STANDARD OPERATING PROCEDURE FOR:

GROUNDWATER SAMPLING

TVA-KIF-SOP-02, Revision 1

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for
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Revision Log SOP for Groundwater Sampling (TVA-KIF-SOP-02)		
Revision and Date	Section Reference	Revision Description
1, December 2009	Throughout	Field Sampling Plan reference was replaced with specific project work plans or applicable SOP references. Metric (English) units were added where appropriate.
	Section 2.0	Added paragraph requiring the wearing of nitrile gloves to prevent contamination of samples.
	Section 3.0	Streamlined test describing role of QA/QC Lead in procedural variations.
	Sections 3.3.1.b and 3.3.2.2.b	Added tubing requirements.
	Table 1	Added tubing requirements.
	Sections 3.4.1.e and 3.4.2.a	Added radionuclides to the analyte lists.

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe collection procedures for groundwater samples from monitoring wells using low-flow purging and sampling techniques or by the volume-averaged purging and sampling method at Kingston Fossil Plant (KIF).

2.0 GENERAL CONSIDERATIONS

Potential hazards associated with the planned tasks shall be thoroughly evaluated prior to conducting field activities. TVA's site-specific Health and Safety Plan (HASP) provides a description of potential hazards and associated safety and control measures.

Sampling personnel must wear powder-free nitrile gloves while performing the procedures described in this SOP. Specifically, powder-free nitrile gloves must be worn while preparing sample bottleware, preparing and decontaminating sampling equipment, collecting samples, and packing samples. At a minimum, nitrile gloves must be changed prior to the collection of each sample, or as necessary to prevent the possibility of cross-contamination with the sample, the sample bottleware, or the sampling equipment.

Field sampling equipment shall be decontaminated in accordance with the *Decontamination of Equipment* SOP (TVA-KIF-SOP-08) prior to use. Although sampling should typically be conducted from least to most impacted location, field logistics may necessitate other sample collection priorities. When sampling does not proceed from least to most impacted location, extra precautions must be taken to ensure that appropriate levels of decontamination are achieved.

The equipment required to properly conduct low-flow purging and sampling or volume-averaged groundwater purging and sampling is listed on the example checklist in Table 1. If a portable generator is used to power the purge pump, it shall be located downwind of the well being sampling to avoid cross-contamination of the sample with the exhaust from the generator motor.

3.0 PROCEDURES

The following sections describe the general operating procedures and methods associated with groundwater sampling. Any variation in these procedures must be approved by the Project Manager (PM) and Quality Assurance/Quality Control (QA/QC) Lead and must be fully documented. Field work cannot progress until deviations are approved or resolved.

3.1 Pre-Job Preparation

The information listed below shall be reviewed prior to sampling activities, if available, and can be beneficial on-site for reference in the field as necessary:

- A list of the monitoring wells to be sampled;
- Information describing well location, using site-specific or topographic maps or Global Positioning System (GPS) coordinates and descriptions tied directly to prominent field markers (positional information or maps are also valuable under severe weather conditions);
- A list of the analytical requirements for each sampling location;
- Boring logs and well construction details, if available;
- Survey data that identify the documented point of reference (V-notch or other mark on well casing) for the collection of depth-to-groundwater as well as total well depth information;
- Previous depth-to-groundwater measurements;
- Previous pump placement depths (dedicated pumps as well as portable pumps) for each sampling location, if available;
- Previous pump settings and pumping and drawdown rates, if available; and
- Previous analytical results for each monitoring well, if known.

Information above is useful when determining the sampling order, pump intake depth, and purge and recharge rates, and can facilitate troubleshooting.

The Field Team Leader shall ensure that the following activities have been completed prior to mobilizing to the site.

a. Obtain equipment necessary for completing the sampling activities (see the example checklist in Table 1).

b. Ensure appropriate laboratory-provided bottleware is available for both the required analyses and for QC samples and that there has been thorough coordination with the analytical laboratory.

c. Obtain site-specific maps or GPS coordinates showing clearly marked monitoring well locations or groundwater sample points.

d. Review the project work control documents such as the *Quality Assurance Project Plan* (QAPP), *Health and Safety Plan* (HASP), and appropriate SOPs in an effort to determine project-specific sampling requirements, procedures, and goals.

e. Verify that legal right-of-entry has been obtained and site access has been granted, where required.

f. Instruct the field team to avoid discussing project data with the public and to refer questions to the TVA Outreach Center.

