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Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations[1]

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1. Scope

1.1 This guide covers methods for purging wells used for ground-water quality investigations and monitoring programs. These methods could be used for other types of programs but are not addressed in this guide.

1.2 This guide applies only to wells sampled at the wellhead.

1.3 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this documente be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this guide means only that the document has been approved through the ASTM consensus process.*

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 and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 4448 Guide for Sampling Groundwater Monitoring Wells[3]

D 4750 Guide for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[2]

D 5088 Guide for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[2]

D 5092 Practice for Design and Installation of Ground-Water Monitoring Wells in Aquifers[2]

D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers[2]

D 5730 Guide for Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water[2]

D 6089 Guide to Documenting a Ground-Water Sampling Event[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *casing volume*—the quantity of water contained in the casing above the screen or open borehole.

3.1.2 *fixed volume purging*—removing a specified number of well volumes to achieve purging.

3.1.3 *flow-through cell (purging)*—a vessel that allows purge water to pass over sensors for continuous measurement of indicator parameters.

3.1.4 *flushing*—see *purging*.

3.1.5 *grab sampling device*—a bailer or similar device that removes an aliquot of water from the well with each insertion and removal from the well.

3.1.6 *indicator parameters (purging)*—those physical or chemical properties, or both, used as a correlative measure to determine when water to be sampled reflects ambient ground-water chemistry.

3.1.7 *low yield well*—a well that does not produce sufficient water such that the objectives of purging and sampling cannot be achieved without first removing all water from the well.

3.1.8 *packer (purging)*—an expandable device used to physically isolate one or more zones in a well.

3.1.9 *purge volume*—the quantity of water removed from the well to accomplish the objectives of purging.

3.1.10 *purging*—the practice of removing stagnant (standing) water from a well prior to sampling.

3.1.11 *purging rate*—the rate at which water is removed from a well or sampling point during purging.

3.1.12 *recovery rate (purging)*—the rate at which the water level in a well returns to equilibrium with the hydraulic conditions of the formation after the removal of water.

3.1.13 *stabilization*—a decrease in the change between measured values to a specified range or percentage of the measured value over a selected number of consecutive readings.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

[4] *Annual Book of ASTM Standards*, Vol 04.09.

3.1.13.1 *Discussion*—The interval between readings is chosen for either a given time period or volume of water removed.

3.1.14 *stagnant water*—the water contained in a well between sampling events that may have interacted with materials or the headspace in the well, or both, and thus may be different from ambient ground water conditions.

3.1.15 *target analyte (purging)*—a chemical constituent or physical characteristic to be analyzed for the purpose of fulfilling program objectives.

3.1.16 *well volume*—the quantity of water contained in the casing and the screen for a screened well, or in the open borehole and casing in an unscreened well. For an unscreened well, this volume may also be referred to as a borehole volume.

3.1.16.1 *Discussion*—Regulations or guidance documents may contain other definitions of well volume and should be consulted.

4. Significance and Use

4.1 Wells used in ground-water quality investigations or monitoring programs are generally purged prior to sampling (Note 1). Purging is done to minimize the bias associated with stagnant water in the well, which generally does not accurately reflect ambient ground-water chemistry (Note 2).

NOTE 1—Some sampling methods, such as passive sampling, do not require the practice of purging prior to sample collection **(1,2)**.[5]

NOTE 2—This guide does not address the practice of post-sample purging (purging again after sampling is completed), which is intended for purposes other than the minimization of bias associated with stagnant water in the well.

4.2 There are various methods for purging. Each purging method may have a different volume of influence within the aquifer or screened interval. Therefore, a sample collected after purging by any one method is not necessarily equivalent to samples collected after purging by the other methods. The selection of the appropriate method will be dependent on a number of factors, which should be defined during the development of the sampling and analysis plan. This guide describes the methods available and defines the circumstances under which each method may be appropriate.

