Illinois Environmental Protection Agency

Bureau of Land • 1021 North Grand Avenue East • P.O. Box 19276 • Springfield • Illinois • 62794-9276

ILLINOIS EPA RCRA CORRECTIVE ACTION CERTIFICATION

This certification must accompany any document submitted to Illinois EPA in accordance with the corrective action requirements set forth in a facility's RCRA permit. The original and two copies of all documents submitted must be provided.

1.0 Facility Identification

Name Wood River Refinery
County Madison
Street Address 900 S. Central Ave
Site No. (IEPA) 1191150002
City Roxana, IL 62084
Site No. (USEPA) ILD 080 012 305

2.0 Owner Information

Name Not Applicable
Mail Address
City
State
Zip Code
Contact Name
Contact Title
Phone

3.0 Operator Information

Name Equilon Enterprises LLC d/b/a SOPUS
Mail Address 17 Junction Drive, PMB #399
City Glen Carbon
State IL
Zip Code 62034
Contact Name Kevin Dyer
Contact Title Senior Principal Program Manager
Phone 618-288-7237

4.0 Type of Submission (check applicable item and provide requested information, as applicable)

- ☐ RFI Phase I Workplan/Report
- ☐ RFI Phase II Workplan/Report
- ☐ CMP Report;
- ☑ Other (describe): Standard Operating Procedures updates

IEPA Permit Log No. B-43R
Date of Last IEPA Letter on Project May 28, 2015
Log No. of Last IEPA Letter on Project B-43R-CA-66, -84

Does this submittal include groundwater information: ☐ Yes ☑ No

Date of Submittal Aug 3, 2015

5.0 Description of Submittal: (briefly describe what is being submitted and its purpose)

Routine updates to previously submitted Standard Operating Procedures (SOPs)

6.0 Documents Submitted (identify all documents in submittal, including cover letter; give dates of all documents)

Cover Letter; SOPs 3, 4, 5, 8, 10, 12, 14, 16, 17, 18, 20, 21, 23, 24, 25, 26, 28, 29, 33, 42, 44R, 46, 47, 48, 49, 51, 52, and 53

7.0 Certification Statement

(This statement is part of the overall certification being provided by the owner/operator, professional and laboratory in Items 7.1, 7.2 and 7.3 below). The activities described in the subject submittals have been carried out in accordance with procedures approved by Illinois EPA. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

For: EquilonEnterprisesLLCd/b/aSOPUS

Date of Submission: 8-3-15

7.1 Owner/Operator Certification

(Must be completed for all submittals. Certification and signature requirements are set forth in 35 IAC 702.126.) All submittals pertaining to the corrective action requirements set forth in a RCRA Permit must be signed by the person designated below (or by a duly authorized representative of that person):

1. For a Corporation, by a principal executive officer of at least the level of vice president.
2. For a Partnership or Sole Proprietorship, by a general partner or the proprietor, respectively.
3. For a Governmental Entity, by either a principal executive officer or a ranking elected official.

A person is a duly authorized representative only if:

1. the authorization is made in writing by a person described above; and
2. the written authorization is provided with this submittal (a copy of a previously submitted authorization can be used).

Owner Signature: ____________________ Date: ____________

Title: ____________________

Operator Signature: [signature] Date: July 27, 2015

Title: Senior Principal Program Manager

7.2 Professional Certification (if necessary)

Work carried out in this submittal or the regulations may also be subject to other laws governing professional services, such as the Illinois Professional Land Surveyor Act of 1989, the Professional Engineering Practice Act of 1989, the Professional Geologist Licensing Act, and the Structural Engineering Licensing Act of 1989. No one is relieved from compliance with these laws and the regulations adopted pursuant to these laws. All work that falls within the scope and definitions of these laws must be performed in compliance with them. The Illinois EPA may refer any discovered violation of these laws to the appropriate regulating authority.

Any person who knowingly makes a false, fictitious, or fraudulent material statement, orally or in writing, to the Illinois EPA commits a Class 4 felony. A second or subsequent offense after conviction is a Class 3 felony. (415 ILCS 5/44 (h))

Professional's Signature: ____________________ Date: ____________

Professional's Name ____________________

Address ____________________ Professional's Seal:

City ____________________

State ______ Zip Code ____________

Phone ____________________

7.3 Laboratory Certification (if necessary)

The sample collection, handling, preservation, preparation and analysis efforts for which this laboratory was responsible were carried out in accordance with procedures approved by Illinois EPA.

Name of Laboratory ____________________

____________________ Date: ____________

Signature of Laboratory Responsible Officer

Mailing Address of Laboratory

Address ____________________

City ____________________

State ______ Zip Code ____________

____

Name and Title of Laboratory Responsible Officer

AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110-1337
www.aecom.com

314 429 0100 tel
314 429 0462 fax

August 3, 2015

Mr. Steven F. Nightingale, PE
Manager, Permit Section
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794

Subject: Routine Updates to Previously Submitted Standard Operating Procedures
Roxana, Illinois
1191150002 – Madison County

Dear Mr. Nightingale:

As part of AECOM's (formerly URS Corporation's) routine quality improvement process, we recently performed a review of the Standard Operating Procedures (SOPs) used by field staff performing activities at the Investigation Site in Roxana, Illinois. Previously revised versions of SOPs were submitted to the Illinois Environmental Protection Agency (IEPA) in September 27, 2013, July 3, 2014, and March 4, 2015 submittals from URS. These procedures were originally submitted, as requested by various IEPA correspondences, within various reports and work plans related to the Investigation Site in Roxana, Illinois. We are submitting this package of updated SOPs for informational purposes.

The SOPs included with this submittal are listed below. All of the SOPs listed received editorial and formatting revisions, including but not limited to updating URS Corporation references to AECOM. A summary of any additional substantive revisions made to the SOPs are included in the table below.

SOP No	SOP Title	Additional Revisions
3	Calibration and Maintenance of Field Instruments	Added discussion regarding fresh air calibration and moisture/dust filters
4	Decontamination	Provided proper Liquinox mixing guidelines and provided more specifics for more equipment with additional sections
5	Utility Clearance Procedures	Updated for consistency with Shell/AECOM procedures
8	Field Reporting and Documentation	Proper method for changing/deleting logbook entries; Clarified logbook, paperwork, Toughbook information
10	Well Gauging Measurements	Editorial and formatting
12	Grouting Procedures	Editorial and formatting
14	Headspace Soil Screening	Editorial and formatting
16	IDW Handling	Removed; Redundant with other plans for the site; Activities are performed in accordance with regulations

SOP No	SOP Title	Additional Revisions
17	Logging	Editorial and formatting
18	Low Flow Groundwater Purging and Sampling	Modified water quality monitoring steps;
20	Well Development	Distinguish between development and redevelopment
21	Monitoring Well Installation	Editorial and formatting
23	Quality Assurance Samples	Editorial and formatting
24	Sample Classification, Packaging and Shipping	Editorial and formatting
25	Sample Containers, Preservative and Holding Times	Editorial and formatting
26	Sample Control and Custody Procedures	Editorial and formatting
28	Soil Sampling	Editorial and formatting
29	Soil Probe Operation	Editorial and formatting
33	Water Quality Monitoring	Removed; Steps incorporated into groundwater sampling related SOPs
42	Groundwater Profiling	Incorporate appropriate water quality monitoring steps; Further define stabilization guidelines
44R	Soil Vapor Purging and Sampling	Incorporate flexibility for potential new shroud design; Modify tracer gas quantity based on conversations with the analytical laboratory
46	Indoor Air Sampling with Canisters	Editorial and formatting
47	Sub-Slab Soil Gas Installation and Sampling with Canisters	Removed reference to valve from the reducer at the port connection
48	Soil Vapor Extraction Well Data Collection and Sampling	Editorial and formatting
49	Soil Vapor Extraction Effectiveness Monitoring	Editorial and formatting
51	Vapor Sample Classification Packaging and Shipping	Editorial and formatting
52	Soil Vapor Field Laboratory Screening	Editorial and formatting
53	Dwyer Digital Manometer	Editorial and formatting

If you have any questions, please contact Wendy Pennington at wendy.pennington@aecom.com (314/743-4166), or Bob Billman at bob.billman@aecom.com (314/743-4108).

Sincerely,
AECOM, on behalf of Shell Oil Products US

Wendy Pennington, PE
Project Engineer

Robert B. Billman
Senior Project Manager

Enclosures Revised SOPs
RCRA Corrective Action Certification

cc: Gina Search, IEPA (Collinsville, IL)
Amy Boley, IEPA (Springfield, IL)
Jim Moore, IEPA (Springfield IL)
Kevin Dyer, SOPUS
Shannon Haney, Greensfelder Hemker
Project File
Repository (Website, Roxana Public Library)

1. Objective

This document defines the standard operating procedure for calibration and maintenance of field instruments frequently used during environmental field activities for the Shell projects in Hartford and Roxana, Illinois. This Standard Operating Procedure (SOP) gives descriptions of the most common used of these instruments and field procedures necessary to calibrate and maintain these field instruments. Calibration and maintenance records for all equipment are maintained with the project file.

2. Equipment

The following equipment is typically required during field instrument calibration and maintenance activities.

- Latex/Nitrile gloves
- Site logbook
- Field data sheets
- Equipment Calibration Record forms
- Distilled ordeionized water
- Decontamination equipment
- Health and Safety Equipment
- Field Instrument Operations Manual
- Calibration gases for Air Monitoring Equipment
- Calibration solutions for Water Monitoring Equipment.

3. Types of Field Instruments Commonly used during Environmental Investigations

The following are some of the more commonly used instruments during environmental investigations.

- Photoionization Detector (PID)
- Flame Ionization Detector (FID)
- Multi-gas Meter (usually includes Explosimeter, Hydrogen Sulfide detector, Oxygen sensor, and Carbon Monoxide meter)
- Single-gas Meter (usually Benzene or Hydrogen Sulfide meters)

- Groundwater Level Indicator
- Petroleum/Groundwater Interface Probe
- Groundwater pH, Temperature, Conductivity, Dissolved Oxygen, Oxidation-Reduction Potential and/or Turbidity Meter(s).

4. *Maintenance*

Maintenance should be performed on all field instruments on a regular basis to ensure instruments are in proper working order at all times and to prolong the instrument life. General maintenance such as regular cleaning of the instrument, battery checks and replacement, and ensuring the instrument is handled and stored properly can easily be performed by AECOM employees. Other maintenance items such as sensor repair, annual calibrations and repair of a malfunctioning piece of equipment should be performed by the instrument manufacturer or licensed dealer and should NOT be performed by AECOM employees, unless specifically directed by equipment supplier. Contact the manufacturer to determine where the instrument should be submitted for these maintenance tasks. The vast range of instruments available for use by the environmental professional have an equally vast maintenance regime and therefore maintenance guidelines specified in the manual for each piece of equipment should be referred to and followed at all times.

5. *Calibration*

Due to the vast number of field instruments available, various parameters potentially monitored, and the wide range of functions potentially performed by each instrument, a description of the calibration of every type of instrument available is not feasible. However, a generalized SOP for general types of field equipment calibration is presented and should be followed while performing calibrations of field instruments.

Air Monitoring Instruments (PID, FID, Multi-gas Meters, Single-gas meters, etc.)

1. Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
2. Allow the instrument to “warm up” and progress through the startup diagnostic routine.
3. Perform a “fresh air” calibration, if possible, for the air meter. This fresh air calibration should be performed using a zero air filter provided with the air monitor or using a zero air calibration gas.

4. Record the initial reading on the proper equipment calibration field form and in the site logbook. Also record the fresh air calibration standard on the field form or in the logbook.
5. Apply the proper calibration gas and proceed with calibration as directed in the operator's manual.
6. Record the final calibrated reading on the field equipment calibration forms or in the field logbook.
7. Verify a moisture and dust filter is in place on the air meter intake nozzle, when applicable.
8. If directed in the operator's manual, at periodic intervals throughout the day the calibration of the instrument should be checked and re-evaluated.

Groundwater Parameter Instruments (Troll 9500, pH-Con 10, turbidimeters, etc.)

Frequently one instrument will have multiple sensors for measuring various parameters in water. With the exception of temperature, each of these parameters can generally be field calibrated.

1. Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
2. Allow the instrument to "warm up" and progress through the startup diagnostic routine.
3. Apply calibration solution(s) as instructed by the instrument prompts and/or the operator's manual.
4. Adjust the reading of the instrument to correlate to the corresponding calibration solution being applied.
5. Record calibration reading(s) in the field logbook or on proper field calibration forms.
6. Dispose of used calibration solution and reseal calibration solution containers for future use.

Water Level Indicator and Petroleum/Water Interface Probe

Field calibration of this instrument is not required. Rather a series of field checks to ensure the instrument is in proper working order will be described.

1. Turn the instrument on. The on/off switch is usually a knob located on the side of the reel in which the measuring tape is rolled onto.

2. Push the "test" button to ensure that the batteries are in working order. If the batteries are working, an audible tone will be heard and a visible light located on the side of the real will illuminate.

3. Immerse the sensor probe in potable water to ensure the audible tone is heard and visible light illuminates when the electrical circuit is completed when the probe enters the water. Make an observation of where the water level is at on the probe when the circuit is completed. Repeat this step several times to familiarize yourself with this contact point. By performing this step, the chance of submersing the probe to a greater depth than necessary is reduced. Over submersion of the probe will result in a greater amount of the probe and measuring tape to be cleaned and decontaminated prior to collection of another groundwater measurement.

6. Decontamination

Small instruments and equipment that comes into contact with environmental media will be cleaned according to SOP No. 4 – Decontamination between each use, and will be stored in such a way as to prevent contamination.

1. Objective

This document defines the standard procedure for decontamination for Shell projects in Hartford and Roxana, Illinois. This SOP serves as a supplement to information which might be in a project Work/O&M/Field Sampling Plans and is intended to be used together with several other SOPs.

The overall objective of multimedia sampling programs is to obtain samples that accurately depict the chemical, physical, and/or biological conditions at the sampling site. Extraneous contaminants can be brought onto the sampling location and/or introduced into the medium of interest during the sampling program (e.g. using sampling equipment that is not properly or fully decontaminated). Trace quantities of contaminants can consequently be captured in a sample and lead to false positive analytical results and, ultimately, to an incorrect assessment of the contaminant conditions associated with the site. Decontamination of sampling equipment (e.g., all non-disposable equipment that will come in direct contact with samples) and field support equipment (e.g., drill rigs, vehicles) is, therefore, required prior to, between, and after uses to ensure that sampling cross-contamination is prevented, and that on-site contaminants are not carried off-site.

2. Equipment

The following is a list of equipment that may be needed to perform decontamination:

- Brushes
- Wash tubs
- Buckets
- Scrapers, flat bladed
- Hot water - high-pressure sprayer
- Sponges or paper towels
- Liquinox detergent (or equivalent)
- Isopropyl alcohol
- Potable tap water
- Deionized or distilled water
- Garden-type water sprayers.
- Plastic sheeting or trash bags

3. Decontamination Procedures

Proper mixing instructions for Liquinox detergent: use 2.5 tablespoons Liquinox detergent (approximately 2.5 capfuls) per gallon of water being added. If another detergent is being used, verify the proper mixing instructions prior to use.

3.1 Personnel

Personnel should be provided space to wash and rinse gloves, and any other personal protective equipment (PPE). A container should be available to dispose of used disposable items such as gloves, or tyvek (if used).

The decontamination procedure for field personnel will include:

1. Glove wash in an Liquinox (or similar) solution
2. Glove rinse in distilled water
3. Outer glove removal, if worn
4. Coverall removal, if worn
5. Inner glove removal

Refer to the project Health and Safety Plan (HASP) for additional information. If conditions change and/or upgrade of PPE is required, refer to the task or project specific HASP for more specific information.

3.2 Groundwater Parameter Equipment (e.g., Troll 9500 or similar)

Equipment used to measure groundwater parameters, which does not come into contact with the sample, should be decontaminated periodically throughout the day, between each well if elevated levels of contamination are anticipated, and at the end of each sampling day. The following steps will be used to decontaminate groundwater parameter measuring equipment:

1. Personnel will dress in appropriate PPE to reduce the potential of personal exposure as required by the project Health and Safety Plan (HASP).
2. Spray or wash sensors with a soap and water mixture (Liquinox or similar along with potable or distilled water).
3. Spray or rinse sensors with distilled water.
4. Wash Flow Cell in a wash tub or bucket containing soap and water mixture (Liquinox or similar along with potable or distilled water) and scrubbed with a bristle brush or similar utensil.

5. Rinse Flow Cell with distilled water in a second tub or bucket.
6. Detergent water and rinse water will be replaced with new solutions periodically throughout the day, at least at mid-day.
7. At the end of each sampling day,
    a. Soak the optical dissolved oxygen (DO) cap in distilled vinegar for 10 to 15 minutes.
    b. Rinse the optical DO cap in distilled water.
    c. Wash the Flow Cell in a wash tub or bucket containing soap and water mixture (Liquinox or similar along with potable or distilled water and scrubbed with a bristle brush or similar utensil.
    d. Rinse Flow Cell with distilled water in a second tub or bucket.
    e. If flow through cell is still odorous, soak in a wash tub or bucket containing soap and water mixture (Liquinox or similar along with potable or distilled water) for 10 to 15 minutes. Also consider performing decontamination activities more often during the next sampling day/event.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent contact with contaminated media. If the equipment is not used immediately after decontamination, the equipment will be stored in such a way as to minimize potential contact with contaminants.

3.3 Groundwater Sampling Pumps

Submersible, non-dedicated, non-disposable groundwater sampling pumps will be decontaminated between each sampling location. The following steps will be used to decontaminate groundwater sampling pumps:

1. Personnel will dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP.
2. Exterior of the sampling pump, including the electrical cord, will be sprayed and/or wiped off with isopropyl alcohol to remove gross contamination. The outer sampling pump casing may be removed, if necessary, to remove gross contamination on sampling pump motor module.

3. Sampling pump, including electrical cord, will be placed in a wash tub or bucket containing a soap and water mixture (Liquinox or similar along with potable or distilled water). Sampling pump will be turned on to circulate the soapy water for a minimum of 5 minutes.

    a. Sampling pump may be scrubbed with a bristle brush, sponge or similar utensil.

    b. If the electrical cord will not fit into the wash tub or bucket, it can be wiped down with a paper towel saturated with a detergent water solution.

4. Sampling pump, including electrical cord, will be placed in a second tub or bucket containing distilled water. Sampling pump will be turned on to circulate rinse water for a minimum of 5 minutes and until all soap has been rinse from pump.

    a. If the electrical cord will not fit into the tub or bucket, it can be wiped down with a paper towel saturated with distilled water.

5. Detergent water and rinse water will be replaced with new solutions periodically throughout the day, at least at mid-day.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent potential contact with contaminants. If the equipment is not used immediately after decontamination, the equipment will be stored in such a way as to minimize potential contact with contaminants.

3.4 Water Level / Interface Probes

The following steps will be used to decontaminate water level meters and water/product interface probes:

1. Personnel will dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP.

2. A paper towel or other disposable media will be saturated with isopropyl alcohol.

3. A portion of a second paper towel or other disposable media will be saturated with a detergent water mixture and the remaining portion of the same paper towel or other disposable media will be saturated with distilled water.

4. The measuring tape and probe will be wiped clean as removed from the monitoring well where gauging activities are being performed by passing through the saturated

disposable media such that the tape passes through the isopropyl alcohol first, detergent water mixture second, and the distilled water last.

5. Care will be taken to replace saturated paper towels if gross contamination is observed or it becomes dry during the process.
6. Probe tip will also be sprayed off with Liquinox (or similar) detergent water solution and distilled water after wiping.
    a. Solinst brand probe tips may also be spray off with isopropyl alcohol, if necessary.
    b. Heron brand probe tips should NOT be cleaned with isopropyl alcohol.
    c. If another brand interface probe is being used, check the equipment manual to verify proper decontamination procedures and solutions.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent potential contact with contaminants. If the equipment is not used immediately after decontamination, the equipment will be stored in such a way as to minimize potential contact with contaminants.

3.5 Other Sampling Equipment

The following steps will be used to decontaminate any other sampling equipment:

1. Personnel will dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP.
2. Gross contamination on equipment will be scraped/wiped off at the sampling or construction site.
3. Equipment will be sprayed and/or wiped off with isopropyl alcohol.
4. Equipment that cannot be damaged by liquid or water will be placed in a wash tub or bucket containing soap and water mixture (Liquinox or similar along with potable or distilled water) and scrubbed with a bristle brush or similar utensil.
5. Equipment that cannot be damaged by liquid or water will then be rinsed with distilled water in a second tub or bucket.
6. Equipment that may be damaged by liquid/water will be carefully wiped clean using a sponge/paper towel with isopropyl alcohol, followed by a sponge/paper towel with detergent water and a sponge/paper towel with deionized or distilled water. Care will be taken to prevent equipment damage.

7. Detergent water and rinse water will be replaced with new solutions periodically throughout the day, at least at mid-day.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent contact with contaminated media. If the equipment is not used immediately after decontamination, the equipment will be stored in such a way as to minimize potential contact with contaminants.

3.6 Drilling and Heavy Equipment

Drilling rigs will be decontaminated at a decontamination station located near a central staging area. The decontamination station may consist of a temporary or permanent structure capable of collecting all decontamination fluids. Mobile decontamination trailers may be used to decontaminate heavy equipment at each site. The following steps will be used to decontaminate drilling and heavy equipment:

1. Review JSA for drilling and heavy equipment decontamination.
2. Personnel will dress in appropriate PPE to reduce personal exposure as required by the HASP.
3. Equipment showing gross contamination or having caked-on drill cuttings will be scraped with a flat-bladed scraper at the sampling or construction site.
4. Equipment that cannot be damaged by water, such as drill rigs, augers, drill bits, and shovels, will be washed with a hot water, high-pressure sprayer then rinsed with potable water. Care will be taken to adequately clean the insides of the hollow-stem augers, backhoe buckets, etc.

Following decontamination, drilling equipment will be placed on the clean drill rig and moved to a clean area. If the equipment is not used immediately, it should be stored in a designated clean area.

3.7 Equipment Leaving the Site

Vehicles used for activities in non-contaminated areas shall be cleaned on an as-needed basis, as determined by the Site Safety Officer, using soap and water on the outside and vacuuming the inside. On-site cleaning will be required for very dirty vehicles leaving the area. Construction equipment such as trucks, drilling rigs, backhoes, trailers, etc., will be pressure washed before the equipment is removed from the site to limit exposure of off-site personnel to potential contaminants.

3.8 Wastewater

Liquid waste water from decontamination activities will be containerized and left at the site where it originated, unless otherwise specified. Check the project/task work plan or with the Project IDW Coordinator for additional information/guidance.

4. Documentation

Sampling personnel will be responsible for documenting the decontamination of sampling and drilling equipment. The documentation will be recorded with waterproof ink in the sampler's field notebook with consecutively numbered pages. The information entered in the field book concerning decontamination should include the following:

- Decontamination personnel
- Date and start and end times
- Decontamination observations
- Weather conditions.

5. Quality Assurance Requirements

Equipment rinsate samples of the decontaminated sampling equipment may be taken to verify the effectiveness of the decontamination procedures. The rinsate sampling procedure will include passing distilled water through or over a decontaminated sampling tool (such as a split spoon) and collecting the rinsate water into the appropriate sample bottles. The rinsate sampling procedure, including the sample number, will be recorded in the field notebook.

1. Objective

This document defines the standard procedures for subsurface utility clearance that will allow staff to work safely and prevent damage to utility systems. This procedure provides descriptions of equipment and procedures necessary to properly clear utilities prior to beginning subsurface field activities for Shell projects in Hartford and Roxana, Illinois.

This document also defines the procedure for contacting the applicable "one-call" service for locating underground utilities. One-call is a public service provided by individual states as a single point of contact for requesting a utility locate from a majority of underground utilities. This service is primarily for locating utilities on public properties and right-of ways.

Utility clearances should be completed prior to the start of any work in the area that could feasibly result in contact with or damage to that utility. Additional information and a checklist can be found in URS Safety Management Standard (SMS) 034 Utility Clearances and Isolation. Please use SMS 034 in conjunction with this SOP.

2. Equipment

Equipment typically used during utility clearance procedures:

- Project map
- Known utility map
- Marking paint
- Stakes or flags
- Permanent marker
- Coloring pencils or permanent marker in different colors
- Measuring tape and/or wheel
- Other related field paperwork, as needed.
- Camera

3. Location Marking

Prior to utility clearance, locations to be drilled or excavated should be marked by the task manager, field personnel scheduled to complete the work, or a knowledgeable assigned designee. Per one-call guidelines excavation areas should be marked either a) with stakes or flags with the necessary radius to be cleared marked on the stake or flag or b) with white marking paint (black paint may be substituted when necessary). When using paint, the extent of the area to be cleared should be marked.

When marking locations, initial adjustments to locations should be made based on visible utilities such as overhead power lines, sewers and other utility corridors. As a general rule drill rig masts and excavating equipment must stay at least 50 horizontal feet away from overhead utilities unless/until the voltage and height of the system has been determined. Depending on the voltage of the overhead lines or site/client requirements, a lesser distance may be used. The table below summarizes the typical minimum distances from overhead power lines.

Minimum Distances from Power Lines	
Nominal System (kV)	**Minimum Required Distance (feet)**
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1,000	45

Operations adjacent to overhead power lines are prohibited unless the power has been shut off (such as lockout/tagout), the minimum distance above has been observed, or the power lines have been isolated (such as using insulating blankets).

4. One-Call

The purpose of the one-call system is to alert member utility companies to a planned drilling or excavating project. The one-call system will inform the person making the utility call which member companies will be notified. Additional contacts may be necessary if suspected utility providers in the area of the proposed work are not members of the public one-call system. Individual states have their own one-call number or the national one-call number, 811, may be used (e.g., Missouri: 1-800-DIG-RITE (344-7483), Illinois: 1-800-892-0123). Some states require the subcontractor actually performing the drilling or excavating to make the initial call (e.g., Illinois).

Once a one-call notification has been placed the utility companies typically have 48-hours (2 business days) to respond. The time does not include weekends or observed holidays. Once a one-call has been placed work should be ready to start within 10 working days. Once work has begun, renewal of utility locates is determined by an individual state's regulations. If the markings of utility locations are destroyed or removed before excavation/drilling commences or is completed, the one-call ticket must be renewed.

A joint meet may also be requested if the area of the proposed work is large and/or complicated. Member utilities must be given 48-hours prior to the joint meet to schedule a representative to attend. Following the joint meet, an additional 48 hours must be allowed for the utility companies to mark their utilities.

The following information should be provided when making a one-call:

- Identification of who is conducting the work as well as any subcontractor such as a drilling or excavating firm. The contact information for the person responsible along with a phone number where they can be easily reached is a minimum.
- Type of work being conducted (e.g. drilling or excavating).
- Location of work being conducted described as best as possible. Addresses in conjunction with relation to buildings or other property features when possible should be used. Other forms of locating include distances and directions from intersections.
- Whether or not a joint meet is required.
- The time frame expected for work to begin.

The following information should be recorded and kept available after the one-call has been made:

- Ticket serial number
- Utilities one-call will notify
- Time and location of joint meet (if applicable)
- Time and date by which utilities are to be cleared
- Log of utilities which have been cleared, either from markings on ground at the location or locator calling to confirm.

Industrial facilities often are responsible for utility locates on their own property and will not be covered by a one-call. Field personnel should coordinate with their contact at such a facility in order to check for known utilities under control or the facility and for any additional clearance efforts which may be required.

When possible, identify the size of underground utilities being marked. The general rule is that the accuracy of marking, from the center of the utility, is the width of the utility plus 1.5-feet. Certain utility companies may require a greater distance from their lines.

The following are the colors from the uniform color code and marking guidelines:

- White (or Black) – Proposed excavations
- Pink – Temporary survey markings
- Red – Electric power lines, cables, conduit and lighting cables
- Yellow – Gas, oil, steam, petroleum or gaseous materials
- Orange – Communication, alarm or signal lines, cables or conduit
- Blue – Potable water
- Purple – Reclaimed water, irrigation and slurry lines
- Green – Sewers and drain lines

These colors shall be used by both the company requesting the utility locate and the member companies marking underground utilities.

5. Private Utility Clearance

Private utility clearance involves using ground penetrating radar (GPR) and/or electromagnetic (EM) technologies to check for utilities prior to beginning secondary utility clearance and excavation or drilling activities. Some clients/sites require private utility clearance as an additional precaution to minimize risk of encountering either active or abandoned buried utilities. GPR and EM should be performed by a trained and qualified subcontractor.