3.2 Water-Level Measurements

Prior to pump placement, an initial depth-to-water level shall be measured. For monitoring wells screened across the water table, this measurement shall be used to determine the required depth to the pump intake (typically, mid-point of the saturated screen length for low-flow purging and sampling). The following procedure shall be used to measure the water levels.

a. Inspect the well head area for evidence of damage or disturbance. Record notable observations in the field logbook.

b. Open the protective outer cover of the monitoring well. Remove any debris that has accumulated around the riser near the well plug. If water is present above the top of the riser and well plug, remove the water prior to opening the well plug. Do not open the well until the water above the well head has been removed.

c. For wells in which unknown levels of volatile organic vapors may be expected or if specified in the project work control documents (such as QAPP), monitor the headspace in the well with a photoionization detector (PID) immediately after opening the well plug. Record the data in the field logbook.

d. If practical, well plugs shall be left open for five minutes to allow the water level to equilibrate before measuring the water level.

e. Using an electronic water-level indicator accurate to 1 mm or 0.01 feet, determine the distance between the established point of reference (usually a V-notch or indelible mark on the well riser) and the surface of the standing water present in the well. Record these data in the field logbook. Repeat this measurement until two successive readings agree to within 1 mm or 0.01 feet.

f. If the monitoring well has the potential to contain non-aqueous phase liquids (NAPLs), probe the well for these materials using an optical interface probe. If NAPL is present, consult the Project Manager for direction on collecting samples for analysis. In general, do not collect groundwater samples from monitoring wells containing NAPL.

g. Decontaminate the water-level indicator (and interface probe, if applicable) and return the indicator to its clean protective casing.

3.3 Well Purging

Wells must be purged prior to sampling to ensure that representative groundwater is obtained from the water-bearing unit. If the well has been previously sampled in accordance with this SOP, then the depth to the pump intake and the pumping rates shall be duplicated to the maximum extent practical during subsequent sampling events. Section 3.3.1 provides a description of low-flow well purging, and Section 3.3.2 provides a description of volume-averaging well purging.

3.3.1 Low-Flow Well Purging

U. S. Environmental Protection Agency (EPA) guidance documents state that "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds." Accordingly, peristaltic pumps (suction) are not recommended for use in low-flow purging and sampling (EPA, April 1996). Adjustable-rate bladder and electric submersible pumps are preferred for use during low-flow purging and sampling activities. Note that a ball valve (or similar valve constructed of polyethylene or brass) may need to be installed to reduce the flow rate to the required level.

The low-flow purging and sampling technique is described below.

a. Using the specific details of well construction and current water-level measurement, determine the pump set depth (typically the mid-point of the saturated well screen or other target sample collection depth adjacent to specific high-yield zones).

b. Attach tubing and supporting rope to the pump and very slowly lower the unit until the pump intake depth is reached. Measure the length of supporting rope required, taking into account the pump length, to attain the required depth. Record the depth-to-the-pump intake in the field logbook.

   Note: Sampling shall use new certified-clean disposable Silastic®, Teflon®, Tygon®, or equivalent tubing.

c. After allowing five minutes for the water level to equilibrate, slowly lower the electronic water-level probe into the well until the probe contacts the groundwater. Record the water level in the field logbook.

d. If the well has been previously sampled using low-flow purging and sampling methods, begin purging at the rate known to induce minimal drawdown. Frequently check the drawdown rate to verify that minimum drawdown is being maintained. If results from the previous sampling event are not known, begin purging the well at the minimum pumping rate of 0.1 liter per minute (L/min) (EPA, July 1996). Slowly increase the pumping rate to a level that does not cause the well to drawdown more than about 10 cm or 0.3 feet, if possible. Never increase the pumping rate to a level in excess of 500 mL/min (approximately 0.13 gallon per minute [gpm]). Record the stabilized flow rate, drawdown, and time on the field data sheets.

