Appendix D
Brookhaven National Laboratory
Low Purge Volume Groundwater Sampling Protocol

BROOKHAVEN NATIONAL LABORATORY ENVIRONMENTAL MONITORING PROCEDURE	Procedure No. **EM-SOP-302** Revision No. **0** Page 1 of 10

Groundwater Sampling Procedure – Low Flow Purging and Sampling Using Dedicated Bladder Pumps

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1.0 PURPOSE

To establish guidelines for the sampling of groundwater monitoring wells utilizing dedicated bladder sample pumps and low flow/low volume purging and sampling methods.

2.0 SCOPE

This procedure applies to the collection of routine groundwater samples for the BNL Environmental Monitoring and Environmental Restoration Programs. The procedure is appropriate for the collection of groundwater samples that will be analyzed for dissolved volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, radionuclides and water quality. This procedure does not apply to sampling the HFBR horizontal groundwater monitoring wells. Alternative sampling methods may be employed on a case-by-case basis (i.e., purging of three casing volumes, use of bailers, or different pumping systems). Alternative methods must be described in an approved Sampling and Analysis Plan.

3.0 DEFINITIONS

3.1 Environmental Restoration (ER) Program: Groundwater monitoring related to BNL Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) activities (e.g., Remedial Investigations, Pre- and Post Record of Decision).

3.2 Environmental Monitoring (EM) Program: Groundwater monitoring related to compliance with DOE Orders and New York State permits.

4.0 EQUIPMENT

4.1 Geoguard7 or equivalent bladder sample pump (dedicated to well).

4.2 Geoguard7 or equivalent gasoline engine driven compressor.

4.3 Geoguard7 or equivalent automatic cycle controller.

4.4 Air line controller/compressor.

4.5 Air line controller/splitter.

4.6 YSI7 or equivalent water quality meter (with pH, temperature, conductivity, dissolved oxygen probes).

4.7 YSI7 or equivalent flow through cell and discharge lines.

4.8 Slope Indicator Co.7, Model 51453 or equivalent electronic water level meter.

4.9 Richter7 Model 89401 or equivalent stainless steel measuring tape and weight.

4.10 Trip blanks (required when taking VOC samples).

4.11 QED7 or equivalent in-line 0.45 μm filters (when required for filtered metals analysis).

4.12 Cooler with ice and thermometer.

4.13 Water proof field notebook and BNL Groundwater Sampling Log sheets.

4.14 BNL Chain-of-Custody forms.

4.15 Black ballpoint pens.

4.16 Calculator.

4.17 Disposable, powder-free vinyl gloves.

4.18 Plastic bags (including sealable bags for samples).

4.19 Paper towels.

4.20 Micro7 or equivalent non-phosphate laboratory grade detergent.

4.21 Distilled/deionized water.

4.22 BNL monitoring well key.

4.23 Personnel protective equipment (as required by the project Health and Safety Plan).

4.24 Sample containers (per project Sampling and Analysis Plan).

4.25 Sample container labels.

4.26 Calibrated buckets.

5.0 RESPONSIBILITIES

BNL and contractor field sampling personnel shall be responsible for collecting groundwater samples; measuring water quality parameters (e.g., pH, conductivity, temperature); operating, maintaining, and calibrating associated equipment as described in this procedure, and for the proper handling of purge water.

6.0 GENERAL INFORMATION

6.1 This procedure does not apply to the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples.

6.2 Groundwater sampling following this procedure shall be performed using dedicated stainless steel/Teflon7 or PVC/Teflon7 bladder sample pumps fitted with Teflon7-lined polyethylene discharge tubing.

6.3 Dedicated sample pumps shall be positioned within the well=s screened section. For wells screened below the water table, the intake section of the dedicated sample pump should be set at the midpoint of the well screen. For wells screened across the water table, the pump should be set in the lower 1/3 of the screened interval. In instances where contaminants may be residing close to the water table, it may be necessary to raise the sample pump intake to within two to three feet of the water table during sampling. Refer to the appropriate Sampling and Analysis Plan for details.

6.4 Compressors or generators shall be situated down wind of the monitoring well being sampled.

6.5 Disposable, powder-free gloves shall be worn by personnel during any contact with compressor, generator or associated fuel.

