STANDARD OPERATING PROCEDURE APPROVAL AND CHANGE FORM

Scientific, Engineering, Response and Analytical Services 2890 Woodbridge Avenue Building 209 Annex Edison New Jersey 08837-3679
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Authors
Name Christopher French Title SERAS Environmental Technician Signature [signature] Date 6/23/15
Name Jean Bolduc Title SERAS Hydrogeologist Signature [signature] Date 6/23/15
Approvals
Name Richard Leuser Title SERAS Deputy Program Manager Signature [signature] Date 6/23/15
Name Title Signature Date
Name Deb Killeen Title SERAS QA/QC Officer Signature [signature] Date 6/23/15
Name Kevin Taylor Title SERAS Program Manager Signature [signature] Date 6/23/15

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GROUNDWATER WELL SAMPLING

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1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides general information on how to collect groundwater samples from monitor wells and other wells for field screening or laboratory analysis. The procedures in this SOP are designed for sampling in conjunction with analysis of the most common groundwater contaminants, i.e. volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, herbicides, polychlorinated biphenyls (PCBs) and metals including cyanide. A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure the methods used are adequate to satisfy the data quality objectives listed in the site specific QAPP (SERAS SOP # 4006, *Preparation of Quality Assurance Project Plans (QAPPs)*).

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

Three methods are generally accepted to collect a groundwater sample from a well for field screening or laboratory analysis: high-flow sampling, low-flow sampling and no-purge sampling. Historically, a high-flow purging method has been used for groundwater sampling. In the mid-1990s, low-flow (low stress) purging and sampling evolved using low pumping rates. No-purge sampling devices, which began to appear in the late 1990s and early 2000s, enabled collecting a sample without the pumping or purging of groundwater prior to sampling.

2.1 High-Flow Purging and Sampling

An adequate purge is normally achieved using this method by removing three well volumes of standing groundwater at relatively high flow rates prior to sampling while recording the pumping rate, discharge volume, water level and routine groundwater parameters over time. Routine groundwater parameters may include pH, specific electrical conductance, turbidity, temperature, dissolved oxygen and oxidation-reduction potential (ORP). It is assumed that stabilization of the groundwater measurements indicates the purge water is representative of ambient water from the underlying aquifer. Groundwater quality parameters are generally considered stabilized after three consecutive sets of readings do not vary by more than 10 percent (%). The time between readings (typically 5 to 10 minutes) should be chosen to ensure enough data have been collected to document the stability of parameters. If the calculated purge volume is large, measurements taken every 15 minutes may be adequate. If the field parameters do not stabilize after three well volumes have been removed, a decision to continue purging or to collect a sample should be made by the Environmental Response Team (ERT) Work Assignment Manager (WAM).

2.2 Low-Flow Purging and Sampling

This method minimizes the purge water volume removed, the water level drawdown, and the turbidity and aeration of the groundwater by using low purging and sampling rates, generally less than 1 liter per minute (lpm) or 0.26 gallon per minute (gpm). The pump intake is set within the zone of highest contaminant concentration or flux in the screened interval, if known.

Otherwise, it is placed at the midpoint of the screened interval or open borehole. The water level in the well is maintained near the static level (within 0.3-foot) during purging and sampling. Water quality parameters (pH, specific electrical conductance, temperature, turbidity, dissolved oxygen and ORP) are monitored for stability during purging to indicate when sampling may commence. It is assumed that vertical flow within the well is not occurring.

2.3 FLUTe Well Sampling

A FLUTe well consists of a downhole liner with multiple sampling ports. Once installed the sampling system is used to purge and sample the well. The sampling system consists of a manifold, valves, tubing and a nitrogen cylinder. The process involves attaching a nitrogen supply line from the manifold to a downhole airline (U-line) to the desired port. The nitrogen supply line from the manifold is now attached to the nitrogen cylinder. The nitrogen fills the U-line at a specific pressure, flushing purge water from the sample port. This port will then be purged dry then allowed to recharge for 5 to 10 minutes (dependent upon recharge) then purging again. This process will be repeated at least three times. Once the purging has been completed a waiting period of 10 to 15 minutes will be observed and the sample can then be collected through the sample/purge line. This procedure will be applied to all sampling ports until completion.

Note: Refer to the FLUTe well installation specifications for the exact nitrogen pressure (PSI) rating. Purging and sampling the well at the wrong PSI may damage the well.

2.4 No-Purge Discrete Sampling

Passive sampling techniques do not involve purging or pumping of the well before collection of a groundwater sample. A discrete sample is collected at a specific location in the well using a grab, diffusion, or adsorption device. These samplers are typically placed in the well and allowed to equilibrate during a deployment period before a sample is collected. Well water within the screened or open interval is assumed to be in equilibrium with the aquifer water and it is also assumed that there is no vertical flow of groundwater in the well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

The analytical method specifies the type of bottle, preservative, holding time and filtering requirements for a groundwater sample. Samples should be collected, when possible, directly from the sampling device into appropriate sample containers. Check that a Teflon liner is present inside the cap of the sample container, if required. Attach a sample identification label. Record all pertinent data in a site-specific logbook. A chain of custody (COC) record will be generated using Scribe.

The samples should be placed in a cooler and maintained at less than or equal (≤) to 6 degrees Celsius (^{O}C) and protected from sunlight. Ideally, samples should be shipped within 24 hours of collection. If large numbers of samples are being collected, shipments may occur on a regular basis after consulting the analytical laboratory where the samples will be shipped for analysis. In all circumstances, samples need to be shipped and analyzed before the holding time expires.

Due to the trace levels at which VOCs are detectable, potential of cross-contamination and the introduction of contaminants must be avoided. Treatment of the sample with sodium thiosulfate preservative is required only if there is residual chlorine in the water that could cause free radical chlorination and change the identity of the original contaminants. This preservative should not be used if there is no chlorine in the water. Quality assurance/quality control (QA/QC) samples are incorporated into the shipment package to provide a check for cross-contamination. Samples for the analysis SVOC, pesticides, herbicides and PCBs do not normally require preservation. Samples for the analysis of VOCs typically require preservation with hydrochloric acid prior to shipment to the laboratory. Groundwater samples collected for metals and cyanide analyses are required to be adjusted with nitric acid to a pH of less than (<) 2 and sodium hydroxide to a pH of greater than (>) 12, respectively. For further details refer to Scientific, Engineering, Response and Analytical Services (SERAS) SOP# 2003, *Sample Storage, Preservation and Handling*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 Effects Caused by Well Installation and Development

The main goal of most well sampling is to obtain a sample that represents the groundwater in a specific location in an aquifer. Improperly installed (i.e. faulty filter pack or poorly grouted seal) or inadequately developed wells may not provide representative groundwater samples. Installation and development logs for the wells to be sampled should be reviewed prior to mobilizing to the field. Newly installed wells should generally not be sampled until at least 24 hours after development.

4.2 Effects Caused by Change in Sample Environment

In-situ groundwater is usually under different conditions of aeration/oxidation, pressure, gas content and temperature than those found at the ground surface. Therefore, the chemical composition of the groundwater may change between the time of collection and the time of analysis. It may be difficult to avoid some of those changes. However, proper sample collection and preparation procedures should be used to minimize chemical changes in groundwater samples.

