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: Equilon Enterprises LLC d/b/a Shell Oil Products US
County: Madison
Street Address: 900 South Central Ave
Site No. (IEPA): 1191150002
City: Roxana
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 update

IEPA Permit Log No.: B-43R
Date of Last IEPA Letter on Project: October 10, 2017
Log No. of Last IEPA Letter on Project: B-43R-CA-82,88,94,97
Does this submittal include groundwater information: ☐ Yes ☑ No

Date of Submittal: 12/20/19

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

Routine Standard Operating Procedure Revisions; SOPs 5, 11, 12, 14, 17, 28, 29, 42 and 48

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

Cover Letter; Revised SOPs

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.

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: Not Applicable

Operator Signature: [signature] Date: 12/19/19

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 Not Applicable

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 Not Applicable

____________________ Date: __________

Signature of Laboratory Responsible Officer

Mailing Address of Laboratory

Address ____________________

City ____________________

State ______ Zip Code __________

____

Name and Title of Laboratory Responsible Officer

AECOM

AECOM
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St. Louis, MO 63110
USA
aecom.com

December 20, 2019

Mr. Kenneth E. Smith, PE
Manager, Permit Section
Illinois Environmental Protection Agency
Division of Land Pollution Control
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794

Routine Standard Operating Procedure Revisions
SOPs Nos. 5, 11, 12, 14, 17, 28, 29, 42 and 48
Equilon Enterprises LLC dba Shell Oil Products US
Roxana, Illinois
1191150002 - Madison County
ILD080012305
Log B-43R

Dear Mr. Smith:

As part of AECOM Technical Services, Inc.'s (AECOM's) routine quality improvement process, we recently performed a review of some of the Standard Operating Procedures (SOPs) used by field staff performing activities at the investigation sites in Roxana, Illinois. Previously revised versions of SOPs have been submitted to the Illinois Environmental Protection Agency (IEPA), most recently on February 12, 2019. 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 your reference and in accordance with proposed revisions to Sections C.7.5 and C.8.4 of the RCRA Post-Closure Permit Application[1] for the Equilon Enterprises LLC d/b/a Shell Oil Products US (SOPUS) facility at the WRB Refining LP Wood River Refinery.

The SOPs included with this submittal are listed below. The SOPs listed below were revised as indicated.

SOP No	SOP Title	Purpose of Revision
5	Utility Clearance Procedures	Editorial and formatting
11	Groundwater Sampling & Well Wizard Operation	Editorial and formatting
12	Grouting Procedures	Editorial and formatting
14	Headspace Soil Screening	Editorial and formatting
17	Logging	Editorial and formatting
28	Soil Sampling	Editorial and formatting

[1] Class 1* Permit Modification – Section C Revision for SOP Reference (Log No. B-43R-CA-82, CA-88, CA-94 and CA-97) was submitted to IEPA on January 29, 2018. A response to this submittal is still pending as of the date of this submittal.

SOP No	SOP Title	Purpose of Revision
29	Soil Probe Operation	Editorial and formatting
42	Groundwater Profiling	Editorial and formatting
48	SVE Well Data Collection and Sampling	Editorial and formatting; Revision due to use of quick connect fittings

Below is an SOP summary table, which indicates the most recent revision date for each SOP for your reference.

SOP No.	SOP Title	Last Updated
3	Calibration & Maintenance of Field Instruments	9/6/19
4	Decontamination	9/6/19
5	Utility Clearance Procedures	12/9/19
8	Field Reporting and Documentation	9/24/19
10	Well Gauging Measurements	9/13/19
11	Groundwater Sampling & Well Wizard Operation	12/9/19
12	Grouting Procedures	12/9/19
14	Headspace Soil Screening	12/9/19
17	Logging	12/9/19
18	Low Flow Groundwater Purging & Sampling	9/23/19
20	Well Development	8/28/19
21	Monitoring Well Installation	7/24/2015
23	Quality Assurance Samples	9/13/19
24	Soil and Groundwater Sample Identification, Packaging & Shipping	9/13/19
25	Sample Containers, Preservation & Holding Times	9/20/19
26	Sample Control & Custody Procedures	9/20/19
28	Soil Sampling	12/9/19
29	Soil Probe Operation	12/9/19
42	Groundwater Profiling	12/9/19
44R	Soil Vapor Purging & Sampling	9/23/19
46	Indoor Air Sampling with Canisters	7/23/2015
47	Sub-slab Soil Gas Installation & Sampling with Canisters	4/4/2017
48	SVE Well Data Collection and Sampling	12/9/19
49	SVE Effectiveness Monitoring at VMPs	8/28/19
51	Vapor Sample Classification, Packaging & Shipping	9/20/19
52	Soil Vapor Field Laboratory Screening	8/29/19
53	Dwyer Digital Manometer	8/29/19
56	LNAPL Recovery	9/20/19

