SAMPLING AND ANALYSIS PLAN

Spic'n Span Cleaners Cleanup Action

Prepared for: Spic'n Span Cleaners, Inc.

Project No. 060172-003-03 • February 9, 2016 Draft

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Aspect CONSULTING

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Aspect Consulting, LLC

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Introduction

Spic'n Span Cleaners, Inc. is conducting a cleanup action under the Washington State Department of Ecology's (Ecology) Voluntary Cleanup Program. The objective of this work is to obtain an unrestricted No Further Action determination from Ecology. The *Supplemental Data Collection Letter* (Collection Letter, Aspect, 2014), in conjunction with the *Remedial Investigation, Feasibility Study, and Cleanup Action Plan* (RI/FS/CAP: Aspect, 2011) present a summary of environmental data, an evaluation of remedial alternatives, and a description of the proposed cleanup action at the Spic'n Span Cleaners Site (Site), located at 652 South Dearborn Street in Seattle, Washington (Spic'n Span Property).

The RI/FS/CAP identified *in situ* thermal treatment using electric resistance heating (ERH) as the preferred cleanup action for the Site. Ecology concurred with the selected remedy in an opinion letter dated February 25, 2013 (Opinion Letter). The thermal treatment system is being designed by TRS Group, Inc. of Longview, Washington (TRS). Subject to the timing of the required permits, thermal treatment is scheduled to begin in the third quarter of 2016.

The RI/FS/CAP included a confirmation sampling plan for sampling to be conducted during and after ERH operation to evaluate performance of the ERH system and confirm that remedial goals for the system are obtained. In their Opinion Letter on the RI/FS/CAP, Ecology concurred with the proposed confirmation sampling plan. Subsequent data collected at the Site to support design has increased the area of treatment for the ERH system to include portions of the neighboring property, currently used as a parking lot (KeyBank Property), as described in the Collection Letter, and the confirmation sampling program has been expanded accordingly.

This sampling and analysis plan (SAP) provides the updated confirmation sampling plan. It includes procedures for sampling of 'hot' soil and groundwater expected to be encountered during treatment. The draft SAP is being submitted to Ecology for review and approval. The approved SAP will be incorporated into the Engineering Design Report (EDR) being prepared by TRS and Aspect.

Note that additional sampling not described in this SAP will be conducted during ERH system operation to confirm proper system operation and compliance with applicable permits. Those additional sampling procedures will be described in the Operation and Monitoring Plan for the ERH system, which will be prepared after air and sewer discharge permits are obtained.

Soil and Groundwater Performance Sampling During Treatment

Soil samples will be collected two to three times while the system is operational. Aspect will collect confirmation samples at times designated by TRS, which will make such designations based on energy input and recovered vapor concentrations. The first round of soil sampling will likely be conducted when 60 percent to 80 percent of the design energy has been input to the subsurface (after approximately 8 to 12 weeks of operation). It is not expected that all regions of the Site will meet compliance with cleanup levels on this first event. However, the sample results will allow TRS to shut down portions of the Site that are clean and redirect energy to remaining regions that are above cleanup levels. Locations that are above the cleanup level in a particular round will be re-sampled in a subsequent soil sample event(s).

The first round of performance soil samples will be collected near the historically highest measured soil concentrations in each area of the Site. Subsequent performance soil sample locations will be chosen based on the previous results. The final performance soil sampling event will occur just prior to system shutdown. Preliminary soil sample locations (CB-1 through CB-14) are shown on Figure 1.

Soil samples will be collected from four depth intervals at the 14 boring locations (approximately 56 samples), including one sample each from the 0- to 7-foot interval, the 7- to 14-foot interval, the 14- to 21-foot interval, and the 21- to 28-foot interval. Samples from each interval will be selected as follows:

- The location exhibiting the highest contamination based on photoionization detector (PID) screening, if significant levels of volatile organic compounds (VOCs) are detected with the PID; or
- The depth of highest contamination noted in adjacent borings.

Soil samples will be collected using the Hot Soil Sampling Standard Operating Procedure (SOP) provided in Attachment A.

Groundwater samples will be collected near the end of treatment, or when performance soil sample results and ERH operational data indicate that a particular area of the Site is clean. Groundwater samples will be collected from existing wells (MW-1 through MW-9 and VE-1) and from three new wells to be installed during ERH system construction (MW-10, MW-11, and MW-12). Well locations are shown on Figure 2. Groundwater samples will be collected using the Hot Groundwater Sampling SOP provided in Attachment B.

Soil and groundwater samples will be analyzed for:

- VOCs, by Environmental Protection Agency (EPA) Method 8260C (all confirmation borings and monitoring wells); and
- Gasoline-range total petroleum hydrocarbons (TPH) as mineral spirits, by NWTPH-Gx at locations within the historical area of TPH impacts (CB-8 through CB-11, VE-1R, MW-2R, MW-3R and MW-10).

Compliance will be evaluated in accordance with the methods described in Washington Administrative Code (WAC) 173-340-740(7) for soil and WAC 173-340-720(9) for groundwater. In accordance with WAC 173-340-(7)(e) and 173-34, no single sample concentration shall be greater than two times the soil cleanup level, and less than 10 percent of the sample concentrations shall exceed the cleanup level. Site cleanup levels are identified in the Collection Letter. Once soil and groundwater concentrations are in compliance with Site cleanup levels on the Spic'n Span and KeyBank Properties, the ERH system will be shut down and post-treatment confirmation sampling will begin.

