DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL (DNREC)
DIVISION OF WASTE AND HAZARDOUS SUBSTANCES (WHS)
REMEDIATION SECTION (RS)

Standard Operating Procedure for Groundwater Sampling and Faucet Delivery

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The purpose of sampling groundwater is to obtain unaltered representative samples from an affected aquifer. This includes the collection of groundwater samples from monitoring wells, direct push sampling equipment, and faucet delivery from a public or private water well used for drinking water. The list of contaminants and the data quality objectives (DQO) for the samples should be documented in either the Sampling and Analysis Plan (SAP) or Work Plan (WP).

The groundwater sampling procedures cover both active (pumping or purging) methods and passive (no purge) sampling. Both sampling methods can be used to collect groundwater samples and the methods selected should be outlined in the site-specific SAP or WP.

Variance from this SOP may be obtained from DNREC-RS by written request prior to sampling.

In general, the following steps should be performed at monitoring wells during each sampling event:

1. Arrive at the facility.
2. Don appropriate Personal Protective Equipment (PPE) per facility-specific Health and Safety Plan (HASP)
3. Check the condition of all wells (e.g., locked and properly sealed, note damage to protective well casing, note access issues, etc.).
4. Set up sampling apparatus (e.g., generators, pumps, passive devices, etc.)
5. Open all facility monitoring wells.
6. Perform organic vapor check, measure water levels and well depth.
7. Sample or measure non-aqueous phase liquids (NAPLs) as required.
8. Begin sampling procedure as described below.
9. Re-glove in preparation for laboratory sample collection
10. Collect laboratory samples as described below.
11. Decontaminate non-disposable equipment/dispose of waste/move equipment before moving to the next sampling location.

Sampling Equipment & Materials for Active Sampling:

- Pump of appropriate size (e.g., Submersible pump and controller)
- PTFE-lined or stainless-steel bailers (for potential light non-aqueous phase liquid- LNAPL)
- Analyte-appropriate tubing with check valve, if necessary
- Generator/Power source (battery)/Inverter
- 5-gallon bucket(s)
- Water quality instrument
- Photoionization detector (PID) or similar device
- Laboratory-provided sample bottles with appropriate preservatives, labels, and chain-of-custody
- Bailing twine or rope
- Water level meter
- In-line 0.45 µm filters
- Appropriate PPE (e.g., gloves, respirator, safety glasses, etc.)
- Field data sheets
- Field logbook
- Copies of the SAP or WP and HASP

Active Sampling Procedures: Monitoring Wells

➢ **Time Frame before sampling after well development:**

- Direct push wells: Forty-eight to seventy-two (48-72) hours
- Drilled wells: Seventy-two hours to one week (72 hours -1 week).

➢ **The following procedures are intended for the initial sampling event**. Volumetric purging is not recommended until the water quality parameters of the aquifer are established.

1. Refer to the Facility Health and Safety Plan (HASP) before proceeding with any work. Describe all work in the field logbook.
2. To reduce potential cross-contamination, the monitoring wells will be sampled from the least contaminated well to the most contaminated well, if information is known.
3. Calibrate any field equipment per the manufacturer's specifications and note the results in the field logbook.
4. Prior to sampling, all monitoring well headspace shall be measured for the presence of organic vapors using a PID or similar device. Any readings shall be noted in the field logbook or field collection data sheet, and activities shall proceed in accordance with the facility HASP.
5. Using a clean, decontaminated electric well sounder, measure the depth to water and depth to bottom in each monitoring well; then record levels in a field book.
6. Using a clean, decontaminated pump, remove water from the monitoring well until the water achieves stabilization based on water quality parameters. Equipment should be lowered into the well slowly and carefully to minimize aeration and avoid possible agitation of sediments in the bottom of the well or mixing of less dense contaminants in the well casing. The use of bailers to collect a sample should be avoided and should only be used to confirm the presence of LNAPL in a well. A summary of active sampling devices is listed in **Table 1** below with advantages and

limitations of each technology.