Copies of this submittal are being sent separately directly to Amy Butler (IEPA, Springfield) and Gina Search (IEPA, Collinsville).

If you have any questions, please contact Wendy Pennington at wendy.pennington@aecom.com (314-802-1196) or Bob Billman at bob.billman@aecom.com (314-802-1122).

Sincerely,

Wendy Pennington
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encl: Revised SOPs 5, 11, 12, 14, 17, 28, 29, 42 and 48
RCRA Corrective Action Certification Form

cc: Amy Butler (IEPA - Springfield, IL)
Gina Search (IEPA - Collinsville, IL)
Kevin Dyer (SOPUS)
Dan Kirk (SOPUS)
Erika Reynolds (Greensfelder Hemker)
Project File
Repositories (Roxana Public Library, website)

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define 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, Joint Utility Locating Information for Excavators (JULIE), 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 AECOM Procedure No. S3AM-331-PR1 Underground Utilities. Please use S3AM-331-PR1 in conjunction with this SOP.

Utility clearances are supposed to be completed/submitted by the company doing the drilling/excavating but they will likely require information from us. We should also confirm, in the field, that utilities have been marked. We should also get locate ticket number and information from subcontractor once it’s available.

2. Other SOPs Referenced in this SOP

- SOP No. 8 – Field Reporting and Documentation

3. 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
- Surveyors, as needed

4. 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, if possible.

As a note, fluorescent paint should not be used when DyeLIF technology is to be used.

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. Additional information can be found in AECOM Procedure No. S3AM-302-PR1 Electrical Safety. Please use S3AM-302-PR1 in conjunction with this SOP.

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) by the owner of the lines.

5. 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. Illinois has their own one-call number Illinois: 1-800-892-0123). Illinois requires the subcontractor actually performing the drilling or excavating to make the initial call (e.g., Illinois), and each drilling subcontractor needs to have their own locating (in this case JULIE) ticket number.

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.
- Re-notification date when activities extend beyond 28 days.

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 of 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.

6. 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. GPR and EM should be performed by a trained and qualified subcontractor.

7. 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.

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 air knife spoils or 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 hand auger spoils or 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.

8. 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.

9. 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,
- Updating the area basemap (AutoCAD) with utility information, if necessary/possible,
- Private utility clearance report from the trained and licensed subcontractor,
- One-call ticket printout documenting the utilities contacted, etc.
- Shell Borehole Clearance form
- AECOM Procedure S3AM-331-PR1 Underground Utilities Checklist
- AECOM Procedure S3AM-302-PR1 Electrical Safety Checklist

Refer to SOP No. 8 Field Reporting and Documentation for further guidance. Documentation should be kept with the project file for future reference.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to describe equipment and field procedures necessary to collect groundwater samples and operate the dedicated Well Wizard pumps for monitoring wells in the Shell Wood River Refinery (WRR) groundwater monitoring program.

2. Other SOPs Referenced in this SOP

- SOP No. 3 – Calibration and Maintenance of Field Instruments
- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 23 – Quality Assurance Samples
- SOP No. 24 – Soil and Groundwater Sample Identification, Packaging and Shipping
- SOP No. 25 – Sample Containers, Preservation and Holding Times
- SOP No. 26 – Sample Control and Custody Procedures

3. Equipment

Equipment typically used during well purging and sampling:

