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Standard Guide for Sampling Ground-Water Monitoring Wells¹

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1. Scope

1.1 This guide covers sampling equipment and procedures and “in the field” preservation, and it does not include well location, depth, well development, design and construction, screening, or analytical procedures that also have a significant bearing on sampling results. This guide is intended to assist a knowledgeable professional in the selection of equipment for obtaining representative samples from ground-water monitoring wells that are compatible with the formations being sampled, the site hydrogeology, and the end use of the data.

1.2 This guide is only intended to provide a review of many of the most commonly used methods for collecting ground-water quality samples from monitoring wells and is not intended to serve as a ground-water monitoring plan for any specific application. Because of the large and ever increasing number of options available, no single guide can be viewed as comprehensive. The practitioner must make every effort to ensure that the methods used, whether or not they are addressed in this guide, are adequate to satisfy the monitoring objectives at each site.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.02 on Sampling Techniques.

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2. Referenced Documents

2.1 ASTM Standards:²

D4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) (Withdrawn 2010)³

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5792 Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives

D5903 Guide for Planning and Preparing for a Groundwater Sampling Event

D6089 Guide for Documenting a Groundwater Sampling Event

D6452 Guide for Purging Methods for Wells Used for Ground Water Quality Investigations

D6517 Guide for Field Preservation of Ground Water Samples

2.2 EPA Standards:⁴

EPA Method 9020A

EPA Method 9022

3. Terminology

3.1 Definitions:

3.1.1 *low-flow sampling*—a ground-water sampling technique where the purge and sampling rates do not result in significant changes in formation seepage velocity.

3.1.2 *minimal purge sampling*—the collection of ground water that is representative of the formation by purging only the volume of water contained by the sampling equipment (that is, tubing, pump bladder).

3.1.2.1 *Discussion*—This sampling method should be considered in situations where very low yield is a consideration

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, <http://www.epa.gov>.

and results from this sampling method should be scrutinized to confirm that they meet data quality objectives (DQOs) and the work plan objectives.

3.1.3 *passive sampling*—the collection of ground-water quality data so as to induce no hydraulic stress on the aquifer.

3.1.4 *water quality indicator parameters*—refer to field monitoring parameters that include but are not limited to pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature, and turbidity that are used to monitor the completeness of purging.

4. Summary of Guide

4.1 The equipment and procedures used for sampling a monitoring well depend on many factors. These include, but are not limited to: the design and construction of the well, rate of ground-water flow, and the chemical species of interest. Sampling procedures may be different if analyses for trace organics, volatiles, oxidizable species, or trace metals are needed. This guide considers all of these factors by discussing equipment and procedure options at each stage of the sampling sequence. For ease of organization, the sampling process can be divided into three steps: well purging, sample withdrawal, and field preparation of samples. Certain sampling protocols eliminate the first step.

4.2 The sampling must be well planned and all sample containers must be prepared prior to going to the field. These procedures should be incorporated in the approved work plan that should accompany the sampling crew so that they may refer to it for guidance on sampling procedures and analytes to be sampled (see Guide **D5903**).

4.3 Monitoring wells must be either purged to remove stagnant water in the well casing or steps must be taken to ensure that only water meeting the DQOs and the work plan objectives is withdrawn during sampling (see Practice **D5792**). When well purging is performed, it is accomplished by either removing a predetermined number of well volumes or by the removal of ground water until stable water quality parameters have been obtained. Ideally, this purging is performed with minimal well drawdown and minimal mixing of the formation water with the stagnant water above the screened interval in the casing. Passive sampling and the minimal purge methods do not attempt to purge the water present in the monitoring well prior to sampling (**1**).⁵ The minimal purge method attempts to purge only the sampling equipment. Each of these methods is discussed in greater detail in Section **6**.