4.3 Presence of Immiscible Fluids

The presence of a floating or sinking organic layer in a well may require re-evaluation of the sampling design. Wells containing Light Non-Aqueous Phase Liquid (LNAPL) are generally not sampled for dissolved concentrations of VOCs and SVOCs (i.e. usually petroleum-derived products). LNAPL can usually be detected on top of the water column in a well using an interface probe, clear bailer or steel tape with color-gauge water finding paste. Wells containing dense non-aqueous phase liquid (DNAPL) are often sampled for VOCs, SVOCs, or PCBs. DNAPL can be detected at the bottom of the water column in a well using an interface probe or clear bailer.

5.0 EQUIPMENT/APPARATUS

All equipment used in groundwater purging and sampling must be constructed of materials that do not introduce contaminants or alter the contaminants being investigated. The devices used in groundwater purging and sampling of wells for a variety of contaminants are listed in Table 1, Appendix A and in Figures 1 through 10, Appendix B and discussed below.

5.1 Bailers

Bailers are best suited to sampling shallow or small diameter wells. Other devices may be more appropriate for deep, larger diameter wells that require removal of large volumes of water. Bailers are generally not recommended for the collection of groundwater samples. Bailers consist of a rigid length of tube, with a ball check-valve at the bottom (standard bailer) or top and bottom (point-source bailer). The four most common types of bailers are made of poly-vinyl chloride (PVC), polyethylene, Teflon and stainless steel. A non-reactive line is used to lower and raise the bailer in the well.

Advantages:

- No power source needed
- Portable
- Inexpensive
- Dedicated, the potential of cross-contamination is minimal
- Readily available
- Simple method for removing small volumes of purge water
- Does not subject the sample to pressure extremes

Disadvantages:

- Time-consuming to purge large volumes of groundwater from well
- The valve at the bottom of the bailer often leaks; thus, the potential exists to lose part of the sample
- Bailing may disturb the water column causing changes to the field parameters to be measured
- May result in aeration of the groundwater and stripping of VOCs and SVOCs from the sample

5.2 No Purge Samplers

No purge or passive samplers make it possible to collect groundwater samples without pumping or purging a well. These samplers are lowered to a desired depth within the screened interval or open borehole. Most of these samplers can be stacked to obtain samples at a series of depths. They can provide reproducible and accurate data, if correctly used for sampling. There are three main categories of no purge samplers currently available, they include:

1. Grab-type samplers provide an instantaneous representation of analyte concentrations within the discrete interval to which they are lowered. These are activated by pulling up, using an up and down motion, or triggering at the surface. These samplers cannot all be used to collect groundwater samples for every type of chemical analysis; therefore, the manufacturer's instructions should be consulted to determine if the target analyte can be sampled with a specific device. Sampler capacities range from 40 milliliters (mL) to over 4 liters (L) but may not provide a sufficient volume of water to enable testing for all chemicals of concern during a single deployment. Some of these samplers are designed to be left in the well for an equilibration period prior to sampling. This period allows the natural conditions to be re-established following any disturbances caused by deploying the sampler down well through the water column.

   Some common grab-type samplers include:

   - HydraSleev

- Snap Sampler
- Discrete Interval Sampler (DIS)
- Kemmerer Sampler

2. Diffusion-equilibrium samplers rely on diffusion of the analytes to attain equilibrium between the sampler and the groundwater. Equilibration times vary from several days to a few weeks depending on the type of sampler, conditions in the well, transmissivity of the aquifer or natural flushing rate of the well, and properties of the contaminant (ITRC, 2006). The minimum recommended time between deploying and retrieving these samplers is generally two weeks. Typically, the samples contain time-averaged concentrations from the last few days of the deployment period.

   Some common diffusion-equilibrium-type samplers include:
   - Regenerated-Cellulose Dialysis Membrane Sampler (RCDMS)
   - Nylon-Screen Passive Diffusion Sampler (NSPDS)
   - Polyethylene Diffusion Bag Sampler (PDB)
   - Rigid Porous Polyethylene Sampler (RPPS)

5.3 FLUTe Well Sampling System

The FLUTe sampling system consists of a manifold, valves, tubing and a nitrogen cylinder. The manifold consists of multiple valves and is a connection point for the nitrogen supply line and downhole airline or (U-line). A water level indicator will be deployed down the water line or (Tag Line) to ensure the groundwater is at the appropriate depth and to ensure the FLUTe liner is intact. Once the water level measurements have been recorded, the sampling process may begin.

Note: Refer to the FLUTe well installation specifications for the exact nitrogen pressure(PSI) setting. Purging and sampling the well at the wrong PSI may damage the well.

Advantages:

- The FLUTe system allows the installation of multiple wells or sampling intervals within one well. In theory, it's more cost effective as only one well has to be installed as opposed to the sampling of multiple wells.
- Sampling is relatively quick as there is very little volume to purge.

Disadvantages:

- Specialized equipment and supplies are required for the well sampling

5.4 Positive Displacement Pumps

Three types of positive displacement pumps typically used for purging and sampling of groundwater wells are bladder, gear-drive, and centrifugal. Positive displacement pumps designed for groundwater monitoring are constructed of non-sorptive materials (stainless steel, Viton and Teflon). Heat dissipated by submersible pump motors (i.e. gear-drive and centrifugal) may increase the sample temperature, causing loss of dissolved VOCs and precipitation of dissolved metals (Nielsen and Nielsen, 2006). Some positive displacement pumps can be easily disassembled for cleaning. However, decontamination of certain centrifugal pumps may be difficult and labor intensive as they contain a number of intricate parts.

Bladder pumps consist of the housing, bladder assembly and intake screen/filter. The housing and intake screen are constructed of stainless steel or PVC, while the replaceable bladder cartridge is made of Teflon or low-density polyethylene (LDPE). Air supply and discharge lines extend to the pump from the surface. Compressed air (typically nitrogen or ultra-zero air) is alternately applied to the supply line using a pump controller at the surface. The on/off cycles of compressed air squeeze the bladder to displace water out of the pump toward the surface then exhaust to allow the bladder to refill. Water enters the pump under hydrostatic pressure through an inlet check valve at the bottom of the pump. A check valve above the bladder prevents back flow into the pump from the discharge line. Bladder pumps can be either portable if the wells are shallow or dedicated if the wells are deep. Portable bladder pumps are limited to a depth of approximately 200 feet; whereas, dedicated bladder pumps are limited to a depth of approximately 1000 feet. Bladder pumps can be used to purge and sample groundwater wells for any type of analyte.

Gear-drive pumps use an electric motor to rotate two meshing gears (a drive gear and an idler made of Teflon). The gears trap and move the water upward from the pump inlet to the discharge line. They can be powered using 12, 24 and 36 volt direct current (VDC) batteries or 110 and 220 volt alternating current (VAC) with an inverter. Fultz Pumps, Inc. makes two models (SP-300 and SP-400) of gear-drive pumps for groundwater monitoring with a lift capability of up to approximately 200 feet. A controller allows the pump flow rate to be adjusted at the surface.

Centrifugal pumps use electric motors to spin or rotate an impeller or series of impellers, which creates centrifugal force, and develops the pressure to move water through the discharge line to the surface. These pumps are available in both variable-speed and fixed-speed configurations. A variable-frequency drive (VFD) controller at the surface enables the discharge rate to be adjusted for the pump. Common models of VFD centrifugal pumps are the Grundfos® Redi-Flo2 and Redi-Flo4. They have maximum operating depths of approximately 300 and 525 feet, respectively. Flow control for fixed-speed centrifugal pumps is accomplished using a throttling valve in the discharge line at the surface.