e. For wells **screened below the static water level**, if the drawdown does not stabilize at a pumping rate of 0.1 L/min (0.026 gpm), continue pumping until the drawdown reaches a depth of two feet above the top of the well screen. If this occurs, stop pumping and collect a groundwater sample once the well has recovered sufficiently to collect the appropriate volume. Document the details of purging, including the purge start time, rate, and drawdown in the field logbook.

f. For wells **screened across the static water level**, if the drawdown does not stabilize at 0.1 L/min (0.026 gpm), continue pumping. However, in general, do not draw down the water level more than 25% of the distance between the static water level and pump intake depth (American Society for Testing and Materials [ASTM], 2002). If the recharge rate of the well is lower than the minimum pumping rate, then collect samples at this point even though indicator field parameters have not stabilized (EPA, July 1996). Commence sampling as soon as the water level has recovered sufficiently to collect the required sample volumes. Allow the pump to remain undisturbed in the well during this recovery period to minimize the turbidity of the water samples. Fully document the pump settings, pumping rate, drawdown, and field parameter readings in the field logbook.

Note: For wells that have very slow recharge rates or that draw down excessively at the minimum pumping rate (0.1 L/min or 0.026 gpm), the procedures described above may not apply. For these "special case" wells, the Field Team Leader shall seek guidance from the TVA PM about the appropriate purging and sampling methodologies to be employed (such as volume-averaged purging and sampling).

g. Once an acceptable drawdown has been established and maintained, begin monitoring designated indicator field parameters. Indicator parameters are pH, oxidation-reduction potential (ORP measured as Eh), dissolved oxygen (DO), specific conductance, temperature, and turbidity. Base the frequency of the measurements on the time required to completely evacuate one volume of the flow through the cell to ensure that independent measurements are made. For example, a 500-mL cell in a system pumped at a rate of 100 mL/min is evacuated in five minutes; accordingly, measurements are made and recorded on the stabilization form (Table 2) at least five minutes apart.

Indicator parameters have stabilized when three consecutive readings, taken at three- to five-minute intervals, meet the following criteria (EPA, July 1996):

- Temperature ± 3% in ºC
- pH ± 0.1 unit
- Specific Conductance ± 3% in µS/cm
- ORP/Eh ± 10 millivolts
- DO ± 10% in mg/L
- Turbidity ± 10% for values greater than five NTUs

The target for monitoring turbidity is readings less than or equal to five nephelometric turbidity units (NTUs), but this value is not mandatory (EPA, July 1996). In some instances, turbidity levels may exceed the desired turbidity level due to natural aquifer conditions—natural turbidity values may exceed 10 NTUs (EPA, April 1996). When these conditions are encountered, the following guidelines shall be considered.

- If turbidity readings are slightly above five NTUs, but trending downward, purging and monitoring shall continue.
- If turbidity readings are greater than five NTUs and have stabilized, sampling can commence.
- If turbidity readings are greater than five NTUs and are not stable, well sampling shall be based upon stabilization of more critical indicator parameters (such as dissolved oxygen for VOC analysis) without attainment of the targeted turbidity.

h. If after four hours of purging, critical indicator field parameters have not stabilized, discontinue purging and collect samples. Fully document efforts used to stabilize the parameters (such as modified pumping rates).

Note: While every effort should be taken to ensure that indicator parameters stabilize, some indicator parameters are more critical with respect to certain contaminant types. It is important to identify which indicator parameters are most important to the project prior to commencement of field activities so that unnecessarily protracted purge times can be avoided. For example, the critical indicator parameter associated with sampling for VOCs is dissolved oxygen, while the critical indicator parameter associated with metals is turbidity.

There are a variety of water-quality meters available that measure the water quality parameters identified above. It is preferred, but not required, to utilize a water quality meter capable of measuring each of the water quality parameters referenced previously (except for turbidity) in one flow-through cell. If daily on-site calibration is recommended by the instrument manufacturer, the calibration procedures specified in the instruction manual shall be followed. Calibration procedures shall be documented in the project field logbook including calibration solutions used, expiration date(s), lot numbers, and calibration results.