5. Criteria and Considerations for Selecting an Appropriate Purging Method

5.1 *Regulations or Other Guidance*—Determine if any State or Federal regulations or guidance exist pertaining to purging monitoring wells. Purging may be addressed as part of a broader regulation or guidance document on field investigations or ground-water monitoring.

5.2 *Historical Data*—Review of historical data can provide the user with information about the chemical and physical behavior of the ground water at the sampling point during purging and details regarding past purging practices.

5.3 *Well Design (Practice D 5092)*—The design of the well must be considered to select an appropriate purging method. Refer to Section 7 for how specific well design details affect the selection of purging methods.

5.4 *Well Development (Guide D 5521)*—Well development is part of the well construction or maintenance process and not part of a purging and sampling event. Information on well development can be found in Guide D 5521.

NOTE 3—Improper or inadequate well development can affect the suitability of the well for use in the sampling program.

5.5 *Hydraulics of the Well*—Selection of a purging method should include an assessment of well-specific hydraulic conditions, which are directly related to formation transmissivity and well design, construction, development, and maintenance. Well and formation hydraulics (the 3-dimensional distribution of head) influence the rate at which water flows through or enters the well intake under laminar flow conditions. Purging strategies are commonly categorized as being suitable for high-yield wells or low-yield wells.

5.6 *Purge Water Management*—Manage purge water in accordance with the site-specific waste management provisions of the sampling and analysis plan. It may be preferable to select a purging method to minimize the purge volume, especially when purge water must be containerized. (See Note 1.)

5.7 *Physical Condition of the Wells*—The physical condition of a well may affect the purging method by limiting the choice of equipment. For example, physical aberrations of the sampling point such as a cracked casing or siltation could preclude the use of certain purging devices.

5.8 *Subsurface Geochemistry*—Knowledge of the subsurface geochemistry can be useful in selecting a purge method that will best achieve the goal of removing stagnant water. It can also be useful in distinguishing between ambient formation water and stagnant water during the purging process. Chemical and biological interaction between formation water and the solid-phase materials in the aquifer, bacteria, or the well materials can modify the chemistry of water standing in the well or in the vicinity of the well. Dissolved gases can be transported into or out of the screened or open interval and added to or removed from the ground water across the free surface of the water in the well.

5.9 *Hydrogeologic Setting*—Optimizing purging rates requires consideration of the hydrogeologic characteristics that control the direction and rate of water movement and the transport of dissolved and colloidal material. Constituents or concentrations of constituents not characteristic of the formation water chemistry at the well intake may be transported from distant areas to the well by induced flow or reversal of flow direction when purging rates are higher than optimal or when purging times are longer than optimal.

6. Equipment Used for Purging

6.1 A variety of devices are appropriate for purging wells. Consideration of the factors in Section 5 may also be useful in selecting purging devices.

6.2 All of the purging methods described herein require water level measurements (see Guide D 4750). For some of the purging methods, measurement of indicator parameters is also required. When pumping devices are used for purging, it is preferable to use a flow through cell for optimal measurement of indicator parameters.

[5] The boldface numbers given in parentheses refer to a list of references at the end of the text.

7. Purging Methods

7.1 *Fixed Volume Purging*:

7.1.1 *Method Description*—This method involves the removal of a specified number of well volumes prior to sampling. The well volume is calculated in the field and multiplied by the specified number to be removed. The minimum number of well volumes to be removed should be prescribed in the sampling and analysis plan and is often selected based on regulatory guidance or requirements.

7.1.2 *Applicability*—Fixed well volume purging is best applied to wells that will yield multiple well volumes during purging without fully dewatering.

7.1.3 *Advantages*:

7.1.3.1 Can use a variety of pumps or grab sampling devices.

7.1.3.2 Does not require chemical measurements for determining when purging is complete.

7.1.4 *Limitations*:

7.1.4.1 May increase the cost associated with management of purge water.

7.1.4.2 Not practical for use in low yield wells.

7.1.4.3 Sometimes the number of well volumes is expressed as a range (for example, 3 to 5 volumes) making actual purge volume open to interpretation and potentially variable between sampling events.