Post-Treatment Groundwater and Soil Vapor Confirmation Sampling

After treatment is complete, groundwater monitoring will be implemented on a quarterly basis to evaluate the potential for rebound. Subsurface temperatures will be monitored with dataloggers during the cool-down period (approximately 1 year) until groundwater temperatures stabilize. Quarterly groundwater monitoring will be conducted during the cool-down period and for 1 year afterwards. Groundwater confirmation samples will be collected from existing Site wells (MW-1 through MW-9, and VE-1) and from three new wells (MW-10, MW-11, and MW-12). Monitoring well locations are shown on Figure 2.

Groundwater samples will be analyzed for:

- VOCs, by EPA Method 8260C (all monitoring wells); and
- Gasoline-range TPH as mineral spirits, by NWTPH-Gx, (VE-1R, MW-2R, MW-3R and MW-10).

Three soil vapor samples will also be collected after subsurface temperatures stabilize. Soil vapor sample locations are shown on Figure 2.

Soil vapor samples will be analyzed for:

- VOCs, by EPA Method TO-15; and
- Petroleum fractions by the Massachusetts Department of Environmental Protection (MassDEP) Air-Phase Hydrocarbon (APH) method.

Groundwater data will be compared to Site cleanup levels, and soil vapor data will be compared to Ecology vapor intrusion screening levels for unrestricted use. After soil vapor data and four consecutive quarters of groundwater data (post cool-down) demonstrate compliance on the Spic'n Span and KeyBank Properties, the ERH system components will be decommissioned. As recommended by Ecology in their Opinion Letter, the need for additional actions downgradient of the Spic'n Span and KeyBank Properties will be evaluated based on groundwater data collected after ERH treatment is complete.

References

Aspect Consulting, LLC, 2011, Remedial Investigation, Feasibility Study, and Cleanup Action Plan, Spic'n Span Cleaners, November 16, 2011.

Aspect Consulting, LLC, 2014, Supplemental Data Collection Letter, Spic'n Span Cleaners, November 18, 2014.

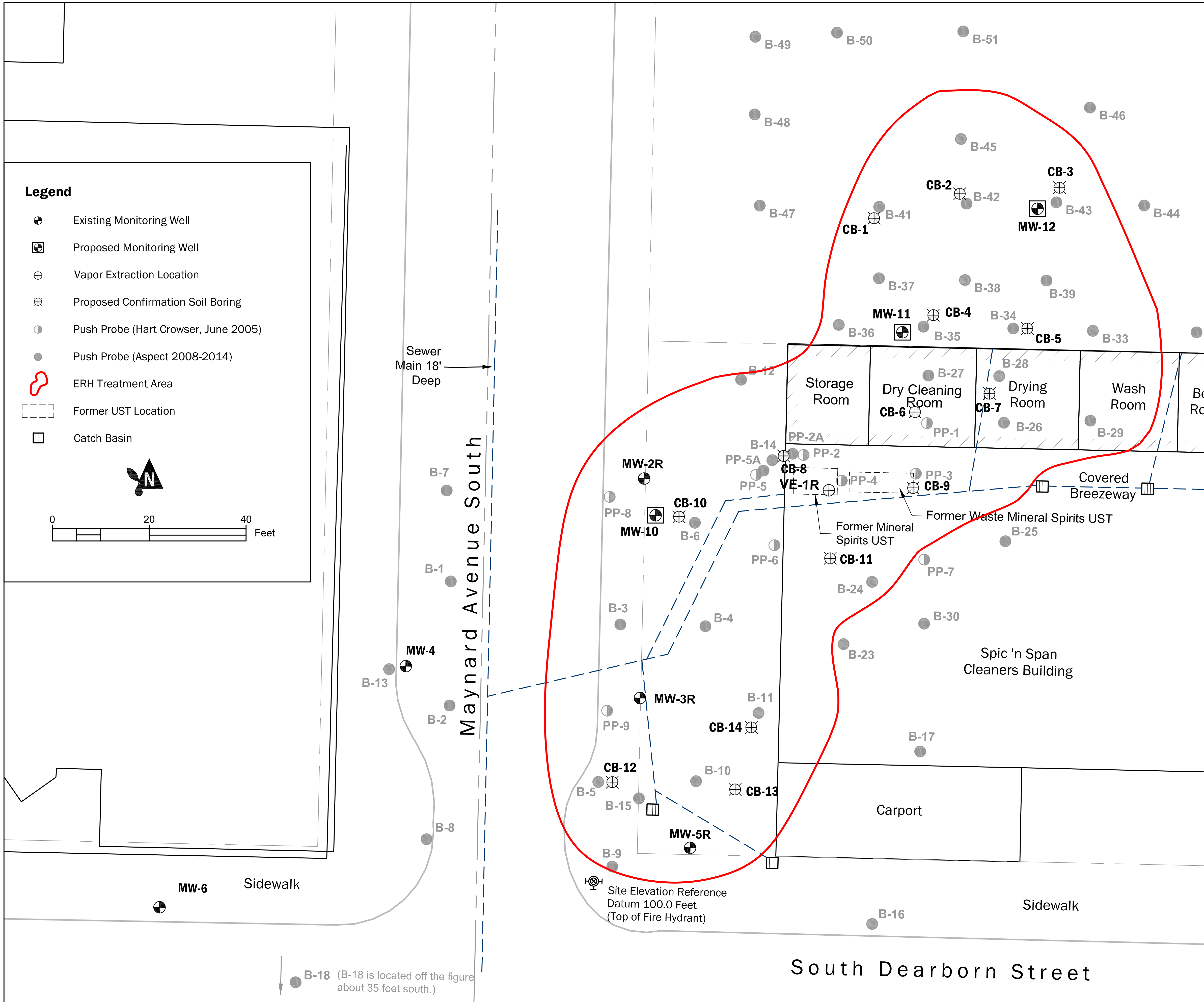
Washington State Department of Ecology, 2013, Opinion on Proposed Remedial Action, Spic N Span Cleaners Inc., 652 South Dearborn Street, Seattle, Washington. February 25, 2013.