6. Secondary Utility Clearance

Secondary utility clearance involves using an air knife, a hand auger, a post-hole digger and/or a shovel to check for utilities prior to beginning the excavation or boring. Some clients/sites require secondary utility clearance as an additional precaution to minimize risk of encountering either active or abandoned buried utilities.

Air Knife/Vacuum Excavation

Air Knife/Vacuum Excavation operations involve air/water jetting combined with a high suction vacuum to create a boring or trench of specified dimensions. Single point borings need to have the hole cleared to below the depth of known utilities in the area and to a diameter 3 inches greater than the diameter of the tools penetrating the ground surface (per Shell guidelines). If the depth of utilities in the area is not known, a minimum depth of 5 to 10 feet can be used, depending on client/property owner requirements.

As an alternative, a “V-trench” or a triangle configuration of air-knife holes can also be used to clear a location. If the air-knife is to be completed in a triangle formation, the air knife holes should be completed in sets of three in as tight a triangle as the boring size will allow, with the center of the boring to be completed at the center of the triangle. Whichever method is selected, the air knife boring(s) must be located so that the absence of underground utilities can be confirmed. Once the location is confirmed as being clear, the air knife hole(s) or trench should be backfilled with an inert material, such as silica sand or flowable fills, unless drilling is to commence right away. Refer to the scope of work or other project documentation for other backfill options.

Hand Auger

Due to access, availability or other reasons, air knifing/vacuum excavation may not be an option. If this is the case, hand augers may be used to clear a location. Due to the size of the hand auger bucket, multiple hand auger holes may be necessary to clear a location for a single boring. If multiple hand augers are necessary, the best option is to complete hand auger holes in sets of three in as tight a triangle as the boring size will allow, with the center of the boring to be completed at the center of the triangle. The same depth requirement for clearance applies to hand auger holes as it does for air knifing/vacuum excavation. Once the location is confirmed as being clear, the hand auger hole(s) should be backfilled with an inert material, as described for air knifing/vacuum excavation holes.

Post-hole digger / Hand Shovel

As a last choice, conventional means such as a post-hole digger or hand shovel may be used to clear a location. This option is generally best only when any known utilities are very shallow or the surface material is extremely coarse (large gravels and rocks). Hand shovels and post-hole diggers have a higher chance of damaging weaker utilities, so caution should be taken when used. If deeper clearance than a foot or two is necessary, either an air knife or hand auger should be used for utility clearance. Other procedures/protocols mentioned above still apply.

7. Final Boring Placement

To the extent possible, excavation or drilling work should not be performed within 5 feet of a confirmed or suspected utility or other subsurface structure. The minimum distance to perform work from any utility may vary and should be confirmed with the utility company. If drilling will be performed within 5 feet of a confirmed or suspected utility, contact the utility company/companies to discuss any potential precautions that should be taken. Shell projects require the secondary utility clearance hole be cased if within 10 feet of a gas line. Casing may also be used if the sidewall caves in or water fills in the secondary utility clearance hole. If an unmarked utility is encountered during secondary utility clearance, contact the project/task manager and/or site contact/property owner for further guidance and information.

8. Documentation

Once private utility locating personnel and one-call personnel have marked any utility lines in the vicinity of the work to be performed, document the markings for the project file. Documentation can include, but is not limited to:

- Photographs showing the markings and surrounding area,
- Field sketch of the vicinity including work locations and utility lines marked,
- Private utility clearance report from the trained and licensed subcontractor,
- One-call ticket printout documenting the utilities contacted, etc.
- Shell Borehole Clearance form
- SMS 034 Utility Clearance Checklist

Documentation should be kept with the project file for future reference.

1. *Objective*

This document defines the standard procedure for field reporting and documentation for Shell projects in Hartford and Roxana, Illinois. This procedure provides descriptions of equipment and field procedures necessary to properly document field activities.

2. *Equipment*

Equipment used during field reporting and documentation may include, but is not limited to:

- Calculator
- Bound field logbook
- Waterproof pen and/or permanent marker
- Necessary field forms/paperwork (various)
- Panasonic Toughbook/Toughpad rugged tablet PC (Toughbook/Toughpad)

3. *Field Reporting and Documentation*

Documentation of observations, activities and data acquired in the field will provide information on the acquisition of samples and also provide a permanent record of field activities. The observations and data will be recorded using one or more of the following:

- Pens with permanent waterproof ink in a permanently bound weatherproof field logbook;
- On any necessary field forms/paperwork;
- In a Toughbook/Toughpad.

Field investigation situations vary widely. No set of general rules can anticipate all information that must be collected for a particular project. The logbooks, field forms/paperwork and Toughbooks/Toughpads will be kept in the field team's possession or in a secure place during the investigation.

Since field records (field logbooks, field forms, and Toughbook/Toughpad entries) are the basis for later written reports, and potentially subject to litigation, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field records become project documents subject to potential legal holds and must be maintained as part of the official project files.

Changes or deletions in the field logbook or on field forms should be lined out with a single strike mark, initialed, and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the sampler's memory.

4. *Field Logbook*

Each project or task should have a dedicated logbook. The following information should be recorded on the front cover of each logbook:

- Project name/location (i.e., Rand, Roxana, WRR, etc.);
- Date range or year of activities included within; and
- Task the logbook is for (i.e., Quarterly Groundwater; Drilling and Well Installs, System O&M, etc.).

The information in the field logbook should typically include the following as appropriate for the task being performed, even if this information is also recorded on field forms and/or a Toughbook/Toughpad:

- Date
- Names of field team members performing work
- Change in field team members throughout the day, if any
- Any PPE upgrades/downgrades (i.e., Tyvek, respirator, etc.)
- Weather conditions
- Names and company of subcontractors (if applicable)
- Names and title/organization of any site visitors (i.e., client, property owner, Agency representative, etc.)
- Time for each observation/entry
- If calibration of field equipment is performed (calibration results are typically recorded on calibration sheets)
- Time of mobilizing to work location
- Work location (i.e., Property, Process Area, Location ID, etc.)
- Work to be performed at location (i.e., water level gauging, drilling/sampling, etc.)
- Location of Sample (i.e., monitoring well ID, borehole location and depth, etc.)
- Description of samples (matrix sampled – i.e., water, soil vapor, soil, etc.)
- Time of sample collection
- Sample ID

- QA/QC samples collected (if applicable)
- Sample analysis planned (i.e., VOC, SVOC, BTEX, etc.)
- Odor observations during field activities, if any (i.e., hydrocarbon-like, petroleum-like, etc.)
- Information concerning sampling changes, scheduling modifications, and change orders
- Time and details of any delay (i.e. operator unavailable, car parked over location, drill rig delays, equipment malfunction, etc.)
- Field observations and/or summary of daily tasks
- Sketch (i.e. well construction details, utility locate markings, etc.)
- Signature/Initials and date by personnel responsible for observations at the end of the entry/day
- If decontamination is performed and on what equipment

It is recommended that each page in the logbook shall be numbered and dated. The entries should be legible and contain accurate and inclusive documentation of the project/task activities. Lines and pages should not be skipped within a logbook. If a page is inadvertently skipped, a diagonal line should be drawn across the page and "Page inadvertently skipped" should be written. The bottom of each page in the field books will be signed or initialed by the person making the entry at the end of the day.

5. *Field Forms/Paperwork*

Data may also be recorded on various field forms and/or in Toughbooks/Toughpads for different tasks performed. If filling out a field form and/or entry in a Toughbook/Toughpad, verify that every line contains an entry with the appropriate information. If something on the field form or Toughbook/Toughpad entry does not apply, that should be indicated using "NA" or similar.

6. *Toughbooks/Toughpads*

The AECOM employees working on the Shell project may also use a field laptop and/or Panasonic Toughbook/Toughpad rugged tablet PC (Toughbook/Toughpad) to collect field data. The Toughbooks/Toughpads have a Microsoft Windows 7 operating system and Microsoft Office software. For data management purposes, they are referred to using sequential numbering (Toughpad 1, Toughbook 1, Toughbook 2, Toughbook 3, etc.). A single field laptop is currently used to enter data generated from the analysis of tedlar bag soil vapor samples in the AECOM office trailer. Multiple electronic data entry programs have been developed. The programs were created using Microsoft Access, a relational database software program. The names and locations of the database files on the Toughbooks/Toughpads are listed in the table below. Note that the number of Toughbook/Toughpad units as well as the applications/primary monitoring use may change over time.

Field PC	**Typical Primary Monitoring Use**	**Path and Name of Database File(s)**
Toughbook 1	Roxana Soil Vapor and Groundwater Monitoring	C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb
Toughbook 2	Roxana Soil Vapor and Groundwater Monitoring	C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb
Toughbook 3	Roxana Soil Vapor and Groundwater Monitoring	C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb
Toughbook 4	RETIRED	
Toughbook 5	Roxana Soil Vapor Extraction (SVE) System	C:\URS Shell SVE System\Shell_SVE_System_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb
Toughbook 6	Rand Avenue Remediation System	C:\URS - Rand Remediation System\RandRemSys_O-M_Data.accdb
Toughpad 1	Roxana Soil Vapor and Groundwater Monitoring	C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb

Field PC	Typical Primary Monitoring Use	Path and Name of Database File(s)
Laptop PC	Tedlar Bag Sample Analysis	C:\URS Shell Monitoring Program\Shell_Backend_Data.mdb C:\URS Shell Monitoring Program\Shell_Backend_Lookups.mdb C:\URS - Rand Remediation System\RandRemSys_O-M_TedlarBag Program.accdb

The various Toughbooks/Toughpads and the field laptop are not automatically synchronized with one another or with a central database. Therefore, the database files must be backed up nightly to a file server in the AECOM-St. Louis office to mitigate the risk of data loss. The database files backed up in this manner also provide a means for aggregation of data into a central project database located in the AECOM-St. Louis office.

7. *Document Control*

Document control refers to the maintenance of inspection and investigation project files. All information below shall be kept in project files. Investigators may keep copies of reports in their personal files, however, all official and original documents relating to inspections and investigations shall be placed in the official project files. Information recorded in electronic format will be saved in the project directory on the office network. The following documents shall be placed in the project file, if applicable:

- Chain-of-Custody Records and bound field logbooks
- Records obtained during the investigation
- Complete copy of the analytical data and memorandums transmitting analytical data
- Official correspondence received or transmitted, including records of telephone calls
- Photographs and negatives associated with the project
- One copy of the final report and transmittal memorandum
- Relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Inappropriate personal observations and irrelevant information should not be placed in the official project files. At the conclusion of the project, the Task Manager should review the file to ensure that it is complete.

1. Objective

This document defines the standard procedure for measuring water and non-aqueous phase liquid (NAPL) levels in monitoring wells for Shell projects in Hartford and Roxana, Illinois. This SOP serves as a supplement to information which might be in a project Work Plan and is intended to be used together with other SOPs.

2. Equipment

The following equipment is typically needed:

- Water Level or Product/Water Interface probe with 0.01-foot increments;
- Well keys;
- Organic vapor monitor;
- Latex/Nitrile gloves;
- Site logbook;
- Field data sheets;
- Toughbook/Toughpad;
- Appropriate decontamination equipment;
- Appropriate personal protective equipment (PPE); and
- Permanent ink pen.

3. Fluid Level Measurement Procedures

Observations made during the fluid (water and/or NAPL) level measurement should be recorded in the field logbook, on appropriate field forms, and/or in the appropriate program in the Toughbook/Toughpad in accordance with the procedures defined in SOP No. 8 Field Reporting and Documentation.

Appropriate PPE, as described in the HASP should be worn during well opening, fluid level measurement, and decontamination. The following procedures will be completed when measuring fluid levels:

1. The water level probe shall be decontaminated prior to use in each monitoring well according to SOP No. 4 Decontamination.

2. Observations regarding the condition of the well, including the well pad, surface completion or protective casing, working padlock, etc. will be documented in the field logbook, on appropriate field forms and/or in the Toughbook/Toughpad.
3. Put on a new, unused pair of disposable latex or nitrile gloves.
4. The well will be approached from upwind, the well cap unlocked and removed, and the air quality monitored in the casing and breathing zone with an FID or PID. Air quality measurements will be recorded in the field logbook, on appropriate field forms and/or in the Toughbook/Toughpad.
5. An electric water level or NAPL/water interface probe will be used to measure the depth to water from the top-of-casing reference point (either PVC or steel monitoring well casing) and/or check for NAPLs in the water column, where applicable.
   a. If no reference point is marked on the well casing, measurements will be made from the north side of the well casing.
   b. If a special well wizard dedicated pump cap is present, the cap will be removed and depth to water measured from the top of casing reference point. If the well wizard dedicated pump cap is unable to be removed, gauge the fluid level through the opening in the cap.
6. Record the depth of water and/or NAPLs, as applicable. Measurements will be made to the nearest 0.01 feet. Regauge and recheck recorded measurements before the probe is removed from the well.
7. If NAPL is detected within a well, the presence of NAPL should be confirmed by visual observations on the interface probe, a clear plastic bailer (disposable or dedicated), or similar. The confirmation method shall be documented along with the measurements in the field logbook, on the field data sheet, and/or in the Toughbook/Toughpad.
8. This procedure can also be used to measure the total depth of the well, if required. A measuring tape with a weight attached to the end can be used in place of the water level or interface probe to measure the total well depth. Measurements will be made to the nearest 0.01 feet.
9. The static water level, the total depth of the well, and the depth of NAPL (if applicable), shall be measured with the probe, recorded on the water level data sheet and/or in the Toughbook/Toughpad, and then immediately rechecked before the probe is removed from the well.

10. All columns of field data sheets shall be completed, including time of measurement. An example water level data sheet is attached to this SOP. If measurements are taken over a several-day period, the date of each measurement should be clearly indicated on the form.
11. Care shall be taken to verify the readings during each water level measurement period. Any significant changes in water level will be noted by comparing the most recent measurement with past measurements. This comparison is easily performed on the Toughbook/Toughpad when entering the data.
12. After any measurement is taken, the water level probe shall be decontaminated as described in SOP No. 4 Decontamination.
13. Place disposable equipment into a plastic garbage bag for disposal.

4. Documentation

The water level data sheet (a sample is attached to this SOP) shall be completed during each measuring event. Field data sheets will include field personnel, date, time, well number, total well depth, water level, static water elevation, and comments. The appropriate information will also be entered into the Toughbook in the field during gauging activities. A field logbook will also be kept during water level measurement activities describing decontamination procedures, calibration procedures, monitoring procedures, and other observations during water level measurement. Both the data sheets and notebook shall be filled out using legible handwriting, and shall be signed and dated by the person completing the page.

Water Level Record

Job No.: ____________________ Project/Event: ________________________________

Client: ____________________ Date: ________________________________

Location: ____________________ Personnel: ________________________________

Well No.	Time	Depth to Water (ft btoc)	Depth to Product (ft btoc)	Depth to Bottom (ft btoc)	All Bolts Present	Lock Present	Working Cap Present	Pad Condition	Comments

G = Pad in good condition
BR = Cracked and Broken
NP = No visible pad present

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the procedures and equipment for the grouting of borings following their completion for Shell projects in Hartford and Roxana, Illinois. If a monitoring well or piezometer is to be installed in the boring refer to the procedure outlined in SOP No. 21 Monitoring Well Installation. If a soil vapor monitoring point is to be installed in the boring, refer to the procedure outlined in SOP No. 57 Soil Vapor Monitoring Point Installation.

2. Equipment

The following is the typical equipment for grouting a borehole:

- Portland Type I or II Cement
- Powdered bentonite
- Potable water
- Appropriate health and safety equipment as specified in the Health and Safety Plan (HASP)
- Log book and/or boring log sheets
- Drums or other suitable container for mixing of grout

3. Procedures

A standard mixture of cement-bentonite grout will consist of the following ratio:

- 1 (94 lb) sack of Portland cement,
- Powdered bentonite (as permitted by state regulations), and
- 7 to 15 gallons of potable water.

A standard mixture of high-solids bentonite grout will consist of the following:

- Powdered bentonite (as permitted by state regulations), and
- 7 to 15 gallons of potable water.

The grouting procedures for either type of grout consist of the following:

1. Mix the bentonite and water first to a creamy consistency.
2. Slowly add the Portland Cement (if used). The amount of bentonite or water can be varied to control the consistency and pumpability of the mix.

3. Pump the mixture through tremie pipe or drill rods placed to the bottom of the boring to displace any water or drilling fluids.

4. Withdraw rods or piping when grout has reached surface.

5. Repeat steps 1 – 4 as augers/drill pipe are removed.

6. Grout the remaining open boring to the surface after the augers are removed. The grout will be tremied into the borehole until it is completely filled.

7. After the grout sets for 24 hours it will be checked for settlement. If necessary, additional grout will be added to top off. Hydrated bentonite chips, or similar, may also be used to top off.

8. Add surface seal (asphalt or concrete) as necessary.

4. Documentation

Documentation will be written in the field book according to SOP No. 8 Field Reporting and Documentation and may include, but is not limited to, the following:

- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and Safety monitoring equipment and readings
- Portland and bentonite bag counts
- The quantity and composition of the grout
- Start and completion dates and times
- Discussion of all procedures and any problems encountered during drilling/grouting.

1. Objective

Volatile Organic Compound (VOC) field headspace screenings will be performed on selected soil samples to obtain preliminary estimates of VOC concentrations. This qualitative data will be used as criteria in selecting soil samples from locations where collection depths have not been predetermined. This document defines the standard procedure for headspace soil screening for Shell projects in Hartford and Roxana, Illinois.

2. Equipment

The following equipment is typically required.

- Quart-sized Zip-Loc bag or equivalent
- Photoionization detector (PID)
- Permanent Marker
- Watch

3. Procedure

The following general procedure is followed:

1. Obtain approximately 1/2 qt of soil and place in clean 1 qt Zip-Loc bag. Immediately seal the Zip-Loc bag. Record the boring location and sample depth on the bag. Note: The selected drilling technology and/or defined sampling plan may limit volume of soil available for field headspace screening.
2. Break soil into about 1 in. sized particles by squeezing the bag, taking care not to compromise the seal.
3. Place sample in a location where it can be left undisturbed for a minimum of 5 minutes. If the temperature is less than 35^{o}F, place the sample bag in a heated vehicle or other location for a minimum of 5 minutes.
4. Measure ambient air background VOC concentrations.
5. After at least 5 minutes has elapsed, obtain PID reading from bag headspace by opening a space in the bag seal just large enough to allow the PID probe to enter unobstructed. Continue monitoring until PID readings drop to background concentrations or stabilize. Note: Soil with high water content or significant contamination may require frequent replacement of moisture/dust trap on PID or use of other types of filters for PID readings to return to background concentrations.

6. Record highest PID reading measured on the field boring log and/or in the field logbook.
7. Archive or dispose of soil per site field sampling plan, work plan or outlined scope of work.

1. Objective

This document defines the standard procedure for logging of soil and rock samples both for environmental and geotechnical characterization purposes for Shell projects in Hartford and Roxana, Illinois. This procedure provides descriptions of equipment and field procedures necessary to log soil and rock samples.

2. Equipment

The following equipment is typically used during soil and rock sample logging:

1. USCS Chart
2. Boring logs
3. Tape measure
4. Pocket Penetrometer, if available
5. Field data sheets/bound field logbook
6. Waterproof ink.

3. Sample Descriptions

This section provides an approach for describing (logging) soil samples in the field. General observations made before, during, and after field activities should be recorded in a bound field logbook in accordance with the procedures defined in SOP No. 8 on field reporting and documentation:

Soil

The soil's description should include as a minimum:

1. Apparent strength (for fine-grained soils) or density (for coarse-grained soil) adjective
2. Water content condition adjective
3. Color description
4. Descriptive adjective for main soil type
    - Particle-size distribution adjective for gravel and sand
    - Plasticity adjective and soil texture (silty or clayey) for inorganic and organic silts or clays
5. Minor soil type name with "y" added (if ≥ 30 percent)
6. Main soil type's name (all capital letters)

7. Geologic name, if known (in parenthesis or in notes column)
8. Descriptive adjective, some or trace, for minor soil type if ≤ 30 percent
9. Minor soil type(s)
10. Inclusions
11. The Unified Soil Classification System (USCS) Group Name and Symbol appropriate for the soil type in accordance with ASTM D 2487, with few exceptions, and (symbol in parenthesis)

The various elements of the soil's description should be stated in the order listed above.

Examples:

Fine-grained soils	Soft, wet, gray, high plasticity CLAY, trace f. sand – Fat CLAY (CH); (Alluvium)
Coarse-grained soils	Dense, moist, brown, medium to fine grained silty SAND, trace fine gravel to coarse sand – Silty SAND (SM); (Alluvium)

When changes occur within the same soil layer, such as change in apparent density, then this change must be indicated ("Becomes XYZ"). Note that only those aspects of the soil description that are different from the description of the overlying soil are mentioned. Note also the depth at which some characteristic is no longer present must be noted ("XYZ grades out").

Apparent Strength and Density

Strength and density descriptive terms are related to blow count resistance using a 2-inch OD, 24-inch long split barrel sampler and standard penetration tests (a 140-pound hammer dropped 30-inches) (ASTM D 1586-84). Strength can also be related to pocket penetrometer resistance. Use the values and descriptions in the table presented below to determine the strength or density.

Strength & Density

Cohesive Clays (clays & silts)			Non-cohesive Granular Soils (sands & gravels)	
Blow Count	**Pocket Penetrometer (tsf)**	**Strength**	**Blow Count**	**Density**
0-2	<0.25	Very soft	0-4	Very loose
3-4	0.25-0.50	Soft	4-10	Loose
5-8	0.50-1.0	Medium stiff	11-30	Medium dense
9-15	1.0-2.0	Stiff	31-50	Dense
16-30	2.0-4.0	Very stiff	>50	Very dense
>30	>4.0	Hard		

A blow count of >50 for a 12-inch interval[1] constitutes spoon refusal and the sample should be terminated at that time.

The strength of the soil can be determined without blow counts using the following guide:

H Hard Soil – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

VST Very Stiff – Soil can barely be imprinted by pressure from the fingers or indented by thumbnail.

ST Stiff – Soil can be imprinted with considerable pressure from fingers or indented by thumbnail.

M Medium Stiff – Soil can be imprinted easily with fingers; remolded by strong finger pressure.

So Soft – Soil can be pinched in two between the thumb and forefinger; remolded by light finger pressure.

Vso Very Soft – Soil exudes between fingers when squeezed; specimen (height = 2 x diameter) sags under its own weight.

[1] Blow counts are recorded for four separate 6-inch sections when driving a 2-foot long split spoon sampler. The blow counts for the second and third 6-inch section should be used to assist with the strength/density determination. The blow counts for the first section should NOT be used due to possible disturbed soil from the augers. The blow counts for the fourth section should NOT be used due to potential compaction from the split spoon.

Water Content

The amount of water present in the soil sample or its water content adjective should be described as dry, moist, or wet as follows:

Descriptors for Water Content (moisture)

Description	Condition
Dry	No sign of water and soil is dry to the touch
Moist	Signs of water and soil is relatively dry to the touch
Wet	Signs of water and the soil definitely wet to the touch; granular soil exhibits some free water when densified

The descriptor "damp" should not be used (use "moist"). The descriptor "saturated" should not be used (use "wet").

Color

The colors should be assigned consistent with a Munsell Color Chart and should be described when the sample is first retrieved at the soil's as-sampled water content (the color will change with water content). A Munsell Color Chart is provided as Appendix A. When the soil is marked with spots of color, the term mottled can be applied with the following descriptors:

Descriptors for Mottling

Abundance	Size	Contract
f: few (<2%)	fine (<5 mm)	faint
c: common (2%-20%)	medium (5-15 mm)	distinct
m: many (>20%)	coarse (>15 mm)	prominent

Soils with a homogeneous texture but having color patterns, which change and are not considered mottled, can be described as streaked.

Soil Types

The constituent parts of a given soil type are defined on the basis of texture in accordance with particle-size designators separating the soil into coarse-grained, fine-grained, and highly organic designations.

Coarse-grained (gravel and sand)

Soils with more than 50% of the particles larger than No. 200 sieve (0.074 mm). The soil components are described on the basis of particle size as follows:

Grade Limits and Grade Standards

Grade Names	
Name	**Grain Size**
Sand	
Fine	#200 to #40 sieve
Medium	#40 to #10 sieve
Coarse	#10 to #4 sieve
Gravel	
Fine	#4 sieve to ¾-inch
Coarse	¾-inch to 3-inches
Cobbles	3-inches to 12-inches
Boulders	>12-inches

The particle-size distribution is identified as well graded or poorly graded. Well-graded coarse-grained soil contains a good representation of all particle sizes from largest to smallest, with ≤12 percent fines. Poorly graded coarse-grained soil is uniformly graded with most particles about the same size or lacking one or more intermediate sizes, with ≤12 percent fines. A table of USC symbols and names for coarse-grained soils is presented below.

USCS Symbols and Names for Coarse-grained Soils

USCS Symbol	Typical Names
GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands, little or no fines
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

The following field identification tests can be used to estimate the grain size distribution of coarse-grained soils:

Feel and Smear Tests – A pinch of soil is handled lightly between the thumb and fingers to obtain an impression of the grittiness or of the softness of the constituent particles. Thereafter, a pinch of soil is smeared with considerable pressure between the thumb and forefinger to determine the degrees of roughness and grittiness, or the softness and smoothness of the soil.

Coarse- to medium-grained sand:	Typically exhibits a very harsh and gritty feel and smear.
Coarse- to fine-grained sand:	Has a less harsh feel, but exhibits a very gritty smear.
Medium- to fine-grained sand:	Exhibits a less gritty feel and smear which becomes softer and less gritty with an increase in the fine sand fraction.
Fine-grained sand:	Exhibits a relatively soft feel and a much less gritty smear than the coarser sand components.
Silt:	Components less than about 10 percent of the total weight can be identified by a slight discoloration of the fingers after smear of a moist sample. Increasing silt increases discoloration and softens the smear.

Sedimentation Test – A small sample of soil is shaken in a test tube filled with water and allowed to settle. The time required for the particles to fall to a distance of 4 inches is about ½ minute for particle sizes coarser than silt. About 50 minutes would be required for particles of 0.005 mm or smaller (often defined as "clay size") to settle out.

Visual Characteristics – Sand and gravel particles can be readily identified visually, however, silt particles are generally indistinguishable to the eye. With an increasing silt component, individual sand grains become obscured, and when silt exceeds about 12 percent, it masks almost entirely the sand component from visual separation. Note that gray fine-grained sand visually appears siltier than the actual silt content.

Fine-grained (clay and silt)

Soils with more than 50% of the particles finer than the No. 200 sieve (0.074 mm) and the fines are silts and clays.

A table of USC symbols and names for fine-grained soils is presented here.

USCS Symbols and Names for Fine-grained Soils

USCS Symbol	Typical Names
ML	Inorganic silts and very fine sands, rock flour, silty, or clayey fine sands, or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays or high plasticity (residual clays), fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

The following field identification tests can be used to estimate the degree of plasticity and size distribution of fine-grained soils:

Shaking (Dilatency) Test: Water is dropped or sprayed on a part of basically fine-grained soil mixed and held in the palm of the hand until it shows a wet surface appearance when shaken or bounced lightly in the hand or a sticky nature when touched. The test involves lightly squeezing the soil pat between the thumb and forefinger and releasing it alternatively to observe its reaction and the speed of the response. Soils which are predominantly silty (nonplastic to low plasticity) will show a dull dry surface upon squeezing and a glassy wet surface immediately upon releasing of the pressure. With increasing fineness (plasticity) and the related decreasing dilatency, this phenomenon becomes less and less pronounced.

Dry Strength Test: A portion of the sample is allowed to dry out and a fragment of the dried soil is pressed between the fingers. Fragments which cannot be crumbled or broken are characteristic of clays with high plasticity. Fragments which can be disintegrated with gentle finger pressure are characteristic of silty materials of low plasticity. Thus, materials with great dry strength are clays of high plasticity and those with little dry strength are predominantly silts.

Thread Test: Moisture is added or worked out of a small ball (approximately 1 ½-inch diameter) and the ball kneaded until its consistency approaches medium stiff to stiff, it breaks, or crumbles. A thread is then rolled out to the smallest diameter possible before disintegration. The smaller the thread achieved, the higher the plasticity of the soil. Fine-grained soils of high plasticity will have threads smaller than 1/32 inch in diameter. Soils with low plasticity will have threads larger than 1/8 inch in diameter.

Smear Test: A fragment of soil smeared between the thumb and forefinger or drawn across the thumbnail will, by the smoothness and sheen of the smear surface, indicate the plasticity of the soil. A soil of low plasticity will exhibit a rough textured, dull smear while a soil of high plasticity will exhibit a slick, waxy smear surface.

