Standard Operating Procedure:

Low-Flow Rate Purging and Sampling of Ground Water Monitoring Wells

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Introduction

Sampling of ground water for contaminants is typically done to achieve one of the following goals, several of which are interrelated:

- To investigate the presence or absence of contaminants
- To delineate a plume
- To determine the concentrations of contaminants at specific points in a plume at a given time
- To understand the transport and fate of contaminants in the system
- To carry out regulatory compliance monitoring
- To evaluate a treatment system through remediation performance monitoring

The common factor in achieving these objectives is that analytical data resulting from ground water samples must accurately represent the contaminant concentrations and geochemistry of the subsurface at the points in space and time where the samples were acquired. Assuming the well screen is properly located and the well is appropriately constructed, the idea is to remove a portion of the water that represents the water in the aquifer at that precise screened location on that date. To accomplish this goal the water must be removed from the aquifer with as little disturbance as possible. Numerous publications and guidelines exist to explain how disturbances to the sample can occur and the impacts of those disturbances, as well as the best techniques for collecting the samples with minimal disturbance. Several of these are provided in the References section of this SOP. This SOP assumes that sampling is being done from a properly constructed and adequately developed well.

Ground water samples can be damaged by aeration, mixing of the stagnant water in the well casing above the screened interval with the sample, the artificial entrainment of particulates pulled from the aquifer minerals or the sand pack (turbidity), and the loss of volatile dissolved compounds. All of these impacts can be caused by pumping water at a very high flow rate through the well screen and by using bailers, which induce surging in the well bore and require pouring or draining to collect the sample into containers for analysis. Low-flow purging and sampling technologies were developed to minimize these problematic issues and increase both accuracy and precision in sample collection.

Low-flow rate purging and sampling consists of a variety of concepts and processes designed to minimize disruption to the well, sand pack, outlying aquifer, and the

collected samples. These techniques are also generally designed to provide confirmation that the water being collected is representative of the formation water through the observation of sensitive indicator parameters. These processes, concepts and techniques include:

- Low pump rates, usually 0.1-0.5 L/min, with no bailers allowed
- Purging and sampling is always performed in the screened interval when standard monitoring wells are used
- Collects samples in the formation immediately adjacent to the well and pump (or tubing) rather than outlying waters
- Sampling follows stabilization of the most sensitive purging indicator parameters
- Dedicated pumps or tubes are desirable but not required
- Short screened intervals are preferred but longer screens can be sampled
- Typically the collected samples are not filtered[1]

The low pumping rates and the elimination of the use of bailers minimize artificial turbidity, aeration, mixing of different waters, VOC loss and outgassing, and reduce equilibrium shift in the water being collected, while maintaining any naturally mobile collidal particulates that might contribute to the total contaminant loading. Since waters are collected from the aquifer in the immediate vicinity of the well, better concentration data at that point are obtained.

The development of low-flow purging and sampling techniques increased the list of parameters that had been routinely monitored during high-speed purging, i.e., temperature, pH, and conductivity, to include DO, Eh, turbidity, and occasionally the contaminant of concern. Field research has shown that temperature, pH and conductivity are relatively insensitive parameters for indicating continuity with formation water compared with those added to the list (Puls and Powell, 1992). Flow-through cells are required during the purging because the DO & Eh (and occasionally pH) values immediately change upon exposure to the atmosphere, such as would occur in an open container. It is also important that all of these parameters be measured accurately when their readings become stabilized. This is due to their importance for understanding contaminant transport and fate, speciation, monitored natural attenuation, performance monitoring and geochemical modeling when used in conjunction with the laboratory analytical data. To accurately measure these parameters requires that all the electrodes within the flow-through cell be properly calibrated using manufacturer's guidelines. This requires little time, is very important, and provides both the person assessing the data and the client for whom data-based decisions will be made with a much better cost to benefit ratio.

[1] Filtration with differing pore size filters (0.1 nm, 1 nm, etc.) might be done in instances where the contribution of colloidal transport to total concentration is desired but this is not commonly done.

Equipment

This equipment list may not include all items needed, which would depend upon a variety of factors including weather, availability of power, analyses to be done in the field, etc., but lists the basic needs and provides a starting point for consideration of items that will be required when in the field.

- Detailed well location map
- Electronic water level tape
- Order of the well sampling (lowest to highest contaminant concentrations)
- Low flow peristaltic sampling pump or controllers for bladder pumps
- Bladder pump (if not dedicated bladder or dedicated tubing)
- Previous water level data
- Tubing (to be dedicated to each well)
- Replacement tubing for peristaltic pump head (single use) and tubing connectors as needed
- Sample bottles, ice chest, chain of custody forms
- Total well depth data
- Containers for purge water (if required)
- Low flow sampling data sheets
- Horiba u-22, u-23 water quality meter, or equivalent, including the flow-through cell
- Bound record book for recording meter calibrations and any issues (to be always kept with the instrument)
- Calibration solutions and instructions, spare DO membranes, etc.
- Cleaning solutions and deionized water
- Kimwipes® or other laboratory tissue
- Markers and pens, calculator
- First aid kit, steel toe boots, hard hat, eyewash bottle, disposable gloves

Procedure

1. Following manufacturer's instructions, calibrate the meter that will be used to collect the low-flow stabilization data. This should be done at least once per day prior to collecting samples and repeated if conditions warrant or should data appear to be overly noisy or otherwise suspect (e.g., DO and Eh not tracking together). Calibration should be done for pH, DO and turbidity. The Eh and conductivity probes should be tested for proper functioning using standardized

solutions and cleaned or replaced if necessary[2]. The DO membrane should be replaced occasionally based upon the manufacturer's guidelines or should calibration prove impossible. Bubbles must not be trapped under the membrane.