Submersible pumps generally use an electric power source. Centrifugal submersible pumps can run off a 12-VDC rechargeable battery, or a 110 or 220-VAC power supply. Most progressive cavity submersible pumps are powered by a 12-VDC battery. Gasoline used to power electrical generators is a potential source of contamination and should be kept well away from purging and sampling equipment. Submersible pumps are available for monitoring wells of various depths and diameters.

Advantages:

- Small diameter pumps are portable and easily transported from well to well
- Relatively low to high pumping rates are possible
- Very reliable and priming is not required
- Mainly constructed of relatively inert materials

Disadvantages:

- Power or compressed air source needed

- Submersible pump might degas the sample
- Deep wells may require pumps that are heavy and cumbersome to use
- Relatively expensive
- Sediment in water may clog intake screen or impellers
- Must be decontaminated between wells
- Because pumping pulls water from the more permeable zones, contaminant contributions from lower permeability zones may be masked in the samples
- Pumping causes mixing which may destroy in-well stratification of contaminant concentrations that could exist and be vital to the investigation

5.5 Suction Pumps

Suction pumps include peristaltic and diaphragm pumps. Peristaltic pumps can be used to purge small diameter wells (two inches or less) and should only be used to sample for inorganic contaminants. Diaphragm pumps are rarely used for the purging or sampling of monitoring wells and are omitted from further discussion. Suction pumps are limited to use in wells with a depth to groundwater of less than approximately 25 feet.

The peristaltic pump is a low volume pump that uses rollers to squeeze flexible tubing (e.g., ⅜- or ¼-inch inner diameter [ID] medical grade silastic) thereby creating suction. It is required that Teflon or Teflon-lined polyethylene tubing, e.g. ⅜- or ¼-inch outside diameter (OD) be connected to the pump when sampling for VOCs, SVOCs, and PCBs. Polyethylene tubing may be used when collecting samples for metals analyses. The tubing can be dedicated to a well for long-term monitoring or should otherwise be discarded. Peristaltic pumps require a power source that is either 12 VDC or 110 VAC.

Advantages:

- Portable, inexpensive, and readily available
- Operates from either 110 VAC or 12 VDC
- Variable flow rate, easily controlled
- Dedicated or new tubing used at each well thus minimizing the chances of cross-contamination

Disadvantages:

- Restricted to wells where water levels are within 25 feet of the ground surface
- Vacuum can cause loss of dissolved gasses and volatile organics
- Generally suitable for only small diameter shallow wells
- Maximum flow rate of some types (e.g. peristaltic pumps) limited to approximately 1.0-Lpm

5.6 Inertial Pumps

The simplest inertial pump consists of a foot valve connected to semi-rigid tubing. These pump systems are available in six sizes from 6 millimeters (mm) to 25-mm OD. Foot valves are usually made of Delrin, Teflon or stainless steel and are self-tapping directly onto the tubing. The tubing commonly used in the inertial pumps is low-density polyethylene for shallow wells and high-density polyethylene, Teflon-lined polyethylene, or Teflon for intermediate and deep wells. Tubing may either be decontaminated or discarded after use or dedicated to the well.

These pumps are most appropriate to use when wells are too deep to bail by hand, too shallow or too small in diameter to warrant the use of a submersible pump, or the water table is deeper than the limit for suction. After the pump is installed in the well, rapid upstrokes and down-strokes lift the water in the tubing. Inertial pumps can be hand operated for depths shallower than approximately 45 feet or motor driven using an actuator for depths deeper than approximately 45 feet. Optimal performance of most inertial pump systems is obtained at depths less than approximately 135 feet.

Advantages:

- Portable, inexpensive, reliable, and readily available
- Offers a rapid method for purging relatively small diameter and shallow to intermediate depth wells
- Easily operated and decontaminated

Disadvantages:

- Produces agitation that could cause turbid groundwater inside the well
- May cause VOC loss from the groundwater due to agitation
- Limited to field screening or sampling narrow-diameter temporary wells
- Restricted to depths of less than approximately 135 feet
- May be time consuming to purge wells with these pumps
- Gas-driven actuator is heavy and fuel fumes may cause sample contamination

5.7 Field Equipment Checklist

5.7.1 General

- Water level indicator/sensor
- Transducer
- Keys for well lock(s)
- Monitoring equipment with a FID or PID
- Logbook
- Calculator
- Sample labels
- Chain of Custody records and custody seals
- Sample containers
- Engineer's rule
- Sharp knife (with locking blade)
- Tool box containing: screwdrivers, pliers, hacksaw, hammer, flashlight, etc.
- Leather work gloves
- Surgical gloves
- Personal Protective Equipment (PPE)
- Five gallon bucket(s)
- Plastic sheeting
- Shipping containers
- Packing materials
- Bolt cutters
- Ziploc plastic bags
- Decontamination solutions (e.g. Liqui-Nox)

- Potable water
- Aluminum foil
- Sprayers
- Preservatives, if needed
- Distilled water
- Fire extinguisher (if using a generator as a power source)
- In-line filters, 0.45 microns (μm) (typically used for sampling of dissolved metals only)
- Flow cell
- Water quality meter (e.g. Horiba or YSI)
- Permanent markers
- Duct tape, clear tape and packaging materials
- Paper towels
- 55-gallon drum(s) for storage of purged groundwater
- First aid kit
- Laptop computer with SCRIBE software
- Portable printer
- Printer paper and labels
- Power strip
- Extension cords

5.7.2 Bailers

- Bailers of appropriate size and construction material
- Nonreactive line

5.7.3 No-Purge Samplers

- Appropriate sampler
- Sample bottles, depending on the type of sampler
- Trigger line and trigger mechanism, depending on the type of sampler

5.7.4 FLUTe Well Sampling System

- Nitrogen cylinder
- FLUTe sampling manifold
- Tubing
- 5 gallon buckets (for purge water)
- Water level indicator (Solinst Model 102)

5.7.5 Positive Displacement Pumps

- Pump(s) and controller(s), depending on the type of pump used
- Generator (120 or 240 volts) or 12-volt power source, depending on the type of pump used
- Compressed air supply, depending on the type of pump used
- Extension cord(s)

- Polyethylene, Teflon or silicone tubing
- Hose clamps
- Safety cable
- Tool box containing: pipe wrenches, wire strippers, electrical tape, heat shrink wrap or tubing, hose connectors, etc.
- Teflon tape
- Winch, pulley or hoist for large submersible pumps (2-inch diameter or greater)
- Gasoline container and gasoline
- Flow meter and gate valve
- Plumbing components (nipples, reducers, plastic pipe connectors)
- Control box

5.7.6 Inertial Pumps

- Pump assembly (foot valve and tubing)
- Gas-driven actuator, if required

5.7.7 Suction Pumps

- Small diameter Teflon or polyethylene tubing (e.g. ⅜-inch OD or ¼-inch ID)
- Roll of small diameter silicone tubing (e.g. ⅜-inch OD or ¼-inch ID)
- 110 VAC generator or 12 VDC power source

6.0 REAGENTS

Reagents are used for preservation of samples, calibration of water quality meters and for decontamination of sampling equipment. Nevertheless, samples should be cooled to $\leq 4^{O}$C and protected from sunlight in order to minimize degradation and any potential reaction due to the light sensitivity of the sample. Refer to SERAS SOP # 2003, *Sample Storage, Preservation, and Handling*, #2006, *Sampling Equipment Decontamination* and #2041, *Calibration of Water Quality Meters* for reagents required for each specific type of application.

