Contamination	Metal < QL	Rinsate blank	S & A
S-1	A-2	Accuracy/Bias	All metals: 75-125 %R	MS	A
S-1	A-2	Accuracy	All metals: 75-125 %R	LCS	A
S-1	A-2	Precision	All metals: < 20% RPD	Laboratory duplicate	A
S-1	A-2	Sensitivity/Contamination	Metal <QL	Method blank	A

Notes:

DQI	Data quality indicator
LCS	Laboratory control sample
MS	Matrix spike
QC	Quality control
QL	Quantitation limit
%R	Percent recovery
RPD	Relative percent difference
SOP	Standard Operating Procedure

[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	VOA/CLP
Concentration Level	Trace concentration/SIM

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-1	Precision	RPD ≤ 35%	Field duplicate	S & A
S-6, S-7	A-1	Accuracy/ Bias-Contamination	VOC < QL	Trip blank	S & A
S-6, S-7	A-1	Accuracy/ Bias-Contamination	VOC < QL	Rinsate blank	S & A
S-6, S-7	A-1	Accuracy/Bias	1,1-Dichloroethene: 61-145 %R TCE: 71-120 %R Benzene: 76-127 %R Toluene: 76-125 %R Chlorobenzene: 75-130 %R	MS/MSD	S & A
S-6, S-7	A-1	Precision	1,1-Dichloroethene: 14% RPD TCE: 14% RPD Benzene: 11% RPD Toluene: 13% RPD Chlorobenzene: 13% RPD	MS/MSD	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	VOA/CLP
Concentration Level	Trace concentration/SIM

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-1	Accuracy	Vinyl chloride-d_3: 65-131 %R Chloroethane-d_5: 71-131 %R 1,1-Dichloroethene-d_2: 55-104 %R 2-Butanone-d_5: 49-155 %R Chloroform-d: 78-121 %R 1,2-Dichloroethane-d_4: 78-129 %R Benzene-d_6: 77-124 %R 1,2-Dichloropropane-d_6 : 79-124 %R Toluene-d_8 : 77-121 %R 1,1,2,2-Tetrachloroethane-d_2: 73-125 %R Trans-1,3-Dichloropropene-d_4: 73-121 %R 2-Hexanone-d_5: 28-135 %R 1,4-Dioxane-d_8: 50-150 %R 1,2-Dichlorobenzene-d_4: 80-131 %R	Deuterated monitoring compounds	A
S-6, S-7	A-1	Accuracy/ Bias-Contamination	VOC < QL	Method blank	A
S-6, S-7	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	SVOA/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-1	Precision	RPD ≤ 70%	Field Duplicate	S & A
S-6, S-7	A-1	Accuracy/Bias-Contamination	SVOC < QL	Rinsate blank	S & A
S-6, S-7	A-1	Accuracy/Bias	Phenol: 12-110 %R 2-Chlorophenol: 27-123 %R N-Nitroso-di-n-propylamine: 41-116 %R 4-Chloro-3-methylphenol: 23-97 %R Acenaphthene: 46-118 %R 4-Nitrophenol: 10-80 %R 2,4-Dinitrotoluene: 24-96 %R Pentachlorophenol: 9-103 %R Pyrene: 26-127 %R	MS/MSD	S & A
S-6, S-7	A-1	Precision	Phenol: 42% RPD 2-Chlorophenol: 40% RPD N-Nitroso-di-n-propylamine: 38% RPD 4-Chloro-3-methylphenol: 42% RPD Acenaphthene: 31% RPD 4-Nitrophenol: 50% RPD 2,4-Dinitrotoluene: 38% RPD Pentachlorophenol: 50% RPD Pyrene: 31% RPD	MS/MSD	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	SVOA/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP[3]**	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-1	Accuracy	Phenol-d_5: 39-106 %R Bis(2-chloroethyl)ether-d_8: 40-105 %R 2-Chlorophenol-d_4: 41-106 %R 4-Methylphenol-d_8: 25-111 %R Nitrobenzene-d_5: 43-108 %R 2-Nitrophenol-d_4: 40-108 %R 2,4-Dichlorophenol-d_3: 37-105 %R 4-Chloroaniline-d_4: 1-145 %R Dimethylphthalate-d_6: 47-114 %R Acenaphthylene-d_8: 41-107 %R 4-Nitrophenol-d_4: 33-116 %R Fluorene-d_{10}: 42-111 %R 4,6-Dinitro-2-methylphenol-d_2: 22-104 %R Anthracene-d_{10}: 44-110 %R Pyrene-d_{10}: 52-119 %R Benzo(a)pyrene-d_{12}: 32-121 %R Fluoranthene-d_{10}: 50-150 %R 2-Methylnaphthalene-d_{10}: 50-150 %R	Deuterated monitoring compounds	A
S-6, S-7	A-1	Accuracy/ Bias-Contamination	SVOC < QL	Method blank	A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	SVOA/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	PCB/CLP
Concentration Level	Low concentration

Sampling Procedure[2]	Analytical Method SOP[3]	DQIs	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
S-6, S-7	A-1	Precision	RPD ≤ 70%	Field duplicate	S & A
S-6, S-7	A-1	Accuracy/Bias-Contamination	PCB < QL	Rinsate blank	S & A
S-6, S-7	A-1	Accuracy/Bias	Aroclor-1016: 29-135 %R Aroclor-1260: 29-135 %R	MS/MSD	S & A
S-6, S-7	A-1	Precision	Aroclor-1016: 15% RPD Aroclor-1260: 20% RPD	MS/MSD	S & A
S-6, S-7	A-1	Accuracy	Decachlorobiphenyl: 30-150 %R	Surrogate spike	A
S-6, S-7	A-1	Accuracy	Aroclor-1016: 50-150 %R Aroclor-1260: 50-150 %R	Laboratory Control Sample	A
S-6, S-7	A-1	Accuracy/ Bias-Contamination	PCB < QL	Method blank	A
S-6, S-7	A-1	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Water
Analytical Group[1]	TAL Metals and Mercury /CLP
Concentration Level	Low concentration/SIM

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-6, S-7	A-2	Precision	RPD ≤ 35%	Field duplicate	S & A
S-6, S-7	A-2	Accuracy/Bias-Contamination	Metal < QL	Rinsate blank	S & A
S-6, S-7	A-2	Accuracy	All metals: 75-125 %R	MS	A
S-6, S-7	A-2	Accuracy	All metals: 75-125 %R	LCS	A
S-6, S-7	A-2	Precision	All metals: < 20% RPD	Laboratory duplicate	A
S-6, S-7	A-2	Sensitivity/Contamination	Metal < QL	Method blank	A

Notes:

DQI	Data quality indicator
MS	Matrix spike
QC	Quality control
QL	Quantitation limit
%R	Percent recovery
RPD	Relative percent difference
SOP	Standard Operating Procedure

[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.

QAPP WORKSHEET #12 (CONTINUED)
MEASUREMENT PERFORMANCE CRITERIA TABLE

Matrix	Air
Analytical Group[1]	VOC
Concentration Level	Low concentration

Sampling Procedure[2]	**Analytical Method SOP**[3]	**DQIs**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
S-12	A-3	Precision	within 25%	Field duplicate	A
S-12	A-3	Accuracy/ Bias-Contamination	VOC < RL	Field blank	S
S-12	A-3	Completeness	≥ 90%	Data completeness defined as data not qualified as rejected after validation	S & A

Notes:

DQI	Data quality indicator
MS	Matrix spike
QC	Quality control
%R	Percent recovery
RL	Reporting limit
RPD	Relative percent difference
VOC	Volatile organic compound

[1] If information varies within an analytical group, separate by individual analyte.

[2] Reference number from QAPP Worksheet #21.

[3] Reference number from QAPP Worksheet #23.

QAPP WORKSHEET #13
SECONDARY DATA CRITERIA AND LIMITATIONS TABLE

(UFP QAPP Section 2.7)

Secondary Data	Data Source (Originating Organization, Report Title, and Date)	Data Source (Originating Organization, Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitation on Data Use
Groundwater sampling data	IDEM. "Preliminary Assessment Report for Lane Street Ground Water Contamination, Elkhart, Indiana." October 2007.	IDEM: groundwater samples; collected 2007.	Residential drinking-water well data summary will be used as a starting point to characterize the nature of contamination at the Lane Street Site.	None
Groundwater and air sampling data	WESTON. "Lane Street Groundwater Site, Elkhart, Indiana" Letter Report. March 2008.	Weston: groundwater and air samples; collected 2007.	Groundwater and indoor air data collected from residences to characterize the nature of contamination at the Lane Street Site.	None
Groundwater sampling and soil data	IDEM. "Site Inspection Report for Lane Street Ground Water Contamination, Elkhart, Indiana." September 5, 2008.	IDEM: groundwater and soil samples; collected 2008.	Soil and groundwater data collected from residences and businesses to characterize the nature of contamination at the Lane Street Site.	None

Notes:

IDEM Indiana Department of Environmental Management

QAPP WORKSHEET #14
SUMMARY OF PROJECT TASKS

(UFP QAPP Section 2.8.1)

Sampling Tasks:

1. Collect water samples from 6 on-site private wells for VOCs.
2. Collect water samples through vertical aquifer sampling at 10-foot depth intervals, up to a depth of 60 ft bgs, at up to 25 locations.
3. Install and develop up to 32 new monitoring wells at vertical aquifer sampling locations. One shallow and one deep well will be installed at 16 locations.
4. Collect soil samples as necessary during vertical aquifer sampling when contaminated soils are encountered.
5. Collect groundwater samples from newly installed monitoring wells.
6. Collect indoor air samples at three residences.
7. Conduct a wetland and habitat delineation/function and value assessment and a screening of databases for endangered species and others of special concern.
8. Take digital photographs to document activities.
9. Log activities and tasks in field notebook.
10. Prepare sample documentation such as chain-of-custody forms, sample labels, custody seals, etc.

Analysis Tasks: The CLP laboratory will analyze soil and groundwater (private well samples, VAS soil and groundwater samples, and groundwater samples from newly installed monitoring well) samples for VOCs, and select samples for VOCs, SVOCs, PCBs, and TAL metals (including mercury). A private laboratory will be contracted to analyze the indoor air samples for VOCs.

QC Tasks: The following QC samples will be collected and analyzed during the sampling event: field duplicates, MS/MSD samples, rinsate blanks, trip blanks, and field blanks.

Secondary Data: See Worksheet #13.

QAPP WORKSHEET #14 (CONTINUED)
SUMMARY OF PROJECT TASKS

Data Management Tasks: Analytical data will be archived in an electronic database after validation.
Documentation and Records: All samples collected will be documented in a logbook using a ballpoint pen. The time of collection, identification number, sampling location, field observations, sampler's name, and analyses will be recorded in the logbook for each sample. Each page of the logbook will be dated, numbered, and signed by SulTRAC personnel. Field data records will be maintained at SulTRAC's Chicago office. SulTRAC will follow custody procedures outlined in SulTRAC's program-level QAPP for the RAC 2 contract. Further specifications are described in the FSP.
Assessment/Audit Tasks: An audit of one off-site laboratory is planned as part of this project.
Data Review Tasks: EPA/Environmental Services Assistance Team (ESAT) will perform Level III – Manual data validation as defined by the CLP SOW for all CLP data and will prepare a case narrative detailing any issues or inconsistencies discovered. The SulTRAC QA officer will review the case narrative and will detail any analytical issues that may potentially affect data quality in the RI/FS report.

QAPP WORKSHEET #15
REFERENCE LIMITS AND EVALUATION TABLE

(UFP QAPP Section 2.8.1)

Reference Limits Table – Soil

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
VOA/CLP	Dichlorodifluoromethane	75-71-8	1.80E+03	RSL-Res	5.00E-03
VOA/CLP	Chloromethane	74-87-3	1.20E+03	RSL-Res	5.00E-03
VOA/CLP	Vinyl chloride	75-01-4	1.50E+00	IDEM-Res	5.00E-03
VOA/CLP	1,2,4-Trichlorobenzene	120-82-1	1.80E+03	IDEM-Res	5.00E-03
VOA/CLP	Trichlorofluoromethane	75-69-4	9.80E+02	IDEM-Res	5.00E-03
VOA/CLP	Bromomethane	74-83-9	9.90E+00	IDEM-Res	5.00E-03
VOA/CLP	Chloroethane	75-00-3	8.00E+01	IDEM-Res	5.00E-03
VOA/CLP	1,1-Dichloroethene	75-35-4	3.10E+02	IDEM-Res	5.00E-03
VOA/CLP	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	4.30E+04	RSL-Res	5.00E-03
VOA/CLP	Acetone	67-64-1	3.50E+04	IDEM-Res	1.00E-02
VOA/CLP	Carbon disulfide	75-15-0	9.00E+02	IDEM-Res	5.00E-03
VOA/CLP	Methyl acetate	79-20-9	7.80E+04	RSL-Res	5.00E-03
VOA/CLP	Methylene chloride	75-09-2	1.20E+02	IDEM-Res	5.00E-03
VOA/CLP	Trans-1,2-Dichloroethene	156-60-5	1.80E+02	IDEM-Res	5.00E-03
VOA/CLP	Methyl tert-butyl ether	1634-04-4	3.50E+02	IDEM-Res	5.00E-03
VOA/CLP	1,1-Dichloroethane	75-34-3	1.30E+03	IDEM-Res	5.00E-03
VOA/CLP	Cis-1,2-Dichloroethene	156-59-2	1.10E+02	IDEM-Res	5.00E-03
VOA/CLP	2-Butanone	78-93-3	4.40E+04	IDEM-Res	1.00E-02
VOA/CLP	Chloroform	67-66-3	3.00E+00	IDEM-Res	5.00E-03
VOA/CLP	1,1,1-Trichloroethane	71-55-6	5.00E+03	IDEM-Res	5.00E-03

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
VOA/CLP	Cyclohexane	110-82-7	7.20E+03	IDEM-Res	5.00E-03
VOA/CLP	Carbon tetrachloride	56-23-5	3.30E+00	IDEM-Res	5.00E-03
VOA/CLP	Benzene	71-43-2	8.40E+00	IDEM-Res	5.00E-03
VOA/CLP	1,2-Dichloroethane	107-06-2	3.00E+00	IDEM-Res	5.00E-03
VOA/CLP	1,4-Dioxane	123-91-1	4.40E+01	RSL-Res	1.00E-01
VOA/CLP	TCE	79-01-6	4.90E+00	IDEM-Res	5.00E-03
VOA/CLP	Methylcyclohexane	108-87-2	7.00E+03	RSL-Res	5.00E-03
VOA/CLP	1,2-Dichloropropane	78-87-5	4.50E+00	IDEM-Res	5.00E-03
VOA/CLP	Bromodichloromethane	75-27-4	1.00E+01	IDEM-Res	5.00E-03
VOA/CLP	Cis-1,3-Dichloropropene	10061-01-5	9.50E+00	IDEM-Res	5.00E-03
VOA/CLP	4-Methyl-2-pentanone	108-10-1	1.20E+04	IDEM-Res	1.00E-02
VOA/CLP	Toluene	108-88-3	8.80E+03	IDEM-Res	5.00E-03
VOA/CLP	Trans-1,3-Dichloropropene	10061-02-6	9.50E+00	IDEM-Res	5.00E-03
VOA/CLP	1,1,2-Trichloroethane	79-00-5	9.40E+00	IDEM-Res	5.00E-03
VOA/CLP	Tetrachloroethene	127-18-4	9.90E+00	IDEM-Res	5.00E-03
VOA/CLP	2-Hexanone	591-78-6	2.10E+02	RSL-Res	1.00E-02
VOA/CLP	Dibromochloromethane	75-25-2	2.80E+02	IDEM-Res	5.00E-03
VOA/CLP	1,2-Dibromoethane	106-93-4	3.00E-01	IDEM-Res	5.00E-03
VOA/CLP	Chlorobenzene	108-90-7	3.80E+02	IDEM-Res	5.00E-03
VOA/CLP	Ethylbenzene	100-41-4	4.60E+03	IDEM-Res	5.00E-03
VOA/CLP	o-Xylene	1330-20-7	6.90E+02	IDEM-Res	5.00E-03
VOA/CLP	m,p-Xylene	1330-20-7	6.90E+02	IDEM-Res	5.00E-03
VOA/CLP	Styrene	100-42-5	1.10E+04	IDEM-Res	5.00E-03
VOA/CLP	Bromoform	75-25-2	2.80E+02	IDEM-Res	5.00E-03
VOA/CLP	Isopropylbenzene	98-82-8	1.40E+03	IDEM-Res	5.00E-03
VOA/CLP	1,1,2,2-Tetrachloroethane	79-34-5	5.00E+00	IDEM-Res	5.00E-03
VOA/CLP	1,3-Dichlorobenzene	95-50-1	2.80E+03	IDEM-Res	5.00E-03
VOA/CLP	1,4-Dichlorobenzene	95-50-1	2.80E+03	IDEM-Res	5.00E-03
VOA/CLP	1,2-Dichlorobenzene	95-50-1	2.80E+03	IDEM-Res	5.00E-03
VOA/CLP	1,2-Dibromo-3-chloropropane	96-12-8	5.40E-03	RSL-Res	5.00E-03
VOA/CLP	1,2,3-Trichlorobenzene	87-61-6	4.90E+01	RSL-Res	5.00E-03

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
SVOA/CLP	Phenol	108-95-2	1.80E+04	RSL-Res	1.70E-01
SVOA/CLP	Bis(2-Chloroethyl)ether	111-44-4	2.10E-01	RSL-Res	1.70E-01
SVOA/CLP	2-Chlorophenol	95-57-8	3.60E+02	IDEM-Res	1.70E-01
SVOA/CLP	2-Methylphenol	95-48-7	3.10E+03	RSL-Res	1.70E-01
SVOA/CLP	2,2'-Oxybis(1-chloropropane)	108-60-1	4.60E+00	RSL-Res	1.70E-01
SVOA/CLP	Acetophenone	98-86-2	7.80E+03	RSL-Res	1.70E-01
SVOA/CLP	4-Methylphenol	106-44-5	3.10E+02	RSL-Res	1.70E-01
SVOA/CLP	N-Nitroso-di-n propylamine	621-64-7	6.10E-01	IDEM-Res	1.70E-01
SVOA/CLP	Hexachloroethane	67-72-1	3.50E+01	RSL-Res	1.70E-01
SVOA/CLP	Nitrobenzene	98-95-3	4.80E+00	RSL-Res	1.70E-01
SVOA/CLP	Isophorone	78-59-1	5.10E+02	RSL-Res	1.70E-01
SVOA/CLP	2-Nitrophenol	88-75-5	NC	NA	1.70E-01
SVOA/CLP	2,4-Dimethylphenol	105-67-9	1.20E+03	RSL-Res	1.70E-01
SVOA/CLP	Bis(2-Chloroethoxy)methane	111-91-1	1.80E+02	RSL-Res	1.70E-01
SVOA/CLP	2,4-Dichlorophenol	120-83-2	1.80E+02	RSL-Res	1.70E-01
SVOA/CLP	Naphthalene	91-20-3	3.60E+00	RSL-Res	1.70E-01
SVOA/CLP	4-Chloroaniline	106-47-8	2.40E+00	RSL-Res	1.70E-01
SVOA/CLP	Hexachlorobutadiene	87-68-3	6.20E+00	RSL-Res	1.70E-01
SVOA/CLP	Caprolactam	105-60-2	3.10E+04	RSL-Res	1.70E-01
SVOA/CLP	4-Chloro-3-methylphenol	59-50-7	6.10E+03	RSL-Res	1.70E-01
SVOA/CLP	2-Methylnaphthalene	91-57-6	3.10E+02	RSL-Res	1.70E-01
SVOA/CLP	Hexachlorocyclopentadiene	77-47-4	3.70E+02	RSL-Res	1.70E-01
SVOA/CLP	2,4,6-Trichlorophenol	88-06-2	1.80E+01	IDEM-Res	1.70E-01
SVOA/CLP	2,4,5-Trichlorophenol	95-95-4	6.10E+03	RSL-Res	1.70E-01
SVOA/CLP	1,1-Biphenyl	92-52-4	3.90E+03	RSL-Res	1.70E-01
SVOA/CLP	2-Chloronaphthalene	91-58-7	6.30E+03	RSL-Res	1.70E-01
SVOA/CLP	2-Nitroaniline	88-74-4	5.50E+02	IDEM-Res	3.30E-01
SVOA/CLP	Dimethylphthalate	131-11-3	1.00E+06	IDEM-Res	1.70E-01
SVOA/CLP	2,6-Dinitrotoluene	606-20-2	6.30E+00	IDEM-Res	1.70E-01
SVOA/CLP	Acenaphthylene	208-96-8	1.10E+03	IDEM-Res	1.70E-01
SVOA/CLP	3-Nitroaniline	99-09-2	NC	NA	3.30E-01
SVOA/CLP	Acenaphthene	83-32-9	3.40E+03	RSL-Res	1.70E-01
SVOA/CLP	2,4-Dinitrophenol	51-28-5	1.20E+02	RSL-Res	3.30E-01

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
SVOA/CLP	Dibenzofuran	132-64-9	7.80E+01	RSL-Res	1.70E-01
SVOA/CLP	2,4-Dinitrotoluene	121-14-2	1.60E+00	RSL-Res	1.70E-01
SVOA/CLP	Diethylphthalate	84-66-2	4.90E+04	RSL-Res	1.70E-01
SVOA/CLP	Fluorene	86-73-7	2.30E+03	RSL-Res	1.70E-01
SVOA/CLP	4-Chlorophenyl-phenyl ether	7005-72-3	NC	NA	1.70E-01
SVOA/CLP	4-Nitroaniline	100-01-6	2.40E+01	RSL-Res	3.30E-01
SVOA/CLP	2-Methyl-4,6-dinitro phenol	534-52-1	4.90E+00	RSL-Res	3.30E-01
SVOA/CLP	N-Nitrosodiphenylamine	86-30-6	9.90E+01	RSL-Res	1.70E-01
SVOA/CLP	1,2,4,5-Tetrachlorobenzene	95-94-3	1.80E+01	RSL-Res	1.70E-01
SVOA/CLP	4-Bromophenyl-phenylether	101-55-3	NC	NA	1.70E-01
SVOA/CLP	Hexachlorobenzene	118-74-1	3.00E-01	RSL-Res	1.70E-01
SVOA/CLP	Atrazine	1912-24-9	2.10E+00	RSL-Res	1.70E-01
SVOA/CLP	Pentachlorophenol	87-86-5	3.00E+00	RSL-Res	3.30E-01
SVOA/CLP	Phenanthrene	85-01-8	4.70E+02	IDEM-Res	1.70E-01
SVOA/CLP	Anthracene	120-12-7	1.70E+04	RSL-Res	1.70E-01
SVOA/CLP	Carbazole	86-74-8	2.10E+02	IDEM-Res	1.70E-01
SVOA/CLP	Di-n-butylphthalate	84-74-2	6.10E+03	RSL-Res	1.70E-01
SVOA/CLP	Fluoranthene	206-44-0	2.30E+03	RSL-Res	1.70E-01
SVOA/CLP	Pyrene	129-00-0	1.70E+03	RSL-Res	1.70E-01
SVOA/CLP	Butylbenzylphthalate	85-68-7	2.60E+02	RSL-Res	1.70E-01
SVOA/CLP	3,3’-dichlorobenzidine	91-94-1	1.10E+00	RSL-Res	1.70E-01
SVOA/CLP	Benzo(a)anthracene	56-55-3	1.50E-01	RSL-Res	1.70E-01
SVOA/CLP	Benzo(b)fluoranthene	205-99-2	1.50E-01	RSL-Res	1.70E-01
SVOA/CLP	Benzo(k)fluoranthene	207-08-9	1.50E+00	RSL-Res	1.70E-01
SVOA/CLP	Chrysene	218-01-9	1.50E+01	RSL-Res	1.70E-01
SVOA/CLP	Bis(2-ethylhexyl)phthalate	117-81-7	3.50E+01	RSL-Res	1.70E-01
SVOA/CLP	Di-n-octylphthalate	117-84-0	7.30E+03	IDEM-Res	1.70E-01
SVOA/CLP	Benzo(a)pyrene	50-32-8	1.50E-02	RSL-Res	1.70E-01
SVOA/CLP	Indeno(1,2,3,-cd)pyrene	193-39-5	1.50E-01	RSL-Res	1.70E-01
SVOA/CLP	Dibenzo(a,h)anthracene	53-70-3	1.50E-02	RSL-Res	1.70E-01
SVOA/CLP	Benzo(g,h,i)perylene	191-24-2	NC	NA	1.70E-01
SVOA/CLP	2,3,4,6-Tetrachlorophenol	58-90-2	1.80E+03	RSL-Res	1.70E-01

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
PCBs/CLP	Aroclor-1016	12674-11-2	3.90E+00	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1221	11104-28-2	1.40E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1232	11141-16-5	1.40E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1242	53469-21-9	2.20E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1248	12672-29-6	2.20E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1254	11097-69-1	2.20E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1260	11096-82-5	2.20E-01	RSL-Res	3.30E-02
PCBs/CLP	Aroclor-1268	11100-14-4	1.80E+00	IDEM-Res	3.30E-02
TAL Metals/CLP	Aluminum	7429-90-5	7.70E+04	RSL-Res	2.00E+01
TAL Metals/CLP	Antimony	7440-36-0	3.10E+01	RSL-Res	6.00E+00
TAL Metals/CLP	Arsenic [b]	7440-38-2	3.90E-01	IDEM-Res	1.00E+00
TAL Metals/CLP	Barium	7440-39-3	1.50E+04	RSL-Res	2.00E+01
TAL Metals/CLP	Beryllium	7440-41-7	1.60E+02	RSL-Res	5.00E-01
TAL Metals/CLP	Cadmium	7440-43-9	1.20E+01	IDEM-Res	5.00E-01
TAL Metals/CLP	Calcium	17852-99-2	NC	NC	5.00E+02
TAL Metals/CLP	Chromium III	16065-83-1	1.20E+05	RSL-Res	1.00E+00
TAL Metals/CLP	Chromium VI [b]	18540-29-9	2.90E-01	RSL-Res	1.00E+00
TAL Metals/CLP	Cobalt	7440-48-4	2.30E+01	RSL-Res	5.00E+00
TAL Metals/CLP	Copper	7440-50-8	3.10E+03	RSL-Res	2.50E+00
TAL Metals/CLP	Iron	7439-89-6	5.50E+04	RSL-Res	1.00E+01
TAL Metals/CLP	Lead	7439-92-1	4.00E+02	RSL-Res	1.00E+00
TAL Metals/CLP	Magnesium	7439-95-4	NC	NC	5.00E+02
TAL Metals/CLP	Manganese	7439-96-5	1.80E+03	RSL-Res	1.50E+00
TAL Metals/CLP	Mercury	7439-97-6	5.60E+00	RSL-Res	1.00E-01
TAL Metals/CLP	Nickel	7440-02-0	1.50E+03	RSL-Res	4.00E+00
TAL Metals/CLP	Potassium	7440-22-4	3.90E+02	RSL-Res	1.00E+00
TAL Metals/CLP	Selenium	7782-49-2	3.90E+02	RSL-Res	3.50E+00
TAL Metals/CLP	Silver	7440-22-4	3.90E+02	RSL-Res	1.00E+00
TAL Metals/CLP	Sodium	7440-23-5	NC	NC	5.00E+02
TAL Metals/CLP	Thallium	7440-28-0	2.40E+01	IDEM-Res	2.50E+00

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level - Soil (mg/kg)	PAL source [a]	CRQL - LOW Soil (mg/kg)
TAL Metals/CLP	Vanadium	7440-62-2	3.90E+02	RSL-Res	5.00E+00
TAL Metals/CLP	Zinc	7440-66-6	2.30E+04	RSL-Res	6.00E+00

Notes:

CAS	Chemical Abstract Services
CLP	Contract Laboratory Program
CRQL	Contract-required quantitation limit
IDEM	Indiana Department of Environmental Management
MDL	Method detection limit
mg/kg	Milligram per kilogram`
NC	No criteria
PAL	Project Action Level
PCB	Polychlorinated biphenyl
RSL	Regional Screening Level
SVOA	Semivolatile organic analysis
TAL	Target Analyte List
VOA	Volatile organic analysis

[a] The PAL is the minimum value of the following values:
RSL-Res: December 2009 Residential RSL
RSL-Ind: December 2009 Industrial RSL
IDEM-Res: IDEM Risk-Integrated System of Closure (RISC) residential soil direct value, May 2009
IDEM-Ind: IDEM Risk-Integrated System of Closure (RISC) industrial soil direct value, May 2009

[b] The PAL value exceeds the CLP CRQL for this analyte. The scope of work will request that the CLP laboratory report the analyte concentration at the method detection limit (MDL) and flag the result with an estimated value flag (J flag).

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Reference Limits Table –Water

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
VOA/CLP	Dichlorodifluoromethane	75-71-8	3.95E+02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Chloromethane	74-87-3	1.88E+02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Vinyl chloride [b]	75-01-4	1.62E-02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Bromomethane	74-83-9	8.66E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Chloroethane	75-00-3	6.20E+01	IDEM-Res	NC	5.00E-01	5.00E+00
VOA/CLP	Trichlorofluoromethane	75-69-4	1.29E+03	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1-Dichloroethene	75-35-4	7.00E+00	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	Acetone	67-64-1	6.90E+03	IDEM-Res	NC	5.00E+00	1.00E+01
VOA/CLP	Carbon disulfide	75-15-0	1.04E+03	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Methyl acetate	79-20-9	3.65E+04	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Methylene chloride	75-09-2	4.80E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Trans-1,2-Dichloroethene	156-60-5	1.00E+02	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	Methyl tert-butyl ether	1634-04-4	1.25E+01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1-Dichloroethane	75-34-3	2.42E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Cis-1,2-Dichloroethene	156-59-2	7.00E+01	IDEM-Res	NC	5.00E-01	5.00E+00
VOA/CLP	2-Butanone	78-93-3	7.06E+03	RSL-tapwater	NC	5.00E+00	1.00E+01
VOA/CLP	Bromochloromethane	74-97-5	NC	NC	NC	5.00E-01	5.00E+00
VOA/CLP	Chloroform [b]	67-66-3	1.93E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1,1-Trichloroethane	71-55-6	2.00E+02	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	Cyclohexane	110-82-7	1.25E+04	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Carbon tetrachloride [b]	56-23-5	1.99E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Benzene [b]	71-43-2	4.13E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,2-Dichloroethane	107-06-2	9.40E-02	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	1,4-Dioxane [b]	123-91-1	6.11E+00	RSL-tapwater	NC	NC	1.00E+02
VOA/CLP	Trichloroethene	79-01-6	2.01E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Methylcyclohexane	108-87-2	NC	NC	NC	5.00E-01	5.00E+00
VOA/CLP	1,2-Dichloropropane [b]	78-87-5	3.86E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Bromodichloromethane [b]	75-27-4	1.17E-01	RSL-tapwater	NC	5.00E-01	5.00E+00

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
VOA/CLP	Cis-1,3-Dichloropropene [b]	10061-01-5	4.33E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	4-Methyl-2-pentanone	108-10-1	1.99E+03	RSL-tapwater	NC	5.00E+00	1.00E+01
VOA/CLP	Toluene	108-88-3	1.00E+03	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	Trans-1,3-Dichloropropene [b]	10061-02-6	4.33E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1,2-Trichloroethane [b]	79-00-5	2.42E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Tetrachloroethene [b]	127-18-4	1.08E-01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	2-Hexanone	591-78-6	4.66E+01	RSL-tapwater	NC	5.00E+00	1.00E+01
VOA/CLP	Dibromochloromethane	75-25-2	8.51E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,2-Dibromoethane [b]	106-93-4	6.53E-03	RSL-tapwater	5.00E-02	5.00E-01	5.00E+00
VOA/CLP	Chlorobenzene	108-90-7	9.13E+01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	Ethylbenzene	100-41-4	1.48E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	o-Xylene	1330-20-7	2.70E+02	IDEM-Res	NC	5.00E-01	5.00E+00
VOA/CLP	m,p-Xylene	1330-20-7	2.70E+02	IDEM-Res	NC	5.00E-01	5.00E+00
VOA/CLP	Styrene	100-42-5	1.00E+02	RSL-MCL	NC	5.00E-01	5.00E+00
VOA/CLP	Bromoform	75-25-2	8.51E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1,2,2-Tetrachloroethane [b]	79-34-5	6.71E-02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,3-Dichlorobenzene	95-50-1	3.70E+02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,4-Dichlorobenzene	95-50-1	3.70E+02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,2-Dichlorobenzene	95-50-1	3.70E+02	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,2-Dibromo-3-chloropropane [b]	96-12-8	3.16E-04	RSL-tapwater	5.00E-02	5.00E-01	5.00E+00
VOA/CLP	1,2,4-Trichlorobenzene	120-82-1	2.32E+00	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,2,3-Trichlorobenzene	87-61-6	2.92E+01	RSL-tapwater	NC	5.00E-01	5.00E+00
VOA/CLP	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5.90E+04	RSL-MCL	NC	5.00E-01	5.00E+00

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
SVOA/CLP	Benzaldehyde	100-52-7	3.65E+03	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Phenol	108-95-2	1.10E+04	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Bis(2-chloroethyl)ether [b]	111-44-4	1.19E-02	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2-Chlorophenol	95-57-8	3.80E+01	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2-Methylphenol	95-48-7	1.80E+03	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2,2'-Oxybis(1-chloropropane) [b]	108-60-1	3.23E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	4-Methylphenol	106-44-5	1.80E+02	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Acetophenone	98-86-2	3.65E+03	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	N-Nitroso-di-n propylamine [b]	621-64-7	9.61E-03	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Hexachloroethane [b]	67-72-1	4.80E+00	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Nitrobenzene [b]	98-95-3	1.22E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Isophorone	78-59-1	7.08E+01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2-Nitrophenol	88-75-5	NC	NC	NC	NC	5.00E+00
SVOA/CLP	2,4-Dimethylphenol	105-67-9	7.30E+02	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2,4-Dichlorophenol	120-83-2	1.10E+02	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Naphthalene	91-20-3	1.43E-01	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	4-Chloroaniline [b]	106-47-8	3.36E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Hexachlorobutadiene [b]	87-68-3	8.62E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Caprolactam	105-60-2	1.83E+04	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	4-Chloro-3-methylphenol	59-50-7	3.65E+03	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2-Methylnaphthalene	91-57-6	3.10E+01	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	Hexachlorocyclopentadiene	77-47-4	5.00E+01	RSL-MCL	NC	NC	5.00E+00
SVOA/CLP	2,4,6-Trichlorophenol [b]	88-06-2	3.60E+00	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2,4,5-Trichlorophenol	95-95-4	3.60E+03	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	1,1-Biphenyl	92-52-4	1.83E+03	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2-Chloronaphthalene	91-58-7	6.10E+02	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2-Nitroaniline	88-74-4	1.10E+02	IDEM-Res	NC	NC	1.00E+01
SVOA/CLP	4,6-Dinitro-2-methylphenol [b]	534-52-1	3.65E+00	RSL-tapwater	NC	NC	1.00E+01

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
SVOA/CLP	N-Nitrosodiphenylamine	86-30-6	1.37E+01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	1,2,4,5-Tetrachlorobenzene	95-94-3	1.10E+01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Hexachlorobenzene [b]	118-74-1	4.20E-02	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	2,4,6-Trichlorophenol [b]	88-06-2	3.60E+00	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2,4,5-Trichlorophenol	95-95-4	3.60E+03	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Dimethylphthalate	131-11-3	3.60E+05	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2,6-Dinitrotoluene	606-20-2	3.65E+01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Acenaphthylene	208-96-8	7.10E+01	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	3-Nitroaniline	99-09-2	NC	NC	NC	NC	1.00E+01
SVOA/CLP	Acenaphthene	83-32-9	4.60E+02	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	2,4-Dinitrophenol	51-28-5	7.30E+01	IDEM-Res	NC	NC	1.00E+01
SVOA/CLP	4-Nitrophenol	100-02-7	NC	NC	NC	NC	1.00E+01
SVOA/CLP	Dibenzofuran	132-64-9	1.50E+01	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	2,4-Dinitrotoluene [b]	121-14-2	2.17E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Diethylphthalate	84-66-2	2.90E+04	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Fluorene	86-73-7	3.10E+02	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	4-Chlorophenyl-phenyl ether	7005-72-3	NC	NC	NC	NC	5.00E+00
SVOA/CLP	4-Nitroaniline [b]	100-01-6	3.36E+00	RSL-tapwater	NC	NC	1.00E+01
SVOA/CLP	Hexachlorobenzene [b]	118-74-1	4.20E-02	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Atrazine [b]	1912-24-9	2.92E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Pentachlorophenol	87-86-5	5.60E-01	RSL-tapwater	2.00E-01	NC	1.00E+01
SVOA/CLP	Phenanthrene	85-01-8	2.30E+01	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	Anthracene	120-12-7	2.30E+03	IDEM-Res	1.00E-01	NC	5.00E+00
SVOA/CLP	Carbazole	86-74-8	4.30E+01	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Di-n-butylphthalate	84-74-2	3.60E+03	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Fluoranthene	206-44-0	1.46E+03	RSL-tapwater	1.00E-01	NC	5.00E+00

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
SVOA/CLP	Pyrene	129-00-0	1.10E+03	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Butylbenzylphthalate	85-68-7	3.54E+01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	3,3’-Dichlorobenzidine	91-94-1	1.49E-01	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Benzo(a)anthracene [b]	56-55-3	2.95E-02	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Chrysene	218-01-9	2.95E+00	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Bis(2-ethylhexyl)phthalate	117-81-7	4.80E+00	RSL-tapwater	NC	NC	5.00E+00
SVOA/CLP	Di-n-octylphthalate	117-84-0	1.50E+03	IDEM-Res	NC	NC	5.00E+00
SVOA/CLP	Benzo(b)fluoranthene [b]	205-99-2	2.95E-02	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Benzo(k)fluoranthene	207-08-9	2.95E-01	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Benzo(a)pyrene [b]	50-32-8	2.95E-03	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Indeno(1,2,3,-cd)pyrene [b]	193-39-5	2.95E-02	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	Dibenzo(a,h)anthracene [b]	53-70-3	2.95E-03	RSL-tapwater	1.00E-01	NC	5.00E+00
SVOA/CLP	2,3,4,6-Tetrachlorophenol	58-90-2	1.10E+03	RSL-tapwater	NC	NC	5.00E+00
PCB/CLP	Aroclor-1016 [b]	12674-11-2	4.30E-01	IDEM-Res	NC	NC	1.00E+00
PCB/CLP	Aroclor-1221 [b]	11104-28-2	6.80E-03	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1232 [b]	11141-16-5	6.80E-03	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1242 [b]	53469-21-9	3.36E-02	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1248 [b]	12672-29-6	3.36E-02	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1254 [b]	11097-69-1	3.36E-02	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1260 [b]	11096-82-5	3.36E-02	RSL-tapwater	NC	NC	1.00E+00
PCB/CLP	Aroclor-1268 [b]	11100-14-4	4.30E-01	IDEM-Res	NC	NC	1.00E+00

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Water (µg/L)	PAL source [a]	CRQL - SIM Water (µg/L)	CRQL - TRACE Water (µg/L)	CRQL - LOW Water (µg/L)
TAL Metals/CLP	Aluminum	7429-90-5	3.65E+04	RSL-tapwater	NC	NC	2.00E+02
TAL Metals/CLP	Antimony	7440-36-0	6.00E+00	RSL-MCL	2.00E+00	NC	6.00E+01
TAL Metals/CLP	Arsenic [b]	7440-38-2	4.48E-02	RSL-tapwater	1.00E+00	NC	1.00E+01
TAL Metals/CLP	Barium	7440-39-3	2.00E+03	RSL-MCL	1.00E+01	NC	2.00E+02
TAL Metals/CLP	Beryllium	7440-41-7	4.00E+00	RSL-MCL	1.00E+00	NC	5.00E+00
TAL Metals/CLP	Cadmium	7440-43-9	5.00E+00	RSL-MCL	1.00E+00	NC	5.00E+00
TAL Metals/CLP	Calcium	17852-99-2	NC	NC	NC	NC	5.00E+03
TAL Metals/CLP	Total Chromium	7440-47-3	1.00E+02	RSL-MCL	2.00E+00	NC	1.00E+01
TAL Metals/CLP	Cobalt	7440-48-4	1.10E+01	RSL-tapwater	1.00E+00	NC	5.00E+01
TAL Metals/CLP	Copper	7440-50-8	1.30E+03	RSL-MCL	2.00E+00	NC	2.50E+01
TAL Metals/CLP	Iron	7439-89-6	2.56E+04	RSL-tapwater	NC	NC	1.00E+02
TAL Metals/CLP	Lead [b]	7439-92-1	3.65E-03	RSL-tapwater	1.00E+00	NC	1.00E+01
TAL Metals/CLP	Magnesium	7439-95-4	NC	NC	NC	NC	5.00E+03
TAL Metals/CLP	Manganese	7439-96-5	8.76E+02	RSL-tapwater	1.00E+00	NC	1.50E+01
TAL Metals/CLP	Mercury	7439-97-6	5.65E-01	RSL-tapwater	NC	NC	2.00E-01
TAL Metals/CLP	Nickel	7440-02-0	7.30E+02	RSL-tapwater	1.00E+00	NC	4.00E+01
TAL Metals/CLP	Potassium	7440-22-4	1.80E+02	IDEM-Res	1.00E+00	NC	1.00E+01
TAL Metals/CLP	Selenium	7782-49-2	5.00E+01	RSL-MCL	5.00E+00	NC	3.50E+01
TAL Metals/CLP	Silver	7440-22-4	1.80E+02	IDEM-Res	1.00E+00	NC	1.00E+01
TAL Metals/CLP	Sodium	7440-23-5	NC	NC	NC	NC	5.00E+03
TAL Metals/CLP	Thallium	7440-28-0	2.00E+00	RSL-MCL	1.00E+00	NC	2.50E+01
TAL Metals/CLP	Vanadium [b]	7440-62-2	2.56E+00	RSL-tapwater	5.00E+00	NC	5.00E+01
TAL Metals/CLP	Zinc	7440-66-6	1.10E+04	RSL-tapwater	2.00E+00	NC	6.00E+01

Notes:

µg/L	Microgram per liter
AES	Atomic emission spectroscopy
CAS	Chemical Abstract Services
CLP	Contract Laboratory Program

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

CRQL	Contract-required quantitation limit
ICP	Inductively coupled plasma
IDEM	Indiana Department of Environmental Management
MCL	Maximum Contaminant Level
NC	No criteria
PAL	Project action level
RSL	Regional Screening Level
SIM	Selected Ion Monitoring
TAL	Target Analyte List

a The PAL is the minimum value of the following values:
RSL-tapwater: December 2009 Tapwater RSL value
RSL-MCL: December 2009 MCL value
IDEM-Res: IDEM Risk-Integrated System of Closure (RISC) residential health protective value, May 2009
IDEM-Ind: I DEM Risk-Integrated System of Closure (RISC) industrial health protective value, May 2009

b The PAL value exceeds the CLP CRQL for this analyte. The scope of work will request that the CLP laboratory report the analyte concentration at the MDL and flag the result with an estimated value flag (J flag).