2. Sample the wells beginning with those having the lowest concentrations of the contaminants of concern and work up to those with the highest concentrations (if this information is known).
3. Observe the condition of the wellhead; the cover, the lock, the standpipe, any standing water, etc., and note observations of anything unusual on the data sheet for that well. Notes should be made regarding anything out of the ordinary throughout the entire sampling procedure.
4. Open the well carefully and be cautious to avoid any dirt, water, or other materials entering the casing. If anything does enter the casing, note this on the data sheet.
5. The depth to water for each well should be approximately known from well logs or previous sampling data. Carefully lower a clean electronic water level measuring tape into the casing until it signals that water has been reached. Raise and lower the tape slowly and carefully to ascertain that you have reached the water table; try to avoid disturbing the water below the surface. Note the depth to 0.01 ft of resolution on the data sheet and remove the tape.
6. Assuming the well contains either a dedicated length of tubing (within suction lift) or a dedicated pump (e.g., bladder pump), ascertain that the tubing/pump remains properly set at the correct depth for sampling (by whatever means this has been established at the site). Note any changes that are necessary.
7. Attach the tubing from the well to new tubing leading to the peristaltic pump or pump controller. The tubing attached to the peristaltic pump, pump controller, etc., must be replaced between wells.
8. Begin pumping the well at a very low flow-rate and calculate the volume pumped per unit time (using a graduated cylinder with stopwatch, or other reasonably accurate approach). Typically, 100 ml/minute is a reasonable initial pumping rate for wells that produce sufficient water having a five-foot or longer well screen. If production is unknown for the well, it can be useful to carefully measure the water level with the tape, while pumping, and track whether or not the cone of depression (drawdown) stabilizes with time. If drawdown doesn't occur to any appreciable extent, the pumping rate can be carefully increased. Effort should be made, however, to adjust the pumping rate so that the cone of depression does not enter the well screen. In fact, drawdown should be minimized to the extent possible to prevent stagnant casing water above the screened interval from being pulled into the screened interval. In a five-foot well screen it might be possible to pump at rates up to 1 L/min with minimal drawdown or disruption to the aquifer but this varies depending upon the specific circumstances. The key is not so much the degree of drawdown but that drawdown is stabilized above the screened interval and, in general, less drawdown is preferable to more drawdown.

[2] It is important and necessary to calibrate and check all the sensors prior to use because the final set of collected data (pH, Eh, DO, conductivity, turbidity and temperature) following stabilization will, in some cases, be used along with the laboratory data to understand the transport and fate, speciation, or natural attenuation of the contaminants present at the site. Data such as pH, DO and Eh are critical to the geochemical and transport and fate modeling required to assess these issues.

9. Stop the pump and place the flow-through cell containing the sensor electrodes, etc., into the flow-path (tubing) between the wellhead and the pump/pump controller. New tubing or connectors to the flow-through cell must be used between wells. Restart the pumping process at the pre-established flow rate and allow the flow-through cell to fill with well water, eliminating all headspace and bubbles from the cell prior to initiating measurements.
10. Begin collecting data from the sensors in the cell using either an automated data logger or by manually transcribing the readings displayed on the meter (follow manufacturer's guidelines for switching between parameter readings, etc.). Readings should be taken approximately every three to five minutes until they have stabilized. Stabilization guidelines are not absolute in terms of requirements and stabilization tends to be somewhat obvious to the operator observing the data as it proceeds. Guidelines are typically as follows:

    > *Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.*[3]

11. Upon stabilization, record all the final data for the flow-through cell parameters (pH, conductivity, Eh, temperature, DO, turbidity) and the flow rate at which they were collected.
12. Collect all samples as required by the parameters to be analyzed and the laboratory protocols. When collecting these samples avoid aeration of the collected waters by minimizing agitation of the sample vessels during collection and by maintaining the pump tubing as near the surface meniscus of the liquid in the sample collection bottle as possible while it fills. Follow all appropriate requirements for storage, tracking and submitting of the samples after collection.
13. Clean the electrodes and flow-through cell with an Alconox solution followed by multiple rinses with deionized water, or by following manufacturer's guidelines, prior to use at the next well.

References

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[3] Puls, Robert W., and Michael J. Barcelona, 1996. "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures." EPA Groundwater Issue, April 1996, 10 Pages. EPA/540/S-95/504

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