- Well keys
- Air monitoring equipment
- Water level indicator or water/product interface probe with 0.01-foot increments
- Assorted tools (safety knife, screwdriver, etc.)
- Water quality parameter meter(s) with appropriate sensors (Hanna/Lamotte or similar)
- Calibration fluids
- Paper towels or Kimwipes
- Calculator
- Field Logbook
- Waterproof permanent marker or pen
- Field data paperwork
- Panasonic Toughbook/Toughpad, or similar electronic data entry device

- Plastic buckets
- 55-gallon drums or truck-mounted tank for holding purged water
- Plastic sheeting, plastic tote or other means of secondary containment to use during purging and sampling
- Compressor
- Controller for the QED Well Wizard pumps (MP10 or similar)
- Air hoses and connections/splitters
- Appropriate health and safety equipment
- Well construction information sheet
- Appropriate decontamination equipment
- Cooler with ice
- Sample jars and labels. Sample bottles with preservatives added will be obtained from the analytical laboratory. Several extra sample bottles will be obtained in case of breakage or other problems.
- Plastic sheeting, plastic tote or other means of keeping sample bottles off the ground and clean.

4. Sampling Procedures

This section provides the step-by-step procedures for collecting groundwater samples in the field via dedicated Well Wizard pumps. Observations made during groundwater sample collection should be recorded in the field notebook, on field data sheets and/or in the Toughbook/Toughpad in accordance with procedures described in SOP No. 8 Field Reporting and Documentation.

1. Before any purging or sampling begins, all reusable well probes, and other sampling devices shall be decontaminated. Mobile decontamination supplies will be provided so that equipment can be decontaminated in the field (SOP No. 4 Decontamination).
2. Electronic equipment used during sampling includes water quality parameter meter(s), and a water level or water/product interface measurement probe. Before going into the field, the sampler shall verify that these instruments are operating properly. The water quality parameter meter(s) require calibration prior to use every day. Calibration times and readings will be recorded in the field notebook and/or on daily calibration sheets to be kept in the project file. Specific instructions for calibrating the field instruments are

provided in SOP No. 3 Calibration and Maintenance of Field Instruments and the instrument manuals.

3. Before well purging begins, the following procedures will be performed at each well:
   - The condition of the outer well casing, concrete well pad, protective posts (if present), and any unusual conditions of the area around the well will be noted on the field sheets and/or in the Toughbook/Toughpad.
   - The presence of a working lock and its condition (e.g., locked) will be verified.
   - Clean plastic sheeting or other form of secondary containment for purgewater collection will be placed around the well.
   - The well will be opened.
   - Appropriate readings will be taken in the breathing zone with a flame ionization detector (FID) or photoionization detector (PID) according to the Health and Safety Plan. The reading will be recorded on the field sheets and/or in the Toughbook/Toughpad.
   - The condition of the inner well cap, tubing connections, and casing will also be noted.
4. Groundwater elevations will be measured to the nearest 1/100 foot at each monitoring well using an electronic water level or interface probe. The groundwater measurements, screened intervals, and total monitoring well depth will be recorded on the field data sheet and/or in the Toughbook/Toughpad. A detailed description of monitoring well gauging activities, including well head vapor readings, is provided in SOP No. 10 Well Gauging Measurements.
5. The presence of nonaqueous-phase liquids (NAPL), dense or light, will be determined using an oil-water interface probe and confirmed by observation on the probe or via clear bailer. If NAPL is identified, its thickness will be measured. The presence of light or dense NAPLs will preclude sampling of the groundwater itself. Note it, close the well and continue to the next well.
6. Following measurement of the static water levels, the monitoring wells will be purged of at least three (3) well volumes. The well purge volume is calculated with one of the following equations:

If a packer is present to isolate the water column around the screened interval:

[(<u>TD of well</u>) – (<u>bottom of packer</u>)] x (<u>ft to gal conversion</u>[1]) x <u>3</u> = __________ gallons
(ft btoc) (ft btoc) (see footnote) # Vols Calculated Purge Volume

If no packer is present and the full water column height is to be considered:

[(<u>TD of well</u>) – (<u>WL</u>)] x (<u>ft to gal conversion</u>[1]) x <u>3</u> = __________ gallons
(ft btoc) (ft btoc) (see footnote) # Vols Calculated Purge Volume

If work is being performed at a group of wells, perform this calculation for all wells in the group prior to proceeding to the next step.