The following table presents the terms used to denote the various degrees of plasticity of soil that passes the No. 200 sieve.

Degrees of Plasticity

Descriptive Term	Degree of Plasticity	Plasticity Index Range
SILT	none	non-plastic
Clayey SILT	slight	1-5
SILT & CLAY	low	5-10
CLAY & SILT	medium	10-20
Silty CLAY	high	20-40
CLAY	very high	over 40

Highly-organic

Soils that primarily consist of organic matter. Identification markers are:

1. Dark and black and sometimes dark brown colors, although not all dark colored soils are organic.
2. Moist organic soils will oxidize when exposed to air and change from a gray/black color to a lighter brown, i.e. The exposed surface is brownish, but when the sample is pulled apart the freshly exposed surface is dark gray/black.
3. Fresh organic soils usually have a characteristic odor which can be recognized, particularly when the soil is heated.
4. Compared to non-organic soils, less effort is typically required to pull the material apart and a friable break is usually formed with a fine granular or silty texture and appearance.
5. Their workability at the plastic limit is weaker and spongier than an equivalent non-organic soil.
6. The smear, although generally smooth, is usually duller and appears siltier.

Minor Soil Types

In many soils two or more soil types are present in the soil. When the percentage of the minor soil type is ≥ 50% of the total sample, the minor soil type is given prior to the major soil type and is indicated by adding a "y" to its name; i.e. silty CLAY.

When the minor soil type percentage is between 1 and 49% of the total sample, the minor soil type is given after the major soil type is given along with an adjective term:

1. Trace – When the soil type's percentage is between 1 and 5% of the total sample.
2. Some – When the soil type's percentage is between 5 and 12% of the total sample.
3. With – When the soil type's percentage is between 13% and 49% of the total sample.

A table of soil descriptors is presented below.

Soil Descriptors

Calcareous:	Containing appreciable quantities of calcium carbonate	
Fissured:	Containing shrinkage cracks, often filled with fine sand or silt, usually more less vertical	
Interbedded:	Containing alternating layers of different soil types	
Intermixed:	Containing appreciable, random, and disoriented quantities of varying color, texture, or constituency	
Laminated:	Containing thin layers of varying color, texture, or constituency	
Layer:	Thickness greater than 3 inches	
Mottled:	Containing appreciable random speckles or pockets of varying color, texture, or constituency	
Parting:	Paper thin	
Poorly graded (well sorted):	Primarily one grain size, or having a range of sizes with some intermediate size missing	
Slickensided:	Having inclined planes of weakness that are slick and glossy in appearance and often result in lower unconfined compression cohesion	
Split graded:	Containing two predominant grain sizes with intermediate sizes missing	
Varved:	Sanded or layered with silt or very fine sand (cyclic sedimentary couplet)	
Well graded (poorly sorted):	Containing wide range of grain sizes and substantial amounts of all intermediate particle sizes	
Modifiers:	Predominant type -	≥ 50%
	With -	13% to 49%
	Some -	6% to 12%
	Trace -	1% to 5%

Inclusions

Additional inclusions or characteristics of the sample can be described by using "with" and the descriptions described above. Examples are given below:

1. With petroleum odor
2. With organic matter
3. With shell fragments
4. With mica.

Layered Soils

Soils of different types can be found in repeating layers of various thicknesses. It is important that all such formations and their thicknesses are noted. Each layer is described as if it is a nonlayered soil using the sequence for soil descriptions discussed above. The thickness and shape of layers and the geological type of layering are noted using the following descriptive terms:

Type of Layer	Thickness	Occurrence
Parting	< 1/16 inch	
Seam	1/16 inch to 0.5 inches	
Layer	0.5 inches to 12 inches	
Stratum	> 12 inches	
Pocket		Small erratic deposit
Lens		Lenticular deposit
Varved (also layered)		Alternating seams or layers of silt and/or clay and sometimes fine sand
Occasional		One or less per foot of thickness of laboratory sample inspected
Frequent		More than one per foot of thickness of laboratory sample inspected

Place the thickness designation before the type of layer, or at the end of each description and in parentheses, whichever is appropriate.

An example of a description of layered soils is:

> Medium stiff, moist to wet ¼" – ¾" interbedded seams and layers of: gray, medium plastic, silty CLAY (CL); and lt. gray, low plasticity SILT (ML); (Alluvium).

Geologic Name

The soil description should include the Field Representative's assessment of the origin of the soil unit and the geologic name, if known, placed in parentheses at the end of the soil description or in the field notes column of the boring log.

Rock

The rock's description should include as a minimum:

1. Rock type
2. Color
3. Grain size and shape
4. Texture (stratification/foliation)
5. Mineral composition
6. Weathering and alteration
7. Strength
8. Other relevant notes.

The various elements of the rock's description should be stated in the order listed above.

Example:

Limestone, light gray, very fine-grained, thin-bedded, unweathered, strong

The rock description should include identification of discontinuities and fractures. The description should include a drawing of the naturally occurring fractures and mechanical breaks.

Rock Type

Rocks are classified according to origin into three major divisions: igneous, sedimentary, and metamorphic. These three groups are subdivided into types according to mineral and chemical composition, texture, and internal structure. Engineering classifications of rocks can be based on ASTM Method C 294.

Division	Class	Type
Igneous	Coarse-grained (Intrusive)	Granite Syenite Diorite Gabbro Peridotite Pegmatite
	Fine-grained (Extrusive)	Volcanic Glass Delsite Basalt
Sedimentary Sedimentary (con't.)	Calcareous	Limestone Dolomite
	Siliceous	Conglomerate Sandstone Quartizite Claystone Siltstone Argillite Shale Chert
Metamorphic	Foliated	Slate Phyllite Schist Amphibolite Hornfers Unfixes
	Nonfoliated	Marble Metaquartzite Serpentinite

Color

Colors should be assigned consistent with a Munsell Color Chart and recorded for both wet and dry conditions as appropriate.

Grain Size and Shape

The grain size description should be classified using the following terms:

Very Coarse-Grained:	Diameter greater than 0.187 inches (4.76 mm).
Coarse-Grained:	Diameter 0.187 inches to 0.0787 inches (4.76 mm to 2.00 mm). Individual grains can be easily distinguished by the naked eye.
Medium-Grained:	Diameter 0.0787 inches to 0.0165 inches (2.00 mm to 0.420 mm). Individual grains can be distinguished with the naked eye.
Fine-Grained:	Diameter 0.0165 inches to 0.0029 inches (0.420 mm to 0.074 mm). Individual grains can be distinguished by the naked eye with difficulty.
Very Fine-grained:	Diameter less than 0.0029 inches (0.074 mm). Individual grains cannot be distinguished by the naked eye.

The grain shape description should be classified using the following terms:

Angular:	Showing very little evidence of wear. Grain edges and corners are sharp. Secondary corners are numerous and sharp.
Subangular:	Showing definite effects of wear. Grain edges and corners are slightly rounded off. Secondary corners are slightly less numerous and slightly less sharp than in angular grains.
Subrounded:	Showing considerable wear. Grain edges and corners are rounded to smooth curves. Secondary corners are reduced greatly in number and highly rounded.
Rounded:	Showing extreme wear. Grain edges and corners are smoother off to broad curves. Secondary corners are few in number and rounded.
Well-Rounded:	Completely worn. Grain edges or corners are not present. No secondary edges or corners are present.

Texture (stratification/foliation)

Significant nonfracture structural features should be described. The thickness should be described using the following terms:

Type of Layer	Thickness	
	English	**Metric**
Thinly laminated	0.1 inches	2.5 millimeters
Laminated	0.1 to 0.5 inches	2.5 to 10 millimeters
Very thinly bedded	0.5 to 2.0 inches	1 to 5 centimeters
Thinly bedded	2.0 inches to 2 feet	5 to 50 centimeters
Thickly bedded	2 to 3 feet	0.5 to 1 meters
Very thickly bedded	3 feet	1 meter

The orientation of the bedding/foliation should be measured from the horizontal with a protractor.

Mineral Composition

A geologist based on experience and the use of appropriate references should identify the mineral composition. The most abundant mineral should be listed first, followed by minerals in decreasing order of abundance. For some common rock types, mineral composition need not be specified (i.e. dolomite, limestone).

Weathering and Alteration

Weathering as defined here is due to physical disintegration of the minerals in the rock by atmospheric processes while alteration is defined here as due to geothermal processes. Terms and abbreviations used to describe weathering or alteration are:

RS Residual Soil – The original minerals of the rock have been entirely weathered to secondary minerals, and the original rock fabric is not apparent. The material can be easily broken.

C Completely Altered or Weathered – The original minerals of the rock have been almost entirely changed to secondary minerals, even though the original fabric may be intact. The material can be easily broken.

H Highly Altered or Weathered – The rock is weakened to such an extent that a sample with a 2-inch minimum diameter can be broken readily by hand across the rock fabric. More than half the rock material is decomposed or altered. Fresh rock is present in a discontinuous framework or as corestones.

M Moderately Altered or Weathered – rock is discolored and noticeably weakened, but sample with a 2-inch minimum diameter cannot usually be broken by hand, across the rock fabric. Less than half of the rock material is decomposed or altered. Fresh or discolored rock is present either as a continuous framework or as corestones.

S Slightly Altered or Weathered – Rock is slightly discolored, but not noticeably lower in strength than fresh rock.

F Fresh – Rock shows no discoloration, no loss of strength, or any other effect of weathering.

Rock Strength

A common qualitative assessment of strength can be used while logging of rock core during drilling. Terms and abbreviations used to describe weathering or alteration are:

ES Extremely Strong – Specimen can only be chipped with geological hammer.

VS Very Strong – Specimen requires many blows of geologic hammer to fracture it.

S Strong – Specimen requires more than one blow of geological hammer to fracture it.

MS Medium Strong – Cannot be scraped or peeled with a pocketknife. Specimen can be fractured with a single firm blow of geological hammer.

W Weak – material crumbles under firm blows with the sharp end of a geological hammer. Can be peeled by a pocketknife with difficulty.

VW Very Weak Rock – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

Descriptors and abbreviations used to describe rock hardness are:

S	Soft - Reserved for plastic material alone.
F	Friable - Easily crumbled by hand, pulverized or reduced to powder and is too soft to be cut with a pocketknife.
LH	Low Hardness - Can be gouged deeply or carved with a pocketknife.
MH	Moderately Hard - Can be readily scratched by a knife blade; scratch leaves heavy trace of dust and scratch is readily visible after the powder has been blown away.
H	Hard - Can be scratched with difficulty; scratch produces little powder and is often faintly visible; traces of the knife steel may be visible.
VH	Very Hard - Cannot be scratched with pocketknife. Leaves knife steel marks on surface.

Rock Discontinuity

Discontinuity is the general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistocity planes, weakness zones, and faults. The following symbols are recommended for the type of rock mass discontinuities.

F	Fault
J	Joint
Sh	Shear
Fo	Foliation
V	Vein
B	Bedding

The spacing of discontinuities is the perpendicular distance between adjacent discontinuities. The spacing should be measured in feet to the nearest tenth, perpendicular to the planes in the set.

EC	Extremely close spacing	<0.07 ft
VC	Very close spacing	0.07 – 0.2 ft
C	Close spacing	0.2 – 0.66 ft
M	Moderate spacing	0.7 – 2 ft
W	Wide spacing	>2 – 6.6 ft
EW	Extremely wide spacing	>6.6 ft

The discontinuities should be described as closed, open, or filled. Aperture is used to describe the perpendicular distance separating the adjacent rock walls of an open discontinuity in which the intervening space is air or water filled. Width is used to described the distance separating the adjacent rock walls of filled discontinuities. The following terms should be used to describe apertures:

Aperture	Description	
<0.1 mm 0.1 – 0.25 mm 0.2 0.25 – 0.5 mm	Very tight Tight Partly open	"Closed Features"
0.5 – 2.5 mm 2.5 – 10 mm >10 mm	Open Moderately open Wide	"Gapped Features"
1 10 cm 1 10 – 100 cm >1 m	Very wide Extremely wide Cavernous	"Open Features"

The following terms are recommended to describe the width of discontinuities such as thickness of veins, fault gouge filling, or joints openings.

W	Wide	0.5 – 2.0 inches
MW	Moderately wide	0.1 – 0.5 inches
N	Narrow	0.05 – 0.1 inches
VN	Very narrow	<0.05
T	Tight	0

For the thickness of faults or shears that are not thick enough to be represented on the boring log and are greater than 2-inches thick, record the measured thickness numerically in feet to the nearest tenth of a foot.

The following terms should be used to describe the planarity of discontinuities:

Wa Wavy

Pl Planar

St Stepped

Amplitude = A

Wavelength = γ

Measured in feet.

The following terms should be used to describe the surface roughness of discontinuities:

VR	<u>Very Rough</u> – Near right-angle steps and ridges occur on the discontinuity surface.
R	<u>Rough</u> – Some ridges and side- angle steps are evident; asperities are clearly visible; and discontinuity surface feels very abrasive.
Sr	<u>Slightly Rough</u> – Asperities on the discontinuity surfaces are distinguishable and can be felt.
S	<u>Smooth</u> – Surface appears smooth and feels so to the touch.
Slk	<u>Slickensides</u> – Visual evidence of striations or a smooth glassy appearing finish.

Filling is the term for material separating the adjacent rock walls of discontinuities. The perpendicular distance between the adjacent rock walls is termed the width of the filled discontinuity. The type of discontinuity infilling should be described using the following terms:

C	Clay	Fe	Iron Oxide
Sd	Sand	g	Gypsum/Talc
H	Healed	q	Quartz
Ch	Chlorite	N	None
Ca	Calcite	O	Other (describe)

The amount of infilling in discontinuities should be described using the following terms:

St	Surface stain
Sp	Spotty
P	Partially filled half surface or opening is filled
F	Filled
N	None

Fracture Description

The location of each naturally occurring fracture and mechanical break is shown in the fracture column of the rock core log. The naturally occurring fractures are numbered and described using the terminology described above for discontinuities.

The naturally occurring fracture and mechanical breaks are sketched in the drawing column.

Dip angles of fractures should be measured using a protractor and marked on the log. For nonvertical borings, the angle should be measured and marked as if the boring was vertical. If the rock is broken into many pieces less than ½ inch to 1-inch long, the log may be crosshatched in that interval or the fracture may be shown schematically.

The number of naturally occurring fractures observed in each foot of core should be recorded in the fracture frequency column. Mechanical breaks, thought to have occurred due to drilling, are not counted. The following criteria can be used to identify natural breaks:

1. A rough brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.
2. A generally smooth or somewhat weathered surface with soft coating or infilling materials, such as talc, gypsum, chlorite, mica, or calcite obviously indicates a natural discontinuity.
3. In rocks showing foliation, cleavage or bedding it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient weakness planes. If drilling has been carried out carefully then the questionable breaks should be counted as natural features, to be on the conservative side.
4. Depending upon the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock types it may be very difficult to decide if the resulting rounded surfaces represent natural or artificial features. When in doubt, the conservative assumption should be made; i.e., assume that they are natural.
5. It may be useful to keep a separate record of the frequency of artificial fractures (and associated lower RQD) for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The results of core logging (frequency and RQD) can be strongly time dependent and moisture content dependent in the case of certain varieties of shales and mudstones having relatively weakly developed digenetic bonds. A not infrequent problem is "discing," in which an initially intact core separates into discs on incipient planes, the process becoming noticeable perhaps within minutes of core recovery. The phenomena are experienced in several different forms:

1. Stress relief cracking (and swelling) by the initially rapid release of strain energy in cores recovered from areas of high stress, especially in the case of shaley rock.

2. Dehydration cracking experienced in the weaker mudstones and shales which may reduce RQD from 100 to 0 percent in a matter of minutes, the initial integrity possibly being due to negative pore pressure.
3. Slaking cracking experienced by some of the weaker mudstones and shales when subjected to wetting.

All these phenomena make core logging of *frequency* and RQD unreliable. Whenever such conditions are anticipated, an engineering geologist should log core as it is recovered and at subsequent intervals until the phenomenon is predictable. An added advantage is that the engineering geologist can perform mechanical index tests, such as the point load or Schmidt hammer test, while the core is still in a saturated state.

4. Drilling information:

- Drill rig manufacturer, model, and driller (if applicable)
- Geologist or geotechnical engineer
- Project name, sample point identification, and location
- Date samples obtained (and times if required)
- Type of sampler (e.g., split spoon, Shelby, California), measurements or method of advancing boring or equipment, method of driving sampler, and weight of hammer
- Drill fluids (if applicable)
- Ground surface or grade elevation (if known)
- Depth penetrated and blow counts/6-inch interval of penetration for ASTM 1586-84 and sample number (if applicable)
- Closed hole intervals and advancement (if applicable)
- Recovery
- Strata changes and changes within samples
- Sampling tool behavior
- Drill string behavior
- Use(s) of borehole
- Disposition(s) of residual soil or cuttings
- Signature or sampling of log (as required).

1. Objective

This document defines the standard operating procedure (SOP) and typical equipment for collection of groundwater samples in monitoring wells, extraction wells, or piezometers using low-flow techniques for Shell projects in Hartford and Roxana, Illinois. The term "Low Flow" refers to the velocity that the groundwater is removed from the soil formation immediately adjacent to the well screen.

In this technique, in order to withdraw water from within the well screen and to lessen drawdown, a pump that minimizes disturbance to the groundwater is operated at a low flow rate. The well is only purged within the screened interval until specific parameters have stabilized. Therefore, the groundwater samples collected are representative of the water bearing formation and hydraulically isolated from the water in the casing. The need to purge three well volumes, as required in traditional techniques, is not necessary with low flow purging and sampling. The low flow procedure described in this SOP is not necessarily applicable for every site or for wells screened in materials with very low permeability.

2. Equipment

The following equipment is typically needed:

- Well construction information for well to be sampled
- Well keys
- Disposable latex or nitrile gloves
- Assorted tools (socket, screwdriver, clamps, etc.)
- New synthetic rope (to alleviate raising and lower of the submersible pump by the electrical wires)
- Pump and required accessories (described in more detail in following section)
- Deep cycle marine battery, or vehicle battery
- Electronic water level indicator or water/product interface probe with 0.01-foot increments
- Graduated cylinder, measuring cup, or similar
- Water quality instrument with appropriate sensors
- Flow-through cell

- Calibration fluids
- Paper towels or Kimwipes
- Trash bags
- Calculator
- Stopwatch
- Panasonic Toughbook®
- Bound field logbook (logbook)
- Waterproof pen and permanent marker
- Plastic buckets
- 55-gallon drums or truck-mounted tank
- Plastic sheeting or similar for clean working surface at each well (i.e. for flow thru cell, sample bottles, etc.)
- Appropriate decontamination equipment (see SOP No. 4)
- Cooler with ice
- Sample containers and labels
- Clear tape
- Groundwater sampling form
- Chain-of-Custody form
- Appropriate health and safety equipment (e.g., photoionization detector (PID))
- Canopy

3. Sampling Procedure

This section provides the step-by-step procedure for collecting groundwater samples in the field. Observations made during groundwater purging and sampling should be recorded in a logbook and Toughbook/Toughpad in accordance with procedures described in SOP No. 8 Field Reporting and Documentation.

The well sampling order should be dependent on expected levels of contamination in each well, if known, and should be determined prior to sampling. Sampling should progress from the least contaminated to the most contaminated well, to the extent possible. Quality assurance/quality control (QA/QC) samples should also be collected during groundwater sampling (SOP No. 23 Quality Assurance Samples).

A. Any reusable equipment used in the sampling procedure that could contact groundwater should be properly decontaminated before each use (see SOP No.4 Decontamination).

B. Equipment should be calibrated based on the manufacturers' instructions. Refer to SOP No. 3 Calibration and Maintenance of Field Instruments for additional information.

C. Before well purging begins, the following steps should be performed at each well:

- Inspect the well and surrounding site for security, damage, and evidence of tampering. If damage or tampering is evident, contact the task or project manager for guidance.
- Place clean plastic sheeting or similar in the work area near the well to keep equipment and sample bottles clean.
- Measure ambient volatile organic compounds (VOCs) background levels in the immediate vicinity of the well (i.e., using a PID or a flame ionization detector (FID) per the Health and Safety Plan (HASP).
- Remove the well cap and immediately measure VOCs at the rim of the well and record the readings in the logbook, in the Toughbook®, and on the groundwater sampling form. Give the water in the well adequate time to reach equilibrium.

D. After the well has reached equilibrium, the groundwater elevation should be measured to the nearest 1/100-foot. The total well depth and screened interval should be obtained from the well construction information. Measuring the total depth prior to sampling should be avoided to prevent resuspension of settled solids in the well casings and to minimize the necessary purge time. The total depth of the well should be confirmed after sampling has been completed, if necessary. A detailed description of monitoring well gauging activities is provided in SOP No. 10 Well Gauging Measurements.

E. Following measurement of the static groundwater elevation, the appropriate equipment will be slowly and carefully placed in the well. If the wells have light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs) and are still to be sampled, care should be taken to place sampling equipment below or above the NAPL. If NAPL is encountered, contact the task or project manager for further direction.

F. Selection of the proper pump is important for low-flow sampling activities. USEPA guidance (1996) notes that dedicated sampling devices capable of purging and sampling are preferred over any other type of device. In addition, the pump must be capable of flow rates between about 50 and 500 mL per minute. A variety of portable sampling devices are available, such as bladder pumps, peristaltic pumps, electrical submersible pumps, gas-driven pumps, inertial lift foot-valve samplers (e.g. check-ball systems), and bailers. However, some of this sampling equipment has drawbacks or has been specifically rejected for low-flow sampling. The peristaltic pump can only be used for shallow applications and it can cause degassing of groundwater and loss of volatiles. Degassing results in the alteration of pH and alkalinity values as well as some loss of volatiles. Also, USEPA guidance asserts that inertial lift foot-valve type samplers and bailers cause too much groundwater disturbance and may invite unacceptable operator variability. Therefore, these sampling devices should be avoided for low-flow sampling activities.

G. Submersible pumps require a battery as a power source. If a deep cycle marine battery will be used, proceed to **Step H**. If a vehicle battery with the vehicle running will be used for an adequate power supply, the following will be performed:

- The vehicle will be positioned such that it is not over a significant amount of vegetation.
- The parking brake will be applied.
- A fire extinguisher will be staged nearby for easy access, if necessary.
- Personnel will remain in attendance of the vehicle while running so the vehicle may be promptly shut off in case of fire, etc.

H. When placing the equipment in the well, the pump intake should be set as follows. Pump placement is best measured from the top of the well down to the pump. Lowering the pump to the bottom of the well and pulling it up the required distance will cause agitation of the sediment and create unnecessary turbidity in the water.

  a. If the well screen is ≤ 10 feet, place the pump intake near the midpoint of the well screen or water column, whichever is deeper.

- *Pump intake (saturated screen) = depth to top of screen + ½ screen length*
- *Pump intake (open screen) = depth to top of water + ½ water column height*

b. If the well screen is > 10 feet, place the pump intake near the midpoint of the upper 10 feet of the well screen or water column, whichever is deeper.

- *Pump intake (saturated screen) = depth to top of screen + 5 feet*
- *Pump intake (open screen) = depth to top of water + 5 feet*

(if water column height is <10 feet, + ½ water column height)

c. In situations in which contaminants of interest are known to concentrate in a certain location of the screened zone (i.e. at the bottom), it may be desirable to position the pump intake to target this zone instead.

I. Tubing should be connected from the pump to a flow-through cell. Then, calculate the volume of water to fill the flow-through cell. According to American Society for Testing and Materials (ASTM) Standard D 6771 (2002), the frequency of measurements should be equal to the time required to completely evacuate one volume of the cell (minimum). This ensures that independent measurements are made.

J. The pump should be started at a low flow rate, approximately 50 to 100 mL/min or the lowest flow rate possible. The pumping rate can be increased up to 500 mL/min as long as significant drawdown does not occur (200 to 300 mL/min is the optimum flow rate for sampling VOCs).

K. Water level measurements should continue as calculated until the measurements indicate that significant drawdown is not occurring. According to ASTM standards (2002), allowable drawdown should never exceed the distance between the top of the well screen and the pump intake. Including a safety factor, also provided by ASTM, drawdown should actually not exceed 25% of this distance. This ensures that water stored in the casing is not purged or sampled. For example, for a 4-foot screen (saturated), the pump should be placed at the midpoint of the screen (two feet from the top of the screen to the pump intake). With a safety factor of 25%, this would require drawdown not to exceed six inches.

If drawdown surpasses 25% of the distance from the pump intake to the top of the screen even while pumping is occurring at the lowest flow rate possible, samplers should refer to project specific criteria.

If drawdown is encountered in exceedance of the above scenario and does not stabilize, contact the task or project manager for further guidance.

L. Allow water to flow through the flow-through cell. Parameter readings should be documented on the groundwater sampling form, in the logbook and/or in the Toughbook/Toughpad. The time between parameter measurements is calculated as follows:

$$T = \frac{V}{Q}$$, where

T = time between measurements (minutes)

V = volume of the flow-through cell (liters)

Q = purge flow rate (liters per minute)

M. Sampling should be in accordance with a Work Plan or other project specific documentation or approved Agency correspondence. However, in most cases, purging will continue until specific parameters have stabilized over three consecutive flow-through cell volumes or until a specific time requirement is met, whichever happens first. **Table 1** provides guidelines that may be used for parameter stabilization as specified by USEPA, ASTM, and in the Nielsen and Nielsen Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling (Nielsen and Nielsen, 2002). These guidelines are to be used in combination with professional judgment. **Table 2** provides the guidelines to be used for groundwater sampling activities on Shell projects. **Table 2** combines relevant stabilization guidelines from **Table 1** in combination with limitations in accuracy for readings collected by the Troll9500 (typical low flow equipment used on the Shell groundwater projects).

Table 1. Stabilization Guidelines for Low-Flow Sampling

Parameter	Stabilization Guidelines		
	EPA	**ASTM**	**Nielsen & Nielsen**
DO	+/- 10%	+/- 10% or +/-0.2 mg/L, whichever is greatest	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 10 mV	+/- 20 mV	+/- 20 mV
PH	+/- 0.1 units	+/- 0.2 units	+/- 0.2 units
Specific Conductivity	+/- 3%	+/- 3%	+/- 3%
Temperature	Not Specified	Not Specified	+/- 0.2 ºC
Turbidity	+/- 10%	Not Specified	Not Specified

Table 2. Stabilization Guidelines used for GW Sampling

Parameter	Stabilization Guidelines (using above standards combined with Troll9500 accuracies)
DO	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 20 mV
PH	+/- 0.2 units
Specific Conductivity	+/- 5% or +/-2µs/cm
Temperature	Not Specified; Monitor and record
Turbidity	Visually Sediment Free, when practical; Monitor and record

N. After the relevant parameters have stabilized, the flow-through cell should be disconnected or bypassed for sampling. If, after a considerable number of readings have been taken, parameters have not stabilized, samplers should contact the task or project manager for further guidance. For Rand and Roxana GW sampling activities, contact the Task Manager after two hours of purging for further guidance.

O. A canopy or modified sampling order should be utilized, as feasible, in an effort to shield the flow-through cell from the weather and elements that may interfere with stabilization parameter readings (i.e. sun and wind). When temperature is not being used as a stabilization parameter, care should still be taken to shield the flow-through cell from the sun so temperature can more accurately be monitored for anomalous readings.

P. A new pair of disposable latex or nitrile gloves should be put on immediately before sampling.

Q. During sampling, the sample shall be collected directly from the tubing (e.g. sample shall not flow through the flow-through cell while filling bottle sets), do NOT allow the sample tubing to come into contact with the sample bottles, and do NOT place sample bottles on the ground (e.g., place bottles in plastic tub or similar).

R. The constituents should be sampled for in the order given below:

- VOCs – Vials should be filled completely so that the water forms a convex meniscus then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles. If air bubbles are observed in the sample vial, remove the lid and attempt to fill the vial two more times, (being careful not to dump out any groundwater currently in the vial). If air bubbles are present twice more, discard the sample vial and repeat the procedure with a new vial. If, after three attempts, air bubbles are still in the vial, make a note of this and place the vial in the cooler.
- Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
- Semivolatile organic compounds, pesticides, polychlorinated biphenyls, and herbicides
- Petroleum hydrocarbons
- Metals (unfiltered)
- Explosives
- Any filtered analytes (use in-line filters if possible) – About 100-1000 mL should be purged through the filter prior to sample collection

S. Place all samples on ice inside a cooler immediately.

T. Each sample should be identified with the Sample ID, location, analysis number, preservatives, date and time of sampling event, and sampler.

U. The sample time and constituents to be analyzed for should be recorded in the logbook, in the Toughbook®, and on the groundwater sampling form.