7.1.4.4 There are no well-specific indicator parameter or target analyte data to determine when the well has been adequately purged.

7.1.4.5 The determination of an appropriate purging device, intake location, and rate of water removal are prerequisite to the effective use of this method.

7.2 *Purging Based on Stabilization of Indicator Parameters*:

7.2.1 *Method Description*—In this method, field measurements of selected parameters are taken to indicate when the well is sufficiently purged. The indicator parameters to be measured and frequency of measurements should be specified in the sampling and analysis plan. The most commonly measured parameters include (but are not limited to) pH, specific conductance, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential. The parameters should be selected based on knowledge of water chemistry and analytes of interest, or regulatory requirements, or both. The frequency of measurement should be based on purging rate. The acceptable variation of parameter values to define stabilization and the minimum number of consecutive stable readings within the prescribed variation for each indicator parameter should be defined in the sampling and analysis plan **(3,4)**. Once stabilization has been reached, purging is complete regardless of the volume of water removed.

7.2.2 *Applicability*—This method can be used in all wells where sufficient yield can be sustained to reliably measure field indicator parameter concentrations.

7.2.3 *Advantages*:

7.2.3.1 Can be performed using a variety of grab sampling and pumping devices.

7.2.3.2 May result in a lower total purge volume.

7.2.3.3 Provides well-specific chemical data to determine when the well has been adequately purged.

7.2.4 *Limitations*.

7.2.4.1 Requires the use and calibration of field parameter measurement instrumentation.

7.2.4.2 Requires knowledge of the instrumentation to be used.

7.2.4.3 Accurate measurement of indicator parameters may be difficult to accomplish when using a grab sampler for purging.

7.3 *Purging Based on Stabilization of Target Analytes*:

7.3.1 *Method Description*—This method uses concentrations of selected target analytes or their chemical analogs, instead of indicator parameters, to determine when a well is sufficiently purged. Data are produced by sequential analysis of the purge water during well purging. Analyte concentrations are determined at the site using a mobile field laboratory unit or smaller portable analytical equipment (Note 4). Depending on equipment capability, analyses may be run on continuous-flow samples or sample aliquots. The frequency of measurement should be based on purging rate. The acceptable variation of target analyte values to define stabilization and the minimum number of consecutive stable readings within the prescribed variation for each target analyte should be defined in the sampling and analysis plan **(3,5)**.

NOTE 4—Examples of such equipment include field gas chromatographs (for organic compounds), field ion chromatographs (for anions), field spectrophotometers (for a large variety of chemical constituents and species), and ion-specific electrodes, colorimetric reagent kits, and titration reagent kits.

7.3.2 *Applicability*—This method can be used for wells where sufficient yield can be sustained to measure target analyte concentrations.

7.3.3 *Advantages*:

7.3.3.1 Can use a variety of grab sampling and pumping devices.

7.3.3.2 May result in a lower total purge volume.

7.3.3.3 Provides well-specific and analyte-specific chemical data to determine precisely when the well has been adequately purged.

7.3.4 *Limitations*:

7.3.4.1 Requires the use and calibration of target analyte measurement instrumentation.

7.3.4.2 Requires knowledge of the instrumentation to be used.

7.3.4.3 Different target analytes may stabilize at different times within the purging process.

7.3.4.4 Accurate measurement of target analytes may be difficult to accomplish when using a grab sampler for purging.

7.4 *Purging Based on Fixed Volume Combined with Indicator Parameter Stabilization*:

7.4.1 *Method Description*—This method uses measurement of indicator parameters in addition to purging fixed well volumes to determine when a well is sufficiently purged of stagnant water. A minimum number of well volumes must be removed regardless of indicator parameter levels. If indicator parameter stabilization does not occur after that minimum volume has been removed, purging continues until achieved. Indicator parameters to be measured and frequency of measurements should be specified in the sampling and analysis plan. The most commonly measured parameters include ,but are not limited to, pH, specific conductance, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential. The parameters should be selected based on knowledge of water chemistry and analytes of interest, or regulatory requirements, or both. The frequency of measurement should be based on purging rate. The acceptable variation of parameter values to define stabilization and the minimum number of consecutive stable readings within the prescribed variation for each indicator parameter should be defined in the sampling and analysis plan.