7.0 PROCEDURES

7.1 Office Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed and the types and amount of equipment and supplies needed (e.g. well diameter and depth of wells to be sampled).

2. Obtain the necessary monitoring and sampling equipment appropriate to the type of contaminant(s) being investigated. Availability of preservatives, packing material, sample labels and shipping coolers.

3. Decontaminate all equipment prior to use, ensure that equipment is in working order and ready to use.

4. Identify all sampling locations and secure correct well-lock keys.

7.2 Field Preparation

1. Mobilize from the least contaminated well to the most contaminated well, if known, to minimize the risk of cross-contamination.

2. Lay plastic sheeting around the well to minimize contamination of sampling equipment from soil and materials that might be adjacent to the well.

3. Remove the lock on the well cap, note the location, note the time of day, note the date and record the information in the site logbook.

4. Remove the well cap (allow 3 to 5 seconds to prevent exposure of vapors).

5. Screen the headspace of the well with an appropriate air monitoring instrument such as a flame ionization detector (FID) or photo-ionization detector (PID) to determine the potential presence of VOCs. Record the FID or the PID readings in the site logbook.

6. Measure the distance from the water surface to the referenced measuring point and record it in the site logbook. A reference point may be the top of the outer protective casing, the top of riser pipe, the ground surface, or the top of a concrete pad. Document the reference point used in the Site logbook. If floating organics are present, the water level and depth to the floating product can be measured with an interface probe operated in accordance with SERAS SOP# 2043, *Manual Water Level Measurements*.

7. Measure the total depth of the well and record the information in the site logbook and/or on a field data sheet.

8. Calculate the volume of water in the well and the volume to be purged using the calculations in Section 8.0, *Calculations*.

9. Select the appropriate purging and sampling equipment.

7.3 Purging and/or Sampling

After field preparation is completed, the purging and sampling of a groundwater well is generally performed using high or low flow methods. Wells that cannot be purged at a low flow rate (approximately 100 mL/min) without going to dryness or contain insufficient water to enable purging should be considered for no-purge sampling. The objective is to conduct consistent and representative sampling of the groundwater wells. The same methods should be used each time the wells are purged and sampled, unless a different method would improve the data quality. Applicable sampling equipment for various contaminants of concern is presented in Table 1 of Appendix A.

7.3.1 High-Flow Purging and Sampling

A representative sample is collected after a known volume of groundwater (usually three well volumes) is pumped at a relatively high flow rate (at or below rates used for development) from the well or the water quality parameters have stabilized. Water quality parameters that can be measured during purging include temperature, electrical conductance, pH, oxidation-reduction potential and turbidity. The volume of water to be purged can be determined as described in Section 8.0 *Calculations* of this SOP. Groundwater quality parameters are generally considered stabilized after three consecutive sets of readings do not vary more than 10%.

The time between readings is based on the purge rate and cumulative volume but is typically 5 to 10 minutes or when every half volume (after the initial well volume) is purged. The well should be purged enough to remove the stagnant water but not enough to induce flow from other areas. Sampling should be performed immediately after purging. Samples for VOCs are collected first when sampling for more than one set of parameters, followed in order by samples for SVOCs, PCBs, and inorganic analyses. Positive displacement and suction lift pumps are recommended for high flow purging and sampling; whereas, the use of bailers and inertial pumps is discouraged. The total volume purged, purge method, purge rate, and the start and end times of purging, water quality parameter readings and sample collection time are recorded in the site's logbook. The static water level and depth to water at the end of purging should also be recorded in the site's logbook.

7.3.2 Low-Flow Purging and Sampling

During low flow purging, the pumping rate is adjusted (typically between 100 and 500 mL/min) to minimize or stabilize the drawdown to within 0.3 foot of the static water level. Both the drawdown and water quality parameters (pH, electrical conductivity, temperature, dissolved oxygen, oxidation-reduction potential and turbidity) are monitored during the purging according to SERAS SOP# 2041, *Operation of the Hydrolab 4a Water Quality Management System*. The water quality parameters are measured in a flow cell. Measurements are typically made every five minutes or after each flow cell volume has been purged.

A sample is collected after the parameters fall within the ranges listed below for three consecutive readings:

Water level drawdown	<0.3 foot
pH	± 0.1 unit
Electrical conductance	± 3%
Temperature	± 3%
Dissolved oxygen	± 3%
Turbidity	± 10% for values greater than 1 NTU
Oxidation-Reduction Potential	± 10 millivolts

Other ranges may apply for some of the parameters listed above depending on the State or Federal guidance that may need to be adopted for evaluating their stabilization. If the parameters have not stabilized after two hours of purging; a) continue purging until stabilization is attained and collect the sample, b) stop purging, do not collect the sample, and record attempts to reach stabilization in the site's logbook, and c) stop purging, collect the sample, and record attempts to reach stabilization in the site's logbook.

Low flow purging and sampling is best performed using positive displacement pumps and in some instances may be conducted using peristaltic pumps when only inorganic parameters are targeted.

7.3.3 No-Purge Discrete Sampling

Passive samplers provide a discrete sample from the screened portion or open interval of a groundwater well without pumping or purging. The sampler must be completely submerged and should be installed at the same depth during each monitoring event for data consistency and comparability. If historical information indicates that contamination in the well is not stratified, a single deployment depth should be selected, and sampler placement at the middle of the screen or open interval may be appropriate. Several samplers can also be deployed at different depths in the well to conduct vertical profiling. These samplers collect a limited sample volume; therefore, the manufacturer should be consulted to ensure the device will provide enough water volume to conduct the required analysis and any QA/QC that may be required in the QAPP. Diffusion and adsorption samplers may require several days or weeks of deployment before a representative sample can be collected; whereas, some grab-type samplers may not require an equilibration period prior to sampling.

7.3.4 FLUTe Well Sampling Procedures

Gather and organize all of the sampling equipment and supplies; manifold, tubing, water level indicator and 5 gallon buckets.

Attach the manifold to the down-hole air line or (U-line). Attach the nitrogen supply line from the cylinder to the block. Once everything is securely attached turn on the nitrogen supply. Attach the sample tubing to the sample port directly adjacent to the U-line. Turn the valve on the manifold to the on position allowing the nitrogen to flow down the U-line. Sample purge water will now flow up and out of the sample port tubing line. Continue to purge until the line runs dry. Allow 5 to 10 minutes to recover and repeat this procedure 2 more times. After the purging process has been completed, allow another 5 to 10 minutes for the port to recover; then sample.

This procedure will be applied to all sample ports until all have been sampled.

Note: Refer to the FLUTe well installation specifications for the exact nitrogen pressure (PSI) setting. Purging and sampling the well at the wrong PSI may damage the well.

7.3.5 General Operating Procedure for Purging and Sampling

The general procedures for devices most commonly used for purging and sampling are:

<u>No-Purge Devices</u>

Consult the manufacturer’s instructions for the deployment and retrieval of the applicable no-purge device selected for monitoring.

<u>Positive Displacement Pumps and Suction Pumps</u>

The following steps describe the use of positive displacement pumps in purging and sampling a well:

1. Determine the volume of water to be purged as described in Section 8.0, *Calculations*, of this SOP if conducting high-flow purging and sampling.

2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with soil or other foreign materials.

3. Assemble pump, hoses and safety cable, and lower the pump into the well. Make sure the pump is set in the screened interval.