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Reference Limits Table –Air

Analytical Group	Analyte	CAS Number	Project Action Level – Air ($\mu g/m^3$)	PAL source [a]	RL – SIM ($\mu g/m^3$)	RL – LOW Level Air ($\mu g/m^3$)
VOA	Dichlorodifluoromethane	75-71-8	2.10E+02	RSL-Res Air	NC	4.90E-01
VOA	Chloromethane	74-87-3	9.4E+01	RSL-Res Air	NC	2.10E-01
VOA	Vinyl chloride	75-01-4	1.60E-01	RSL-Res Air	2.60E-02	2.60E-01
VOA	Bromomethane	74-83-9	5.20E+00	RSL-Res Air	NC	3.90E-01
VOA	Chloroethane	75-00-3	2.30E+01	IDEM-Res	NC	2.60E-01
VOA	Trichlorofluoromethane	75-69-4	7.30E+02	RSL-Res Air	NC	5.60E-01
VOA	1,1-Dichloroethene	75-35-4	2.10E+02	RSL-Res Air	4.00E-02	4.00E-01
VOA	Acetone	67-64-1	3.20E+03	IDEM-Res	NC	1.20E+00
VOA	Carbon disulfide	75-15-0	7.30E+02	RSL-Res Air	NC	1.60E+00
VOA	Methylene chloride	75-09-2	5.20E+00	RSL-Res Air	NC	6.90E-01
VOA	Trans-1,2-Dichloroethene	156-60-5	6.30E+01	RSL-Res Air	4.00E-01	4.00E-01
VOA	Methyl tert-butyl ether	1634-04-4	9.40E+00	RSL-Res Air	3.70E-01	3.60E-01
VOA	1,1-Dichloroethane	75-34-3	1.50E+00	RSL-Res Air	8.20E-02	4.00E-01
VOA	Cis-1,2-Dichloroethene	156-59-2	3.70E+01	IDEM-Res	8.00E-02	4.00E-01
VOA	2-Butanone	78-93-3	3.10E+03	IDEM-Res	NC	2.90E-01
VOA	Chloroform	67-66-3	8.30E-01	IDEM-Res	NC	4.90E-01
VOA	1,1,1-Trichloroethane	71-55-6	2.30E+03	IDEM-Res	1.10E-01	5.40E-01
VOA	Cyclohexane	110-82-7	6.20E+03	IDEM-Res	NC	3.40E-01
VOA	Carbon tetrachloride [b]	56-23-5	4.10E-01	RSL-Res Air	NC	6.30E-01
VOA	Benzene	71-43-2	3.10E-01	RSL-Res Air	1.60E-01	3.20E-01
VOA	1,4-Dioxane [b]	123-91-1	3.20E-01	RSL-Res Air	NC	3.60E-01
VOA	Trichloroethene	79-01-6	1.20E+00	RSL-Res Air	1.10E-01	5.40E-01
VOA	1,2-Dichloropropane [b]	78-87-5	2.40E-01	RSL-Res Air	NC	4.60E-01
VOA	Bromodichloromethane	75-27-4	1.10E+00	IDEM-Res	NC	6.70E-01
VOA	Cis-1,3-Dichloropropene	10061-01-5	NC	NC	NC	4.50E-01
VOA	4-Methyl-2-pentanone	108-10-1	3.10E+03	RSL-Res Air	NC	4.10E-01
VOA	Toluene	108-88-3	5.20E+03	RSL-Res Air	7.60E-02	3.80E-01
VOA	Trans-1,3-Dichloropropene	10061-02-6	NC	NC	NC	4.50E-01
VOA	1,1,2-Trichloroethane	79-00-5	1.50E-01	RSL-Res Air	1.10E-01	5.40E-01
VOA	Tetrachloroethene	127-18-4	4.10E-01	RSL-Res Air	1.40E-01	6.80E-01

QAPP WORKSHEET #15 (CONTINUED)
REFERENCE LIMITS AND EVALUATION TABLE

Analytical Group	Analyte	CAS Number	Project Action Level – Air (µg/m^3)	PAL source [a]	RL – SIM (µg/m^3)	RL – LOW Level Air (µg/m^3)
VOA	2-Hexanone	591-78-6	3.10E+01	RSL-Res Air	NC	2.00E+00
VOA	Dibromochloromethane [b]	75-25-2	9.00E-02	RSL-Res Air	NC	8.50E-01
VOA	1,2-Dibromoethane [b]	106-93-4	4.10E-03	RSL-Res Air	5.00E-02	7.70E-01
VOA	Chlorobenzene	108-90-7	5.20E+01	RSL-Res Air	NC	4.60E-01
VOA	Ethylbenzene	100-41-4	9.70E-01	RSL-Res Air	8.80E-02	4.30E-01
VOA	o-Xylene	95-47-6	7.30E+02	RSL-Res Air	8.80E-02	4.30E-01
VOA	mixed-Xylene	1330-20-7	1.00E+02	RSL-Res Air	1.80E-01	4.30E-01
VOA	Styrene	100-42-5	1.00E+03	RSL-Res Air	NC	4.20E-01
VOA	Bromoform	75-25-2	1.70E+00	IDEM-Res	NC	1.00E+00
VOA	1,1,2,2-Tetrachloroethane [b]	79-34-5	4.20E-02	RSL-Res Air	1.40E-01	6.90E-01
VOA	1,3-Dichlorobenzene	541-73-1	1.10E+02	IDEM-Res	NC	6.00E-01
VOA	1,4-Dichlorobenzene [b]	106-46-7	2.20E-01	RSL-Res Air	NC	6.00E-01
VOA	1,2-Dichlorobenzene	95-50-1	2.10E+02	RSL-Res Air	NC	6.00E-01
VOA	1,2,4-Trichlorobenzene [b]	120-82-1	2.10E+00	RSL-Res Air	NC	3.70E+00
VOA	1,2-Dichloroethane	107-06-2	9.40 E-02	RSL-Res Air	8.20E-02	4.0E-01
VOA	Isopropylbenzene	98-82-8	4.00E+02	IDEM-Res	NC	4.90E-01

Notes:

µg/m^3	Microgram per cubic meter
CAS	Chemical Abstract Services
ICP	Inductively coupled plasma
IDEM	Indiana Department of Environmental Management
NC	No criteria
PAL	Project action level
RSL	Regional Screening Levels
Res	Residential
SIM	Selected Ion Monitoring
VOA	Volatile organic analysis

a The PAL is the minimum value of the following values:
RSL-Res Air: May 2010 RSL value
IDEM-Res: IDEM Draft Vapor Instrusion Pilot Program Guidance Supplement, February 4, 2010

b The PAL value exceeds the RL for this analyte. The scope of work will request that the laboratory report the analyte concentration at the MDL and flag the result with an estimated value flag (J flag).

QAPP WORKSHEET #16
PROJECT SCHEDULE/TIMELINE TABLE

(UFP QAPP Section 2.8.2)

Activity	Organization	Date		Deliverable	Deliverable Due Date
		Anticipated Date of Initiation	Anticipated Date of Completion		
Phase I Field Sampling with one round of groundwater sampling	SulTRAC	March 2011	July 2011	Site Management Plan Phase I FSP Phase I QAPP Data Management Plan Health and Safety Plan	30 days after Phase I work plan approval
Phase I Data Evaluation	SulTRAC	July 2011	August 2011	Technical Memorandum: Phase I Investigation	45 days after receipt of Phase I validated data
Phase I Field Sampling continued: second round of groundwater sampling	SulTRAC	September 2011	September 2011	None – Work conducted under EPA-approved Phase I FSP and QAPP	NA
Phase I Data Evaluation Addendum	SulTRAC	October 2011	November 2011	Technical Memorandum Addendum: Second round of groundwater sampling data	45 days after receipt of Phase I validated data
Phase I Completion	SulTRAC	November 2011	November 2011	Work Assignment Completion Report (WACR)	45 days after receipt of the Work Assignment Closeout Notification (WACN)

Notes:

EPA	Environmental Protection Agency
FSP	Field Sampling Plan
QAPP	Quality Assurance Project Plan

QAPP WORKSHEET #17
SAMPLING DESIGN AND RATIONALE

(UFP QAPP Section 3.1.1)

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be collected, and the sampling frequency (including seasonal considerations). (May refer to map or Worksheet #18 for details).

The Phase I field investigation will characterize the contamination source(s) and delineate the extent of contamination. Therefore, groundwater, soil, and air samples will be collected as summarized below.

SulTRAC will collect one groundwater sample from each of six private water wells. One duplicate sample will be collected. All samples will be analyzed offsite for VOCs at a CLP laboratory. Proposed private-well sampling locations are shown on Figure B-3.

The objective is to develop information to determine the horizontal and vertical extent of groundwater contamination. This investigation will be performed in two events, consisting of a combination of vertical aquifer sampling and monitoring well installation. The VAS is proposed to be performed at 25 locations, at 10-foot intervals, from the groundwater surface to approximately 60 feet bgs. A maximum of 150 groundwater samples and 15 duplicate samples will be sent to an off-site CLP laboratory for VOC analysis.

Once the preliminary results from the VAS sampling are received, SulTRAC will review the data and determine the exact depth and location of the nested well sets. The deep monitoring well will be constructed to an assumed maximum depth of 60 feet bgs, and a second shallower monitoring well will be constructed a few feet away. Following the installation of the monitoring wells, they will be developed. Two rounds of groundwater sampling are planned. Newly installed monitoring wells will be sampled for VOCs for a maximum of 32 samples and 4 duplicate samples per sampling event. Four monitoring wells will be sampled and analyzed for SVOCs, PCBs, and TAL metals during the first round of groundwater sampling. If the data indicates that other chemicals of concern are present in the groundwater, then the second round of groundwater sampling will include the chemicals discovered as well as VOCs.

Up to ten subsurface soil samples will be collected during the VAS sampling. One duplicate sample will be collected. The proposed VAS soil sampling locations are shown on Figure B-3. Soil samples will be collected where contamination is suspected, based on visual and field screening techniques, as well as from some predetermined locations as described in the FSP (SulTRAC 2011). Soil samples will be analyzed for VOCs, SVOCs, PCBs, and TAL metals.

SulTRAC will collect two indoor air samples at each of the three proposed residences shown on Figure B-3. The indoor air samples will be collected using Summa canisters and will include one duplicate and one field blank.

A technical memorandum will be submitted to the EPA detailing the results of the Phase I field investigation.

QAPP WORKSHEET #18
SAMPLING LOCATIONS/IDS, SAMPLE DEPTHS, SAMPLE ANALYSES, AND SAMPLING PROCEDURES TABLE

(UFP QAPP Section 3.1.1)

Sampling Location / ID Number [1]	**Matrix**	**Depth (feet bgs)**	**Analytical Group**	**Sampling SOP Reference [2]**
25 vertical aquifer sampling locations	Groundwater [3]	Up to 60	CLP SOW SOM01.2 (VOA, SVOA, and PCBs) CLP SOW ILM05.4 (TAL metals, mercury)	S-6, S-7
6 private wells	Groundwater [4]	Varied	CLP SOW SOM01.2 (VOA, SVOA, and PCBs) CLP SOW ILM05.4 (TAL metals, mercury)	S-6, S-7
32 locations	Groundwater [5]	30 to 60	CLP SOW SOM01.2 (VOA, SVOA, and PCBs) CLP SOW ILM05.4 (TAL metals, mercury)	S-6, S-7
10 locations	Soil [6]	Any 2-ft interval between 30 and 60 ft bgs	CLP SOW SOM01.2 (VOA, SVOA, and PCBs) CLP SOW ILM05.4 (TAL metals, mercury)	S-1
3 locations	Air [7]	Not applicable	Method TO-15, VOCs	S-12

Notes:

CLP	Contract Laboratory Program
GC	Gas chromatograph
ID	Identification
PCB	Polychlorinated biphenyl
SVOA	Semivolatile organic analysis
TAL	Target Analyte List
VAS	Vertical aquifer sampling
VOA	Volatile organic analysis
VOC	Volatile organic compound

1 See Figure B-3for sampling locations and Table B-2 for sample number and IDs.

2 See Worksheet #21 for a list of sampling methods S-1 through S-12.

3 Samples will be collected at 10-ft intervals, between the water table and 60 feet bgs, from each VAS location.

4 Samples will be collected from 6 private drinking-water wells before in-line filters or treatment.

5 Samples will be collected from 32 newly installed monitoring wells; exact well locations will be finalized after VAS sampling is completed. Samples will be collected using conventional low-flow techniques.

6 Samples will be collected from soil borings during VAS sampling if evidence of gross contamination is noted, as well as from some pre-determined locations, as described in the FSP (SulTRAC 2011).

7 Samples will be collected from three residences. Two samples will be collected from each of the three residences.

QAPP WORKSHEET #19
ANALYTICAL METHODS, CONTAINERS, PRESERVATIVES, AND HOLDING TIMES TABLE

(UFP QAPP Section 3.1.1)

Matrix	Analytical Group	Analytical and Preparation Method	Containers (number, size, type)	Preservation Requirements (chemical, temperature, etc.)	Maximum Holding Time (preparation/analysis) [1]
Water	VOCs	CLP SOW SOM01.2 TRACE and FASP-VOA-MS	Three 40-milliliter (mL) glass vials with polytetrafluoroethylene (PTFE)-lined septa and open-top screw caps	No headspace Cool to 4 ºC ± 2 ºC Adjust pH to less than 2 with HCl	NA/14 days
Water	SVOCs	CLP SOW SOM01.2	Two 1-liter amber glass bottles fitted with PTFE-lined screw caps	Cool to 4 °C ± 2 °C immediately after collection; keep away from light	7 days/40 days
Water	PCBs	CLP SOW SOM01.2	Two 1-liter amber glass bottles fitted with PTFE-lined screw caps	Cool to 4 °C ± 2 °C immediately after collection; keep away from light	7 days/40 days
Water	TAL Metals, Mercury	CLP SOW ILM05.4	One 1-liter high-density polyethylene bottle One 1-liter high-density polyethylene bottle with 0.45-micrometer (µm) filter for filtered surface water sample	HNO_3 to pH < 2 and cool to 4 ˚C (±2 ˚C) immediately after collection	NA/6 months (Metals) NA/28 days (mercury)
Air	VOCs	TO-15	One leak-free stainless steel, certified-cleaned, evacuated canister.	None	30 days

QAPP WORKSHEET #19 (CONTINUED)
ANALYTICAL METHODS, CONTAINERS, PRESERVATIVES, AND HOLDING TIMES TABLE

Matrix	Analytical Group	Analytical and Preparation Method	Containers (number, size, type)	Preservation Requirements (chemical, temperature, etc.)	Maximum Holding Time (preparation/analysis) [1]
Soil	VOCs	CLP SOW SOM01.2	Three (2-$NaHSO_4$ and 1-CH_3OH) 40-mL glass containers with PTFE-lined septa and open-top screw caps, pre-weighed and containing magnetic stir bars and one container of sample filled with no headspace for determination of moisture content OR At least three coring tools used as transport devices (for example, 5-gram samplers) and one container of sample filled with no headspace for determination of moisture content	Cool to 4 °C ± 2 °C immediately after collection Frozen (-7 ºC to -15 ºC)	14 days 48 hours (frozen) to preservation at laboratory 14 days for analysis after preservation
Soil	SVOCs	CLP SOW SOM01.2	Two 4-ounce or one 8-ounce wide-mouth glass jar	Cool to 4 °C ± 2 °C immediately after collection	14 days/40 days
Soil	PCBs	CLP SOW SOM01.2	Two 4-ounce or one 8-ounce wide-mouth glass jar	Cool to 4 °C ± 2 °C immediately after collection	14 days/40 days
Soil	TAL Metals, Mercury	CLP SOW ILM05.4	Two 4-ounce or one 8-ounce wide-mouth glass jar	Cool to 4 °C ± 2 °C immediately after collection	NA/6 months (Metals) NA/28 days (mercury)

Notes:

µm	Micrometer
CH_3OH	Methanol
CLP	Contract laboratory program
HCl	Hydrochloric acid
HNO_3	Nitric acid
mL	Milliliter
NA	Not applicable
$NaHSO_4$	Sodium bisulfate
PCB	Polychlorinated biphenyl
PTFE	Polytetrafluoroethylene
SOW	Statement of work
SVOC	Semivolatile organic compound
TAL	Target Analyte List
VOC	Volatile organic compound

[1] Holding time is applicable from validated time of sample receipt and is measured to time of sample extraction and analysis.

QAPP WORKSHEET #20
FIELD QUALITY CONTROL SAMPLE SUMMARY TABLE

(UFP QAPP Section 3.1.1)

Matrix	Analytical Group	Analytical and Preparation SOP Reference[a]	No. of Sampling Locations	No. of Samples[b]	No. of Field Duplicates[c]	No. of MS/MSDs[c]	No. of Trip Blanks[e]	No. of Equipment Rinsates[f]	Total No. of Samples to Laboratory
Soil	VOA/CLP	A-1	10	10	1	1	1	4	17
Soil	SVOA/CLP	A-1	10	10	1	1	0	4	16
Soil	PCBs/CLP	A-1	10	10	1	1	0	4	16
Soil	TAL Metals, Mercury/CLP	A-2	10	10	1	1	0	4	16
VAS-Groundwater	VOA/CLP	A-1	25	150	15	8	10	4	187
Indoor Vapor	VOA[g]	A-3	3	6	1	0	0	1[h]	8
PW-Groundwater	VOA/CLP	A-1	6	6	1	1	1	0	9
MW-Groundwater	VOA/CLP	A-1	32	64	7	4	6	2	83
MW-Groundwater	SVOA/CLP	A-1	4	4	1	1	0	1	7
MW-Groundwater	PCB/CLP	A-1	4	4	1	1	0	1	7
MW-Groundwater	TAL Metals, Mercury/CLP	A-2	4	4	1	1	0	1	7

Notes:

CLP	Contract Laboratory Program
MS/MSD	Matrix spike/matrix spike duplicate
MW	Monitoring Well
PCB	Polychlorinated biphenyl
PW	Private Well
SOP	Standard Operating Procedure
SVOA	Semivolatile organic analysis
TAL	Target Analyte List
VAS	Vertical aquifer sampling
VOA	Volatile organic analysis
VOC	Volatile organic compound

[a] Sample numbers in this table reflect field QC samples collected for the entire duration of the Phase I field sampling.
[b] Analytical and preparation SOPs are listed in Worksheet #23.
[c] Field duplicates are collected at a rate of 1 per 10 investigative samples of the same matrix.
[d] MS/MSD samples are collected at a rate of 1 per 20 investigative samples of the same matrix.
[e] A trip blank will be provided with each shipping container to be analyzed for VOCs.
[f] Equipment blank samples are collected at a rate of 1 per sample team per week of sampling activities of the same matrix.
[g] Samples for indoor air will be submitted to a private laboratory.
[h] One field blank will be submitted with the field samples.

QAPP WORKSHEET #21
PROJECT SAMPLING SOP REFERENCES TABLE

(UFP Section 3.1.2)

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
S-1	Soil Sampling, Revision No. 1, December 1999, SOP 005	Tetra Tech EM Inc.	Spoon or spatulas, trowel, split-spoon sampler, coring tools	N	None
S-2[a]	Monitoring Well Installation, Revision No. 4, April 2009, SOP 020	Tetra Tech EM Inc.	Casing materials, well screen materials, filter pack materials, annular sealant, grouting materials, tremie pipe, surface completion and protective casing materials, concrete surface pad and bumper post, uncontaminated water	N	None
S-3 [a]	Monitoring Well Development, Revision No. 4, June 2009, SOP 021	Tetra Tech EM Inc.	Pumps, air compressors, bailers, surge blocks	N	None
S-4	Static Water Level, Total Well Depth, and Immiscible Layer Measurement, Revision No. 1, July 2009, SOP 014	Tetra Tech EM Inc.	Electrical water level indicator, interface probe, PID or flame ionization detector (FID)	N	None
S-5[a]	General Equipment Decontamination, Revision No. 2, December 1999, SOP 002	Tetra Tech EM Inc.	Scrub brushes, large wash tubs or buckets, Alconox, distilled water	N	None
S-6	Groundwater Sampling Revision No. 4 June 2009, SOP 010	Tetra Tech EM Inc.	Sample bottles, high-density polyethylene bailer, or peristaltic pumps	N	None

QAPP WORKSHEET #21 (CONTINUED)
PROJECT SAMPLING SOP REFERENCES TABLE

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
S-7	Groundwater Sample Collection Using Micropurge Technology, Revision No. 1, July 2009, SOP 015	Tetra Tech EM Inc.	Sample bottles, adjustable flow rate pump (bladder, piston, peristaltic, or impeller)	N	None
S-8[a]	Organic Vapor Monitoring, Revision No. 3, July 2009, SOP 003	Tetra Tech EM Inc.	Organic vapor air monitoring meter, manufacturer-supplied calibration gas, manufacturer-supplied calibration kits (including tubing and regulator)	N	None
S-9 [a]	Packaging and Shipping Samples, Revision No.6, December 2008, SOP 019	Sullivan International Group, Inc.	Coolers, ice, cushioning material (bubble wrap, etc.), COC forms and seals, airbills, resealable plastic bags, tape, appropriate dangerous-goods airbills (if necessary)	N	None
S-10 [a]	Recording of Notes in Field Logbook, Revision No. 1, December 2008, SOP 024	Tetra Tech EM Inc.	Field logbook(s), ballpoint pens with permanent ink	N	None
S-11	Field Measurement of Groundwater Indicator Parameters, Revision No. 2, July 2009, SOP 061	Tetra Tech EM Inc.	Single or multi-parameter water quality measuring system, specific conductance calibration solutions, pH buffer solutions, deionized water, rinse bottle, sample cups, waste container, logbook	N	None
S-12	Compendium Method TO-15, 2nd Edition, EPA/625/R-96/010b (EPA 1999)	USEPA	Leak-free stainless steel evacuated canisters	N	None

QAPP WORKSHEET #21 (CONTINUED)
PROJECT SAMPLING SOP REFERENCES TABLE

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
S-13	Investigation Derived Waste Management, Revision No. 00, SOP No. 016	Sullivan International Group, Inc.	Organic vapor air monitoring meter, PPE (e.g., protective gloves, safety glasses, etc.), sample collection equipment depending upon the waste	N	None

Notes:

COC	Chain of custody
GC	Gas chromatograph
FID	Flame ionization detector
HDPE	High-density polyethylene
PID	Photo-ionization detector
SOP	Standard Operating Procedure
VAS	Vertical Aquifer Sampling

a SulTRAC will use these non-sampling SOPs for field activities other than sampling, as specified in the SOP.

QAPP WORKSHEET #22
FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION TABLE

(UFP QAPP Section 3.1.2.4)

Field Equipment	**Calibration Activity**[a]	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**	**SOP Reference**	**Comments**
Multiparameter Water Quality Meter[b]	**Oxidation-reduction potential:** 2 standard solutions **pH:** 2 standard solutions **Conductivity:** 1 standard solution **Temperature:** no standard solution **Turbidity:** 2 standard solutions **Dissolved oxygen:** 2 standard solutions	Daily: before first field measurement and after final field measurement	± 10 millivolts ± 0.01 pH unit ± 3% ± 0.1 °C ± 10% ± 10%	Repeat calibration; correct measurements for drift if necessary	Field team leader or field team members	F-1 (Field Measurement of Water Temperature, SOP 011, Revision No. 2, November 1999) F-2 (Field Measurement of pH, SOP 012, Revision No. 3, November 1999) F-3 (Field Measurement of Specific Conductance, SOP 013, Revision No. 2, November 1999)	See note below
PID	Gas calibration standard or equivalent	Daily: before first field measurement	10% of reading < 2,000 ppm 20% of reading > 2,000 ppm	Repeat calibration; correct measurements for drift if necessary	Field team leader or field team members	F-4 (Field Measurement of Organic Vapor Air, SOP 003, Revision No. 2, December 1999)	None

Notes:

SulTRAC will measure water temperature, pH, ORP, and specific conductance in purged groundwater (private well sampling, VAS, and monitoring well sampling) until these parameters have stabilized.

ORP	Oxidation-reduction potential
ppm	Part per million
VAS	Vertical aquifer sampling

[a] The field equipment will be calibrated per manufacturer's instructions.

[b] Standard solutions will be provided by the vendor to calibrate this instrument.

QAPP WORKSHEET #23
ANALYTICAL SOP REFERENCES TABLE

(UFP QAPP Section 3.2.1)

Reference Number	Title, Revision, Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
A-1	CLP SOW SOM01.2 for Organics Analysis, Multi-Media, Multi-Concentration	Definitive	VOA, SVOA	GC/MS	CLP Laboratory	Yes
A-1	CLP SOW SOM01.2 for Organics Analysis, Multi-Media, Multi-Concentration	Definitive	PCB	GC/electron capture detector	CLP Laboratory	Yes
A-2	CLP SOW ILM05.4 for Inorganic Analysis, Multi-Media, Multi-Concentration	Definitive	TAL Metals, Mercury	ICP/AES ICP/mass spectroscopy Cold vapor atomic absorption	CLP Laboratory	Yes
A-3	Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/ Mass Spectrometry (GC/MS)	Definitive	VOA	GC/MS	Sub-contract Laboratory	No

Notes:

AES	Atomic emission spectroscopy
CLP	Contract Laboratory Program
GC/MS	Gas chromatography/mass spectrometry
ICP	Inductively coupled plasma
NA	Not applicable
PCB	Polychlorinated biphenyl
SOW	Statement of work
SVOA	Semivolatile organic analysis
TAL	Target Analyte List
VOA	Volatile organic analysis
VOC	Volatile organic compound

QAPP WORKSHEET #24
ANALYTICAL INSTRUMENT CALIBRATION TABLE

(UFP Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
GC/Mass Spectroscopy	**VOCs:** Run five calibration standard solutions and a blank **SVOCs:** Run five calibration standard solutions and a blank	12-hour continuing calibration acceptance criteria	RRF ≥ 0.010 or per SOW/SOP Initial, RSD ≤ 20% or 40%, depending on compound. Continuing, %D ≤ 25 or 40 depending on compound	Inspect the system for problems, clean the ion source, change the column, service the purge and trap device, and take CAs to achieve the technical acceptance criteria.	CLP Laboratory Analyst – Private Laboratory Analyst	A-1, A-3
GC/Electron Capture Detector	**Pesticides:** Run five calibration standard solutions and a blank **PCBs:** Run five calibration standard solutions and a blank	12-hour continuing calibration acceptance criteria	Resolution per SOW Initial, calibration factor (CF) RSD ≤ 20% Continuing, CF %D ≤ 15 for opening and ≤ 50 for closing	Inspect the system for problems, change the column, bake out the detector, clean the injection port, and take other CAs to achieve the acceptance criteria.	CLP Laboratory Analyst	A-1
ICP/AES	Run one calibration mixed standard solution and a blank	Each continuing calibration verification (CCV) analyzed shall reflect the conditions of analysis of all associated analytical samples (the preceding 10 analytical samples or the preceding analytical samples up to the previous CCV)	Deviation from the initial calibration verification: metals 90-110%	Inspect the system for problems, clean the system, verify operating conditions, and take CAs to achieve the technical acceptance criteria.	CLP Laboratory Analyst	A-2

QAPP WORKSHEET #24 (CONTINUED)
ANALYTICAL INSTRUMENT CALIBRATION TABLE

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
ICP/Mass Spectroscopy	Run one calibration standard solution and a blank	Each CCV analyzed shall reflect the conditions of analysis of all associated analytical samples (the preceding 10 analytical samples or the preceding analytical samples up to the previous CCV)	Deviation from the initial calibration verification: metals 90-110%	Inspect the system for problems, clean the system, verify operating conditions, and take CAs to achieve the technical acceptance criteria.	CLP Laboratory Analyst	A-2

Notes:

%D	Percent difference
AES	Atomic emission spectroscopy
CA	Corrective action
CCV	Continuing calibration verification
CF	Calibration factor
CLP	Contract Laboratory Program
GC/MS	Gas chromatography/mass spectrometry
ICP	Inductively coupled plasma
RRF	Relative response factor
RSD	Relative standard deviation
SOP	Standard Operating Procedure
SOW	Statement of work

[1] See Worksheet #23 for analytical methods.

QAPP WORKSHEET #25
ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE TESTING AND INSPECTION TABLE

(UFP QAPP Section 3.2.2)

Instrument/ Equipment	Maintenance Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action (CA)	Responsible Person	SOP Reference[1]
GC/Mass Spectroscopy	Daily Check, Instrument tune (4-bromofluorobenzene or decafluorotriphenylphosphine)	Injector syringe, injector septum, injector liner/seal, injector port, guard column, column splitter, analytical column, ion source, detector, traps, and gas supply	See A-1, A-3	See A-1, A-3	Inspect the system for problems, clean the ion source, change the column, and service the purge and trap device.	CLP Laboratory Analyst, trained analyst	A-1, A-3
GC/Electron Capture Detector	Daily Check, Initial Calibration Verification	Injector syringe, injector septum, injector liner/seal, injector port, guard column, column splitter, analytical column, ion source, detector, traps, and gas supply	See A-1	See A-1	Inspect the system for problems, change the column, bake out the detector, and clean the injection port.	CLP Laboratory Analyst	A-1
ICP/AES	Daily Check, Initial Calibration Verification	Nebulizer, injection tube, flame optimization, gas supply, and detector	See A-2	See A-2	Inspect the system for problems, clean the system, verify operating conditions, and take CAs to achieve the technical acceptance criteria	CLP Laboratory Analyst	A-2

QAPP WORKSHEET #25 (CONTINUED)
ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE TESTING AND INSPECTION TABLE

Instrument/ Equipment	**Maintenance Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action (CA)**	**Responsible Person**	**SOP Reference[1]**
ICP/Mass Spectroscopy	Daily Check, Initial Calibration Verification	Nebulizer, injection tube, plasma optimization, gas supply, and detector	See A-2	See A-2	Inspect the system for problems, clean the system, verify operating conditions, and take CAs to achieve the technical acceptance criteria.	CLP Laboratory Analyst	A-2

Notes:

%D	Percent difference
AES	Atomic emission spectroscopy
CA	Corrective action
CLP	Contract Laboratory Program
GC/MS	Gas chromatography/mass spectrometry
ICP	Inductively coupled plasma

[1] See Worksheet #23 for identification of analytical methods.

QAPP WORKSHEET #26
SAMPLE HANDLING SYSTEM

(UFP QAPP Appendix A)

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field sampling personnel/SulTRAC
Sample Packaging (Personnel/Organization): Field sampling personnel/SulTRAC
Coordination of Shipment (Personnel/Organization): Field sampling personnel/SulTRAC
Type of Shipment/Carrier: Cooler packed with ice and packing material such as bubble wrap/FedEx or other overnight courier
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Laboratory personnel/CLP laboratory and subcontracted laboratory
Sample Custody and Storage (Personnel/Organization): Laboratory personnel/CLP laboratory and subcontracted laboratory
Sample Preparation (Personnel/Organization): Laboratory personnel/CLP laboratory and subcontracted laboratory
Sample Determinative Analysis (Personnel/Organization): Laboratory personnel/CLP laboratory and subcontracted laboratory
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): See Worksheet #27
SAMPLE DISPOSAL
Personnel/Organization: Laboratory personnel/CLP laboratory and subcontracted laboratory
Number of Days from Analysis: TBD (or in accordance with individual laboratory SOP)

QAPP WORKSHEET #27
SAMPLE CUSTODY REQUIREMENTS

(UFP Appendix A)

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to the laboratory): As listed in Worksheet #21, packing and shipping procedures are detailed in S-9. SulTRAC will use EPA's Field Operations and Records Management System (FORMS II Lite) software to manage sample collection, documentation, chain of custody, and reporting. Field personnel will input data into FORMS II Lite and then use the software to generate sample labels, bottle tags, and chain-of-custody forms to track samples from the field to the laboratory. Because FORMS II Lite captures sample management information electronically, the information is easily exportable to databases or various reporting formats.

Chain-of-custody forms will be signed in ink by the samplers and the individual relinquishing custody. SulTRAC will then follow the sample packaging and shipment procedures summarized below to ensure that samples arrive at the laboratory with the chain of custody intact.

1- Immediately after sample collection, sample containers will be labeled with the appropriate identifiers. Clear tape will be placed over the sample container's labels to prevent smearing.

2- The samples will be placed in Ziploc plastic bags and then in a cooler containing double-sealed bags of ice and maintained at 4 ± 2^{o}C. The cooler will remain in a secured area or in view of the sampler until it is properly sealed for shipment to the laboratory.

3- Prior to shipping, the chain-of-custody forms, airbills, and all other relevant documents will be completed. Chain-of-custody forms will be sealed in plastic bags and taped to the inside of the cooler lid. Cushioning material, such as bubble wrap, will be placed in the cooler.

4- A temperature blank consisting of a jar or vial containing water will be included in every cooler to be used by the laboratory to determine the cooler temperature at the time of sample receipt.

5- The shipping cooler will then be sealed with tape and custody seals in a manner that will indicate whether the cooler was opened. The preferred procedure includes placement of custody seals at diagonally opposite corners of the cooler. The custody seals will be covered with clear plastic tape or strapping tape.

The field sampler is personally responsible for the care and custody of the samples until they are transferred to other personnel or properly dispatched to an overnight carrier or directly to a laboratory. When transferring possession of the samples, the individuals relinquishing and receiving the samples sign, date, and note the time of transfer on the chain-of-custody form. Commercial carriers are not required to sign off on the chain-of-custody form as long as the form is sealed inside the sample cooler and the custody seals remain intact.

QAPP WORKSHEET #27 (CONTINUED)
SAMPLE CUSTODY REQUIREMENTS

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal): The laboratory sample custodian will receive all incoming samples and indicate receipt by signing the accompanying custody forms and retaining copies of the signed forms as permanent records. The laboratory sample custodian will record all pertinent information concerning the sample, including the persons delivering and receiving the sample, the date and time received, the method by which the sample was transmitted to the laboratory, sample condition at the time of receipt (sealed, unsealed, or broken container; temperature; or other relevant remarks), the sample identification number, and any unique laboratory identification number associated with the sample. This information should be entered into a computerized laboratory information management system (LIMS).

The laboratory will provide a secure storage area, restricted to authorized personnel, for all samples. Only the custodian can distribute samples to laboratory personnel authorized to conduct the required analyses. Laboratory analytical personnel are responsible for the care and custody of the sample upon receipt.

At the completion of sample analysis, any unused portion of the sample, together with all identifying labels, will be returned to the custodian. The returned tagged sample will be retained in secure storage until the custodian receives permission to dispose of the sample. Sample disposal will occur only on the order of the laboratory project manager in consultation with EPA or SulTRAC or when it is certain that the information is no longer required or the samples have deteriorated. Likewise, laboratory records will be maintained until the information is no longer required and final disposition is ordered by the laboratory project manager in consultation with EPA or SulTRAC.

Sample Identification Procedures: Sample identification will be as described in Section 8.2 of the FSP. Each sample will also be assigned an identifying number by CLP FORMS II Lite software. Before or during the sampling event, the user will enter information regarding the site, project, sampling team, analysis, location, matrix (VAS – vertical aquifer sample, PW – private well, MW – monitoring well, IA – indoor air sample), collection time and date, and sample and tag numbers.

When the laboratory receives a sample shipment, its LIMS will generate the in-house identification numbers in accordance with the sample receipt(s) and chain-of-custody SOPs.

QAPP WORKSHEET #28
QC SAMPLES TABLE

(UFP QAPP Section 3.4)

Matrix	Soil
Analytical Group	VOA/CLP
Concentration Level	Low concentration
Sampling SOP	S-1
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or Other SulTRAC staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Deuterated Monitoring Compounds	All samples	Reanalyze sample. If upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If upon reanalysis, the monitoring compound does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	%R as presented in Worksheet #12

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Soil
Analytical Group	SVOA/CLP
Concentration Level	Low concentration
Sampling SOP	S-1
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias-Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Deuterated monitoring compounds	All samples	Reanalyze sample. If upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If upon reanalysis, the monitoring compound does not meet criteria, results are reported in narrative.	Laboratory Analyst	Accuracy	%R as presented in Worksheet #12

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Soil
Analytical Group	PCBs/CLP
Concentration Level	Low concentration
Sampling SOP	S-1
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or Other SulTRAC Staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias-Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Surrogate Spike	All samples	Reanalyze sample. If upon reanalysis, the surrogate meets criteria, report reanalysis results. If upon reanalysis, the surrogate does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	30-150 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Laboratory Control Sample	1 per extraction batch of 20 samples maximum	Reanalyze sample. If upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If upon reanalysis, the laboratory control sample does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	80-100 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Soil
Analytical Group	TAL Metals and Mercury/CLP
Concentration Level	Multi-concentration
Sampling SOP	S-1
Analytical Method/ SOP Reference	A-2
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Sensitivity/ Contamination	No target compounds > QL
MS	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy/Bias	75-125 %R
Laboratory Duplicate	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Precision	<20% RPD

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Soil
Analytical Group	TAL Metals and Mercury/CLP
Concentration Level	Multi-concentration
Sampling SOP	S-1
Analytical Method/ SOP Reference	A-2
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Laboratory Control Sample	1 per extraction batch of 20 samples maximum	Reanalyze sample. If upon reanalysis, the analyte meets criteria, report reanalysis results. If upon reanalysis, the laboratory control sample does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	80-100 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	VOA/CLP
Concentration Level	Low concentration
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Deuterated Monitoring Compounds	All samples	Reanalyze sample. If, upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If, upon reanalysis, the monitoring compound does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	%R as presented in Worksheet #12

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	VOA/CLP
Concentration Level	Trace concentration/ SIM
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff / SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Deuterated Monitoring Compounds	All samples	Reanalyze sample. If upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If upon reanalysis, the monitoring compound does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	%R as presented in Worksheet #12

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	SVOA/CLP
Concentration Level	Low concentration/ SIM
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff/ SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias-Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Deuterated monitoring compounds	All samples	Reanalyze sample. If upon reanalysis, the monitoring compounds meets criteria, report reanalysis results. If upon reanalysis, the monitoring compound does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	%R as presented in Worksheet #12

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	PCBs/CLP
Concentration Level	Low concentration
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-1
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff /SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias-Contamination	No target compounds > QL
MS/MSD	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy and Precision	%R and RPD as presented in Worksheet #12
Surrogate Spike	All samples	Reanalyze sample. If upon reanalysis, the surrogate meets criteria, report reanalysis results. If upon reanalysis, the surrogate does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	30-150 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Laboratory Control Sample	1 per extraction batch of 20 samples maximum	Reanalyze sample. If upon reanalysis, the monitoring compound meets criteria, report reanalysis results. If upon reanalysis, the laboratory control sample does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	80-100 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	TAL Metals and Mercury/CLP
Concentration Level	Multi-concentration
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-2
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC staff/ SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Method Blank	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. If sufficient volume is not available, reanalyze affected extracts.	Laboratory Analyst	Accuracy/Bias-Contamination	No target compounds > QL
MS	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Accuracy/Bias	75-125 %R
Laboratory Control Sample	1 per extraction batch of 20 samples maximum	Reanalyze sample. If upon reanalysis, the analyte meets criteria, report reanalysis results. If upon reanalysis, the laboratory control sample does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	80-100 %R

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Water
Analytical Group	TAL Metals and Mercury/CLP
Concentration Level	Multi-concentration
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	A-2
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC staff/ SulTRAC
Analytical Organization	CLP Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	Frequency/ Number	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Laboratory duplicate	1 per extraction batch of 20 samples maximum	If sufficient volume is available, extract and reanalyze samples in affected batch. Otherwise, analyze laboratory control sample to see if problem is analysis or sample.	Laboratory Analyst	Precision	<20% RPD

QAPP WORKSHEET #28 (CONTINUED)
QC SAMPLES TABLE

Matrix	Air
Analytical Group	VOA
Concentration Level	Trace concentration/SIM
Sampling SOP	See FSP
Analytical Method/ SOP Reference	A-3
Sampler's Name/ Organization	Cheryl Gorman or other SulTRAC Staff / SulTRAC
Analytical Organization	Private Laboratory
No. of Sampling Locations	See Worksheet #18

QC Sample	**Frequency/ Number**	**CA**	**Person(s) Responsible for CA**	**DQI**	**Measurement Performance Criteria**
Method Blank	After the CCV/LCS	Inspect the system and re-analyze blank	Laboratory Analyst	Accuracy/Bias Contamination	No target compounds > RL
Laboratory Control Sample	1 per extraction batch of 20 samples maximum	Reanalyze sample. If upon reanalysis, the compound meets criteria, report reanalysis results. If upon reanalysis, the laboratory control sample does not meet criteria, the results are reported in the narrative.	Laboratory Analyst	Accuracy	80-100 %R

Notes:

CA	Corrective Action	RPD	Relative percent difference
CLP	Contract Laboratory Program	SIM	Selected ion monitoring
DQI	Data quality indicator	PCB	Polychlorinated biphenyl
MS	Matrix spike	SOP	Standard operating procedure
MSD	Matrix spike duplicate	SVOA	Semivolatile organic analysis
QL	Quantitation limit	TAL	Target Analyte List
QC	Quality control	VOA	Volatile organic analysis
%R	Percent recovery		

QAPP WORKSHEET #29
PROJECT DOCUMENTS AND RECORDS TABLE

(UFP QAPP Section 3.5.1)

Document	**Where Maintained**
Field notes/logbook	Project file (field data), SulTRAC offices
Chain-of-custody forms	Project file (laboratory data), SulTRAC offices
Laboratory raw data package	EPA for CLP laboratory and subcontracted laboratory data; project file (laboratory data)
Field Photographs	Project file (field data), SulTRAC offices
Audit Reports	Project file (field data), SulTRAC offices
Corrective Action Reports	Project file (field data), SulTRAC offices
IDW Disposal Records	Project file (field data), SulTRAC offices
Laboratory equipment calibration logs	EPA for CLP and subcontracted laboratory
Validated data	Project file (laboratory data), SulTRAC offices

QAPP WORKSHEET #30
ANALYTICAL SERVICES TABLE

(UFP QAPP Section 3.5.2.3)

Matrix	Analytical Group	Concentration Level	Sampling Location/ ID Number	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person, and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person, and Telephone Number)
Soil	VOA	Low concentration	See Table B-2, Figure B-3	A-1	21 days	CLP laboratory identified by EPA Region 5	CLP laboratory identified by EPA Region 5
	SVOA	Low concentration		A-1	21 days		
	PCBs	Low concentration		A-1	21 days		
	TAL Metals and Mercury	Multi-concentration		A-2	21 days		
Air	VOA	Low concentration	See Table B-2	A-3	21 days	Subcontract laboratory	Subcontract laboratory

QAPP WORKSHEET #30 (CONTINUED)
ANALYTICAL SERVICES TABLE

Matrix	Analytical Group	Concentration Level	Sampling Location/ ID Number	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person, and Telephone Number)
Water	VOA	Low/trace/SIM concentration	See Figure B-3, Table B-2	A-1	21 days	CLP Laboratory identified by EPA Region 5	CLP Laboratory identified by EPA Region 5
	SVOA	Low concentration		A-1	21 days		
	PCB	Low concentration		A-1	21 days		
	TAL Metals and Mercury	Multi-concentration		A-2	21 days		

QAPP WORKSHEET #31
PLANNED PROJECT ASSESSMENTS TABLE

(UFP QAPP Section 4.1.1)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organization)	Person(s) Responsible for Responding to Assessment Findings (Title and Organization)	Person(s) Responsible for Identifying and Implementing CAs (Title and Organization)	Person(s) Responsible for Monitoring Effectiveness of CAs (Title and Organization)
Off-site Laboratory Assessment	Once	Internal	SulTRAC	Richard Baldino, Project QA Manager, SulTRAC	Laboratory QA officer	TBD	TBD
Field Audit	Once	Internal	SulTRAC	Richard Baldino, Project QA Manager, SulTRAC	Laboratory QA officer	TBD	TBD

QAPP WORKSHEET #32
ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES

(UFP QAPP Section 4.1.2)

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Time Frame of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response (Name, Title, Organization)	Time Frame for Response
Off-site Laboratory Assessment	Written audit report	Laboratory QA Officer	TBD	Letter	Richard Baldino, Project QA Manager, SulTRAC	TBD

QAPP WORKSHEET #33
QA MANAGEMENT REPORTS TABLE

(UFP QAPP Section 4.2)

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Name, Title, Organization)	Report Recipient(s) (Title and Organization)
Phase I Data Validation Report	Once for field sampling, Phase I	21 days after receipt of Phase I analytical results from laboratory	Richard Baldino, Project QA Manager, SulTRAC	Bernard Schorle, WAM, EPA Region 5

QAPP WORKSHEET #34
VERIFICATION (STEP I) PROCESS TABLE

(UFP QAPP Section 5.2.1)

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Chain-of-custody forms	Chain-of-custody forms will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody form should be initialed by the reviewer, a copy of the chain-of-custody form should be retained in the project file, and the original and remaining copies should be taped inside the cooler for shipment.	Internal	Field Team Leader (TBD) or William Earle, SulTRAC
Audit reports	Upon report completion, a copy of all audit reports will be placed in the project file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the project file. At the beginning of each week and at the completion of the site work, project file audit reports will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the Project Manager will be notified to ensure that action is taken.	Internal	Richard Baldino, Project QA Manager
Field notes/ logbook	Field notes will be reviewed internally and placed in the project file. A copy of the field notes will be attached to the final report.	Internal	William Earle, SulTRAC
Laboratory data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All received data packages will be verified externally in accordance with the data validation procedures specified in Worksheet #35.	Internal External	CLP Laboratory Tracey Koach, SulTRAC
Laboratory EDDs	All laboratory EDDs will be verified against the laboratory data packages by the laboratory performing the work for completeness and technical accuracy prior to submittal. SulTRAC will review 10% of the received EDDs.	Internal, External	CLP Laboratory and Richard Baldino, Project QA Manager

QAPP WORKSHEET #35
VALIDATION (STEPS IIA AND IIB) PROCESS TABLE

(UFP QAPP Section 5.2.2)

Step IIa/IIb	**Validation Input**	**Description**	**Responsible for Validation (Name, Organization)** [1]
IIa	Communication	Establish that required communication procedures were followed by field or laboratory personnel.	Cheryl Gorman, Project Manager SulTRAC
IIa	Sampling Methods and Procedures	Establish that the required sampling methods were used and that any deviations were noted. Ensure that the sampling procedures and field measurements met performance criteria and that any deviations were documented.	Project QA Officer SulTRAC
IIa	Field Transcription	Authenticate transcription accuracy of sampling data (for example, from field logbook to report).	Cheryl Gorman, Project Manager SulTRAC
IIa	Chain of Custody	Examine traceability of samples from sample collection to sample analysis.	EPA (CADRE) and Tracey Koach, Analytical Coordinator, SulTRAC
IIa	Analytes	Ensure that required lists of analytes were reported as specified in governing documents (such as method, procedure, or contract).	Project QA Officer SulTRAC
IIa	Holding time	Confirm that holding time requirements are met.	EPA (CADRE), Chemist, SulTRAC
IIa	Instrument calibration	Confirm that instrument calibration requirements are met.	EPA (CADRE), Chemist, SulTRAC
IIa	Analytical method	Confirm that analytical methods are specified in QAPP.	EPA (CADRE), Chemist, SulTRAC
IIb	Sampling Plan	Determine whether the sampling plan was executed as specified (for example, the number, location, and types of field samples were collected and analyzed as specified in the Sampling and Analysis Plan [SAP]).	Cheryl Gorman, Project Manager SulTRAC, Project QA Officer SulTRAC
IIb	Co-located Field Duplicates	Compare results of co-located field duplicates with criteria established in the UFP-SAP.	Project QA Officer SulTRAC
IIb	Project Quantitation Limits (PQL)	Determine that PQLs were achieved as outlined in the UFP-SAP and that the laboratory successfully analyzed the standard at the PQLs.	Project QA Officer SulTRAC

QAPP WORKSHEET #35 (CONTINUED)
VALIDATION (STEPS IIA AND IIB) PROCESS TABLE

(UFP QAPP Section 5.2.2)

Step IIa/IIb	**Validation Input**	**Description**	**Responsible for Validation (Name, Organization)** [1]
IIb	Performance criteria	Confirm that QC samples meet specified performance criteria; document any deviations in data evaluation summary report	EPA (CADRE), Chemist, SulTRAC

Note:

1 EPA is responsible for conducting CADRE of analytical data generated by the CLP laboratory. EPA review will be conducted in accordance with CLP National Functional Guidelines (NFG) for data validation. EPA will provide SulTRAC with a summary data review report.