Limitations

Work for this project was performed for Spic'n Span Cleaners, Inc, Gerald Steven and Sandra Belle Ostroff, and the Louis and Emma Ostroff Trust Living Trust Agreement (collectively, the Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

FIGURES



ERH Performance Soil Sampling Locations

Sampling and Analysis Plan
Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

JAN-2016	BY: JJP/SCC	FIGURE NO. 1
PROJECT NO. 060172P	REVISED BY: -	

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2016-01 Sampling & Analysis Plan\060172-02 NEW BASE MAP.dwg ERH Performance Sampling || Date Saved: Feb 04, 2016 3:34pm || User: egeissinger

Groundwater Performance, Confirmation and Soil Vapor Sampling Locations

Sampling and Analysis Plan
Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

JAN-2016	BY: JJP/SCC	FIGURE NO. 2
PROJECT NO. 060172P	REVISED BY: -	

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ATTACHMENT A

Hot Soil Sampling Procedures

TRS Accelerating Value	**PROJECT-SPECIFIC PROCEDURE**	**PROCEDURE No: 4.3**

Project-Specific Procedure:

Hot Soil Sampling

Project Specific Guidelines Developed for:

Aspect Consulting, LLC
Spic'n Span Cleaners Cleanup Action

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide a procedure for the safe collection of representative soil samples during, or after, the application of Electrical Resistance Heating (ERH). This procedure specifically addresses sampling of soil that has been heated as a result of the ERH process.

2.0 SCOPE

This SOP serves as a guideline for the collection of soil samples during, or after, the application of ERH. To minimize the risk due to electrical hazards, lockout/tagout (LOTO) procedures must be applied to the ERH power control unit (PCU) throughout the duration of the soil sampling effort. Only authorized persons trained in procedures and requirements described in SOP 1.1 are permitted to conduct LOTO on TRS equipment. Samples collected using this SOP are generally used for evaluating treatment effectiveness, and/or confirming treatment goals have been met.

TRS Group, Inc. (TRS) does not assume responsibility for non-TRS personnel using this SOP. Personnel shall use this procedure in conjunction with site specific sample analysis plans, permit requirements, and applicable health and safety regulations. These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure.

3.0 DEFINITIONS

Authorized employee – Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by the TRS LOTO program.

Competent Person – Any designated employee who is capable of identifying existing and predictable hazards associated with hot soil sampling and who has authorization to take prompt corrective measures to eliminate them.

ERH – Electrical Resistance Heating. ERH is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

LOTO – Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with SOP 1.1, to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

4.0 EQUIPMENT LIST

1) Soil Sampling Field Form and pen (recommend indelible).
2) Drill rig and related equipment. Soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. Geoprobe® Dual Tube Sampling Systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole, especially at depths greater than 20 feet below ground surface (ft bgs).
3) Ice bath for soil samples. An example is a cooler filled with ice. The cooler (or container) must be equipped with an opening at the bottom to allow water from melting ice to drain.

4) Standard cooking thermometer. Calibrated to both 0°C and 100°C.
5) LOTO equipment as described in TRS SOP 1.1.
6) Sample containers, labels, and chain-of-custody forms (as required by the laboratory for the analysis).
7) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses)
8) Hearing protection adequate for sampling equipment decibel level.
9) Latex gloves. Additional option: cotton or leather outer gloves (wear over inner latex gloves).
10) Site specific PPE requirements. Refer to site specific Health and Safety Plan (HASP).
11) Packaging material and shipping labels.

5.0 HOT SOIL SAMPLING PROCEDURES

A soil sampling event begins with the shutdown and application of LOTO to the PCU. This is done to prevent any electrical hazards between the steel drill string and sampling personnel. The vapor recovery system should continue to operate to maintain capture of steam in the subsurface, rather than allowing it to exit through the sample borehole. Interim and final soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. As the probe casing is extracted from the subsurface, it should be considered to be very hot, and handled with proper precaution and personal protective equipment.

5.1 Safety Considerations

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, hot soil, other hot surfaces, or hazardous chemicals. Exposure to these hazardous can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols such as the following restrictions:

- The ERH PCU system must be turned off and LOTO applied during soil sampling activities.
- High temperatures and steam may be encountered when collecting subsurface soil samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Personnel shall be trained on hazards and engineering controls associated with drilling before beginning sampling operations. Potential hazards include rotating equipment, overhead loads, and slips trips and falls.

Refer to the site specific Sampling and Analysis Plans (SAPs) and HASP for site specific requirements and restrictions.