V. Chain-of-custody procedures should be started (SOP No. 26 Sample Control and Custody Procedures).

W. Sample equipment should be decontaminated (SOP No. 4 Decontamination).

4. References

ASTM 2002, Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations, ASTM D6771-02, American Society for Testing and Materials. West Conshohocken, PA.

Nielsen, David and Nielsen, Gillian. Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling. Second Edition. NEFS-TG001-02. April 2002.

USEPA. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504. OSWER, April 1996.

1. Objective

The objective of groundwater monitoring well development or redevelopment is to clear the well of accumulated sediments so that representative groundwater samples and water quality readings and/or water levels may be collected for Shell projects in Hartford and Roxana, Illinois. Development activities are typically performed when a well, intended for sampling, is installed. Redevelopment activities are typically performed when 10% or more of a well screen has been occluded by sediment if the well is typically sampled as part of a routine sampling program; or when 75% or more of a well screen has been occluded by sediment if the well is typically only gauged as part of a routine groundwater program[1]. Accumulated sediments need to be suspended in the water column in order to be removed. Common methods to suspend sediments include using a surge block, injecting air into the water column of the well, using a submersible pump, or using a bailer. Once the sediment is suspended, the water and sediment can be removed from the well using a submersible pump, an air bladder pump, air-lift, or a bailer.

2. Equipment

Equipment typically used during well development includes:

- Well installation information
- Well keys
- Disposable latex or nitrile gloves
- Assorted tools (safety utility knife, screwdriver, etc.)
- Pump and required accessories (battery, tubing, etc.) or air-lift equipment
- Electronic water level indicator with 0.01-foot increments
- Graduated cylinder, measuring cup or similar
- Paper towels or Kimwipes (decontamination equipment)
- Calculator
- Bound field logbook and/or groundwater development sheet
- Waterproof pen or permanent marker
- Plastic Buckets or truck-mounted poly tank
- 55-gallon drums, if needed

[1] Redevelopment criteria presented are arbitrary guidelines based on site knowledge and experience, and are not a formal requirement.

- Appropriate health and safety equipment (e.g. photoionization detector (PID), etc.)

Additional equipment typically used during well development for wells with LNAPL includes:

- Water/product interface probe with 0.01-foot
- *NuWell 220* dispersant polymer

3. *Procedure*

The preferred method for development will be surging and removing water with a submersible pump or air-lift system. The following procedures will be used when developing a new well or redeveloping an existing well which does not contain LNAPL.

1. Place a clean, plastic drop cloth on the ground around the well to be developed.
2. Put on a new, unused pair of disposable latex or nitrile gloves.
3. The well will be approached from upwind, the well cap unlocked and removed, and the air quality monitored in the casing and breathing zone with an FID and PID.
4. Check the well for LNAPL, if necessary, using an interface probe. Measure the depth to groundwater and/or LNAPL to the nearest hundredth of a foot. (SOP No. 10 Well Gauging Measurements).
5. Measure the total depth of the well to the nearest hundredth of a foot. Note whether the bottom of the well feels hard or soft.
6. Calculate the amount of water to be removed (3 to 5 well volumes).
    - For Development of newly installed wells: Remove 1x the amount of water added by drillers during installation along with 5 well volumes of water.
    - For Redevelopment of existing wells: Remove 3 well volumes of water.

installed depth – depth to water = height of water column

height of water column * gallons/foot conversion = 1 well volume

Well Diameter	**Gal/ft Conversion**
0.75 inch	0.0229
1 inch	0.0408
1.5 inches	0.0918
2 inches	0.163
4 inches	0.652
6 inches	1.468

If LNAPL is present, go to **Step 7**. If NAPL is not present or gauging for LNAPL is not required, go to **Step 8**.

7. If LNAPL is observed within the monitoring well, refer to the project work plan, scope of work or task/project manager for further guidance. If developing using a dispersant, follow the step below.
    - *NuWell 220* dispersant polymer may be added into the well in accordance with the dosage guide below or the manufacturer's dosage recommendations
        - 2" monitoring well – add 0.12 ounces per foot of water within the well

          (Example: 20-foot deep 2" monitoring well, DTW = 7 feet;

          13 feet of water * 0.12 ounces per foot = 1.56 oz of *NuWell 220*)
        - 4" monitoring well – add 0.46 ounces per foot of water within the well.
    - Go to **Step 8** and continue with this procedure.
8. If using a separate surge block, attach the decontaminated surge block to the appropriate lengths of pole section and push the surge block to the bottom of the well. Pull and push the surge block up and down vigorously to agitate the water and suspend the sediments in the well. Once sufficient re-suspension has occurred, pull the surge block/bailer out of the well. A submersible pump or bailer may also be used to surge the well (go to **Step 9**).
9. Attach an appropriate length of polyethylene tubing to a submersible pump, or use an air-lift system, and lower the pump to the bottom of the well. (If using a bailer, attach an appropriate length of string to the bailer and lower the bailer to the bottom of the well.
10. Place the discharge end of the tubing such that purged water will be collected in a bucket, poly-tank, 55-gallon drum, or other.
11. Turn on the pump and adjust the flow rate, if possible, to pump at a sufficiently high rate to allow the sediments to be removed without causing the pump to clog.
12. Vigorously surge the well during purging in order to continuously agitate and suspend the sediment within the bottom of the well.

13. Continue surging and pumping until:

    [Development] – newly installed wells

    - the volume of any water added during installation near the screened zone has been removed,
    - 5 well volumes of water have been removed, and
    - relatively visually sediment-free water is observed during purging
    - sediment in the screen zone has been removed to the extent practicable.

    [Redevelopment] – existing wells

    - 3 well volumes of water have been removed, and
    - relatively visually sediment-free water is observed during purging
    - sediment in the screen zone has been removed to the extent practicable.

14. Remove the pump and allow the well to recover. Re-measure the total well depth. If the measured depth indicates 10% or more occlusion for sampled well screens (or 75% or more occlusion for gauged well screens), repeat steps 7 through 10. If the measured depth indicates less than 10% well screen occlusion for sampled wells (or less than 75% well screen occlusion for gauged wells) and all sediment has been removed from the screen to the extent practicable, disconnect the tubing from the pump and place into the appropriate waste container.

$$\frac{\text{installed total well depth} - \text{sump length} - \text{measured total well depth}}{\text{screen length}} (100\%) = \%\ \text{occlusion}$$

15. Dismantle the surge block and pole connectors, if used, for decontamination.

16. Pick up and appropriately dispose of any plastic sheeting and other disposables into the appropriate waste container. Close and properly label the 55-gallon drum(s). Refer to the project IDW coordinator for further information/guidance.

17. Decontaminate the pump, wiring, and any other reusable equipment (SOP No. 4 Decontamination).

Note in the field log book and on any field data sheets the approximate number of gallons of water removed during development of each well, well screen depth interval, depth to bottom prior to well development, and depth to bottom after well development.

1. Summary

The purpose of this Standard Operating Procedure (SOP) is to define the general procedures and typical equipment for installation of groundwater monitoring wells and piezometers for Shell projects in Hartford and Roxana, Illinois. A piezometer is simply a small diameter monitoring well. Therefore, the equipment and procedures for building a piezometer are the same as those used to install a monitoring well. The step-by-step procedures described herein are sufficiently detailed to allow field personnel to be familiar with proper installation techniques of any size monitoring well.

2. Equipment

The following is an equipment list typical for well drilling and installation:

- Drill rig capable of installing wells of the desired diameter to the desired depth in the expected formation materials and conditions
- Well casing and well screen
- Bentonite pellets or chips
- Filter pack sand
- Portland Type I or II Cement and powdered bentonite for grouting
- Protective well casing with locking cap
- Appropriate decontamination supplies as specified in SOP No. 4 Decontamination
- Location map
- Plastic bags (Ziploc or similar)
- Self-adhesive labels
- Weighted tape measure
- Water level or Interface probe
- Deionized or distilled water
- Appropriate health and safety equipment as specified in the Health and Safety Plan (HASP)
- Log book
- Boring log sheets
- Well construction form

- Plastic sheeting, if necessary
- Roll-off box and/or drums for containment of cuttings and Decontamination and/or development water (if necessary).

3. Procedures

Decontamination

Between well installation locations, all drilling and installation equipment will be decontaminated according to the protocols listed in SOP No. 4 Decontamination.

Instrument Calibration

Before going into the field, the sampler shall verify that field instruments are operating properly. Refer to SOP No. 3 Calibration and Maintenance of Field Instruments, as well the manufacturer's instructions for more information.

Drilling and Well Installation Procedures

Drilling Technique

Boreholes will be advanced using drilling methods specified in the Work Plan or other project document and a drill rig capable of completing the monitor well(s) to the depth(s) specified in the Scope of Work. Before drilling, well locations will be numbered and staked. The necessary permits and utility clearances (SOP No. 5 Utility Clearance Procedures) will be obtained prior to commencement of drilling activities. Appropriate health and safety measures will be followed during drilling and well installation activities as specified in the Health and Safety Plan (HASP).

During the drilling operation, the cuttings from the boring will be containerized or placed directly onto the ground or on plastic. Refer to the project IDW Coordinator for additional information, guidance and disposal.

Monitor Well Drilling Operations

The procedures for drilling are as follows:

- Set up drilling rig at staked and cleared borehole location.
- Record location, date, time and other pertinent information in the field book and on the boring log.
- Advance borehole of appropriate size using hollow-stem augers or similar. Refer to SOP No. 29 Soil Probe Operation if a geoprobe-style drilling rig is being used.

- Collect samples at the predetermined intervals, if appropriate, for sample description and/or chemical analysis as specified in the Work Plan. See SOP No. 17 Logging, SOP No. 28 Soil Sampling, and SOP No. 38 Methanol Preservation Sampling (Terracore) for further instructions.
- Complete the borehole to the desired depth.

Well Design Specifications

The following general specifications will be:

Boring Diameter: The boring will be of sufficient diameter to allow for the accurate placement and proper installation of the screen, riser, filter pack, seal, and grout.

Well Casing: Well riser will consist of new threaded, flush joint, PVC or stainless steel. Well diameter and thickness will be determined prior to the start of work. Risers will extend approximately two to three feet above the ground surface for stick-up surface completions, or a sufficient depth below ground surface to accommodate an expandable well cap and lock with the flush-mount surface completion vault. The tops of all well casings will be fitted with expandable locking caps.

Well Screens: Screen length for each well will be project specific and determined prior to the start of work (typically 5 to 10 ft in length). Well screens will consist of new threaded, flush joint, PVC or stainless steel (depending on project requirements) pipe with factory-machine slots/ wrapped screen with an inside diameter equal to or greater than that of the well casing. The slot size will be designed to be compatible with aquifer and sand pack material and may vary on different projects. The schedule thickness of a PVC screen will be the same as that of the well casing. All screen bottoms will be fitted with a cap or plug of the same composition as the screen and should be within 0.5 foot from the open part of the screen. Traps or sumps may be used.

Well Installation Procedure

The following procedures will be initiated within 12 consecutive hours of boring completion for uncased holes or partially cased holes and within 48 consecutive hours for fully cased holes. Once installation has begun, no breaks in the installation procedure will be made if no unusual conditions are encountered until the well seal has been placed and hydrated.

The procedure for monitoring well installation is as follows:

1. Decontaminate all well materials according to SOP No. 4 Decontamination. Following decontamination, all personnel that handle the casing will don a clean pair of gloves.

2. Measure each section of casing, and screen, to nearest 0.10 foot.
3. Assemble screen and casing as it is lowered into the borehole.
4. Lower screen and casing to about 6 inches above the bottom of the boring.
5. Record the level of top of casing and calculate the screened interval. Adjust screen interval by raising assembly to desired interval if necessary and add sand to raise the bottom of the boring.
6. Calculate and record the volume of the filter pack, bentonite seal, and grout required for existing boring conditions.
7. Begin adding filter pack sand around the annulus of the casing a few feet at a time. Repeated depth soundings shall be taken to monitor the level of the sand.
8. Allow sufficient time for the filter sand to settle through the water column outside the casing before measuring the sand level.
9. Extend the filter pack sand to about 2 feet above the top of the well screen, unless otherwise specified for the scope of work.
10. Following sand filter pack placement in the shallow wells, install a minimum 2 foot-thick seal of bentonite pellets or chips by slowly adding the pellets to avoid bridging. The thickness of the completed bentonite seal shall be measured before the pellets are allowed to swell. The completed bentonite seal shall be allowed to hydrate for a minimum of 20 minutes before proceeding with the grouting operations.
11. Grout the remaining annulus from the top of the bentonite seal to about 3 feet below the surface as measured after the augers are removed. The grout will be mixed and tremied into the borehole until the annulus is completely filled in accordance with procedures in SOP No.12 Grouting Procedures. The base of the tremie pipe should be placed approximately 5 feet above the bentonite seal.
12. After the grout sets for 24 hours it will be checked for settlement. If necessary, additional grout or bentonite chips will be added to top off the annulus.
13. The proper protector, concrete pad and bollards, if required, will be installed according to specifications in this SOP. Bollards, and possibly the stick-up protective casing, will be painted a high visibility color.
14. AECOM personnel will clearly mark the well number at each location in some way.

Well Installation Specifications:

Filter Pack: The annular space around the well screen will be backfilled with clean, washed, silica sand sized to perform as a filter between the formation material and the well screen. The filter pack will extend about two feet above the screen and may be tremied into place. The final depth to the top of the filter pack will be measured directly using a weighted tape measure or rod and not by using volumetric calculation methods. The grain size of the filter pack will be shown on the well construction log.

Bentonite Seal and Grout: A minimum two-foot thick bentonite pellet/chip seal will be placed in the annulus above the filter pack. The thickness of the seal may vary slightly based on site conditions. The thickness of the seal will be measured immediately after placement, without allowance for swelling. Bentonite slurry seals should have a thick batter-like consistency. Slurry seals will have a maximum placement thickness of 8 feet. High-solids bentonite or cement-bentonite grout will then be placed from the top of the bentonite seal to the ground surface. The cement grout will consist of a mixture of Portland cement (ASTM C150) and clean water as described in SOP No. 12 Grouting Procedures. The grout will be placed by pumping through a tremie pipe. The lower end of the tremie pipe will be kept within five feet of the top of the bentonite seal. Grout will be pumped through the tremie pipe until undiluted grout flows from the annular space at the ground surface. The tremie pipe will then be removed and more grout added to compensate for settling. After 24 hours, the drilling contractor will check the site for grout settlement and add more grout to fill any depression. This will be repeated until firm grout remains at the surface.

Protection of Well: URS personnel will, at all times during the progress of the work, take precautions to prevent tampering with the wells or entrance of foreign material into them. Upon completion of a well, a suitable cap will be installed to prevent foreign material from entering the well. The wells will be enclosed in a steel protective casing. Steel casings will be, at a minimum, 4 inches in diameter and will be provided with locking caps and locks. All locks will be keyed alike. If the well is to be a stickup a 1/4-inch drainage hole can be drilled in the protective steel casing centered approximately 1/8-inch above the internal mortar collar for drainage. The well designation will be painted or otherwise marked on the protective casing. Marking will be done prior to well development. A minimum 2-foot by 2-foot, 4 to 8-inch-thick concrete pad, sloped away from the well, should be constructed around the protective casing at the final ground level elevation. Three or four 2-inch-diameter or larger steel posts will be equally spaced around the well, for stick-up surface completions, and embedded in separate concrete filled holes just outside of the concrete pad.

The protective steel posts should extend approximately 1 foot above the well riser. Any well that is to be temporarily removed from service or left incomplete due to delay in construction, will be capped with a water tight cap and equipped with a "vandal-proof" cover satisfying applicable state or local regulations or recommendations.

Once the well is installed and surface completion is finished, the new monitoring well will be developed and surveyed within 30 days. Refer to SOP No. 20 Well Development for additional information regarding development of a well.

4. Documentation

Observations and data acquired in the field during drilling and installation of wells will be recorded to provide a permanent record. A boring log will be completed for each boring according to the procedures outlined in SOP No. 17 Logging.

Additional documentation for well construction will be recorded in the field book according to SOP No. 8 Field Reporting and Documentation and will typically include the following:

- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and Safety monitoring equipment and readings
- Grout, sand, and bentonite volume calculations prior to well installation
- The quantity and composition of the grout, seals, and filter pack actually used during construction
- Screen slot size (in inches), slot configuration, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer
- Coupling/joint design and composition
- Protective casing composition and nominal inside diameter
- Start and completion dates
- Discussion of all procedures and any problems encountered during drilling and well construction.

In addition, the well installation details will be shown in a diagram which will be drawn in the field book. Each well diagram will consist of the following (denoted in order of decreasing depth from ground surface):

- Reference elevation for all depth measurements
- Project and site names
- Well number
- Date(s) of installation
- The depth at which the hole diameter changes (if appropriate)
- The depth of the static water level and date of measurement(s)
- Total depth of completed well
- Depth of any grouting or sealing
- Nominal hole diameter(s)
- Amount of cement used for grouting or sealing
- Depth and type of well casing
- Description (to include length, internal, diameter, slot size, and material of well screen(s)
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development
- Drilling date(s)
- Other construction details of monitoring well including grain size of well filter pack material and location of all seals and casing joints.

1. Objective

This document defines the standard Quality Assurance/Quality Control (QA/QC) samples for Shell projects in Hartford and Roxana, Illinois. QA/QC samples are typically collected during field studies for various purposes which include the isolation of site effects (control samples), define background conditions (background sample), and evaluate field/laboratory variability (e.g., matrix spikes/matrix spike duplicates (MS/MSDs), equipment blanks, trip blanks, duplicates, split samples). This SOP is intended to be used together with several other SOPs.

2. Equipment

The following equipment is typically used:

- Waterproof coolers (hard plastic or metal)
- Nitrile gloves, or similar
- Custody seals
- Field forms such as Chain of Custody (COC) or sample collection sheet
- Field notebook
- Ice
- Bubble wrap
- Clear tape
- Duct tape
- Zip Loc bags
- Sample containers and labels
- Waterproof pen
- Permanent marker
- Trash bags

3. QA/QC Samples

Refer to the project work plan or scope of work for a description of relevant QA/QC samples.

- Background Sample – a sample (usually a grab sample) collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

- Split Sample – Two or more representative subsamples taken from one environmental sample in the field. Prior to splitting, the environmental sample is homogenized to correct for sample heterogeneity that would adversely impact data comparability. Field split samples are usually analyzed by different laboratories (interlaboratory comparison) or by the same laboratory (intralaboratory comparison). Field splits are typically used to assess sample handling procedures from field to laboratory and laboratory's comparability. Field Duplicate – Field duplicates should be samples collected side by side or by collecting one sample and immediately collecting the second sample. Field duplicates represent the precision of the whole method, site heterogeneity, field sampling and the laboratory analysis. When results for both duplicate and sample values are greater than 5 times the practical quantitation limit (PQL), satisfactory precision is indicated by a relative percent difference (RPD) less than or equal to 25% for aqueous samples, and 50% for non-aqueous samples. Where one or both of the results of a field duplicate pair are reported at less than 5 times the PQL, satisfactory precision is indicated if the field duplicate results agree within 2 times the quantitation limit for aqueous samples and within 5 times the quantitation limit for soil samples. Field duplicate results that do not meet these criteria may indicate unsatisfactory precision of the results.

- Trip Blanks – A sample which is prepared by the laboratory using analyte free water prior to the sampling event in a laboratory provided container and is stored with the investigative sample bottles and samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to assess volatile organic compound (VOC) cross contamination of samples during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If VOC samples are to be shipped, trip blanks are to be provided with each cooler containing VOC samples.

- Equipment Field Blanks – a sample collected using distilled or deionized water which has been collected using investigative sample collection equipment in the same manner that investigative samples are collected (e.g. run over/through equipment). This identifies contamination resulting from the field equipment, sampling procedure, or sample container, preservative. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field cleaned. Equipment blanks should be labelled with the ID of the next sample to be collected.

- Temperature Blanks – A container of water shipped with each cooler of samples requiring preservation by cooling to 4°C ± 2°C (ice). The temperatures of the blanks are measured at the time of sample receipt by the laboratory. No temperature blank is necessary for samples designated as "waste".
- Field Blanks – A sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example air-borne dust or organic vapors which could contaminate a soil sample). Analyte-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.
- Material Blanks – Samples of sampling materials (e.g., material used to collect/wipe samples, etc.), construction materials (e.g., well construction materials), or reagents (e.g., organic/analyte free water generated in the field, water from local water supplies used to mix well grout, etc.) collected to measure any positive bias from sample handling variability. Commonly collected material blanks are listed below:
  - Wipe Sample Blanks – A sample of the material used for collecting wipe samples. The material is handled, packaged, and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.
  - Grout Blanks – a sample of the material used to make seals around the annular space in monitoring wells.
  - Filter Pack Blanks – a sample of the material used to create an interface around the screened interval of a monitoring well.
  - Construction Water Blanks – a sample of the water used to mix or hydrate construction materials such as monitoring well grout.
  - Organic/Analyte Free Water Blanks – a sample collected from a field organic/analyte free water generating system. The sample is normally collected at the end of sampling activities since the organic/analyte free water system is recharged prior to use on a study. On large studies, samples can be collected at intervals at the discretion of the project leader. The purpose of the organic/analyte free water blank is to measure positive bias from sample

handling variability due to possible localized contamination of the organic/analyte free water generating system or contamination introduced to the sample containers during storage at the site. Organic/analyte free water blanks differ from field blanks in that the sample should be collected in as clean an area as possible (a usual location for the organic/analyte free water system) so that only the water generating system/containers are measured.

- Matrix Spike – A sample collected in the same manner as the investigative sample, with known concentrations of analytes added by the laboratory prior to laboratory analysis, which is introduced into a second aliquot. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used to assess the accuracy and precision of the analytical process on an analytical sample in a particular matrix, and can be indicative of matrix effects/analyte recoveries. A group of up to 20 field samples of the same matrix (e.g., water, soil, sediment, waste) being analyzed for the same constituents may be associated with a single matrix spike (MS) sample of a matrix spike/matrix spike duplicate (MS/MSD) pair.
- Matrix Spike Duplicate – A sample collected in the same manner as the investigative sample, with known concentrations of analytes added by the laboratory prior to laboratory analysis (same concentrations of analytes as the matrix spike), which is introduced into a third sample aliquot. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike duplicate is an additional measure of accuracy and precision.

4. Sample Containers

Certified commercially clean sample containers will be obtained from the contract analytical laboratory. The lab will indicate the type of sample to be collected in each bottle type, and the preservative (if applicable) of each bottle. A work plan or other project documentation may list the appropriate sample containers for the specific analyses require for each project/task.

5. Sample Preservation

Samples will be preserved prior to, or at the time of the sample collection. Chemical preservatives, if necessary, will be added to the sample containers either by the laboratory prior to shipment to the field, or in the field by sampling personnel.

After sample collection, each container will be labeled (see SOP No. 24 Sample Classification, Packaging and Shipping for additional information) and stored on ice at 4°C ± 2°C in an insulated cooler until packed for shipment to the laboratory. The ice or the sample bottles will be bagged in sealed storage bags, or as otherwise recommended by the laboratory. Freezing samples will not be permitted. Any breakable sample bottles need to be wrapped in protective packing material (bubble wrap) to prevent breakage during shipping.

6. QA/QC Sample Collection Frequency

The table below outlines common frequencies for QA/QC sample collection. Refer to the project work plan or scope of work for a description of relevant QA/QC samples.

QA/QC Sample	Frequency
Background Sample	Optional/Project or Task Specific
Split Sample	Optional/Project or Task Specific
Field Duplicate Sample	One per 10 samples collected per matrix Project or Task Specific
Trip Blank	One per cooler containing VOC samples Project or Task Specific
Equipment Field Blanks	One per 10 samples collected Project or Task Specific
Temperature Blanks	Laboratory specific One per cooler Project or Task Specific
Field Blanks	Optional/Project or Task Specific One per 20 samples collected per matrix
Material Blanks	Optional/Project or Task Specific One per matrix
Matrix Spike	One per 20 samples collected per matrix Project or Task Specific
Matrix Spike Duplicate	One per 20 samples collected per matrix Project or Task Specific

1. Objective

This document defines the standard protocols for sample classification/identification, labeling, packaging, and shipping for Shell projects in Hartford and Roxana, Illinois. This SOP serves as a supplement a work plan, sampling and analysis plan or other project documentation, and is intended to be used together with several other SOPs.

2. Equipment

The following equipment is typically needed for sample classification, packaging and shipping:

- Chain of custody form
- Sample bottles (laboratory provided)
- Sample labels
- Water proof pen or similar
- Trash bag or similar for lining cooler
- Bubble wrap
- Ice
- Re-sealable storage bags
- Custody seal
- Clear packing tape
- Shipping label
- Waterproof cooler

3. Procedures

Sample Classification/Identification

Samples collected during site activities shall have discrete and site specific sample identification code (ID). These sample IDs are necessary to identify and track each of the many samples collected for analysis during the life of project. In addition, the sample IDs can be used in a database to identify and retrieve the analytical results received from the laboratory.

Each sample is identified by a unique code which indicates the specific project, site identification, sample location number, sample matrix identifier, sample depth, and/or date. If used, sample matrix identifiers may include the following:

GP - Geoprobe

GWP - Groundwater Profile

PZ - Piezometer

MW - Monitoring Well

CPT – Cone Penetrometer Testing

ROST - Rapid Optical Screening Tool

VMP - Vapor Monitoring Point

TB - Trip Blank

EB - Equipment Blank

DUP - Duplicate Sample

MS - Matrix Spike Sample

MSD - Matrix Spike Duplicate Sample

An example of the sample identification number codes for a groundwater monitoring well sample collected for field analysis for the Shell Sites will be:

MW13-PROJ-070713-EB.

Where “MW” indicates Monitoring Well, “13” indicates the well location, “PROJ” indicates the abbreviated project name (ROX, WRR, etc.), “070713” indicates the date, and “EB” indicates an equipment blank.

The project abbreviation, sample sequence, sampling locations, and sample type will be established prior to field activities for each sample to be collected. On-site personnel will obtain assistance from the Task or Project Manager in defining any special sampling requirements.

Sample Labeling

Sample labels will be filled out as completely as possible by a designated member of the sampling team prior to beginning field sampling activities each day. The date, time, sampler initials/signature should not be completed until the time of sample collection. All sample labels shall be filled out using waterproof ink, preferably black. Below is information typically included on a sample label:

- Sampler's company affiliation
- Project/Site location

- Sample identification code
- Date and time of sample collection
- Analyses required
- Method of preservation or preservative (if any)
- Sample matrix (i.e., soil, groundwater, surface water)
- Sampler's signature or initials.

Labels will be affixed to the sample bottle. The sample bottle will be wiped off to remove any dirt, moisture and/or contamination that may have become adhered to the outside of the bottle. Clear tape will be applied in order to keep the label attached to the sample and to keep the label legible. If waterproof or weatherproof labels are used to label sample bottles, clear tape is NOT required. If a sample bottle displays a tared weight from the laboratory, clear tape will NOT be used.

Sample Packaging and Shipping

For packaging and shipping of air or soil vapor samples, refer to SOP No. 51 Vapor Sampling Classification, Packaging and Shipping. Below describes packaging and shipping procedures for water and soil samples.

After sample collection, each container will be labeled as described above, and then stored on ice at 4°C (+/- 2°C) in an insulated cooler until packed for shipment to the laboratory. Coolers will be lined with a trash bag or similar and either the ice or the sample bottles will be bagged in sealed storage bags, or as otherwise recommended by the laboratory.

Sample bottles will be wiped off to remove any dirt, moisture and/or contamination that may have become adhered to the outside of the bottle. To the extent possible, the sample containers will be placed in re-sealable storage bags and wrapped in protective packing material (bubble wrap). Samples will then be placed right side up in a lined cooler with ice and a completed chain-of-custody (COC) form (placed in a separate zip-locked bag). A custody seal will be placed over the lid and body of the cooler on the side from which the cooler is opened. The cooler will be wrapped with clear packing tape, including over the custody seal, for delivery to the laboratory. Samples will be hand delivered or shipped by overnight express carrier for delivery to the analytical laboratory. All samples must be shipped for laboratory receipt and analyses within specific holding times. This may require daily shipment of samples with short holding times. The temperature of all coolers will be measured upon receipt at the laboratory. A temperature blank may be included in each cooler for temperature measurement purposes, per laboratory specific requirements.

Sample Documentation and Tracking

Field Notes - Documentation of observations and data acquired in the field will recorded on field sampling sheets, in a bound field logbook and/or in a Toughbook/Toughpad to provide a permanent record of field activities. Refer to SOP No. 8 Field Reporting and Documentation for additional information.