7. Set up the compressor and connections as follows to maximize groundwater flow and minimize sampling time:

   a. If a packer is present in the well, attached the pressure gauge (black hose with gauge attached) to the smaller quick-connect fitting at the well head. If no packer is present, skip this step. Attach one end of the air hose to the pressure gauge hose, if present, or the larger quick-connect fitting at the well head. If only one well is being sampled, use the vented air hose, with the vent at the well head. If multiple wells are being sampled at a time, do not use the vented air hose for either well.

   b. Attach the other end of the air hose to the "out" connection of the control box. If multiple wells are being sampled at a time, connect the "+" splitter to the "out" connection of the control box and connect the air line from each well to the splitter.

      - If you use the splitter to sample multiple wells at a time at a cluster of 4 wells (e.g., P-89A, P-89B, P-89C, P-89D), the sequence is typically as follows but will vary from well cluster to cluster depending on operational packers and purge volume calculations:

         i. Purge "B" and "C" well first. Typically, the volume required to be removed from "A" is twice that to be removed from "C".

         ii. Sample "C" well first.

         iii. Once "C" well is sampled, disconnect the air hose from the "C" well and move to "D" well

iv. Begin purging “D” well.

v. Sample “D” well.

vi. Once “D” well is sampled, disconnect the air hose from the “A” well and move to “A” well.

vii. Begin purging “B” well.

viii. Sample “A” well.

ix. Once “D” well is sampled, disconnect both ends of the air hose connected to “D” well.

x. Sample “B” well.

- Typically, using the splitter to sample multiple wells at a time can make for fast paced work. Make sure to keep watch of the 5-gallon buckets used to collect/measure purged water to prevent overflow.

8. Verify the compressor has enough gasoline in its tank to perform the sampling to be done. Connect the compressor air hose to the “in” connection of the control box.
9. Verify the compression ring in the open end of the elbow joint for the tubing at the well head is in good condition. Replace if necessary.
10. Place the elbow joint and accompanying rigid tubing to the water tubing at the well head and tighten the fitting for a secure fit.
11. Place secondary containment (shallow totes or plastic sheeting) on the ground and place the 5-gallons buckets to collect the purged water within the secondary containment.
12. Prepare the sample bottles and labels for each sample to be collected.
13. Start the compressor, turn the control box on (MP-10 or similar), and begin purging the well(s).
14. Purging will continue until the required volume of water has been removed (minimum 3 well volumes). If the well is pumped dry during purging, consult the Task Manager.
15. Once the appropriate amount of water has been purged from the well, collect a sample for groundwater quality parameters:

[1] For a 1-inch diameter well, use 0.0408 gal/ft; For a 1.5-inch diameter well, use 0.0918 gal/ft; For a 2-inch diameter well, use 0.163 gal/ft; For a 4-inch diameter well, use 0.652 gal/ft; For a 6-inch diameter well, use 1.468 gal/ft.

- Rinse the sample cup with distilled water and fill with sample water.
- Immerse the probes in the sample and swirl gently, keeping the probes in the sample until the display stops flashing or readings have generally stabilized.
- Record the water quality parameters of the sample.
- Repeat previous steps if additional readings are to be collected.
- When finished, decontaminate the sample cup and sonde as described in SOP No. 4 Decontamination.

16. Samples for chemical analysis will be collected within 24 hours after purging is completed. For quickly recovering wells, a sample may be collected immediately after purging is completed.

    The following sampling procedure is to be used:

    a) Identification labels for sample bottles will be filled out for each well.
    b) Bottles will be kept clean and off the ground using plastic sheeting, plastic tote or similar.
    c) If collecting a sample for VOC analysis, attempt to obtain the ideal flow rate of 200-300 mL/minute. VOC sample vials should be completely filled so the water forms a convex meniscus at the top, then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles in the vial which indicate air space. If air bubbles are observed in the sample vial, repeat the procedure until no air bubbles appear (reattempting zero headspace within a sample vial may be performed up to 3 times prior to a new sample vial being required).
    d) After VOC sample bottles are filled, sample bottles for additional analysis should be filled in the order given below:
        - Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
        - Semivolatiles organic compounds
        - Petroleum hydrocarbons
        - Total metals
        - Any filtered analytes (use in-line filters if possible) – about 100-1000 mL should be purged through the filter prior to sample collection.