QAPP WORKSHEET #36
VALIDATION (STEPS IIA AND IIB) SUMMARY TABLE

(UFP QAPP Section 5.2.2)

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (Title and Organization)
IIa/IIb	Soil	VOAs	Low	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Soil	SVOAs	Low	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Soil	PCBs	Low	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Soil	TAL Metals (mercury)	Multi	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Groundwater	VOAs	Low/Trace/SIM	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Groundwater	SVOAs	Low	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Groundwater	PCBs	Low	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Groundwater	TAL Metals (mercury)	Multi	CADRE criteria and NFG	CADRE validation and Level III validation by EPA/ESAT and review of case narrative by SulTRAC
IIa/IIb	Air	VOAs	Trace/SIM	TO-15 and Laboratory SOP	Validation by SulTRAC

Note:

[1] EPA is responsible for conducting CADRE of analytical data generated by the CLP laboratories. EPA review will be conducted in accordance with CLP NFG for data validation. EPA will provide SulTRAC with a summary data review report. The SulTRAC analytical coordinator will review this report to verify that project-specific QC criteria have been met.

QAPP WORKSHEET #37
USABILITY ASSESSMENT

(UFP QAPP Section 5.2.3)

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: A team of SulTRAC personnel will perform the data usability assessment. SulTRAC's project manager will be responsible for information in the usability assessment. The project manager will also be responsible for assigning task work to the individual task members who will be supporting the data usability assessment. Note that the data usability assessment will be conducted on validated data. The results of the data usability assessment will be presented in the final project report.

Precision – Results of laboratory duplicates will be presented separately in tabular format. For each duplicate pair, the RPD will be calculated for each analyte whose original and duplicate values are both greater than or equal to the QL. The RPDs will be checked against the measurement performance criteria presented in Worksheet #12. The RPDs exceeding criteria will be identified in the tables. Additionally, the RPD of each analyte will be averaged across all duplicate pairs whose original and duplicate values are both greater than or equal to the QL, and the combined overall average RPD for each analysis will be calculated for the laboratory duplicates. A discussion will follow, summarizing the laboratory precision results. Any conclusions about the precision of the analyses will be drawn, and any limitations on the use of the data will be described.

Accuracy/Bias – Results for laboratory method blanks and instrument blanks will be presented separately in tabular format for each analysis for both Aroclors and mercury. The results for each analyte will be checked against the measurement performance criteria presented in Worksheet #12. Results for analytes that exceed criteria will be identified in the tables. A discussion will follow summarizing the laboratory accuracy/bias results. Any conclusions about the accuracy/bias of the analyses based on contamination will be drawn, and any limitations on the use of the data will be described.

Overall Accuracy/Bias – The results will be presented in tabular format to allow comparison of these results to the sample batch they apply to. These results will be compared to the requirements listed in Worksheet #12. A discussion will follow summarizing overall accuracy/bias results. Any conclusions about the overall accuracy/bias of the analyses will be drawn, and any limitations on the use of the data will be described.

Sensitivity – Results for all laboratory-fortified blanks will be presented separately in tabular format for each analysis. The results for each analyte will be checked against the measurement performance criteria presented in Worksheet #12 and cross-checked against the QLs presented in Worksheet #15. Results for analytes that exceed criteria will be identified on the tables. A discussion will follow, summarizing the laboratory sensitivity results. Any conclusions about the sensitivity of the analyses will be drawn, and any limitations on the use of the data will be described.

Representativeness – The large numbers of samples collected in Phase I is considered representative of site conditions, as long as completeness criteria in Worksheet #12 are met.

Comparability – The results of this study will be used as a benchmark for determining comparability of data collected during any potential future sampling events using the same or similar sampling and analytical SOPs.

Completeness – A completeness check will be performed on all data generated by the laboratory. Completeness criteria are presented in

QAPP WORKSHEET #37 (CONTINUED)
USABILITY ASSESSMENT

Worksheet #12. Completeness will be calculated for each analyte as follows. For each analyte, completeness will be calculated as the number of data points for each analyte and individual matrix that meet the measurement performance criteria for precision, accuracy/bias, and sensitivity, divided by the total number of data points for each analyte. A discussion will follow, summarizing the calculation of data completeness. Any conclusions about the completeness of the data for each analyte will be drawn, and any limitations on the use of the data will be described.
Describe the evaluative procedures used to assess overall measurement error associated with the project: NA
Identify the personnel responsible for performing the usability assessment: SulTRAC's analytical coordinator will review analytical data and the CADRE data review report to assess usability of the data. SulTRAC's project manager will review RPDs for samples and assess the overall usability of the data set in close consultation with the EPA WAM.
Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies: The usability assessment will be documented in the data validation letter report, which will be generated 21 days after the CADRE-validated Phase I analytical results are received from the CLP laboratory.

REFERENCES

Hazard Ranking System (HRS). 2009. “HRS Documentation Record.” April.

Indiana Department of Environmental Management (IDEM). 2007. “Preliminary Assessment Report for Lane Street Ground Water Contamination, Elkhart, Indiana, Elkhart County.” October 5.

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TABLE

(One Sheet)

TABLE B-2
SAMPLING SUMMARY

Sample Type	Sample ID Prefix	Matrix	No. of Sampling Locations	No. of Samples per Location	Total No. of Samples [a]		
					VOC by CLP	SVOC, PCB, Filtered TAL Metals by CLP	VOC by Private Laboratory
Private Wells	PW-	Groundwater	5	1	5	0	0
Vertical Aquifer Sampling (VAS) [b]	VAS-GW	Groundwater	25	6	150	0	0
Soil Borings [c]	VAS-SO	Soil	10	1	10	10	0
Monitoring Wells [d]	MW-	Groundwater	32	2	64	4	0
Indoor Air Samples	IA-	Air	3	2	0	0	6
TOTAL			**75**		**229**	**14**	**6**

Notes:

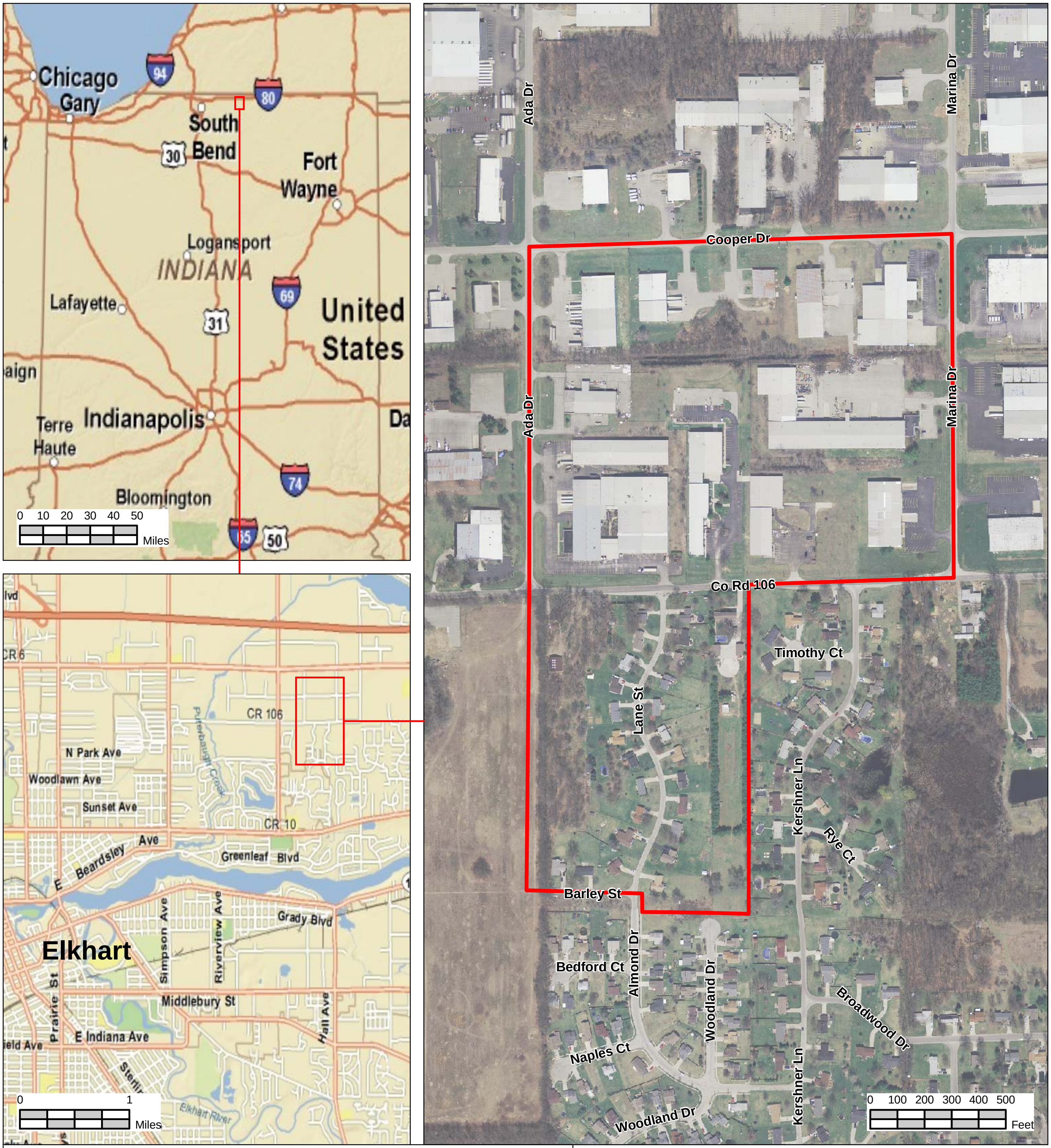
a	Total number of samples does not include field duplicate or QC samples.
b	Samples will be collected at 10-foot intervals from the groundwater table to a maximum depth of 60 feet bgs.
c	One soil sample will be collected from a VAS location when evidence of contamination is observed.
d	Two monitoring wells will be installed at 16 different locations throughout the site; one shallow well screened from 10-20 feet bgs and one deep well installed with a 5-foot screen somewhere from 20-60 feet bgs, depending on the analytical results from the VAS sampling. The number of samples includes two rounds of groundwater sampling.

bgs	Below ground surface		
CLP	Contract Laboratory Program	QC	Quality control
GW	Groundwater	SO	Soil
IA	Indoor air	SVOC	Semivolatile organic compound
MW	Monitoring well	TAL	Target Analyte List
PCB	Polychlorinated biphenyl	VAS	Vertical aquifer sampling
PW	Private well	VOC	Volatile organic compound

FIGURES

(Three Sheets)

FIGURE B-1: LANE STREET SITE OVERVIEW



🟥 Approximate site boundary

N

LANE STREET INVESTIGATION SITE
ELKHART COUNTY, INDIANA

QUALITY ASSURANCE PROJECT PLAN

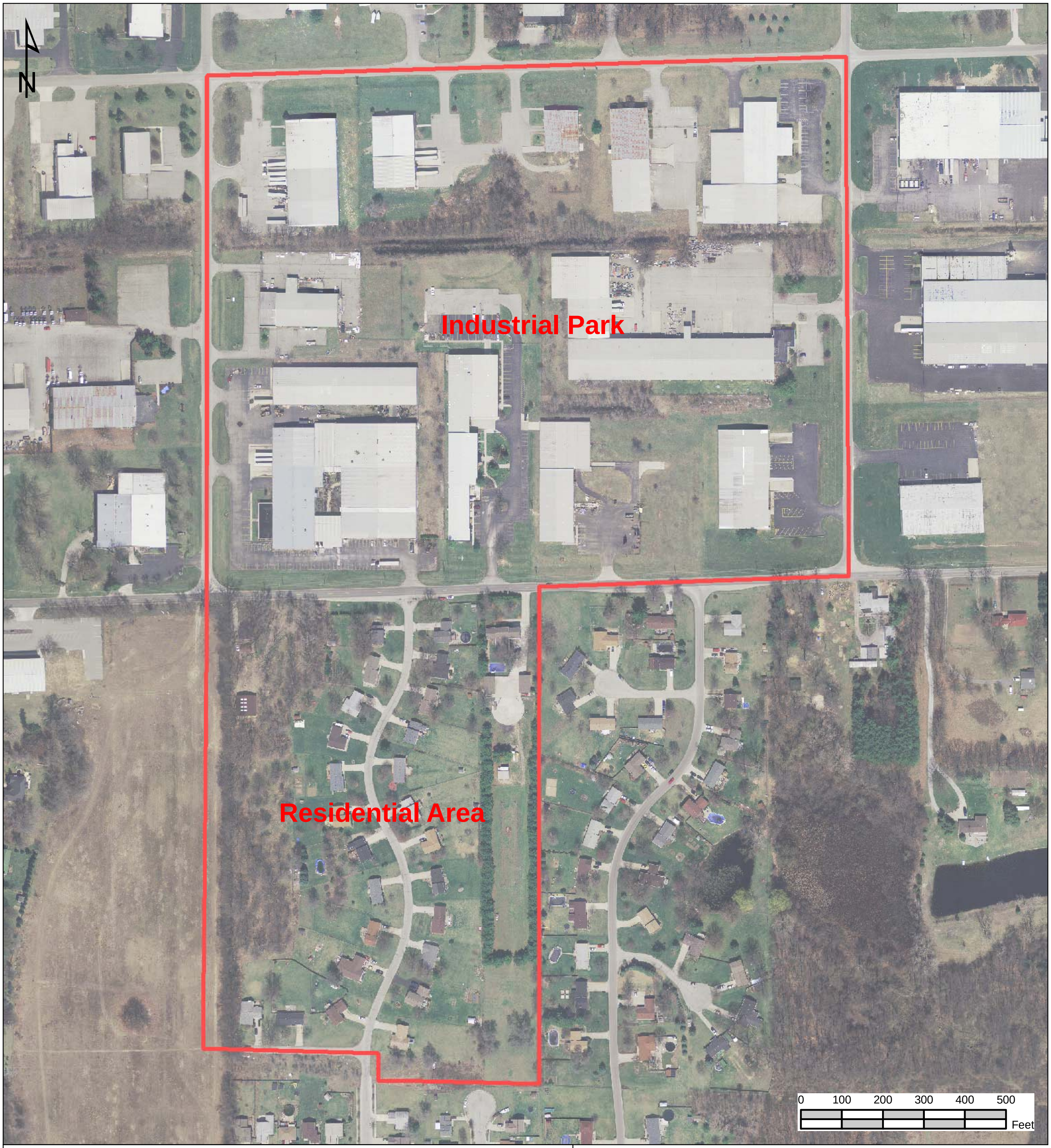
FIGURE B-1

LANE STREET SITE OVERVIEW

EPA REGION 5 RAC 2 | REVISION 1 | FEBRUARY 2011

ST SulTRAC

FIGURE B-2: LANE STREET SITE BOUNDARIES



🟥 Approximate site boundary

LANE STREET INVESTIGATION SITE
ELKHART COUNTY, INDIANA

QUALITY ASSURANCE PROJECT PLAN

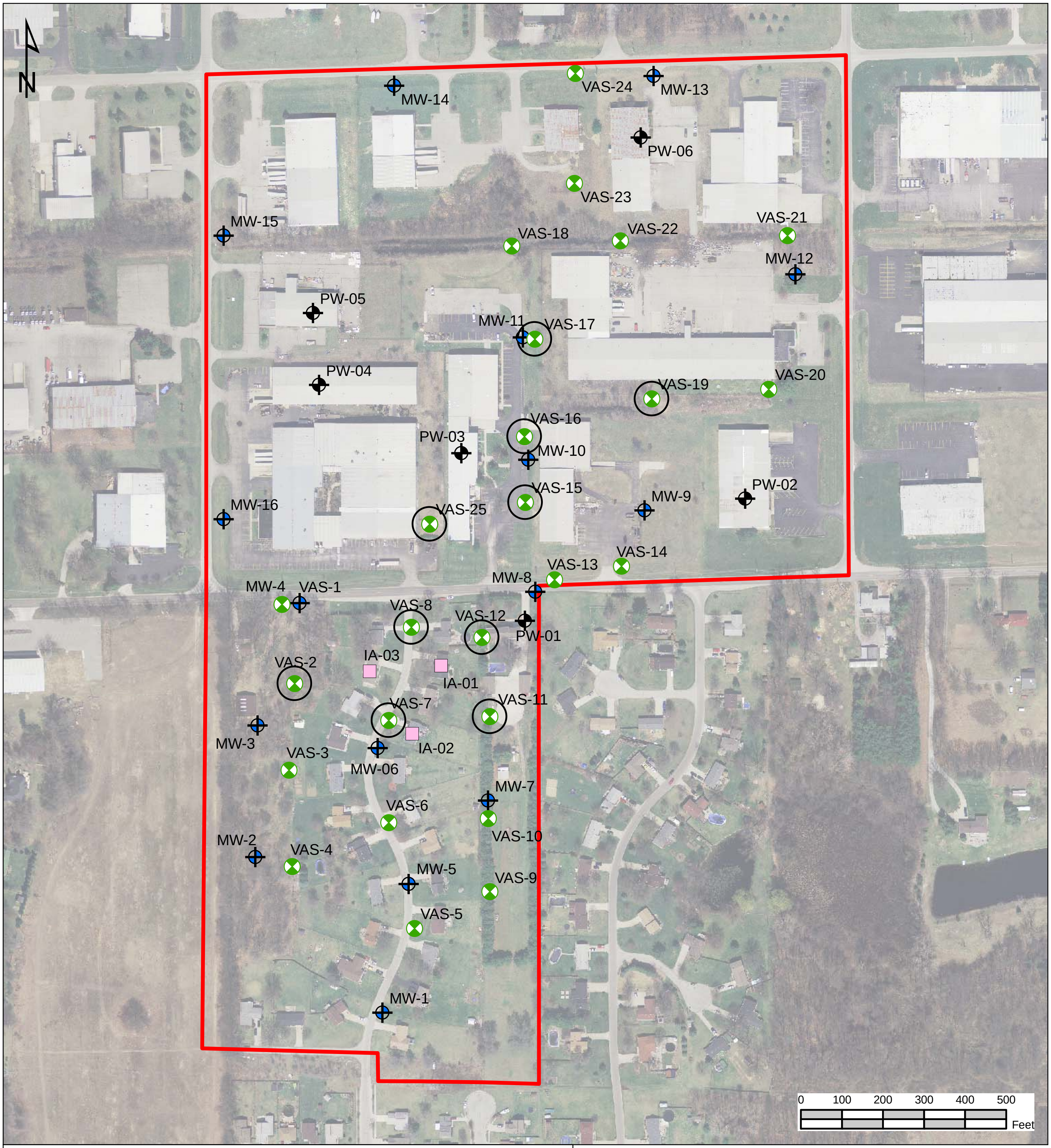
FIGURE B-2

LANE STREET SITE BOUNDARIES

EPA REGION 5 RAC 2 | REVISION 1 | FEBRUARY 2011

ST SulTRAC

FIGURE B-3: LANE STREET SITE PROPOSED SAMPLING LOCATIONS



- ⊗ Proposed VAS sampling location
- ⌖ Proposed nested well sampling location
- ◎ Proposed VAS soil sampling location
- ⌖ Private well sampling location
- 🟪 Proposed indoor air sampling location
- ▭ Approximate site boundary

LANE STREET INVESTIGATION SITE
ELKHART COUNTY, INDIANA

QUALITY ASSURANCE PROJECT PLAN

FIGURE B-3

LANE STREET SITE
PROPOSED SAMPLING LOCATIONS

EPA REGION 5 RAC 2 | REVISION 1 | FEBRUARY 2011

ST SulTRAC

APPENDIX B-1

STANDARD OPERATING PROCEDURES

SOP 002	General Equipment Decontamination, Revision No. 2, December 1999
SOP 003	Organic Vapor Monitoring, Revision No. 3, July 2009
SOP 005	Soil Sampling, Revision No. 1, December 1999
SOP 010	Groundwater Sampling, Revision No. 4, June 2009
SOP 014	Static Water Level, Total Well Depth, and Immiscible Layer Measurement, Revision No. 1, July 2009
SOP 015	Groundwater Sample Collection Using Low-Flow Sampling Methodology, Revision No. 1, July 2009
SOP 016	DRAFT Investigation Derived Waste Management, Revision No. 00, December 2009
SOP 019	Packaging and Shipping Samples, Revision No.6, December 2008
SOP 020	Monitoring Well Installation, Revision No. 4, April 2009
SOP 021	Monitoring Well Development, Revision No. 4, June 2009
SOP 024	Recording of Notes in Field Logbook, Revision No. 1, December 2008
SOP 054	Using the Geoprobe System, Revision No. 1, December 1999
SOP 061	Field Measurement of Groundwater Indicator Parameters, Revision No. 2, July 2009

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. 3

Last Reviewed: July 2009

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Title: **Organic Vapor Air Monitoring**

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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 or upgrading personal protective equipment (PPE), delineating areas where protection is needed, assessing the potential health effects of exposure, and determining the need for specific medical monitoring. Organic vapor air monitoring is also commonly used as a screening tool to identify relatively impacted environmental media and to provide a real-time basis for selecting samples for chemical analysis.

Various types of air monitoring instruments are available for measuring organic vapors. Common organic vapor monitoring instruments used by Tetra Tech include HNu® or Photovac 2020ComboPRO® photoionization detectors (PID), Foxboro® organic vapor analyzer (OVA) flame ionization detectors (FID), Photovac MicroFID, and MiniRae 2000 or 3000 PIDs. It should be noted that this standard operating procedure (SOP) discusses only some of the air monitoring instruments available to field personnel. The particular type of meter or monitoring system to be used should be identified in the project work plan or field sampling plan and selected on a site-specific basis depending on the data collection needs, the types of organic vapors to be monitored, and the sampling procedures to be used.

1.1 PURPOSE

This SOP establishes the general requirements and procedures for using various instruments to conduct organic vapor air monitoring in the field. It also discusses general factors to consider when conducting organic vapor air monitoring.

1.2 SCOPE

This SOP applies to general procedures for calibrating and operating organic vapor air monitoring instruments in the field. The project work plan or field sampling plan should identify the types of instruments to be used and the actual project-specific field parameters to be measured. The project-specific health and safety plan should identify chemical-specific action levels for health and safety purposes. For each type of air monitoring instrument, the manufacturer’s manual should be consulted for specific operating instructions.

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.

Breathing zone: The area where field workers would be inhaling potentially impacted air, generally from about 3 to 5 feet above the ground surface. The breathing zone will vary depending on the types of work activities being performed. Air monitoring is conducted in this zone to ensure that it is representative of the air being breathed by field team members.

Head space: The vapor mixture trapped above a solid or liquid in a sealed vessel.

1.4 REFERENCES

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Coast Guard, and U.S. Environmental Protection Agency (EPA). 1985. "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities." U.S. Government Printing Office. Washington, DC.

1.5 REQUIREMENTS AND RESOURCES

The following items are typically required to monitor organic vapors in air using this SOP:

- Organic vapor air monitoring meter
- Manufacturer-supplied calibration gas
- Manufacturer-supplied calibration kits including tubing and regulators
- Resealable plastic bags for conducting soil head space measurements (if applicable)
- Sample jars for conducting water head space measurements (if applicable)
- Sharpie or similar type of permanent marker
- Container to collect soil or water used for head space measurements (if applicable)
- Logbook or field data sheets

2.0 APPLICATIONS, DETECTION METHODS, AND LIMITATIONS

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. The following subsections discuss general application, detection methods, and limitations when using a PID and an OVA FID.

2.1 APPLICATION

The 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]).

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.

Each type of unit (PID or FID) has some limitations as to the detection of various categories of compounds or for specific organic compounds. Examples are described below in Section 2.2. The user manual for the specific instrument should be used to confirm its applicability for measurements of the organic vapors of concern at the site.

2.2 DETECTION METHODS

The PID ionizes molecules using ultraviolet (UV) radiation and can be used with a variety of electron voltage lamps best matched to the compound of concern at a site. The UV radiation strips electrons from the molecules, producing ions that produce a current proportional to the number of ions generated. The PID is more sensitive to aromatic and unsaturated compounds than the OVA FID. The PID is nonspecific for gas and vapor detection for organic and some inorganic compounds. The PID is also sensitive to 0.1 ppm of benzene. Sensitivity is related to the ionization potential of the compound being monitored. PIDs will only detect compounds that have ionization energies similar to the energy of the photons the detector uses. Gases with ionization potential values below the electron volt (eV) output of the lamp will be detected. The most common PID lamp used is the 10.6 eV lamp because it detects most volatile organic compounds; however, 9.5 eV and 11.7 eV lamps are also commonly available. It is recommended that the ionization potential of the chemicals of concern be known in order to select the most appropriate lamp for a specific project. Ionization potential information can be obtained from the vendor, in the manufacturer’s manual, or on line (for example, at http://www.detectorsbyaic.com/ion_potential.html).

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 chlorine, hydrogen cyanide, and ammonia. The OVA FID is also less sensitive to aromatics and unsaturated compounds than the PID. However, the OVA FID is less sensitive to high humidity than the 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 specific to that particular gas or vapor.

2.3 LIMITATIONS

The PID cannot be used to:

- Detect methane
- Detect a compound that has a higher 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

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 detect contaminants in oxygen-deficient atmospheres; operation in these conditions requires system modification.

3.0 PROCEDURES

The procedures outlined in this SOP are general and typically apply to various types of monitoring instruments used to measure organic vapors in air. General procedures for testing and calibrating the instruments are presented first, followed by procedures for using the instruments and making field measurements, guidelines for recording information accurately, and a discussion of variables that may affect outdoor air monitoring. The particular monitoring instrument should be identified in the project work plan or field sampling plan and should be operated in accordance with the manufacturer's instruction manual.

3.1 TESTING AND CALIBRATION PROCEDURES

Each air monitoring instrument should be calibrated according to manufacturer's specifications. General procedures applicable to most equipment are as follows:

- Equipment should be thoroughly cleaned, and then calibrated and tested before the startup of sampling at each site.
- Equipment should be calibrated and tested using manufacturer-provided calibration gas and calibration connector kits.
- Batteries should be charged prior to startup of field work, and the battery charge level should be checked at the start of each day. The battery charge life will vary depending on the particular monitoring instrument to be used and the application.
- It is recommended that extra batteries be kept on hand when conducting field work.
- The PID can typically run continuously on a fully charged battery for at least 8 hours. The PID battery should be recharged for 14 hours.
- 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.
- Calibration and testing of field equipment should be documented every time it is performed. Calibration and testing information should be recorded in field logbooks (or field data sheets, if applicable).
- If testing and calibration measurements are out of tolerance, the instrument must be serviced or repaired.

3.2 FIELD MEASUREMENT PROCEDURES

Each air monitoring instrument should be operated according to manufacturer's specifications. The actual field procedures will vary depending on the type of air monitoring to be conducted. Almost all PIDs and OVA FIDs have a recommended warm-up period (see the manufacturer's operations manual for the specific type of meter to be used). Similarly, many instruments are affected by moisture, humidity, and dust. The use of an external filter on the probe tip is recommended in these situations. Finally, many instruments include a data logging option that can be used, if desired. A general procedural summary for air monitoring associated with health and safety and field screening applications is presented below.

3.2.1 Health and Safety Monitoring

The site-specific health and safety plan will specify the types of contaminants of concern, health and safety related action levels, and the types of PPE necessary. The goal of air monitoring for health and safety purposes is to ensure that field work is conducted in accordance with the health and safety plan and to identify conditions where upgrading the level of PPE may be necessary. General procedures for conducting health and safety air monitoring for organic vapors are as follows:

- Following the instrument manual, calibrate and test air monitoring equipment.
- Approach the sampling location from the upwind direction.
- Monitor organic vapors in the breathing zone (multiple levels of monitoring may be required depending on the work being performed).
- Monitor down-hole vapor concentrations, if drilling.
- Take readings at a frequency appropriate for the types of tasks being conducted, the types of organic vapors expected, and the levels of organic vapors being detected (monitor at a more frequent rate if organic vapors are detected and they are near the site-specific action levels specified in the health and safety plan).
- Record information in a field log book, on field data sheets, or on an air monitoring log sheet (record site name, date and time, sampling location, PID or FID readings, and pertinent weather information).
- Upgrade the level of PPE, implement engineering controls, or stop work if organic vapors are sustained in the breathing zone above action levels specified in the site-specific health and safety plan.

3.2.2 Field Screening

The site-specific work plan or field sampling plan will specify the media to be sampled, the sampling methods and procedures to be used, and field screening requirements. Typically, the goals of air monitoring for field screening purposes are to identify relatively higher organic vapor concentrations in soil, groundwater, or other media to select subsequent sampling locations, or to select environmental samples to send to a laboratory for chemical analysis. General procedures for conducting field screening air monitoring for organic vapors are as follows:

- Following the instrument manual, calibrate and test air monitoring equipment.
- Work from the upwind direction, when possible.
- Directly screen soil cores or drill cuttings by running the tip of the meter along the soil surface while taking care not to get soil into the probe.
- Depending on sampling protocol, dig into or freshly “break” the soil and measure vapors at the newly exposed surface.
- When collecting soil samples for head space measurements, place soil in a resealable plastic bag, record the sampling location and depth on the bag with a Sharpie or other type of permanent marker, wait at least 5 minutes for vapors to accumulate (the bag may be placed in direct sunlight or in a warm area while waiting), shake the bag vigorously, and then insert the probe into the bag without placing the tip directly in the soil (while taking care not to let vapors escape).
- Directly screen purged well water (or surface water) by running the tip of the meter along the water surface while taking care not to get water into the probe.
- When collecting water samples for head space measurements, place water in a jar and tightly close the lid, record the sampling location and depth on the jar with a Sharpie or other type of permanent marker, wait at least 5 minutes for vapors to accumulate (the jar may be placed in direct sunlight or in a warm area while waiting), shake the jar vigorously, and then slightly open the lid and insert the probe into the jar without placing the tip directly in the water (while taking care not to let vapors escape).
- Record information in a field log book, on field data sheets, or on an air monitoring log sheet (record site name, date and time, sampling location, PID or FID readings, and pertinent weather information).

3.3 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.
- 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.

3.4 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.

- **Background vapor emissions:** Vapor emission from other activities in the area of the field investigations can also impact readings. Operations such as vehicle maintenance or fueling facilities can affect readings associated with perimeter monitoring.

- **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

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Quality Assurance Approved	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

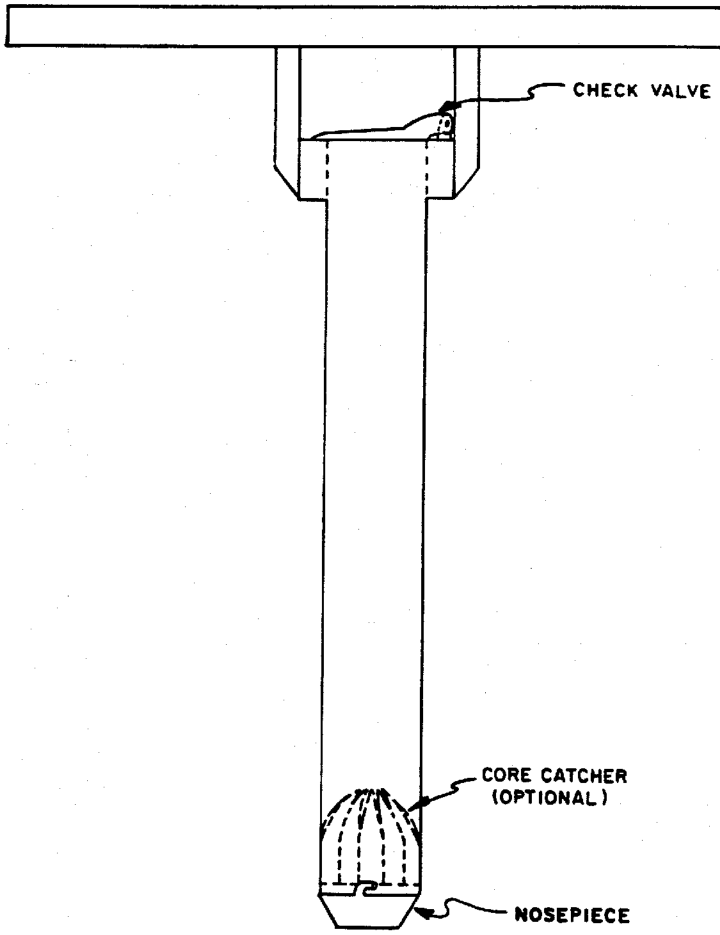


FIGURE 2

TRIER

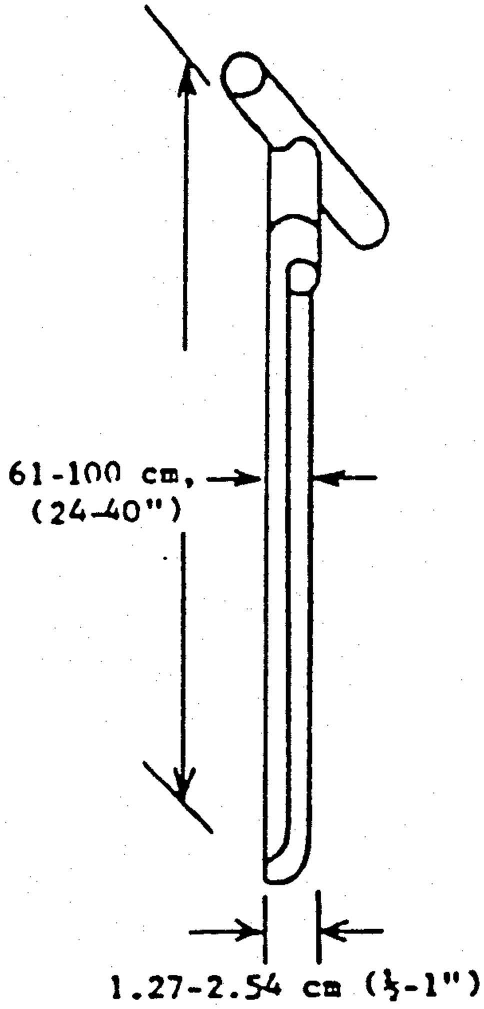


FIGURE 3

GENERIC SPLIT-SPOON SAMPLER

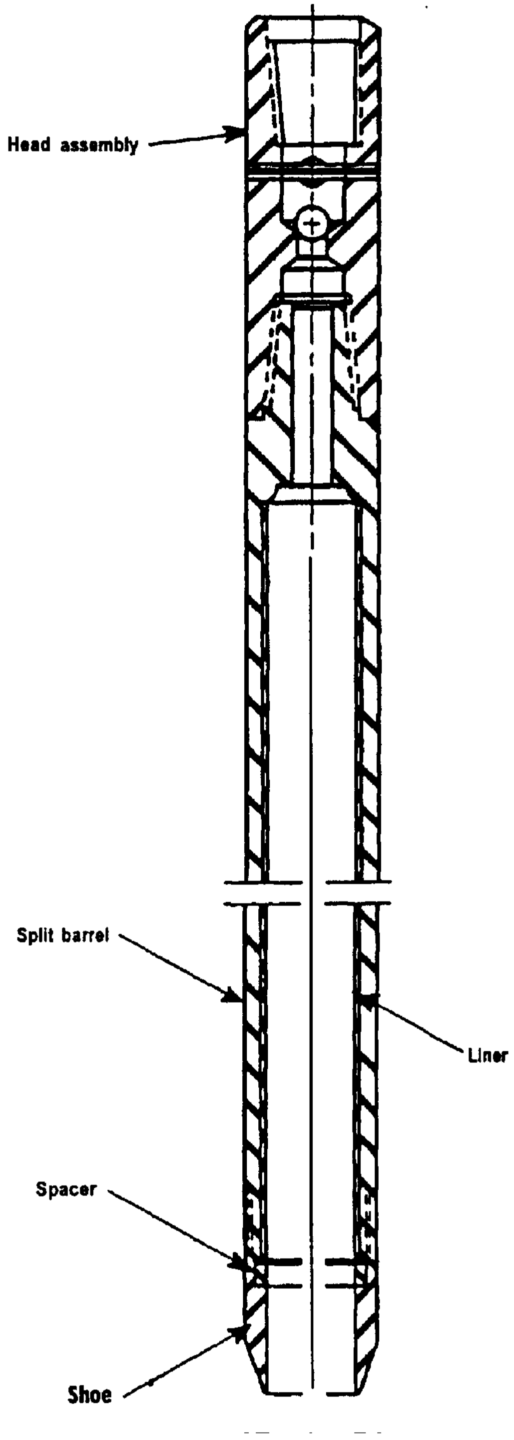
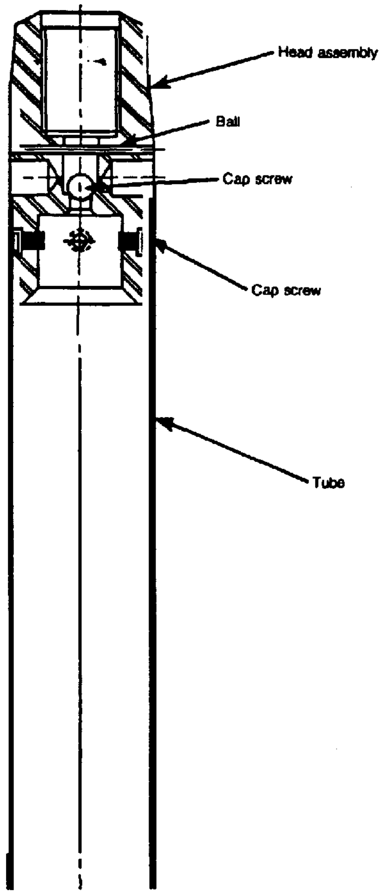


FIGURE 4

THIN-WALL TUBE SAMPLER



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SOP NO. 010

REVISION NO. 4

Last Reviewed: June 2009

6-19-09

Quality Assurance Approved

Date

1.0 BACKGROUND

Groundwater sampling may be required for a variety of reasons, such as to examine potable or industrial water supplies, check for and track contaminant plume movement in the vicinity of a land disposal or spill site, conduct Resource Conservation and Recovery Act (RCRA) compliance monitoring, or examine a site where historical information is minimal or nonexistent, but where groundwater may be contaminated.