Sample Chain-of-Custody - During field sampling activities, traceability of the sample must be maintained from the time the samples are collected until laboratory data are issued. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. The COC should contain project and sample specific information. Sample labels should be checked against the COC to ensure everything intended for analysis is listed on the COC.

The person responsible for delivery of the samples to the laboratory will sign the COC form, retain a copy of the COC form, document the method of shipment, and send the original COC form with the samples. Additionally, an electronic copy of the COC should be forwarded to applicable project contacts (e.g., task manager, project chemist, etc.). Refer to SOP No. 26 Sample Control and Custody Procedures for additional information about COCs.

1. Objective

This document defines the standard protocols for sample containers, preservation and hold times for Shell projects in Hartford and Roxana, Illinois. This SOP is intended to be used together with several other SOPs.

2. Equipment

The following equipment is typically required for this SOP:

- Waterproof coolers (hard plastic or metal)
- Custody seals
- Field forms such as Chain of Custody (COC) or sample collection sheet
- Field notebook
- Ice
- Bubble wrap
- Clear tape
- Duct tape
- Re-sealable bags
- Sample containers and labels
- Waterproof pen
- Permanent marker
- Nitrile gloves, or similar
- Trash bags

3. Sample Containers

Certified commercially clean sample containers will be obtained from the contract analytical laboratory. The lab will indicate the type of sample to be collected in each bottle type, and the preservative (if applicable) of each bottle. The work plan may list the appropriate sample containers for the specific analyses required for each project.

4. Sample Preservation

Samples will be preserved prior to, or at the time of the sample collection, if applicable. Chemical preservatives, if necessary, are typically added to the sample containers by the laboratory prior to shipment to the field. In some cases, preservatives may be added to the sample containers in the field by sampling personnel.

After sample collection, each container will be labeled and stored on ice at 4°C (+/- 2°C) in an insulated cooler until packed for shipment to the laboratory. The ice or samples will be bagged per laboratory specific requirements. Freezing samples will not be permitted. Any breakable sample bottles need to be wrapped in protective packing material (i.e., bubble wrap) to prevent breakage during shipping. Refer to SOP No. 24 Sample Classification, Packaging and Shipping for additional information.

5. Sample Hold Times

Samples will be hand delivered or shipped via overnight express carrier for delivery to the analytical laboratory. All samples must be shipped for laboratory receipt and analyses as soon as possible and within specific holding times. This may require daily shipment of samples with short holding times. The hold time varies for each type of analysis, and therefore, it will be necessary to check with the lab to verify the hold times to determine how frequently samples need to be sent to the lab. Typical hold times are provided in **Table 1**.

Table 1 Typical Sample Holding Times & Preservation

Analysis	Holding Time	Preservation
Alkalinity	14 days	Cool to 4°C
Ammonia NH3	28 days	Cool to 4°C - H2SO4 to pH<2
Asbestos	1 year	None
BOD 5	48 hours	Cool to 4°C
BOD 5 Inhibited	48 hours	Cool to 4°C
BTEX	14 days	Cool to 4°C; HCl
Chloride	28 days	Cool to 4°C
Chlorophyll	24 hrs to filtration - 28 days after filtration	Freeze filters in 90% acetone
Chromium VI (Hexavalent) in water	24 hours	Cool to 4°C
COD	28 days	Cool to 4°C - H2SO4 to pH<2
Conductivity	28 days	Cool to 4°C
Cyanide in Soil	14 days	Cool to 4°C
Cyanide in Water	14 days	Cool to 4°C NaOH to pH>12; 0.6 g ascorbic acid
EDB/DBCP	14 days	Cool to 4°C; sodium thiosulfate
Fluoride in Soil	28 days	Cool to 4°C
Fluoride in Water	28 days	Cool to 4°C
Grain Size Sediment	6 months	None required

Table 1 Typical Sample Holding Times & Preservation

Analysis	Holding Time	Preservation
Guaiacols/Catechols/Phenols	30 days	Cool to 4°C; H2SO4 to pH<2
Halogenated Hydrocarbons HH	7 days water/14 days soil	Cool to 4°C
Hardness	6 months	HNO3 to pH<2
Herbicides	7 days water/14 days soil	Cool to 4°C
Hydrocarbon chlorinated	7 days water/14 days soil	Cool to 4°C Ascorbic acid
Ignitability	None	Cool to 4°C
Iron and sulfur bacteria	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Mercury in Water	28 days	Cool to 4°C; HNO3 to pH<2
Metals -- Except Cr(6) and Hg	180 days	HNO3 to pH <2
Metals, dissolved	6 months	Filter - then add HNO3 to pH<2
Nitrate NO3-	48 hours	Cool to 4°C
Nitrate-Nitrite	28 days	Cool to 4°C; H2SO4 to pH<2
Nitrite NO2-	48 hours	Cool to 4°C
Nitrogen Pesticides	7 days water/14 days soil	Cool to 4°C
NWTPH-Dx and NWTPH-HCID	7 days water/14 days soil	Cool to 4°C HCl to pH<2
NWTPH-Gx	14/14 days	Cool to 4°C HCl to pH<2
Oil & Grease in Water	28 days	Cool to 4°C; HCl to pH<2
Oil and Grease in Soil	28 days	Cool to 4°C
PAH Hazardous Waste Designation w/o HPLC	7 days water/14 days soil	Cool to 4°C
PAH Polynuclear Aromatic Hydrocarbons	7 days water/14 days soil	Cool to 4°C
PCBs only	7 days water/14 days soil	Cool to 4°C
Percent Solids Soil/Tissue	7 days	Cool to 4°C
Personal Monitors	None	None
Pesticides/PCBs	7 days water/14 days soil	Cool to 4°C

Table 1 Typical Sample Holding Times & Preservation

Analysis	Holding Time	Preservation
pH	24 hours	Cool to 4°C
Phenolics in Soil (4AAP)	28 days	Cool to 4°C
Phenolics in Water (4AAP)	28 days	Cool to 4°C; H3PO4; FeSO4 and CuSO4
Phosphorus, Total and Dissolved	28 days	Cool to 4°C; H2SO4 to pH<2
PM10	1 year	Cool to 4°C
PM2.5	30 days	Cool to 4°C
Semivolatile Organics /SVOCs	7 days water/14 days soil	Cool to 4°C
Settleable Solids(SS)	48 hours	Cool to 4°C
Specific conductance	28 days	Cool to 4°C
Sulfate	28 days	Cool to 4°C
Sulfide	7 days	Zinc acetate; NaOH to pH>9
TOC in Soil	28 days	Cool to 4°C
TOC in Water	28 days	Cool to 4°C; H2SO4 to pH<2
Total Dissolved Solids(TDS)	7 days	Cool to 4°C
Total Kjeldahl Nitrogen (TKN)	28 days	Cool to 4°C; H2SO4 to pH<2
Total Non-Volatile Solids(TNVS)	7 days	Cool to 4°C
Total Non-Volatile Suspended Solids(TNVSS)	7 days	Cool to 4°C
Total Persulfate Nitrogen (TPN)	28 days	Cool to 4°C; H2SO4 to pH<2
Total Solids(TS)	7 days	Cool to 4°C
Total Suspended (TSS)	7 days	Cool to 4°C
Total Volatile Solids(TVS)	7 days	Cool to 4°C
Tributyl tin	7 days water/14 days soil	Cool to 4°C
Turbidity	48 hours	Cool to 4°C
Volatile Organics/VOCs	7 days water/14 days soil	Cool to 4°C; HCl

1. Objective

This document defines the standard procedure for the control and custody of environmental samples for Shell projects for Hartford and Roxana, Illinois. This SOP is intended to be used together with several other SOPs.

2. Equipment

The following equipment is typically needed for sample control and custody procedures:

- Waterproof coolers (hard plastic or metal)
- Custody seals
- Field forms such as a Chain of Custody (COC) or sample collection sheet
- Field notebook
- Re-sealable bags
- Waterproof pen
- Permanent markers
- Nitrile gloves, or similar

3. Sample Control and Custody

Once the samples are collected, they must remain in the custody of the sampler or another worker from the site. The samples can also remain unattended in a locked vehicle or jobsite trailer so tampering with the samples will not be possible.

During field sampling activities, traceability of the samples must be maintained from the time the samples are collected until the laboratory data is issued. Initial information concerning the collection of the samples will be recorded in the field log book as outlined in SOP No. 8 Field Reporting and Documentation. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. If the COC is not three-part (minimum) carbon-copy form, then photocopy the COC after signatures have been obtained, and before the samples and original copy leave the site.

The sampler will be responsible for initiating and filling out the COC form during sample collection. The COC will be signed by the sampler or the field person responsible for sample handling when the sampler relinquishes the samples to anyone else, or prior to being placed in a sealed cooler for shipment. One COC form will be completed for each cooler of samples collected daily and if samples are not hand delivered, the COC will be placed in a Zip-Loc bag and shipped inside the cooler. Additionally, an electronic copy of the COC should be forwarded to applicable project contacts (e.g., task manager, project chemist, etc.). COC forms will be used to document the transport and receipt of samples from the field to the lab. Information required on a COC includes the following:

- Samplers signature and company affiliation
- Company contact information (address, project contact, telephone, email
- Project number/Project name
- Date and time of collection
- Sample IDs
- Sample matrix
- Analyses requested
- The total number of containers being sent to the lab for each sample and analysis requested
- The appropriate preservative used (where applicable), designating the number of containers to be analyzed with that preservative
- If any samples are to be placed on hold at the laboratory, this should be clearly indicated on the COC in the comments section
- Turnaround time (TAT) requested
- Deliverables requested
- Signature of person(s) relinquishing custody, dates, and times
- Signature of person(s) accepting custody, dates, and times
- Method of shipment
- Shipping air bill number (if appropriate)
- Appropriate project-specific Incident and SAP numbers (for Shell projects)
- Special instructions or field notes, if applicable
- Numerated pages (Page__of__)

The person responsible for delivery of the samples to the laboratory will sign the COC form, retain a copy of the COC form, document the method of shipment, and send the original COC form with the samples. Refer to SOP No. 24 Sample Classification, Packaging and Shipping for more information regarding packing and shipping samples. Upon receipt at the laboratory, the person receiving the samples will sign the COC form. The original COC will remain with the samples until final disposition of the samples by the laboratory. The laboratory will dispose of the samples in an appropriate manner after data reporting (standard disposal times are laboratory dependent).

1. Objective

This document defines the standard procedure for collection of soil samples for environmental characterization purposes for Shell projects in Hartford and Roxana, Illinois. This procedure provides general descriptions of typical equipment and field procedures necessary to collect soil samples.

2. Equipment

The following equipment is typically used to collect soil samples:

- Hand Auger (if required to collect sample)
- Latex/Nitrile gloves
- Organic Vapor meter (e.g. PID)
- Surveyor's stakes, pin flags, spray paint or similar
- Portable field table
- Stainless steel knife, if needed
- Stainless steel spoon or scoop, if needed
- Stainless steel bowl, if needed
- Sample containers
- Decontamination equipment
- Plastic Sheeting, if necessary
- Field data sheets/bound field logbook
- Health & Safety equipment
- Cooler with ice.

3. Soil Sample Collection Procedures

This section provides step-by-step procedures for collecting soil samples in the field. Observations made during soil sample collection should be recorded on applicable field sheets and/or in a bound field logbook in accordance with the procedures defined in SOP No. 8 Field Reporting and Documentation:

A. Remove appropriate sample containers from the transport container (i.e., cooler), and prepare the sample containers for receiving samples.

B. Fill out a self-adhesive label with the appropriate information and affix it to the appropriate sample container, or fill out the sample label attached by the laboratory. Place clear polyethylene tape over the completed label to protect it from dirt and water (unless a tare weight has been recorded by the lab on the container or a waterproof/weatherproof label is used). Sample labels can be prepared prior to sample collection except for sample time and date, and depth, if necessary. Labels can be filled in with the date and time of sample collection just prior to collecting the sample. Sample containers will be kept cool with their caps on until they are ready to receive samples.

C. Place labeled sample containers near the sampling location.

D. Place clean plastic sheeting on the ground surface or the field table at the sampling area as needed.

E. Put on a pair of new nitrile or latex gloves.

F. Decontaminate the reusable sampling equipment as described in detail in SOP No. 4 Decontamination prior to beginning sampling activities.

G. Advance the sampler (direct push sampler, hand auger, split-spoon, etc.) to the desired sample depth and retrieve the sample.

H. VOC samples cannot be composited without losing volatiles. Therefore, collect a discrete VOC sample prior to compositing the remaining soil (if doing so). Collect the VOC sample with a Terra Core sampler (SOP No. 38 Methanol Preservation Sampling (Terracore)), or by placing it directly into an appropriate sample container. If the sample is transferred to a jar, the entire jar must be filled without any voids and the top surface of the soil should be smeared to prevent VOCs from escaping when opening the jar. After collecting the sample at the desired location within the sample interval, place the remainder of the sample into a stainless steel bowl/Ziploc bag, break up large chunks and mix the soil, if a composite sample is to be collected. Fill the remaining sample containers from the steel bowl.

I. Place the sample containers on ice in a cooler to maintain the samples at approximately 4^{o}C as described in SOP No. 25 Sample Container, Preservation and Holding Times.

J. Begin chain-of-custody procedures. A sample chain-of-custody form is included in SOP No. 26 Sample Control and Custody Procedures. Ship the cooler to the laboratory for analysis within 24-48 hours of sample collection in accordance with the procedures described in SOP No. 24 Sample Classification, Packaging and Shipping.

K. Decontaminate the sample equipment as described in SOP No. 4 Decontamination.

L. Field notes shall be kept on applicable field sheets and/or in a bound field logbook.

4. Possible Soil Sample Collection Methods

- Geoprobe (micro or macro samplers)
- Split Spoon sampler using a conventional drill rig
- Hand Auger
- Surface Sampling with a stainless steel spoon or scoop.

1. *Objective*

This document defines the standard operating procedure (SOP) and typical equipment for sampling with the use a hydraulically advanced direct push GeoProbe® (or similar) to obtain representative subsurface soil samples for geologic logging and physical and chemical laboratory testing for Shell projects in Hartford and Roxana, Illinois.

2. *Equipment*

The following equipment is typically used:

- Hydraulic percussion hammer Geoprobe® or similar rig
- Probe/sample rods (macro core or dual-tube)
- Acetate liners
- Disposable sample retainers
- Photoionization detector (PID)
- Surveyor’s stakes, pin flags, spray paint or similar
- Stainless steel knife and resealable plastic bags (Ziplock)
- Sample containers
- Decontamination equipment
- Health and safety equipment
- Field data sheets
- Field logbook
- Water proof or permanent ink pen

3. *Procedure*

The general procedure for using the Geoprobe® equipment for sampling is as follows. The specific soil probe operation procedures may vary slightly based on individual drilling contractors’ SOPs for soil probe operation:

A. Locate boring using facility drawings to check utilities. Refer to SOP No. 5 Utility Clearance Procedures.

B. Log boring location on site base map.

C. Hydraulically push or drive probe rods with acetate sample liner, or dual tube system with acetate liner to the first sample depth

D. Remove probe/inner rods and retrieve acetate liner. Visually log and classify the soil (SOP No. 17 Logging), select specimen, if necessary, for physical and/or chemical testing (SOP No. 28 Soil Sampling). Record information on field data sheets and/or in field logbook.

E. Replace sampler acetate liner.

F. Monitoring breathing zone according to requirements in the project Health and Safety Plan (HASP).

G. Insert acetate sample liner and attached rods in exiting probe hole and push or drive sampler to the next sample depth, repeat sampling procedure.

H. Repeat Geoprobe® sampling until the target depth is reached.

I. Record total depth.

J. Retrieve probe rods.

K. Backfill probe hole with bentonite grout or similar as required by the work plan unless a monitoring well, piezometer, soil vapor port or similar installation is to be completed (refer to appropriate SOP for an installed feature).

L. Place survey stake or similar at boring location.

M. Record data collected on boring log and in log book.

N. Decontaminate equipment (SOP No. 4 Decontamination).

4. Decontamination

Refer to the HASP for personnel decontamination procedures; refer to SOP No. 4 Decontamination for equipment decontamination procedures.

1. Objective

This document defines the standard operating procedure (SOP) and typical equipment for collection of groundwater profiling samples within hydraulically advanced GeoProbe® (or similar) hollow drill rods and well screens using a peristaltic pump or ball and check valve for Shell projects in Hartford and Roxana, Illinois.

During groundwater profiling activities, groundwater samples are collected at predetermined intervals. Sampling intervals are specified in the scope of work for a specific project/task. Groundwater samples are collected by using a GeoProbe® to hydraulically advance a 4- or 5-foot stainless steel slotted sampler with a typical screen slot size of 0.002 inches to pre-determined intervals below ground surface. In this technique, in order to lessen drawdown within the hollow drill rods, a pump that minimizes disturbance to the groundwater is operated at the lowest possible flow rate. Purging is performed until specific parameters have stabilized over three consecutive flow-through cell volumes or until one hour of purge time has elapsed, whichever occurs first. Therefore, the groundwater samples collected are representative of the water bearing formation and hydraulically isolated from the water in the casing.

2. Equipment

Equipment typically used during well purging and sampling:

- Polyethylene tubing
- Ball and check valve
- Disposable latex or nitrile gloves
- Assorted tools (knife, screwdriver, etc.)
- Pump and required accessories (described in more detail in following section)
- Electronic water level indicator or water/product interface probe with 0.01-foot increments
- Graduated cylinder, measuring cup or similar
- Water quality parameter instrument with necessary sensors
- Flow-through cell
- Calibration fluids
- Paper towels or Kimwipes
- Calculator

- Bound field logbook (logbook) and/or Groundwater Sampling Form
- Waterproof pen and permanent marker
- Plastic buckets with lids
- 55-gallon drums or truck-mounted tank
- Plastic sheeting
- Appropriate decontamination equipment (see SOP No. 4)
- Cooler with ice
- Sample containers and labels
- Chain-of-Custody form
- Appropriate health and safety equipment (e.g., photoionization detector (PID)).

3. Sampling Procedure

This section provides the step-by-step procedure for collecting groundwater profile samples in the field. Observations made during groundwater purging and sampling should be recorded in a logbook in accordance with procedures described in SOP No. 8 Field Reporting and Documentation.

A. Any reusable equipment used in the profile sampling procedure that could contact groundwater should be properly decontaminated before each use (see SOP No.4 Decontamination).

B. Equipment should be calibrated based on the manufacturers' instructions. Refer to SOP No. 3 Calibration and Maintenance of Field Instruments for more information.

C. Underground utilities at the location of each soil probe will be cleared prior to commencement of probing activities (SOP No. 5 Utility Clearance Procedures). Following utility clearance the sampler will be advanced to the predetermined depth and opened. A groundwater measurement of the water within the screen and rods will be collected to the nearest 1/100th of a foot (SOP No. 10 Well Gauging Measurements). Measurements will be recorded in the logbook and on any pertinent field forms. The volume of water within the screen and rods will then be calculated.

D. Following measurement of the static groundwater elevation, the appropriate equipment will be slowly and carefully placed in the rods. If the rods have light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs) care should be taken to place sampling equipment below or above the NAPL.

When placing the tubing in the well, the water intake (i.e., ball and check valve assembly) should be set near the middle or slightly above the middle of the screened interval. If the screen length allows, the water intake should be at least two feet from the bottom of the screen. Placing the water intake near the top of the water column can cause stagnant water from the casing to be purged, but placing the water intake near to the bottom of the well can cause mobilization and entrainment of settled solids from the bottom of the well.

E. Tubing should be connected from the pump to a flow-through cell. New tubing should be used for each profiling interval.

F. The pump should be started at a low flow rate, approximately 100 mL/min or the lowest flow rate possible. Refer to SOP No. 18 Low Flow Groundwater Purging and Sampling for additional low flow procedure information.

G. Allow water to flow through the flow-through cell. Parameter readings should be documented on the groundwater sampling form and/or in the logbook. The time between parameter measurements is calculated as follows.

$$T = \frac{V}{Q}$$, where

T = time between measurements (minutes)

V = volume of the flow-through cell (liters)

Q = purge flow rate (liters per minute)

H. In most cases, purging will continue until specific parameters have stabilized over three consecutive flow-through cell volumes. **Table 1** provides guidelines that may be used for parameter stabilization as specified by USEPA, ASTM, and in the Nielsen and Nielsen Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling (Nielsen and Nielsen, 2002). These guidelines are to be used in combination with professional judgment. **Table 2** provides the guidelines to be used for Roxana, WRR and Rand groundwater profiling activities. **Table 2** combines relevant stabilization guidelines from **Table 1** in combination with limitations in accuracy for readings collected by the Troll9500 (typical low flow and groundwater profiling equipment used on the Rand and Roxana groundwater projects).

Table 1. Stabilization Guidelines for Low-Flow Sampling

Parameter	Stabilization Guidelines		
	EPA	**ASTM**	**Nielsen & Nielsen**
DO	+/- 10%	+/- 10% or +/-0.2 mg/L, whichever is greatest	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 10 mV	+/- 20 mV	+/- 20 mV
PH	+/- 0.1 units	+/- 0.2 units	+/- 0.2 units
Conductivity	+/- 3%	+/- 3%	+/- 3%
Temperature	Not Specified	Not Specified	+/- 0.2 ºC
Turbidity	+/- 10%	Not Specified	Not Specified

Table 2. Stabilization Guidelines used for Rand, WRR and Roxana GW Sampling

Parameter	Stabilization Guidelines (using above standards combined with Troll9500 accuracies)
DO	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 20 mV
PH	+/- 0.2 units
Specific Conductivity	+/- 5% or +/-2µs/cm
Temperature	Not Specified; Monitor and record
Turbidity	Visually Sediment Free, when practical; Monitor and record

I. After the relevant parameters have stabilized or the required purging time has elapsed, the flow-through cell should be disconnected or bypassed for sampling. Samples will be collected by allowing the groundwater to flow from the tubing directly into the laboratory supplied containers. Do NOT allow the sample tubing to come into contact with the sample bottles, and do NOT place sample bottles on the ground (e.g., place bottles in a plastic tub or similar).

J. A new pair of disposable latex or nitrile gloves should be put on immediately before sampling.

K. The constituents should be sampled for in the order given below:

- VOCs – Vials should be filled completely so that the water forms a convex meniscus then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles. If air bubbles are observed in the sample vial, remove the lid and attempt to fill the vial two more times, (being careful not to dump out any groundwater currently in the vial). If air bubbles are present twice more, discard the sample vial and repeat the procedure with a new vial. If, after three attempts, air bubbles are still in the vial, make a note of this and place the vial in the cooler.
- Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
- Semivolatile organic compounds
- Petroleum hydrocarbons
- Metals (unfiltered)
- Any filtered analytes (use in-line filters if possible).

L. Place all samples on ice inside a cooler immediately.

M. Each sample should be identified with the Sample ID, location, analysis number, preservatives, date and time of sampling event, and sampler.

N. The sample time and constituents to be analyzed for should be recorded in the logbook and/or on the groundwater sampling form.

O. Chain-of-custody procedures should be started (SOP No. 26 Sample Control and Custody Procedures).

P. Sample equipment should be decontaminated (SOP No. 4 Decontamination) or replaced as applicable.

Q. The GeoProbe® rods/screen should then be advanced to the next predetermined profiling depth and the process of purging and sampling repeated.

R. Upon completion of each boring, each GeoProbe® hole will be sealed with bentonite grout from the bottom up using the GeoProbe® rods as a tremie pipe and the surface will be returned to the original condition (SOP No. 12 Grouting Procedures). Purge water will be placed in 55-gallon drums (or similar) that are labeled, sealed, and staged at a pre-determined location on-site (refer to the IDW Coordinator for more information). The GeoProbe® unit and rods will be cleaned between profiling holes using a steam pressure washer (SOP No. 4 Decontamination). Decontamination water will be containerized in 55-gallon drums (or similar) and labeled (refer to the IDW Coordinator for more information).

1. Objective

This document defines the standard operating procedure (SOP) and necessary equipment for collection of soil vapor samples from vapor monitoring points / sampling ports using stainless steel canisters for Shell projects in Hartford and Roxana, Illinois.

2. Equipment

The following equipment is typically needed:

- Field book
- Disposable nitrile gloves
- Cut resistant gloves
- Ultra-fine permanent marker
- Paper towels
- Decontamination equipment
- Soil vapor sampling logs
- Small brush or broom
- Charcoal filter
- 15 mL hand pump with gauge (inches Hg)
- Peristaltic pump
- Rotometer or equivalent
- PID, combustible gas detector (e.g., Mini-RAE, Landtec GEM 2000)
- Stainless steel canisters with flow controllers (supplied by the laboratory)
- Sample bags (2 - 1 liter per sample) (e.g., Tedlar, Kynar, Solef)
- Sample train assembly (configuration and parts shown on **Figure 1**)
- Vacuum gauge (0 – 30 inches Hg)
- Teflon® tubing (laboratory-grade) – 1/8" ID – ¼" OD
- Tygon® tubing (laboratory-grade) – 3/16" ID – 3/8" OD
- Tracer gas (e.g., Grade 5 helium)
- Tracer gas shroud (e.g., plastic tote)
- Tracer gas meter (e.g., Dielectric Technologies MGD-2002 or equivalent)

- Watch or timer
- Standard field tools (e.g., ratchet set, safety cutting tools, pry bar, etc.)
- Shipping supplies (e.g., UN boxes, shipping labels, hazard labels, packing tape)

3. *Vapor Port Development Purging*

If the port has been newly installed, the port must be developed by purging 3 volumes of the sampling assembly including 3 volumes of the sand pack. If development is not required, proceed to **Section 4** or **Section 5** below for the appropriate sampling procedures

1. Open vapor point vault to check integrity of individual soil vapor monitoring port(s) (VMP). Each port should have a hose barb connected to a 4-way polycarbonate stopcock (4-way) using silicone tubing. The 4-way should be in the “off” position.
2. Connect peristaltic pump and Tygon tubing connected to the 4-way.
3. Connect charcoal filter exhaust to the discharge end of the tubing assembly.
4. Calculate Purge volume:
    - Vapor Port tubing (1/8-in diameter): 2.41 mL/foot (single volume)
    - Sample train assembly / Tygon® tubing (1/4-in diameter): 9.65 mL/foot (single volume)
    - Sand Pack: 18,765 mL (4.95 gallons – single volume – assuming 18 inch sand pack)
5. Open 4-way and begin purging port at a rate no greater than 2 L/min. Document time started.
6. Once 3 volumes are reached, stop pump and close 4-way. Document time stopped.
7. Move to next depth or replace vault cover and clean up at location.

4. *Vapor Port Sampling – With No Tracer Gas*

To perform vapor port sampling with tracer gas shroud, proceed to **Section 5** below.

1. Open vapor point vault to check integrity of individual soil vapor monitoring port(s) (VMP). Each port should have a hose barb connected to a 4-way valve using silicone tubing. The 4-way should be in the “off” position.
2. Perform stainless steel canister vacuum check, per the steps listed in **Section 6** of this SOP.

3. Setup the sample assembly using the configuration shown in **Figure 2**. The flow controller (one for each stainless steel canister provided by the laboratory) will be connected to the stainless steel canister inlet. Do not re-use flow controllers between samples. Flow controllers can be set to different rates as specified by the project work plan, depending on size of container to be filled. For a 1-Liter stainless steel canister, approximately 5 minutes is a standard collection time (~167 ml/min).
4. Perform sample train leak check, per the steps listed in **Section 6** of this SOP.
5. Remove the 4-way and connect the sample train to the VMP using Swagelok® fittings.
6. Open Port Valve.
7. Calculate Purge volume:
   - Vapor Port tubing (1/8-in diameter): 2.41 mL/foot (single volume)
   - Sample train assembly (1/4-in diameter): 9.65 mL/foot (single volume)
8. Open Valve #2.
9. Purge the three volumes from the vapor monitoring port purge using the 15 mL hand pump. If the pump gauge holds a vacuum, and the purge cannot be completed, the VMP screen may be saturated with water and will not yield a representative sample. If this happens, do not sample the VMP. Similarly, if water is pulled out during the purge, do not sample the VMP. Record purge results in Toughbook or on sample sheets.
10. Close Valve #2.
11. Open stainless steel canister valve completely and record the time in Toughbook or on sample sheets.
12. After approximately 5 minutes or other appropriate sampling duration, or if the vacuum gauge reading drops below 5 inches Hg before approximately 5 minutes, close the stainless steel canister valve completely. Record the time in Toughbook or on sample sheets. **The vacuum gauge should reach less than 10 inches Hg, but should not be allowed to drop below 2 inches of Hg.**
13. Connect peristaltic pump to tubing connected to Valve #2 and open Valve #2 to collect a sample in a sample bag. The sample bag should be filled at a rate no greater than 200 ml/min.
14. Disconnect the sample train from the VMP and reconnect the 4-way.
15. Disconnect flow controller, stainless steel canister, and used tubing from sample assembly.