6.6 Clean, disposable gloves shall be worn when handling any dedicated or decontaminated sampling equipment, sample containers, and during the collection of samples. See appropriate Health and Safety Plan for precautions on the type of gloves required.

6.7 All non-dedicated sampling and measuring equipment must be decontaminated before use.

6.7.1 At a minimum, equipment should be disassembled (when appropriate) and scrubbed in a non-phosphate, laboratory grade detergent and distilled water solution, then rinsed with copious amounts of distilled water.

6.7.2 If sampling request is not part of either the ER Sitewide Groundwater Sampling and Analysis Plan or the EM Groundwater Sampling and Analysis Plan check with the project specific Sampling and Analysis Plan to determine if other chemicals must be used for decontamination procedures (e.g., hexane, isopropanol, nitric acid).

6.8 All sample vials and containers shall be stored in a clean carrying case. Remove the sample containers only when needed.

6.9 Unless otherwise noted in the ER Program Sitewide Groundwater Monitoring Sampling and Analysis Plan or EM Groundwater Sampling and Analysis Plan, purge water shall be disposed of on the ground at least 20 feet from the monitoring well. If purge water requires treatment at the wellhead and/or containerization, follow the procedures noted in EM-SOP-800 and EM-SOP-802.

6.10 Field analysis equipment (e.g., YSI7 instrument sonde with pH, conductivity, temperature turbidity and dissolved oxygen probes) shall be calibrated in accordance with the manufacturer's procedures (see procedure EM-SOP-101). All calibration methods, procedures and results shall be documented in the calibration log.

7.0 INSTRUCTIONS

7.1 Document the date, well identification, and unusual occurrences in the field logbook and on the Groundwater Sampling Log (see Attachment 1). Document all field measurements on the Groundwater Sampling Log.

7.2 Inspect the protective casing and general well condition and document any items of concern in the appropriate area on the Groundwater Sampling Log.

7.3 Unlock the protective casing. If the well is not vented, allow several minutes for the water level to equilibrate. Refer to the appropriate Health and Safety Plan for air monitoring or other health and safety requirements. If fumes or gases are present, call the project hydrogeologist/manager and have the situation diagnosed by the Industrial Hygiene (IH) Group. Avoid breathing any fumes or gases emanating from monitoring wells.

Note: If it is necessary to place any sampling equipment on the ground a clean sheet of plastic shall be spread out near the well to prevent contact between the equipment and the ground surface.

7.4 Measure the depth to water (DTW) from the measuring point (MP) located on the well (inner) casing using an electronic measuring device.

7.4.1 Record the DTW from the MP (DTW_{MP}) measurement on the Groundwater Sampling Log.

7.4.2 To determine the DTW from land surface (DTW_{LS}), subtract the well stickup height from the DTW_{MP}. As required, the water level measuring device can be left in the well for additional measurements during well purging.

7.5 Check Sampling and Analysis Plan to determine whether the dedicated sample pump needs to be repositioned. In some shallow wells, where contaminants may be residing close to the water table, it may be necessary to raise the sample pump intake to within two to three feet of the water table during sampling. This applies only to wells screened across the water table.

7.5.1 If the pump needs to be repositioned, a calibrated stainless steel measuring tape or a water level meter can be used to determine the position of the top of the bladder pump. Compare this measurement with the previously collected DTW_{MP} measurement, and raise the pump to the proper position below the water table and properly secure the air/discharge line at the wellhead. Repositioning of the pump should be done slowly to reduce water turbulence in the well.

7.6 Purge Volume Determination

7.6.1 Minimum Purge Volume: A minimum of two times the volume of the sample pump and tubing shall be purged prior to the sampling of the well to insure that any stagnant water from the last sampling event has been removed from the pump and tubing. Determine the diameter of the discharge tubing. Depending upon the tubing diameter, use Attachment 2 or Attachment 3 to determine the

minimum purge volume. The purge volumes presented in Attachments 2 and 3 are based upon the diameter and length of the bladder pump discharge tubing (based upon a pump position in the mid-section of the well screen). The calculation for determining this volume of water to be removed from the pump and tubing is as follows:

$$PV_{min} = [\text{Pump Volume} + (TL \times TF)] \times 2$$

where:

PV_{min} =	The minimum volume of water to be purged from a well.
Pump Volume =	0.14 gal (550 ml) for standard 44-inch long pump (or pump volume of 0.29 gal [1.1 liter] for 80-inch long pumps).
TL =	Tubing Length, see Attachments 2 and 3 (in feet).
TF =	Tubing Factor which is 0.0102 gal/ft (39 ml/ft for tubing diameter of 2 inch) or 0.0159 gal/ft (60 ml/ft for tubing diameter of 5/8 inch).