5.2 Hot Soil Sampling Procedures

Sampling shall be completed in order from sample locations having the lowest anticipated concentrations of contaminants of concern (COC) to locations having highest anticipated COC concentrations (i.e.; outside treatment area, treatment area boundary, locations within the source area). The steps outlined below must be followed for both interim and final hot soil sampling.

1) Telephone the TRS PM the day prior to sampling to schedule a remote shutdown. A shutdown period of at least 12 hours is preferred prior to soil sampling.
2) An authorized person shall apply LOTO to the ERH PCU by site specific instructions. Note: this procedure can only be completed by personnel who have been trained and certified by TRS in LOTO procedures.
3) Position drill rig in the area to be sampled and perform a visual check for any safety concerns. Potential concerns include: high voltage lines, uneven terrain, underground utilities, and egress limitations with rig placement.

4) Hand auger, or air knife the first five feet of the boring to clear location for potential buried utilities.

5) Advance the push sampler to the depth required and collect samples. The sample sleeves used must be made of Teflon®, brass, or stainless steel. Sample sleeves made of other materials such as acrylic or other materials can melt and bias sample results.

6) The sample sleeves must be capped immediately and placed into the ice bath to begin the cool down process. Water from melting ice must be allowed to drain, as the sample sleeves should not be submerged at any time.

7) The sample sleeves should be cooled until the soil nears ambient temperature (approximately 20°C or 70°F). A standard cooking thermometer can be inserted through the end cap for temperature monitoring. The sample sleeve may be opened and sampled once near-ambient temperatures have been reached.

8) Soil samples including quality control (QC) samples are collected, labeled, preserved and shipped per the site specific Sampling and Analysis Plan.
9) Plugging/sealing of the soil borehole will be in accordance with Federal, State, and Local regulatory and client requirements.
10) Soil cuttings not consumed in the sampling process will be disposed of according to Federal, State, and Local regulatory and client requirements.

6.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook.

At a minimum, the following information shall be maintained in the sample logbook related to hot soil sampling at ERH project sites:

- date,
- sample identification and corresponding location,
- sample time,
- sample identifications and analysis to be performed,
- chain of custody number,
- shipping information,
- deviations from this SOP, and
- any other information deemed relevant to the sample results.

Copies of chains of custody forms and shipping documentation shall be maintained and kept with the sample log book.

7.0 REFERENCES

TRS Group, Inc., 2009. SOP 1.1, Lockout/Tagout (LOTO), Rev 1. July.

ATTACHMENT B

Hot Groundwater Sampling Procedures

TRS Accelerating Value	**PROJECT-SPECIFIC PROCEDURE**	**PROCEDURE No: 4.4**

Procedure Title:

Hot Groundwater Sampling

Project Specific Guidelines Developed for:

Aspect Consulting, LLC
Spic'n Span Cleaners Cleanup Action

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide uniform procedures for the safe and representative collection of groundwater samples during or after the application of Electrical Resistance Heating (ERH). This procedure specifically addresses sampling of groundwater that has been heated due to the ERH process.

2.0 SCOPE

This SOP serves as a guideline for the collection of groundwater samples during the application of ERH using modified low-flow sampling procedures. This SOP draws information from the United States Environmental Protection Agency's (USEPA's) groundwater issue paper, Low-Flow (minimal drawdown) Ground-Water Sampling Procedure (Puls and Barcelona, 1996) with modifications to accommodate groundwater temperatures that have been drastically elevated as a result of ERH application. To minimize the risk due to electrical hazards, lockout/tagout (LOTO) procedures should be applied to the ERH power control unit (PCU) throughout the duration of the groundwater sampling effort. Only authorized persons trained in procedures and requirements described in TRS internal SOP 1.1 are permitted to conduct LOTO on TRS equipment.

The USEPA guidance document recommends continual monitoring of water levels during the purge and sample process to ensure that minimal drawdown is occurring (Puls and Barcelona, 1996). Due to the safety hazards associated with opening well heads at active ERH project sites, groundwater level measurements (depth to groundwater) will not be collected as part of hot groundwater sampling activities. If the TRS project site has been constructed with pressure transducers to monitor groundwater gradients, readings from the transducers should be monitored as feasible to minimize groundwater drawdown. If previous sampling records or hydrogeologic data is available, this information should be used to develop target flow rates for the groundwater sampling effort.

These procedures assume that dedicated tubing and pumping systems have been established prior to application of electrical energy to the subsurface. If intrusive work is required to complete the sampling efforts, additional safety precautions may be required.

Samples collected using this SOP are generally used for optimizing system performance, evaluating treatment effectiveness, and/or confirming treatment goals have been met. Personnel should use this procedure in conjunction with site specific sample analysis plans and permit requirements. These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, should be documented.

TRS Group, Inc. (TRS) does not assume responsibility for non-TRS personnel using this SOP. Personnel shall use this procedure in conjunction with site specific sample analysis plans, permit requirements, and applicable health and safety regulations. These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure.

3.0 DEFINITIONS

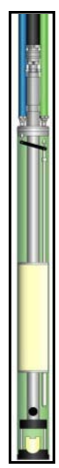
Authorized employee – Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person – Any designated employee who is capable of identifying existing and predictable hazards associated with hot groundwater sampling and who has authorization to take prompt corrective measures to eliminate them.