4.4 The types of chemical species that are to be sampled, as well as the reporting limits, are prime factors for selecting sampling devices (**2, 3**). The sampling device and all materials and devices the water contacts must be constructed of materials that will not introduce contaminants or alter the analytes of concern in any way. Material compatibility is further discussed in Section **8**.

4.5 The method of sample collection can vary with the parameters of interest. The ideal sampling scheme employs a

completely inert material, does not subject the sample to pressure change, does not expose the sample to the atmosphere, or any other gaseous atmosphere before conveying it to the sample container or flow cell for on-site analysis. Since these ideals are not always obtainable, compromises must be made by the knowledgeable individual designing the sampling program. These concerns should be documented in the data quality objectives (DQOs) of the sampling plan (see Practice **D5792**) (**4**).

4.6 The degree and type of effort and care that goes into a sampling program is always dependent on the chemicals of concern and their reporting levels as documented in the project's DQOs. As the reporting level of the chemical species of analytical interest decreases, the precautions necessary for sampling generally increase. Therefore, the sampling objective must clearly be defined ahead of time in the DQOs. The specific precautions to be taken in preparing to sample for trace organics are different from those to be taken in sampling for trace metals. A draft U.S. EPA guidance document (**5**) concerning monitoring well sampling, including considerations for trace organics, is available to provide additional guidance.

4.7 Care must be taken not to contaminate samples or monitoring wells. All samples, sampling devices, and containers must be protected from possible sources of contamination when not in use. Water level measurements should be made according to Test Method **D4750** before placing, purging, or sampling equipment in the well. Redox potential, turbidity, pH, specific conductance, DO (dissolved oxygen), and temperature measurements should all be performed on the sample in the field, if possible, since these parameters change too rapidly to be conducted by a fixed laboratory under most circumstances. Field meter(s) or sondes equipped with flow-through cells are available that are capable of continuously monitoring these parameters during purging if they are being used as water quality indicator parameters. These devices prevent the mixing of oxygen with the sample and provide a means of determining when the parameters have stabilized. Certain measurements that are used as indicators of biological activity, such as ferrous iron, nitrite, and sulfite, may also be conducted in the field since they rapidly oxidize. All temperature measurements must be done prior to any significant atmospheric exposure.

5. Significance and Use

5.1 The quality of ground water has become an issue of national concern. Ground-water monitoring wells are one of the more important tools for evaluating the quality of ground water, delineating contamination plumes, and establishing the integrity of hazardous material management facilities.

5.2 The goal in sampling ground-water monitoring wells is to obtain samples that meet the DQOs. This guide discusses the advantages and disadvantages of various well sampling methods, equipment, and sample preservation techniques. It reviews the variables that need to be considered in developing a valid sampling plan.

6. Well Purging

6.1 Water that stands within a monitoring well for a long period of time may become unrepresentative of formation

⁵ The boldface numbers in parentheses refer to a list of references at the end of this guide.

water because chemical or biochemical change may alter water quality or because the formation water quality may change over time (see Guide D6452). Even if it is unchanged from the time it entered the well, the stagnant water may not be representative of formation water at the time of sampling. There are two approaches to purging that reflect two differing viewpoints: to purge a large volume of ground water and to purge a minimum of, or no ground water before collecting a sample. The approach most often applied is to purge a sufficient volume of standing water from the casing, along with sufficient formation water to ensure that the water being withdrawn at the time of sampling is representative of the formation water. Typically, three to five well volumes are used. An alternative method that is gaining acceptance is to minimize purging and to conduct purging at a low flow rate or to eliminate purging entirely.

6.2 In any purging approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around the well. Two potential negative effects are the introduction of ground water that is not representative of water quality immediately around the monitoring well and artificially high velocities entering the well resulting in elevated turbidity and analytical data that reflects the absorption of contaminants to physical particles rather than soluble concentrations in ground water. It may also result in cascading water from the top of the screen that can result in changes in dissolved gases, redox state, and ultimately affect the concentration of the analytes of interest through the oxidation of dissolved metals and possible loss of volatile organic compounds (VOCs). There may also be a lingering effect on the dissolved gas levels and redox state from air being introduced and trapped in the sandpack. In no instance shall a well be purged dry. If available, the field notes or purge logs generated during previous sampling or development of the well, as well as construction logs, should be reviewed to assist in the selection of the most appropriate sampling method.