Determine the depth to middle of the screen zone and identify the appropriate PV_{min} on Attachment 2 or 3. Note this value on the Groundwater Sampling Log.

7.6.2 Maximum Purge Volume: The maximum purge volume for most wells will be 0.25 (1/4) of one well casing volume. For some shallow wells, the PV_{min} may be ∃0.25 casing volume. In these cases, the PV_{min} shall be purged followed by measurement of field parameters and collection of samples (see Section 7.9). The maximum purge volume (PV_{max}) is calculated as follows:

$$PV_{max} = (DTB - DTW_{LS})\, F_c \times 0.25$$

where:

PV_{max} =	One quarter of one well casing volume (gal).
DTB_{LS} =	Depth to Bottom from Land Surface (feet)
DTW_{LS} =	Depth to Water from Land Surface (feet)
F_c =	Casing factor, see Table 1 (gal/ft)

Table 1: Casing Factor (F_c)

Well Diameter (inches)	Casing Factor (gal/ft)
2	0.162
4	0.652

7.7 Set up flow-through cell and water quality meter. Note: attach discharge tubing to the bottom of the flow-through cell (fill from bottom up). The flow-through cell will allow for continuous water quality readings.

7.8 Begin purging the well according to the manufacturer's instructions for operating the bladder pump (Attachment 4). The purge rate should be kept to a minimum, preferably less than 0.25 gal/minute (~1.0 liter per minute). Variation in the purge rate should be minimized.

7.9 Following the removal of the minimum purge volume, begin monitoring the field water-quality parameters (i.e., redox, specific conductance, pH, dissolved oxygen and turbidity). If the minimum purge volume (PV_{min}) is $\exists$ 0.25 casing volume (PV_{max}), purge the minimum volume and begin monitoring the field water quality parameters. Monitor the indicator parameters approximately every two minutes (approximately every 0.5 gal.) and record the results on the Groundwater Sampling Log. (Note: A minimum of 500 ml of purge water is required to fully exchange the water in the flow-through cell between measurements.) The well shall be considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows:

$\forall$ 0.1 Standard Units for pH
$\forall$ 10 mv for redox
$\forall$ 3 % for specific conductance
$\forall$ 10 % for DO and turbidity

(Note: Turbidity shall be considered stabilized after three consecutive measurements of <10 NTU. Record the final water temperature measurement on the Groundwater Sampling Log.)

If one or more key indicator parameters fail to stabilize after purging 0.25 well casing volumes (the maximum purge volume), purging will be discontinued, and sampling will be initiated. In cases where the calculated minimum purge volume is ∃ 0.25 casing volume, monitor the indicator parameters following the removal of PV_{min} approximately every two minutes (approximately every 0.5 gal.) for a maximum of six minutes (i.e., three sets of readings). Any parameters, which fail to achieve stabilization, should be noted on the Groundwater Sampling Log.

7.10 Turn pump off and disconnect the flow through cell. Turn pump on and reduce the dedicated pump flow rate to the minimum capabilities of the pump (approximately 100 milliliters per minute or less). Collect the appropriate samples from the (dedicated) pump discharge hose. Sample analytes and frequencies are as noted in the ER Program Groundwater Sampling and Analysis Plan or the ES Program Groundwater Sampling Plan (including QA samples).

7.11 If the sample requires filtering (i.e., a sample collected for dissolved metals analysis), use a QED7 or equivalent in-line filter. Refer to the appropriate Sampling and Analysis Plan for details. Pump approximately 100 ml of water through filter prior to sampling.