Groundwater is usually sampled through an in-place well, either temporarily or permanently installed. SOP No. 020 (Monitoring Well Installation) provides guidance for installing new monitoring wells. However, it can also be sampled anywhere groundwater is present, such as in a pit or a dug or drilled hole.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for determining the quality of groundwater entering, leaving, or affected by site activities through groundwater sampling. The samples are obtained by retrieving water from a well screened in the aquifer or aquifers underlying a site.

1.2 SCOPE

This SOP provides general guidance for groundwater sampling activities conducted in the field. SOP No. 015 (Groundwater Sample Collection Using Micropurge Technology) provides additional specific guidance for using low-flow methods to collect groundwater samples.

1.3 DEFINITIONS

Bailer: A cylindrical sampling device with valves on either end, used to extract water from a well. Bailers are usually constructed of an inert material such as stainless steel or polytetrafluoroethylene (Teflon). The bailer is lowered and raised by means of a cable that may be cleaned and reused, or by disposable rope.

Electrical Water Level Indicator: An electrical device that has a light or sound alarm connected to an open circuit, used to determine the depth to liquid. The circuit is closed when the probe intersects a conducting liquid. The wire used to raise and lower the probe is usually graduated.

Immiscible Phase: A liquid phase that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink, and light immiscible phases float on water.

Interface Probe: An electrical probe that determines the distance from the surface to air-water, air-immiscible, or immiscible-water interfaces.

Purge Volume: The volume of water that needs to be removed from the well prior to sampling to ensure that the sample collected is representative of the formation groundwater.

Riser Pipe: The length of well casing above the ground surface.

Total Well Depth: The distance from the reference measuring point (top of well casing or ground surface) to the bottom of the well.

Water Level: The level of water in a well, measured as depth to water or as elevation of water, relative to a reference mark or datum.

1.4 REFERENCES

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1.5 REQUIREMENTS AND RESOURCES

There are various options available to obtain groundwater samples. The procedures are outlined in the following section. The equipment needed to accomplish these procedures includes the following:

- Organic vapor detector with a flame ionization detector (FID) or a photoionization detector (PID)
- Pipe wrench and/or other tools needed to open monitoring wells (socket wrench, mallet, etc.)
- Electrical water level indicator or interface probe
- Purging device (type needed depends on well depth, casing diameter, and type of sample desired; see sampling devices below)
- Graduated cylinder or bucket
- Sampling device (type needed depends upon depth to water and type of sample desired)
    - Teflon bailer
    - Stainless steel bailer
    - Teflon bladder pump
    - Stainless steel submersible (non-oil-bearing) pump
    - Existing dedicated equipment
    - Peristaltic pump
- Sample containers
- Wastewater containers

- Field logbook
- Stopwatch

Additional equipment is required to complete measurement of field parameters (for example, pH, specific conductance, and temperature) of the groundwater in the well. Refer to Tetra Tech SOP 061 (Field Measurement of Dissolved Oxygen, Oxidation-Reduction Potential, pH, Specific Conductance, Temperature, and Turbidity Using a Multi-Parameter Water Quality Meter) or individual field parameter SOPs as appropriate.

2.0 PROCEDURE

Prior to sampling, a site-specific sampling plan should be developed. The plan should take into consideration the site characteristics and should include:

- Specific, repeatable well measurement techniques and reference points for determining the depth to water and the depth to the bottom of the well
- Specific method of purging and selection of purging equipment
- Specific methods and equipment for measurements of field parameters
- Specific method of sample collection and the sampling equipment that will be used
- Specific parameters for which samples will be analyzed
- Order in which sample bottles will be filled, based on the analytical parameters

The following sections discuss procedures for approaching the well, establishing a sample preparation area, making preliminary well measurements, purging the well, and collecting samples.

2.1 APPROACHING THE WELL

In general, all wells should be assumed to pose a health and safety risk until field measurements indicate otherwise. Approach the well from the upwind side. Record well appearance and the general condition of the protective casing, surface seal, and surrounding area in the logbook.

Once at the well, the lead person should systematically use the organic vapor detector to survey the immediate area around the well (from the breathing zone to the top of the casing to the ground). If elevated FID and PID meter readings are encountered, retreat to a safe area and instruct the sampling team to either let vapors dissipate and approach the well again or put on the appropriate level of personal protective equipment (PPE), as specified in the site-specific health and safety plan. See SOP No. 003 (Organic Vapor Air Monitoring) for additional air monitoring guidance.

Some monitoring wells have the potential to contain pressurized headspace—for example, through the generation of gases from contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities; or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. Tetra Tech personnel shall employ the following practices to minimize these hazards:

- Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety eye protection.
- Do not place the face or any other part of the body over the well when opening because this may place you in a strike zone.
- Open the well cover at arm's length, then step away and allow the well to off gas and stabilize.

Upon opening the well casing, the lead person should systematically survey inside the well casing, above the well casing in the breathing zone, and in the immediate area around the well. If elevated FID or PID meter readings in the breathing zone are encountered (see health and safety plan for action levels), retreat and put on appropriate PPE. It is important to remember that action levels are based on readings in the breathing zone, not within the well casing. Representative organic vapor detector readings should be recorded in the logbook. Also look out for insects or other animals that may nest in well openings, and refer to the health and safety plan for specific hazards.

2.2 ESTABLISHING A SAMPLE PREPARATION AREA

The sample preparation area is generally located upwind or to either side of the well. If elevated readings are encountered using an organic vapor detector, this area should be taped off and the sample preparation area should be located upwind of the well, where ambient conduction are measured.

2.3 MAKING PRELIMINARY WELL MEASUREMENTS

Several preliminary well measurements should be made prior to initiating sampling of the well. These include determining water level and total well depth measurements, determining the presence of immiscible phases, and calculating purge volumes. All preliminary measurements will be recorded in the logbook or the Groundwater Sampling Data Sheet (included as an exhibit to this SOP) as they are determined. SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement) provides additional information concerning these preliminary measurements.

2.3.1 Water Level and Total Well Depth Measurements

Tetra Tech typically uses an electric water level indicator for water level and total well depth measurements. This device sounds an alarm or triggers a light when the measuring probe touches the water surface, thus closing an electrical circuit. The electric cable supporting the probe is usually graduated to 0.01 foot and can be read at the well site directly. The distance between the static water level and the marked or notched location at the top of the riser pipe is measured. The height of the riser pipe above ground surface, as obtained from well location survey data, is then subtracted from the total reading to give the depth to static water. To improve accuracy, three separate readings should be made, and the values averaged. This helps to eliminate any errors due to kinks or bends in the cables, which may change in length when the water level indicator is raised and lowered.

The total well depth can be measured by lowering the probe into the well until resistance is met, indicating that the probe has reached the bottom of the well. The total well depth is then read to the 0.01-foot fraction. The distance between the bottom of the well and the marked or notched location on the riser pipe is measured. The height of the riser pipe above the ground surface, as obtained from well survey data, is then subtracted from the total reading to give the depth to the bottom of the well. To improve accuracy, three separate readings should be made, and the readings averaged.

2.3.2 Determining if Immiscible Nonaqueous-Phases Liquids are Present

If immiscible, nonaqueous-phase liquid (NAPL) are present, the following measurement activities should be undertaken. Organic liquids are measured by lowering an interface probe slowly to the surface of the liquid in the well. When the audible alarm sounds, record the depth. If the alarm is continuous, a floating immiscible layer has been detected. To determine the thickness of this layer, continue lowering the probe slowly until the alarm changes to an oscillating signal. The oscillating signal indicates that the probe has detected an aqueous layer. Record this depth as the depth to water and determine the thickness and the volume of the immiscible layer.

Continue lowering the probe into the well to determine if dense immiscible phases (sinkers) are present. If the alarm signal changes from oscillating to a continuous sound, a heavier immiscible layer has been detected; record this depth.

Continue lowering the probe to the bottom of the well and record the total depth. Calculate and record the sinker phase volume and total water volume in the well (see equation in Section 2.3.3). If immiscible phases are present, immediately refer to Section 2.5.3 or 2.5.4 of this SOP for sample collection procedures.

2.3.3 Determination of Purging Volume

If the presence of immiscible phases does not need to be determined, determine the depth to water and the total depth of the well as described in Section 2.3.1. Once these measurements have been made and recorded, use Table 1 to calculate the total volume of water in the well. Multiply this volume by the purging factor to determine purging volume. The minimum purging factor is typically three casing volumes but may be superseded by site-specific program requirements, individual well yield characteristics, or stabilization of field parameters measured during purging. Field parameters (for example, pH, specific conductance, and temperature) should be measured prior to purging and after each well volume. All field parameter data should be recorded in the field logbook, Groundwater Sampling Data Sheet, or personal digital assistant (PDA). Refer to specific Tetra Tech SOP 061 as appropriate for more detailed procedures for determining these field parameters.

The volume of water in the well is based on the following formula:

$$V = \pi r^2 h \times 7.48$$

where

V = static volume of water in the well (gallons)
r = inside radius of the well (feet)
h = length of water in the well (total well depth minus depth to water) (feet)
7.48 = conversion factor (cubic feet to gallons)

Common well sizes and corresponding volumes are as follows:

- 1-inch well = h x 0.041 gal/ft
- 2-inch well = h x 0.163 gal/ft
- 3-inch well = h x 0.367 gal/ft
- 4-inch well = h x 0.652 gal/ft

2.4 PURGING THE WELL

Currently, Tetra Tech standards allow for six options for purging wells:

1. Teflon bailers
2. Stainless steel bailers
3. Teflon bladder pumps
4. Stainless steel submersible (non-oil-bearing) pumps
5. Existing dedicated equipment
6. Peristaltic pumps (these devices are for shallow wells only)

As previously stated, the minimum purging volume is typically three casing volumes. Exceptions to this standard may be made in the case of low-yield wells. When purging low-yield wells, purge the well until the water level is equal to the top of screen elevation (if possible). Samples should be collected no sooner than 2 hours after purging and when sufficient groundwater volume is available.

The well should be purged until measured field parameters have stabilized. If any field parameter has not stabilized, additional purging should be performed. To be considered stable, field parameters should change by no more than the stabilization criteria listed on Table 1 between each well volume purged. If the above conditions have not been met after a specified period of time, purging will be considered complete and sampling can begin. Refer to the field sampling plan or quality assurance project plan for specified time period. Record the final well stabilization parameters on the Groundwater Sampling Data Sheet, and indicate if the well purging was considered complete due to stabilized parameters or exceeding the specified period of time.

At no time should the purging rate be high enough to cause the groundwater to cascade back into the well, as this could result in excessive aeration and potential stripping of volatile constituents.

The actual volume of purged water can be measured using several acceptable methods:

- When bailers are used, the actual volume of each bailer's contents can be measured using a calibrated bucket.
- If a pump is used for purging, the pump rate can be determined by using a bucket of known volume, stopwatch, and the duration of pumping time necessary to purge the known volume.

2.5 SAMPLE COLLECTION

This section first describes general groundwater sample collection procedures. This section also describes procedures for collecting groundwater samples for volatile organic analysis (VOA) and for collecting samples when light or heavy immiscible layers are present in a monitoring well. Samples of light and heavy immiscible layers should be collected before the well is purged. Site-specific sampling plans may indicate that, based on the presence of NAPL, no groundwater sample is to be collected.

2.5.1 General Groundwater Sampling Procedures

The technique used to withdraw a groundwater sample from a well should be selected based on the parameters for which the sample will be analyzed. To ensure that the groundwater samples are representative, it is important to avoid physically altering or chemically contaminating the sample during collection, withdrawal, or containerization. If the samples are to be analyzed for volatile organic compounds, it is critical that air does not become entrained in the water column.

Acceptable sampling devices for all parameters are double check valve stainless steel or Teflon bailers, bladder pumps, low-flow positive displacement pumps, or for shallow wells, peristaltic pumps. Additional measurements of field parameters should be performed at the time of sampling.

In some cases, it may become necessary to use dedicated equipment already in the well to collect samples. This is particularly true of high-volume, deep wells (>150 feet) where bladder pumps are ineffective and bailing is impractical. If existing equipment must be used, however, determine the make and model of the pump and obtain information on component construction materials from the manufacturer or facility representatives. If an existing pump is to be used for sampling, make sure the flow volume can be reduced so that a reliable VOA sample can be taken. Record the specific port, tap, or valve from which the sample is collected. If nondedicated sampling equipment is used, the least contaminated wells should be purged and sampled first and most contaminated wells should be purged and sampled last (if past sampling data are available to make this determination).

General sampling procedures are as follows:

- Clean sampling equipment should not be placed directly on the ground. Use a plastic drop cloth or feed line from clean reels. Never place contaminated lines back on reels.
- Check the operation of the bailer check valve assemblies to confirm free operation.
- If the bailer cable is to be decontaminated and reused, it must be made of Teflon-coated stainless steel.
- Lower sampling equipment slowly into the well to avoid degassing the water and damaging the equipment.
- Pump flow rates should be adjusted to eliminate intermittent or pulsed flow. The settings should be determined during the purging operations.

- A separate sample volume should be collected to measure necessary field parameters. Samples should be collected and containerized following procedures outlined in the project-specific field sampling plan (FSP), quality assurance project plan (QAPP), and in the order of the parameters' volatilization sensitivity. Table 2 lists the preferred collection order for common groundwater parameters.

Intermediate containers should never be used to prepare VOA samples and should be avoided for all parameters in general. All VOA containers should be filled at a single sampling point or from a single bailer volume. Also refer to site-specific sampling plan for other sample handling requirements that may be unique to a site or to specific chemical constituents.

2.5.2 Collection of Volatile Organics Samples

This section discusses in detail the collection of samples for VOA using either a bailer or bladder pump. Other pumps (such as positive displacement or peristaltic) can be used. The following factors are critical to the collection of representative samples for VOA: ensuring that no air has become entrained in the water column, achieving low pump flow rates (less than 100 milliliter [mL] per minute, if possible), avoiding flow surges, and adjusting sample preservatives if they are found to cause reactions with the sample.

2.5.2.1 Collection with Bailers

Samples for VOA should be collected from the first bailer removed from the well after purging is complete. The most effective means requires two people. One person should retrieve the bailer from the well and pour its contents into the appropriate number of 40-mL VOA vials held by the second person. Each vial should be capped and inverted to check if any air bubbles are present. If a bubble exists, unscrew the cap and add more water, or discard and repeat if vials are not pre-preserved. If bubbling persists in a vial containing acid preservative, the sample may need to be collected without the preservative and the laboratory notified to add preservative upon receipt. The sample should be transferred from the bailer to the sample container in a manner that will limit the amount of agitation in order to reduce the loss of volatile organics from the sample.

Always fill VOA vials from a single bailer volume. If the bailer is refilled, samples cannot be considered duplicates or splits.

2.5.2.2 Collection with a Bladder Pump (Well Wizard)

To successfully perform VOA sampling with a Well Wizard bladder pump, the following steps must be completed:

1. Following manufacturer's directions, activate the pump. Full water flow from the discharge tubing will begin after 5 to 15 pumping cycles. These initial pumping cycles are required to purge air from the pump and discharge tubing. The discharge and recharge settings must be manually set and adjusted to pump at optimum flow rates. To activate the bladder, it is best to set the initial cycle at long discharge and recharge rates.

2. Reduce water flow rate for VOA sample collection. To reduce the water flow rate, turn the throttle control valve (located on the left side of the Well Wizard pump control panel) counterclockwise.

3. Collect VOA sample from discharge tubing. VOA vials must be placed beneath the discharge tubing while avoiding direct contact between the vials and the tubing. Never place tubing past the mouth of the VOA vial. The pump throttle control must be turned as necessary to maintain a trickle of water in order to obtain a meniscus in the vial.

4. Continue with non-VOA sampling. Increase pump flow rate by turning the throttle control knob clockwise.

2.5.3 Sampling of Light Immiscible Floaters

The approach used when collecting a sample of a floating layer depends on the depth to the floating layer and the thickness of that layer. If the thickness of the floater is 2 feet or greater, a bottom-filling valve bailer should be used. Slowly lower the bailer until contact is made with the floater surface, and lower the bailer to a depth less than that of the floater-water interface depth as determined by preliminary measurements with the interface probe.

When the thickness of the floating layer is less than 2 feet and the depth to the surface of the floating layer is less than 15 feet, a peristaltic pump can be used to extract a sample.

When the thickness of the floating layer is less than 2 feet and the depth to the surface of the floating layer is beyond the effective "lift" of a peristaltic pump (greater than 25 feet), a bailer can be modified to allow filling from the top only (an acceptable alternative is to use a top- loading Teflon or stainless-steel bailer). Disassemble the bailer's bottom check valve and insert a piece of 2-inch-diameter Teflon sheet between the ball and ball seat. This will seal off the bottom valve. Remove the ball from the top check valve, thus allowing the sample to enter from the top. To overcome buoyancy when the bailer is lowered into the floater, place a length of 1-inch stainless steel pipe on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). As an alternative, use a top-loading stainless-steel bailer. Lower the device, carefully measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. Lower the bailer an additional one-half thickness of the floating layer and collect the sample. This technique is the most effective method of collection if the floating layer is only a few inches thick.

2.5.4 Sampling of Heavy Immiscible Sinkers

The best method for collecting a sample of a sinker is the use of a double check valve bailer. The key to sample collection is controlled, slow lowering and raising of the bailer to and from the bottom of the well. Sample collection methods are equivalent to those described in Section 2.5.3 above.

TABLE 1

STABILIZATION CRITERIA FOR WATER QUALITY PARAMETERS

Parameter	**Stabilization Criterion**
pH	± 0.1 units
Specific Conductance	± 3 percent
Oxidation-Reduction Potential	± 10 millivolts
Turbidity	± 10 percent (when greater than 10 nephelometric turbidity units [NTU])
Dissolved Oxygen	± 0.3 milligrams per liter or ± 10 percent

TABLE 2

ORDER OF PREFERRED SAMPLE COLLECTION

1. VOA
2. Purgeable organic halogens (POX)
3. Total organic halogens (TOX)
4. Cyanide
5. Extractable organics
6. Purgeable organic carbon (POC)
7. Total metals
8. Dissolved metals
9. Total organic carbon (TOC)
10. Phenols
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

Tetra Tech EM Inc.

EXHIBIT: 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/c Reading µmhos/cm at ___°C

pH: pH 4.00 - _______ at _________ °C
pH 7.00 - _______ at _________ °C
pH 10.00 - ______ at _______ °C
Slope ________________

Dissolved Oxygen: D.O. Meter ____ mg/L at _°C

PID: Calibration Gas ___________ PPM ______ Span ______ Reading __

PURGING

Time	Discharge Rate (mL/min)	Dissolved Oxygen (mg/L)	pH	Eh/ORP (mV)	Temp. (°C)	Specific Conduct. (µmhos/cm at °C)	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: ____

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. 1

Last Reviewed: July 2009

KRiesing	*July 2009*
Quality Assurance Approved	Date

Title: **Static Water Level, Total Well Depth, and Immiscible Layer Measurement**

Revision No. 1, July 2009
Last Reviewed: July 2009

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 often needed to determine a purging volume prior to sampling.

1.1 PURPOSE

This standard operating procedure (SOP) provides guidelines for field personnel measuring: (a) static water levels, (b) total water depths, and (c) immiscible layers in monitoring wells or piezometers.

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

Electrical Water Level Meter: 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 or dense nonaqueous-phase liquids (DNAPL) sink in water; light immiscible phases or light nonaqueous-phase liquids (LNAPL) float on water.

Interface Probe: An electrical probe used to determine the presence and thicknesses of LNAPL or DNAPL 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 (VOC) in the gaseous phase. Ionization detectors are generally not compound-specific and thus measure only total volatile organic compounds. A 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

Photovac and Minirae 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 left open and allowed to stabilize by equilibrating to existing atmospheric pressure prior to measuring. The static water 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

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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 meter
- Interface probe
- PID or FID
- Decontamination supplies (wash and rinse solutions, buckets, paper towels, etc.)
- Keys or wrenches for well locks and well caps
- Light source such as a flashlight or mirror to inspect inside well vaults

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific health and safety plan
- Appropriate signage and traffic control to protect personnel during monitoring activities

2.0 PROCEDURES

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

Procedures for measuring the depth to water and the 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. In addition, as a general rule wells with the lowest known contaminant concentrations should be measured first followed by progressively more contaminated wells. This technique helps avoid cross-contamination from a more contaminated water source to a less contaminated water source resulting in inaccurate or false sample analytic results.

Before initiating any measuring activities, the ambient air at a monitoring well head should be monitored for possible emissions of VOCs using a PID or an FID. The site-specific health and safety plan for on-site activities should provide action levels and the rationale for selection of the appropriate ionization detector.

The sampling team should wear appropriate respiratory protection equipment when necessary. The sampling team should approach wells from the upwind side and 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 for VOCs. VOC monitoring for comparison to action levels should occur in the breathing zone(s) rather than from within the well casing. If PID or FID readings of VOCs are above action levels, the sampling team should retreat to a safe area and determine if engineering controls, increased PPE, or both are necessary to reduce exposure to VOCs above action levels listed in the site-specific health and safety plan.

Sampling team should be careful when opening a well to check for insects or reptiles within the protective casing and use appropriate work gloves when reaching inside. The site-specific health and safety plan should be consulted for information on insects or reptiles that may be present in the project area.

2.1 STATIC WATER LEVEL MEASUREMENT

An electric water level meter is typically used to measure static water levels. The electrical probe of the meter is lowered into the monitoring well until the light or sound alarm is activated indicating the probe has touched the water surface. To ensure accuracy, the well or piezometer should be opened to allow groundwater in the well to equilibrate with atmospheric pressures before measuring depth to water. Ideally, static groundwater measurements will be collected prior to purging or sampling activities. The static water level is read directly from the graduated tape on the meter to the nearest 0.01-foot. Two to three measurements should be taken over several minutes to ensure water levels are not fluctuating. If water levels continue to fluctuate, the groundwater has not equilibrated or become static. Measurements should continue until static water levels readings are obtained before recording a final measurement. 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. Surveyed elevations should be used if available to establish the water level elevation. The well number, measurement date and time, and individual readings should be recorded in a field logbook.

2.2 TOTAL WELL DEPTH MEASUREMENT

Total well depth can also be measured using an electric water level meter. The electrical probe of the indicator is lowered into the monitoring well until resistance is met, indicating that the probe has reached the bottom of the well. During measurement, the probe should be positioned in the well so that resistance is met, but there is no slack in the measuring tape. The total well depth is read directly from the graduated tape on the indicator to the nearest 0.01-foot. Measurements become less accurate with increased depth as the length of measuring tape deployed increases and the distance under the water column increases making it more difficult to determine if the bottom of the well has reached. In this circumstance, a weighted water level meter or measuring tape may be necessary to allow the user to “feel” the bottom of the well. Care should be taken to ensure the use of only inert and chemical-free weighted devices such as stainless steel are used. 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. The well number, measurement date and time, and individual readings should be recorded in a field logbook.

2.3 IMMISCIBLE LAYER DETECTION AND MEASUREMENT

A LNAPL 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 slowly 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. The well number, 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 DNAPL immiscible layer is present, the interface probe is lowered into the monitoring well and allowed to slowly drop below the water causing an oscillating alarm. 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 DNAPL layer within the well casing. The DNAPL layer is then 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 DNAPL layer in the monitoring well. The well number, measurement date and time, and individual readings 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 LOW-FLOW SAMPLING METHODOLOGY

SOP NO. 015

REVISION NO. 1

Last Reviewed: July 2009

KRiesing	July 28, 2009
Quality Assurance Approved	Date

Title: **Groundwater Sample Collection Using Low-Flow Sampling Methodology**
Revision No. 1, July 2009
Last Reviewed: July 2009

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 that included removal of water in the casing of a monitoring well (purging), followed by sample collection. The water in the casing was removed so that 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 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 movement of contaminants while sorbed onto colloid particles constitutes a significant component of contaminant transport. 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 may cause a significant increase in suspended colloids, which in turn may bias analytical results.

Low-flow sample collection, sometimes referred to as micropurge, low-stress, or minimal drawdown groundwater sample collection, is a groundwater sampling method that minimizes increased colloid mobilization by removing water from a well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. During low-flow 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 (i.e., a rate of discharge less than or equal to the rate of recharge). Research indicates that colloid mobilization will not increase above steady-state conditions during low-flow discharge. Therefore, the sample collected by this method 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 low-flow sampling methodology. The following sections describe the equipment to be used and the methods to be followed to promote uniform sample collection techniques. Sampling is to be conducted by field personnel who are experienced in sample collection and handling for environmental investigations.

1.2 SCOPE

This SOP applies to groundwater sampling using low-flow sampling methodology. It is intended to be used as an alternate SOP to SOP No. 010 (Groundwater Sampling), which provides guidance for the general aspects of groundwater sampling. This SOP provides procedures to be used for various methods of low-flow sample collection. The specific type of sampling pump to be used should be specified in the project-specific work plan or field sampling plan.

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 the 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

U.S. Environmental Protection Agency (EPA), Office of Research and Development. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. Publication: EPA/540/S-95/504. http://www.epa.gov/ahaazvuc/download/issue/lwflw2a.pdf

EPA, Office of Solid Waste and Emergency Response. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Publication: EPA542-S-02-001. http://www.epa.gov/tio/tsp/download/gw_sampling_guide.pdf

1.5 REQUIREMENTS AND RESOURCES

The following equipment is required to complete low-flow groundwater sample collection:

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, or impeller)
- Power source for the pump (such as a battery or generator, or compressed air source)
- 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 EPA guidance titled *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (1996) and *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers* (2002). These references may be consulted for a more detailed description of low-flow sampling theory.

Low-flow groundwater sampling 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 low-flow 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 and budget of a particular investigation 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 manufacturers' directions (see SOP No. 061 for more details regarding measurement of groundwater indicator parameters). 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 and turbidity meter cannot be calibrated in the field; they are checked against a known standard. 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 °C). 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 Low-Flow Groundwater Sampling Data Sheet (example included as Figure 1), on a personal digital assistant (PDA), 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. If nondedicated sampling equipment is used, the least contaminated wells should be purged and sampled first and most contaminated wells should be purged and sampled last (if past sampling data are available to make this determination). 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 minimize 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. Hook-up to the appropriate power source should be the last step prior to activating the pump to ensure all connections are completed prior to starting the pump.

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 (0.33 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- to 5-minute intervals:

- pH ±0.1 unit
- SC ±3 percent
- Eh ±10 mv
- Turbidity ±10 percent, when greater than 10 nephelometric turbidity units(NTU)
- DO ±10 percent, or 0.3 milligrams per liter (mg/L)

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 volume of water in the well is based on the following formula:

$$V = \pi r^2 h \times 7.48$$

where

V = static volume of water in the well (gallons)
r = inside radius of the well (feet)
h = length of water in the well (total well depth minus depth to water) (feet)
7.48 = conversion factor (cubic feet to gallons)

Common well sizes and corresponding volumes are listed below.

- 1-inch well = h x 0.041 gal/ft
- 2-inch well = h x 0.163 gal/ft
- 3-inch well = h x 0.367 gal/ft
- 4-inch well = h x 0.652 gal/ft

If a stabilized drawdown in the well cannot be maintained within 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate, or turn the pump off for 15 minutes, and allow for recovery. Under no circumstances should the well be pumped dry. Resume pumping at a lower flow rate; if the water draws down to the top of the screened interval again, turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging, then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or groundwater sampling log. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

The final pH, SC, Eh, turbidity, and DO values should be recorded. All data should be recorded on the Low-Flow Groundwater Sampling Data Sheet (Figure 1), a PDA, or in a logbook.

2.3 SAMPLE COLLECTION

Following purging, the flow-through cell shall be disconnected, and groundwater samples should be 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. Depending on the project-specific types of analyses required, the preferred order of sample collection is as follows:

1. Volatile organic compounds (VOC)
2. Purgeable organic halogens (POX)
3. Total organic halogens (TOX)
4. Cyanide
5. Extractable organics
6. Purgeable organic carbon (POC)
7. Total metals
8. Dissolved metals
9. Total organic carbon (TOC)
10. Phenols
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

See SOP No. 010 (Groundwater Sampling) for more information on groundwater sample collection.

FIGURE 1
LOW-FLOW GROUNDWATER SAMPLING DATA SHEET

Date/Time of Sample Collection: ______________/___________Project Site/Subsite: __________________________
Sample ID: ____
Field ID:____________________________Point Name:
Depth to Well Bottom: _______________ ft. below top of casing (PVC cap)
Depth to Water Level: _______________ ft. below PVC cap
Depth to Water Level: _______________ ft below PVC cap prior to sampling
Method of Purging: Bladder Pump Submersible Pump Peristaltic Pump
Minimum Purge Volume: Two-inch well ________ Liters
Four-inch well ________ Liters
Control Box Settings: Box #______Refill=______Discharge=________
Throttle=____________psi
Total Purged _________Liters Purge Rate goal = 0.5 Liters/Min.
Actual Purge Rate:_______________Liters/Min

Purge Calcs

PHYSIO-CHEMICAL PARAMETERS DURING PURGING

Measure in order listed	Initial reading									Stabiliz-ation Criteria	Final
Time											
PH										+/- 0.2	
Temperature (°C)										+/- 2.0 °C	
Specific Conductance (µmhos/cm)										+/- 3%	
Turbidity (NTU)										+/- 10%	
Dissolved Oxygen (mg/L)										+/- 0.2	
ORP (mV)										+/- 10	
Each Volume Purged (L)											
Total Liters Purged											

Duplicate Sample Collected? No Yes (Sample ID of Duplicate) __________________________________
MS/MSD Sample Collected? No Yes ____
Sample Remarks (odors, colors, sediment): ____
Comments____
Sample(s) Collected By: ____
Well Volume purge Calc: Length of tubing X 9.6 (ml/ft) + 130 (bladder volume) = Total required purge (liters) before collection of parameters.

STANDARD OPERATING PROCEDURE (SOP) APPROVAL FORM

SULLIVAN INTERNATIONAL GROUP, INC.
ENVIRONMENTAL SOP

INVESTIGATION DERIVED WASTE MANAGMENT
SOP NO. 016
REVISION NO. 00

DRAFT

Last Reviewed: December 4, 2009

Quality Assurance Approved ____________________ Date ____________

1.0 BACKGROUND

In the process of conducting field operations in the pre-remedial and remedial phases of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) investigations, Investigation Derived Waste are often generated. IDWs consist of fluids from well development, purging, and pump tests; drilling fluids and cuttings from well installations; soil cuttings from borings; soils from test pits; residues from testing treatment technologies; personal protective equipment (PPE); decontamination solutions used to clean non-disposable equipment; and any other material or equipment that may be contaminated to the point it cannot be sufficiently cleaned to permit further safe use.

The National Contingency Plan (NCP) states "the field investigation team should, when handling, treating or disposing of investigation derived waste onsite, conduct such activities in compliance with applicable or relevant and appropriate requirements (ARARs) to the extent practicable, considering the exigencies of the situation" (NCP, 55 FR 8756). In addition, operations should, at all times, be conducted with the central idea of maximum protection for the workers at the site, the population around the site, and the environment in general.

Ten major concerns control the disposition of IDW at a site:

- types and concentrations of contaminants,
- volume of IDW,
- media affected by the contaminants (e.g., groundwater and for soil),
- location of the site (e.g., residential versus unpopulated area),
- public access to the site (e.g., will children play in the area),
- prior knowledge of conditions at the site (e.g., known as opposed to suspected contamination),
- potential worker exposure,
- potential environmental impact from disposal,
- state and federal regulatory requirements, and
- cost.

1.1 PURPOSE

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 SCOPE

The procedures and management options for the different categories of IDW described in this document are to be used by field personnel to manage IDW generated during site investigations. On the occasion that field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use. The scope of this Standard Operating Practice (SOP) is to define the procedural requirements for managing and sampling investigative derived waste (IDW) generated during the site investigation process while striving for three goals:

- **Minimization:** All site investigations shall be conducted in such a way as to generate the least amount of IDW. Every effort will be made to return as much material to the site of generation as is permitted by law and is protective of personnel and the environment.
- **Management:** The IDW that cannot be disposed of onsite shall be managed in a manner consistent with the final method of remediation of the site, if known. If the final remediation method for the site is not known, the IDW generated will be managed, stored, transported, and disposed of in a manner consistent with all appropriate laws and regulatory requirements.
- **Mediation:** Each site and each sponsor is unique. The most important goal is to assist each sponsor in successfully negotiating with the controlling regulatory agencies. This negotiation should result in an IDW handling method that is the most time efficient, cost effective, and appropriate. The IDW handling method must also be in accordance with all regulations and cause the least adverse impact to the facility, the community surrounding the facility, and the environment.

1.3 DEFINITIONS

Investigation Derived Waste: wastes that are generated from field investigation activities, approved and overseen by DEQ or EPA, specifically designed to determine the nature and extent of contamination. IDW is typically generated during the site assessment or remedial investigation and feasibility study stage of a cleanup. The critical determination to be made prior to categorizing waste as IDW is whether the waste was generated from an activity which determines the nature and extent of contamination. IDW includes, but is not limited to: drilling mud, cuttings, and purge water from test borings and well installation; purge water, soil and other materials from collection of samples; contaminated personnel protective equipment, and solutions used to decontaminate non-disposable protective clothing and equipment used during field investigation activities. IDW does not include wastes that are generated from actual removal or remedial activities.

Personal protective equipment: Safety equipment that workers wear or use to prevent injury on the worksite. PPE includes, but is not limited to, gloves, Tyvek suits, and safety glasses.

Onsite: within the property or facility boundaries as defined in the project specific Quality Assurance Project Plan (QAPP) and/or Work Plan.

1.4 REFERENCES

U.S. Environmental Protection Agency, Memorandum, *Discharge of Wastewater from CERCLA Sites into POTWs,* OSWER Directive 9330.2-04, April 15, 1986.

U.S. Environmental Protection Agency, *Guidance on Remedial Actions for Superfund Sites with PCB Contamination,* Office of Emergency and Remedial Response, EPA/540/G-90/007, August 1990.

U.S. Environmental Protection Agency, *CERCLA Compliance with the CWA and SDWA*, Fact Sheet 9234.2-06/FS, Office of Solid Waste and Emergency Response, February 1990.

U.S. Environmental Protection Agency, *Management of Investigation Derived Waste*, Superfund Publication 9345.3-02FS, Office of Solid Waste and Emergency Response, February 1991.

U.S. Environmental Protection Agency, *Management of Investigation Derived Waste During Site Inspections,* OSWER Directive 9345.3-02, Office of Solid Waste and Emergency Response, May 1991.

U.S. Environmental Protection Agency, Superfund LDR Guide 5, *Determining When LDRs Are Applicable to CERCLA Response Actions,* OSWER Directive 9347.3-05FS, June 1989.

U.S. Environmental Protection Agency, 40 CFR, Parts 261.20 through 261.33.

1.5 REQUIREMENTS AND RESOURCES

Equipment required for characterizing and handling the material includes:

- Field screening equipment such as a photoionization detector (PID), organic vapor analyzer (OVA), and/or an onsite gas chromatograph (GC).
- Personal protective equipment. Level of protection is based on the type and expected concentration of contaminants. The minimum protective equipment includes Occupational Safety and Health Act approved hard hat, safety glasses, protective gloves, and hard toed boots or shoes.
- Sample collection equipment. The type required is dependent on the waste type as well as the container type.

2.0 PROCEDURES

2.1 INVESTIGATION DERIVED WASTE CHARACTERIZATION

The first step in selecting the method of material handling to use at a site is to determine the potential contaminants of concern by reviewing site records, information gathered during the Preliminary Assessment/Site Inspection, Hazard Ranking System scoring, and interviews with persons knowledgeable about activities at the site. Early sampling results also can be used to indicate whether the wastes generated will exhibit hazardous characteristics. Published Environmental Protection Agency (EPA) guidance [EPA, Office of Solid Waste and Emergency Response (OSWER) Directive 9345.3-02, *Management of Investigation Derived Waste During*

Site Investigations, May 1991] discourages the containerizing and sampling of IDW just to establish hazardous components because of the resulting increase in investigation costs.

The next step in selecting the material handling method is to establish which federal, state, or local regulations apply to the material and which are the corresponding ARARs. Establishing the status of the IDW with regard to RCRA is critical. A waste material is hazardous under RCRA if it exhibits one of four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 *Code of Federal Regulations* (CFR) 261.20 through 261.24. Identified contaminants may also be considered hazardous under RCRA if they are listed in 40 CFR 261.30 through 261.33. EPA guidance [EPA, Office of Solid Waste and Emergency Response Directive 9345.3-02FS, *Management of Investigation Derived Waste*, February 1991] states it is permissible to handle a material as nonhazardous with regard to RCRA until it is proved to be a RCRA hazardous waste material. Nevertheless, if available information and best professional judgment indicate that, to maximize protection, a material should be managed as RCRA hazardous waste, regardless of known status, RCRA Subtitle C requirements should be followed.

Even if a material is not considered hazardous waste under RCRA, it may still contain hazardous contaminants regulated by federal, state, and local laws and regulations. It is the responsibility of the sponsor to determine the status of the material as it relates to RCRA and other statutes. Other potential ARARs include the Clean Water Act, which contains the requirements for the discharge of aqueous IDW to surface water and treatment facilities, and the Toxic Substance Control Act, which contains the requirements for handling IDW contaminated with polychlorinated biphenyls (PCBs) in concentrations of 50 parts per million (ppm) or greater.

After the potential contaminants are identified, it is the responsibility of the client to consult the appropriate state and federal regulatory agencies to ensure all local, state, and federal laws and regulations are followed. The IDW issue must be addressed and resolved for each project before initiating field activities.

2.1.1 Placement of Wastes

If there is any possibility of the waste material containing a RCRA hazardous substance and being restricted under the Land Disposal Restrictions (LDRs), the material must not be "placed." To assist in defining "placement" at CERCLA sites, EPA uses the concept of Areas of Contamination (AOC). EPA Superfund LDR Guide 5 states, "An AOC is delineated by the areal extent (or boundary) of contiguous contamination. Such contamination must be continuous, but may contain varying types and concentrations of hazardous substances." *[Determining When LDRs Are Applicable to CERCLA Response Actions*, Office of Solid Waste and Emergency Response (OSWER) Directive No.9347.3-05FS, June 1989].

Placement as defined by EPA occurs when waste material:

- is moved offsite,
- is moved out of an AOC for treatment or storage then returned to the same or a different AOC and returned to the environment,
- is stored in a container within the AOC then returned to the same AOC and returned to the environment, or

- is consolidated from several AOCs into a single AOC and returned to the environment.

If placement does not occur, the LDRs are not applicable to the CERCLA action regardless of the contaminants in the material. Therefore, before containerizing material or moving it outside an AOC, the status of the material, as it relates to RCRA and the LDRs, must be determined.

2.2 GENERATION AND HANDLING OF INVESTIGATION DERIVED WASTE

All the IDW will fall into one of four categories:

- non-RCRA regulated (nonhazardous),
- non-RCRA regulated (hazardous),
- RCRA regulated (nonhazardous), or
- RCRA regulated (hazardous).

2.2.1 Non-RCRA Regulated Materials

Waste materials that do not exhibit one of the four characteristics (ignitability, corrosivity, reactivity, or toxicity) as defined in 40 CFR 261.20 through 261.24 or do not contain contaminants listed in 40 CFR 261.30 through 261.33 are not regulated under RCRA.

Provision should be made for those cases in which it is logistically more convenient for the project team to move the waste material to a central collection point for storage before determination of disposal method. Should this be necessary, extreme care must be exercised to segregate those materials that field screen "clean" from those that show contamination.

Any and all containers in which IDW is stored must be clearly labeled as to the contents, the locations at which the material was generated, the date, and a person to contact including the telephone number. There may also be facility specific labeling requirements. At no time shall a container be labeled as containing hazardous material until a determination is made as to whether the material is hazardous.

In any case, the material must be removed from public access and stored in clean, sealed containers at a single, secure collection point at the facility until a final disposal method is determined. No IDW shall be removed from the facility or released to the environment without permission from the client and the controlling regulatory agencies.

2.2.1.1 Soils

Soils include drill cuttings, surface soils, and sediments. For drilling operations, drilling cuttings will be contained in 55-gallon drums, on plastic sheeting, or in other suitable containers pending characterization and disposal. Alternatively, permission may be sought from the controlling regulatory agencies to bury drill cuttings in shallow pits lined with plastic sheeting and installed directly adjacent to the borings. If waste characterization indicates the soil is not contaminated, it may be spread on the ground. At the conclusion of drilling operations, these pits will be covered by surface soils and reseeded either by the drilling contractor or the facility. The location and size of the pits will be included in the field logbook and in the report of the investigation for future reference. Surface soils and sediments, in excess of sampling requirements, will be returned directly to their source point. For test pits, the soil will be stockpiled onsite (on plastic sheeting, covered by plastic sheeting) adjacent to the excavations and used to refill the pits when sampling is completed. Test pits can then be covered with surface soils and reseeded. These procedures are in accordance with published EPA guidance (EPA, OSWER Directive No.9345.3-02, May 1991; *Management of Investigation Derived Waste During Site Inspections).* The logic for using this method is threefold: (1) it eliminates the moving and costly sampling of soils; (2) the problem of what to do with drums or stockpiles of soils is eliminated; and (3) if contamination is subsequently identified in the soil samples from the boring, the pit of drill cuttings can be addressed during the remediation process for the overall site.

Soils containing only volatile contaminants for which onsite burial is not allowed or is logistically inconvenient will be field screened with an OVA or comparable field screening instrument. It is preferred that representative samples also be analyzed by an onsite GC if possible. Before initiating the field effort, it will be necessary to negotiate a field screening action level with the controlling regulatory agencies.

Soils that field screen less than the established field screening limit can (with the approval of the controlling regulatory agencies) either be spread back on the site or taken to a central collection point for disposal at the facility. Soils that screen higher than the established field screening limit will be collected and segregated either at the site or at a central collection point. These soils will be stockpiled in an area lined with, and covered by, plastic sheeting (preferably black to resist breakdown of the plastic from exposure to sunlight) or placed in sealed, labeled containers.

Soils in which the contaminants of concern are such that they would not register on the field screening equipment (e.g., metals, semivolatiles) must be stockpiled either onsite or at a central collection point in a plastic lined and plastic covered area and held until the results of the sample analyses have been received. The results of these analyses can be used to indicate the status of the soils.

If no soil samples are collected when drilling (e.g., while installing monitoring wells) and screening indicates possible contamination or is inconclusive, a representative sample will be collected from the cuttings and analyzed for the contaminants of concern. While awaiting the results of these analyses, the material should be stockpiled onsite in a plastic lined and plastic covered area, placed in labeled containers or, if moved to a central collection point, kept segregated from other material until contaminant levels are established. Labels should include a contact name and telephone number. If analytical results are below established ARARs, the soils can be spread back on the site or used by the client as fill material with the regulatory agencies' permission. If analytical results show levels of contamination exceeding established ARARs, the onsite treatment facility should be used, if available, or the material shall be containerized and disposed of as directed by the client.

2.2.1.2 Fluids

Fluids include drilling fluids, development/purge water, and decontamination fluids. For areas in which there is no indication of contaminants that are RCRA regulated, permission will be sought from the controlling regulatory agencies to allow the development and purge waters generated in the well installation and sampling process to be released into the sewer system of the facility. If the controlling agencies will not allow this action, or if there is any possibility of the fluids' being contaminated, all fluids will be containerized in labeled containers and stored at the site or at a central collection point. Labels should include a contact name and telephone number. Purged groundwater must always be containerized separately from decontamination fluids.