3.3.2 Volume-Averaging Well Purging

Wells must be purged prior to sampling to ensure that representative groundwater is obtained from the water-bearing unit. If the well has been previously sampled in accordance with this SOP, then the depth-to-the-pump intake and the pumping rates shall be duplicated to the maximum extent practical during subsequent sampling events.

3.3.2.1 Calculate Purge Volumes

Based on the depth-to-water (DTW) and total depth (TD) measurements, the volume of standing water in the well must be calculated using the following procedures.

a. Subtract DTW from TD to calculate the length of the standing water column in the well.

b. Multiply the length of the standing water column by the volume calculation (liters per linear meter of depth) based on the inner casing diameter (see example list below) to determine the total standing water volume; this represents one well volume.

- 1-inch well = 0.509 L/linear meter (0.041 gallon per linear foot)
- 2-inch well = 2.204 L/linear meter (0.163 gallon per linear foot)
- 4-inch well = 8.110 L/linear meter (0.653 gallon per linear foot)
- 6-inch well = 18.24 L/linear meter (1.469 gallons per linear foot)
- 8-inch well = 32.43 L/linear meter (2.611 gallons per linear foot)

c. Multiply the well volume calculated in the previous step by three or five to obtain the respective total purge volume (the target purge volume is between three and five standing well volumes). For wells with multiple casing diameters (such as open bedrock holes), calculate the volume for each segment. Take the sum of the values and multiply by three and five to determine the minimum and maximum purge volumes, respectively.

d. Fully document the volume calculation in the field logbook.

3.3.2.2 Purge the Monitoring Well

a. Determine the appropriate pump to be used for purging—the preferred and most commonly used methods involve the use of a surface centrifugal or peristaltic pump whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small. Where the water level is below the limit of suction or there is a large volume of water to be purged, use the variable speed electric submersible pump as the pump of choice (EPA, 2007). In some cases (shallow wells with small purge volumes), purging with a disposable bailer may be appropriate.

b. Set the pump immediately above the top of the well screen or one to one-and-a-half meter (three to five feet) below the top of the water table (EPA, 2007). Lower the pump if the water level drops during purging.

Note: Use new certified-clean disposable Silastic®, Teflon®, Tygon®, or equivalent tubing for purging and sampling.

Note: Although volume-averaged sampling involves purging a specified volume of water (such as three to five well volumes) rather than basing purge completion on the stabilization of water quality indicator parameters, measuring and recording water-quality indicator parameters during purging provides information that can be used for assessment and remedial decision-making purposes. Indicator parameters are pH, ORP or Eh, DO, specific conductance, temperature, and turbidity.

c. During well purging, monitor the discharge rate using a graduated cylinder or other measuring device, water-quality indicator parameters (if desired), and DTW as follows:

- Initially, within three minutes of startup,
- After each well volume is purged, and then
- Immediately before purge completion.

d. Record pump discharge rates (L/ min or gpm) and pump settings in the field logbook. Also, record any changes in the pump settings and the time at which the changes were made.

e. Maintain low pumping rates to avoid overpumping or pumping the well to dryness, if possible. If necessary, adjust pumping rates, pump set depth, or extend pumping times to remove the desired volume of water (EPA, 2007).

f. Upon reaching the desired purge water volume, turn off the purge pump. Do not allow the water contained in the pump tubing to drain back into the well when the pump is turned off. Use an inline check valve or similar device, or if using a peristaltic pump, remove the tubing from the well prior to turning off the pump. It is preferred to collect samples within two hours of purging, but acceptable for collection up to 24 hours of purging. Do not collect samples after 24 hours of purging.

Note: The removal of three to five well volumes may not be practical in wells with slow recovery rates. If a well is pumped to near dryness at a rate less than 1.9 L/min (0.5 gpm), the well shall be allowed to completely recover prior to sampling. If necessary, the twohour limit may be exceeded to allow for sufficient recovery, but samples must be collected within 24 hours of purge completion.