e) Fill bottles for metals and general minerals almost full.

f) Time of sampling will be recorded in the field book, Toughbook/Toughpad and/or on the groundwater sampling data sheet.

g) Replace "L" tubing within well

h) The well cap will be replaced and well locked.

i) Field documentation will be completed, including the chain-of-custody (SOP No. 26 Sample Control and Custody Procedures).

j) Place the sample containers on ice in a cooler to maintain the samples at approximately 4°C as described in SOP No. 25 Sample Containers, Preservation and Holding Times.

k) 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.

l) Decontaminate the sample equipment as summarized below and described in detail in SOP No. 4 Decontamination.

m) If a field sampling data sheet for groundwater samples will be completed with information from each sampling location, the data sheet will be completely filled in. If items on the sheet do not apply to a specific location, the item will be labeled as not applicable (NA).

n) Field notes shall be kept in a bound field book and/or the Toughbook/Toughpad. Refer to SOP No. 8 Field Reporting and Documentation for additional information.

17. Once purging and sampling is completed, either turn off the compressor, or move the air hose connection to the next well to be sampled (refer to **Step 7** above for clarification).

The well sampling order will be dependent on expected levels of contamination in each well, if known, and will be determined prior to sampling. Sampling will typically progress from lesser contaminated wells to more contaminated wells. Quality assurance/quality control (QA/QC) samples will be collected during groundwater sampling (SOP No. 23 Quality Assurance Samples).

5. Decontamination

Decontamination of any reusable field/sampling equipment will be performed as described in SOP No. 4 Decontamination.

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. Other SOPs Referenced in this SOP

- SOP No. 8 – Field Reporting and Documentation

3. 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 project/task Health and Safety Plan (HASP)
- Log book and/or boring log sheets
- Drums or other suitable container for mixing of grout

4. 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 allowable grouting compound should be confirmed with the regulatory agency or permit, if applicable.

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 down 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.

5. 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

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure for preforming field headspace screenings. 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. Other SOPs Referenced within this SOP

None.

3. Equipment

The following equipment is typically required.

- Resealable zipper bag, or glass jars with plastic lids.
- Photoionization detector (PID)
- Permanent Marker
- Watch (or similar to keep time)

4. Procedure

The following general procedure is to be followed:

1. Obtain approximately 1/2 qt of soil and place in clean resealable zipper bag or glass jar with plastic lid. Immediately seal the zipper bag or jar. Record the boring location and sample depth on the bag or jar. **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/shaking the jar, 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 sample 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 or jar headspace by opening a space in the 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.
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

The purpose of this Standard Operating Procedure (SOP) is to define 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. Other SOPs Referenced within this SOP

- SOP No. 8 – Field Reporting and Documentation

3. 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 pen and/or permanent marker
7. Munsell Color Chart
8. Water and clean VOA
9. HCL

4. 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 (using Munsell soil chart when available)

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. See page 9 of 20 for more information on when to use, "some", "trace", or "with".
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.

<u>*Soil Types*</u>

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:

<u>Feel and Smear Tests</u> – 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	Calcareous	Limestone Dolomite
	Siliceous	Conglomerate Sandstone Quartizite Claystone Siltstone Argillite Shale Chert
Metamorphic	Foliated	Slate Phyllite Schist Amphibolite Hornfels 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 describe 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.

5. 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

The purpose of this Standard Operating Procedure (SOP) is to define 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. Other SOPs Referenced within this SOP

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 24 – Soil and Groundwater Sample Identification, Packaging and Shipping
- SOP No. 25 – Sample Containers, Preservation and Holding Times
- SOP No. 26 – Sample Control and Custody Procedures
- SOP No. 38 – Methanol Preservation Sampling (Terracore)

3. Equipment

The following equipment is typically used to collect soil samples:

- Hand Auger (if required to collect sample)
- Labels
- Latex/Nitrile gloves
- Photoionization detector (PID)
- Portable field table
- Stainless steel spoon or scoop, if needed
- Stainless steel bowl, if needed
- Resealable Zipper bags, if needed
- Sample containers
- Decontamination equipment
- Plastic Sheeting, if necessary
- Field data sheets/bound field logbook
- Health & Safety equipment

- Cooler with ice.