If no samples of the fluid have been collected for analyses at the end of the generation process, a representative sample of the fluid will be collected and analyzed for contaminants of concern. If analytical samples were collected (such as from a monitoring well), the results of these analyses can be used to indicate the status of the fluids. The object of these analyses is to gather enough data to obtain written permission from the controlling regulatory agencies to release the fluids into the storm water collection or sanitary sewer systems at the facility. If analytical results show levels of contamination exceeding established ARARs, the fluid can be treated by using the onsite water treatment facility (if available), or the IDW shall be disposed of as directed by the client.

2.2.1.3 Personal Protective Equipment

Personal protective equipment (PPE) includes all gloves, Tyvek® suits, and other disposable equipment. All PPE that cannot be adequately decontaminated to permit safe reuse will be double plastic-bagged, collected, and placed in an approved industrial waste bin.

2.2.2 RCRA Regulated Materials

A waste material is regulated under RCRA if it exhibits one of four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.20 through 261.24 or the identified contaminants as listed in 40 CFR 261.30 through 261.33.

2.2.2.1 Soils

Soils include drill cuttings, surface soils, and sediments. For areas in which there are known or suspected RCRA-regulated contaminants, permission will be sought from the controlling regulatory agencies to bury disturbed soils in shallow, plastic lined pits onsite, cover them with surface soils, and reseed. The location and size of the pits will be included in the field logbook and project reports for future reference. This procedure is in accordance with published Environmental Protection Agency (EPA) guidance (EPA, OSWER Directive 3945.3-02, May 1991, *Management of Investigation-Derived Waste During Site Inspections).*

If onsite burial is not permitted or is logistically inconvenient, soils will be field screened for volatile contaminants as described above and stockpiled at the site in an area lined with, and covered by, plastic sheeting, preferably black to resist breakdown of the plastic from exposure to sunlight. Stockpiling the soil at the site without containerization will prevent placement (as defined by EPA) from occurring and thus avoid activating potential land disposal restrictions. Soils that field screen less than the established field screening limit can be spread back on the site with the approval of the controlling regulatory agencies.

If it is logistically impossible to stockpile the material at the site, or if contaminants are such that field screening would be inconclusive, the material shall be collected in approved containers, preferably a steel roll-off box. These containers must be labeled as to the contents, the date(s) of collection, and the location at which the material was generated. If the IDW will be submitted to a disposal facility, representative samples will be collected and submitted to an approved laboratory to be analyzed for ignitability, corrosivity, reactivity, and for Toxicity Characteristic Leachate Procedure, as well as any other contaminants requested by the controlling regulatory agencies.

If the results of the analyses are below established ARARs, the soils can be spread back on the site or used by the client as fill material with the regulatory agencies' permission. If analytical results indicate the IDWs are RCRA regulated, the approved onsite treatment facility should be used (if available), or the containers shall be disposed at an RCRA permitted disposal/treatment facility (TSD). RCRA regulated IDW may remain stored onsite for the time period allowed by the client's generator status. State time requirements may be slightly different so be sure to check with the state regulatory agency.

- **Large Quantity Generator** (>1,000 kg hazardous waste per month): 90 days.
- **Small Quantity Generator** (100-1,000 kg hazardous waste per month): 180 days or 270 days if TSD is greater than 200 miles away.
- **Conditionally Exempt Small Quantity Generator** (<100 kg hazardous waste per month): no time restrictions.

2.2.2.2 Fluids

Fluids include drilling fluids, development/purge water, and decontamination fluids. For areas in which known or suspected RCRA-regulated contaminants exist, all fluids will be containerized in properly labeled containers (i.e., drums or tanks) and stored at the site. At the end of the generation process, if no samples of the fluids have been collected, a representative sample will be collected and analyzed for contaminants of concern. If analytical samples were collected (such as from a monitoring well), the results of these analyses can be used in place of collecting and analyzing additional samples to indicate the status of the fluids. If analytical results show levels of contamination below established ARARs, the fluids can be released to the storm water or sanitary sewer system of the facility with the controlling regulatory agencies' approval. If analytical results indicate the IDW is RCRA regulated or other contaminants are present at levels exceeding established ARARs, the onsite treatment facility should be used (if available), or the containers shall be disposed of at a RCRA TSD Facility.

RCRA regulated IDW may remain stored onsite for the time period allowed by the client's generator status. State time requirements may be slightly different so be sure to check with the state regulatory agency.

- **Large Quantity Generator** (>1,000 kg hazardous waste per month): 90 days.
- **Small Quantity Generator** (100-1,000 kg **hazardous waste** per month): 180 days or 270 days if TSD is greater than 200 miles away.
- **Conditionally Exempt Small Quantity Generator** (<100 kg hazardous waste per month): no time restrictions.

2.2.2.3 Personal Protective Equipment

PPE includes all gloves, Tyvek® suits, and other disposable equipment. All PPE that cannot be adequately decontaminated to permit safe reuse will be double plastic-bagged, collected, and placed in approved containers at a central collection point. These containers will then be disposed of at a RCRA TSD Facility.

2.3 INVESTIGATIVE-DERIVED WASTE DISPOSAL OPTIONS

Table 5.1 presents various disposal options for the five most common types of IDW.

Table 5.1. Investigative-Derived Waste Disposal Options

Type of IDW	Generation process	Disposal options
Soil	Borehole drilling Test pits Surface soil sampling	Consolidate in a pit (within the Area of Contamination) Return to pit immediately after generation Spread around boring/pit Send to an existing onsite treatment/disposal unit (TDU) Containerize and dispose of appropriately Store for future disposal
Sludges/sediments	Sludge pit Sediment sampling	Return to pit immediately after generation Containerize and dispose of appropriately Store for future disposal
Aqueous liquids	Well installation Well purging during sampling/development and pump/treat tests	Pour onto ground Send to Publicly Owned Treatment Works (POTW) or facility treatment works Send to existing TDU Store for future disposal
Disposal personal protective equipment (PPE)	Sampling procedures	Send to onsite TDU Place in onsite industrial dumpster Containerize and dispose of appropriately Store for future disposal
Decontamination fluids	Decontamination of PPE and other equipment	Send to onsite TDU Containerize and dispose of appropriately Store for future disposal

2.3.1 Onsite Disposal

This option should never be used when the release of IDW to the surface of the site could degrade surface conditions (e.g., contaminated well water poured on clean surface soil or contaminated soils from depth spread on an uncontaminated surface).

Two questions must be answered before using this option:

- Is returning the waste to the generation site the safest and most protective method for personnel and the environment?

  For example, returning potentially contaminated soil excavated from sampling pits may not be protective if the site is in a residential area or if access to the site cannot be tightly controlled. If wastes contain highly toxic constituents or high concentrations of constituents, they may endanger workers or the environment if returned to their source without access restrictions or a cover (e.g., exposure to air could volatilize certain chemicals).

- Is returning the waste to the generation site allowed by the controlling regulatory agencies?

  Written permission should be obtained from both state and federal regulatory agencies before releasing the material back to the environment. Releasing this material without the permission of the controlling regulatory agencies could be construed as an uncontrolled release of a regulated waste and cause the client and the person or persons releasing the material to spend a great deal of time and money re-collecting it and paying fines. This permission should be obtained by developing sampling criteria and critical contaminant levels with the regulators before initiating the field effort. Unfortunately, there are currently no standard contaminant concentration levels applicable for all contaminants everywhere, so sampling criteria and critical contaminant levels must be negotiated with the controlling regulatory agencies on a case-by-case basis.

If both of these considerations are met, the preferred method of waste disposal is to return the waste to the site of generation through burying cuttings adjacent to borings, spreading cuttings onsite, returning sludges and residues to holding pits, releasing purged well waters to surface of site, or other methods. This method reduces the volume of waste to be moved and at the same time helps to limit the spread of contamination offsite.

2.3.2 Onsite Treatment

If onsite disposal of the material is not permitted, a method of treating the material onsite, or at a central location at the facility, should be selected. It should be recognized that the effectiveness of a treatment method is a function of the suite of contaminants involved and, therefore, must be chosen on a case by case basis. In addition, approved treatment methods will vary from state to state, and a list of approved methods should be obtained from the controlling regulatory agencies. In any case, a preferred treatment option should be established before initiating field operations.

2.3.3 Offsite Disposal

If onsite disposal is prohibited and no treatment method is viable or permitted, the alternative would be to have the material handled under the waste disposal contracts in place at the facility. Because this would likely mean the use of either sanitary or hazardous waste landfills for disposal, it is the least attractive option on the basis of cost, environmental stewardship, and future potential liability for the sponsor. In addition, in the case of RCRA hazardous materials, the client's RCRA waste-generating status must be kept in mind and the permitted amounts of RCRA waste must not be exceeded as a result of an influx of IDW from site investigations.

3.0 RESPONSIBILITIES

Sullivan International Group: Sullivan is responsible for the identification of potential contaminants and for the characterization of IDW. The ultimate responsibility for proper determination of IDW waste status and proper disposal lies with the client.

Site Manager: The Site Manager, or Field Team Leader, is responsible for ensuring that field activities are completed to meet the project objectives, are conducted in accordance with the project plans and requirements, and all activities are performed according to the respective procedures. The Site Manager is responsible for ensuring all site personnel are trained in the procedures, the procedures are adhered to, and all activities are documented.

Field Team: All members of the field team (samplers, technicians, field geologists, engineers, etc.) are responsible for understanding and implementing this field procedure as well as ensuring all team members also perform work in accordance with this procedure.

Client: The client (e.g., USACE, USEPA) is responsible for establishing the status of the waste material as it relates to federal, state, and local regulations. Designated representatives of the client are responsible for signing all invoices, manifests, and bills of lading to transport and for dispose of waste material.

It is the responsibility of all field personnel to identify, document, and submit recommendations to improve the quality, usability, and implementability of this procedure.

4.0 RESTRICTIONS/LIMITATIONS

This Standard Operating Practice does not address those areas in which material contains radionuclide contamination. Should this be suspected, a health physicist must be involved to develop waste handling procedures and onsite to monitor activities at all times.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

PACKAGING AND SHIPPING SAMPLES

SOP NO. 019

REVISION NO. 6

December 2008

K Riesing

Quality Assurance Approved

December 18, 2008

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 four primary agencies that have regulatory or advisory guidelines: (1) the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR, *Code of Federal Regulations*, Title 49 [49 CFR] Parts 106 through 180); (2) the International Air Transportation Association (IATA) Dangerous Goods Regulations (DGR); (3) International Civil Aviation Organization (ICAO), which provides technical instructions for safe transportation of hazardous materials (dangerous goods) by air; and (4) United Nations (UN) “Recommendations of the Committee of Experts on Transport of Dangerous Goods.”

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, the HMR, ICAO, and UN. 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 2008).

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 2008). 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 (DOT). 2007. Code of Federal Regulations, Title 49, Parts 171 through 180, especially Parts 171 (general), 172 (table, emergency response, and so on), and 173 (for shippers). Available from http://www.access.gpo.gov/nara/cfr/cfr-table-search.html#page1. Updated annually, late in the year or early in the following year.

DOT. 2008. “Hazardous Materials Table”. (49 CFR 172.101 Table) Available on-line from http://phmsa.dot.gov/hazmat/library. Updated irregularly.

DOT. 2008. “Emergency Response Guidebook”. Available on-line at http://phmsa.dot.gov/hazmat/library/erg. Updated annually.

Federal Express. 2008. “Dangerous Goods Shipping”. Available on-line from http://www.fedex.com/us/services/options/dangerousgoods/index.html. Note especially “Declaration Forms”, which can be filled out on-line or downloaded for future use, and “Resources”, which includes the “Dangerous Goods Job Aid” on how to fill out the form, mark the package, and so on, the “Shipping Checklists” and the 1-800 numbers for assistance.

International Air Transport Association (IATA). 2008. “Dangerous Goods Regulations. 2009”. For sale at http://www.iata.org/ps/publications/dgr.htm. Updated annually, with new edition available late in year.

U.S. Environmental Protection Agency. 2007. “Contract Laboratory Program Guidance for Field Samplers”. EPA 540-R-07-06. Available on-line at http://www.epa.gov/superfund/programs/clp/download/sampler/clp_sampler_guidance.pdf. July.

The following additional in-house resources are also available:

Email: Contact either the TtEMI Health & Safety Director and the Regional Safety Officers at EMI.HASPApprovers or your Office Health and Safety Representative (all are included at EMI.HealthSafety).

On-line: TtEMI Intranet Page “Dangerous Goods Shipping” at http://home.ttemi.com/C14/Dangerous%20Goods%20Shipping/default.aspx. Includes the “Dangerous Goods Shipping Manual”, various “Emergency Response Guide” excerpts, and other information, updated regularly.

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 Peroxides

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 Materials

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 1, explosives, includes any chemical compound, mixture, or device that by itself is capable of chemical chain reaction sufficient to produce a substantial, instantaneous release of gas, heat, and/or pressure. Tetra Tech does not ship substances that fall under this class.

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. DOT defines flammable liquids as substances with a flash point less than 140 °F. Most class 3 samples include solvents, oil, gas, or paint-related material collected from drums, tanks, or pits.

Class 4 are flammable solids; substances liable to spontaneous combustion; and substances which, in contact with water, emit flammable gasses. Tetra Tech does not ship substances that fall under this class.

Class 5, oxidizers and organic peroxides, include substances that readily yields oxygen, which may result in the ignition of combustible materials. Organic peroxide is combustible and reacts as an oxidizer in contact with other combustible materials. By itself, an organic peroxide can be flammable or explosive. Tetra Tech does not ship substances that fall under this class.

Division 6, toxic and infectious 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. Tetra Tech does not ship substances that fall under this class.

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 [:Ci/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 (bottom and sides) 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 top 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 absorb 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; identification number; and name, address, and phone numbers 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. Four copies of the Shipper’s Declaration are required and it must be typed. 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 ___
- Shipper’s reference number (project number)
- 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.

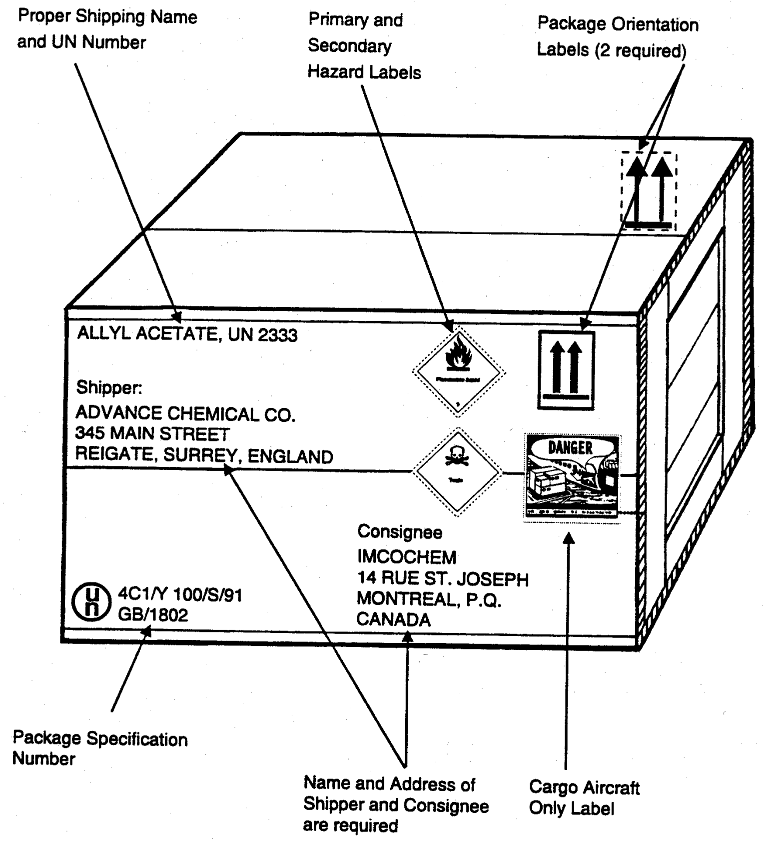
- Improper labeling and marking of package. If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment.

- 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.

Also contact Tetra Tech health and safety representatives using the website identified on Page 3 of this SOP.

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

Filling Out the FedEx Dangerous Goods Airbill

- The Dangerous Goods Airbill has two sections
    - The top section of the page is the airbill portion.
    - The bottom section is the Shipper's Declaration for Dangerous Goods.
- The sender *must complete* the following fields on the pre-printed airbill:
    - Section 1: Date
    - Section 1: Sender's Name
    - Section 7: Total Packages
    - Section 7: Total Weight
- Declaration for Dangerous Goods:
    - Under the section labeled "Proper Shipping Name" fill in the infectious substance (i.e., HIV, HCV, etc.) in the parentheses.
    - Under the "Quantity and Type of Packing" section, fill in the amount of specimen in the box (in mls).
    - List an emergency telephone number in the space provided at the bottom of the airbill.
    - Sign and date the airbill in the bottom right corner.

IMPORTANT: You must follow explicitly all packaging and labeling instructions for shipping infectious substances. Correct spelling and legibility are important. Otherwise, your package will be delayed or may be rejected by FedEx.

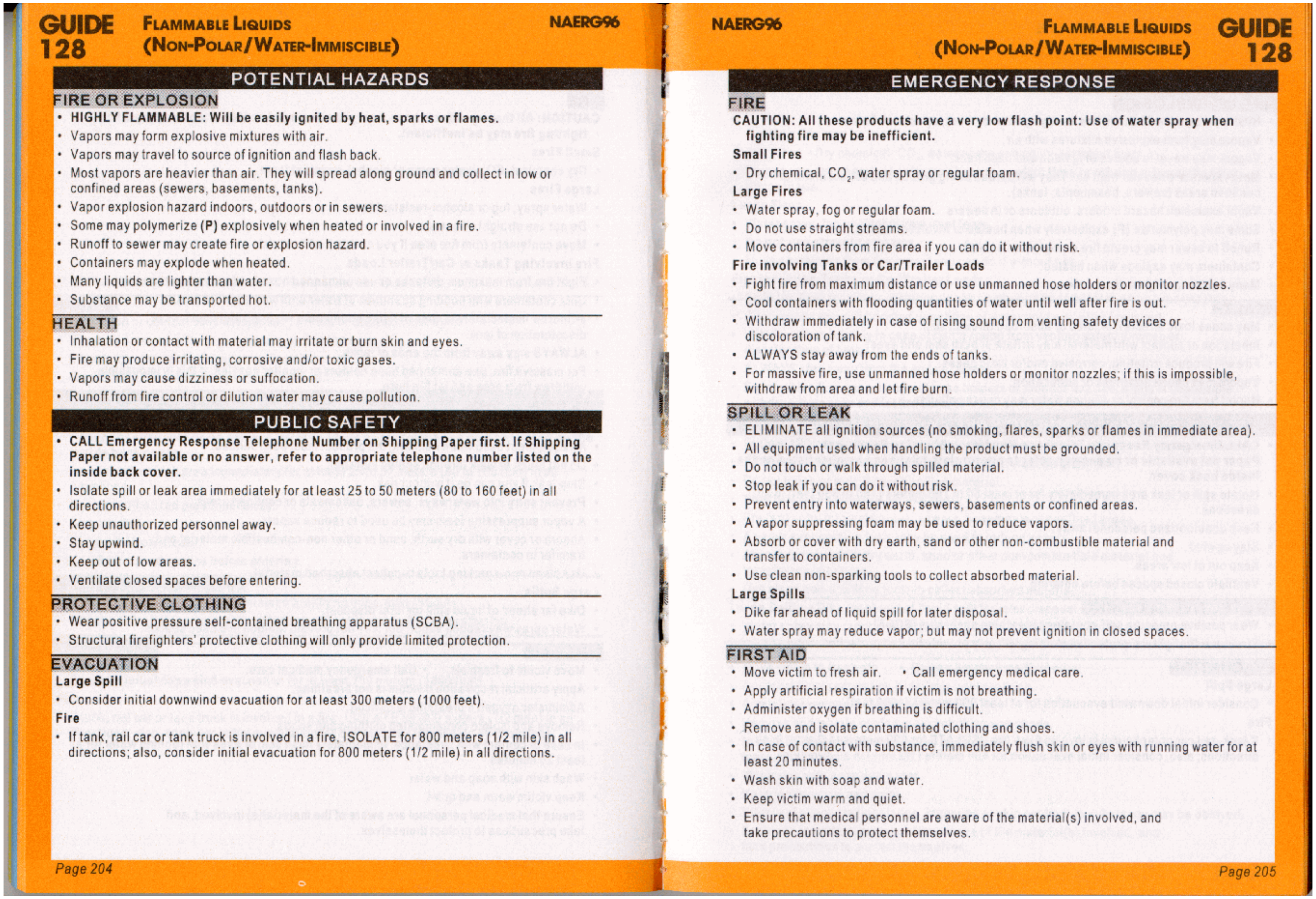
FedEx Dangerous Goods Airbill

Sender's Copy

The World On Time.

FOR SHIPMENTS WITHIN USA, AK, AND HI ONLY

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.

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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.

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Source: DOT and others. 1996.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

SOP NO. 020

REVISION NO. 4

Last Reviewed: April 2009

KRiesing

Quality Assurance Approved

May 21, 2009

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, over both the short and the long term, (2) collecting groundwater samples representative of in situ aquifer chemical characteristics, (3) conducting aquifer testing, and (4) measuring water levels for determining groundwater potentiometric head and groundwater flow direction.

This standard operating procedure (SOP) focuses on common methods and minimum standards for oversight and documentation of monitoring well installation for Tetra Tech EM Inc. (Tetra Tech) projects. Detailed specifications for well design and installation may vary in response to site-specific conditions; however, some elements of well installation are common to most situations. Well installation conducted according to this SOP will have complete and approved construction specifications, usually in a work plan or site-specific field sampling plan. In most cases, Tetra Tech will provide oversight and documentation of the well installation process conducted by a drilling subcontractor. This SOP is based on widely recognized methods described by the U.S. Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM). In addition, monitoring wells should be designed 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).

An experienced and knowledgeable person (preferably a hydrogeologist) will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the groundwater. Personnel installing wells should work under the supervision of a registered professional, and the requirements of the state where the work is being performed should be followed as to the specific requirements for the registered professional and his or her level of involvement and oversight.

The following types of monitoring well materials, installation procedures, and record-keeping requirements are included in this SOP:

Monitoring well materials

- Casing materials
- Well screen materials
- Filter pack materials
- Annular sealant (bentonite pellets or chips)
- Grouting materials
- 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

Record-keeping procedures

- Surveying
- Permits
- Well construction and borehole logging
- Monitoring well identification

Well installation methods will depend to some extent on the borehole drilling method. Specific boring or drilling protocols are detailed in other SOPs. The boring method, in turn, will depend on site-specific geology, hydrogeology, and project requirements. Drilling methods commonly used for well installation include hollow-stem augering, cable tool, mud-rotary, air rotary, air casing hammer, sonic, and rock coring.

1.1 PURPOSE

This SOP establishes the requirements and procedures for monitoring well installation and associated documentation. 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 the 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 construction details are documented in a standardized format.

1.2 SCOPE

This SOP applies to the oversight and documentation of monitoring well installation. 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 026 for borehole logging, 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 or conductor 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: Clean 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. 2004. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers. D5092-04. West Conshohocken, Pennsylvania.

California Department of Toxic Substances Control. 1995. Monitoring Well Design and Construction for Hydrogeologic Characterization. Guidance for Groundwater Investigations. July.

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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. http://www.epa.gov/swerust1/cat/wwelldct.pdf

EPA. 1992. RCRA Ground Water Monitoring Technical Enforcement Guidance Document. Office of Solid Waste and Emergency Response. Washington, DC. OSWER-9950-1. November.

EPA. 1994. Monitor Well Installation. Environmental Response Team SOP #2048 (Rev. #0.0, 03/18/96). http://www.ert.org

1.5 REQUIREMENTS AND RESOURCES

To conduct oversight and document the installation of a monitoring well, the person at the drill site should be a geoscientist or engineer who has relevant professional training and experience. The site geoscientist is responsible for oversight and documentation of all well installation activities. The site geoscientist shall understand the project objectives and regularly communicate from the field with the project manager or technical project team members. The site geoscientist shall verify that all permits are obtained, and that the well locations are cleared for overhead and underground utilities or other obstructions.

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 for example)

2.0 MONITORING WELL INSTALLATION PROCEDURES

For reference, 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 record-keeping requirements associated with monitoring well installation. Monitoring well design and 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. The riser, well screen, and filter pack and annular sealant placement equipment should be certified as clean by the manufacturer and delivered to and maintained in clean condition at the site. Where this is not possible, all materials or tools 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). 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 generally discusses material specifications for the following well construction components:

- Casing and well screen
- Filter pack
- Annular sealant (bentonite pellets or chips)
- Grout
- Tremie pipes
- Surface completion components (protective casing, lockable and watertight cap, and padlock)
- Concrete surface pad
- Uncontaminated water

Figures 2A and 2B shows the construction details of a typical monitoring well, with above grade or flush mounted surface completion, respectively.

2.1.1 Casing Materials

The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. 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 best 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.

The minimum internal diameter of the well screen should be chosen based on the particular application. A minimum inside 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. This determination is often made in the field based on the grain size and distribution of borehole material encountered.

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 groundwater sampling. The procedure for determining the grain size and gradation of the filter pack is to be presented in each site-specific field sampling plan or work plan. 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 the protective casing. A watertight 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 watertight protective cover of sufficient strength to withstand heavy traffic. The well riser should be fitted with a locking watertight 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 protective casing is 4 inches in diameter, the concrete pad should be 3 feet square and 4 inches thick. If the well casing is 8 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 above grade, with the edge tapered to match the existing grade.

If the monitoring well is located in a high-traffic area and finished at surface grade, a traffic-bearing, flush-mounted cover should be used whenever possible. For wells finished with protective casing above grade, a minimum of three bumper posts (bollard) should be installed around the pad to protect the well. The 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 tops of the posts should be capped or filled with concrete. Bumper posts are not required for flush-mounted monitoring wells.

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 or municipal tap water. 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

Screen length, depth, 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:

1. 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.

2. Wells with low recharge should have screens of sufficient length and diameter so that adequate sample volume can be collected.

3. Wells should be screened over sufficiently short intervals to allow for monitoring of discrete migration pathways.

4. 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.

5. 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.

6. The screened interval should not extend across an aquiclude or aquitard.

7. 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.

8. 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.

9. 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.

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 slot size and well pack material are determined based on the specifications described in the work plan. The well-screen slot size can only be selected after the filter pack grain size is specified. In monitoring wells, the well screen should retain 90 to 100 percent of the filter pack sands. Cumulative weight percent vs. grain size in thousandths of an inch (standard size for screen slots) of the selected filter sand is used to select the appropriate screen size.

Next, the screen and riser are 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 the riser pipe. Progressively lower the assembled length of pipe.
4. The length of the assembled pipe should not extend above the top of the drill rig or be longer than the lateral extent of fall protection surrounding the drill rig as a safety precaution.

The well sump or cap, well screen, and riser should be certified clean by the manufacturer or should be decontaminated before assembly and installation. Flush joints should be tightened, and welds should be watertight 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 to allow for compaction during well development.
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, the secondary filter pack must not extend into an overlying hydrologic unit. An on-site geoscientist 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 weighted 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. Should collapse occur, re-drilling of the borehole to remove collapsed material will be necessary.

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 or pumping 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 watertight 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 approximately 1 inch, 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. Figures 2A and 2B show above grade and flush mounted completion details.

2.2.7 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. Conductor casing is then anchored in the underlying impermeable layer (aquitard) by advancing the casing at least 1 foot into the aquitard and grouting the annular space between the conductor casing and borehole from the bottom of the casing to the surface. After the grout has cured, a smaller diameter borehole is drilled through the conductor casing. 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 RECORD -KEEPING PROCEDURES

Record-keeping 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. Upon completion of the well installation the paperwork must be checked for completeness and technical accuracy by another qualified person as soon as practical.

2.3.1 Surveying

Although not a part of this SOP, the 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 elevations should be surveyed to the nearest one-hundredth of a foot.

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). Additionally, boring logs should be completed (SOP 026) 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 as specified in the field work plan. 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

DRILLING INFORMATION

RIG TYPE ________________________
DRILLING BEGAN:
DATE __________ TIME _________
BORING DIAMETER (in) ___________
BORING DEPTH (ft) _______________
WELL INSTALLATION BEGAN:
DATE __________TIME _________
WELL DEPTH (ft) _________________

ANNULAR SEAL

PORTLAND CEMENT (lbs) _____________
BENTONITE (lbs) ____________________
WATER (gal) ________________________
FROM (ft) __________TO (ft) ___________

BENTONITE SEAL

TYPE __________________________
BENTONITE (lbs) ________________
WATER (gal) ____________________
FROM (ft) ________TO (ft) _________

FINE SAND

SAND SIZE _____________________
SAND (lbs) _____________________
FROM (ft) ________TO (ft) _________

FILTER PACK

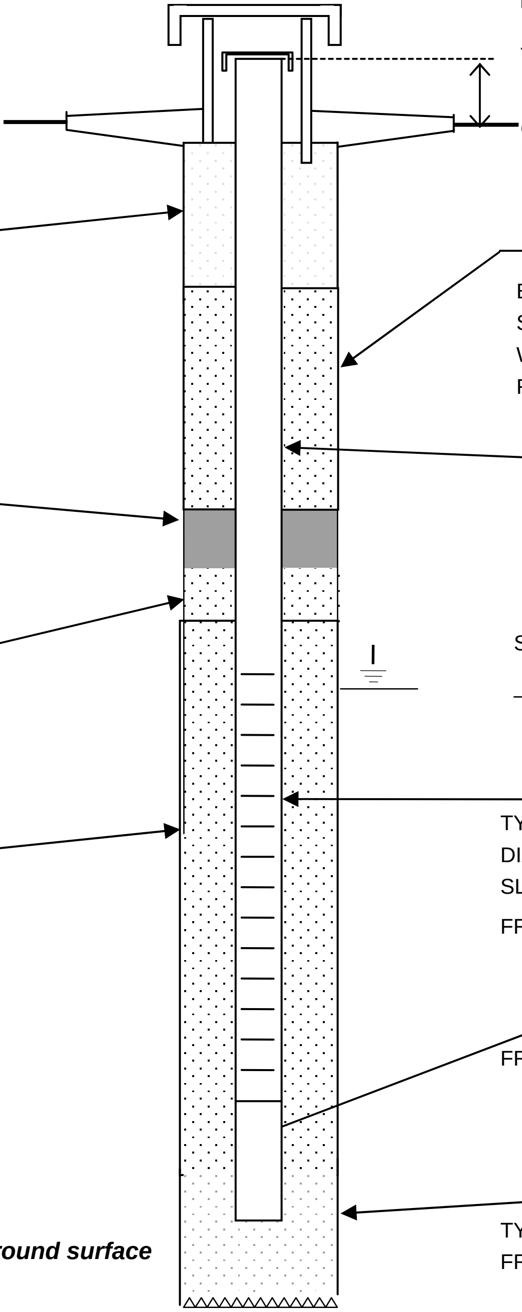
SAND SIZE ______________________
SAND (lbs) ______________________
FROM (ft) ________TO (ft) ________

CENTRALIZERS

INTERVALS ______________________
____

SURFACE COMPLETION

ABOVE GROUND W/ CRASH POSTS



MONITORING WELL

MONITORING WELL ID ___________
PROJECT ______________________
SITE ___________________________
BOREHOLE ID ___________________

TOP OF CASING (ft)

GROUND SURFACE ELEVATION (ft)

BENTONITE/SAND SLURRY

BENTONITE (lbs) ________________
SAND (lbs) _______________________
WATER (gal) _____________________
FROM (ft) _________TO (ft) __________

CASING

TYPE ____________________________
DIAMETER (in) _____________

STATIC WATER LEVEL (ft)
____

WELL SCREEN

TYPE __________________________
DIAMETER (in) __________________
SLOT SIZE (in) ___________________
FROM (ft) _________TO (ft) __________

SUMP

FROM (ft) _________TO (ft) __________

BOREHOLE BACKFILL

TYPE ____________________________
FROM (ft) _________TO (ft) __________

All measurements are in feet below ground surface except for well casing stickup

Notes____
____
____

FIGURE 2A

MONITORING WELL TYPICAL CONSTRUCTION DETAILS – ABOVE GRADE COMPLETION

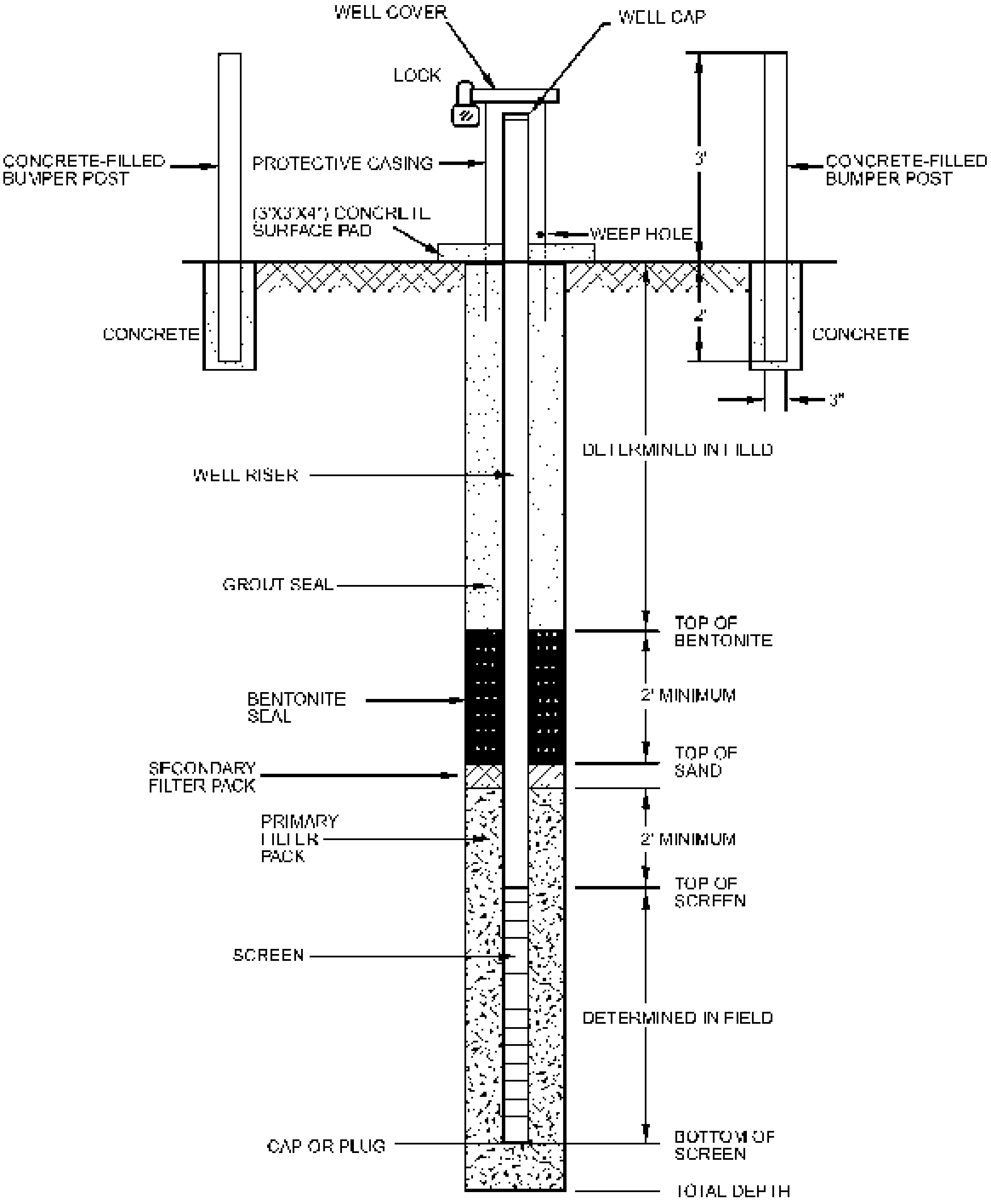


FIGURE 2B

MONITORING WELL TYPICAL CONSTRUCTION DETAILS – FLUSH MOUNTED COMPLETION

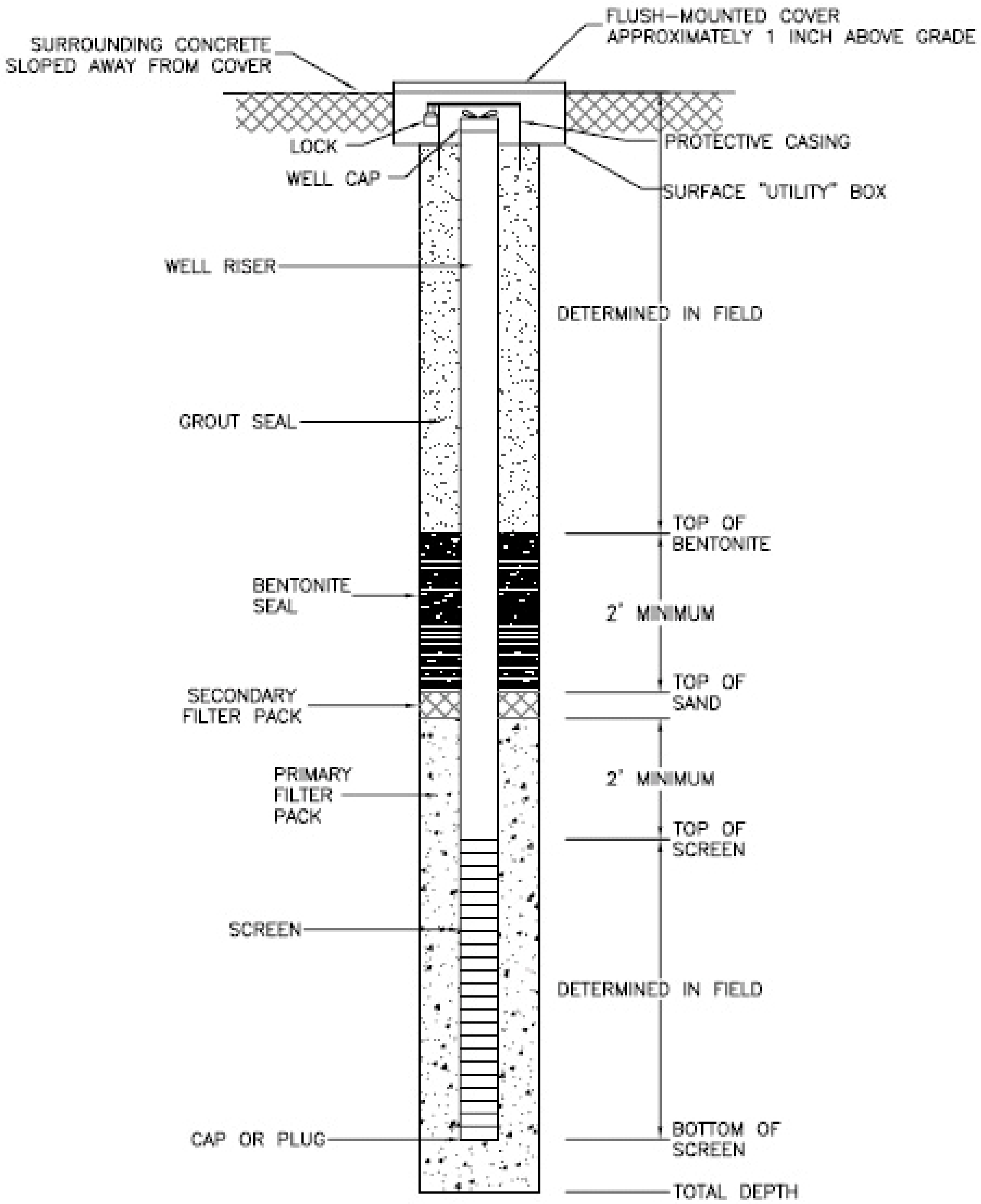
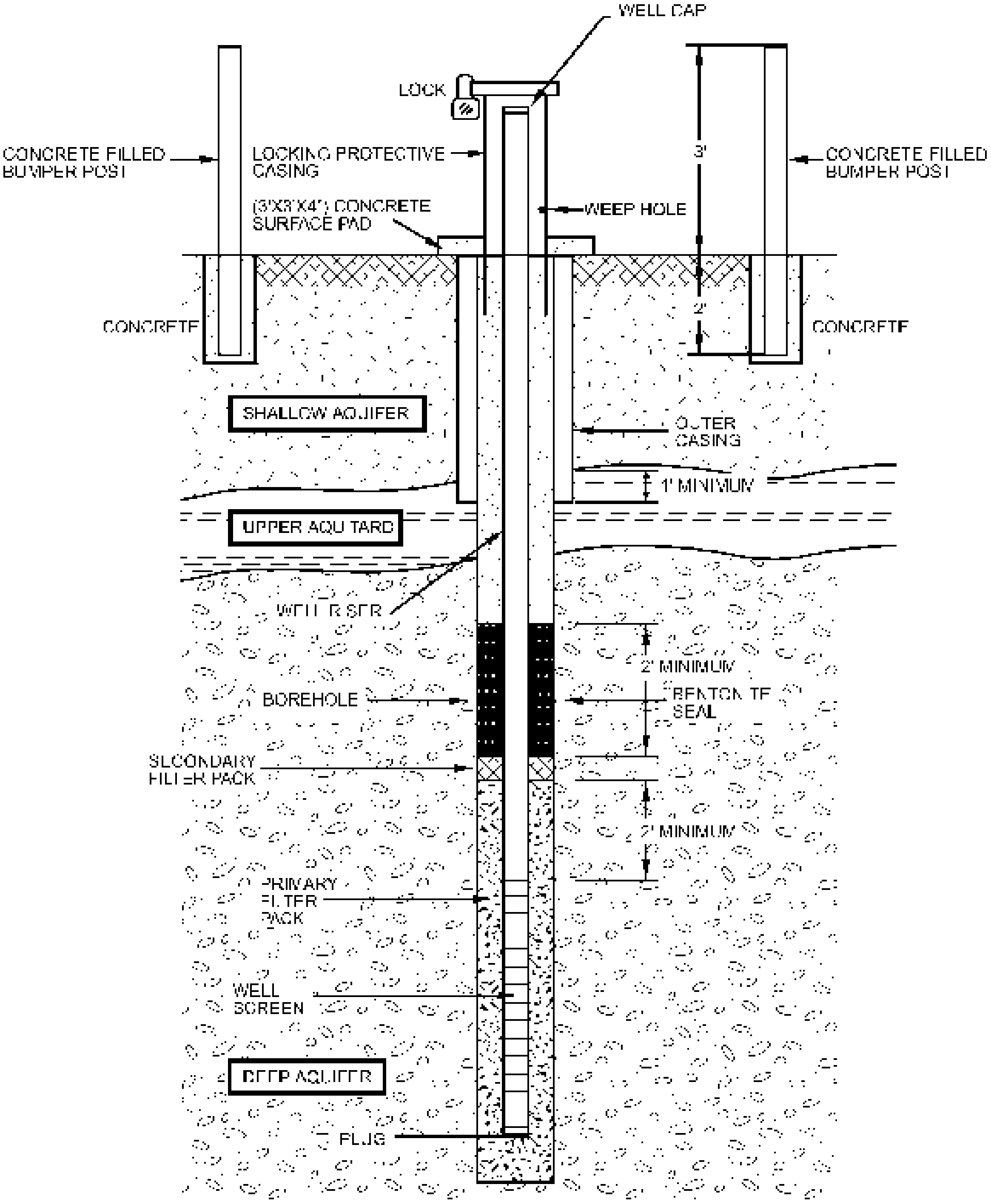


FIGURE 3

MULTIPLE CASING WELL CONSTRUCTION DIAGRAM



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

SOP NO. 021

REVISION NO. 4

Last Reviewed: June 2009

KRiesing
Quality Assurance Approved

06-19-09
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 mechanical surging, overpumping, air-lift pumping, backwashing, surge bailing, and well jetting; these methods can be used individually or in combination to achieve the most effective well development.