3.4 Sampling

3.4.1 Low-Flow Sampling

The following procedure shall be followed for the collection of low-flow groundwater samples.

a. Record the final pump settings in the field logbook immediately prior to sample collection.

b. Measure and record the indicator parameter readings immediately prior to sample collection on both the stabilization form and in the field logbook.

c. Record comments pertinent to the color and obvious odors (such as sulfur odor or petroleum hydrocarbons odor) associated with the water.

d. Arrange and label necessary sample bottles and ensure that preservatives are added, as required. Include a unique sample number, time and date of sampling, the initials of the sampler, and the requested analysis on the label. Additionally, provide information pertinent to the preservation materials or chemicals used in the sample.

e. Ensure that the sampling tubing remains completely filled during sampling and that the water does not descend back into the well. Minimize turbulence when filling sample containers, especially for samples for VOCs, by allowing the liquid to run gently down the inside of the bottle. Fill the labeled sample bottles in the following order:

- Volatile Organic Compounds (VOCs),
- Semivolatile Organic Compounds (SVOCs),
- Pesticides/PCBs,
- Total Petroleum Hydrocarbons (TPH),
- Metals, Cyanide, and Radionuclides,
- Filtered Metals and Radionuclides, if required, and then
- Other water-quality parameters.

f. Immediately seal each sample and place the sample on ice in a cooler to maintain sample temperature preservation requirements in accordance with procedures outlined in the *Sample Labeling, Packing, and Shipping* SOP (TVA-KIF-SOP-07).

g. Note the sample identification and sample collection time in field logbook and on Chain-of-Custody form (refer to *Field Documentation* SOP TVA-KIF-SOP-06).

h. Once sampling is complete, retrieve the sample pump and associated sampling equipment and decontaminate in accordance with procedures outlined in the *Decontamination of Equipment* SOP (TVA-KIF-SOP-08).

i. Close and secure the well. Clean up and remove debris left from the sampling event. Be sure that investigation-derived wastes are properly containerized and labeled.

j. Review sampling records for completeness. Add additional notes as necessary.

3.4.2 Sampling after Volume-Averaging Purge

The procedures described below shall be followed utilized in the collection of groundwater samples after a volume-averaged purge has been conducted. Volume-averaging purge methods are described in Section 3.3.2.

a. If sampling with a pump, care shall be taken to minimize purge water descending back into the well through the pump tubing. Minimize turbulence when filling sample containers, especially for samples for VOC analysis, by allowing the liquid to run gently down the inside of the bottle. Fill the labeled sample bottles in the following order:

- Volatile Organic Compounds (VOCs),
- Semivolatile Organic Compounds (SVOCs),
- Total Petroleum Hydrocarbons (TPH),
- Pesticides\PCBs,
- Metals, Cyanide, and Radionuclides,
- Filtered Metals and Radionuclides, if required, and then
- Other water-quality parameters.

b. If sampling with a bailer, slowly lower a clean, disposable bailer through the fluid surface. Retrieve the bailer and fill the sample bottles as described above. Care shall be taken to minimize disturbing the sample during collection.

Note: Suction pumps (peristaltic pumps) may cause degassing, pH modification, and loss of VOCs; accordingly, peristaltic pumps (suction) are not recommended for use in collection of VOC samples (EPA, 1996). Peristaltic pumps are acceptable for volume-averaged well purging and collection of groundwater samples for analyses other than VOCs. Samples analyzed for VOCs shall be collected with a bailer.

3.5 Sample Handling, Packing, and Shipping

Samples shall be marked, labeled, packaged, and shipped in accordance with the *Sample Labeling, Packing, and Shipping* SOP (TVA-KIF-SOP-07).

3.6 Field Quality Control Samples

Field quality control (QC) samples may include trip blanks, equipment rinsate blanks, field duplicate samples, and matrix spike and matrix spike duplicate samples. A description of common field QC samples and the associated collection method are provided in the project-wide QAPP and the *Field Quality Control Sampling* SOP (TVA-KIF-SOP-11).

3.7 Field Logbook Documentation

Field logbooks shall be maintained by the Field Team Leader to record daily activities. In addition to the minimum requirements discussed in the *Field Documentation* SOP (TVA-KIF-SOP-06), the field logbooks shall document those sampling characteristics specific to this SOP and as defined in the applicable project work control documents.