Table 1: Active Groundwater Sample Collection Technologies

Type	Advantages	Limitations
Bailer	Ease of use, no additional equipment required, collection of LNAPL	Disturbance of water column, not ideal for Volatile Organic Compounds (VOCs), limited volume, collects sample from top few feet of well, sample may not be representative of the aquifer
Bladder Pump	Minimal disturbance of water column, can be used in low yielding wells, can be used in deeper wells; tubing can be reused; ideal for all types of contaminants	Required bonded tubing, equipment can be cumbersome, cannot be used in very deep wells (see manufacturer specifications)
Inertial Pump	No external power to operate, can be used in narrow diameter or obstructed wells, can be used on low yielding wells	Disturbs water column, not ideal for deeper wells (±50 ft. bgs) or for large well networks, not ideal for certain contaminants
Peristaltic Pump	Minimal disturbance of water column, ease of use, can be used in low yielding wells, tubing can be reused, can collect continuous water quality data	Not ideal for VOCs, cannot be used in deeper wells (>20 ft), single-use tubing creates an abundance of investigation derived waste (IDW)
Submersible Pumps	Can be used in wells with variety of diameters and depths, can pump large volumes of water quickly, can pump very deep wells, can collect continuous water quality data	Not ideal for certain contaminants, difficult to use in low yielding or turbid wells, must decontaminate between uses

7. Measure the water level during purging to indicate well yield in relation to purging pump rate. Measure the purging rate by directing the pump discharge into a bucket, or container of known volume, and timing how long it takes to fill the container (e.g., 5-gallons in 30 seconds equals 10-gallons/minute).

    - If the water level drops during purging, lower the pump deeper into the well, and note that the purge rate exceeds the well yield. If a well is purged dry, please refer to **Special Condition A** below.

8. During purging, field measurements of selected parameters are performed. Measure the water quality parameters at the start of the purge and at regular intervals (for example: every 3-minutes), or as stated in the SAP, Work Plan, or other approved procedure, until three consecutive measurements achieve stabilization. Indicator parameters are presented in **Table 2** below. All measurements may be made simultaneously using a water quality meter. The priority water quality parameters for stability are temperature, pH, specific electrical

conductance, oxidation reduction potential (ORP), turbidity, and dissolved oxygen (DO), with any changes in visible quality or odor also being noted. If stability is not achieved after 30-minutes of pumping, additional water can be purged and water quality reading collected, until stability is reached. If stability still cannot be reached after 60-minutes, please refer to **Special Condition B** below. As each well is purged, the data collected will be compared to the other wells at a facility and with historical data whenever possible. Water quality data should be recorded in a field collection data sheet for each monitoring well where a sample is collected.

Table 2: Stabilization Criteria with References for Water Quality Indicator Parameters[1]

Parameter	Stabilization Criteria	Reference
pH	+/- 0.1	Puls and Barcelona, 1996; Wilde et al., 1998
specific electrical conductance (SEC)	+/- 3%	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	+/- 10 millivolts	Puls and Barcelona, 1996
turbidity	+/- 10% (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996; Wilde et al., 1998
dissolved oxygen (DO)	+/- 0.3 milligrams per liter	Wilde et al., 1998

9. While wearing fresh nitrile gloves, fill all appropriate sample bottles directly from the pump tubing. The samples shall be collected in accordance with the SAP, Work Plan, or other approved procedure. Every effort should be made to minimize the disturbance of the samples to reduce volatilization.
10. Groundwater samples should be preserved using the appropriate preservative in accordance with the Standard Operating Procedures for Chemical Analytical Programs (SOPCAP) under HSCA. ***Do not add preservatives prior to filtration of metals samples***.
11. Sample containers must not be rinsed with sample water before final filling due to the possible presence of floating, free phase products in the well, which can adhere to the sample container wall and bias the analyses.
12. **Metals:** Collect a sample for total and dissolved metals analysis if the well is being sampled for the first-time following installation. The portion for the dissolved metals analysis may be filtered in the field using a single-use 0.45-µm acrylic copolymer prepackaged, disposable in-line filter. The pump may be used to pump the groundwater through the in-line filter and into the sample container. To reduce the potential for redox reactions because of aeration, a very slow flow rate must be maintained (not to exceed 100 mL/minute). The collection of only total or dissolved metals must meet criteria presented in **Special Condition C** below.
13. **Volatile Organic Compounds (VOCs)**: Continue pumping at low flow rate (100 mL/min or less) for VOC sampling. Ensure that the sample collected for the analysis of volatile organic compounds (VOCs) does not contain headspace or bubbles. If any air bubbles are present, the sample must be re-collected using a fresh sample container with fresh preservative. All samples collected should be filled to the capacity required for analysis.

[1] USEPA (2002). Groundwater Sampling Guidelines for Superfund and RCRA Project Managers. Technology Innovation Office, Washington, DC.