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 procedures 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

In most cases, well development is conducted by a drilling contractor with oversight and documentation by Tetra Tech. This SOP applies to the development of newly installed monitoring wells. The SOP identifies the most commonly used well development methods. Selection of a particular method or combination will depend on site conditions, equipment limitations, and other factors. The method selected and the rationale for selection should be described in the site-specific sampling plan or work plan. All modifications to proposed well development methods should be documented in a field logbook and/or Well Completion Record.

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.

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

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 pumping.

Surging: An uneven flow and strong momentum given to a fluid, as water in a tank, resulting in a rapid, temporary rise in pressure.

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.

Turbidity: Muddy looking water created by having sediment or foreign particles stirred up or suspended.

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.

1.4 REFERENCES

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1.5 REQUIREMENTS AND RESOURCES

To conduct oversight of and document monitoring well development, the person at the drill site should be a geoscientist who has relevant professional training and experience. The site geoscientist is responsible for oversight and documentation of all well development activities. The site geoscientist shall understand the project objectives and regularly communicate from the field with the project manager or technical project team members.

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 to 48 hours after the placement of the grout seal, depending on the grout cure rate and well development method to be used. 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 on Figure 1. For shallow wells with limited bentonite or grout seal heights, care should be taken to avoid damaging the seal by surging. 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 action 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 downhole submersible pump lowered to the bottom of the well. In cases were the water table is less than 25 feet from the top of the casing, it is possible to overpump the well with a centrifugal pump at the ground surface. 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 around the monitoring well screen, 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 where applicable.

The type of geologic material, the design, 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 of 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 affect the organic constituent concentrations of the water samples collected from the well.

The presence of light nonaqueous-phase liquids (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 to 48 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 liquids [DNAPL] are 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 remove a minimum of 3 well volumes and continue if necessary until water quality parameters are 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 is free of drilling fluids, cuttings, or other materials introduced during well construction. 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 geoscientist 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. Upon completion of the well development, the data sheet must be checked for completeness and technical accuracy by another qualified person as soon as practical.

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 the 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 (gal/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 mud 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. If, after several attempts, all parameters have stabilized except turbidity, the well may be considered developed with the exception noted in the field log and/or Well Completion Report.

- 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

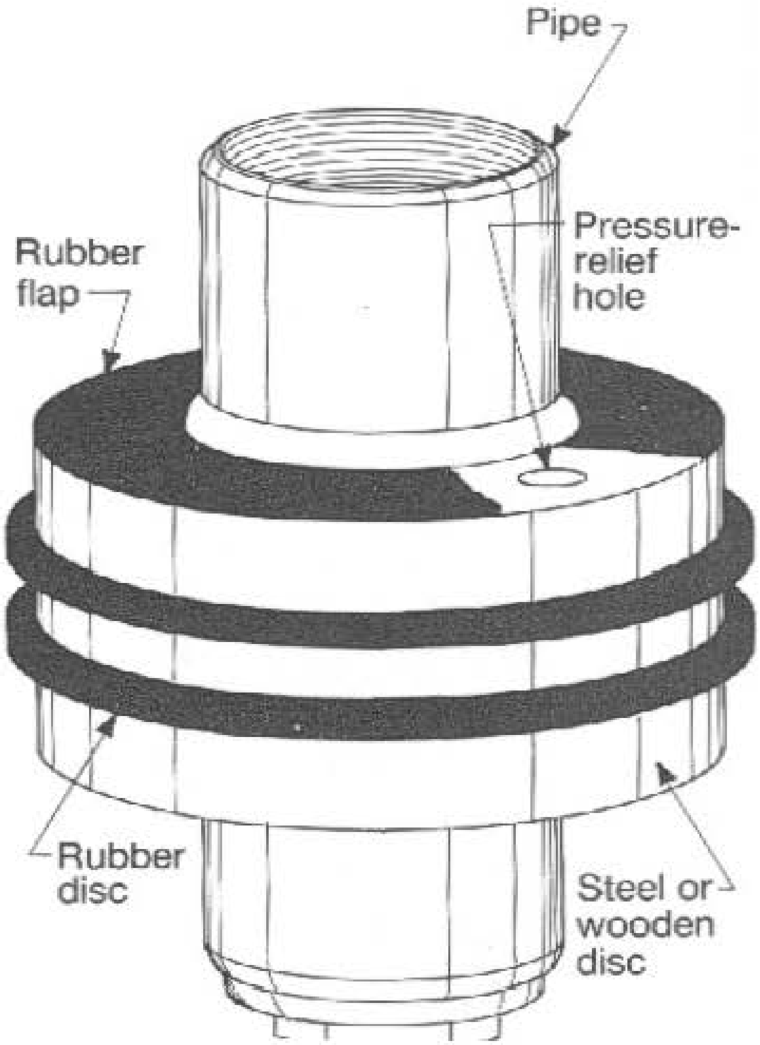

FIGURE 2

WELL DEVELOPMENT DATA SHEET

BORING NO. ____________ WELL NO. ____________ Sheet ___ of ___

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

____ Jetting (Airlift) ______________________
____ Surge Block ______________________
____ Bailing ______________________
____ Pumping ______________________
____ Other ______________________

PURGE VOLUME CALCULATION

Casing Volume: ____________ Ft. of water
x ________________ Gallons/Foot
= ________________ Gallons / 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 (Assume porosity = 30%)
= ________________ Gallons Within Sand Pack
Single Purge Volume: ______________ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)

FLUIDS ADDED

Lost Drilling Fluid: ________________ Gallons
Lost Purge Water: ________________ Gallons
Water During Installation: ______________ Gallons
Total Fluids Added: ________________ Gallons
Source of Added Water: ______________________
Ground Water Quality Parameters of Added Water Measured: Y N
Sample Collected of Added Water: Y N
Sample Designation of Added Water: ____________________

Minimum Purge Volume: ______________ Gallons
Actual Purge Volume: ______________ Gallons
Volume Measured by: ____________________
Rate of Development ________ Gallons/Minute (Hour,Day)
Pumping Rate/Depth ______________ @ ______ Ft. (Below Grade.)
Immiscible Phases Present: Y N Thickness ________

INSTRUMENT CALIBRATION

pH Meter: ______________________________
pH 4.0 = __________ @ _____ °C
pH 7.0 = __________ @ _____ °C
pH 10.0 = _________ @ _____ °C
Dissolved Oxygen Meter: ______________________

Spec. Conductance Meter: ______________________________
Standard _________ μmhos/cm@ 25°C
Reading __________________ μmhos/cm @ ______ °C
Turbidity Meter: ______________________________
Other: ______________________________

Total Volume Discharged	Rate of Discharge	Time	Temp	pH	Specific* Conductance	Turbidity or D.O.	Clarity, Odor, PID Readings, Other:

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

RECORDING OF NOTES IN FIELD LOGBOOK

SOP NO. 024

REVISION NO. 1
May 18, 1993

Last Reviewed: December 2008

KRiesing
Quality Assurance Approved

December 5, 2008
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, after the fact, activities and events during their performance of 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 and detailed; and they must 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 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 written on loose paper, they must be transcribed as soon as possible into a regular field logbook by the same person who recorded the notes.

Logbooks can be obtained from an individual's office supply room or directly from outside suppliers. Logbooks must meet the requirements specified in this SOP and should include preprinted pages that are consecutively numbered. If the numbers must be written by hand, the 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 that 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.
- Each logbook 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 issued logbook should be assigned number 1, the next issued logbook 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 stand out, 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 using a Sharpie® or similar type permanent ink marker:

- Logbook identification number
- 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 decision 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, contact name, 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)
- 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, if necessary, necessarily including a single line through the entry being corrected. Initial and date any corrections made in the logbook.
- After last entry on each page, initials of the person recording notes. No information is to be entered in the area following these initials.
- At the end of the day, signature of the person recording notes and date at the bottom of the last page. Indicate the end of the work day by writing "Left site at (time)." A diagonal line must be drawn across any remaining blank space at the bottom of this last 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 or disposable camera used (if applicable)
- Name of the photographer.

The following information should be entered into the logbook when collecting samples:

- Location description
- Name(s) of sampler(s)
- Collection time
- Designation of sample 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.

If pre-printed field data forms are available (forms such as the micropurge field data collection form), data should be entered on these pre-printed forms rather than into field logbooks. Note in the logbook that the field data are recorded on separate forms.

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

USING THE GEOPROBE SYSTEM

SOP NO. 054

REVISION NO. 1

Last Reviewed: December 1999

John

Quality Assurance Approved

March 28, 1994

Date

1.0 BACKGROUND

This standard operating procedure (SOP) details all procedures for using the Geoprobe System, a hydraulically operated sampling probe, and its specialized sampling tools. The procedures described within this SOP include soil gas sampling, groundwater sampling, and soil sampling procedures as well as procedures for installing piezometers and vapor sampling implants. This SOP also describes general procedures for rod removal, backfilling, and decontamination which are common elements to all sampling procedures. This SOP No. 054 replaces former draft SOP No. 054 (Geoprobe Soil Gas Sampling) and draft SOP No. 055 (Geoprobe Groundwater Sampling).

Use of the Geoprobe System is only one of many sampling techniques used by Tetra Tech EM Inc. (Tetra Tech); however, it is a preferred sampling method when certain conditions prevail. Specifically, Geoprobe sampling should be considered when sampling is limited to relatively shallow depths and any of the following are factors: (1) costs must be kept very low, (2) the time period is short to perform the sampling, (3) maneuverability is important, and (4) the required sampling volume is limited.

Prior to the use of the Geoprobe equipment, all buried utility lines and other underground structures must be marked because this equipment can penetrate buried piping and tanks. A diagram of the Geoprobe system is shown in Figure 1.

1.1 PURPOSE

The purpose of SOP No. 054 is to establish positioning, preparing, and sampling procedures; piezometer and vapor sampling implant installation procedures; rod removal procedures; backfilling procedures; and decontamination procedures to guide field personnel.

1.2 SCOPE

The procedures outlined in SOP No. 054 are applicable to all Tetra Tech personnel involved in soil gas, soil, or groundwater sampling using the Geoprobe System or any of its specialized equipment. It also is applicable to all personnel using the Geoprobe System to install piezometers and vapor sampling implants. This SOP, in fact, applies to all uses of the Geoprobe System.

1.3 DEFINITIONS

Because Geoprobe Systems is a corporation specializing in an innovative sampling process, many of the terms used to describe its equipment are specialized and specific. For this reason, familiarity with hydraulic system, soil sampling, soil gas sampling, and groundwater sampling terms is necessary. These terms are discussed below.

1.3.1 Hydraulic System Terms

The following terms are principally used to discuss the basic operation of the hydraulic punch and its major components. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.2, 1.3.3, and 1.3.4 below.

Hydraulic Punch: The principal part of the Geoprobe System, the hydraulic punch, looks very much like a small mobile drilling rig and is usually attached to a truck or van. The punch's hydraulic system uses the weight of the vehicle for support and a hydraulic system installed in the vehicle to advance sampling tools into the soil (see Figure 1).

Hammer: The hydraulic hammer pounds the rods and accessories into the soil once the hydraulic punch is unable to push it farther (see Figure 1).

Control Panel: The control panel is located near the hydraulic punch and contains the levers that control the movement of the punch (see Figure 2).

Probe Lever: This lever is found on the control panel and causes the hydraulic punch to push the drive rod and accessories into the soil. Overall, this lever controls the vertical movement of the punch (see Figure 2).

Hammer Lever: This lever is found on the control panel and engages the hydraulic hammer when the hammer release valve is moved to its extended position (see Figure 2).

Hammer Release Valve: This lever is found on the front of the hydraulic punch and allows the hammer to work when in its extended position. If the valve is not extended, pushing the hammer lever will not engage the hammer.

Foot Lever: This lever is found on the control panel and lowers the foot of the hydraulic punch so that it rests on the ground to stabilize the punch (see Figure 2).

Extend Lever: This lever is found on the control panel and controls the horizontal movement of the hydraulic punch. The lever extends the punch out of the van or truck. It also enables the hydraulic punch to extend about 2 feet from the rear of the vehicle (see Figure 2).

Fold Lever: This lever is found on the control panel and folds and unfolds the hydraulic punch so that it can be easily moved and stored (see Figure 2). This lever enables the hydraulic punch to move from the horizontal position to the vertical position.

Electrical Control Switch: This switch is found on the control panel and turns on the Geoprobe System's hydraulic system. None of the other levers work until this switch is turned on. It has slow, fast, and off speed positions (see Figure 2).

Vacuum System Panel: The vacuum system panel is located near the right rear of the vehicle and contains the vacuum system controls, the hydraulic oil cooling switch, and the remote ignition (see Figure 2).

Remote Ignition: This device is found on the vacuum system panel and allows one to start the vehicle's engine from near the hydraulic punch instead of walking around the vehicle and climbing into the vehicle's cab (see Figure 2).

Hydraulic Oil Cooling Switch: This switch is found on the vacuum system panel and turns on the auxiliary cooling system for the hydraulic oil (see Figure 2).

Vacuum/Volume (Vac/Vol) Pump Switch: This switch is found on the vacuum system panel and allows pressure to build up in the vacuum tank (see Figure 2).

Vacuum Line Valve: This valve is found on the vacuum system panel and opens and closes the vacuum line (see Figure 2).

Sample Line Gauge: This gauge is found on the vacuum system panel and registers the sample line pressure in inches of mercury (see Figure 2).

Drive Rod: The Geoprobe drive rod (sometimes called a probe rod) is a high-strength-steel, hollow tube with a 1-inch outer diameter. Though the rods come in 1-foot, 2-foot, and 3-foot lengths, the standard length is 3 feet. Each rod is threaded on both ends and has a male end and a female end (see Figure 3).

Drive Cap: This cap is a steel cap screwed onto the male end of the drive rod so that the rod can be pushed or hammered into the soil without damaging its threads. The drive cap is always installed to the top of the drive rod before advancing probe rods or sampling tools (see Figure 3).

Pull Cap: This cap is a steel cap that screws onto the male end of the drive rod and is used to pull the drive rod from the soil once the sample has been collected (see Figure 3).

Anvil: This piece of steel is placed inside the hydraulic punch at the point where the hammer actually makes contact. The anvil transfers the force of the hammer to the drive cap (see Figure 3).

Rotary-Impact Carbide-Tipped Drill Bit: This 18-inch or 24-inch steel drill bit fits directly into the hydraulic punch and is used to drill through concrete or hard asphalt. The bit does not spin with appreciable torque but is driven by the hammer, spinning only slightly to clear itself of debris (see Figure 3).

Chain-Assisted Pull Cap: This modified pull cap is attached to the hydraulic punch with a chain. It is most useful when the drive rod, for one reason or another, is not aligned directly underneath the hydraulic punch. With this cap, the rod can still be pulled using the punch (see Figure 3).

Rod Extractor: This tool threads onto a drive rod and is sent down into the hole made by a drive rod that has broken in the soil. The rod extractor, which looks a little like a drill bit, is then hammered into the broken rod and is used to pull the broken rod from the soil (see Figure 3).

Rod Pull Plate: This steel plate has a hole in its center through which a drive rod can be fitted. It is used to extract drive rods when installing piezometers, soil gas implants, or to expose the screen to groundwater when using a screen point sampler (see Figure 3).

O-Ring: An O-ring is a rubber ring used to seal sections of drive rods or various other Geoprobe tools so that, once together, they are air- and water-tight.

Teflon Tape: This inert, sticky tape can be used to create air-tight seals when pieces of the drive rod or accessories are threaded together. The tape can replace an O-ring.

1.3.2 Soil Sampling Terms

These terms are usually used when discussing soil sampling using the Geoprobe System. Sometimes, though, the terms are used when discussing other sampling techniques. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.1 above and Sections 1.3.3 and 1.3.4 below.

Shelby Tube: This tube is used to collect large samples of cohesive soils. Its greatest disadvantages are that it cannot be used to sample from depths greater than about 10 feet and has no mechanism to stay closed until reaching the proper depth (see Figure 4).

Shelby-Tube-Drive Head: This 2-inch diameter piece of steel attaches to the Shelby tube using hex bolts. The Shelby-tube-drive head consists of two parts: a standard 2-inch Shelby tube drive head and a Geoprobe drive rod adapter. This allows the 2-inch wide Shelby tube to be driven by the hydraulic punch, which is actually designed for 1-inch diameter drive rods (see Figure 4).

Hex Bolts: These are the bolts used to attach a Shelby tube to a drive head (see Figure 4).

Extruder Latch: This device secures the Shelby tube to the extruder rack during the extrusion process that removes the soil from the tube (see Figure 4).

Extruder Piston: This piston is threaded onto a drive rod, and with the help of the hydraulic punch, extrudes the soil sample from the Shelby tube (see Figure 4).

Probe-Drive Systems: This sampling system allows samples to be collected at deeper depths than the Shelby tube system. Each probe-drive sampler remains closed until it reaches the depth desired and then is opened by those operating the punch by removing a stop pin (see Figure 5). The sampler is then pushed through the soil at the desired depth and removed. Three types of probe-drive samplers exist: the standard sampler, the Kansas sampler, and the large bore probe-drive sampler.

Standard Probe-Drive Sampler: This probe-drive sampler has a diameter of 1 inch and lengths of 10 or 24 inches. Its greatest difference from the other probe-drive sampler is that it does not have a removable cutting shoe (see Figure 5).

Stop Pin: This pin stops the point of a probe-drive sampler from retracting into the sampler tube. Once it is removed, the sample can be collected (see Figure 5).

Piston Rod: This rod connects the drive head of a probe-drive sampler to the sampler's point. Once the stop pin is removed, this rod slides through the sampler, allowing the point to retract inside the tube (see Figure 5).

Drive Head: This head is the top of a probe-drive sampler, which allows the piston rod to slide straight up the sample tube after the piston stop has been removed and the drive rod is advanced (see Figure 5).

Cutting Shoe: This portion of the probe-drive sampler cuts through the soil once the point is allowed to retract inside. The Kansas samplers and large-bore sampler have removable cutting shoes (see Figure 5).

Extruder Rack: This device holds soil samplers in place during extrusion. The Shelby tube extruder rack is shown in Figure 4, and the standard probe-drive extruder rack is shown in Figure 5.

Extension Rod: This long, thin, threaded, solid rod is dropped through a drive rod to the probe-drive sampler so that the stop pin can be removed. Often more than one extension rod (an extension rod string) must be put together to reach the stop pin (see Figure 5).

Extension Rod Handle: This small metal handle screws to the top of the extension rod string so that it can be turned easily while being used to remove the stop pin (see Figure 5).

Large-Bore Probe-Drive Sampler: This probe-drive sampler is 1-1/8 inches in diameter and 24 inches long. Its larger width allows for the collection of larger samples. The diameter also allows for acetate or brass liners to be used in sample collection. These liners can make viewing the sample easier and preparing it for analysis simpler.

Kansas Sampler: This specially designed probe-drive sampler has a removable cutting shoe to enable easy extraction of soil and to allow the shoe to be replaced without replacing the complete sampler.

Kansas Stainless Sampler: This sampler has a stainless-steel sampling tube. It works in the same way as the Kansas sampler.

1.3.3 Soil Gas Sampling Terms

The following terms are used principally to discuss soil gas sampling. A few terms, though, are used while discussing groundwater sampling as well. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1 and 1.3.2 above and Section 1.3.4 below.

Expendable Point: These points fit into an expendable point holder that has been threaded into the lead drive rod. When the drive rod is pulled back, these points do not move with it, leaving a gap from which soil gas can be collected. The points are ultimately left in the ground (see Figure 6).

Expendable Point Holder: This holder threads into the leading drive rod. It is used for driving expendable points (see Figure 6).

Retractable Point Holder: This holder lifts off its point, leaving a gap so that soil gas can be drawn, but unlike expendable points, the holder does not separate completely and ultimately is retrieved with the lead drive rod (see Figure 6).

Gas Sampling Cap: When using the standard soil gas sampling method, the gas sampling cap replaces the drive cap on top of the drive rod and allows tubing to be connected to the drive rod. A soil gas sample is drawn through the probe rod through this cap and into a sample container (see Figure 6).

Post-Run Tubing (PRT) System: This system collects soil gas drawn directly through a tube instead of through the drive rod itself. The system involves one of two specially designed point holders, each threaded on top so that an adapter that has been attached to the tube can be screwed into it after being advanced down the drive rod string. The two point holders differ in that one uses a retractable point and the other uses an expendable point (see Figure 7).

PRT Expendable Point Holder: This holder is threaded into the leading probe rod and is used for driving expendable points (see Figure 7).

PRT Adapter: The PRT adapter attaches the tubing through which the soil gas is to be drawn to the point holder, which has been driven to the proper sampling depth (see Figure 7).

Polyethylene Tubing: This tubing is the preferred tubing for connecting the PRT system to the sample container. Its stiff nature, however, sometimes makes it difficult to attach to the sample container and a coupler of Tygon tubing is necessary (see Figure 7).

Tygon Tubing: This tubing is the preferred tubing for connecting soil gas sampling containers to the drive rod and vacuum system. It often is also necessary as a coupler sample between the stiff polyethylene tubing used with PRT sampling systems and the sample container.

Glass Bulb: This bulb of glass has valves on each side and a neoprene septum through which gas can be withdrawn. The bulb is used to collect soil gas and can be used as the container in which the gas is taken for analysis (see Figure 8).

Tedlar Bag: This small bag has a valve on it. It is placed in an air-tight chamber, the air in the chamber is evacuated, and the bag fills with soil gas. The bags can then be taken for analysis.

Tedlar Bag Chamber: Tetra Tech uses these modified, air-tight kitchen containers as vacuum chambers. These chambers are modified with nipples on each side, which enable it to be attached to a vacuum pump, to a Tedlar bag, and to the Tygon tubing.

1.3.4 Groundwater Sampling Terms

The following terms are used to discuss groundwater sampling. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1, 1.3.2, and 1.3.3 above.

Mill-Slotted Well Point: This 3-foot long tube has 15 mill-cut slots in it, each 2 inches long and 0.020 inches wide. Only the bottom 2 feet of this tube is slotted, and sometimes mill-slotted well points come in two parts: a 2-foot slotted section and a 1-foot unslotted section. The slots allow groundwater to enter (see Figure 9).

Geoprobe Screen Point Sampler: This sampler has a 19-inch screen that encases a perforated stainless-steel sleeve. Once in place, the screen allows the water to enter the tube and prevents coarse sediment from entering the tube (see Figure 9).

Thieving Tube: This tube is used to extract the water from either mill-slotted well points or Geoprobe screen point samplers, Tetra Tech uses polyethylene tubing as thieving tubes. This tubing is lowered into the water, capped on top, and then extracted. The result is much like putting a straw into a glass of water, sealing the straw with a finger and lifting it. This method is used primarily for the collection of groundwater samples to be analyzed for volatile organic compounds. A check valve can also be attached to the thieving tube which seals the bottom and holds the groundwater within the tube.

Check Valve: This stainless steel valve has a small ball which, when attached to a thieving tube, floats to the top of the groundwater table and then sinks, ultimately sealing the thieving tube with groundwater. Oscillating the thieving tube will allow groundwater to rise within the tube for larger retrieval volume.

Well Mini-Bailer: This specially designed bailer drops through the drive rods and into the groundwater in the mill-slotted well point or screen point. A small ball in the bailer floats to the top and then sinks, ultimately sealing the bailer after it fills with about 40 milliliters of groundwater.

1.4 REFERENCES

The following references were used to prepare this SOP:

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Fisher Scientific. 1991. "The Fisher Catalog of Scientific Instruments."

Geoprobe Systems. 1990. "8-M Operations Manual." July 27.

Geoprobe Systems. 1991. "Accessory Tools Catalog."

Geoprobe Systems. 1992. "Equipment and Tools Catalog."

2.0 POSITIONING, PREPARING AND SAMPLING PROCEDURES

The Geoprobe System uses a hydraulic punch that is usually installed in the back of a van or truck to first push and then to hammer its hollow drive rod through soils. Depending on which tools are attached to the end of the drive rod and which sampling equipment is attached to it, the Geoprobe can be used to remove soil, soil gas, or groundwater. It can also be used to drill through cement or concrete and can aid in the installation of piezometer wells and vapor sampling implants. The following sections detail the procedures for positioning the Geoprobe unit, preparing the sampling system, and sampling with the Geoprobe unit.

2.1 POSITIONING THE GEOPROBE UNIT

Before the Geoprobe System can be used, the Geoprobe hydraulic punch and accessories must be properly positioned near the sampling site. The hydraulic punch and other equipment also needs to be prepared. In cases where concrete or other hard surfaces hinder sampling, the Geoprobe must be used to reach soil. This section details methods to perform these activities.

To position and unload the Geoprobe System use the following procedures:

1. Drive the vehicle containing the Geoprobe System to the sampling location and align the center of the rear of the vehicle with the point at which the sample will be taken. The rear bumper should be 1 to 2 feet from the sampling point so that the foot of the hydraulic punch can be extended out over it.
2. Shut off the vehicle.
3. Put it in park.
4. Set the emergency brake before proceeding.
5. One person only should operate the hydraulic punch and the assembly and disassembly of probe rods and accessories. A second person is usually necessary to handle the samples and to decontaminate equipment. All personnel present must wear steel-toed shoes, gloves, and eye protection. When drilling through concrete or using the hydraulic hammer, ear protection is also necessary.
6. Once ready to take the sample, start the engine using the remote ignition located in the right rear of the vehicle. As a safety device, the remote ignition will not work unless the vehicle is in park.
7. Activate the hydraulic system by turning on the electrical control switch. The vehicle’s engine must be running for the hydraulic system to work.
8. Slowly extend the Geoprobe out of the vehicle using the extend lever. Always use the slow speed on the hydraulic controls when positioning the hydraulic punch. The punch and mast should be far enough out of the van or truck so that the mast will not strike the roof when it is unfolded.
9. Unfold the hydraulic punch out of the vehicle using the fold lever. Once the punch has been lined up perpendicular to the ground surface, lower the foot of the punch using the foot lever until the vehicle itself is raised about 1 foot on its springs. This stabilizes the vehicle and punch. **Never lift the vehicle completely off the ground using the foot lever.** Doing so destabilizes the vehicle and hydraulic punch and may cause damage to equipment or injury to those nearby. Also, as pressure is placed on the rod, tools, and accessories, the foot of the punch may begin to lift. Do not allow it to lift farther than 6 inches from the ground. Allowing it to lift farther than 6 inches may throw the vehicle off balance and cause the rod to bend or break.

The Geoprobe System is now positioned. If it is necessary to drill through concrete or hard asphalt, use the following procedures:

1. Raise the hydraulic punch using the probe lever and then deactivate the hydraulic system by turning the electrical control switch to off. The hydraulic system should always be turned off when the hydraulic controls are not being used.

2. Place the drill bit into the hydraulic hammer. The bit is not used with a drive rod or anvil.

3. Activate the hammer rotation control knob, which is located on the hydraulic hammer, by turning the knob counter-clockwise. This allows the drill bit to rotate when the hammer lever on the control panel is pressed.

4. Activate the hammer release valve, which is located on the hydraulic hammer, by pulling the lever out and down.

5. To drill through solid surfaces, both the probe and hammer mechanisms of the hydraulic punch must be used. The hammer mechanism drives the drill bit in a percussion fashion and causes it to turn slightly. The probe mechanism allows the hammer and bit to be raised and lowered so that the bit can clear itself of debris. Once ready to begin, turn on the hydraulic system.

6. Fully depress the hammer lever. This lever needs to remain depressed throughout the drilling procedure and keeps the bit pounding and rotating.

7. Put pressure on the bit by pressing the probe lever down. Using this lever, advance the bit in small increments through the concrete or other hard surface. If advanced too quickly, the bit will bind and stop rotating. Should this happen, raise the punch slightly to allow the bit to rotate. If too little pressure is placed on the bit, too little percussion will occur, and drilling will be slow.

8. Continue drilling, in small increments, until soil has been reached. At that time prepare for sampling.

2.2 PREPARING THE SAMPLING SYSTEM

Before the hydraulic punch is used to sample, decisions must be made concerning which type of sample will be taken, whether several samples will be taken at varying depths, and which type of Geoprobe sampling equipment will be used. The following sections discuss preparation procedures for soil sampling, soil gas sampling, and groundwater sampling.

2.2.1 Soil Sampling

The samplers attached to the hydraulic punch for soil sampling come in two forms. The first type is the 2-inch diameter Shelby tube system that is common to other soil sampling methods. The second system uses various specially designed probe-drive systems that remain completely sealed while being pushed or driven to a particular depth. They then are opened to allow a sample to be collected. The Shelby tube and probe-drive systems are discussed below.

Shelby Tube System

The Shelby tube is a thin-walled steel tube, 2 inches in diameter and 30 inches long, with four mounting holes around its top. It allows large amounts of soil to be sampled at once, but the soil must be relatively cohesive. Because the tube remains open at all times, the tube cannot be driven to great depths and must be removed and replaced after coring 30 inches of soil. Usually, the Shelby tube system is chosen when large amounts of soil are needed at depths no deeper than 10 feet. Rocky or sandy soils are not conducive to this sampling method.

To prepare for sampling using Shelby tubes, use the following procedures:

1. First attach a Shelby tube to the Shelby-tube-drive head by putting the head's hex bolts through the holes in the tube.
2. Next, screw a Geoprobe drive rod adapter into the top of the drive head to allow the 2-inch-wide Shelby tube to be driven by the hydraulic punch and hammer, which are actually made for 1-inch outer diameter drive rods.
3. A drive cap is then screwed onto the top of Geoprobe drive rod adapter. The tube is now ready to be attached to the hydraulic punch.
4. To attach the tube, raise the hydraulic punch using the probe lever and then turn off the Geoprobe hydraulic system.
5. Lift the hammer latch and insert the anvil inside.
6. Place the assembled Shelby tube sampler so that it is aligned under the anvil.

The hydraulic punch is now ready to drive a Shelby tube and collect a sample core. For collecting soil cores at depths of greater than 30 inches, attach sections of probe rod to an assembled Shelby tube sampler and drive the sampler down the same hole using a new Shelby tube for each 30-inch increment in depth.

Probe-Drive Systems

All of the probe-drive systems work in essentially the same way. A sampler is attached to a hollow drive rod, inserted into the hydraulic punch, and punched or hammered into the soil. Once the sampler reaches the depth at which the sample is to be taken, a stop pin in the sampler is removed using an extension rod that has been dropped through the inside of the hollow drive rod. The release of the stop pin allows the point of the sampler to retract inside the sample tube as the sampler is further advanced into the soil. The probe is then punched through the soil where the sample is to be taken. The rod and probe are then pulled to the surface for sample extraction.

Currently, three types of samplers are used in the probe-drive systems: the standard probe-drive sampler, the Kansas sampler, and the large bore probe-drive sampler. Preparation of each is slightly different. Each is discussed separately below.

Standard Probe-Drive Samplers

The standard probe-drive sampler comes in 10- and 24-inch lengths. The proper length is determined by the size of the sample desired. The point of this sampler is connected to a piston rod that will slide through its length. At its top, the piston rod is connected to the drive head, which keeps it centered and holds the piston stop pin, which stops the piston from sliding.

To prepare the standard probe-drive sampler, use the following procedures:

1. Insure that the sampler is assembled and complete, and that the piston stop pin which is reverse threaded is tightly locked so that the sampler point will not slide into the sampling tube.
2. Attach a shortened Geoprobe drive rod to the sampler so that the total length is nearly the standard 3 feet. If the 10-inch sampler is used, a 2-foot drive rod should be attached, and if the 24-inch sampler is used, a 1-foot drive rod should be attached.
3. Screw a drive cap onto the top of the shortened drive rod. The sampler is now ready for attachment to the hydraulic punch.
4. To insert the probe-drive sampler, raise the hydraulic punch using the probe lever, and then turn the hydraulic system off.

5. Lift the hammer latch and insert the anvil inside.
6. Place the assembled standard probe-drive sampler and shortened drive rod directly under the anvil so that the drive cap touches the anvil and the point of the sampler is aimed at the place where the sample is to be taken. The standard probe-drive sampler and the hydraulic punch should both be vertical.

Kansas Samplers

The Kansas sampler is much like the standard probe-drive sampler. However, it has a removable hardened cutting shoe near its point that allows it to penetrate rockier soils and to be easily replaced and decontaminated. Kansas samplers come in two versions: the Kansas Stainless Sampler, which has a stainless-steel tube, and the Kansas Sampler, which has an alloy steel tube.

To prepare a Kansas sampler, use the following procedures:

1. Ensure that the hardened cutting shoe is in place.
2. Assemble and install the Kansas sampler in the same manner as the standard probe-drive sampler (see Procedures 2 through 7 above).

Large Bore Samplers

The large bore sampler, similar to both types of Kansas samplers, has a removable cutting shoe and works in the same manner. It is slightly larger than the Kansas samplers, usually 24 inches long and 1-1/8 inches wide. The larger bore allows for the use of acetate or brass liners. The soil, therefore, can be removed easily by removing the liner. The acetate liner allows for easy visual examination of the core and can be easily sliced away so that the sample can be prepared for the laboratory. The brass liners come in four 6-inch sections that allow for easy separation and packaging of 6-inch soil samples. Some laboratories accept full 6-inch brass liners, allowing the samples to be collected with a very minimal disturbance to the soil matrix.

To prepare a large-bore sampler, use the following procedures:

1. Place the desired liner into the sampler by unscrewing the cutting shoe and sampler drive head from the two ends and then inserting the liner.
2. Assemble the sampler and attach a 12-inch drive rod to the sampler.
3. Screw a drive cap onto the top of the drive rod.
4. Place the assembled sampler and drive rod under the hydraulic punch in the manner detailed in the section above for preparing standard probe-drive samplers (see Procedures 5, 6, and 7 above).

2.2.2 Soil Gas Sampling

Two main methods are used to collect soil gas using the Geoprobe system: the standard method and the PRT system.

To use the standard method, the drive rods are decontaminated and assembled in an air-tight manner as they are punched into the soil. To ensure an air-tight seal, either Teflon tape or an O-ring can be placed on the male threads of the drive rods. The probe rods are driven approximately 6 inches below the area from where the sample is to be taken. The rods are then lifted approximately 6 inches leaving the expendable point and a small opening between the point and the end of the rod behind. A gas sampling cap is then attached to the top of the rod, a vacuum pump removes the necessary volume of gas, and the sample is collected.

To collect soil gas samples using the PRT system, polyethylene tubing attached to a stainless steel adapter is pushed through the drive rod after the rod is in place. The tubing and adapter is then reverse threaded onto the top of the PRT expendable point holder, and the gas is collected through the tubing. This method increases the accuracy of soil gas sampling, eliminates the potential for leaks in the rod, and simplifies probe rod decontamination.

Standard Method

Only decontaminated drive rods can be used with the standard method. Rods should be decontaminated using the procedures in Section 6.0 of this SOP.

To prepare a decontaminated drive rod for soil gas sampling using the standard method, use the following procedures:

1. Screw an expendable point holder into the female end of a 3-foot drive rod. (Note: a retractable point can also be used with this method; however, decontamination requirements almost always preclude its use.)
2. Place an expendable point into this holder.
3. Screw a drive cap onto the male end of the drive rod.
4. Place the rod into the hydraulic punch.
5. Turn on the hydraulic system.
6. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.
7. Place the assembled drive rod directly under the anvil so that the drive cap faces the anvil and the expendable point is aimed at the desired sampling location.
8. Push sampler and hydraulic punch through the soil to gather the sample.

PRT System

Two types of PRT systems are available. The first uses an expendable point holder and expendable point like the standard method. The second uses a retractable point holder that lifts off of the drive-point without actually separating from it. Both systems allow the threading of a PRT adapter and tubing through the drive rod so that the gas can be taken from the depth required without being sucked through the drive rod.

To prepare the drive rod and sampler for PRT soil gas sampling, use the following procedures:

1. Select the desired PRT sampler (either one with an expendable point or one with a retractable point) and ensure that the PRT adapter easily screws into the threads on top of the sampler. This step is necessary to ensure that the adapter will fit easily when it is affixed from above ground.
2. If using the sampler with an expendable point, attach the point.

3. Screw the sampler to the end of a shortened drive rod so that the total length of the sampler is nearly 3 feet.
4. Screw the drive cap to the other end of the drive rod.
5. Attach the drive rod and sampler to the hydraulic punch using the same procedures detailed in the standard method (see Procedures 4, 5, and 6 above).

2.2.3 Groundwater Sampling

The Geoprobe System offers two systems for collecting groundwater, each with several groundwater sampling options. The first method involves the use of a mill-slotted well point. The second method uses a specially designed Geoprobe screen point sampler.

Mill-Slotted Well Points

The mill-slotted well point is a 2- or 3-foot length of hollow steel tubing with 15-millcut slots in it, each 2 inches long and 0.020 inches wide. Once in place, groundwater enters the tube through these slots. To prepare the mill-slotted well point, use the following procedures:

1. Screw a solid drive point into the female end of the sampler.
2. If a 2-foot well point is being used, screw the sampler to a 1-foot length of drive rod.
3. Screw a drive cap to the other end of the well point or 1-foot drive rod.
4. Place the sampler and rod into the hydraulic punch by raising the punch as much as necessary and turn hydraulic system off.
5. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.
6. Place the mill-slotted well point sampler under the anvil with the drive cap near the anvil and the point aimed at the sampling location.

Geoprobe Screen Point Sampler

The Geoprobe screen point sampler has a 19-inch screen encased in a perforated stainless-steel sleeve. The screen remains encased in the sleeve until the screen point sampler reaches the desired depth. The rod is then pulled back approximately 19 inches, leaving the screen exposed to the formation. Flexible tubing can be pushed through the drive rod and attached to the sampler using the adapters for the PRT soil gas system, enabling groundwater to be removed without touching the drive rod. Decontaminating the drive rod is subsequently easier.

To prepare a Geoprobe screen point sampler, use the following procedures:

1. Close the screen on the sampler.
2. Attach its expendable point.
3. Attach the sampler to a shortened drive rod so that the assembly is nearly 30 inches long.
4. Place the sampler into the hydraulic punch using the methods detailed for mill-slotted well points (see Procedures 4, 5, and 6 above).

2.3 SAMPLING

Sampling procedures for the Geoprobe hydraulic punch are similar for all samplers and sampling media. This section presents general procedures that apply to all samplers and sample types, and specific operating procedures for soil, soil gas, and groundwater.

2.3.1 General Procedures

All control panel switches have a slow and fast position. All switches should initially be set at the slow position when positioning the punch and the sampling tools. In all cases, the hydraulic system should be shut off when not in operation and when adapters and additional drive rods are put into place. The hydraulic punch should be turned off any time it is not actually in operation.

The Geoprobe hydraulic punch is designed with a key safety feature that will shut it off if the controls are released. If the operator senses that something is wrong, he or she must release the controls and stop operating the punch until all is well. At no time should the foot of the punch be allowed to lift higher than 6 inches off the ground because the punch will destabilize and may bend the drive rod or sampling tube.

Also, at no time should part of a human body be placed on top of a drive cap while the cap is near the anvil or under the foot of the hydraulic punch.

Once the assembled sampler or drive rod is under the anvil, both it and the hydraulic punch should be vertical. Positioning the drive rod and sampler is critical in order to drive the rod vertically. Not positioning the sampler or drive rod vertically will result in problems when attaching subsequent drive rods needed to reach the proper depth and with rod retrieval.

To begin probing in soils of normal texture, use the following procedures:

1. Activate the hydraulic punch and push down on the probe lever on the control panel so that the probe slowly lowers itself. Always use the slow control on the first rod or sampler.
2. Continue to press on the probe lever until the rod or sampler is completely forced into the soil. The point of the rod will then be nearly 3 feet into the soil.

Soils and other materials are often too hard for the hydraulic punch's probe mechanism to penetrate. When this occurs, the hammer on the hydraulic punch should be used in accordance with the following procedures:

1. Ensure that the hammer rotation valve is closed.
2. Use the hydraulic punch to put pressure on the rod, sampler, and soil. When the probe rod refuses to move, the foot of the hydraulic punch will begin lifting off the ground. Never allow the foot to lift more than 6 inches off the ground, but never use the hammer with the foot resting on the ground surface.
3. If the probe foot lifts off the ground, the hydraulic punch may no longer be perpendicular. If this occurs, use the machine's fold lever, which is located on the control panel, to correct the punch's position.
4. Press the hammer lever on the control panel. The rod should now advance. Never use the hammer unless there is downward pressure on the drive cap because doing so may damage the equipment.
5. Stop hammering periodically and check to see if the probe rods can be advanced using the probe mechanism only.

When samples are to be taken at depths of greater than 3 feet, additional drive rods must be added to those already in the ground. Shelby tube soil sampling procedures for adding rods are discussed in Section 2.3.2. For all other sampling methods, use the following procedures to add drive rods:

1. Using the probe lever, raise the hydraulic punch off the portion of the drive rod protruding from the ground.
2. Unscrew the drive cap from the drive rod.
3. If using the standard method of collecting soil gas or other sampling methods that will draw the sample through the length of the entire drive rod, wrap the threads of the drive rod with Teflon tape or push an O-ring over the threads to make the drive rod string air- and water-tight.
4. Screw another drive rod onto the first drive rod protruding from the ground. Tighten the rods together with a pipe wrench.
5. Screw a drive cap onto the top of the new drive rod.
6. Place the hydraulic punch over the new drive rod and push the rod farther into the ground.

As the rod string is pushed farther into the ground, it will sometimes begin to loosen. The rods should remain tight so that the threads are not damaged. Occasionally, stop probing and twist the rod string with a pipe wrench to ensure that all of the joints remain tightly sealed.

2.3.2 Soil Sampling

This section presents procedures used to sample soils using either the Shelby tube sampling method or any of the probe-drive systems. In all cases, sampling tools should never be advanced farther than their length once they are opened because the sampler will overfill. If the sampler overfills, it could be damaged or expand, causing it to fall off the drive head.

<u>Shelby Tube Sampling Procedures</u>

Because the Shelby tube does not remain closed until it reaches the desired sampling depth and because it is not connected to a drive rod but to a Shelby drive head, sampling procedures for Shelby tubes differ greatly from soil sampling with other methods. New drive rods cannot be continuously added. Sampling at depths of greater than 30 inches requires a step-like procedure. For example, to sample to a depth of 90 inches, three Shelby tubes are needed. The first is advanced from 0 to 30 inches and then removed. The second is pushed through the hole made by the first and advanced to a depth of 60 inches and removed. The third is also pushed through the 60-inch deep hole and advanced from 60 to 90 inches.