4. 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. Secure label with clear tape, unless a waterproof/weatherproof label is use. If a tare weight has been recorded by the laboratory on the container, do not use clear tape to secure label. 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 or equivalent (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/zipper 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 4ºC as described in SOP No. 25 Sample Container, Preservation and Holding Times.

J. Begin chain-of-custody procedures as described 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 (refer to SOP No. 8 Field Reporting and Documentation)

5. Possible Soil Sample Collection Methods

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

1. *Objective*

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure 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. *Other SOPs Referenced within this SOP*

- SOP No. 4 – Decontamination
- SOP No. 5 – Utility Clearance Procedures
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 12 – Grouting Procedures
- SOP No. 17 – Logging
- SOP No. 28 – Soil Sampling

3. *Equipment*

The following equipment is typically used:

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

- Field logbook
- Water proof or permanent ink pen

4. Procedure

The general procedure for using the Geoprobe® equipment for sampling is as follows. Prior to sampling crews will begin monitoring breathing zone according to requirements in the project Health and Safety Plan (HASP). The specific soil probe operation procedures may vary slightly based on individual drilling subcontractors' procedures for soil probe operation.

A. Locate boring using facility drawings and/or site base map to check utilities. Refer to SOP No. 5 Utility Clearance Procedures.

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

C. Remove probe/inner rods and retrieve acetate liner. Visually log and classify the soil (SOP No. 17 Logging), select sample 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.

D. Decon the sampler

E. Replace sampler acetate liner with a new/clean liner.

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

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

H. Record total depth.

I. Retrieve probe rods.

J. 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 or SOP No.12 Grouting Procedures).

K. Place survey stake, pin flag, or similar at boring location.

L. Record data collected on boring log, or other field paperwork, and in log book (refer to SOP No 8. Field Reporting and Documentation).

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

N. Perform equipment blank (EB) as needed

5. Decontamination

Refer to the HASP for exclusion zone setup and personnel decontamination guidance; refer to SOP No. 4 Decontamination for equipment decontamination procedures.

1. *Objective*

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure 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. 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. *Other SOPs Referenced within this SOP*

- SOP No. 3 – Calibration and Maintenance of Field Instruments
- SOP No. 4 – Decontamination
- SOP No. 5 – Utility Clearance Procedures
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 10 – Well Gauging Measurements
- SOP No. 12 – Grouting Procedures
- SOP No. 18 – Low Flow Groundwater Purging and Sampling
- SOP No. 26 - Sample

3. *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)

- Water level indicator and/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 or 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)).

4. 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, and/or on field paper work

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).

D. 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.
(DTB - DTW) = WH (feet); (WH)*(πr^2) * 1gal/0.134cf=x gallons with in screen/rods

E. 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 respectively. When placing the tubing in the rods, 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.[1]

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

G. 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. The diameter of the rods and of the water level/interface probe may preclude the ability to check water levels during purging and sampling activities.

H. 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)

[1] 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.

Q = purge flow rate (liters per minute)

I. 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 YSI Pro DSS (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 YSI Pro DSS 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

J. After the relevant parameters have stabilized or the required purging time has elapsed, the flow-through cell should be disconnected or bypassed for sampling. A new pair of disposable latex or nitrile gloves should be put on immediately before 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).

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 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, the 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 drill rig unit and rods will be decontaminated between profiling holes using a steam pressure washer or similar (SOP No. 4 Decontamination). Decontamination water will be containerized in 55-gallon drums (or similar) that are labeled, sealed, and staged at a predetermined location on-site (refer to the IDW Coordinator for more information).