14. Complete all sample labels or use pre-printed labels, affix labels to respective samples, and place the samples into a cooler with ice filled resealable bags (do not use loose ice) to maintain a sample temperature in accordance with SOPCAP.
    - Please take caution that ice meltwater does not inundate, damage, or loosen the samples and/or sample labels. Complete all relevant sample paperwork (e.g., tags, chain-of-custody form, etc.) depending upon the required analyses.
15. Decontaminate all non-disposable equipment used during purging and sampling.
16. Once all samples have been collected, pack samples for shipment to the laboratory for analysis.
17. Close and secure the well. Note in field book the conditions of the well and if any repairs or maintenance is needed.
18. After the analytical results have been received from the laboratory, the electronic data deliverable (EDD) should be submitted to DNREC-RS via DNREC's EQuIS Data Submittal process[2].

Special Conditions:

All special conditions should be noted in the field logbook and documented in reporting to DNREC. The conditions here should also be monitored and evaluated against previously collected data. If this is the first time sampling the well, well development data should be used to make these determinations. Many of the special conditions can be avoided through the use of passive samplers.

A. If at any time a well purges dry, record conditions in the field logbook, allow groundwater to recover to near static conditions in the well, and sample immediately without additional purging of any additional groundwater.
B. For a well that does not reach stabilization after sixty (60) minutes of pumping, a sample may be collected and after at least one (1) well volume has been purged. Please note in the field logbook which parameter(s) did not stabilize after sixty (60) minutes.
C. Despite well development and pre-sampling purging, ground-water samples are often turbid and analytical results may not be truly representative of dissolved contaminants in groundwater. This is a special concern when sampling for metals in groundwater. Therefore, groundwater samples collected in newly constructed wells should be sampled both for total metals and dissolved metals analysis prior to submission to the laboratory. Sampling for both provides a quality check of well development and water quality as a whole, as well as for the dissolved phase for metals.

[2] https://dnrec.alpha.delaware.gov/waste-hazardous/equis/

Considerations for direct push groundwater sampling:

- Groundwater data collected (grabbed) directly from direct-push sampling equipment are typically used **for screening purposes only**, and the data should not be considered appropriate for risk assessment purposes.
- Groundwater may be collected directly from direct push sampling equipment using either dedicated tubing fitted with a check-valve, small diameter bailer, or a peristaltic pump.
- Purging multiple well volumes is useful to lower turbidity in the sample. However, under certain circumstances (such as limited groundwater availability), this may not be possible. The amount of purge volume shall be noted in the field logbook for all sampling locations.
- When using the tubing check valve approach to obtain a sample from the direct push equipment:
  1. first oscillate the tubing to fill the tube,
  2. then smoothly and quickly pull the tubing out of the sampler while rolling up the tubing.
  3. Remove the tubing check valve from the lower end of the sample tubing.
  4. Next, drain the sample from the lower end of the tubing directly into the vials.

  This procedure will minimize disturbance of the sample, especially for volatile compounds.

- **Non-Aqueous Phase Liquid (NAPL) Measurement** - NAPL can usually be detected and sampled with the tubing check valve assembly in direct push equipment. To detect and sample NAPL:
  1. first thread the check valve into the lower end of the tubing but leave out the check ball.
  2. Smoothly lower the tubing with the check valve down the bore to the bottom of the equipment.
  3. Then, from the surface, drop the check ball down into the tubing.
  4. Allow enough time for the check ball to reach the bottom of the tubing.
  5. Then quickly and smoothly oscillate the tubing up and down two (2) or (3) times to seat the check ball in the check valve.
  6. Firmly pinch the top of the tubing and smoothly and quickly pull the tubing out of the equipment.
  7. Visually check the tubing at the water level and at the base of the tubing for any NAPL.
     a. In coarse grained formations, only a few minutes or a couple of hours may be required to have NAPL collect in the direct push equipment.
     b. In fine-grained formations, it may be necessary to leave the direct push equipment installed overnight to allow NAPL to collect.
- Appropriate decontamination procedures must be used between sampling locations to eliminate the potential for cross contamination and incorrect data results.