Samplers must be ready to change sampling methods if necessary. For example, if soils are not cohesive, they tend to drop out of the Shelby tube as it is pulled from the ground. Also, if the soils are not cohesive, they tend to collapse into the hole left by the initial tube before the second and third tubes can be pushed into place. For this reason, use of the Shelby tube method is impractical at depths of greater than 10 feet. Rocky soils are also difficult to sample with a Shelby tube sampler because they tend to destroy the sampler while it is being driven into the ground.

To sample using the Shelby tube method, use the following procedures:

1. Turn on the hydraulic system and slowly press the Shelby tube into the soil using the probe lever on the control panel.
2. Once the tube has reached the sampling depth or has been extended to nearly its full 30-inch length, stop the hydraulic punch and raise it off the drive cap and Shelby tube drive head.
3. Unscrew the drive cap.
4. Screw on a pull cap.
5. Lower the hydraulic punch and lift the hammer latch. Remove the anvil. Place the latch around the pull cap so that the latch will hold the cap to the hydraulic hammer.
6. Using the probe lever, raise the hydraulic punch to pull the Shelby tube from the ground.

If the desired sampling depth is greater than 30 inches, additional Shelby tubes and probe rods must be used. The tubes are then prepared for probing using the methods presented in Sections 2.2.1 and 2.3.1 above. To advance the Shelby tube deeper, the tubes are pushed through the hole left by the first tube using the method detailed above.

Once a Shelby tube core has been retrieved from a sampling point, it must be extruded from the Shelby tube sampler using the following procedures:

1. Lower the hydraulic punch using the probe lever so that its mast will not strike the top of the van as it is folded.
2. Lift the foot of the hydraulic punch using the foot lever.
3. Slowly and carefully fold the hydraulic punch using the fold lever.
4. Once the punch is horizontal, the Shelby tube extruder bracket can be placed onto the punch's foot. This bracket will hold the Shelby tube in place and allow the punch to push the soil out of the tube.
5. Screw an extruder piston onto a drive rod and a drive cap on the drive rod's other end.
6. Place the drive rod into place under the horizontal drive punch.
7. Place the full Shelby tube into the extruder rack and secure it with the extruder latch.
8. A pan or container should be held at the end of the Shelby tube to collect sample material as it is extruded.
9. The probe lever activates the hydraulic punch and pushes the soil from the Shelby tube.

Tetra Tech's SOPs on packaging and documenting samples, SOPs Nos. 016, 017, 018, and 019, should be used to prepare the sample for analysis.

Probe-Drive System Sampling Procedures

All three types of probe-drive samplers work in essentially the same way. The sampler is advanced to just before the proper sampling depth and then the drive point is released by removing a stop pin using solid extension rods that have been dropped through the hollow drive rod. The point is then pushed back into the body of the sampler as the sampler fills with the soil sample.

In addition to the general procedures listed in the Section 2.3.1, the probe must be stopped at just before the desired sampling depth so that the stop pin can be removed. Pushing the probe too far will require starting over.

To use the probe-drive sampling system to sample soil, use the following procedures:

1. Attach additional drive rods as discussed in the general procedures in Section 2.3.1.
2. Stop the hydraulic probe just before the desired sampling depth.
3. Raise the hydraulic punch, turn off the hydraulic system, and remove the drive cap.
4. Insert an extension rod into the drive rod and screw additional extension rods together until the assembly reaches the same depth as the sampler.
5. Attach a small extension rod handle to the top of the extension rod.
6. Rotate the extension rod handle clockwise until the leading extension rod has turned the stop pin and disengaged it.
7. Pull and unscrew each extension rod from the hollow drive rod. The stop pin should be attached to the bottom of the extension rod string. If not, repeat Procedures 1 through 6.
8. To sample, mark the drive rod with tape or chalk about 10 inches above the ground if a 10-inch sampler is used or 24 inches from the ground if a 24-inch sampler is used.
9. Replace the drive cap and start the hydraulic system.
10. Drive the rod until the tape or chalk mark touches the ground. Be careful not to overdrive the sampler. Doing so could compact the soil in the sampler or cause it to balloon outward, making soil removal and extrusion difficult.
11. Raise the hydraulic punch and replace the drive cap with the pull cap. Remove the anvil.
12. Latch the pull cap underneath the hydraulic hammer latch and pull the rods out of the ground, disassembling the rod as needed.
13. Check to ensure that a soil sample is now in the sampler.

Once a soil sample has been removed from the ground, it can be extruded using the Geoprobe. The tools supplied by Geoprobe Systems for extruding soil from probe-drive samplers do not require the Geoprobe to be folded and horizontal. If liners are used with large-bore samplers, extrusion is usually unnecessary. When extrusion is necessary for probe-drive samplers, use the following procedures:

1. Raise the foot of the hydraulic punch off the ground using the foot lever on the control panel.
2. Attach the extruder rack onto the foot of the punch so that its crossbeam rests on top of it.

3. Completely disassemble the sampler. In all cases, remove the piston, point, and drive head of the sampler. If using the Kansas and large-bore samplers, unscrew the removable cutting shoe as well.
4. Insert the sample tube into the extruder with its cutting end up.
5. Insert a disposable wooden dowel or the reusable steel piston above the soil and below the hydraulic punch so that pressure on the dowel or piston from the punch will push the soil out of the bottom of the sample tube.
6. Position proper sampling jars or trays under the sample tube and very slowly use the probe lever to force the soil out of the tube. Injury can result if the soil is quickly forced from the tube.

The soil sample is now ready for packaging or on-site laboratory analysis. For large-bore samplers, the soil may be contained in a plastic sleeve that can be sliced away once the soil is to be packaged or in a brass sleeve that may be capped on both ends and shipped to the laboratory as is. Tetra Tech's SOPs on packaging and documenting samples for analysis should be followed when collecting samples using the Geoprobe System.

2.3.3 Soil Gas Sampling Procedures

The standard method and the PRT system are used for collecting soil gas using the Geoprobe System. The standard method requires the drive rods to be sealed together with either O-rings or Teflon tape to ensure an air-tight seal so that soil gas from depths other than the bottom of the drive-rod string cannot penetrate the system.

The PRT system draws soil gas through continuous tubing that is dropped through the drive rod after the drive rod has reached the desired level. The tubing is then attached directly to the point holder at the end of the drive-rod string.

For both methods, the drive rod should be driven to the desired depth. The drive cap should be replaced by the drive pull cap, and the rod should be pulled back out of the hole approximately 6 inches. This 6-inch void is the area where the soil gas sample is collected from. A pipe wrench or vise-grip pliers should be attached to the pipe just above the foot of the hydraulic punch so that the wrench or pliers rests on the foot to stop the drive rod from working its way back down into the hole.

Tygon tubing should be replaced between each sample for both sampling methods to avoid cross contamination.

The standard method and the PRT system sampling procedures are presented below. In addition, procedures for collecting soil gas in Tedlar bags, glass bulbs, and adsorption tubes is also presented below.

Standard Method

To gather a sample using the standard method, raise the hydraulic punch as mentioned above and replace the drive cap with a gas sampling cap. This cap is designed to fit the drive rods and is used to connect them by tube to a vacuum supply. Once the tubing has connected the gas sampling cap to the vacuum supply, remove the volume of air necessary to ensure that none of the gas being drawn was in the rod during probing, and then collect the sample in either Tedlar bags, glass bulbs, or adsorption tubes as discussed below.

PRT System

To use the PRT system (with either an expendable or a retractable point) to collect soil gas samples use the following procedures:

1. Secure the PRT adapter to the end of a piece of polyethylene tubing 1 to 2 feet longer than the total length of the drive-rod string. The adapter must fit tightly within the tubing. If it does not, tape it into place. Also, ensure that the O-ring is in place on the threaded end of the adapter.

2. Remove the drive cap from the probing rod and lower the adapter into it, holding on to the tubing.

3. Grasp the excess tubing and apply downward pressure. Turn the tubing counter-clockwise to engage the adapter threads on the sampler holder.

4. Pull up lightly on the tubing to test engagement of threads. If the adapter has not engaged, try again. If it repeatedly does not engage, soil may have intruded into the drive rod either during probing or, in the case of the retractable point, when the rod was pulled back to leave the point opening. Use the threaded extrusion rods to clean out the threads.

5. In most cases, the adapter will easily screw into place. The sampler is now ready to collect samples in either Tedlar bags, glass bulbs, or adsorption tubes using the procedures presented below. After the sample is collected and the sampler and tube is removed from the ground, the O-ring should be checked to ensure that a good seal exists between the sampler and adapter. If the O-ring is tightly smashed, the seal should be good.

6. Discard polyethylene tubing and use new polyethylene tubing for each sample.

Tedlar Bags

Soil gas can be collected for chemical analysis in a 500-cubic-centimeter Tedlar gas sampling bag by inducing a vacuum on the exterior of the bag. The following procedures should be used to collect soil gas samples in Tedlar bags:

1. For the PRT system, connect a short (6- to 12-inch) piece of Tygon tubing to the free end of the polyethylene tubing protruding out of the drive rod. For the standard method, connect the Tygon tubing to the soil gas sampling cap.

2. Attach the other end of the Tygon tubing to one end of the Tedlar bag chamber. Tetra Tech uses modified, plastic, air-tight kitchen containers for these chambers. They are inexpensive and work well.

3. Connect another piece of Tygon tubing 2 feet to 3 feet long to the other end of the Tedlar bag chamber and to the nipple on the bottom of the vacuum system panel.

4. Place the lid on the Tedlar bag chamber.

5. Turn the vacuum/volume (vac/vol) pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before turning on the pump switch.

6. Open the vacuum line valve and purge three times the volume of ambient air out of the Tedlar bag chamber and PRT tubing or probe rods. The equations for determining purge volumes are as follows:

   Probe rods or tubing

   $$V = \pi r^2 H$$

   where

   V = Volume
   π = 3.14159
   r = Radius of tube or rod
   H = Length of tube or rod

Vacuum chamber

$$V = LWH$$

where

V = Volume
L = Length of chamber
W = Width of chamber
H = Height of chamber

7. Close the line valve.

8. Clamp the Tygon tubing shut with hemostats.

9. Remove the lid from the Tedlar bag chamber.

10. Connect a Tedlar gas sampling bag to the fitting inside the Tedlar bag chamber and open the valve on the gas sampling bag.

11. Place the lid back on the Tedlar bag chamber, seal it tightly, and remove the hemostats.

12. Turn the vac/vol pump switch on and open the vacuum line valve to create a vacuum in the chamber. The Tedlar bag should fill once the vacuum is created. The rate at which the Tedlar gas sampling bag fills depends on the permeability of the soil. The minimum amount of soil gas needed for analysis is approximately 0.5 liter. If less than 0.5 liter is collected after 4 minutes of sampling, raise the soil gas probe 0.5 foot and continue to evacuate the vacuum chamber for another minute. If the minimum required volume of soil gas is not collected, repeat the procedure. If the minimum required volume of soil gas is still not collected, abandon the collection process. All steps conducted should be accurately recorded in the logbook even if no samples are satisfactorily collected.

13. After the soil gas sample is collected in the Tedlar bag, clamp the Tygon tubing with hemostats.

14. Turn off the vacuum pump.

15. Remove the vacuum chamber lid.

16. Close the valve on the Tedlar gas sampling bag and remove the bag from the chamber. Label the Tedlar bag with the appropriate information.

Glass Bulbs

The following procedures should be used to collect soil gas in glass bulbs:

1. Turn the vac/vol pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before starting the vacuum pump. The inside scale of the vacuum tank gauge is calibrated in inches of mercury. The outside scale is calibrated for volume in liters (at standard temperature and pressure). Obtain the desired vacuum and turn the vacuum pump off.

2. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.

3. Connect one end of the labeled glass bulb to the Tygon tubing.

4. Connect another piece of Tygon tubing 3 feet to 5 feet long to the other end of the glass bulb and to the nipple on the bottom of the vacuum system panel.

5. Open the two stopcocks on the glass bulb.

6. Turn off the vacuum pump.

7. Turn the vacuum line valve to its open position.

8. Purge three times the volume of ambient air within the rods, bulb, and tubing. Equations for figuring out volumes are presented in the Tedlar bag discussion.

9. Turn the vacuum line valve to its closed position. Allow the pressure in the sample train to equalize (the sample line gauge should read zero).

10. Close the stopcocks on the glass bulb.

11. Remove the glass bulb and label it with the appropriate information.

Adsorption Tubes

The following procedure should be used to collect soil gas in adsorption tubes:

1. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.

2. Connect this piece of tubing to the nipple on the bottom of the vacuum system panel and purge three volumes of air from the drive rod or PRT system as described in the discussion of the Tedlar bag method.

3. Use hemostats to clamp the Tygon tubing attached to the drive rod or PRT.

4. Insert the adsorption tube between the Tygon tubing from the drive rod or PRT and the Tygon tubing attached to the vacuum system panel.

5. Remove the hemostats and draw the required volume of air through the adsorption tube.
6. Remove the adsorption tube and place the appropriate caps on the tube ends.
7. Clearly label package, and ship the samples as required by the laboratory or Tetra Tech and U.S. Environmental Protection Agency (EPA) SOPs.

Soil Gas Sampling Pointers

If the needle on the vacuum line valve does not move, the soil at the sampling depth may be saturated, pore space may be too tight to yield a sample, or sampling train may be plugged. If the needle moves back to zero very quickly, either the soil at the sampling depth is very permeable or a leak is present in the sampling train.

In some soils, the needle may return to zero very slowly. The time it takes for the needle to return to zero is called the "recovery" time. Recovery time should be noted for each sample taken. This information will allow relative comparison of soil permeability. Recovery times of greater than 10 minutes should be considered suspect. The effect of leakage in the sampling system increases with longer recovery times. After 10 minutes, the operator should consider either changing the sampling depth, location, or length of pullback from the sampling tip, or switching entirely from soil gas sampling to grab sampling and analysis of soil.

2.3.4 Groundwater Sampling

The two options for sampling groundwater using the Geoprobe System follow procedures similar to those presented in Sections 2.3.2 and 2.3.3 above. The sections below detail procedures for using mill-slotted well point samplers and Geoprobe screen point samplers to sample groundwater.

Mill-Slotted Well Point Sampler

Once the mill-slotted well point reaches groundwater, the water will begin to flow through the slots. When the sample is to be analyzed for volatile organic compounds, do not use a vacuum to suck groundwater from the drive rod. If the sample is to be analyzed for other parameters such as metals, semivolatiles, pesticides, or explosives, using a vacuum on the drive rod is acceptable. In all cases, polyethylene tubing can be used as a thieving rod by lowering its end into the drive rod, capping or sealing the tube's top, and then removing it. The preferred method for collecting samples for volatile organic analysis is to use a well mini-bailer. To collect groundwater samples with a mini-bailer, use the following procedures:

1. Raise the hydraulic punch, turn off the hydraulic system, and remove the drive cap.
2. Lower a well mini-bailer into the drive rod until it reaches the bottom. As it reaches the bottom, the check ball on the bailer's end will float in the groundwater and then slowly sink to the bottom.
3. Allow a couple of seconds for the ball to sink and set.
4. Pull the well mini-bailer out of the drive rod. The bailer should contain about 20 milliliters of groundwater.
5. Package and document the samples in accordance with Tetra Tech SOPs No. 016, 017, 018, and 019, or a similar EPA-approved procedure.

If a bailer is not required and volatile organic samples are not being collected, a foot valve sampler, vacuum trap, or peristaltic pump can be used to collect samples. Once the sample has been removed and packaged, the mill-slotted well point can be removed and decontaminated.

Geoprobe Screen Point Sampler

The Geoprobe screen point sampler contains a screen and screen plug that allows water to enter the rod. To collect groundwater samples with a Geoprobe screen point sampler, use the following procedures:

1. Push the sampler below the depth necessary to reach groundwater.
2. Raise the hydraulic punch and replace the drive cap with a pull cap. Also, remove the anvil.
3. Latch the pull cap under the hammer latch, and use the probe lever to lift the drive rod about 18 inches. Because the sampler has a expendable point, the point should stay at the deepest depth, and the screen and screen connector should fall out of the bottom of the sampler. Sometimes, however, the screen stays within the sampler and is lifted the 18 inches with the drive rod.
4. To ensure that the screen is exposed, attach a vice grip or pipe wrench to the rod above the foot of the hydraulic punch and raise the hydraulic punch. Then remove the pull cap

and place an extension rod through the tubing to push the screen into place. Additional extension rods can be attached to reach the desired depth.

To remove the groundwater sample for volatile organic analysis, with a well mini-bailer, follow steps 1 through 5 under the mill-slotted well point section above. Tubing can be used as a thieving rod with or without a check valve to collect groundwater samples as well. If the sampler is supplied with the optional PRT expendable point holder, then a PRT adapter can be pushed through the drive rod and threaded into place by following the PRT system Procedures previously discussed. A vacuum trap system or peristaltic pump can then be used to withdraw the sample. The PRT system method, however, should never be used when the sample is to be analyzed for volatile organic compounds because it involves using a vacuum to remove the sample.

3.0 PIEZOMETER AND VAPOR SAMPLING IMPLANT INSTALLATION PROCEDURES

The Geoprobe System's ability to quickly probe into soil allows for easy installation of both piezometers and vapor sampling implants. Both installation procedures are discussed below.

3.1 PIEZOMETER INSTALLATION

Piezometers are tubes that extend to groundwater and enable easy sampling of groundwater on a routine basis (see Figure 10). In addition to installing the piezometer, piezometers must be protected from the weather and from contamination. A well-head protector must therefore be installed around them. In some soil types, preparing the well-head protector may be the first step to installing a piezometer. For this reason, the directions below should be read completely before beginning piezometer installation. If a post-hole digger is to be used for well-head protector installation, Procedure 5 should be performed first. The piezometer should then be advanced through this hole.

To install temporary or permanent piezometers, use the following procedures:

1. Use the hydraulic punch to drive the temporary casing to the desired piezometer installation depth. Use the general procedures outlined in Section 2.3.1 above for details on driving the piezometer casing. The different temporary casings that can be used are described below. Geoprobe Systems also manufactures special drive caps, expendable points, and pull caps that fit these types and sizes of pipe.

a) 1-7/16-inch outside diameter by 1-3/16-inch inside diameter, RW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Two sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch inside diameter, polyvinyl chloride (PVC) pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe.

b) 1-13/16-inch outside diameter by 1-1/2-inch inside diameter, EW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 15- to 20-foot depth. Three sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch insider diameter PVC pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe, or (3) 1-1/2-inch outside diameter by 1-inch inside diameter, PVC pipe.

c) 1-1/4-inch outside diameter by 1-inch inside diameter, NPT-threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Only 3/4-inch outside diameter by 1/2-inch inside diameter, PVC pipe piezometer wells can be installed inside of the temporary casing. If using NPT-threaded pipe, couplers are needed to attach each section of pipe.

2. Once the piezometer casing is at the proper depth, remove the drive cap and install the selected size piezometer pipe inside of the temporary casing.

3. Using a pull plate, remove the temporary casing.

4. If the hole stays open, attempt to install a sand pack around the slotted portion of the piezometer, and then place dry granular bentonite on top of the sand pack as a seal. One foot of bentonite is recommended for a good seal.

5. Dig an 8-inch nominal-diameter hole around the piezometer pipe. This hole should extend to a depth of 1.5 to 2 feet. A post-hole digger can be used for this procedure if the hole is dug prior to driving the temporary casing. The bottom 6 inches of this hole should be filled with dry granular or slurry bentonite. The remainder of the hole should be filled with concrete. A steel, locking, aboveground or flush-mount well protector should be inserted into the wet concrete to provide well-head security. A concrete pad can also be constructed around the steel well-head protector.

3.2 VAPOR SAMPLING IMPLANT INSTALLATION

Figure 11 presents diagrams of vapor sampling implants. To install vapor sampling implants, first punch a drive rod to the desired depth using an expendable point holder and an expendable point. Once at the desired sampling depth, use the following procedures:

1. Disengage the expendable point and retract the probe rod about 1 foot by raising the hydraulic punch, replacing the drive cap with a pull cap, removing the anvil, latching the pull cap onto the hydraulic hammer using its latch, and raising the hydraulic punch again using the probe lever.

2. Lock the rod into place so that it does not sink back into the hole by using vice grip pliers or a pipe wrench.

3. Unlatch the pull cap and raise the hydraulic punch again, leaving room to work freely.

4. Remove the pull cap.

5. Attach appropriate stainless-steel tubing to the vapor implant. If tubing is precut, allow 48 inches more than the required depth of the implant.

6. Insert the implant and tubing down the inside diameter of the probe rods until it stops. Note the length of the tubing inserted to ensure that the desired depth has been reached. Allow the excess tubing to extend out of the drive rod's top.

7. Pour glass beads down the inside diameter of the probe rod using a funnel to create a permeable layer around the implant.

8. Use the tubing extending from the drive rod to stir the beads into place. Do not lift up on the tubing while doing so.

9. Position the remaining tubing through the hole on a rod pull plate, and then place the drive rod through that hole.

10. Attach the plate to the hydraulic punch using its chain and slowly pull the rod up another 18 to 24 inches. While the punch pulls the rod, push down on the tubing so that it stays in place.

11. Pour bentonite seal mixture down the inside diameter of the probe rod. Stir the mixture using the tubing as before. The initial mixture may also be topped with distilled water to initiate the bentonite seal depending on the site and on the role the vapor implant is to play.

12. Pull the drive rod from the hole using the probe rod pull plate already attached, and then plug the hole using granular bentonite or a bentonite slurry mixture.

The vapor sampling implant should now be in place and the stainless steel tubing connected to it should be protruding from the ground. The vapor implant tubing should be protected by a well-head protector in the same manner as the top of the piezometer. Procedure 5 in Section 3.1 describes well-head protector installation.

4.0 ROD REMOVAL PROCEDURES

Throughout the above discussions, it has occasionally been necessary to remove drive rods and samplers. The standard removal procedures involve raising the hydraulic punch, turning off the hydraulic system, replacing the drive cap with a pull cap, removing the anvil, and then latching the pull cap under the hammer latch. The hydraulic punch can then be used to pull the rod from the ground.

Two deviations to this procedure often occur. The first deviation is necessary when sampling tubes are to be left inside the hole as the drive rod is removed, especially when soil gas implants or piezometers have been installed. Because of the presence of these sampling tubes, a pull cap cannot be screwed onto the top of the drive rod. Instead, a rod pull plate is used. This plate is a piece of steel with a hole in it large enough for a drive rod to fit through it. The plate has a hook on one end. The tubing and rod are pushed through the plate, and the pull plate is attached to the latch on the hydraulic punch by a chain. As the punch pulls up, the plate shifts, and the inside of the hole binds on the rod. This binding usually holds the rod to the plate and results in the rod being pulled up as the punch is raised.

The second deviation occurs when the rods have not been pushed perpendicular to the ground. In these cases, a specially designed chain-assisted pull cap is used. This cap looks like a pull cap but has a chain on it that fits under the latch of the hammer. Once the cap is screwed to the drive rod and latched to the probe, raising the probe raises the rod.

In a few cases, drive rods break while in the ground. To retrieve these rods, a rod extractor is used. This extractor looks something like a drill bit and is screwed to the end of a probe rod. A hammer is then used to pound the extractor into the top of the broken rod. The extractor joins the broken rod to the second drive rod so that they can be pulled out together.

5.0 BACKFILLING PROCEDURES

Unless otherwise specified in the site-specific sampling plan, holes made by sampling with Geoprobe System tools are to be backfilled with dry, fine, granular bentonite. Water may be added to activate the bentonite. Tops of the holes may then be filled with soil or concrete as necessary for each particular site.

6.0 DECONTAMINATION PROCEDURES

Between holes, the probe rods and sampling tools must be decontaminated. Because no provisions for decontamination are included in the Geoprobe System, a separate decontamination station must be provided. A wire brush, a barrel brush for reaming out the rods, and soft brushes will clean sticky soil from the probe rods and sampling tools. Follow Tetra Tech SOP No. 002 decontamination procedures when sampling soil or groundwater.

When sampling for soil gas by the standard method, Geoprobe rods and samplers are heated approximately 15 to 20 minutes by a 100,000-British thermal unit heater until they are too hot to touch with the bare hand. They are then allowed to cool before reuse. Do not heat the rods too much or the rod metal will fatigue.

When sampling for soil gas by the PRT method, the probe rods do not have to be decontaminated. However, the PRT expendable point holder and PRT adapter do need to be decontaminated. They can be heated on the dash of the vehicle with the defrost system or scrubbed in Alconox and water. Equipment blank samples can be collected, if necessary, as part of the quality control process.

Sampling plans may have different decontamination requirements. Most plans also require rinsate sample collection as part of the quality control process.

FIGURE 1
GEOPROBE SYSTEM

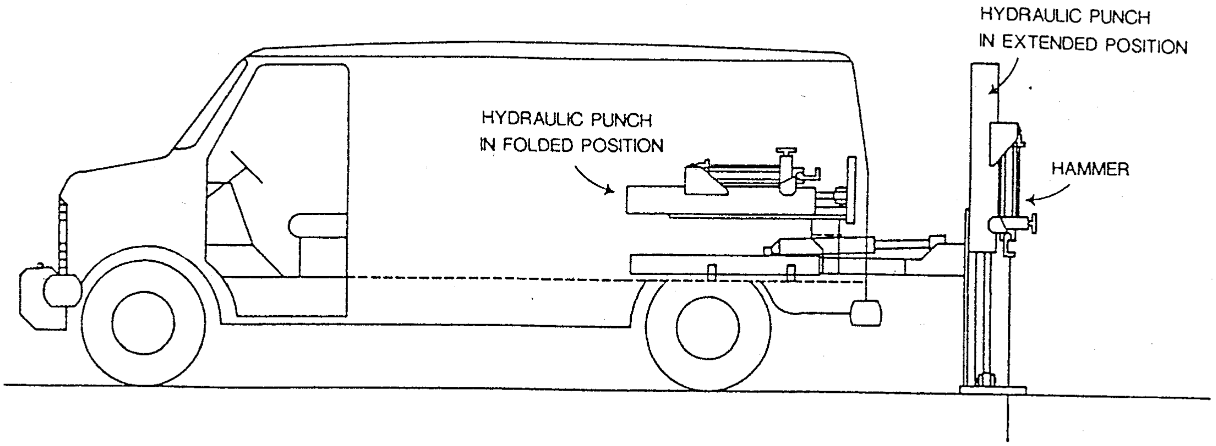
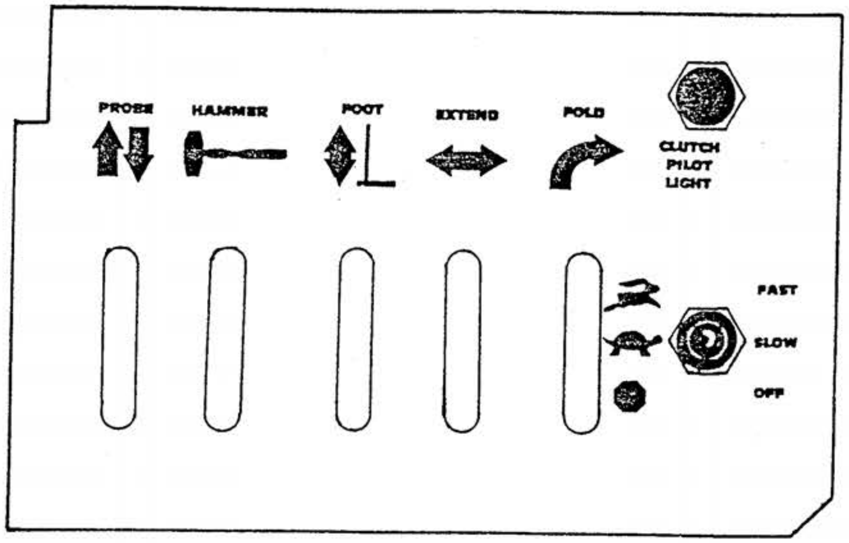
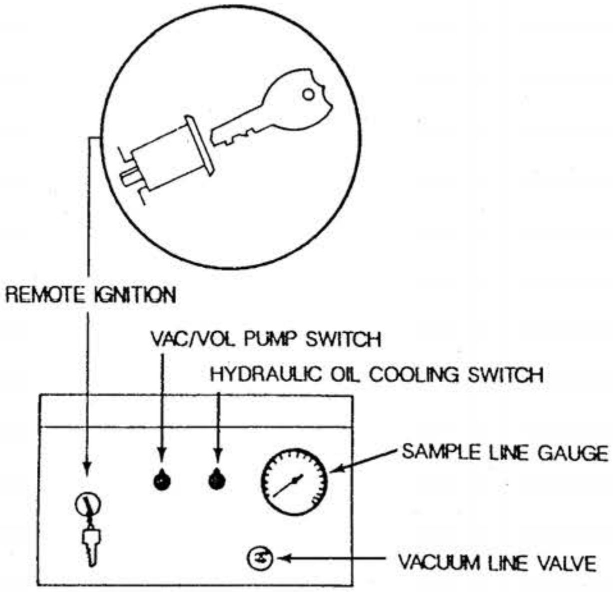


FIGURE 2

CONTROL AND VACUUM SYSTEM PANELS



CONTROL PANEL



VACUUM SYSTEM PANEL

FIGURE 3

GENERAL ACCESSORY TOOLS

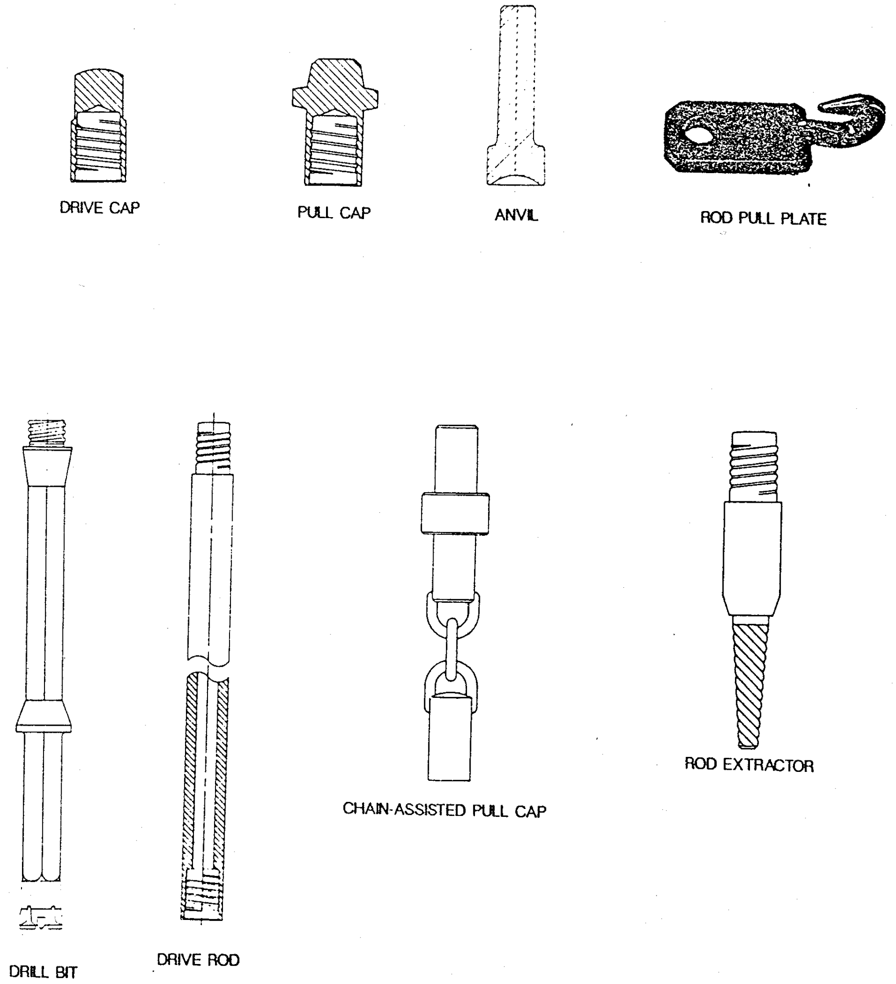
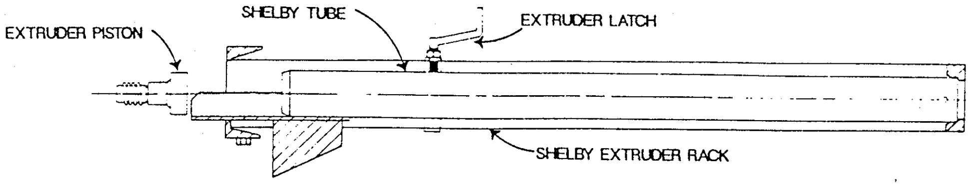


FIGURE 4

SHELBY TUBE ACCESSORIES



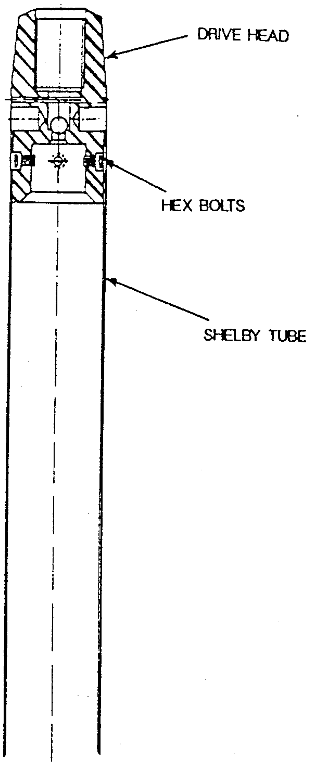


FIGURE 5

PROBE-DRIVE SYSTEM

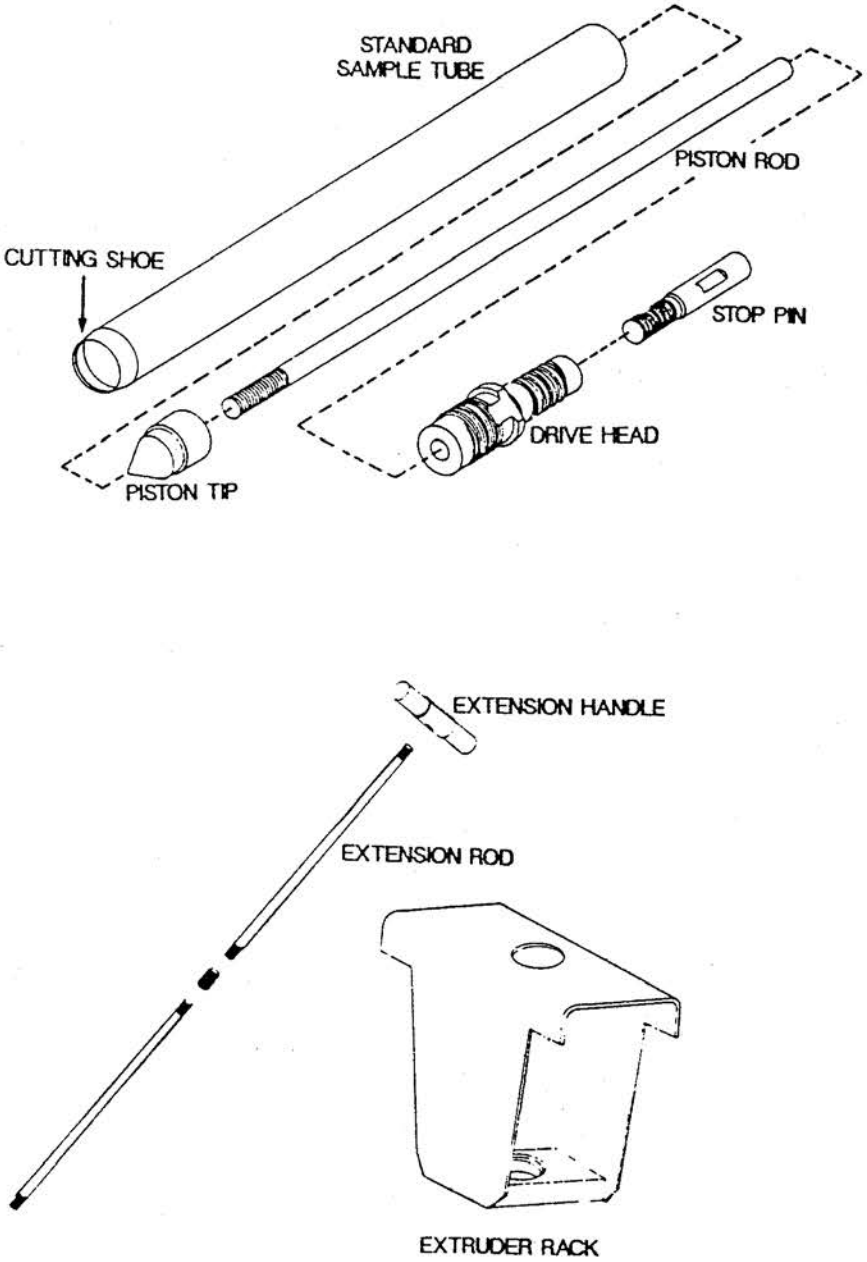
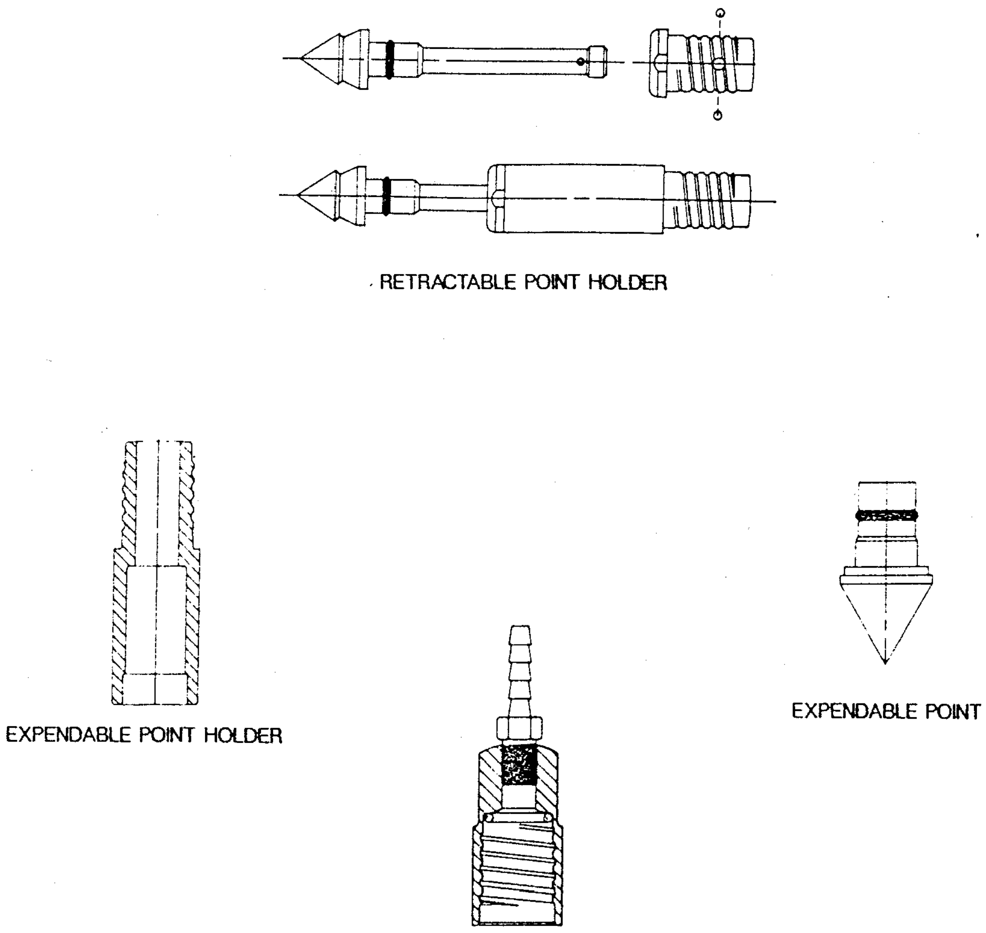


FIGURE 6

STANDARD SOIL GAS TOOLS



RETRACTABLE POINT HOLDER

EXPENDABLE POINT HOLDER

GAS SAMPLING CAP

EXPENDABLE POINT

FIGURE 7

POST-RUN TUBING (PRT) SYSTEM

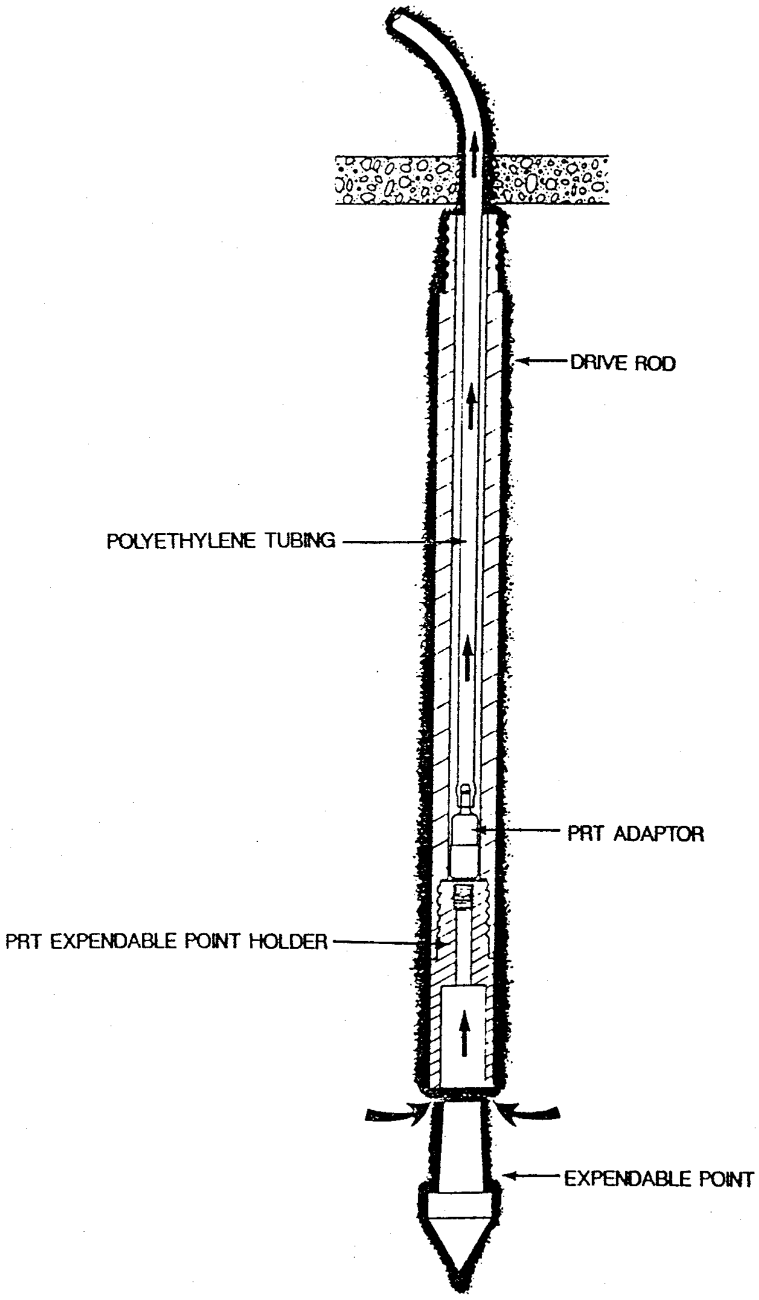
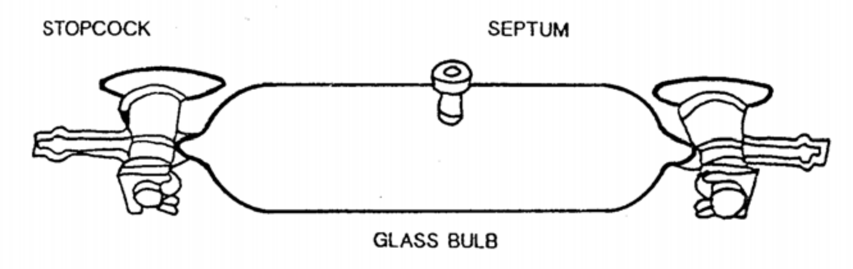


FIGURE 8

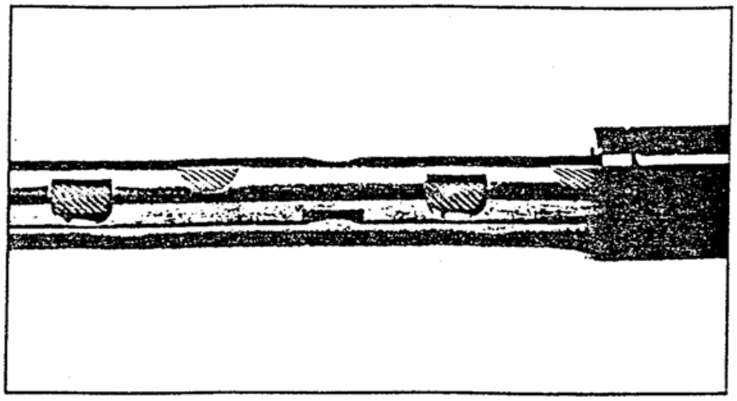
SOIL GAS SAMPLE CONTAINER



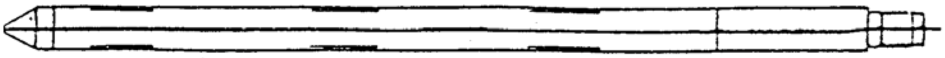
Note: Tedlar bags are also used for collection of soil gas samples; however, they are not shown on this figure.