16. From the soil vapor in the sample bag obtain readings for total volatile organics with a photoionization detector (PID) and for CO2, CH_4, LEL, and oxygen (O2) with a landfill gas meter. Record readings in Toughbook or on sample sheets. If FID or PID is not on-site, label and retain bag for reading at field trailer.
17. Perform stainless steel canister vacuum check, per the steps listed in **Section 6** of this SOP.
18. Setup on the next depth or replace vault cover and clean up at location.
19. Decontaminate any non-designated equipment (e.g., sample assembly) following procedures listed in **Section 7**.

5. Vapor Port Sampling – With Tracer Gas Shroud

To perform vapor port sampling with no tracer gas shroud, proceed to **Section 4** above.

1. Open vapor point vault to check integrity of individual soil vapor monitoring port(s) (VMP). Each port should have a hose barb connected to a 4-way valve using silicone tubing. The 4-way should be in the "off" position.
2. Perform stainless steel canister vacuum check, per the steps listed in **Section 6** of this SOP.
3. Setup the sample assembly using the configuration shown in **Figure 3**. The flow controller (one for each stainless steel canister provided by the laboratory) will be connected to the stainless steel canister inlet. Do not re-use flow controllers between samples. Flow controllers can be set to different rates as specified by the project work plan, depending on size of container to be filled. For a 1-Liter stainless steel canister, approximately 5 minutes is a standard collection time (~167 ml/min).
4. Perform sample train leak check, per the steps listed in **Section 6** of this SOP.
5. Remove the 4-way and connect the sample train to the VMP using Swagelok® fittings.
6. Open Port Valve.
7. Place an enclosure shroud over the VMP and assembled sample train as shown in **Figure 3**. The shroud should have openings for:

- The introduction of tracer gas;
- Pressure relief to the atmosphere and access of a tracer gas monitoring device;
- Tygon tubing to connect to the peristaltic pump for Valve #1 (out) and Valve #2 (in and out).

The shroud should have sufficient glove access to open or close all valves within. As shown in **Figure 3**, the shroud must also be sealed to the ground with hydrated bentonite or equivalent.

8. Introduce tracer gas into the shroud at a known rate until the atmosphere within the shroud contains a sufficient quantity (typically 20% to 50%) of tracer gas.
9. Calculate Purge volume:
   - Vapor Port tubing (1/8-in diameter): 2.41 mL/foot (single volume)
   - Sample train assembly (1/4-in diameter): 9.65 mL/foot (single volume)
10. Open Valve #1.
11. Purge the three volumes from the vapor monitoring port purge using the 15 mL hand pump. If the pump gauge holds a vacuum, and the purge cannot be completed, the VMP screen may be saturated with water and will not yield a representative sample. If this happens, do not sample the VMP. Similarly, if water is pulled out during the purge, do not sample the VMP. Record purge results in Toughbook or on sample sheets.
12. Connect peristaltic pump to the purge tubing to collect a sample of the tracer gas from the shroud in sample bag #1. The sample bag should be filled at a rate no greater than 200 ml/min.
13. Close Valve #1.
14. From the soil vapor in sample bag #1, obtain readings for tracer gas with tracer gas detector. If tracer gas readings are elevated, analyze sample bag #1 using a landfill gas detector to obtain a direct methane reading. See **Section 6** for acceptance criteria.
15. Open stainless steel canister valve completely and record the time in Toughbook or on sample sheets.
16. After approximately 5 minutes, or other appropriate sampling duration, or if the vacuum gauge reading drops below 5 inches Hg before approximately 5 minutes, close the stainless steel canister valve completely. Record the time in Toughbook or on sample sheets. **The vacuum gauge should reach less than 10 inches Hg, but**

should not be allowed to drop below 2 inches of Hg. Record the concentration of tracer gas within the shroud after closing the canister valve.

17. Connect peristaltic pump to tubing connected to Valve #2 and open Valve #2 to collect a sample in sample bag #2. The sample bag should be filled at a rate no greater than 200 ml/min.
18. Break seal on the shroud and disconnect flow controller, stainless steel canister, and used tubing from sample assembly.
19. From the soil vapor in sample bag #2 obtain readings for total volatile organics with a PID, for CO_2, CH_4, LEL, and oxygen (O_2) with a landfill gas meter, and for tracer gas concentration with the tracer gas detector. See **Section 6** for acceptance criteria. Record readings in Toughbook or on field sheets. If FID or PID is not on-site, label and retain sample bag #2 for reading at field trailer.
20. Perform stainless steel canister vacuum check, per the steps listed in **Section 6** of this SOP.
21. Disconnect the sample train from the VMP and reconnect the 4-way.
22. Move to next depth or replace vault cover and clean up at location.
23. Decontaminate any non-designated equipment (e.g., sample assembly) following procedures listed in **Section 7**.

6. Quality Control

Quality control procedures have been developed to verify equipment integrity, sample quality, and sample repeatability.

In addition to the procedures listed below, the following items are also of concern:

- Care should be taken to keep all sampling equipment, especially the stainless steel canisters, safe from damage.
- No samples are to be collected in an area where vehicle or other equipment exhaust is being discharged.

Field Duplicates

A field duplicate will be collected for 10% of the samples collected.

Field duplicates are collected by using a sample assembly with an additional 3-way union. A stainless steel canister with a flow controller is attached to each of the 3-way unions on the assembly. For sampling, both stainless steel canister valves should be opened and closed simultaneously. Use the appropriate procedure described above to collect samples.

Stainless Steel Canister Vacuum Check

The stainless steel canister vacuum check will be performed for 100% of the stainless steel canisters.

Prior to Sampling

1. Remove brass cap from stainless steel canister.
2. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
3. Open valve completely.
4. Record reading on the canister tag. The canister should show a vacuum of approximately 28 inches of mercury (Hg). If the canister does not show a vacuum or shows a vacuum of less than 26 inches of Hg, then:
   - Label the canister tag with "Insufficient vacuum – No Sample";
   - Set canister aside for return to the laboratory; and
   - Contact task manager and lab coordinator if canister failures affect field work.
5. Close valve completely.
6. Remove the pressure gauge.
7. If not immediately using the stainless steel canister for sample, place and tighten brass cap on stainless steel canister.

After Sampling

1. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
2. Open valve completely.
3. Record reading. There should still be a vacuum in the stainless steel canister. If the canister does not show a net loss in vacuum after sampling of at least 10 inches Hg, evaluate and document the problem. If necessary, contact the project manager immediately to determine the value of using another stainless steel canister to recollect the sample.
4. Close valve completely.
5. Remove the pressure gauge.
6. Place and tighten brass cap on stainless steel canister.

Sample Train Vacuum Leak Check

The sample train leak check will be performed for 100% of the samples collected.

1. Assemble the sampling apparatus as shown in **Figure 1**.
2. Keep the stainless steel canister and Valve #1 in the "off" or "closed" position. Valve #2 should be in the "open" position.
3. Attach the 15 mL hand pump to sample train at Valve #2.
4. Withdraw air from the sampling apparatus until a vacuum between 15 and 20 inches Hg is achieved. Observe the induced vacuum for at least five minutes.
5. If the change in vacuum over five minutes is equal to or less than 0.5 inch Hg, the system leak rate is acceptable.
6. If the change in vacuum over five minutes is greater than 0.5 inch Hg, check, tighten or replace the fittings and connections and repeat the leak check.

Tracer Gas Check

An appropriate number of samples will be collected using a tracer gas, as per the project work plan or activity plan.

1. Tracer gas should be introduced near the VMP to test the integrity of the probe seal and the above ground connections.
2. Collect the soil vapor sample per procedures in **Section 5**.
3. If the concentration of the tracer gas in a sample is ≤10% of the concentration of the tracer gas in the shroud:
   - Prior to stainless steel canister sampling: continue with sample collection.
   - Following stainless steel canister sampling: the sample is acceptable.
4. If the concentration of the tracer gas in the sample is >10% of the concentration of the tracer gas in the shroud:
   - Prior to stainless steel canister sampling: check methane levels.
     - If methane reading ≥2%, continue with sample collection.
     - If methane reading ≤2%, stop sample collection. Check fittings and valves before restarting sample collection.
   - Following stainless steel canister sampling: check methane levels.
     - If methane reading ≥2%, the results may be biased high by methane.

  - If methane reading <2%, sample likely compromised. Call task manager to inform of need for re-sample.
- If a sample is found to be compromised, 2 additional attempts (3 attempts total) should be made to collect a sample.
  - With each additional attempt, visually check stainless steel tubing and fittings for holes and loose connections, and place an additional layer of bentonite seal in the interior of the well vault.
  - After 3 attempts, if a successful sample has not been collected, the VMP will not be sampled for that quarter.

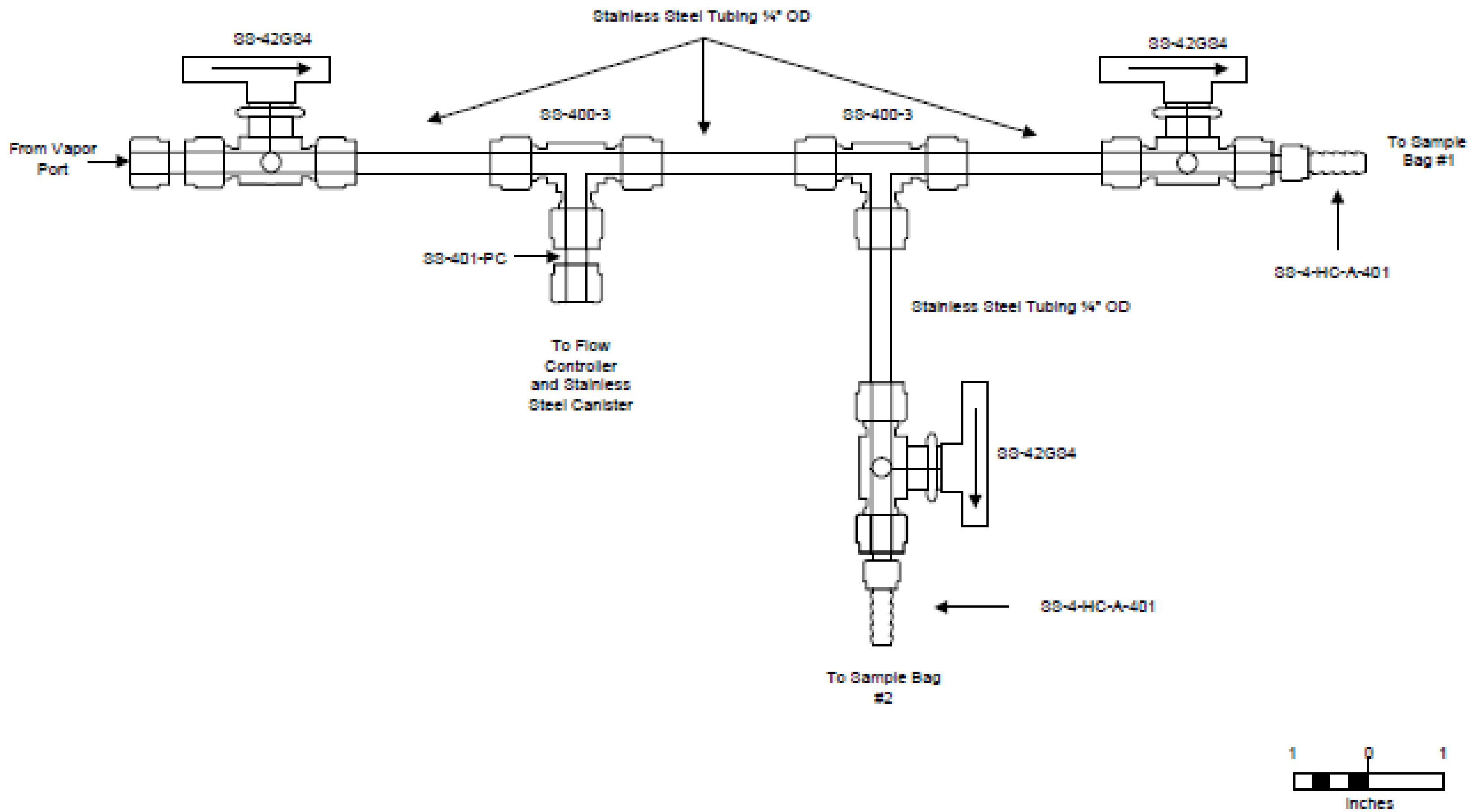
7. Decontamination

- Non-designated stainless steel assemblies will be thoroughly decontaminated by purging with at least half a liter of air (e.g., with hand pump or peristaltic pump).
- Should a stainless steel assembly come into contact with groundwater, it will be decontaminated using a Liquinox® detergent wash followed by a distilled water rinse.
- Multiple stainless steel assemblies will be available to sample crews to allow for equipment to be cleaned and dried sufficiently before being reused.

8. Shipping

- Sample information shall be recorded on a chain of custody for the laboratory following procedures outlined in SOP No. 26 Sample Control and Custody Procedures.
- Samples will be shipped to the laboratory following DOT regulations. If there is the possibility that samples may be classified as hazardous, samples must be shipped as such. For procedures, see SOP No. 51 Vapor Sampling Classification, Packaging and Shipping, and check with one of the office hazardous shipping personnel.

P:\Environmental\Shell Oil Product US\-SHELL CONTRACT PROGRAM FILES_SOPs\SOP No 44R Figure 1 - SV Assembly.vsd 9/19/2013 1:21 PM

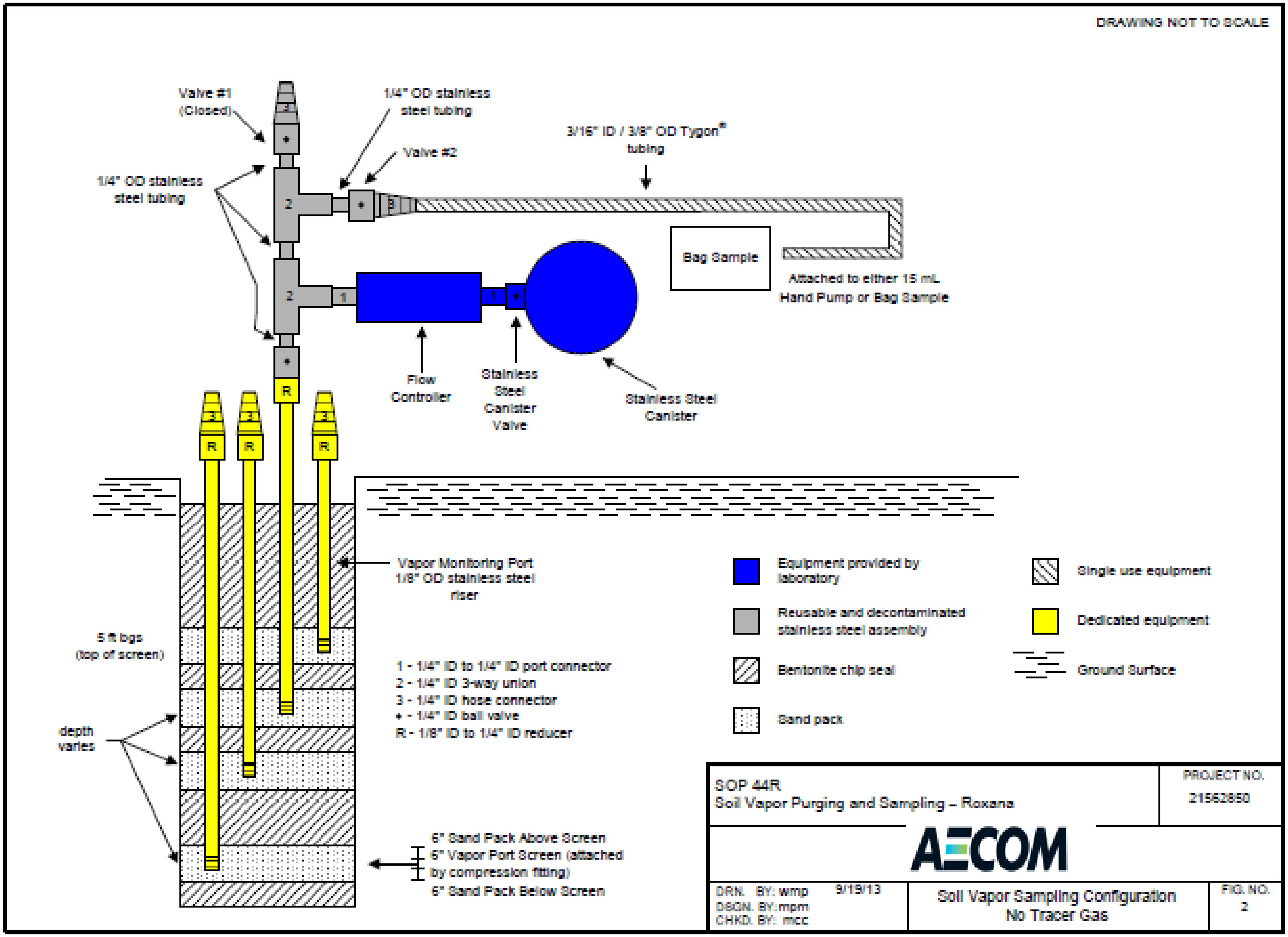


Notes:
1) All components listed with Swagelok part numbers.
2) Assembly shown for standard sample.
3) Duplicate assembly includes an additional 3-way union between the two shown.
4) All fittings shown are compression fittings with SS-400-Set ferules and SS-402-1 nuts.

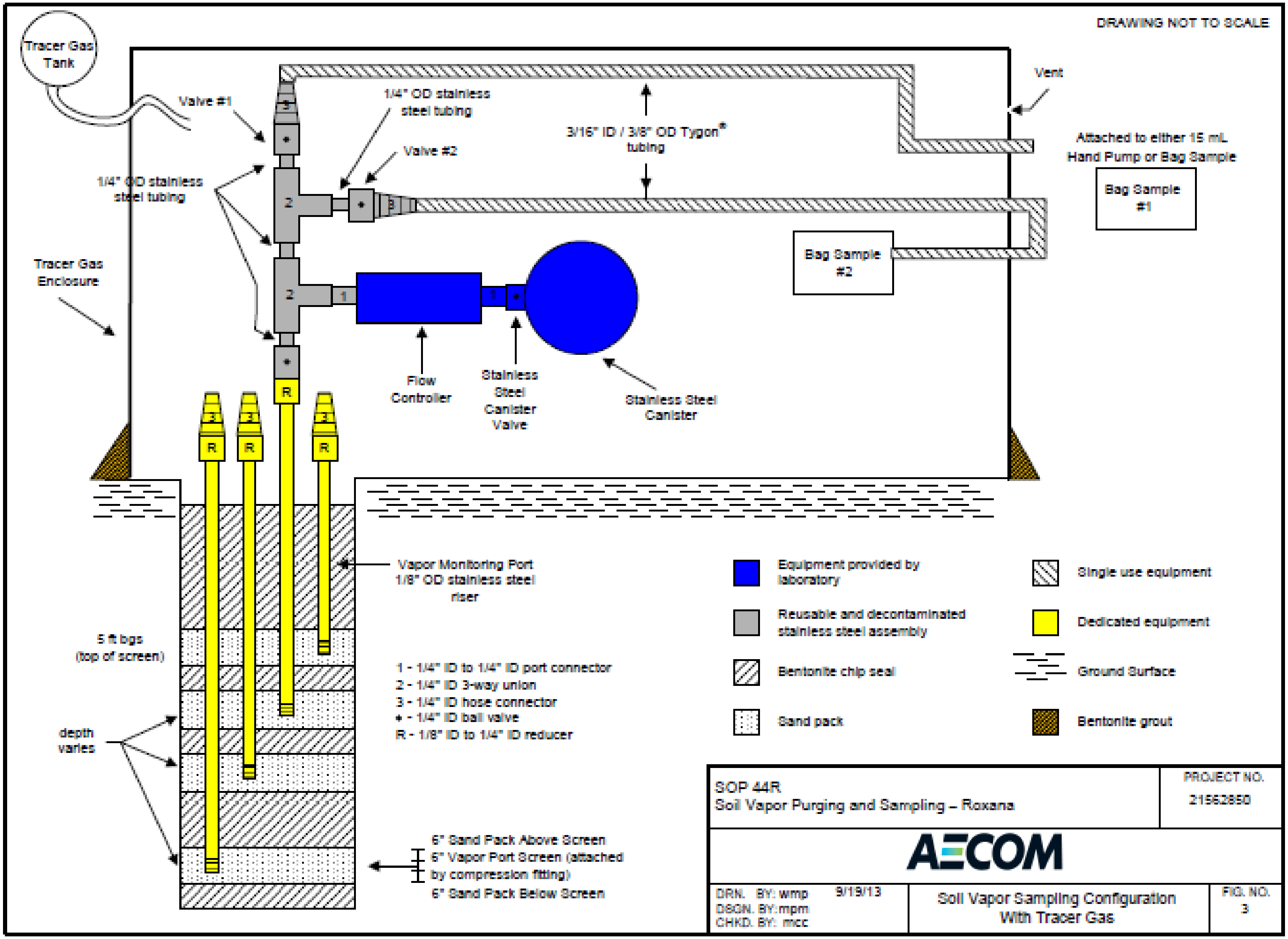
Source: http://swagelok.com/products.aspx; Accessed April 2, 2012.

SOP 44R Soil Vapor Purging and Sampling – Roxana	PROJECT NO. 21562850
AECOM	
DRN. BY: wmp 9/19/13 DSGN. BY: mpm CHKD. BY: mcc	Soil Vapor Sampling Assembly
FIG. NO. 1	

P:\Environmental\Shell Oil Product US\I-SHELL CONTRACT PROGRAM FILES_SOPs\SOP No 44R Figure 2 - SV Configuation no Shroud.vsd 9/19/2013 1:22 PM



P:\Environmental\Shell Oil Product US\I-SHELL CONTRACT PROGRAM FILES\I_SOPs\SOP No 44R Figure 3 - SV Configuration with Shroud.vsd 9/19/2013 1:22 PM



1. Objective

This document defines the standard operating procedure (SOP) and typical equipment for collection of indoor air samples using canisters for the Shell project in Roxana, Illinois.

Work involving location access must be conducted by a team of at least two personnel. One member of the team will be designated as the field lead. The field lead will be responsible for interaction with site occupants.

2. Equipment

The following equipment is typically used for this procedure:

- Field book
- Leather gloves
- Ultra-fine permanent marker
- Paper towels or Kimwipes
- Sampling logs
- Vacuum pressure gauge (-30 to 0 inches Hg)
- Photoionization Detector (PID) (e.g., RAE Instruments MiniRAE 3000 or equivalent)
- Flame Ionization Detector (FID) (e.g., Thermo Scientific TVA-1000 or equivalent)
- 4-gas meter (e.g., RAE Instruments QRAE II or equivalent)
- Methane detector (e.g., LANDTEC GEM-2000 or equivalent)
- Calibration gas
- Canisters with flow controllers (project specific appropriate size, supplied by the laboratory) or equivalent
- Swagelok® connectors and compression fittings
- Watch or timer
- Safety equipment (e.g. first aid kit, eye wash, 20lb fire extinguisher, etc.)
- Standard field tools (e.g., ratchet set, safety cutting tools, wrenches, zip-ties, etc.)
- Shipping supplies (e.g., UN boxes, shipping labels, hazard labels, packing tape)

3. Ambient Air Sampling

Prior to mobilizing to perform indoor air sampling, ensure the following:

- Access has been granted for the building in question for the period necessary for installation.
- Perform daily safety meeting, reviewing weather, procedures, and location concerns (access, animals, etc.).
- Verify that the occupant is present and is at least 18 years old. If no occupant is at least 18 years of age, installation will be rescheduled.

Mobilize equipment into the location, minimizing re-entries, and perform the following:

1. Verify that screening instruments are operating properly. Instruments indicating negative concentrations shall be re-zeroed.
2. Assess air quality, using a four gas meter, methane detector, FID and PID, in the room where work is to be performed. If necessary locate any sources for potential elevated readings.
3. If VOC or LEL readings are above the levels stated in the site Health and Safety Plan (HASP) work will cease until ambient air conditions have resumed safe levels.
4. If oxygen levels drop below 19.6% vacate the residence.
7. Perform walk through assessment survey. See Appendix B of the Vapor Intrusion Investigation Work Plan for Roxana, Illinois (Prepared for Shell Oil Products US and dated March 2011) for more information on the walk through assessment survey. Based on the walk through assessment survey, choose appropriate indoor air sampling locations for the event.
8. Perform canister vacuum check, per the steps listed in Section 4 of this SOP.
9. Assemble a canister with the appropriate flow controller.
10. Choose sampling locations related to the purpose of the work plan. Ensure that each location for the sample media and equipment is available so as to reduce potential harm to the sample or personal injury to building occupants or field personnel.
11. Record sample identification, canister number and initial vacuum on the sample data sheet and the canister sample tag.
12. Remove the brass cap from the inlet of the flow controller.
13. Place the canister in the appropriate sample location and open the canister valve one turn and record the sample start time on the sampling data sheet and the canister sample

tag. For a 6-Liter canister set at -28 inches mercury (Hg) over a 24-hour period the flow rate is set by the analytical laboratory at 3.5 ml/min.

14. Record a detailed description of the sample location on the data sheet.
15. Allow canister to sample for chosen sample duration. The final vacuum reading should be between 5 and 10 inches of mercury. Do not allow the canister to equilibrate with the atmosphere. When the appropriate duration has elapsed, shut the valve.
16. Remove flow controller from canister, obtain final canister pressure readings, and replace brass cap on the canister, per the steps listed in Section 4 of this SOP.
17. Record the stop time and final vacuum reading on the sampling data sheet and the canister sample tag.
18. Record sample information on the Chain of Custody and prepare sample for transportation to the laboratory.

4. Quality Control

Quality control procedures have been developed to verify equipment integrity, sample quality, and sample repeatability.

In addition to the procedures listed below, care should be taken to keep all sampling equipment, especially the canisters, safe from damage.

Canister Vacuum Check

The canister vacuum check will be performed for 100% of the canisters.

Prior to Sampling

1. Attach a pressure gauge to the canister inlet.
2. Open valve completely.
3. Record reading. The canister should show a vacuum of approximately -28 inches of Hg. If the canister has a vacuum of equal to or less than -25.5 inches of Hg (adjusted for any elevation effects), then:
4. Label the canister with "Insufficient vacuum – No Sample";
5. Set canister aside for return to the laboratory; and
6. Contact project manager and lab coordinator if canister failures affect field work.

10. Close valve completely.
11. Remove the pressure gauge.

After Sampling

1. Attach a pressure gauge to the canister inlet.
2. Open valve completely.
3. Record reading. There should still be a slight vacuum in the canister. If the canister does not show a significant net loss in vacuum after sampling, evaluate and document the problem. If necessary, contact the project manager immediately to determine the value of using another canister to recollect the sample.
4. Close valve completely.
5. Remove the pressure gauge.
6. Seal canister with brass cap.

5. Shipping

Sample information shall be recorded on a chain of custody for the laboratory following procedures outlined in SOP No. 26 Sample Control and Custody Procedures.

Samples will be shipped to the laboratory following DOT regulations. If there is the possibility that samples may be classified as hazardous, samples must be shipped as such. Check with one of the office hazardous shipping personnel. (Refer to SOP No. 51 Vapor Sampling Classification, Packaging and Shipping for more information.)

1. Objective

This document defines the standard operating procedure (SOP) and typical equipment for sub-slab soil-gas sampling with canisters for the Shell project in Roxana, Illinois.

Work involving location access must be conducted by a team of at least two personnel. One member of the team will be designated as the field lead. The field lead will be responsible for interaction with site occupants.