Passive Sampling:

The use of passive samplers to collect environmental groundwater samples has gained wide-spread acceptance due to the ability to reduce short and long-term labor costs, equipment costs, and IDW to collect samples. Many of the samplers are considered more sustainable for long-term monitoring than equipment deployed during active sampling methods. The type of passive sampling technology should be carefully considered to meet the needs of the project DQOs. A comparison of sample analytical results may be required at facilities that employed active sampling methods at the beginning of the project life cycle before exclusively switching to passive methods. Additional decision-making considerations for using or switching to passive sampling may include, facility-constraints, required sample volume, analyte constraints of the technology, and equilibrium or sorption time constraints. Please consult the Interstate Technology Regulatory Council (ITRC) passive sampling technology document for additional information. Examples of passive groundwater sampling technologies including advantages and limitations are included in **Table 3** below.

When considering passive sampling for a project, the considerations below should be followed:

- If sampling requires a switch from active to passive methods, a data comparison analysis may be needed. The DNREC project officer should be consulted about any data comparison methods used to evaluate the previously collected data and the data collected using passive samplers.
- Some types of passive samplers require additional procedures that may be outside of the SOPCAP to calculate an analytical value. These procedures should be submitted to DNREC for review by a chemist prior to deployment of the sampling device.
- Any residence time requirements of passive samplers need to be documented in the SAP or WP.
- Any non-conformance issues should be communicated to the DNREC project officer.
- All sampler manufacturer's procedures should be followed when using or deploying the device to collect an appropriate sample.

Passive sampling technologies are classified into three categories based on the collection method.

1. **Grab samplers**: are devices that capture groundwater along with the contaminants and are a representation of conditions at the sampling point at the moment of sample collection.
2. **Equilibrium samplers**: are devices that rely on the device to reach and maintain equilibrium with groundwater. Some samplers in this class are time-weighted toward conditions at the sampling point during the latter portion of the deployment period.
3. **Accumulation samplers**: are devices that rely on diffusion and sorption to accumulate analytes from the groundwater. Samples are a time-integrated representation of conditions at the sampling point over the entire deployment period.

The passive technologies that can be deployed in groundwater monitoring wells are listed below in **Table 3**. Many of these devices can also be deployed to other aqueous media including surface water. In general, these technologies are relatively easy to use, can reduce sampling variability, reduce field time for sample collection, and eliminate the need for purge water treatment or disposal. Some of the technologies can also be used at discrete intervals from within the monitoring well and assist in vertical profiling. For the best results in groundwater monitoring wells, the samplers need to be deployed to the screened interval of the well. In the case of open bore hole wells with known areas of interest (fractures), the sampling device shall be deployed to the area of interest (i.e., fracture). Accumulation type samplers are best for the collection of data used for ecological risk assessments.

Table 3: Passive Groundwater Sample Technologies by Collection Methods

Type	Advantages	Limitations
Grab Type Samplers		
HydraSleeveTM	Can be used for a wide variety of contaminants, can be used in deeper wells, can be used in low yielding wells, can be used in all phases of remedial sampling, good for inorganics	Can only be deployed to one inch or larger diameter wells, sample volume is limited by screen length, larger sleeves require additional people or equipment to sample
Snap Sampler®	Can be used for a wide variety of contaminants, can be used in deeper wells, can be used in low yielding wells, can be used in all phases of remedial sampling, good for inorganics, less IDW	Can only be deployed to two inch or larger diameter wells, sample volume limited to 1.5-2.1 Liters and screen length, can be a cumbersome device
Equilibrium Type Samplers		
Ceramic Filter	Can be reused after decontamination, no depth limit in wells, wide range of contaminants can be sampled	Limited sample volume, can be expensive, contaminants limited by the filter pore size
Dual Membrane PDB	Can collect more contaminants than regular passive diffusion bags, can collect water quality parameters	Sample volume, requires extended deployment time (up to 3 weeks), extra care in sampler handling, not recommended for turbid wells
Nylon Screen Passive Diffusers	Easily deployed to groundwater wells, little IDW, samplers can be reused	Limited sample volume, limited number of contaminants
Passive Diffusion Bag (PDB)	Can monitor multiple zones in a water column, can reuse sampler, reduces interference from turbidity, easy to deploy, less IDW, effective for long-term monitoring	Cannot detect certain contaminants, must use carefully in wells with high hydraulic conductivity, not suitable for initial sampling or rapid response, sample collection time period may vary by COCs and/or DQOs
Peeper sampler	Devices are easily deployable; the devices are generally contaminant-specific including PFAS	Technology can be expensive, limited to larger (>2-inch) diameter wells, may need several sampling devices for multiple contaminants