6.3 The most often applied purging method has an objective to remove a predetermined volume of stagnant water from the casing prior to sampling. The volume of stagnant water can either be defined as the volume of water contained within the casing and screen, or to include the well screen and any gravel pack if natural flow through these is deemed insufficient to keep them flushed out. Research with a tracer in a full-scale model 2-in. polyvinyl chloride (PVC) well (6) indicates that pumping five to ten times the volume of the well via an inlet near the free water surface is sufficient to remove all the stagnant water in the casing. This approach (with three to five casing volumes purged) was suggested by the U.S. EPA (7).

6.4 In deep or large-diameter wells having a volume of water so large as to make removal of all the water impractical, it may be feasible to lower a pump or pump inlet to some point well below the water surface, purge only the volume below that point, then withdraw the sample from a deeper level. Research indicates this approach should avoid most contamination associated with stagnant water (6, 8). Sealing the casing above the purge point with a packer may make this approach more dependable by preventing migration of stagnant water from

above. But the packer must be above the top of the screened zone, or stagnant water from above the packer may flow into the purged zone through the well's gravel/sand pack.

6.5 An alternate method is based on research by Barcelona, Wehrmann, and Varlien (1) and Puls and Powell (2). Their research suggests that purging at rates less than 1 L/min (approximately 0.25 gal/min) provides more reproducible VOCs and metals analytical results than purging at high rates. This method is based on the premise that at very low pumping rates, there is little mixing of the water column and laminar ground-water flow through the screen provides a more consistent sample. This sampling method also produces less turbid samples that may eliminate the need for filtration when collecting metals. This method is commonly referred to as low-flow sampling.

6.6 The low-flow sampling approach is most applicable to wells capable of sustaining a yield approximately equal to the pumping rate. A monitoring well with a very low yield may not be applicable to this technique, since it may be difficult to reduce the pumping rate sufficiently to prevent mixing of the water column in the well casing in such a well. The water level in the well being sampled should be continuously monitored using an electronic water-level indicator during low-flow sampling. Such a water-level indicator could be set below the water surface after sufficient water has been withdrawn to fill the pump, tubing, and flow cell. The water-level indicator would then produce a continuous signal indicating submersion. When the well is purged, if the water level falls below the water-level indicator probe, the signal indicates that the water level has fallen below the maximum allowable drawdown and the pumping rate should be decreased. Pumping is started at approximately 100 mL/min discharge rate and gradually adjusted to match the well's recharge rate. The selection of the type of pump is dependent on site-specific conditions and DQOs. The bladder pump design is most commonly used in this sampling method; however, the depth limitation of this pump may necessitate the use of a gas-driven piston pump in some instances.

6.7 A variation on the above purging approaches is to monitor one or more indicator parameters until stabilization of the selected parameter(s) has been achieved. Stabilization is considered achieved when measurements are within a pre-defined range. This range has been suggested to be approximately 10 % over two successive measurements made 3 min apart by the U.S. EPA (4). More recent documents (9) have suggested ranges ± 0.2 °C for temperature, ± 0.1 standard units for pH, ± 3 % for specific conductance, ± 10 % for DO, and ± 10 mV for redox potential. A disadvantage of the stabilization approach is that there is no assurance in all situations that the stabilized parameters represent formation water. These criteria should therefore be set on a site-by-site basis since if set too stringent, large volumes of contaminated purge water may be generated without ensuring that the samples are any more representative. In a low yielding formation, this could result in the well being emptied before the parameters stabilize. Also, if significant drawdown has occurred, water from some distance away may be pulled into the screen causing a steady parameter reading but not a representative reading. If these