2. Equipment

The following equipment is typically used for this procedure:

- Field book
- Leather gloves
- Ultra-fine permanent marker
- Paper towels or Kimwipes
- Calculator
- Decontamination equipment
- Sample logs
- Small brush or broom
- 15 mL hand pump with gauge
- Vacuum pressure gauge (-30 to 0 inches mercury)
- Peristaltic pump
- Bios Dry Cal flow meter or equivalent device
- Portable analyzer with Flame Ionization Detector (FID) (e.g., Thermo Scientific TVA-1000 or equivalent)
- Portable analyzer with Photo-ionization detector (PID) (e.g., RAE Instruments MiniRAE 3000 or equivalent)
- LEL meter (e.g., RAE Instruments QRAE II or equivalent)
- Landfill gas detector (e.g., LANDTEC GEM-2000 or equivalent)
- Tracer gas meter (e.g., Dielectric MGD-2002 or equivalent)
- Tracer gas shroud (e.g., plastic tote)
- Tracer gas (e.g. Grade 5.0 helium or equivalent) with regulator

- Canisters with flow controllers (project specific appropriate size, supplied by the laboratory) or equivalent
- Swagelok® T-Connector (2 per sample train assembly) – ¼” ID
- Swagelok® Port Connector (3 per sample train assembly) – ¼” ID to ¼” ID
- Swagelok® Ball Valves (2 per sample train assembly) – ¼” ID
- Swagelok® Barb Connector (2 per sample train assembly) – ¼” ID
- Swagelok® Bulkhead Reducing Union (1 per sample train assembly) – ¼” ID
- Swagelok® Ferrules (6 per sample) – ¼” ID
- Swagelok® Nuts (6 per sample) – ¼” ID
- Teflon® hard tubing (food or laboratory grade) – 1/8” ID – ¼” OD (connects 1-Liter Tedlar® bags to Tygon® tubing)
- Tygon® soft tubing (food or laboratory grade) – 3/16” ID – 3/8” OD
- Small diameter continuous SS-316 stainless tubing – 1/8” OD
- 1-Liter Tedlar® bags (2 per sample)
- Hydrogen gas
- Calibration gas
- Watch or timer
- Lighting (e.g., head lamps)
- Rotary hammer drill
- 7/8 concrete drill bit
- 5/16 concrete drill bit
- Extension cord with GFI adapter
- Measuring tape
- Duct tape
- Quikrete® concrete crack sealer (14lb bottle)
- Concrete trowel
- Modeling clay
- Shop vacuum

- Spray bottle with water
- Safety equipment (e.g. first aid kit, eye wash, 20lb fire extinguisher, etc.)
- Standard field tools (e.g., ratchet set, safety cutting tools, wrenches, etc.)
- Shipping supplies (e.g., UN boxes, shipping labels, hazard labels, packing tape)

3. Preliminary Procedures

Prior to mobilizing to install Sub-slab monitoring probes (SSMPs), ensure the following:

- Verify access has been granted for the building in question for the period necessary for installation;
- A utility locate will not be conducted as utilities cannot be located beneath a building. A review of surrounding features (e.g. drains, meters, etc.) will be performed to determine where utilities are entering the building. The owner of the building should also be consulted for their knowledge of any additional known utilities.
- Perform daily safety meeting, reviewing weather, procedures, and location concerns (access, animals, etc.)
- Verify that the occupant is present and is at least 18 years old. If no occupant is at least 18 years of age, installation will be rescheduled.

Mobilize equipment into the location, minimizing re-entries, and perform the following:

1. Verify that screening instruments are operating properly. Instruments indicating negative concentrations shall be re-zeroed.
2. Assess indoor air quality, using a four gas meter, methane detector, FID and PID, in the room where a SSMP is to be installed. If necessary locate any sources for potential elevated readings.
3. If VOCs or LEL readings are above the levels stated in the site Health and Safety Plan (HASP) work will cease until ambient air conditions have resumed safe levels.
4. If oxygen levels drop below 19.6% vacate the residence.

4. Installation Procedures

1. Collect sub-slab soil-gas samples at up to three locations per building of interest (or as otherwise defined in project planning documents).
2. Mentally divide the slab into three rectangles of roughly equal size and select sample locations near the center of each rectangle. Adjust the locations as needed to account for logistical factors. Select an area where visible damage to the floor will be minimized. Avoid areas with tile or wood floors.

3. Construct a sampling probe using a reducer connected to a short length of 1/4" stainless steel tubing. Select a length of stainless steel tubing so that the bottom of the probe is close to the bottom of the sub-slab (typically a 4" probe for a 6" sub-slab). Attach the reducer via a port connector, as shown in the sample train configuration in **Figure 1**.
4. If possible, pre-cut the 1/4" stainless steel tubing before deploying to the field and bring a variety of lengths (e.g. 4", 6", and 12").
5. Drill down into the slab approximately 1 to 2 inches using a rotary hammer drill with a 7/8" diameter concrete bit. Clean out the dust using a shop vacuum (do not use a shop vacuum to clean out the dust from drilling if the hole extends all the way through the sub-slab).
6. Continue drilling down using a 5/16" diameter concrete bit to below the slab. Use the drill bit to measure the thickness of the slab and record the value.
7. Use modeling clay to seal the hole until the sampling train configuration is set.
8. Label the SSMP with indelible marker or paint pen on removable duct tape.
9. Record all measurements in the project logbook, including:
   - Slab thickness;
   - Borehole diameter; and
   - Time when clay seal was installed

5. Sampling Procedures

1. Perform canister vacuum check, per the steps listed in Section 7 of this SOP.
2. Setup the sample train configuration as shown in **Figure 1**. The flow controller (one for each canister provided by the laboratory) will be connected to the canister inlet. Do not reuse flow controllers between locations. Each flow controller is pre-set by the laboratory to collect the sample over a two-hour period. Flow controllers can be set to a different rate if desired by project, depending on size of container to be filled. For a 1-Liter canister set at 28 inches mercury (Hg) over a two hour period the flow rate is set at 6.7 ml/min.
3. Perform sample train leak check, per the steps listed in Section 7 of this SOP.
4. Remove the temporary modeling clay and install the probe in the hole, with the sampling train configuration already attached. Use the tubing in the sampling train configuration to hold the union at the correct height in the hole (just below the top). Use modeling clay to seal around the probe to set it in place.
5. Open Valve #1 located at the end of the sampling train.

6. Place a shroud over the SSMP and assembled sample train as shown in **Figure 1**. The shroud should have openings for:
   - The introduction of tracer gas;
   - Pressure relief to the atmosphere and access of a tracer gas monitoring device;
   - Tygon tubing to connect to the peristaltic pump for Valve #2 (out).
7. The shroud should have sufficient glove access to open or close all valves within as shown in **Figure 1**. Open Valve #1. Attach a hand pump with 15 mL stroke volume and built-in vacuum gauge to the purge tubing connected to Valve #1. Two or three strokes should purge out the system. There should not be much vacuum build up on the gauge during purging if the sub-slab material is dry and porous. If no vacuum is observed during purge, close Valve #1.
   a. If the sampling point will hold a -15 inches of Hg vacuum for 1 minute, the sampling location is not suitable for canister sampling. Unplug the probe by inserting a wire the length of the probe or by forcing air into the probe. If this does not work, install a sampling probe at another location.
8. Introduce tracer gas into the shroud at a known rate until the atmosphere within the shroud has a concentration of approximately 50% tracer gas. The tracer gas check will be performed within the first 30 minutes of sample collection.
9. Open Valve #1.
10. Connect a peristaltic pump to the purge tubing connected to Valve #2 to collect a sample in a 1-Liter Tedlar® bag. The 1-Liter Tedlar® bag should be filled at a rate no faster than 200 ml/min.
11. Close Valve #1.
12. From the soil vapors in the 1-Liter Tedlar® bag obtain readings for tracer gas with the tracer gas detector. If tracer gas readings are elevated, analyze the Tedlar® bag using a landfill gas detector to obtain a direct methane reading. Following procedures listed in Section 7 for elevated tracer gas readings in Tedlar® bags.
13. Open canister valve completely and record the time.
14. After approximately 2 hours, or if the vacuum gauge reading drops below -5 inches of Hg before 2 hours, close the canister valve completely. Record the time. The vacuum gauge should reach less than -10 inches of Hg, but should not be allowed to drop below -2 inches of Hg.
15. Open Valve #2.

16. Connect peristaltic pump to tubing connected to Valve #2 to collect a sample in a 1-Liter Tedlar® bag. The 1-Liter Tedlar® bag should be filled at a rate no faster than 200 ml/min.
17. From the soil vapor in the 1-Liter Tedlar® bag obtain readings for total volatile organics with a photoionization detector (PID), with a Flame Ionization Detector (FID), and for CO2, CH4, LEL, and oxygen (O2) with a landfill gas meter. Record readings from each instrument.
18. Break down sampling train configuration.
19. Remove flow controller from canister, obtain final canister pressure readings, and replace brass cap on the canister, per the steps listed in Section 4 of this SOP.
20. Decontaminate any non-designated equipment (e.g., Swagelok® connectors and valves) following procedures listed in Section 8.

6. Remove and Seal the Sampling Probe

1. Remove the probe from the floor and decontaminate.
2. Temporarily plug the hole with modeling clay.
3. Remove all modeling clay that was used for the seal and fill the hole with Quikrete® Gray Concrete Crack Sealer or equivalent until it is flush with the remainder of the sub-slab. Use a concrete trowel to smooth out excess concrete, if necessary.

7. Quality Control

Quality control procedures have been developed to verify equipment integrity, sample quality, and sample repeatability.

In addition to the procedures listed below, care should be taken to keep all sampling equipment, especially the canisters, safe from damage.

Field Duplicates

A field duplicate will be collected for 10% of the samples collected.

Field duplicates are collected by attaching a T-fitting to the end of the tubing prior to the flow controller. A canister with a flow controller is attached to each end of the T-fitting. For sampling, both canister valves are opened and closed simultaneously. Use the procedure described above to collect samples.

Canister Vacuum Check

The canister vacuum check will be performed for 100% of the canisters.

Prior to Sampling

- Attach the pressure gauge provided by the laboratory to the canister inlet.
- Open valve completely.
- Record reading. The canister should show a vacuum of approximately -28 inches of Hg. If the canister has a vacuum of equal to or less than -25.5 inches of Hg (after adjustment for any elevation effects), then:
  - Label the canister with "Insufficient vacuum – No Sample";
  - Set canister aside for return to the laboratory; and
  - Contact project manager and lab coordinator if canister failures affect field work.
- Close valve completely.
- Remove the pressure gauge.

After Sampling

- Attach the pressure gauge provided by the laboratory to the canister inlet.
- Open valve completely.
- Record reading. There should still be a slight vacuum in the canister. If the canister does not show a significant net loss in vacuum after sampling, evaluate and document the problem. If necessary, contact the project manager immediately to determine the value of using another canister to recollect the sample.
- Close valve completely.
- Remove the pressure gauge.

Sample Train Vacuum Leak Check

The sample train leak check will be performed for 100% of the samples collected.

- Assemble the sampling apparatus as shown in **Figure 1**.
- Keep the canister, Ball Valve #1, and Ball Valve #3 in the "off" or "closed" position. Ball Valve #2 should be in the "open" position.
- Attach the 15 mL hand pump to sample train attached where indicated.
- Withdraw air from the sampling apparatus until a vacuum of at least -10 inches of Hg is achieved on the flow controller. Close Ball Valve #2. Observe the induced vacuum for at least five minutes.

- If the change in vacuum over five minutes is equal to or less than -0.5 inches of Hg, the system leak rate is acceptable.
- If the change in vacuum over five minutes is greater than -0.5 inches of Hg, check, tighten or replace the fittings and connections and repeat the leak check.

Tracer Compound Check

All samples will be collected using a tracer compound.

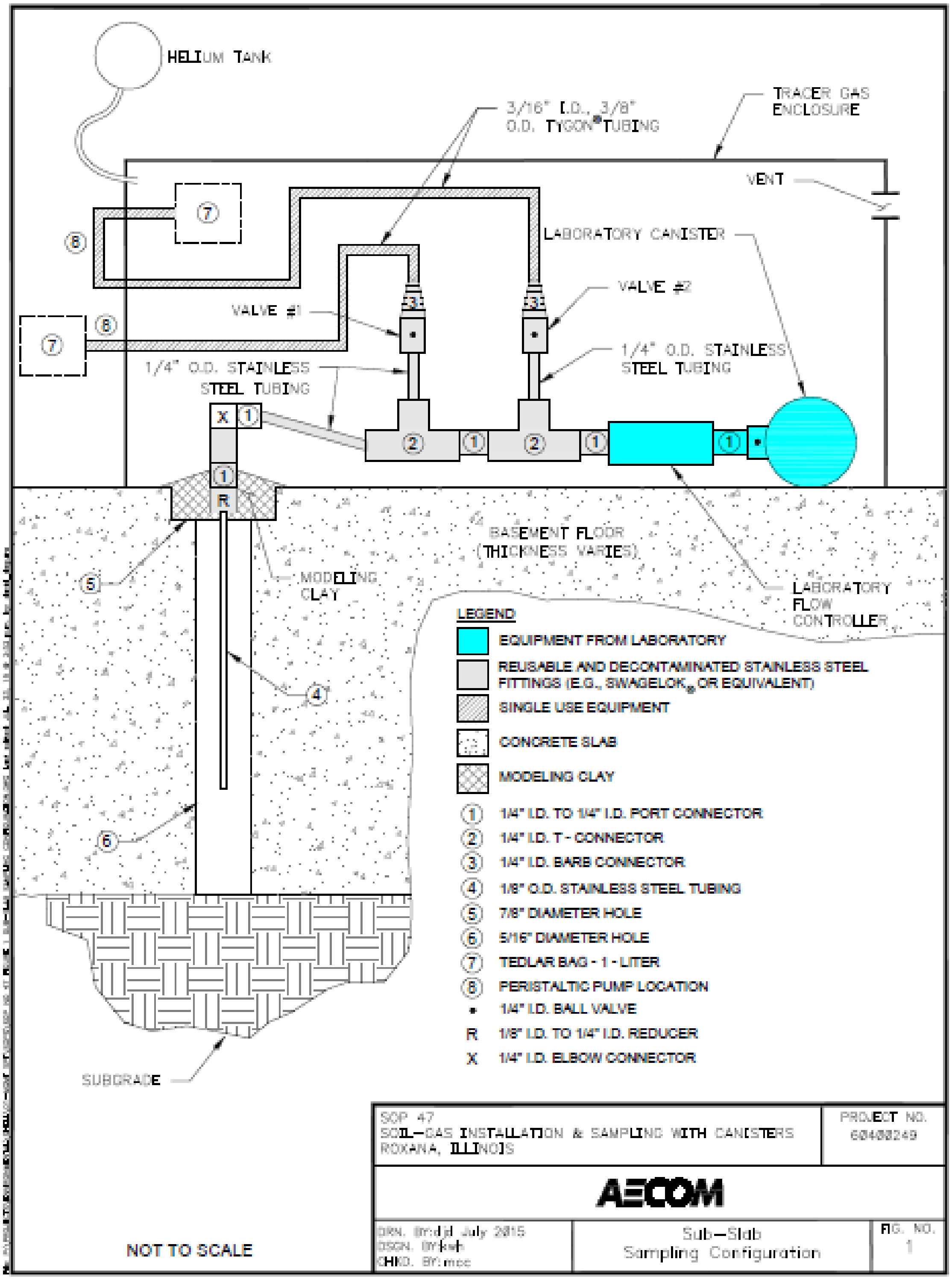
- Tracer gas should be introduced near the SSMP to test the integrity of the probe seal and the above ground connections.
- Collect the 1-Liter Tedlar® sub-slab bag per procedures in Section 5.
- If the concentration of the tracer gas in a sample is <10% of the concentration of the tracer gas in the shroud, the sample is acceptable.
- If the concentration of the tracer gas in the sample is >10% of the concentration of the tracer gas in the shroud, analyze the 1-Liter Tedlar® bag using a landfill gas detector to obtain a direct methane reading. If methane levels are not elevated, tighten or replace the fittings and connections and repeat the leak check.

8. Decontamination

- Designated stainless steel Swagelok® connectors or equivalent will be thoroughly decontaminated using a Liquinox® wash followed by a distilled water rinse.
- Multiple sets of stainless steel Swagelok® connectors or equivalent will be available to sample crews to allow for equipment to be cleaned and dried sufficiently before being reused.
- Do not reuse Tygon® and Teflon® tubing. Tubing will be disposed of after sampling each SSMP. Do not reuse ferrules from compression fittings.

9. Shipping

- Sample information shall be recorded on a chain of custody for the laboratory following procedures outlined in SOP No. 26 Sample Control and Custody Procedures.
- Samples will be shipped to the laboratory following DOT regulations, as outlined in SOP No. 51 Vapor Sampling Classification, Packaging and Shipping.



HELIUM TANK
3/16" I.D., 3/8" O.D. TYGON® TUBING
TRACER GAS ENCLOSURE
VENT
LABORATORY CANISTER
VALVE #1
VALVE #2
1/4" O.D. STAINLESS STEEL TUBING
1/4" O.D. STAINLESS STEEL TUBING
BASEMENT FLOOR (THICKNESS VARIES)
MODELING CLAY
LABORATORY FLOW CONTROLLER
SUBGRADE
LEGEND
EQUIPMENT FROM LABORATORY
REUSABLE AND DECONTAMINATED STAINLESS STEEL FITTINGS (E.G., SWAGELOK® OR EQUIVALENT)
SINGLE USE EQUIPMENT
CONCRETE SLAB
MODELING CLAY
1 1/4" I.D. TO 1/4" I.D. PORT CONNECTOR
2 1/4" I.D. T - CONNECTOR
3 1/4" I.D. BARB CONNECTOR
4 1/8" O.D. STAINLESS STEEL TUBING
5 7/8" DIAMETER HOLE
6 5/16" DIAMETER HOLE
7 TEDLAR BAG - 1 - LITER
8 PERISTALTIC PUMP LOCATION
• 1/4" I.D. BALL VALVE
R 1/8" I.D. TO 1/4" I.D. REDUCER
X 1/4" I.D. ELBOW CONNECTOR
NOT TO SCALE
SOP 47
SOIL-GAS INSTALLATION & SAMPLING WITH CANISTERS
ROXANA, ILLINOIS
PROJECT NO. 60400249
AECOM
DRN. BY:djd July 2015
DSGN. BY:kwh
CHKD. BY:mce
Sub-Slab Sampling Configuration
FIG. NO. 1

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for data and soil vapor sample collection related to the Shell Roxana soil vapor extraction (SVE) remediation system. This SOP is applicable to:

- Collecting data from and sampling Roxana Soil Vapor Extraction (SVE) wells
- Collecting data from and sampling the West Fenceline and Public Works header lines and/or the RTO exhaust stack.

2. Equipment

The following equipment is typically used for SVE well data collection and sampling:

- Crow bars (2) (if needed)
- Extension cord (if needed)
- SVE Data Collection sheets and Toughbook with SVE Monitoring software
- Impact driver (or socket set) with 3/4 and 9/16 sockets (if needed)
- Oil/Water Interface probe
- Isopropyl alcohol
- Dwyer Series 475 Mark III Digital manometer (measuring appropriate range(s))
- Nut driver – 5/16 (if needed)
- Paper towels
- PPE
  - ANSI Class II safety vest
  - Hardhat
  - Nitrile gloves
  - Leather gloves
  - Safety glasses
  - Safety goggles (when working within WRR)
  - Steel-toe boots
  - FRC Clothing (when working within WRR)

- Power inverter (if needed)
- Sump pump (if needed)
- Geotech® peristaltic pump (or equivalent)
- 1- Liter Tedlar® bags
- Traffic barricades (orange cones)
- Tygon® tubing – 3/16” ID x 3/8” OD
- Teflon® tubing – 3/16” ID x 1/4” OD
- Black collection bag (trash bag)

The following equipment is typically used for the West Fenceline and Public Works header line and RTO exhaust stack data collection and sampling:

- Combination wrench 1/2 and 9/16 inch
- Extension cord
- Gast high flow vacuum pump
- Geotech® peristaltic pump
- Manometer(s) (measuring appropriate range(s))
- PPE
    - ANSI Class II safety vest
    - Hardhat
    - Nitrile gloves
    - Safety glasses
    - Safety goggles
    - Steel-toe boots
    - FRC Clothing
- Summa canister
- Pressure gauge
- Regulators (flow controllers)
- Calibrated rotometer (or equivalent)

- Sample train
- Tedlar® bags
- Tygon® tubing – 3/16” ID x 3/8” OD
- Teflon® tubing – 1/8” ID x 1/4” OD
- Black collection bag (trash bag)

3. Procedures for SVE Wells

This section provides step-by-step procedures for data collection and soil vapor sampling of SVE wells. The field data sheet or the appropriate fields in the SVE Monitoring software should be filled out completely with the appropriate observations and data collected during sampling. All applicable components of the Health and Safety Plan, including completion of Job Safety Analysis (JSA) forms, will be followed while performing the activities described in this SOP.

Upon Arrival at Well

1. Position truck between the well to be sampled (work zone) and on-coming traffic, turn on hazard lights.
2. Place traffic cones in front of and behind the truck.
3. Unlock the well vault, remove well vault bolts, use crow bars (if needed) to release vault latch, and pry open vault lid for underground wells or open above ground well vault to access well. Engage safety latch or chain (if present) to secure vault lid in open position. Record position of main SVE valve.
4. If sufficient rain water is present in vault to impede work, use a sump pump to drain the vault.
    - If water in vault has no evidence of sheen water can be pumped to ground surface.
    - If water in vault has evidence of sheen water must be pumped into 5–gallon containers and transferred to polyethylene tank located in rear of work vehicle. Containerized water from wells located within the refinery is transported to Site 9 in WRR for proper management. Containerized water from wells located outside the refinery is transported to Tannery property for proper management.

Sample Collection

1. Connect manometer to sample port and record the vacuum on the SVE well by connecting the appropriate digital manometer (SOP No. 53 Dwyer Digital Manometer) to the sample port of the well and turning the sample port lever to the open position. If the vacuum reading fluctuates, record the highest, lowest, and the most consistent reading.
2. Write the well ID, date, sample time, vacuum, and sampler's initials on the Tedlar® bag.
3. Connect a clean piece of disposable Tygon® tubing to the sample port of the SVE well.
4. Insert Tygon® tubing into the peristaltic pump head.
5. Connect power cord to peristaltic pump and plug into battery, vehicle cigarette lighter, or other available power source (car battery adapter).
6. Inset hard plastic (e.g. Teflon) reducer on end of Tedlar® bag which will later connect to Tygon® tubing.
7. Turn on the peristaltic pump with sample port open to purge Tygon® tubing for approximately 10 seconds.
8. Connect Tedlar® bag to Tygon® tubing.
9. Once the Tedlar® bag is full, close valve on Tedlar® bag, turn peristaltic pump off, close sample port, remove Tygon® tubing from Tedlar® bag and sample port and dispose of tubing.
10. Place Tedlar® bag sample in black collection bag to protect from sunlight while other samples are being collected and transported to on-site screening lab.

Fluid Level Measurement

1. Turn the main SVE valve to its fully closed position, if necessary.
2. Remove the sample plug from the well cap.
3. Turn the interface probe on and lower probe into the SVE well. Record fluid levels and total depth as described in SOP No. 10 Well Gauging Measurements. Additionally, record if the bottom surface of the well is hard or soft. Decontaminate the probe and tape as described in SOP No. 4 Decontamination.

4. Record the condition of the probe and tape upon removal (e.g. clean, visual or olfactory evidence of petroleum hydrocarbon, sludge, foam, silt) and any well defects or maintenance issues.
5. Replace the sample plug into the well cap.
6. Return the main SVE valve to its original position, if closed in Step 1 above.
7. Disengage safety latch and lower vault lid. Replace well vault bolts (if needed) and lock the well vault.
8. Load traffic cones and other equipment and move to next well location.

4. Procedures for the Header Lines and Exhaust Stack

This section provides step-by-step procedures for data collection and soil vapor sampling of the Public Works and West Fenceline Headers located immediately upstream of the VLS units and the RTO Exhaust stack.

4.1. Data/Sample Collection at the Regenerative Thermal Oxidizer (RTO) Unit – PW and WFL Header Lines

1. Connect appropriate manometer to sample port on the header line and record the vacuum (SOP No. 53 Dwyer Digital Manometer). Write the sample ID, date, sample time, vacuum, and sampler's initials on the Tedlar® bag.
2. Connect one end of a clean piece of disposable Tygon® tubing to the header sample port and the other end to the inlet port of the Gast® high flow sample pump.
3. Connect clean section of Tygon® tubing to the outlet port of the Gast® high flow sample pump.
4. Connect power cord to Gast® high flow pump and plug into ac power source, (extension cord with GFI plugged into wall outlet)
5. Inset hard plastic reducer on end of Tedlar® bag which will later connect to Tygon® tubing.
6. Turn on the Gast® high flow pump with sample port open and allow pump to run for approximately 10 seconds to purge the tubing.
7. Connect Tedlar® bag to Tygon® tubing on the outlet port of the Gast® high flow sample pump.
8. Once the Tedlar® bag is full, close valve on Tedlar® bag.

9. Turn Gast® high flow pump off, close sample port, and remove/dispose of Tygon® tubing from Tedlar® bag and sample port.
10. Place Tedlar® bag with sample in black collection bag to protect from sunlight while other samples are being collected and transported to on-site screening lab.

4.2. Summa Canister Sample Collections - PW and WFL Header Lines

Prior to Sampling - PW and WFL Header Lines

1. Remove brass cap from stainless steel canister.
2. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
3. Open valve completely.
4. Record the vacuum reading on the canister tag. The canister should show a vacuum of approximately 28 inches of mercury (Hg). If the canister does not show a vacuum or shows a vacuum of less than 26 inches of Hg, then:
   - Label the canister tag with “Insufficient vacuum – No Sample”;
   - Set canister aside for return to the laboratory; and
   - Contact task manager and lab coordinator if canister failures affect field work.
5. Close valve completely.
6. Remove the pressure gauge.
7. If not immediately using the stainless steel canister for sample, place and tighten brass cap on stainless steel canister.

Sampling - PW and WFL Header Lines

1. Collect a Tedlar® bag sample using steps 1 through 9 from Section 4.1 above.
2. Remove brass cap, attach particulate filter and sample train to the canister using wrenches.
3. Using a clean piece of disposable silicone tubing, connect the hose barb attached to the sample train to the exhaust port on the Gast® pump.
4. Open the sample canister. Allow sample to enter the canister until the vacuum reads approximately between 5 and 10 inches of Hg. **The vacuum gauge should reach less than 10 inches Hg, but should not be allowed to drop below 2 inches of Hg.**
5. Turn off Gast® pump and close valve to the sample port.

6. Close the sample canister valve completely and remove the sample train using wrenches. Replace brass cap onto canister while leaving the particulate filter in place.
7. Close the sample port on the exhaust/header line and properly dispose of any used silicone tubing.

After Sampling - PW and WFL Header Lines

1. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
2. Open valve completely.
3. Record reading. There should still be a vacuum in the stainless steel canister. If the canister does not show a net loss in vacuum after sampling of at least 10 inches Hg, evaluate and document the problem. If necessary, contact the project manager immediately to determine the value of using another stainless steel canister to recollect the sample.
4. Close valve completely.
5. Remove the pressure gauge.
6. Place and tighten brass cap on stainless steel canister.

4.3. Data/Sample Collection at the Regenerative Oxidizer Unit – Exhaust Stack

1. Connect appropriate manometer to sample port on the exhaust stack and record the vacuum (SOP No. 53 Dwyer Digital Manometer). Write the sample ID, date, sample time, vacuum, differential pressure, and sampler's initials on the Tedlar® bag.
2. Connect a clean piece of disposable Tygon® tubing to the sample port of the exhaust stack and insert into peristaltic pump.
3. Inset hard plastic reducer on end of Tedlar® bag which will later connect to Tygon® tubing.
4. Turn on the Geotech® peristaltic pump with sample port open. Allow pump to run for at least 60 seconds to purge the sample line.
5. Use a calibrated rotometer or equivalent to set the speed of the peristaltic pump at approximately 125mL/min.
6. At the beginning of poppet valve switch, connect Tedlar® bag to Tygon® tubing.
7. After 2 cycles of poppet valve switching, close valve on Tedlar® bag,

8. Turn peristaltic pump off, close sample port, and remove/dispose of Tygon® tubing from Tedlar® bag and sample port.

9. Place Tedlar® bag with sample in black collection bag to protect from sunlight while other samples are being collected and transported to on-site screening lab.

4.4. Summa Canister Sample Collection – Exhaust Stack

<u>*Prior to Sampling - Exhaust Stack*</u>

1. Remove brass cap from stainless steel canister.
2. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
3. Open valve completely.
4. Record reading on the canister tag. The canister should show a vacuum of approximately 28 inches of mercury (Hg). If the canister does not show a vacuum or shows a vacuum of less than 26 inches of Hg, then:
   - Label the canister tag with "Insufficient vacuum – No Sample";
   - Set canister aside for return to the laboratory; and
   - Contact task manager and lab coordinator if canister failures affect field work.
5. Close valve completely.
6. Remove the pressure gauge.
7. If not immediately using the stainless steel canister for sample, place and tighten brass cap on stainless steel canister.