7.12 Upon the completion of sampling, decontaminate all non-dedicated sampling and measuring equipment. Properly discard all non-cleanable materials such as gloves, hoses and rope. All equipment not decontaminated in the field should be wrapped in plastic.

7.13 Secure and lock the well.

7.14 Deliver samples to the appropriate analytical laboratory. Record all final field water quality data on the Field Data Summary Sheet. A copy of the COC and Field Data Summary Sheet should be sent to the Environmental Information Management System custodian for data entry.

8.0 RECORDS

All groundwater sampling documents shall be maintained in the appropriate ERD or ESD project files in accordance with BNL Records Management Program requirements.

9.0 REFERENCES

9.1 United States Environmental Protection Agency Region II, Groundwater Sampling Procedure, Low Stress (Low Flow) Purging and Sampling (March 16, 1998).

9.2 BNL Environmental Restoration Program, Sitewide Groundwater Monitoring Program Sampling and Analysis Plan.

9.3 BNL Environmental Monitoring Program, Facility Groundwater Monitoring Program Sampling and Analysis Plan.

9.4 BNL Groundwater Monitoring Program Quality Assurance Project Plan.

9.5 BNL Assessment of a Low Purge Volume Sampling Technique for the Collection of Groundwater Samples (April 1, 1999).

9.6 This procedure was previously issued as BNL Environment, Safety and Health Services Division Procedure EM-SOP-25.

9.7 BNL Health and Safety Plan for Routine Environmental Sampling.

9.8 BNL Environmental Monitoring Procedure 101, Environmental Sampling.

9.9 BNL Environmental Monitoring Procedure 800, Waste Container Inventory Control.

9.10 BNL Environmental Monitoring Procedure 802, Purge Water Disposition and Radionuclide/Volatile Organic Compound Treatment.

10.0 ATTACHMENTS

10.1 Attachment 1 - Groundwater Sample Log.

10.2 Attachment 2 - Minimum Purge Volume Calculation Chart for Bladder Pumps Fitted With 0.5 Inch Discharge Tubing.

10.3 Attachment 3 - Minimum Purge Volume Calculation Chart for Bladder Pumps Fitted With 0.625 Inch Discharge Tubing.

10.4 Attachment 4 - Geoguard System Operation

Attachment 1
BNL Groundwater Sample Log

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Sample ID (COC#-UID)_____ Well ID_____ Date ____/____/____

Sampling Personnel_____ Project_____ WQ Inst#_____

Well Depth (ft)_____ Screen Interval (ft)_____ Well diameter (in)_____

Sampling Device_____ Discharge Tubing Size_____

Depth to Water from MP (ft)_____ Casing Stickup_____

Depth to Water from LS (ft)_____ One Casing Volume (gal)_____

Pump Start Time_____ Pumping Rate (gpm)_____

Minimum Purge Volume (gal)_____ Maximum Purge Volume (gal)_____

Time	Volume Purged (g)	DO (mg/L)	PH (SU)	Turb (NTU)	Cond (uS/cm)	Redox (mv)	Comments
		+/- 10 mv	+/- 3%	+/- 10%	+/- 0.1 SU	+/- 10%	Final Water Temperature (^{0}C)
							Sample Collect Times
							Voc:
							WQ:
							Semi-VOC:
							Metals:
							Tritium:
							Gamma:
							Gross A/B:
							Sr-90:
							Other:

Purge Water Disposition_____

Comments_____

	Good	Poor	Replace	Comments
Paint Condition				
Pad				
Lock				
ID Tag				
Discharge Tube				
Fittings				
Sample Pump				
Purge Pump				

NS = Not Scheduled NA = Not Applicable

Attachment 2
Minimum Purge Volume Calculation Chart for Bladder Pumps Equipped with 0.5 (1/2) Inch Diameter Discharge Tubing[a]