4. Attach a flow meter to the outlet hose to measure the volume of water purged or measure it with a container of known volume. If a meter is unavailable a five-gallon bucket may be used along with a stop watch.

5. Use a ground fault circuit interrupter (GFCI) or ground the generator to avoid possible electric shock.

6. Attach the power supply for submersible pumps or compressed gas cylinder or compressor for bladder pumps, and purge the well until the specified volume of water has been removed (or until field parameters, such as temperature, pH and conductivity have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, reduce the pumping rate.

7. Collect the sample, starting with VOCs and dispose of the purge water as specified in SERAS SOP # 2049 *Investigation-Derived Waste Management*.

8. Cap the sample container tightly and place the pre-labeled sample container into a cooler. Use a water proof marker is for labeling or a Scribe-generated Label.

9. Replace the well cap and decontaminate the pump.

10. Log the collection time, sampling method, and analyses required for all samples in the site logbook.

11. Package samples and complete necessary paperwork.

7.4 Filtering

Samples collected for dissolved metals analysis require filtration. Groundwater is primarily filtered to exclude silt and other particulates from the samples that would interfere with the laboratory analysis. In-line filters are used specifically for the preparation of groundwater samples for dissolved metals analysis, and for filtering large volumes of turbid groundwater. An in-line filter can be used with a peristaltic pump to transfer the sample from the original sample bottle, through the filter, and into a new sample container. The filter must be replaced between sampling locations.

The filters used in groundwater sampling are self-contained and disposable. Disposable filters are preferred and often used to reduce cross-contamination of groundwater samples. Disposable filter chambers are constructed of polypropylene material, with an inert filtering material within the housing. Disposable filters have barb or national pipe thread (NPT) fittings on the inlet and outlet sides of the housing to connect to 3/8-inch or 5/8-inch tubing.

7.5 Special Considerations for VOC Sampling

The proper collection of a sample for VOC analysis requires minimal disturbance of the sample to limit volatilization. Sample retrieval equipment suitable for the collection of VOCs is:

- Positive displacement bladder pumps
- Some submersible pumps
- No-purge samplers

Field conditions and other constraints will limit the choice of certain systems. The concern must be to collect a valid sample that has been subjected to the least amount of turbulence possible.

The following procedures are required to be used:

1. Open the vial, set cap in a clean place, and collect the sample. When collecting duplicate samples; collect both samples at the same time.

2. Fill the vial to almost overflowing. Do not rinse the vial, or let it excessively overflow. It needs to have a convex meniscus on the top of the vial before securing the cap.

3. Check that the cap has not been contaminated and place the cap directly over the top and screw down firmly. Do not over tighten the cap.

4. Invert the vial and tap gently. Observe vial for at least 10 seconds. If an air bubble appears, unscrew the cap and pop the bubble or refill with more sample then re-seal. Do not collect a sample with air trapped in the vial.

5. The holding time for unpreserved samples to be analyzed for VOCs is 7 or 14 days for preserved samples. Samples should be shipped or delivered to the laboratory as fast as practical in order to allow the laboratory time to analyze the samples within the holding time. Ensure that the samples are stored at $\leq 4^{O}C$ during transport but do not allow them to freeze. The most readily available method of cooling is to use ice packed in double-sealed plastic bags (e.g. Ziploc bags).

8.0 CALCULATIONS

To calculate the volume of a well, use the following equation:

$$\text{Well Volume (gallons)} = \pi r^2 hk$$

where:

π = 3.14
r = radius of monitor well (feet)

h = height of the water column (feet). (This may be determined by subtracting the:
depth to water from the total depth of the well as measured from the same reference point).
k = conversion factor, 7.48 gallons per cubic foot (gal/ft^3)

The inner diameter of most monitoring wells is typically 2 to 4 inches. If the inner diameter of the monitoring well is known, standard conversion factors can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitoring well diameters can be calculated as follows:

$$\text{Volume (gal/ft.)} = \pi r^2 k$$

OR

$$\text{Volume} = 23.5r^2$$

where:

π = 3.14
r = radius of well (feet)
k = conversion factor (7.48 gal/ft^3)

For a 2-inch diameter well, the volume, in gallons per linear foot, can be calculated as follows:

$$\text{Volume/linear ft.} = \pi r^2 k$$
$$= 3.14 \times (1/12)^2 \times (7.48\ gal/ft^3)$$
$$= 0.163\ gal/ft$$

The well radius must be in feet to be able to use the equation.

The conversion factors (***f***) for the most common diameter monitor wells are as follows:

Well diameter-inches	2	3	4	6
Volume (gal/ft.)	0.1631	0.3670	0.6528	1.4680

If you use the conversation factors than the equation is modified as follows:

$$\text{Well Volume} = hf$$

where:

h = height of water column (feet)
f = conversion factor

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific QA/QC activities that apply to the implementation of these procedures will be listed in the Quality Assurance Project Plan prepared for the applicable sampling event. The following general QA procedures will also apply:

1. All sample collection data, including purge methods and time, sample collection methods, times of collection, analyses required, and decontamination procedures (if any) must be documented on site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer or instrument-specific SOPs, unless otherwise specified in the QAPP. Equipment check-out and calibration is necessary prior to purging and sampling and must be done according to the instruction manuals supplied by the manufacturer.

3. The collection of rinsate (equipment, field) blanks is recommended to evaluate the potential for cross-contamination from non-dedicated purging and/or sampling equipment. The determination of how many field (rinsate, equipment) blanks to be collected is dependent on the project's data quality objectives.

4. Trip blanks are required if analytical parameters include VOCs.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. This may include but is not limited to: location information, water quality parameter measurements, purging start and end times, water levels, depth to groundwater measurements, purge method and total volume pumped. These data are essential to providing an accurate and complete final deliverable. The SERAS Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA) and SERAS health and safety guidelines. More specifically, depending upon the site specific contaminants, various protective programs must be implemented prior to sampling the first well. The site's health and safety plan (HASP) should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and other PPE.

When working around VOCs:

1. Avoid breathing volatile constituents venting from the well.

2. Check the well head-space with a FID/PID prior to sampling.

3. If monitoring results indicate organic concentration above the action level, it may be necessary to conduct sampling activities in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling:

1. Lifting injuries associated with pump and bailers retrieval; moving equipment.

2. Use of pocket knives for cutting discharge hose.

3. Heat/cold stress as a result of exposure to extreme temperatures in protective clothing.

4. Slip, trip, fall conditions as a result of pump discharge.

5. Restricted mobility due to the wearing of protective clothing.

6. Electrical shock associated with use of submersible pumps is possible. Use a GFCI or a copper grounding stake to avoid this problem.

12.0 REFERENCES

Interstate Technology Regulatory Council (ITRC), 2006, Technology *Overview of Passive Sampler Technologies*, Prepared by the ITRC Diffusion Sampler Team, 94 pp.

Nielsen, D.M., and Nielsen, G.L., 2006, Ground-Water Sampling, In: Nielsen, D.M. (ed.), *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring*, 2nd Edition, Taylor and Francis, Boca Raton, Florida, pp. 959-1112.