ERH – Electrical Resistance Heating. ERH is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

Bladder Pump – Submersible pump with external control unit used for pumping fluids at greater depths. The bladder pump consists of an internal flexible bladder that is positioned within a rigid pump body constructed of stainless steel. The inner bladder is equipped with one-way inlet and outlet valves and passively fills with water when the pump is at depth by virtue of hydrostatic pressure. Following the fill cycle, compressed air from a cylinder or compressor at the wellhead is delivered to the pump through tubing and is used to compress the bladder. The applied pressure then causes the flexible bladder to compress and closes the bottom check valve, forcing water from the bladder into the discharge tubing. During a vent cycle, the pressure is released from the drive tubing. The bladder returns to its initial state as water re-enters the pump, while the top check valve prevents water already in the discharge tubing from falling back into the bladder. The pumping sequence consists of repeated fill/compress cycles, using a pneumatic controller positioned at the wellhead.






LOTO – Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with SOP 1.1, to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

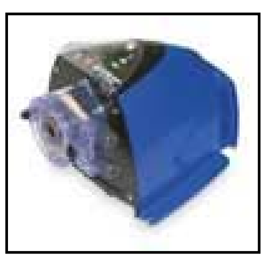
Low-Flow Purging – A USEPA approved purge and sample method used to minimize stress on the formation (minimal drawdown) which results in less mixing of stagnant casing water with formation water. Additional advantages of using low-flow purging methods include the following:

- Samples are more representative of actual contaminant loading.
- Disturbance at the sampling point is minimal which minimizes sampling artifacts.
- Less operator variability occurs between sampling events.
- Decreased amount of investigation-derived waste (IDW) is produced.
- Need for filtration is reduced.
- Sample consistency is increased.

Flow-rates during low-flow purging/sampling are site-specific, based on hydrology, but are generally in the order of 0.1 to 0.5 L/min. Proper screen location, screen length, well construction and well development techniques may impact the effectiveness of low-flow purging. (Puls and Barcelona, 1996)

Multi-probe and Flow-Through Cell – The flow through cell allows for in-line sampling of water quality parameters with the Multi-probe to determine stabilization for water sampling. At a minimum, groundwater quality parameters include pH, conductivity, temperature, and either dissolved oxygen (DO) or turbidity. Examples of multiprobes used for collecting water quality parameters include the Horiba U-22 and YSI 556 (shown below).

Peristaltic Pump – A positive displacement pump used for pumping fluids. Generally, flexible tubing is fitted inside a circular pump casing. A rotor with a number of "rollers", "shoes" or "wipers" attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to move through the tube.



Trip Blank – The purpose of trip blanks it to identify any potential contamination of samples during sample handling and shipment. These blanks are prepared in the laboratory by filling a volatile organic analysis (VOA) bottle with distilled/deionized water. Trip blanks shall accompany shipment of empty bottles to the site and shipment of samples back to the laboratory.

VOA Vials – EPA recommended glass sampling containers used to collect liquid samples for laboratory analysis. VOA vials have a nominal volume of 40 mL and are manufactured of clear or amber borosilicate glass. Depending on type of analysis being conducted, the VOA vials may contain small amounts of preservative when shipped from the laboratory. When collecting samples in VOA vials, fill the vial completely full (ensure that a meniscus has formed at the top of the vial before securing the cap) and check that there are no air bubbles in the closed sample. If there is a preservative present, use caution to not overfill the vial.

4.0 EQUIPMENT LIST

The required equipment for groundwater sampling may differ from this SOP based on the requirements set by the local regulatory oversight agency. Typically, the required equipment will be as follows:

1) Groundwater Sampling Field Form pen (recommend indelible).
2) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses)
3) Latex gloves. Additional option: leather or cotton outer gloves should be worn to protect against water having high temperatures (wear over inner latex gloves).
4) Site specific personal protective equipment (PPE) requirements. Refer to site specific HASP.
5) Pump and operating components.
    - Peristaltic pump utilized when the depth to water is 20 feet below ground surface (ft bgs) or less. Dedicated tubing shall be installed prior to ERH application.
    - Dedicated bladder pump with compressed air for depth to groundwater greater than 20 feet. Dedicated pumps shall be installed prior to ERH application.
6) Tubing (should be installed prior to ERH application)
    - Disposable Teflon™ and Silicone tubing (Masterflex™) for use with the peristaltic pump. Silicone tubing should be used only above the ground surface at the pump head in order to

minimize potential for degradation by contaminants. The silicone tubing is then connected to the TeflonTM tubing, which is lowered to depth within the well.

- Dedicated bladder pumps and tubing if using a bladder pump.

7) Power supply (12 volt automotive battery or similar, or portable generator).
8) Cooler with ice.
9) 10-ft length of ¼-inch stainless steel tubing
10) One-ft length of four-inch diameter pipe
11) Tray or container for ice bath.
12) Field water quality measuring equipment w/flow-through cell or similar device for monitoring groundwater parameters (pH, conductivity, ORP, temperature, DO, etc.) and calibration standards.
13) Turbidity meter.
14) Buckets for purge water.
15) Sample containers (with preservative as required by the laboratory analytical method), labels, and chain-of-custody forms (as required by the laboratory for the analysis). Pre-printed labels are generally available from the laboratory if requested in advance.
16) Scissors or tubing cutter (for cutting tubing lengths).
17) Packaging material and shipping labels.
18) LOTO equipment as described in TRS SOP 1.1.