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. Other SOPs referenced in this SOP

- SOP No. 4 Decontamination
- SOP No. 10 Well Gauging Measurements
- SOP No. 51 Vapor Sample Classification, Packaging and Shipping
- SOP No. 52 Soil Vapor Field Laboratory Screening
- SOP No. 53 Dwyer Digital Manometer

3. Equipment

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

- Pry 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, or adjustable wrench (if needed)
- Oil/Water Interface probe
- Isopropyl alcohol
- Dwyer Series 475 Mark III Digital manometer (measuring appropriate range(s)), or equivalent
- Nut driver – 5/16 (if needed)
- Paper towels
- PPE
    - ANSI Class II safety vest

  - Hardhat
  - Nitrile gloves
  - Cut Resistant gloves
  - Safety glasses
  - Safety goggles (when working within Wood River Refinery (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 (new or decontaminated as outlined in SOP No. 4 Decontamination)
- 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) and collection string

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
- Dwyer Series 475 Mark III Digital manometer (measuring appropriate range(s)), or equivalent
- 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 rotameter (or equivalent)
- Sample train
- 1- Liter Tedlar® bags (new or decontaminated as outlined in SOP No. 4 Decontamination)
- Tygon® tubing – 3/16” ID x 3/8” OD
- Teflon® tubing – 1/8” ID x 1/4” OD
- Black collection bag (trash bag) and collection string

4. 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 (attached) 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, shall 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 available with the truck in use.
2. Place traffic cones in front of and behind the truck. Place wheel chocks around one of the tires of the truck.
3. Unlock the well vault, remove well vault bolts, use pry 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, weight and/or chain (if present) to secure vault lid in open position. Record position of main SVE valve.

4. Use a sump pump to drain rain water from the vault, if present.
   - If water in vault has **NO** evidence of sheen water can be pumped to the surrounding ground/road surface.
   - If water in vault has evidence of sheen water must be pumped into 5–gallon containers 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.

<u>Sample Collection</u>

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 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, or use dedicated tubing if present.
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 shall 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.
10. Place Tedlar® bag sample in black collection bag to minimize exposure to sunlight while other samples are being collected and transported to on-site screening lab.

Fluid Level Measurement

1. If necessary, close the valve a little to completely if the reading is not clear or difficult to obtain.
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. If water in SVE well is splashing and an accurate reading cannot be obtained, reduce well vacuum by partially closing the well valve and collect reading as quickly as possible. 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 adjusted in Step 1 and/or 3 above.
7. Disengage safety latch, weight and/or 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.

5. 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.

5.1. 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, or dedicated tubing if present,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 shall 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 on sample collection string to minimize exposure to sunlight while other samples are being collected and transported to on-site screening lab.

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

Prior to Sampling - PW and WFL Header Lines

1. Attach the vacuum gauge provided by the laboratory to the stainless-steel canister inlet.
2. Open valve completely.
3. Record the vacuum reading on the canister tag. 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.
4. Close valve completely.
5. Remove the vacuum gauge.

Sampling - PW and WFL Header Lines

1. Collect a Tedlar® bag sample using steps 1 through 9 from Section 4.1 above.
2. Thread the sample train to the particulate filter and then quick-connect the setup to the canister.
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. Close valve to sample port and turn off GAST® pump.
6. Close the sample canister valve completely and remove the sample train.
7. Close the sample port on the exhaust/header line..

After Sampling - PW and WFL Header Lines

1. Attach the vacuum gauge provided by the laboratory to the stainless-steel canister inlet using quick connect fittings.
2. Open valve completely.
3. Record reading. There should still be a vacuum in the stainless-steel canister. If the final vacuum reading is not between -10 and -2 inches Hg, contact the task manager or project manager immediately to determine the value of using another stainless steel canister to recollect the sample.
4. Close valve completely.
5. Remove the vacuum gauge.

5.3. 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 the piece of dedicated disposable Tygon® tubing connected to the sample port of the exhaust stack and insert into peristaltic pump.
3. Inset hard plastic reducer on end of Tedlar® bag which shall later connect to Tygon® tubing.

4. Attach pump head to the lower RPM shaft on the Geotech® peristaltic pump. Turn on peristaltic pump with sample port open. Allow pump to run for at least 60 seconds to purge the sample line.
5. Use a calibrated rotameter or equivalent to set the speed of the peristaltic pump at approximately 125mL/min to 140mL/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 on the sample collection string to minimize exposure to sunlight while other samples are being collected and transported to on-site screening lab.

5.4. Summa Canister Sample Collection – Exhaust Stack

Prior to Sampling - Exhaust Stack

1. Attach the vacuum gauge provided by the laboratory to the stainless-steel canister inlet using quick connect fittings.
2. Open valve completely.
3. Record reading on the canister tag. 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.
4. Close valve completely.
5. Remove the vacuum gauge.