U. S. Environmental Protection Agency, Region 9 Laboratory, Richmond, CA, 09/2004, Field Sampling Guidelines, Document #1220, "*Groundwater Well Sampling*"

ASTM Method D4468-01 "*Standard Guide for Sampling Ground-Water Monitoring Wells*", ASTM 2013

13.0 APPENDICES

A – Table
B - Figures

APPENDIX A
Tables
SERAS SOP #2007
April 2015

TABLE 1. Acceptable Purging and Sampling Equipment for Contaminants of Concern

Equipment	VOCs	SVOCs	PCBs	Pesticides/Herbicides	Metals Plus Cyanide
Bailer	X	X	X	X	X
Peristaltic/Centrifugal Pump	X	X	3	3	3
Submersible Pump	3	1	1	1	1
Bladder Pump	1	1	1	1	1
Inertial Pump	X	X	X	X	X
Diffusion Sampler	1	3	X	X	X
Adsorption Sampler	2	2	2	2	X
Grab Sampler	2	2	2	2	2

X – Not recommended for definitive data
1 – Recommended method
2 – Useful with limitations
3 – Better methods exists

APPENDIX B
Figures
SERAS SOP #2007
June 2015

FIGURE 1. Bailer

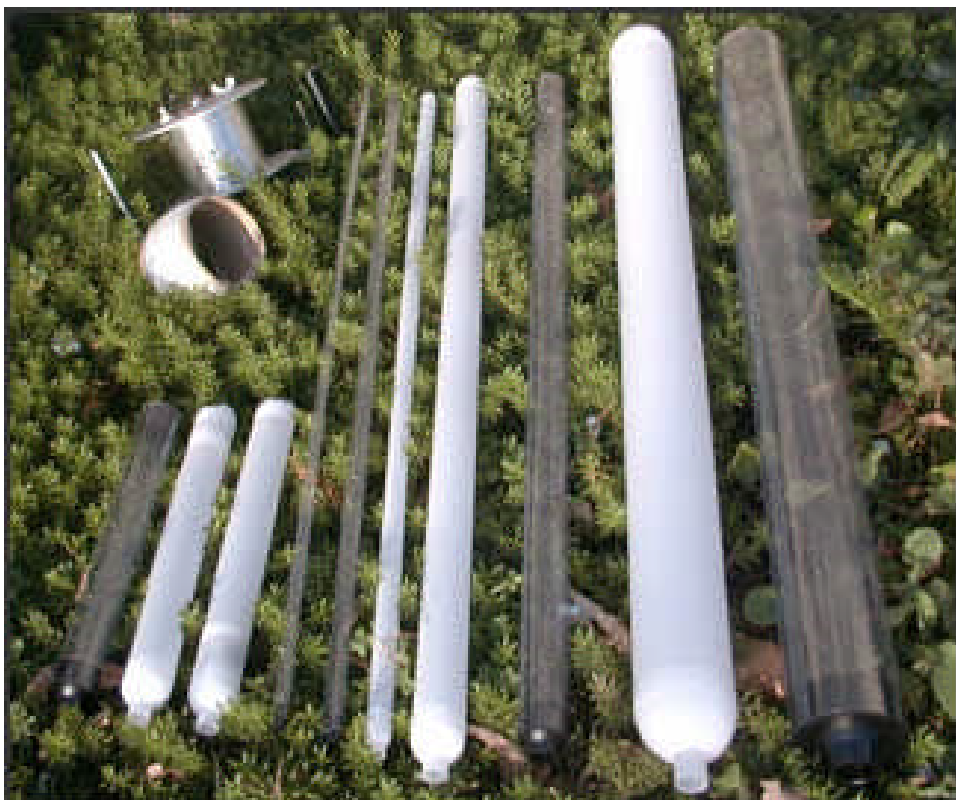

FIGURE 2. Grab-type Sampler

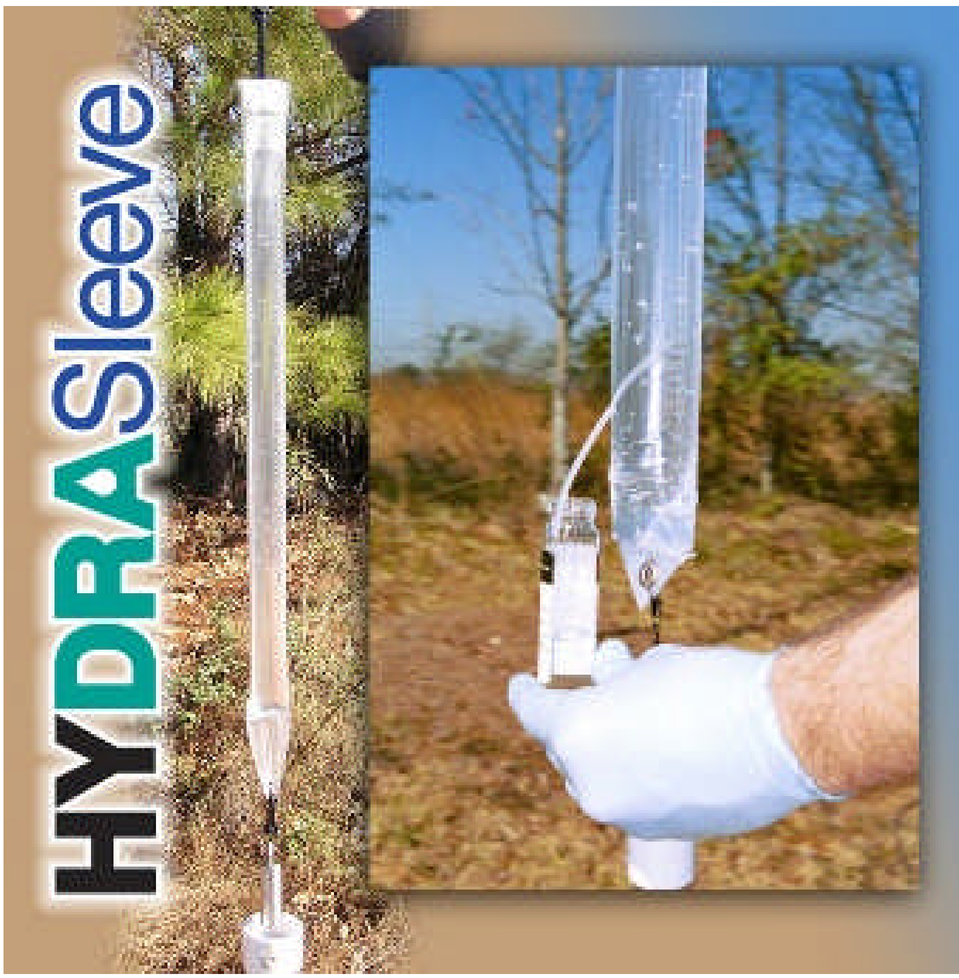