5.0 HOT GROUNDWATER SAMPLING PROCEDURES

Groundwater purging is generally accepted as a required component of groundwater sampling in order to remove non-representative water from the well casing (Puls and Barcelona, 1996). Low-flow purging and sampling techniques will be used to minimize the impact on groundwater chemistry and collect representative samples. This technique also reduces the amount of investigation derived waste (IDW) produced from a well.

5.1 Safety Considerations

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, or hazardous chemicals. Exposure to these hazards can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols, such as the following restrictions:

- At no time will a 110/120 volt extension cord from a line source be used in an energized electrode field. An alternative power source such as a 12 volt automotive battery or portable generator must be used when samples will be collected with electrical energy applied to the subsurface. Typically, ground water sampling is performed while the ERH is offline and locked out.

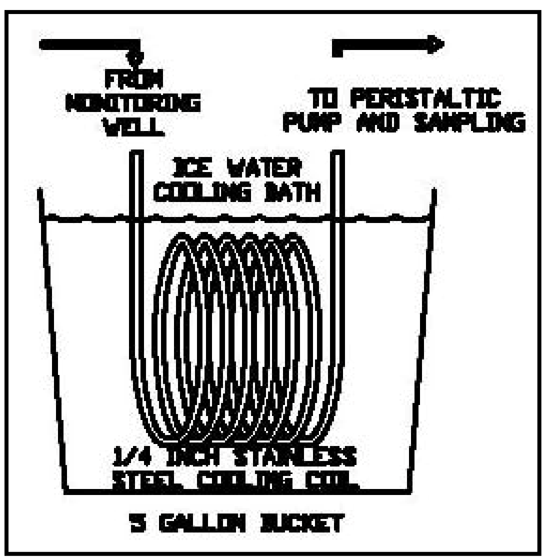
- Extreme temperatures and steam may be encountered when collecting groundwater samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Dedicated tubing and pumping systems shall be established prior to application of electrical energy to the subsurface.
- The ERH PCU system should be turned off and LOTO applied during groundwater sampling activities.
- Refer to the site specific Sampling and Analysis Plans (SAPs) and HASP for site specific requirements and restrictions.

5.2 Ice Bath Construction

Groundwater heated through the ERH process presents both a potential safety hazard and a potential concern for collecting representative samples. If a boiling or near-boiling liquid is collected in a volatile organic analysis (VOA) vial, the formation of air bubbles as the sample cools within the VOA vial renders the sample non-representative. Additionally, hot liquids collected in the VOA vial may result in failure of the VOA septum.

The ice bath is designed to cool the groundwater prior to sampling while limiting the impact on groundwater chemistry and contaminant concentrations. Cooling the groundwater prior to sampling allows for both the safe handling of highly elevated water temperatures and prevents the formation of volatile organic compound (VOC) bubbles in the VOA vial after sample collection.

Prior to initial sampling, a cooling coil shall be constructed by wrapping a 10-ft length of ¼-inch stainless steel tubing 6 full turns around a 4-inch diameter pipe. The ends of the tubing shall be fashioned such that both ends of the tubing extend upward, as shown in the figure below.



5.3 Pumps

Peristaltic pumps are used for purging and sampling wells that have a depth to water of 20-ft bgs or less. A dedicated 1/4-inch Teflon™ sample tube will be set within the well and a ¼-inch sample valve will be installed at the surface for sampling with a peristaltic pump. Installation of the sample valve is mandatory in order to prevent steam from escaping from the well during ERH application.

Pneumatically operated bladder pumps will be used for purging and sampling wells that with depth to water greater than 20 feet. The well head completion will be modified to allow for two tubes to pass independently through the sealed well head assembly. One tube will be used to deliver compressed air to the pump and the other tube will be used for sample recovery.

Either dedicated bladder pumps with Teflon™ tubing or dedicated Teflon™ tubing for use with a peristaltic pump will be installed prior to initiating heating of the ERH treatment volume. The use of pre-installed, dedicated sample equipment will reduce the risk of exposure to steam, hot water, or contaminants, since the well head will not have to be opened.

Regardless of which pumping system is used, the pump-intake shall be located in the middle or slightly above the middle of the screened interval. If the pump-intake is too close to the bottom of the well, increased entrainment of solids may occur. Pump-intake placement should only be used at the top of the water column in unconfined aquifers screened across the water table, where this is the desired sampling point. By placing the intake in the middle or near-middle of the screened interval, the amount of mixing between the overlaying stagnant casing water with the water within the screened interval is minimized.

5.4 Hot Groundwater Sampling

The project team should coordinate, in advance, with all applicable parties to schedule an ERH system shutdown. The TRS PM and TRS SHSO shall determine a site-specific shutdown period. Sampling shall be completed in order from the wells having the lowest anticipated concentrations of contaminants of concern (COC) to wells having the highest anticipated COC concentrations (from exterior wells to boundary control wells to wells located within the source area). The groundwater sampling procedure is as follows:

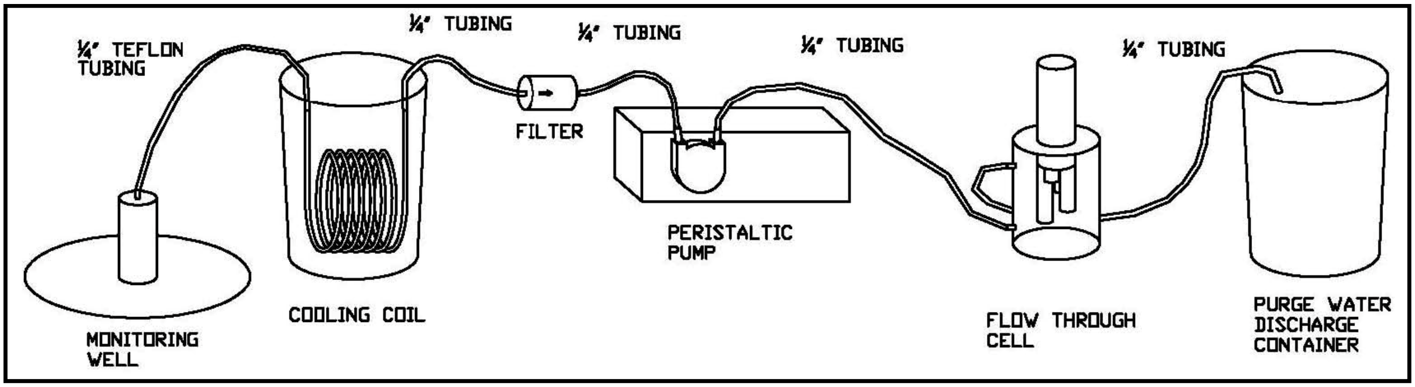
1) Calibrate probes used to monitor water quality parameters according to the manufacturer's instructions (as necessary). Calibration frequencies should adhere to the manufacturer's recommendations.
2) Cease power application to the treatment area and perform LOTO procedures on the ERH PCU if required by site specific protocols. Note: LOTO application shall only be completed by personnel who have been trained and certified by TRS according to SOP 1.1.
3) Confirm that the pump inlet (end of tubing for peristaltic pump or screened opening on the bladder pump) is located within the screened interval.
4) Connect ¼-inch sample tubing from the valve on the well to the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath as described in Section 5.2.

5) Connect the pump to the cooling coil. For wells with a depth to water less than 20 feet, connect the cooling coil and peristaltic pump to the monitoring wellhead. For wells having a depth to water greater than 20-ft bgs, connect pump controls to the previously deployed bladder pump and connect the cooling coil and compressed air source.

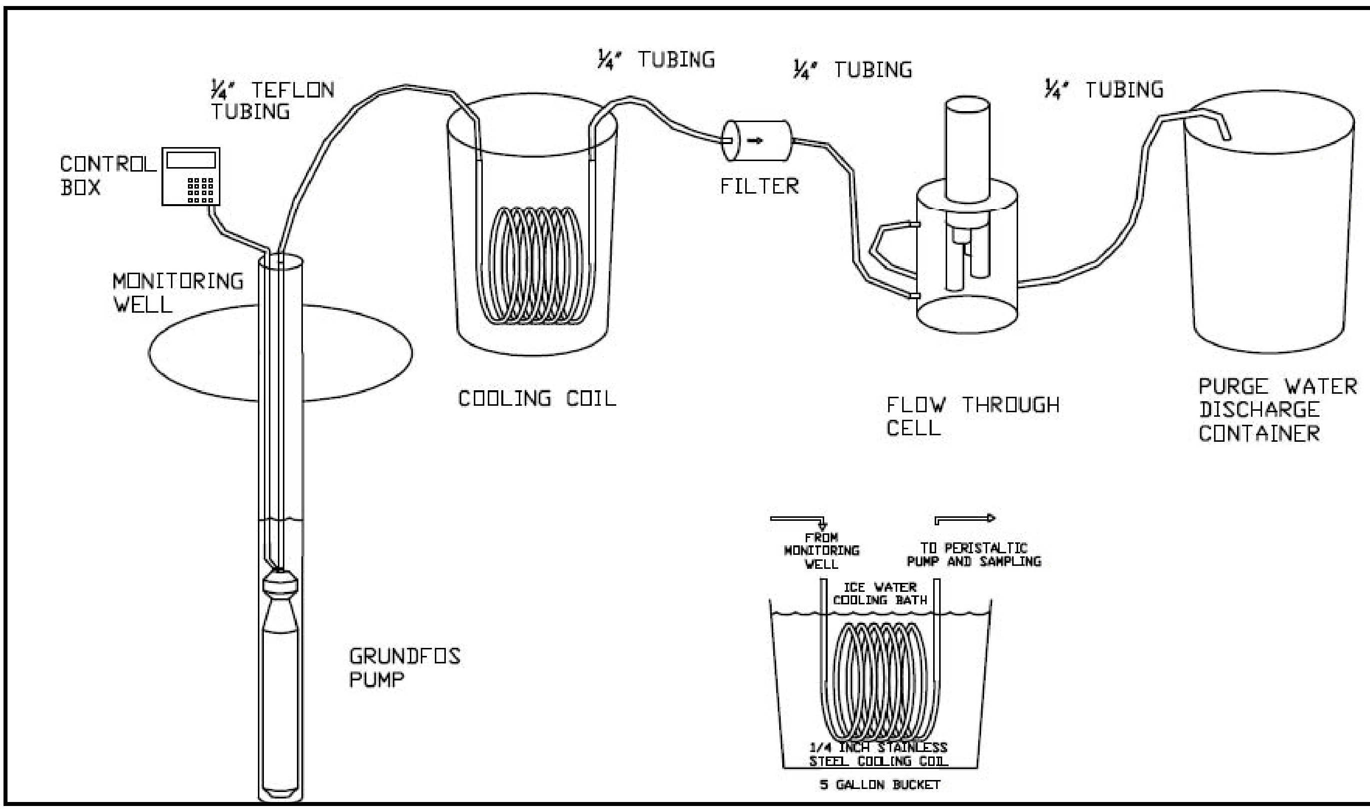
6) Connect the cooling coil discharge tubing to a flow-through cell with the calibrated meter probes/sensors securely held in the flow-through cell.