Sampling - Exhaust Stack

1. Collect a Tedlar® bag sample using steps 1 through 7 from **Section 5.3** above.
2. Thread the sample train to the particulate filter, which is then threaded to the regulator. Quick-connect the setup to the canister.

3. Using a clean piece of disposable silicone tubing, connect the hose barb attached to the sample train to the sample port on the exhaust stack.
4. 10 seconds after hearing 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. Sample collection should end approximately 10 seconds after two additional poppet valve switches (total sample collection time should be approximately 6 minutes. **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.
6. Close the sample port on the exhaust line.

After Sampling - Exhaust Stack

1. Attach the vacuum gauge provided by the laboratory to the stainless-steel canister inlet using quick connect fittings.
2. Open valve completely.
3. Record reading. There should still be a vacuum in the stainless-steel canister. If the final vacuum reading is not between -10 and -2 inches Hg, contact the task manager or project manager immediately to determine the value of using another stainless steel canister to recollect the sample.
4. Close valve completely.
5. Remove the vacuum gauge.

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.

SVE Monthly Effectiveness

Well ID	Date	Tech	Time Arrived	Valve Position Arrival	% Open	Vacuum (in H2O)	Tedlar Sample Time	DTP	DTW	DTB	Hard/Soft Bottom	Tape Condition	Valve Position Departure	% Open	Time Left	Comments
SVE-3R				Open / Closed									Open / Closed			
SVE-4				Open / Closed									Open / Closed			
SVE-5				Open / Closed									Open / Closed			
SVE-6				Open / Closed									Open / Closed			
SVE-7				Open / Closed									Open / Closed			
SVE-8				Open / Closed									Open / Closed			
SVE-9				Open / Closed									Open / Closed			
SVE-10				Open / Closed									Open / Closed			
SVE 11				Open / Closed									Open / Closed			
SVE-12				Open / Closed									Open / Closed			
SVE-13				Open / Closed									Open / Closed			
SVE-14				Open / Closed									Open / Closed			
SVE-15				Open / Closed									Open / Closed			
SVE-16				Open / Closed									Open / Closed			
SVE-17				Open / Closed									Open / Closed			
SVE-18				Open / Closed									Open / Closed			
SVE-19				Open / Closed									Open / Closed			
SVE-20				Open / Closed									Open / Closed			
SVE-21				Open / Closed									Open / Closed			
SVE-22				Open / Closed									Open / Closed			
SVE-23				Open / Closed									Open / Closed			
SVE-24				Open / Closed									Open / Closed			
SVE-25				Open / Closed									Open / Closed			
SVE-26				Open / Closed									Open / Closed			
SVE-27				Open / Closed									Open / Closed			
SVE-28				Open / Closed									Open / Closed			
SVE-29				Open / Closed									Open / Closed			

SVE Monthly Effectiveness

Well ID	Date	Tech	Time Arrived	Valve Position Arrival	% Open	Vacuum (In H2O)	Tedlar Sample Time	DTP	DTW	DTB	Hard/Soft Bottom	Tape Condition	Valve Position Departure	% Open	Time Left	Comments
SVE-30				Open / Closed									Open / Closed			
SVE-31				Open / Closed									Open / Closed			
SVE-32				Open / Closed									Open / Closed			
SVE-33				Open / Closed									Open / Closed			
SVE-34				Open / Closed									Open / Closed			
SVE-35				Open / Closed									Open / Closed			
SVE-36				Open / Closed									Open / Closed			
SVE-37				Open / Closed									Open / Closed			
SVE-38				Open / Closed									Open / Closed			
SVE-39				Open / Closed									Open / Closed			
SVE-40				Open / Closed									Open / Closed			
SVE-41				Open / Closed									Open / Closed			
SVE-42				Open / Closed									Open / Closed			
SVE-43				Open / Closed									Open / Closed			
SVE-44				Open / Closed									Open / Closed			
SVE-45				Open / Closed									Open / Closed			
SVE-46				Open / Closed									Open / Closed			
SVE-47				Open / Closed									Open / Closed			