<u>*Sampling - Exhaust Stack*</u>

1. Collect a Tedlar® bag sample using steps 1 through 7 from Section 4.3 above.
2. Remove brass cap, attach particulate filter and sample train to the canister using wrenches.
3. Using a clean piece of disposable silicone tubing, connect the hose barb attached to the sample train to the sample tubing on the peristaltic pump.
4. At the beginning of the poppet valve switch, open the sample canister. Allow sample to enter the canister though 2 cycles of poppet valve switching and the vacuum reads approximately between 5 and 10 inches of Hg. **The vacuum gauge should reach less than 10 inches Hg, but should not be allowed to drop below 2 inches of Hg.**

5. Close the sample canister valve completely and remove the sample train using wrenches.
6. Close the sample port on the exhaust line and properly dispose of any used silicone tubing.

After Sampling - Exhaust Stack

1. Attach the pressure gauge provided by the laboratory to the stainless steel canister inlet.
2. Open valve completely.
3. Record reading. There should still be a vacuum in the stainless steel canister. If the canister does not show a net loss in vacuum after sampling of at least 10 inches Hg, evaluate and document the problem. If necessary, contact the project manager immediately to determine the value of using another stainless steel canister to recollect the sample.
4. Close valve completely.
5. Remove the pressure gauge.
6. Place and tighten brass cap on stainless steel canister.

5. *Sample Screening, Classification, Packaging and Shipping*

Refer to SOP No. 51 Vapor Sample Classification, Packaging and Shipping for information related to packing and shipping samples to the laboratory for analysis, if necessary. Refer to SOP No. 52 Soil Vapor Field Laboratory Screening for information related to on-site field laboratory screening of samples collected.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for the collection of soil vapor samples from vapor monitoring points related to the Shell Roxana Soil Vapor Extraction (SVE) system. This SOP details the necessary procedures to follow so that representative samples are collected. These procedures are applicable to any soil vapor sample collected at vapor monitoring points (VMPs). Important uses of these data include:

- SVE system performance evaluation
- Hydrocarbon plume definition

2. Equipment

The following equipment is typically used for sample collection.

- Dwyer Series 475 Mark III Digital manometer
- 1-Liter Tedlar® bags
- Tygon® tubing - 3/16" ID x 3/8" OD
- Polyethylene tubing – 3/16" ID x 1/4" OD
- Peristaltic pump – 60-350 RPM
- BIOS DC-LITE flow calibrator or calibrated rotometer (0-500 mL/min)
- 60-mL syringe
- Crescent wrench (or equivalent hand tools)
- Black collection bag (trash bag)
- New or dedicated 3-way micro valves for purging and sampling
- SVE System Effectiveness Monitoring Forms or Toughbook® with SVE Monitoring software

3. Procedures

Initial Vacuum/Pressure Measurement

Using a Dwyer Series 475 Mark III digital manometer, the initial vacuum/pressure is measured. Basic manometer operation instructions can be found in SOP No. 53 Dwyer Digital Manometer.

At VMP monitoring locations the positive fitting of the manometer shall be connected to the VMP. The negative fitting on the manometer shall remain open to the atmosphere. The pressure and time, are immediately read and recorded to the nearest hundredth of an inch (or tenth of an inch if using 0-200 manometer) of water column on the SVE System Effectiveness Monitoring Form or Toughbook/Toughpad with SVE Monitoring software. Immediately following the recording of the vacuum/pressure measurement, the VMP shall be closed to the atmosphere.

VMP Purging

After obtaining the initial vacuum/pressure measurements and prior to soil vapor sample collection, each monitoring location shall be purged a predetermined amount based on the volume of the VMP riser and screen. The purge volume shall be equivalent to a minimum of three VMP volumes. The actual purge volume removed shall be recorded on the appropriate field form. If the VMP will not yield the purge volume or if water and/or product are encountered during purging, this observation shall be documented in the appropriate field form. The VMP screen is presumed to be submerged when this condition is encountered. No sample is to be collected and no stabilized reading is required.

To purge VMP monitoring locations, a 60-mL plastic syringe is attached to the VMP to allow the removal of the required purge volume. The syringe plunger shall be drawn back to evacuate a purge volume.

VMP Sampling

Upon completion of VMP purging, soil vapor sample collection using Tedlar® sample media may commence. If water and/or product are encountered during sample collection, this observation shall be documented on the appropriate field form. Note that samples which indicate the presence of water and/or product shall not be analyzed.

Tedlar® Bag Samples

Air samples for on-site screening shall be collected using a Tedlar® bag and a peristaltic pump. For VMP monitoring locations, the inlet of the peristaltic pump tubing is attached to the VMP and the positive pressure (output) side of the peristaltic pump shall be attached to the inlet side of the flow calibrator (or rotometer) using a combination of Tygon® and polyethylene (or equivalent) tubing. Prior to flow-rate adjustment and sample collection, the sample identification, date, time of initial vacuum reading, and initial vacuum/pressure reading (if applicable) shall be clearly marked on the Tedlar® bag.

Flow Rate Adjustment

The rotometer[1] shall be used to adjust the flow rate of the peristaltic pump to allow a flow rate of 200 mL/minute. For VMPs, this adjustment shall be performed by observing the flow rate

[1] Rotometers are checked and calibrated on an annual basis.

indicated by the ball height and adjusting the peristaltic pump to allow a flow rate of 200 mL/minute. *Notes: The initial settings on the pump should be set to allow for the minimum flow possible. It is important to set the flow rate as quickly as possible in order to minimize the amount of additional sample purge.* After setting the sample flow, sample collection shall be immediately initiated. Care shall be taken at this time to avoid unintentionally adjusting (by bumping or handling) the pump speed control.

Sample Collection

After setting the sample flow, the rotometer shall be removed from the sample train and a new, clean, pre-labeled one-liter Tedlar® bag shall be connected to the tubing exiting from the output side of the peristaltic pump. A wire tie shall be used, if necessary, to make the connection between the bag and the pump a leak-proof fitting. Immediately open the valve on the Tedlar® bag approximately one turn. *Please note: The sample time is the same time as the acquisition of the initial vacuum/pressure reading. If a vacuum/pressure reading was not collected, the sample start time shall be documented on the appropriate field form* Based on the flow rate to collect a 1-liter vapor sample, the peristaltic pump shall be allowed approximately five (5) minutes to collect the sample. Total sample collection time, which may exceed five (5) minutes, is dependent on the soil characteristics of the stratum from which the sample is being collected. Upon retrieval of the one-liter sample volume, close the valve on the Tedlar® bag, turn off the peristaltic pump, and close the VMP to the atmosphere. Place the sample bag in a black trash bag or container that will minimize exposure to sunlight. These samples are taken to the field laboratory for screening throughout the day (refer to SOP No. 52 Soil Vapor Field Laboratory Screening).

Duplicate samples shall be collected by repeating the procedure detailed above. The duplicate sample shall be collected immediately after the first sample (original sample) has been collected. Due to the nature of the coarse-adjustment valves that are typically installed on Tedlar® bags, the use of a sample splitter is not recommended and will often result in the collection of unequal sample volumes. Duplicate samples shall be obtained at a frequency of one per every twenty original samples collected.

Post-Sample Collection

Dismantle the sample train, dispose of all non-dedicated lines used for sample collection. New sample lines at each sample location shall be used, except for dedicated equipment. Non-dedicated, reusable equipment shall be decontaminated according to SOP No 4 Decontamination.

Venting

Following sample collection, VMPs are vented (opened to atmosphere) for 15 minutes. This allows for VMP stabilization to occur.

Final (Stabilized) Vacuum/Pressure Measurement

After venting, a final, stabilized vacuum/pressure measurement shall be recorded. A pressure is considered to be stabilized when it does not fluctuate more than 5% in one minute. The manometer shall be allowed a maximum of thirty (30) minutes to stabilize before the vacuum/pressure is recorded. If the manometer does not stabilize within the 30-minute period, the range in which the vacuum/pressure fluctuates over an additional one (1) minute period will be documented on the appropriate field form. The highest reading observed within the observed range will also be recorded on the appropriate field form. (*Please note: If the manometer reading fluctuates between two vacuums, the lowest/weakest vacuum observed will be recorded on the field form. If the manometer reading fluctuates between a vacuum and a pressure, the highest pressure observed will be recorded on the field form. If the manometer reading fluctuates between two pressures, the highest/strongest pressure observed will be recorded on the field form. In all cases, the range in the manometer readings over the additional one-minute period will be recorded on the field form.)*

At VMP monitoring locations, the manometer should be turned on, zeroed, and connected to the well as it was for the initial pressure. Once the pressure is stabilized the reading should be taken. The manometer can then be removed and the VMP can be closed to the atmosphere.

Note: Any monitoring location where water/product is encountered during purge or Tedlar® collection, where the requisite volume cannot be purged, or where the VMP screen is submerged will not have a stabilized pressure collected.

URS
Shell Oil Products US
SVE Effectiveness Monitoring

SVE:____________________________ Date:____________________________

Technician(s):______________________ Time Arrived:______________________

SVE System Running at_____________ in wc

Gauge Reading_______________ in Hg Gauge type/brand_________________

Valve Position Upon Arrival: Open / Closed Position/Notch # :_________
Valve Position Upon Departure: Open / Closed Position/Notch # :_________

Vacuum Reading:_____________ in wc Time:___________ Surface Temp of Flow Meter

If Surging:__________ in wc to___________ in wc ___________°F

Flow Differential (pitot / venturi):___________ in wc Time:___________

If Surging:__________ in wc to___________ in wc
Water in Pitot Tube: Yes / No

Tedlar Bag Sample: Yes / No If Yes: Time Sample Taken:__________________

Well/Vault Integrity
Quantity of Water in Vault:__________________ Short Circuiting: Yes / No

Drain Plug: In / Out / Pulled - Time:___________ Hear Well Surge Yes / No

Condition of Well/Vault/Valves:

SILT and WATER INVESTIGATION

Time:____________ DTW:____________ Bottom: Hard / Soft

TD:_____________

Condition of Tape After Removal:
Circle One: Dilution Valve / Stinger / Bubbler Tube / None in Well

Date Well Last Cleaned:_______________ Header Line Last Cleaned:____________________

AIR ANALYSIS

FID TVA 1000 4-Gas Meter

PID ppm FID ppm %O_2 %CO_2 %LEL

Dilution Probe Used: Yes / No If Yes, Dilution Ratio:______________________

1. Purpose and Scope

This document defines the standard protocols for sample classification, packaging and shipping for Shell projects in Hartford and Roxana, Illinois. This SOP is intended to be used together with several other SOPs.

2. Equipment

The following equipment is typically used for sample classification, packaging and shipping:

- Chain of Custody (COC)
- Sample canisters
- Sample labels
- Waterproof pen
- UN-approved shipping box
- Shipping labels
- Packing materials
- Packing tape

3. Procedures

Sample Identification

Samples collected during site activities shall have discrete and site specific sample identification numbers. These sample IDs are necessary to identify and track each of the many samples collected for analysis during the life of a project. In addition, the sample IDs can be used in a database to identify and retrieve the analytical results received from the laboratory.

Each sample is identified by a unique code which indicates the sample location type, sample location number, sample depth, and/or date collected. The sample locations will be numbered sequentially.

An example of the sample identification number codes for a vapor monitoring port collected for field analysis will be: VMP-1-5-090110.

Where "VMP" indicates a Vapor Monitoring Port sample, "1" indicates the site location number, "5" indicates the top of the sample depth interval, "090110" indicates the MMDDYY date the sample was collected.

The sampling locations and sample sequence identifiers will be established prior to field activities for each sample to be collected. On-site personnel will obtain assistance from the Task or Project Manager in defining any special sampling requirements. Other sample identification may be specified by the Task or Project Manager on an individual project basis.

Sample Labeling

Sample labels will be filled out as completely as possible by a designated member of the sampling team prior to beginning field sampling activities each day. The date, time, sampler initials/signature, and the last field of the sample identification number should not be completed until the time of sample collection. All sample labels shall be filled out using waterproof ink. At a minimum, each label shall contain the following information:

- Sampler's company affiliation
- Project/Site location
- Sample identification code
- Date and time of sample collection
- Analyses required
- Canister ID
- Initial and final vacuum readings
- Sampler's signature or initials.

Sample Handling and Shipping

After sample collection, each container will be labeled as described above, and then stored in a fashion which will protect the stems of the stainless steel canisters. A determination will be made prior to sample collection if the samples will be handled as hazardous materials for shipping and transportation purposes. If the samples are to be handled as hazardous material, a trained hazardous material shipper will be required to pack and ship samples.

When shipping samples designated as hazardous material, the sample containers will be placed right side up in a UN approved shipping box with a “This End Up” sticker, a “Cargo Aircraft Only” sticker, and a “Flammable Gas” placard. No more than the specified number of samples will be placed in an individual box for shipment (check regulations prior to packing). If the samples are designated non-hazardous, they do not require a UN approved shipping box or stickers/placards, and there is no limit to the number of canisters shipped in a box.

The box will be taped with a custody seal for delivery to the laboratory. Samples will be hand delivered or shipped by overnight express carrier for delivery to the analytical laboratory. All samples must be shipped for laboratory receipt and analyses within specific holding times. A chain-of-custody (COC) form will accompany each box.

Sample Documentation and Tracking

Field Notes

Documentation of observations and data acquired in the field will be recorded on field sampling sheets, in a bound field logbook and/or in a Toughbook/Toughpad to provide a permanent record of field activities. Refer to SOP No. 8 Field Reporting and Documentation for additional information.

Sample Chain-of-Custody

During field sampling activities, traceability of the sample must be maintained from the time the samples are collected until laboratory data are issued. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. The COC should contain project and sample specific information. Sample labels should be checked against the COC to ensure everything intended for analysis is listed on the COC.

The sampler/shipper will sign the COC form, retain a copy of the COC form, document the method of shipment, and send the original COC form with the samples. Additionally, an electronic copy of the COC should be forwarded to applicable project contacts (e.g., task manager, project chemist, etc.). Refer to SOP No. 26 Sample Control and Custody Procedures for additional information about COCs.

1. Introduction

The purpose of this Standard Operating Procedure (SOP) is to provide a consistent methodology for the screening of soil vapor samples from the Shell projects in Hartford and Roxana, Illinois. Whenever possible, the soil vapor samples collected for the various work tasks will be screened on the same day of collection. If same-day screening is not possible due to time constraints, instrument problems, etc., the samples will be screened within 24-hours of sample collection. This SOP details the necessary procedures to follow in order to ensure that valid total vapor phase hydrocarbons, oxygen, methane and carbon dioxide concentration data is collected and adequately documented. These procedures are applicable to any vapor sample collected at the Roxana site, but are particularly useful for samples collected from vapor monitoring ports (VMPs), soil vapor extraction (SVE) wells, and sub-slab (SS) ports that are located throughout the Village. Important uses of these data include:

- Evaluation of indoor air or sub-slab methane concentrations
- Screening of indoor air or sub-slab petroleum hydrocarbon concentrations
- Evaluation of the performance of the Roxana Soil Vapor Extraction System.
- Evaluation of the performance of the Rand Avenue Remediation System
- Ambient air samples can either be collected and analyzed on-location using real-time instrumentation, or collected in Tedlar™ sample media and analyzed at a dedicated sample screening station.

2. Equipment

The following materials are typically used to perform sample screening, either on-site or at a dedicated sample screening station:

- Thermo Scientific TVA-1000 (TVA-1000), RAE Instruments PPbRAE-3000 (PPbRAE), and LANDTEC GEM-2000 (GEM-2000) real-time monitors (or similar);
- Calibration gas cylinders, including;
  - Methane in air at concentrations of 50; 500; 5,000, and 32,500 ppmv
  - Isobutylene in air at concentrations of 10, 50 and 1,000 ppmv
  - Hydrocarbon-free air
  - 35 percent by volume concentration CO2
- Regulators for calibration gas cylinders

- SKC sorbent tubes (part # 226-09) used for methane determination
- ¼-inch O.D. Teflon™ or Tygon™ tubing cut to length
- 10-to-1 dilution probe (Thermo Environmental Instruments Part #CR010MR)
- Disposable 3-way plastic valves used to switch the sample between methane and total hydrocarbon analyses.

3. Procedure

The following instruments will be used to screen soil vapor samples:

- TVA-1000 or performance equivalent for volatile organic compounds (VOCs) and methane by flame ionization detector (FID) and for VOCs by photoionization detector (PID)
- PPbRAE or performance equivalent for VOCs by PID for low-concentration samples
- LANDTEC GEM-2000 or performance equivalent for methane, lower explosive limit (LEL), oxygen and carbon dioxide.

Immediately prior to use, each instrument will undergo a calibration check. In the event that instrument accuracy is not within 15-percent of the designated calibration check standard concentration, the instrument will be recalibrated. Field personnel will follow applicable instrument operation SOP's and/or manufacturer's recommended procedures for the calibration and operation of the instruments. Calibration data will be documented on the appropriate calibration forms for each instrument.

Calibration Procedures Applicable to All Field Screening Analyses

Instruments will be calibrated in accordance with applicable SOPs and/or manufacturers recommended procedures immediately prior to sample screening. If the screening instruments are to be used throughout the work day, a mid-day and end-day calibration check will be performed. Further, the TVA-1000 instrument detectors and associated dilution probe will be bump checked (1-point accuracy check) approximately every two hours in order to document instrument stability. In the event that a bump check indicates a deviation greater than ± 15percent from the designated bump-gas concentration, a full instrument calibration will be performed. Due to negligible (<5-percent) instrument drift throughout the day, the GEM-2000 and PPbRAE will not undergo bi-hourly bump checks. Instead, if the GEM-2000 is used throughout the work day, calibration accuracy checks will be conducted at approximately midday, and again at the conclusion of the sample event.

As stated above, calibration of the GEM-2000, TVA-1000, and PPbRAE will be performed in accordance with applicable SOPs and/or manufacturer recommended procedures. However, the wide range of petroleum hydrocarbons and methane concentrations present at the site (i.e., greater than four orders-of magnitude) may be outside of the linear range of the TVA-1000 FID. To meet a primary data quality objective of the project (i.e., to quickly and accurately determine whether a potentially explosive condition is present at a sampling location), the FID calibration will be based on a calibration standard that is approximately 10% of the LEL for methane (5,000 ppmv). However, additional QC procedures will be implemented to ensure quality data for both hydrocarbon and methane concentrations.

The linearity of instrument response will be verified by using 50 ppmv, 500-ppmv methane standards. If significant non-linear response (i.e., greater than 15% relative root mean square error) is observed, a nonlinear calibration curve will be developed. The relative response factor for isobutylene (which is used here as a surrogate for petroleum vapors) will be determined by using a 1,000 ppmv (nominal) isobutylene calibration standard. (1,000 ppmv is approximately 10% of the LEL for gasoline.)

Calibration shall be considered adequate when check standards are within +/- 15%. If the calibration check standards are outside that range, a second check standard will be run and if the check standard fails again, the instrument will be recalibrated and data obtained since the last check standard was successfully run will be flagged as estimated values.

Screening of Concentrated Samples Utilizing a Dilution Probe

Because samples will need to be analyzed which are above the measurement range of the FID or which may not have sufficient oxygen content to analyze reliably, dilution of some samples will be required prior to screening. The 10:1 dilution probe will be calibrated using the 32,500 ppmv methane standard. Calibration of the dilution probe is considered complete when the FID response to this standard is within ± 15-percent of 3,250 ppmv.

The critical orifice in the dilution probe is density-dependent. As it will be calibrated using a 3.25% methane standard that has a density of 98.6% that of air, samples that have a density significantly different from that will be subject to some level of deterministic error. Samples that have extremely high hydrocarbon or methane concentrations have the potential to have significantly varying densities, which can introduce significant error when the screening relies on the dilution probe. For example, error in excess of 10% will be present at concentrations of methane above 40% (if significant concentrations of petroleum hydrocarbons are not present).

Because the average density of petroleum hydrocarbon vapors is variable, the error is not as readily quantified for elevated concentrations petroleum hydrocarbons. Assuming an average density of 2.5 times that of air (i.e., density equivalent to isopentane), error in excess of 10% will be present at concentrations of petroleum hydrocarbon above 17% (if significant concentrations of methane are not present).

The density error associated with methane and heavier hydrocarbons have the potential to offset each other. Because the average density of measured hydrocarbon will not be known, data associated with an estimated error greater than 10% due to the presence of hydrocarbon or methane will be flagged as estimated, rather than corrected for an assumed density. As the concentrations at which significant error is introduced are well above project action levels, estimated concentrations at these ranges are considered adequate to meet project data quality objectives.

Screening of Samples Utilizing a Charcoal Scrubber Tube to Filter Heavy Hydrocarbons

Use of the sorbent tube to screen out hydrocarbons other than methane affects the function of the FID instrument by lessening the flow of air through the detector. Preliminary testing indicates that a 25% to 30% reduction in instrument response occurs over the linear calibration range of the instrument. To calibrate the instrument for use of the sorbent tube, the 50, 500 and 5,000-ppmv methane standards will be run with the sorbent tube to determine the relative response of the instrument to methane passed through the sorbent tube. The relative response factor (RRF) for each calibration standard will be calculated as:

$$RRF = \frac{FID_{sorb}}{FID_{raw}}$$

Where;

RRF = relative response factor;

FID_{sorb} = Instrument response with sorbent tube; and

FID_{raw} = Instrument response to calibration standard without sorbent tube

The average RRF shall be used as a correction factor for samples analyzed using the sorbent tube. It is not necessary to correct instrument response (other than multiplying the displayed value by 10) when using the 10:1 dilution probe in conjunction with the sorbent tube. When using the dilution probe, the majority (approximately 90-percent) of the sample that is analyzed is actually dilution air that does not pass through the sorbent tube.

4. Sample Screening

Most soil vapor samples collected in Tedlar™ bags will be screened at a fixed location using the instrumentation noted above. The fixed location facilitates the use of the instrumentation, allows for a more stable environment in which to screen the samples, and provides adequate space in which to perform the screening and complete the associated documentation. However, to allow rapid screening of indoor air and sub-slab soil vapor, such samples can be analyzed on site, using the same field instrumentation. The calibration of these instruments, as outlined in Section 3.0, will be performed in such a way that instrument response is most accurate in the concentration range that corresponds to project action levels.

The TVA-1000 has been configured with a switching device (disposable 3-way valve) to allow sample to be passed through an SKC carbon sorbent tube to remove petroleum hydrocarbons (i.e., site data indicate that the remainder will be primarily methane).

Procedures for Sample Screening On Site

- Screen air sample with GEM-2000 landfill gas analyzer. Quickly document methane, LEL, oxygen and carbon dioxide concentrations on the appropriate sample screening data sheet;
- Screen sample with the TVA-1000 PID or PPbRAE PID instrument and quickly document the concentration on the appropriate data sheet; and
- Set the TVA-1000 to sample through the SKC sorbent tube used in conjunction with the FID.

  Calculate the methane concentration as;

  $$C_{meth} = \frac{\text{FID}}{\text{RRF}};$$

  Where

  C_{meth} = methane concentration (ppmv); and

  FID = FID reading (ppmv)

- Switch the TVA-1000 to sample without the sorbent tube. Screen the sample with the TVA-1000 and quickly record the vapor concentration by FID on the appropriate data sheet; and
- The hydrocarbon concentration portion of the FID response should be calculated as;

  $$PHC = C_{raw} - C_{meth};$$

  Where

  PHC = petroleum hydrocarbon concentration (ppmv); and

  C_{raw} = FID reading without sorbent tube (ppmv)

Procedures for Sample Screening at a Dedicated Sample Screening Station

The sampling instrumentation for the dedicated sample screening station has been configured such that the TVA-1000 can be operated with a 10:1 dilution valve, if concentrations are outside the operational range of the FID (i.e., if there is insufficient oxygen to support the FID flame or if the sample is above the linear range of the instrument).

- Open the valve on the Tedlar™ bag sample approximately one turn and attach to the inlet of the GEM-2000 landfill gas analyzer. Quickly document oxygen and carbon dioxide concentrations on the appropriate sample screening data sheet;
- Immediately connect the sample bag to the PPbRAE PID instrument and quickly document the concentration on the appropriate data sheet. If the instrument registers over range, the VOC concentration by PID will be completed using the TVA-1000 PID;
- If the oxygen concentration in the sample is less than approximately 16-percent, configure the TVA-1000 for use with a 10-to-1 dilution probe. The dilution probe will allow for the sample to be screened by FID without flameout associated with low oxygen concentration samples. If the oxygen concentration is below 16 percent in a sample but a flameout does not occur on the TVA-1000, it should be screened without the 10-to-1 dilution probe. The dilution probe must be separately calibrated and should be used for sample screening by FID only;
- Set the TVA-1000 to sample through the SKC sorbent tube. Record the reading as the methane concentration. If the 10-to-1 dilution probe is used, the displayed concentration (FID) must be multiplied by 10;
- Switch the TVA-1000 to sample without the sorbent tube. Immediately connect the sample bag to the TVA-1000 probe inlet and quickly record the vapor concentration by FID on the appropriate data sheet. If the 10-to-1 dilution probe is used, the displayed concentration (FID) must be multiplied by 10; and
- The hydrocarbon (HC) concentration portion of the FID response should be calculated as:

$$HC = C_{raw} - C_{meth}.$$

Procedures Applicable to All Sample Screening

Because concentrations of hydrocarbons in some samples are elevated, the carbon in the sorbent tube can be saturated with hydrocarbon relatively quickly. If possible, use historical data to screen samples from low hydrocarbon concentration to high hydrocarbon concentration to avoid sorbent tube saturation. Therefore, the following protocols are in place to assure quality data:

- The sorbent tube will be replaced at least every 10 samples;
- The sorbent tube will also be replaced, if breakthrough is observed (readily apparent) or if concentrations do not go to zero after sample is removed from analyzer inlet; and Associated sample lines (Teflon™ or Tygon™ tubing), valves, etc. will be replaced if concentrations do not return to zero after sample is removed from analyzer inlet.

5. Conclusion

The screening of soil gas samples must be conducted in an organized and precise manner. The resultant data will be valid only if proper procedure and associated QA/QC is followed. It is imperative that personnel conducting the sample screening strictly adhere to the protocol detailed above. Because the samples are collected in 1-liter bags, the samples must be removed from the instrument inlets as soon as a stable reading can be documented. Failure to do so will result in an inadequate amount of sample volume to complete all the screening parameters. Larger bags cannot be used due to time constraints during sample collection.

1. Introduction to the Dwyer Digital Manometer

The Dwyer Series 475 Mark III Digital Manometer is used by personnel in the field to measure vacuum/pressure at wells throughout the Shell projects in Hartford and Roxana, Illinois. Personnel responsible for using a manometer are required to read the manufacturer's instruction manual and be trained in the operation of the instrument.

2. Zeroing the Manometer

The manometer is zeroed before each measurement. This is done by either depressing the "zero" button located on the front of the manometer, or adjusting the knob ("zero adjust knob") on the top of the manometer (depending on which model is being used) while both positive and negative connections are open to the atmosphere. The "zero" button will automatically zero the instrument. The knob must be turned either clockwise (more positive) or counterclockwise (more negative) depending upon whether the manometer is reading positive or negative.

3. Vacuum / Pressure Measurement

The manometer shall be set on the "inches of water column" unit setting which can be done by depressing the "E/M" button and scrolling until "in/H2O" is found.

The positive fitting of the manometer shall be connected to the appropriate vacuum measurement fitting located on the well. The negative fitting on the manometer shall remain open to the atmosphere. The vacuum/pressure is immediately read and recorded to the nearest hundredth of an inch (or tenth of an inch if using 0-200 manometer) of water. The manometer can then be removed from the vacuum measurement fitting.

4. Maintenance and Calibration

If the "low bat" indicator is lit on the manometer display, the battery needs to be replaced. A weak battery can cause improper operation or inaccurate measurements. The battery is changed by unscrewing the flathead screws located on the bottom of the manometer and removing the battery plate. The 9 volt alkaline battery will slide out and can then be unclipped from the wiring. Install a fresh battery and secure the battery plate. When replacing the cover, be sure the rubber sealing gasket is properly seated in the gasket channel of the endcap. Note the endcap will only fit one way.

In the event that the manometer comes in contact with water or other conditions which cause the display to either not power on, or to read incorrectly, the manometer should be sent back to the manufacturer for calibration.

Exceeding the range of the manometer will not damage it or affect calibration if the maximum pressure is not exceeded. Exceeding the maximum pressure will cause permanent damage to the sensor and may rupture the housing and/or cause injury. The maximum pressure is shown on the rear label of the manometer.

Manometers should be sent back to the manufacturer or certified calibration agency every twelve (12) months for calibration following the "Manometer Calibration Schedule." Calibration and maintenance records as well as calibration certificates are maintained on site.