7) Connect tubing from the discharge of the flow-through cell to the purge water collection bucket.

PUMPING SET-UP WITH PERISTALTIC PUMP



PUMPING SET-UP WITH SUBMERSIBLE PUMP



8) Begin purging the well at a low- flow rate. Target pumping rates should generally be in the order of 0.1 to 0.5 liters per minute (L/min) to ensure stabilization of parameters and reduce mixing of formation water with stagnant well casing water. (Puls and Barcelona, 1996). Depending on site parameters and pumping method used, maintaining a steady low-flow rate may require pumping up to a rate of 1 L/min. Adjustments to the pumping rate are best made within the first 15 minutes of purging to minimize purging time.

9) The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. At the initiation of well purging and after recording pumping rates, water quality parameters are measured and recorded with a multi-parameter water quality meter equipped with a flow-through cell. The measured water quality parameters are temperature, turbidity, specific conductance, pH, DO, and oxygen reduction potential (ORP or Redox). Pumping shall continue until the water quality parameters have stabilized (refer to Section 5.4.1) or the minimum purge volume has been removed (refer to Section 5.4.2).

10) After all water quality parameters have stabilized (refer to Section 5.4.1) and the minimum purge volume is purged (refer to Section 5.4.2), sampling may begin. If all parameters have stabilized, but turbidity remains above 10 NTUs, decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling initiated. For low yield wells, sampling commences as soon as the well has recovered sufficiently to collect the appropriate volume for the anticipated samples. If well purging has caused the well to become dry, refer to Section 5.4.3 for sampling procedures.

11) Disconnect the tubing from the inlet side of the flow-through cell. The tubing from the pump outlet will be used to fill the groundwater sample bottles. Samples for VOCs shall be collected first followed by semi-volatile organic compounds (SVOCs). All other parameters should be collected in order from most volatile to least.

12) Groundwater samples including quality control (QC) samples are labeled and preserved per the site-specific Sampling and Analysis Plan (SAP).

13) All pertinent information will be documented in the sample log book and on the chain of custody forms including: date, time of sample, sample identification, analysis being completed, and any other information deemed relevant to the sample results. The following additional information shall be documented in the sample logbook: time at beginning and end of well purging, flow rate and any changes during the well purge, equipment used for well purge, and water quality parameter readings used to determine sample time.

14) Package and ship samples with a laboratory supplied trip blank to the offsite laboratory for analysis.

15) Meters used for groundwater sampling effort shall be decontaminated according to manufacturer recommendations. Dispose of decontamination liquids and purge water in accordance with site-specific documents.

5.4.1 Water Quality Parameters

Readings are recorded on the purge data sheets every 3 to 5 minutes. Field parameters are monitored until stabilization occurs. Unless local regulatory requirements differ, readings are generally considered stable when three consecutive readings are within the following criteria:

- Specific conductance readings within 3 percent
- Redox potential within 10mV
- pH within +/-0.1 standards units
- Turbidity and DO readings within 10 percent

5.4.2 Minimum Purge Volume

The minimum purge volume is three times the static saturated well volume. The equation to calculate the minimum purge volume is:

$$V = 7.48*rw2(td-dtw)$$

Where V = one purge volume in gallons; rw = radius of well casing in feet; td = total depth of well in feet; dtw = typical depth to groundwater in feet.

5.4.3 Dry Well Sampling

If well purging has caused the well to become dry, the following procedures will be used to sample the well and allow for recharge:

1) A column of water is drawn in the cooling coil tubing with the pump.
2) The well sample valve and the peristaltic pump inlet valve are closed and the pump shut off.
3) The cooling coil is disconnected from the well sample valve.
4) The cooling coil is carefully removed from the ice bath.
5) The pump inlet valve is opened.
6) The sample is decanted into the sample vials from the pump end of the tubing via gravity flow.

The process is repeated until the sample volume is collected. Any other sample fractions (cations, anions) are sampled from the well end of the cooling coil tubing.

6.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, should be documented in the sample logbook.

Calibrations of water quality meters used to measure water quality readings shall be completed according to the manufacturer's recommendations. Calibration results shall be maintained in a written log kept at the site throughout the operational phase of the project.

At a minimum, the following information shall be maintained in the sample logbook related to well purging and groundwater sample collection:

- date,
- sample/purge location identification,
- type of pump used for well purge,
- duration of well purge,
- sample time,
- flow rate (including changes throughout purge),
- meter(s) used for collection of water quality parameters and calibration documentation,
- water quality parameter readings,
- volume of purge water collected prior to sampling,
- sample identifications and analysis to be performed,
- chain of custody number,
- shipping information,
- procedures used for equipment decontamination,
- deviations from this SOP, and
- any other information deemed relevant to the sample results.

Copies of chains of custody forms and shipping documentation shall be maintained and kept with the sample log book.

7.0 REFERENCES

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, EPA/540/S-95/504.