FIGURE 9

GROUNDWATER SAMPLING TOOLS



SCREEN POINT SAMPLER IN OPEN POSITION



MILL-SLOTTED WELL POINT

FIGURE 10

PIEZOMETER INSTALLATION

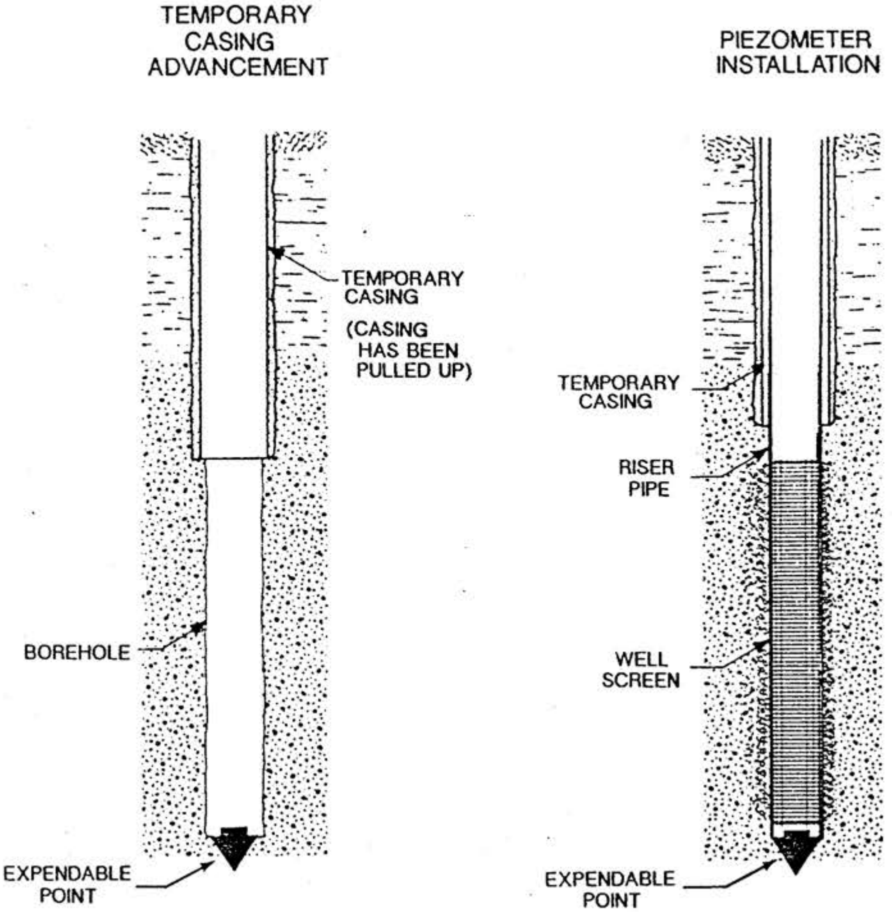
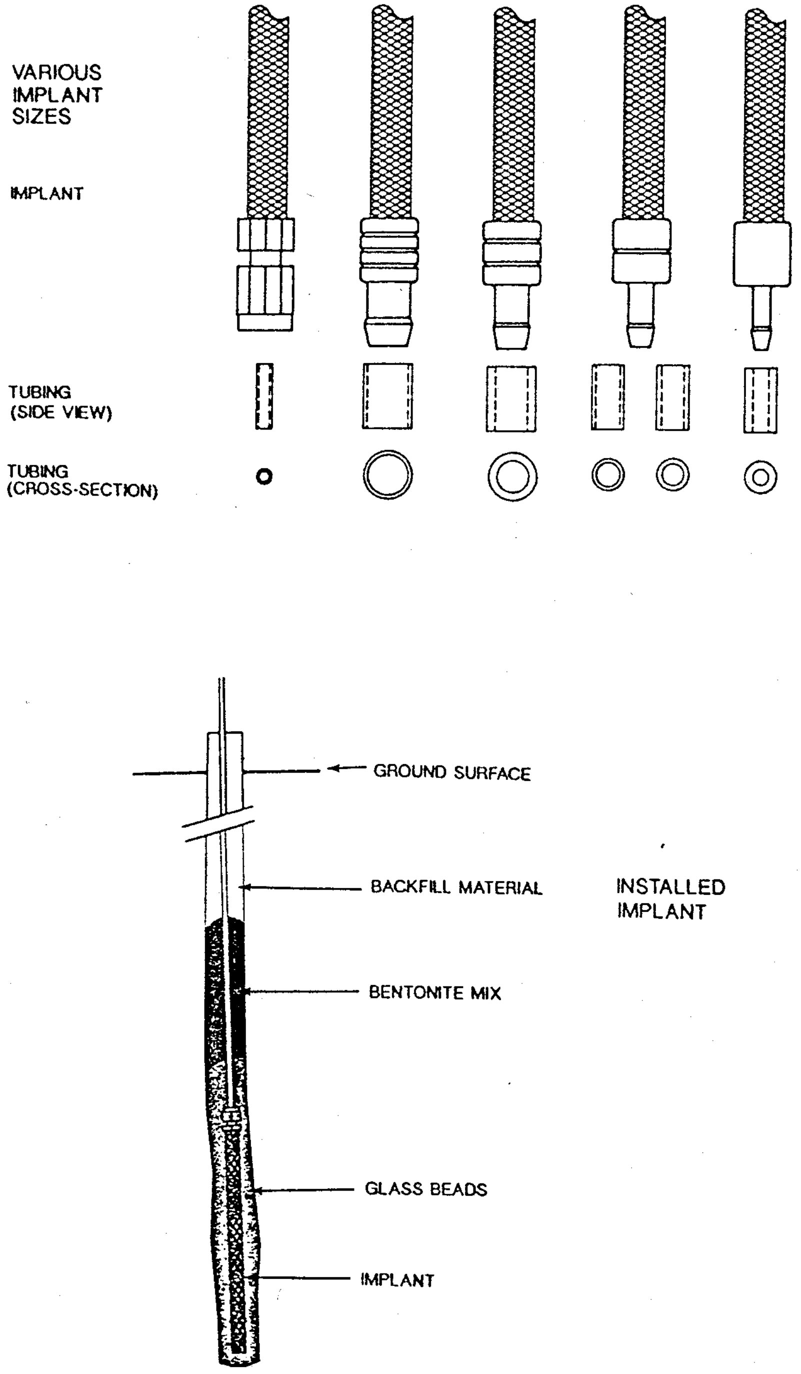


FIGURE 11

VAPOR SAMPLING IMPLANTS



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF GROUNDWATER INDICATOR PARAMETERS

SOP NO. 061

REVISION NO. 2

Last Reviewed: July 2009

	July 2009
Quality Assurance Approved	Date

1.0 BACKGROUND

Various water quality monitoring systems can be used for determining groundwater indicator parameters in the field. Commonly measured field indicator parameters include pH, specific conductance, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity. Groundwater field measurements are typically collected in conjunction with groundwater sampling or monitoring well development (see SOPs 010, 015, and 021).

Various types of water quality systems exist including down-hole systems and flow through cells. Tetra Tech used several common water quality meters including various types of In-Situ, YSI, Hydac, and Horiba meters (see Figure 1 at the end of this SOP). The sampling team should select the type of meter or monitoring system based on site-specific conditions including data collection needs, the types of wells being sampled, and the sampling procedures used. Multiple parameter systems should be used when multiple field parameters are to be measured.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the general requirements and procedures for using various water quality monitoring systems for determining groundwater pH, specific conductance, temperature, ORP, DO and turbidity in the field.

1.2 SCOPE

This SOP applies to general procedures for calibrating and operating water quality monitoring systems in the field. The project work plan or field sampling plan should identify the types of systems to be used and the actual project-specific field parameters to be measured. For each type of water quality system, the manufacturer’s manual should be consulted for specific operating instructions.

1.3 DEFINITIONS

Single Parameter System: A meter or monitoring system consisting of a single probe designed to measure a single indicator parameter.

Multiple Parameter System: A meter or monitoring system consisting of multiple probes capable of measuring multiple indicator parameters.

Open Container Measurements: Field measurements performed in an open container such as a cup, a jar, or a bucket where an air/water interface exists.

Flow-Through Chamber or Cell: A plastic cell or chamber connected to the sample pump discharge tubing so that a continuous flow of water passes across the probes. Additional tubing is used to route water from the flow-through cell to a waste container or final discharge point.

Down-Hole Monitoring System: A meter or monitoring system where probes are submerged by inserting them into the well. The probes are attached to the meter (located at the well head or ground surface) by one or more cables.

pH: A measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14 with strongly acidic solutions at the low end, strongly basic solutions at the high end, and “pure” or neutral water at 7. Field measurements of pH are recorded in standard units.

Specific Conductance: The ability of a solution to conduct electricity; a measure of the solution’s ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity. Conductivity of the same water changes substantially with temperature. Specific conductivity is generally found to be a good measure of the concentration of total dissolved solids (TDS) and salinity. Conductivity is measured by placing two electrodes (with opposite electrical charge) in the water. For a known electrical current, the voltage drop across the electrodes reveals the solution’s resistance. Since the resistance of aqueous solution changes with temperature (resistance drops with increasing temperature), the resistance is corrected to the resistance of the solution at 25 ºC. Field measurements are recorded in units of microsiemens per centimeters (µS/cm).

Temperature: The degree of hotness or coldness of the solution being measured. Field measurements are typically recorded in degrees Celsius (°C).

ORP: ORP, or redox potential, is the tendency of a chemical species to acquire electrons and be reduced. In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when new chemical species are introduced. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (to be oxidized by reducing the new species). Just as the transfer of hydrogen ions between chemical species determines the pH of an aqueous solution, the transfer of electrons between chemical species determines the reduction potential of an aqueous solution. Like pH, the reduction potential represents an intensity factor. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity. Field measurements are typically recorded in millivolts (mV).

DO: Dissolved oxygen (or oxygen saturation) is a relative measure of the amount of oxygen dissolved or carried in a given medium. In aquatic environments, dissolved oxygen is a relative measure of the amount of oxygen (O_2) dissolved in the water. Field measurements are typically recorded in milligrams per liter (mg/L).

Turbidity: Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids). Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand, very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid. Field measurements are typically recorded in Nephelometric Turbidity Units (NTU).

1.4 REFERENCE

Essential Handbook of Ground-Water Sampling by Gillian Nielsen, 2007.

Tetra Tech EM Inc. July 2009. SOPs 010, 015, and 021

1.5 REQUIREMENTS AND RESOURCES

The following items are typically required to measure groundwater pH, specific conductance, temperature, ORP, DO, and turbidity using this SOP:

- Single or multiple parameter water quality measuring system
- 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 (specific to each type of system)
- Waste container to collect purge water
- Logbook or field data sheets

2.0 PROCEDURES

The procedures outlined in this SOP are general and may apply to various types of water quality monitoring systems to measure groundwater pH, specific conductance, temperature, ORP, DO and turbidity in the field. General procedures for testing and calibrating the monitoring systems are presented first, followed by procedures for using the instruments and making field measurements. Each particular monitoring system should be identified in the project work plan or field sampling plan and should be operated in accordance with the manufacturer’s instruction manual.

2.1 TESTING AND CALIBRATION PROCEDURES

Each field meter or monitoring system should be calibrated according to manufacturer's specifications. In general, equipment should be thoroughly cleaned then calibrated and tested before the start-up of sampling at each site. Equipment should be calibrated and tested using manufacturer provided solutions and standards. Care should be taken to rinse the probes between testing and calibration to prevent cross contaminating solutions. Solutions should be poured from the manufacturer's container into another container to prevent compromising the entire solution provided by the manufacturer. Calibration and testing of field equipment should be documented each time it is performed in field logbooks (or field data sheets, if applicable). If testing and calibration measurements are out of tolerance, the instrument must be serviced or repaired.

2.2 FIELD MEASUREMENT PROCEDURES

Each field meter or monitoring system should be operated according to manufacturer's specifications. The actual field procedures will vary depending on the type of monitoring system being used (open container systems, flow-through cell systems, or down-hole systems) and the types of field parameters being measured. In addition, most systems include a data logging option. A description of open container, flow-through cell, and down-hole measurement processes are discussed below, followed by a general procedural summary and a summary of common errors associated with field measurements of indicator parameters.

2.2.1 Open Container Measurements

Open container measurements consist of collecting groundwater and placing it in a cup or container for field measurements using a hand held system. This method of field measurements is commonly used when bailing wells, but can also be used when pumping wells. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications. Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan. To make open container field measurements, samplers collect groundwater from the well and place in a cup or container large enough to adequately submerge the probe or probes, as specified in the manufacturer's operations manual. For open containers, measurements should be taken in the following order: temperature, specific conductance, pH, and turbidity. Open container systems are not recommended for low-flow sampling as flow-through systems are more appropriate. The probes and cup or container should be thoroughly rinsed after each field measurement and between sampling locations.

2.2.2 Flow-Through Cell Measurements

Flow-through cell systems consist of measuring groundwater parameters as a continuous flow of water passes across the probes through a cell or chamber, and is primarily used when pumping wells and using low-flow sampling procedures. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications. Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan.

The flow-through cell or chamber is placed "in line" between the discharge tubing of the pump and the container used to collect purged water. The outlet from the pump must be connected to the sample chamber input. The sample chamber outlet must then be connected or routed to a waste container (or to another designated discharge point). Tubing, fittings, and adaptors are generally required and may be provided by the manufacturer. Pump discharge tubing and chamber inlets and outlets are typically 1/2 or 3/8 inch diameter.

After the cell or chamber is connected to the pump discharge tubing and waste collection container, the sensors should be inserted into the sensor mounting plate in their respective ports. Any unused sensor ports must have plugs installed to close off the sample chamber. The probe cables are then connected to the meter following manufacturer's specifications.

With the system connected, the sampler should turn on the pump according to the manufacturer's instructions and then turn on the water quality monitor. Before recording any values, the sample chamber should be full, all air should be voided, and all of the displayed values should be stable. The probes and sample chamber should be thoroughly rinsed between sampling locations.

2.2.3 Down-Hole Measurements

Down-hole measurement systems consist of inserting the probes (or a multi-parameter sensor housing) inside a well to obtain field measurements, and is primarily used when pumping wells. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications.

Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan.

The probes or sensor are attached to a hand held meter or control unit by a cable and lowered inside the well to be sampled. Limiting factors when using down-hole systems include probe or sensor diameters and available cable lengths. The probes should be thoroughly decontaminated between sampling locations...

2.2.4 General Procedures for Field Measurements of Indicator Parameters

The following section discusses general procedures that typically apply to making field measurements of indicator parameters using various types of field instruments. Each particular type of meter or monitoring system should be identified in the project work plan or field sampling plan and should be operated in accordance with the manufacturer’s instruction manual.

1. Inspect the instrument and batteries prior to the field effort.
2. Check the integrity of the buffer solutions used for field calibration since frequent replacement is necessary as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at proper levels and no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended) following manufacturer's instructions and record data in field logbook or on field data sheets.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to several minutes. If the parameter values continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be occurring in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize should be clearly noted in the logbook or field data sheet. For DO, provide for sufficient flow past the membrane by gently stirring the sample. Probes without stirrers placed in wells (down-hole measurements) may be gently moved up and down to achieve the required mixing.
6. Read and record the value of each parameter being measured making sure units of measure are clearly recorded.
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in accordance with manufacturer’s instructions

2.2.5 Common Errors or Problems Associated With Field Measurements

The project work plan or field sampling plan should clearly identify the types of parameters to be measured, the measurement frequency, and “stabilization” requirements. It is essential to ensure that the type of monitoring system selected is compatible with the monitoring well sampling or development methods to be utilized. Some common errors to avoid are identified below:

- No, or incorrect equipment calibration
- Incorrect or expired calibration standards
- Poor equipment maintenance
- Inadequate training or unfamiliarity with equipment
- No record of units of measure and “+” or “-“ values for ORP
- Too much time taken to measure temperature sensitive parameters
- DO and ORP measured in closed systems (flow-through cell or down-hole) instead of closed cell systems

FIGURE 1

THE HORIBA U-10 WATER QUALITY MONITORING SYSTEM
THE IN-SITU TROLL 9500 LOW-FLOW SYSTEM
THE YSI HAND HELD 556 METER

Horiba U-10

In-Situ Troll

YSI 556

APPENDIX B-2

SUPERFUND REMOVAL ACTION LEVELS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

NOV 10 1998

MEMORANDUM

TO: Regional Emergency Response Managers
EPA Regions I - X

FROM: Steve Luftig, Director /s/
Office of Emergency and Remedial Response

SUBJECT: Retransmittal of the latest Superfund Removal Action Levels

A variety of tools are available to On-Scene Coordinators (OSCs) and other site managers to determine whether to provide alternate drinking water supplies under Superfund removal authority. One of the key resources for this task is the Removal Action Levels (RALs), which were established in Office of Solid Waste and Emergency Response (OSWER) Directive 9360.101, *Interim Final Guidance on Numeric Removal Action Levels for Contaminated Drinking Water Sites* (October 1987.)

This directive defined two types of RALs: (1) numeric levels for individual substances, which apply generally across most sites, and (2) site-specific levels which are determined on a case-by-case basis, using a more detailed analysis of conditions at a particular site. The 1987 OSWER directive established numeric RALs for 34 substances. The Office of Emergency and Remedial Response (OERR)/Emergency Response Division (ERD) updated the table of numeric RALs in April 1991. This update used the same methodology described in the 1987 OSWER directive, and expanded the RAL list to include 165 substances.

ERD later issued OSWER Directive 9360.1-02, *Final Guidance on Numeric Removal Action Levels for Contaminated Drinking Water Sites* (October 1993.) This directive adopted a new methodology to determine RALs based on the short-term acceptable risk (STAR) procedures promulgated by the EPA Office of Water (OW) in the *Guidance for Determining Unreasonable Risks to Health* (EPA/OW/Office of Science and Technology, 1992). This method remains the primary approach to determine RALs for Superfund removal actions.

Objective

OERR last updated the RAL tables in April 1997. This memorandum retransmits the amended tables to ensure that Superfund field personnel are using the most current and appropriate tool to evaluate threats to public health caused by contaminated drinking water sources. Regions should ensure that they are using the April 1997 RALs in the same manner that previous versions were used (i.e., as one factor in determining whether to provide alternate water supplies under Superfund removal authority.) This update does not in any way restrict the flexibility to develop and apply site-specific RALs. The updated numeric RALs apply to new removal starts begun since the date of issuance, and are not intended to affect completed removal actions or actions which were ongoing at the time the update was issued.

Please note that the list of RALs is not intended to be definitive. For instance, a substance which is not included in the RAL list might be present in drinking water at a site. In this case, the site manager may refer to the attached copy of the October 1993 memo for RALs. This memo describes in detail the appropriate methodology to determine whether the non-RAL listed substance is likely to present a threat to human health. Under no circumstances should field personnel assume that response actions cannot be taken because a contaminant of concern does not appear in the RAL tables.

If you have any comments, questions or suggestions about the RAL tables or their use, please contact Dan Thornton of my staff at (703) 603-8811.

Attachments

cc: EPA HQ Emergency Response Coordinators

NUMERIC REMOVAL ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES

Tables

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

April 1997

Table Acronyms

CAS #	Chemical Abstract Number
DWEL	Drinking Water Equivalent Level (calculated by multiplying the oral RfD by 70 kilograms (adult body weight) and dividing by the average volume of water (2 liters) consumed per day)
Longer-term HA (Child)	Drinking Water Health Advisory for 10 kg child consuming 1 liter water per day for up to 7 years
MCL	Maximum Contaminant Level (National Primary Drinking Water Standard)
MCLG	Maximum Contaminant Level Goal
MFL	Million Fibers per Liter
Treat. Tech.	MCL is based on the capability of the treatment technology
URTH-STAR	Draft Short-term Risk Level (STAR) recommended for an Unreasonable Risk to Health (URTH) under Safe Drinking Water Act

NUMERIC REMOVAL ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
PRIMARY DRINKING WATER STANDARDS AND HEALTH ADVISORIES
April 1997

Chemical		Cancer Risk		Standards and Health Advisories				Superfund
ORGANICS	**CAS #**	**Cancer Group**	**10-4 Cancer Risk (µg/L)**	**DWEL (µg/L)**	**Longer-term HA (Child) (µg/L)**	**MCL/MCLG (µg/L)**	**URTH -STAR- Level (µg/L)**	**Removal Action Level (µg/L)**
Acenaphthene	83329	—	—	2,100	—	—	—	2,100
Acetone	67641	D	—	3,500[a]	—	—	—	3,500
Acifluoren (tackle)	62476599	B2	100	400	100	— / 0	—	100
Acrylamide (2-Propenamide)	79061	B2	1	7	20	Treat. Tech ./ 0	1	1
Acrylonitrile	107131	B1	6	—	—	— / 0	—	6
Adipates (Diethylhexyl)	103231	C	3,000	20,000	20,000	400 / 400	—	4,000
Alachlor	15972608	B2	40	400	—	2 / 0	40	40
Aldicarb (Temik)	116063	D	—	35	—	7 / 7	—	35
Aldicarb sulfone	1646884	D	—	35	—	7 / 7	—	35
Aldicarb sulfoxide	—	D	—	35	—	7 / 7	—	35
Aldrin	309002	B2	0.2	1	0.3	—	—	0.2
Ametyrn	834128	D	—	300	900	—	—	300
Ammonium sulfamate	7773060	D	—	8,000	20,000	—	—	8,000
Anthracene	120127	D	—	11,000	—	—	—	11,000
Atrazine	1912249	C	—	200	50	3 / 3	30	30
Baygon	114261	C	—	100	40	—	—	40
Bentazon	25057890	D	—	1,000	300	— / 20	—	300
Benz(a)anthracene	56553	B2	—	—	—	—	—	—
Benzene	71432	A	100	—	—	5 / 0	100	100
Benzo(a)pyrene	50328	B2	0.2	—	—	0.2 / 0	—	0.2
Benzo(b)fluoranthene	205992	B2	—	—	—	—	—	—
Benzo(k)fluoranthene	207089	B2	—	—	—	—	—	—
bis-2-Chloroisopropyl ether	108601	D	—	1,000	4,000	—	—	1,000

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Bromacil	314409	C	—	5,000	3,000	—	—	3,000
Bromochloromethane	74975	D[a]	—	50	100	—	—	50
Bromodichloromethane	75274	B2	60	700	4,000	100 (80[b]) / 0	—	100
Bromoform	75252	B2	400	700	2,000	100 (80[b]) / 0	—	400
Bromamethane (Methyl bromide)	74839	D	—	50	100	—	—	50
Butanone (2-) (see Methyl ethyl ketone)								
Butyl benzyl phthalate	85687	C	—	7,000	—	—	—	7,000
Butylate	2008415	D	—	2,000	1,000	—	—	1,000
Carbaryl	63252	D	—	4,000	1,000	—	—	1,000
Carbofuran	1563662	E	—	200	50	40 / 40	50	50
Carbon tetrachloride	56235	B2	30	30	70	5 / 0	30	30
Carboxin	5234684	D	—	4,000	1,000	—	—	1,000
Chloral hydrate (Trichloroacetaldehyde monohydrate)	302170	C	—	60	200	60[c] / 40	—	60
Chloramben	133904	D	—	500	200	—	—	200
Chlordane	57749	B2	3	2	—	2 / 0	2	2
Chlorobenzene (see Monochlorobenzene)								
Chlorodibromomethane (Dibromochloromethane)	124481	C	—	700	2,000	100 (80[b]) / 60	—	600
Chloroform (Trichloromethane)	67663	B2	600	400	100	100 (80[b]) / 0	—	100
Chloromethane (Methyl chloride)	74873	C	—	100	400	—	—	100
Chlorophenol (2-)	95578	D	—	200	500	—	—	200
Chlorothalonil	1897456	B2	150	500	200	—	—	150
Chlorotoluene, o-	95498	D	—	700	2,000	—	—	700

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Chlorotoluene, p-	106434	D	—	700	2,000	—	—	700
Chloropyrifos	2921882	D	—	100	30	—	—	30
Chrysene	218019	B2	—	—	—	—	—	—
Cumene (see Isopropylbenzene)								
Cyanazine	21725462	C	—	70	20	— / 1	—	10
2,4-D (2,4-Dichlorophenoxyacetic acid)	94757	D	—	400	100	70 / 70	100	100
Dacthal (DCPA)	1861321	D	—	400	5,000	—	—	400
Dalapon	75990	D	—	900	300	200 / 200	—	300
Di[2-ethylhexy1]adipate	103231	C	3,000	20,000	20,000	400 / 400	—	4,000
Diazinon	333415	E	—	3	5	—	—	3
Dibenzo[a,h]anthracene	53703	B2	—	—	—	—	—	—
Dibromoacetonitrile	3252435	C	—	800	2,000	—	—	800
Dibromochloromethane (see Chlorodibromomethane)								
Dibromochloropropane (DBCP)	96128	B2	3	—	—	0.2 / 0	3	3
Dibromomethane (Methylene Bromide)	74953	D	—	—	—	—	—	—
Dibutyl phthalate (Di-n-butyl phthalate)	84742	D	—	4,000	—	—	—	4,000
Diacamba	1918009	D	—	1,000	300	—	—	300
Dichloroacetic acid	79436	B2	—	100	1,000	600[c] / 0	—	100
Dichloroacetonitrile	3018120	C	—	300	800	—	—	300
Dichlorobenzene -o (1,2)	95501	D	—	3,000	9,000	600 / 600	3,000	3,000
D chlorobenzene -m (1,3-)	541731	D	—	3,000	9,000	—	—	3,000
Dichlorobenzene -p (1,4-)	106467	C	—	4,000	10,000	75 / 75	750	750
Dichlorodifluoromethane (Freon-12)	75718	D	—	5,000	9,000	—	—	5,000

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Dichloroethane (1,1-)	75343	C[a]	—	—	—	—	—	—
Dichloroethane (1,2-) (Ethylene dichloride)	107062	B2	40	—	700	5/ 0	40	40
Dichloroethylene (1,1-)	75354	C	—	400	1,000	7 / 7	70	70
Dichloroethylene (cis- 1,2-)	156592	D	—	400	3,000	70 / 70	400	400
Dichloroethylene (trans- 1,2-)	156605	D	—	600	2,000	100 / 100	600	600
Dichloromethane (Methylene chloride)	75092	B2	500	2,000	—	5 / 0	—	500
Dichlorophenol (2,4-)	120832	D	—	100	30	—	—	30
Dichloropropene (1,2-)	78875	B2	60	—	—	5 / 0	—	60
Dichloropropene (1,3-) (cis and trans)	542756	B2	20	10	30	— / 0	—	10
Dieldrin	60571	B2	0.2	2	0.5	—	—	0.2
Diethyl phthalate	84662	D	—	30,000	—	—	—	30,000
Diethylhexyl (see Adipates)								
Diethylhexyl phthalate	117817	B2	300	700	—	6.0	—	300
Dimethrin	70382	D	—	10,000	10,000	—	—	10,000
Diethyl methylphosphonate	756796	C	700	7,000	2,000	—	—	2,000
Diethyl phthalate	131113	D	—	—	—	—	—	—
DIMP (Diisopropylmethylphosphonate)	1445756	D	—	3,000	8,000	—	—	3,000
Dinitrobenzene (1,3-)	99650	D	—	5	40	—	—	5
Dinitrotoluene (2,4-)	121142	B2	5	100	300	—	—	5
Dinitrotoluene (2,6-)	25321146	B2	5	40	400	—	—	5
Dinitrotoluene, tg[d] (2,6- & 2,4-)	—	B2	5	—	—	—	—	5
Dinoseb	88857	D	—	40	10	7 / 7	—	10
Dioxane p- (1,4-)	123911	B2	700	—	—	—	—	700

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Dioxin (see 2,3,7,8-TCDD)								
Diphenamid	957517	D	—	1,000	300	—	—	300
Diphenylamine	122394	D	—	1,000	300	—	—	300
Diquat	85007	D	—	80	—	20 / 20	—	80
Disulfoton	298044	E	—	1	3	—	—	1
Dithiane (1,4-)	505293	D	—	400	400	—	—	400
Diuron	330541	D	—	70	300	—	—	70
Endothall	145733	D	—	700	200	100 / 100	—	200
Endrin	72208	D	—	10	3	2 / 2	—	3
Epichlorohydrin	106898	B2	400	70	70	Treat. Tech. / 0	70	70
Ethylbenzene	100414	D	—	3,000	1,000	700 / 700	1,000	1,000
Ethylene dibromide (1,2-) (EDB)	106934	B2	0.04	—	—	0.05 / 0	0.05	0.05
Ethylene dichlode (see 1,2-Dichloroethane)								
Ethylene glycol	107211	D	—	40,000	6,000	—	—	6,000
Ethyl ether	60297	—	—	7,000[a]	—	—	—	7,000
Ethylene thiourea (ETU)	96457	B2	30	3	100	—	—	3
Fenamipos	22224926	D	—	9	5	—	—	5
Fluometuron	2164172	D	—	400	2,000	—	—	400
Fluorene	86737	D	—	1,400	—	—	—	1,400
Fluorotrichloromethane (Freon-11)	75694	D	—	10,000	3,000	—	—	3,000
Fonofos	944229	D	—	70	20	—	—	20
Formaldehyde	50000	B1	—	5,000	5,000	—	—	5,000
Freon-11(see Fluorotrichloromethane)								

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Freon-12 (see Dichloroodifluoromethane)								
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	76131	—	—	1,100,000[a]	—	—	—	1,100,000
Gylphosate	1071836	E	—	4,000	1,000	700 / 700	—	1,000
Heptachlor	76448	B2	0.8	20	5	0.4 / 0	0.8	0.8
Heptachlor epoxide	1024573	B2	0.4	0.4	0.1	0.2 / 0	0.4[e]	0.4
Hexachlorobenzene	118741	B2	2	30	50	1 / 0	—	2
Hexachlorobutadiene	87683	C	—	70	100	— / 1	—	10
Hexachlorocyclohexane, gamma (see Lindane)								
Hexachlorocyclopentadiene	77474	D	—	200	—	50 / 50	—	200
Hexachloroethane	67721	C	—	40	100	—	—	40
Hexane (n-)	110543	D	—	—	4,000	—	—	4,000
Hexazinone	51235042	D	—	1,000	3,000	—	—	1,000
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	2691410	D	—	2,000	5,000	—	—	2,000
Ideno[1,2,3-c,d]pyrene	193395	B2	—	—	—	—	—	—
Isophorone	78591	C	4,000	7,000	15,000	—	—	7,000
Isopropyl methylphosophonate	6838933	D	—	4,000	30,000	—	—	4,000
Isopropylbenzene (Cumene)	98828	—	—	1,400[a]	—	—	—	1,400
Kerb (see Pronamide)								
Lindane (Hexachlorocyclohexane, gamma)	58899	C	—	10	30	0.2 / 0.2	2	2
Malathion	121755	D	—	800	200	—	—	200
Maleic hydrazide	123331	D	—	20,000	5,000	—	—	5,000
MCPA (4-Chloro-2-methylphenoxy)-acetic acid)	94746	E	—	50	100	—	—	50

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Chemical		Cancer Risk		Standards and Health Advisories				Superfund
ORGANICS	CAS #	Cancer Group	10-4 Cancer Risk (µg/L)	DWEL (µg/L)	Longer-term HA (Child) (µg/L)	MCL/MCLG (µg/L)	URTH -STAR- Level (µg/L)	Removal Action Level (µg/L)
Methomyl	16752775	D	—	900	300	—	—	300
Methoxychlor	72435	D	—	200	50	40 / 40	50	50
Methyl bromide (see Bromomethane)								
Methyl chloride (see Chloromethane)								
Methyl ethyl ketone (2-Butanone)	78933	D[a]	—	21,000[a]	—	—	—	21,000
Methyl parathion	298000	D	—	9	30	—	—	9
Methyl tert butyl ether	1634044	C	—	1,000	3,000	—	—	1,000
Methylene bromide (see Dibromomethane)								
Methylene chloride (see Dichloromethane)								
Metolachlor	51218452	C	—	3,500	2,000	—	—	2,000
Metribuzin	21087649	D	—	500	300	—	—	300
Monochloracetic acid (Chloroacetic acid)	79118	—	—	70[a]	—	—	—	70
Monochlorobenzene (Chlorobenzene)	108907	D	—	700	2,000	100 / 100	700	700
Napthalene	91203	D	—	100	400	—	—	100
Nitroguanidine	556887	D	—	4,000	10,000	—	—	4,000
Nitrophenols p-	25154556	D	—	300	800	—	—	300
Octachlorocamphene (see Toxaphene)								
Oxamyl	23135220	E	—	900	200	200 / 200	—	200
Paraquat	1910425	E	—	200	50	—	—	50
Pentachloronitrobenzene (PCNB)	82688	C[a]	—	100[a]	—	—	—	20
Pentachlorophenol	87865	B2	30	1,000	300	1 / 0	30	30
Perchloroethylene (see Tetrachloroethylene)								
Phenol	108952	D	—	20,000	6,000	—	—	6,000

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ORGANICS	CAS #	Cancer Group	10-4 Cancer Risk (µg/L)	DWEL (µg/L)	Longer-term HA (Child) (µg/L)	MCL/MCLG (µg/L)	URTH -STAR- Level (µg/L)	Removal Action Level (µg/L)
Picloram	1918021	D	—	2,000	700	500 / 500	—	700
Polychloroinated biphenyls (PCBs)	1336363	B2	0.5	—	—	0.5 / 0	0.5	0.5
Prometon	1610180	D	—	500	200	—	—	200
Pronamide (Kerb)	23950585	C	—	3,000	800	—	—	800
Propachlor	1918167	D	—	500	100	—	—	100
Propazine	139402	C	—	700	500	—	—	500
Propham	122429	D	—	600	5,000	—	—	600
Pyrene	129000	D	—	1,100	—	—	—	1,100
RDX (Hexahydro-1,3,5-trinitro-1,3,5,triazine)	121824	C	30	100	100	—	—	100
Simazine	122349	C	—	200	70	4 / 4	—	40
Styrene	100425	C	—	7,000	2,000	100 / 100	1,000	1,000
T (2,4,5-)	93765	D	—	350	800	—	—	350
Tackle (See Acifluorfen)								
TCDD (2,3,7,8-) (v) (Dioxin)	1746016	B2	0.00002	0.00004	0.00001	0.00003 / 0	—	0.00003
Tebuthiuron	34014181	D	—	2,000	700	—	—	700
Temik (see Aldicarb)								
Terbacil	5902512	E	—	400	300	—	—	300
Terbufos	13071799	D	—	5	1	—	—	1
Tetrachloroethane (1,1,1,2-)	630206	C	100	1,000	900	—	—	900
Tetrachlorothane (1,1,2,2-)	79345	C[a]	20[a]	—	—	—	—	20
Tetrachloroethylene (Perchloroethylene)	127184	—	70	500	1,000	5 / 0	70	70
Toluene	108883	D	—	7,000	2,000	1,000 / 1,000	—	2,000
Toxaphene (Octachlorocamphene)	8001352	B2	3	400	—	3 / 0	3	3

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Chemical ORGANICS	CAS #	Cancer Risk		Standards and Health Advisories				Superfund
		Cancer Group	10-4 Cancer Risk (µg/L)	DWEL (µg/L)	Longer-term HA (Child) (µg/L)	MCL/MCLG (µg/L)	URTH -STAR- Level (µg/L)	Removal Action Level (µg/L)
TP (2,4,5-) (2(2,4,5-Trichlorophenoxy-propionic acid)	93721	D	—	300	70	50 / 50	70	70
Trichloroacetaldehyde (Chloral) See Chloral hydrate (hydrated form of trichloroacetaldehyde)								
Trichloroacetic acid	76039	C	—	4,000	4,000	60[c] / 300	—	3,000
Trichlorobenzene (1,2,4-)	120821	D	—	400	100	70 / 70	—	100
Trichlorobenzene (1,3,5-)	108703	D	—	200	600	—	—	200
Trichloroethane (1,1,1-)	71556	D	—	1,000	40,000	200 / 200	1,000	1,000
Trichloroethane (1,1,2-)	79005	C	—	100	400	5 / 3	—	30
Trichloroethylene (Trichloroethane)	79016	B2	300	300	—	5 / 0	300	300
Trichloromethane (see Chloroform)								
Trichlorophenol (2,4,6-)	88062	B2	300	—	—	—	—	300
Trichlorophenoxypropionic acid (2(2,4,5-)) (see 2,4,5-TP)								
Trichloropropane (1,2,3-)	98184	B2	500	200	600	—	—	200
1,1,2-Trichloro-1,2,2,-trifluoroethane (see Freon 113)								
Trifluralin	1582098	C	500	300	80	—	—	80
Trinitroglycerol	55630	—	—	—	5	—	—	5
Trinitrotoluene (2,4,6-)	118967	C	100	20	20	—	—	20
Vinyl chloride	75014	A	1.5	—	10	2 / 0	2	2
Vydate (see Oxamyl)								
Xylenes (mixed)	1330207	D	—	60,000	40,000	10,000 / 10,000	40,000	40,000

[a] Based on data from IRIS or HEAST in the absence of a published U.S. EPA, Office of Water value

[b] Total for all trihalomethanes combined cannot exceed 80 µg/L

[c] Total for all haloacetic acids cannot exceed 60 µg/L

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[d] Technical Grade (tg); 2,4- and 2,6-Dinitrotoluene are unlikely to occur alone

[e] Based on special considerations

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Chemical		Cancer Risk		Standards and Health Advisories				Superfund
INORGANICS	**CAS #**	**Cancer Group**	**10-4 Cancer Risk (μg/L)**	**DWEL (μg/L)**	**Longer-term HA (Child) (μg/L)**	**MCL/MCLG (μg/L)**	**URTH -STAR- Level (μg/L)**	**Removal Action Level (μg/L)**
Ammonia	7664417	D	—	—	—	—	—	34,000[a] (taste)
Antimony	7440360	D	—	10	10	6 / 6	—	10
Arsenic	7440382	A	2	—	—	50 / —	—	50
Asbestos fibers > 10 μm	1332214	A	700 MFL	—	—	7 MFL / 7 MFL	70 MFL	70 MFL[b]
Barium	7440393	D	—	2,000	—	2,000 / 2,000	—	2,000
Beryllium	7440417	B2	0.8	200	4,000	4 / 4	—	4
Boron	7440428	D	—	3,000	900	—	—	900
Bromate	15541454	—	—	—	—	10 / 0	—	10
Cadmium	7440439	D	—	20	5	5 / 5	5	5
Chloramines (measured free chlorine)	10599903	D[a]	—	3,300	1,000	4,000 / 4,000	—	4,000
Chlorine	7782505	D	—	4,000	—	4,000 / 4,000	—	4,000
Chlorine dioxide	10049044	D	—	350	—	800 / 300	—	800
Chlorite	7758192	D	—	100	—	1,000 / 80	—	1,000
Chromium III (see Chromium total)	16065831							
Chromium VI (see Chromium total)	18540299							
Chromium (total)	—	D	—	200	200	100 / 100	200	200
Copper	7440508	D	—	—	—	Treat. Tech. / 1,300	1,300	1,300
Cyanide	57125	D	—	800	200	200 / 200	—	200
Fluoride	16984488	—	—	4,200	—	4,000 / 4,000	5,000[c]	5,000
Hypochlorite	7681529	—	—	—	—	— / 4,000	—	—
Hypochlorous acid	7790923	—	—	—	—	— / 4,000	—	—
Lead at tap	7349921	B2	—	—	—	Treat. Tech. / 0	30[c]	30

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INORGANICS	CAS #	Cancer Group	10-4 Cancer Risk (µg/L)	DWEL (µg/L)	Longer-term HA (Child) (µg/L)	MCL/MCLG (µg/L)	URTH -STAR- Level (µg/L)	Removal Action Level (µg/L)
Manganese	7439965	D[a]	—	—	—	— / —	—	—
Mercury	7439976	D	—	10	—	2 / 2	10	10
Molybdeum	7439987	D	—	200	10	—	—	10
Nickel	7440020	D	—	600	500	100 / 100	—	500
Nitrate	14797558	—	—	56,000	—	10,000 / 10,000	10,000	10,000
Nitrite	14797650	—	—	5,600	—	1,000 / 1,000	1,000	1,000
Nitrate+Nitrite	—	—	—	—	—	10,000 / 10,000	10,000	10,000
Selenium	7782492	—	—	200	—	50 / 50	200	200
Silver	7440224	D	—	200	200	—	—	100[d]
Strontium	7440246	D	—	9,000	25,000	—	—	25,000
Sulfate	7757826	—	—	—	—	500,000/ 500,000	—	250,000 (aesthetics)
Thallium	7440280	—	—	2	7	2 / 0.5	—	2
Vanadium	7440622	D	—	250[a]	—	—	—	250
White phosphorus	772314	D	—	0.5	—	—	—	0.5
Zinc	7440666	D	—	10,000	3,000	—	—	3,000
Zinc chloride (measured as zinc)		D	—	10,000	3,000	—	—	3,000

[a] Based on data from IRIS or HEAST in the absence of a published U.S. EPA, Office of Water value

[b] MFL = million fibers per liter

[c] Based on special considerations

[d] Secondary Maximum Contaminant Level intended to protect general public from argyuria (a cosmetic effect) over a lifetime