The Field Team Leader shall review the field logbook entries for completeness and accuracy and shall indicate this review by initialing each page of the logbook. The Field Team Leader is responsible for completion of the required data collection forms.

3.8 Decontamination and Waste Management

Sampling equipment decontamination shall be performed in a manner consistent with the *Decontamination of Equipment* SOP (TVA-KIF-SOP-08). Decontamination procedures shall be documented in the field logbook. Investigation-derived wastes produced during sampling or decontamination shall be managed in accordance with *Management of Investigation-Derived Waste* SOP (TVA-KIF-SOP-12).

4.0 REFERENCES

- American Society for Testing and Materials (ASTM). *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*, D 6771-02. 2002.
- Tennessee Valley Authority (TVA). *Decontamination of Equipment* SOP (TVA-KIF-SOP-08). 2010.
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- TVA. *Field Quality Control Sampling* SOP (TVA-KIF-SOP-11). April 2009.
- TVA. *Health and Safety Plan* (HASP), Kingston site-specific plan, 2009.
- TVA. *Management of Investigation-Derived Waste* SOP (TVA-KIF-SOP-12), 2010.
- TVA. *Quality Assurance Project Plan* (QAPP), 2009.
- TVA. *Sample Labeling, Packing, and Shipping* SOP (TVA-KIF-SOP-07). March 2009.

- United States Environmental Protection Agency (EPA), Office of Research and Development, Office of Solid Waste and Emergency Response. *Ground Water Issue,* “Low-Flow (Minimal Drawdown Sampling Procedures). Document Number EPA/540/S-95/504,” April 1996.
- U.S. EPA. Region 4, *Groundwater Sampling Operating Procedure*. Document Number SESDPROC-301-R1, November 2007.
- U.S. EPA. Region I, *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*, Revision 2, July 1996.

Table 1: Suggested Groundwater Sampling Equipment & Material Checklist

Item Description	**Check**
Health & Safety	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex™/Tyvek® suits and booties (if necessary)	
Paperwork	
Health and Safety Plan	
Project work control documents	
Well construction data, location map, field data from previous sampling events	
Chain-of-custody forms and custody seals	
Field logbook	
Measuring Equipment	
Flow measurement supplies (for example, graduated cylinder and stop watch)	
Electronic water-level indicator capable of detecting non-aqueous phase liquid	
Photoionization detector	
Sampling Equipment	
GPS device	
Monitoring well keys	
Tools for well access (for example, socket set, wrench, screw driver, T-wrench)	
Laboratory-supplied certified-clean bottleware, preserved by laboratory (if necessary)	
Appropriate trip blanks and high-quality blank water	
Sample filtration device and filters	
Submersible pump, peristaltic pump, or other appropriate pump	
Appropriate sample and air line tubing (Silastic®, Teflon®, Tygon®, or equivalent)	
Stainless steel clamps to attach sample lines to pump	
Pump controller and power supply	
Oil-less air compressor, air line leads, and end fittings (if using bladder pump)	
In-line groundwater parameter monitoring device (for example, YSI-556 Multi-Parameter meter and flow-through cell)	
Turbidity meter	
Bailer	
Calibration standards for monitoring devices	
Decontamination and Waste Management Equipment (see TVA-KIF-SOP-08)	
Packaging and Shipping Supplies (see TVA-KIF-SOP-07)	

Table 2. Low Flow Indicator Parameter Stabilization Form

Groundwater Sampling

Date:
Site:
Monitoring Well #:
Pump Intake Depth (ft):
Personnel:

Initial DTW (ft):

Recharge Rate (sec):
Discharge Rate (sec):
Pressure (psi):

Stabilization Criteria:

Temperature: ± 3°C	pH: +/- 0.1 unit
SC: +/- 3%	ORP: +/- 10 mV
DO: +/-10%	Turbidity: ±10% (± 1 NTU for values < 10)

Time	DTW (ft)	Pumping Rate (ml/min)	Temperature (°C)	Specific Conductivity (µS/cm or mS/cm)	Dissolved Oxygen (mg/L)	pH	ORP(mV)	Turbidity (NTU)

End of Procedure