7.4.2 *Applicability*—This method can be applied to wells that can be purged of multiple well volumes without fully dewatering.

7.4.3 *Advantages*:

7.4.3.1 Can be performed using a variety of grab sampling and pumping devices.

7.4.3.2 Provides well-specific indicator parameter data to determine when the well has been adequately purged.

7.4.4 *Limitations*:

7.4.4.1 Requires the use and calibration of field parameter measurement instrumentation.

7.4.4.2 Requires knowledge of the instrumentation to be used.

7.4.4.3 Not practical for use in low yield wells.

7.4.4.4 Accurate measurement of indicator parameters may be difficult to accomplish using grab samplers for purging.

7.4.4.5 Sometimes the number of well volumes is expressed as a range (that is, 3 to 5 volumes) making the minimum purge volume open to interpretation and potentially variable between sampling events.

7.5 *Low Flow/Low Volume (Minimal Drawdown) Purging*:

7.5.1 *Method Description*. Low-flow/low-volume purging differs from purging as defined in 3.1. It is based on the theory that water moving through the well intake is representative of the formation water surrounding the intake. This method involves sampling intake-zone water without disturbing any stagnant water above the intake by pumping the well at low flow rates while maintaining minimal drawdown of the water column within the well (Note 5). Pumping at low rates, in effect, isolates the column of stagnant water in the well and negates the need for its removal **(3,4)**. Indicator parameters should be monitored during pumping, with stabilization indicating that purging is completed. Alternatively, analytical data from low-flow/low volume purging and sampling can be compared to data from a previously-used method (fixed-volume purging, well evacuation/recovery), with comparability of the data used to indicate efficacy.

NOTE 5—The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical, taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 to 0.5 L/min are used; however, this is dependent on site-specific hydrogeology. Some extremely coarse textured formations have been successfully sampled in this manner at flow rates up to 1 L/min **(3)**.

7.5.2 *Applicability*—Low-flow/low-volume purging can be applied to any well or borehole where the sustained yield is sufficient to maintain the water level in the well without continued drawdown of this level.

NOTE 6—Optimal low flow purging rates should be determined on a well-specific basis and documented.

7.5.3 *Advantages*:

7.5.3.1 Can minimize purge volume, reducing the costs associated with management of purge water.

7.5.3.2 Can reduce turbidity of samples, often obviating the need to filter samples.

7.5.3.3 Can be used to target specific sampling zones within the well intake (that is, preferential flow zones, fractures).

7.5.3.4 Reduces the chance of sample alteration due to aeration, agitation or mixing of zones within the formation.

7.5.3.5 Can be performed using a variety of pumping devices.

7.5.3.6 Can minimize the mobilization of particulate or colloidal matter resulting in the minimization of transport of hydrophobic substances attached to these materials.

7.5.4 *Limitations*.

7.5.4.1 Measurement of indicator parameters requires the calibration and use of field instruments.

7.5.4.2 Cannot be performed with grab samplers or with pumping devices that cannot pump at the desired rate.

7.5.4.3 The use of portable pumps, as opposed to dedicated pumps, can disturb the stagnant water column and increase colloidal density (suspended solids), which will increase the time and purge volume required to achieve indicator parameter stabilization **(6)**

7.6 *Well Evacuation Purging*:

7.6.1 *Method Description*—Well evacuation purging is the dewatering of the well prior to sampling. Sampling is then performed either during or after well recovery.