FIGURE 3. Diffusion-Equilibrium Sampler

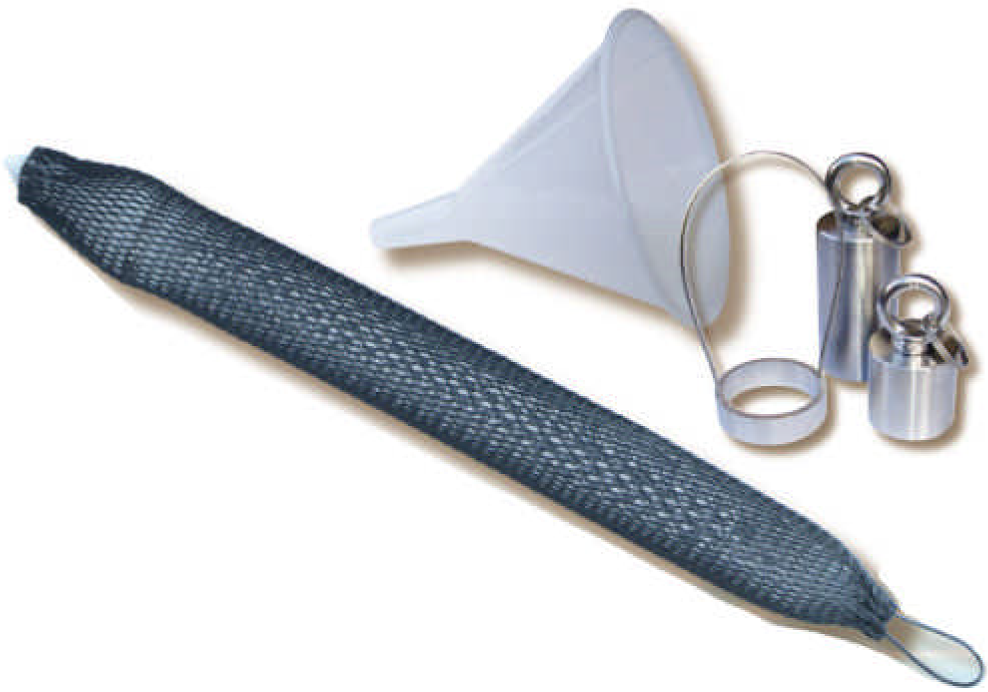

FIGURE 4. Bladder Pump

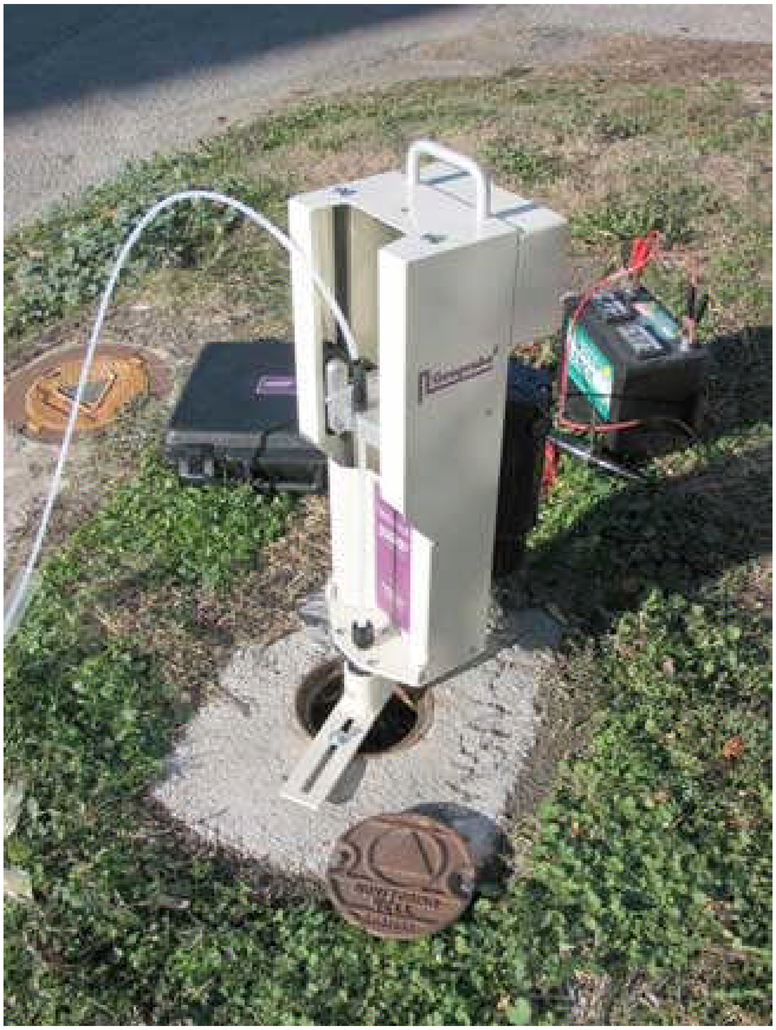

FIGURE 5. Gear-Driven Pump

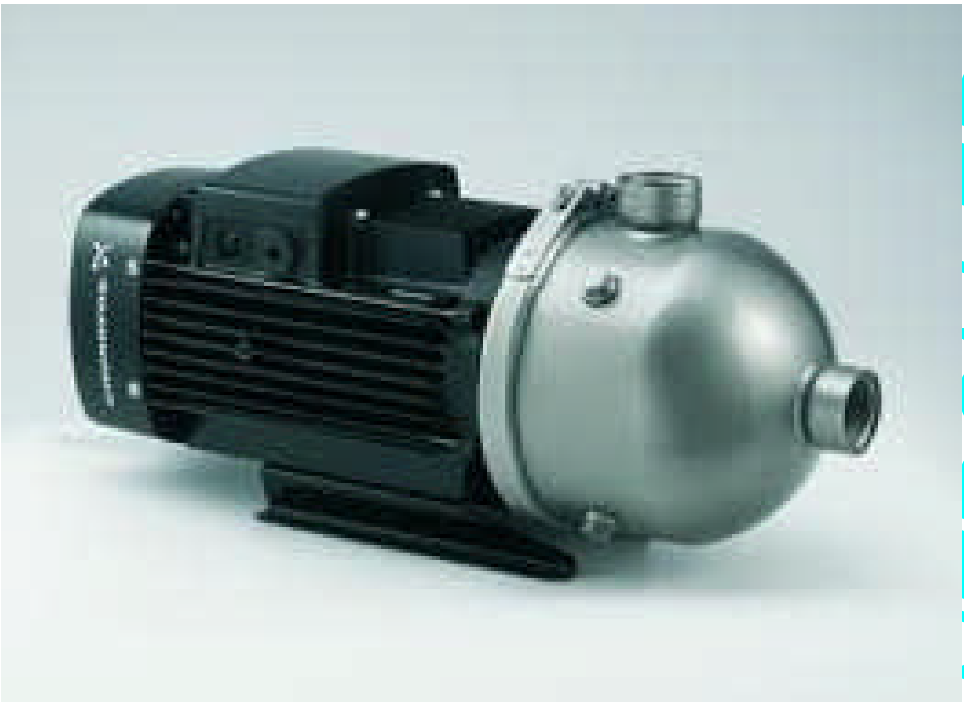

FIGURE 6. Centrifugal Pump

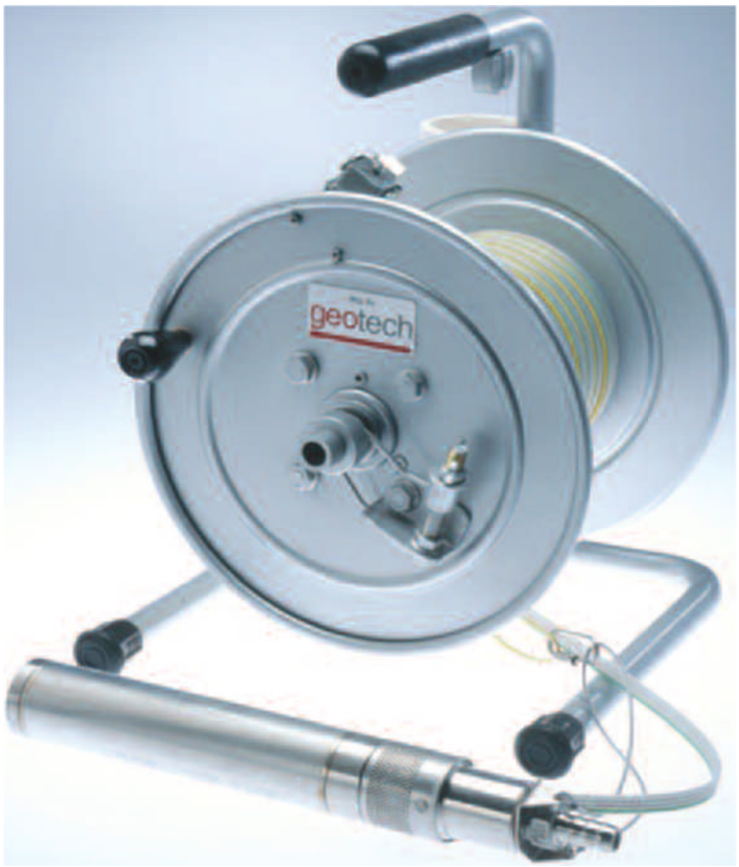

FIGURE 7. Peristaltic Pump

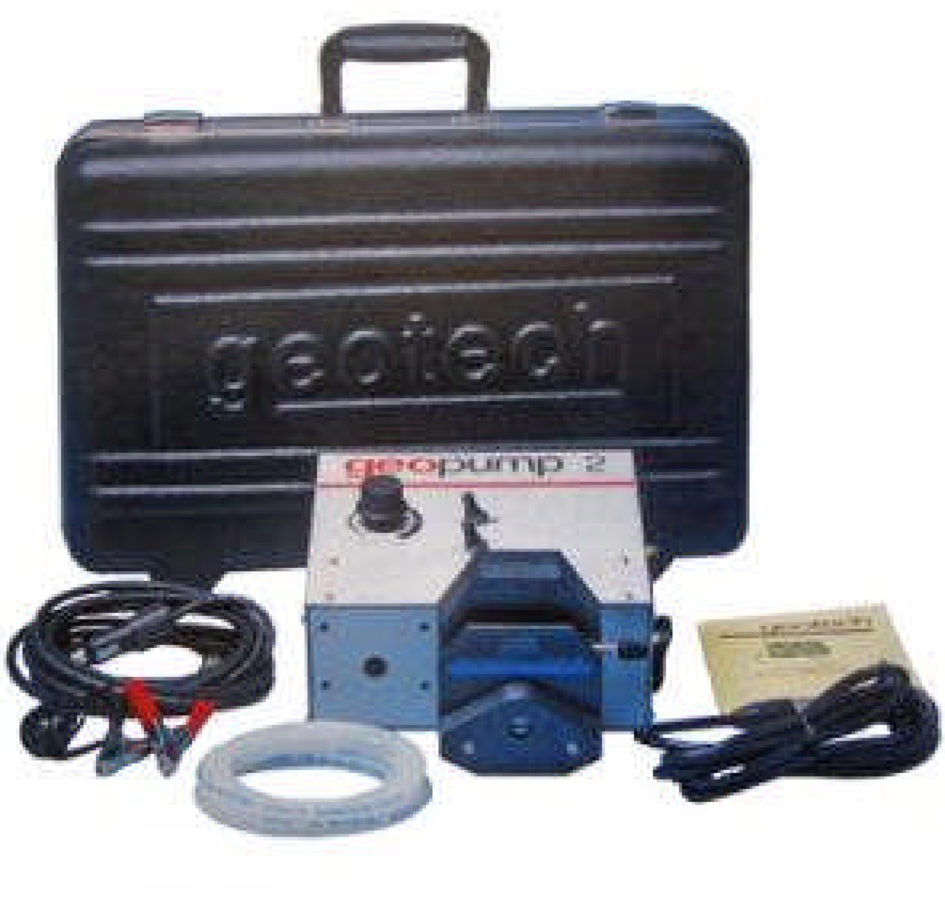

FIGURE 8. Diaphragm Pump

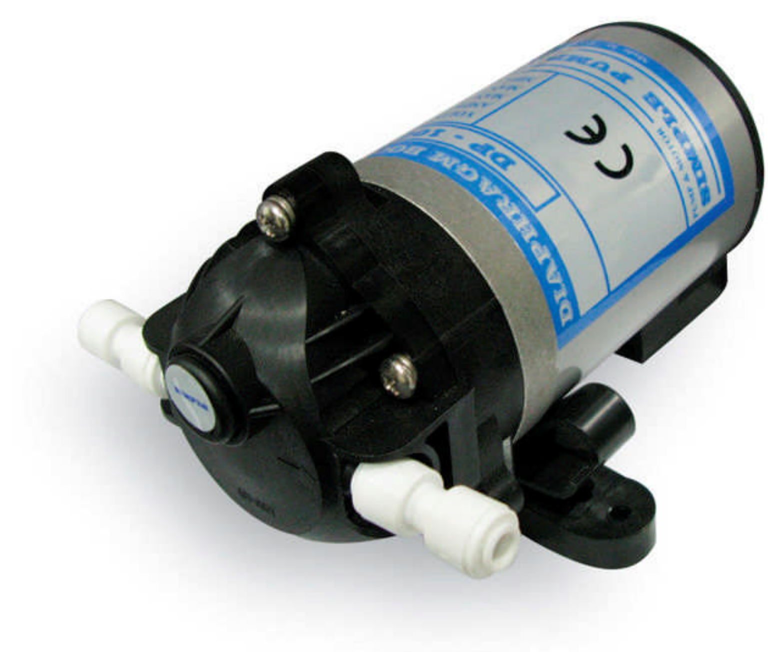

FIGURE 9. Foot-Valve Pump

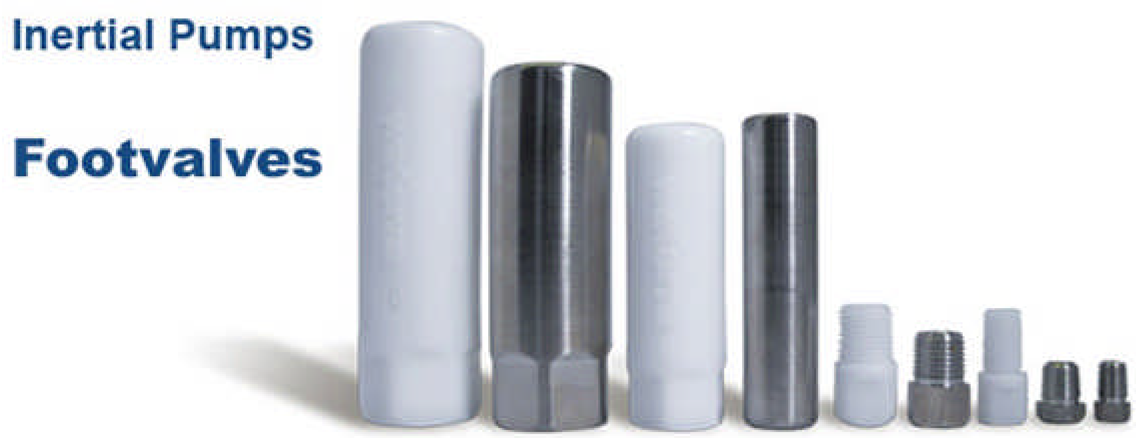

FIGURE 10. FLUTe Well System