Type	Advantages	Limitations
Regenerated-cellulose dialysis membrane (RCDM)	Can collect more contaminants than regular passive diffusion bags, can collect water quality parameters	Not commercially available, once constructed the sampler must stay hydrated, deployment can be cumbersome
Rigid Porous Polyethylene Sampler (RPPS)	Can be reused after decontamination, no depth limit in wells, wide range of contaminants can be sampled	Limited sample volume, can be expensive, contaminants limited by the filter pore size, limited to larger (>2-inch) diameter wells
Accumulation Type Samplers		
DGT® Sampler	Can achieve low detection limits, good for turbid wells	Not available for many contaminants
Min Traps®	Designed for inorganics, excellent for use in determining performance of certain remedial measures	Can produce "false negative results", oxidation of certain minerals can occur
Polar Organic Integrated Sampler (POCIS)	Good for turbid wells, reusable after decontamination	May not be appropriate for all contaminants due to residence time
Semi-Permeable Membrane Devices (SPMDS)	Can achieve low detection limits, good for turbid wells	Can develop biofilms which can interfere with extraction in the lab, not ideal for short deployment times

Investigation Derived Waste (IDW) Management

The management of IDW should be included in the SAP or WP prepared for the facility. The management plan should indicate how all solid and liquid wastes will be generated, stored, treated, or disposed of in accordance with all Federal, state, and local laws. Steps should be taken to minimize cross-contamination or adding waste streams they may affect the classification of the generated wastes. Additionally, strategies can be employed to reduce or eliminate IDW altogether. Any novel approaches to the reduction or elimination of IDW should be discussed with your DNREC-RS project officer.

Groundwater Sampling Procedure for Faucet Delivery

Groundwater samples can be obtained from private domestic wells, public water supply wells, industrial supply wells, agricultural or irrigation wells or other wells specifically designed to deliver a continuous water supply to the consumer. The data collected from these samples serve to identify risks posed to certain groundwater pathways created by the well. The collected data can also be used to assist in plume delineation.

Equipment:

Sample bottles with labels, nitrile gloves, appropriate writing implement, field logbook, water quality meter, hose, chain of custody, field paperwork including the SAP, WP, and/or HASP.

Procedures:

1. Locate well location(s) on the DNREC NavMap page[3]. For any public wells to be sampled, also consult with the DNREC-RS project officer. The location(s) for sampling should also be indicated in the site-specific SAP or WP.
2. Sketch the building characteristics, buildings, direction, land use and other pertinent observations in the field logbook.
3. From the well location (or information obtained from the DNREC NavMap page), record information about the well including; well ID, well type, and well/facility setting information, age of well, depth, pressure tanks, treatment system, well driller's log lithologies, any past water analysis, odor/taste/corrosion problems, type and age of piping, septic systems, buried fuel tanks, surrounding land uses and other pertinent information. A short interview with the well owner is also recommended. Record this information in the field logbook.
4. Collect the sample from the first available sampling point after the well. Avoid a sampling point following any treatment or storage tank, if possible. Remove any attachments to the sample location with as little contamination as possible. If required, attach a hose to the sample location if possible. For the initial sampling event, measure water quality parameters as presented in the monitoring well sampling section.
   Note: If access is not granted into the home or building, a sample can be collected from an outdoor spigot. These locations generally by-pass any treatment on a private domestic well or miscellaneous public well; however, the sampling team should verify with the well owner. If the treatment bypass of an outdoor spigot cannot be confirmed, take all precautions to preserve or treat the samples collected to ensure a properly preserved and/or treated sample is sent to the laboratory.
5. Turn on the valve at the sample location and estimate the discharge. If sampling from a sink, make sure you are sampling cold water.
6. Note starting time and monitor water quality parameters in the field logbook. Once stabilization is achieved, decrease the discharge to create a non-turbulent flow.
   Note: During subsequent sampling events, you may use a timed approach for purging.
7. Record all samples and procedures in field logbook.
8. Affix labels to all samples and handle appropriate chain of custody requirements.
9. After the analytical results have been received from the laboratory, the electronic data deliverable (EDD) should be submitted to DNREC-RS via DNREC's EQuIS Data Submittal process.[4]

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[3] https://dnrec.maps.arcgis.com/apps/webappviewer/index.html?id=573d0ba17dd04c0eb2d7a8f15f74f5d
[4] https://dnrec.alpha.delaware.gov/waste-hazardous/equis/