7.6.2 *Applicability*—This method can be applied to any well in which dewatering of the well or borehole can be accomplished.

7.6.3 *Advantages*:

7.6.3.1 Can be performed using a variety of pumps or grab samplers.

7.6.3.2 Does not require the measurement of chemical constituents during purging.

7.6.4 *Limitations*:

7.6.4.1 May generate a large volume of purge water (Note 6).

7.6.4.2 May not be advisable to evacuate wells below the top of the well intake. This could result in significant alteration of the sample chemistry through aeration and agitation of the incoming formation water **(7,8)**.

7.6.4.3 May significantly elevate turbidity levels in samples.

7.6.4.4 Length of time between dewatering and sampling is at the discretion of the sampler and may vary between sampling points and sampling events.

NOTE 7—Wells that are typically evacuated (that is, low yield wells) generally produce lower purge volumes than higher yield wells purged using the fixed volume method.

7.7 *Use of Packers in Purging*:

7.7.1 *Method Description*—In a single intake well, the pump inlet is suspended below the packer, generally within the intake zone, to purge and sample the well. The intake is isolated by installing the packer within the casing or competent rock above the intake zone and actuating the packer. Packers are generally ineffective in isolating sampling zones when installed within the intake zone. Where pumping occurs or head differences exist, due to the potential for leakage around the packers. Water level measurements should be made in the well, in accordance with Guide D 4750, to check for leakage of stagnant water in the well casing past the packer. A measurable water level drop during pumping indicates leakage. If leakage is detected, the packer should be reset and purging attempted again until no leakage is indicated.

7.7.1.1 In a multiple intake well, an intake is isolated by installing one packer within the casing below the intake and one packer in the casing above the intake with a pump suspended between the packers, followed by expansion of the packers. To detect leakage past the packers, pressure transducers should be installed above the upper packer and below the lower packer to monitor for pressure fluctuations during pumping. Manually measuring water levels above the upper packer can be substituted for a pressure transducer in this zone. If leakage is indicated, the packers should be reset and purging attempted again until no leakage is indicated.

7.7.2 *Applicability*—Packers can be used in any well in which the static water level is above the top of the well intake, but are most efficient in wells in which the static water level is significantly above the top of the well intake. Conversely, packers cannot be installed within the screened or fracture rock interval as this could result in leakage around the packer, where pumping occurs or head differences exist.

7.7.3 *Advantages*:

7.7.3.1 Can minimize purge volume, reducing the costs associated with management of purge water.

7.7.3.2 Can be used with a variety of pumping devices.

7.7.3.3 In multiple screened wells, allows the hydraulic and chemical isolation of each screened interval.

7.7.4 *Limitations*:

7.7.4.1 Cannot be used in wells in which the static water level is always within or below the well intake.

7.7.4.2 Not practical for use in low-yield wells.

7.7.4.3 Packers are not typically used when purging with bailers.

8. Other Considerations

8.1 *Decontamination*—All equipment used in the well should be properly cleaned before each use (See Guide D 5088). The clean equipment should not be allowed to contact the ground or other surface that could impart contaminants.

8.2 *Field Measurements*—Many of the purging methods involve the measurement of indicator parameters. The indicator parameters to be measured and frequency of measurements should be specified in the sampling and analysis plan. The most commonly measured parameters include, but are not limited to, pH, specific conductance, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential. Manufacturer's operating instructions should be followed for each individual instrument.

8.3 *Calibration of Equipment*—All instrumentation used during purging should be calibrated. Instructions for calibration are specific to the individual instrument and manufacturer's instructions should be followed. The frequency and timing of calibration should be in accordance with the sampling and analysis plan.

9. Reporting

9.1 Purging procedures and equipment used must be documented in the field. Specific guidance on documenting a ground-water-sampling event is provided in Guide D 6089.

10. Keywords

10.1 ground water; ground-water sampling; indicator parameters; purging; water quality

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