Depth to Mid-Screen (ft.)[b]	Minimum Purge Volume		Depth to Mid-Screen (ft.)[b]	Minimum Purge Volume	
	Liters	Gallons		Liters	Gallons
5	1.5	0.4	**155**	13.2	3.5
10	1.9	0.5	**160**	13.6	3.6
15	2.3	0.6	**165**	14.0	3.7
20	2.7	0.7	**170**	14.4	3.8
25	3.0	0.8	**175**	14.7	3.9
30	3.4	0.9	**180**	15.1	4.0
35	3.8	1.0	**185**	15.5	4.1
40	4.2	1.1	**190**	15.9	4.2
45	4.6	1.2	**195**	16.3	4.3
50	5.0	1.3	**200**	16.7	4.4
55	5.4	1.4	**205**	17.1	4.5
60	5.8	1.5	**210**	17.5	4.6
65	6.2	1.6	**215**	17.9	4.7
70	6.6	1.7	**220**	18.3	4.8
75	6.9	1.8	**225**	18.6	4.9
80	7.3	1.9	**230**	19.0	5.0
85	7.7	2.0	**235**	19.4	5.1
90	8.1	2.1	**240**	19.8	5.2
95	8.5	2.2	**245**	20.2	5.3
100	8.9	2.3	**250**	20.6	5.4
105	9.3	2.4	**255**	21.0	5.5
110	9.7	2.5	**260**	21.4	5.6
115	10.1	2.7	**265**	21.8	5.7
120	10.5	2.8	**270**	22.2	5.8
125	11.8	2.9	**275**	22.6	5.9
130	11.2	3.0	**280**	22.9	6.1
135	11.7	3.1	**285**	23.3	6.2
140	12.0	3.2	**290**	23.7	6.3
145	12.4	3.3	**295**	24.1	6.4
150	12.8	3.4	**300**	24.5	6.5

a: Minimum purge volume equals two times calculated volume of pump (500 ml) and discharge tubing (39 ml/ft.).
b: Measured from land surface - refer to well screen data printed on well ID tag.

Attachment 3
Minimum Purge Volume Calculation Chart for Bladder Pumps Equipped with 0.625 (5/8) Inch Diameter Discharge Tubing [a]

Depth to Mid-Screen (ft.)[b]	Minimum Purge Volume		Depth to Mid-Screen (ft.)[b]	Minimum Purge Volume	
	Liters	Gallons		Liters	Gallons
5	1.6	0.4	**155**	19.7	5.2
10	2.3	0.6	**160**	20.3	5.4
15	2.9	0.8	**165**	20.9	5.5
20	3.5	0.9	**170**	21.5	5.7
25	4.1	1.1	**175**	22.1	5.8
30	4.6	1.2	**180**	22.7	6.0
35	5.2	1.4	**185**	23.3	6.1
40	5.8	1.5	**190**	23.9	6.3
45	6.4	1.7	**195**	24.5	6.5
50	7.0	1.8	**200**	25.0	6.6
55	7.6	2.0	**205**	25.7	6.8
60	8.2	2.2	**210**	26.3	6.9
65	8.8	2.3	**215**	26.9	7.1
70	9.4	2.5	**220**	27.5	7.3
75	10.0	2.6	**225**	28.1	7.4
80	10.6	2.8	**230**	28.7	7.6
85	11.2	2.9	**235**	29.3	7.7
90	11.8	3.1	**240**	29.9	7.9
95	12.4	3.3	**245**	30.5	8.0
100	13.0	3.4	**250**	31.1	8.2
105	13.7	3.6	**255**	31.7	8.4
110	14.3	3.8	**260**	32.3	8.5
115	14.9	3.9	**265**	32.9	8.7
120	15.5	4.1	**270**	33.5	8.8
125	16.1	4.2	**275**	34.1	9.0
130	16.7	4.4	**280**	34.7	9.2
135	17.3	4.6	**285**	35.3	9.3
140	17.9	4.7	**290**	35.9	9.5
145	18.5	4.9	**295**	36.5	9.6
150	19.1	5.0	**300**	37.0	9.8

a: Minimum purge volume equals two times calculated volume of pump (500 ml) and discharge tubing (60 ml/ft.).
b: Measured from land surface - refer to well screen data printed on well ID tag.

Attachment 4
GEOGUARD System Operation

1.0 PREPARATION

1.1 Connect the 12 VDC battery to the controller.

1.2 Attach the small female quick-connect on one of the air lines to the appropriate male quick- connect fitting on the splitter at the top end of the pump tubing assembly.

1.3 Attach the other end of this air line (with the male quick-connect fitting attached) to the corresponding female quick-connect fitting on the controller panel.

1.4 To the male quick-connect fitting on the controller panel, attach the corresponding female quick-connect fitting which is at one end of the remaining air line.

1.5 The other end of this air line must be attached to the drive air source. A minimum of 30 psi drive pressure is required for controller operation.

2.0 TO START THE ENGINE DRIVEN COMPRESSOR, REFER TO THE OPERATING AND MAINTENANCE INSTRUCTIONS, FORM NO. 271977.

3.0 OPERATION OF CONTROLLER

3.1 Model 5001

3.1.1 Rotate the "pressure" knob on the controller panel to the left.

3.1.2 Rotate the "exhaust" knob on the controller panel to the right.

3.1.3 Move toggle switch to the on position.

3.1.4 Rotate the pressure knob until the line on the knob face is in the eight o'clock position. This corresponds to approximately 3 - 5 seconds of pressurization time.

NOTE: The amount of time required to fully evacuate the bladder will depend on the drive air pressure and the depth of the pump. At any given pressure, deeper applications will take more time. For any given depth, lower pressure will require more time and higher pressure will require less.

3.1.5 Rotate the exhaust time knob such that the line on the knob face points to approximately eight o'clock. This position corresponds to approximately 9 seconds.

NOTE: In wells which recover rapidly and in which the level of water over the pump intake is at least 10 feet, the exhaust time knob will require only minor adjustment from the ten o'clock position for the pump to completely fill.

3.1.6 Let the controller move through 3 to 5 full cycles before adjusting the pressure and exhaust times. This is to allow pump discharge tubing to fill with water.

4. DISCHARGE

4.1 When water begins to flow from the discharge tubing, watch the flow relative to the pressure time.

4.2 If the controller switches to the exhaust mode (recognizable by the hiss of escaping air) before the flow of water from the discharge tubing ceases, slightly increase the pressure time by rotating the pressure knob slightly to the right (clockwise). Allow the controller to move through one complete cycle. If more time is required to fully discharge pump, continue to rotate the pressure knob to the right in small increments (allowing one complete cycle to occur between each change in pressure time) until the controller switches just as the water stops flowing from the discharge tube. When this happens, the discharge side of the cycle is optimally adjusted.

4.3 If water stops flowing from the discharge tubing, several seconds before the controller switches to exhaust, slightly rotate the pressure knob to the left (decreasing pressure time) and allow one full cycle to be completed. Continue to adjust the pressure time knob (allowing one full cycle between adjustments) until the controller switches to exhaust at the moment water stops flowing from the discharge tube.

5. REFILL

5.1 The exhaust mode adjustment is similar to the pressure mode adjustment except that this adjustment vents the pump until it can completely refill.

5.2 Adjustment of the exhaust time (pump refill) should follow the pressure time adjustment.

5.3 Optimum performance of the pump is achieved by proper adjustment of both pressure and exhaust periods.

5.4 It is possible to determine when the optimal refill time is achieved by first adjusting the discharge time as explained above. Next, decrease the exhaust time until the fill threshold is reached. You will know this by observing the discharge of water from the discharge tubing. If the pressure time is properly adjusted, such that the controller switches from pressure to exhaust at the moment flow from the discharge tube stops, then just enough pressure time is applied to evacuate a completely filled bladder.

5.5 If the exhaust time is shortened to the point that the pump will not fully refill, then the pump will stop discharging before the controller switches from pressure to exhaust on the next cycle. If this occurs, simply increase the exhaust time slightly to allow the pump to completely refill.

6. FLOW RATE ADJUSTMENT

6.1 The large knob on the lower right front panel of the controller labeled Pressure Adjust is used for regulating the flow and pressure of the drive air to the pump.

6.2 For maximum flow and pressure, rotate this knob clockwise as far as possible. Maximum flow rate may be desired during the purge activity. However, when sampling for sensitive parameters such as volatile organics, where sample agitation or aeration must be avoided, or when pumping through flow cell, the flow from the discharge tube can be decreased by rotating the pressure adjust knob in a counter clockwise direction. The output pressure gauge on the panel indicates the pressure within the air line to the pump and correspondingly operates only when the controller is in the pressure (discharge) mode.