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Standard Guide for Sampling and Analysis of Residential and Commercial Water Supply Wells in Areas of Exploration and Production (E&P) Operations[1]

This standard is issued under the fixed designation D8006; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide presents a methodology for obtaining representative groundwater samples from domestic or commercial water wells that are in proximity to oil and gas exploration and production (E&P) operations. E&P operations include, but are not necessarily limited to, site preparation, drilling, completion, and well stimulation (including hydraulic fracturing), and production activities. The goal is to obtain representative groundwater samples from domestic or commercial water wells that can be used to identify the baseline groundwater quality and any subsequent changes that may be identified. While this guide focuses on baseline sampling in conjunction with oil and gas E&P activities, the principles and practices recommended are based on well-established methods that have been in use for many years in other industrial situations. This guide recommends sampling and analytical testing procedures that can identify various chemical species present including metals, dissolved gases (such as methane), hydrocarbons (and other organic compounds), as well as overall water quality.

1.2 This guide provides information on typical residential and commercial water supply well systems and guidance on developing and implementing a sampling program, including determining sampling locations, suggested purging techniques, selection of potential analyses and laboratory certifications, data management, and integrity. It also includes guidance on personal safety. The information included pertains to baseline sampling before beginning any activities that could present potential risks to local aquifers, periodic sampling during and after such work, and ongoing monitoring relating to known or potential groundwater constituents in the area. This guide does not address policy issues related to frequency or timing of sampling or sampling distances from the wellhead. In addition, it does not address reporting limits, sample preservation, holding times, laboratory quality control, regulatory action levels, or interpretation of analytical results.

1.3 These guidelines are not intended to replace or supersede regulatory requirements and technical methodology or guidance nor are these guidelines intended for inclusion by reference in regulations. Instances where this guide is in conflict with statutory or regulatory requirements, practitioners shall defer to the latter. These guidelines are intended to assist in developing sampling programs to meet project goals and objectives. However, site-specific conditions, regulatory requirements, site-specific health and safety issues, technical manuals and directives, and program data quality objectives should be evaluated and consulted along with the information contained in this guide for each individual site and sampling program.

1.4 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 document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.5 Users are responsible for investigating and identifying all the legal and regulatory requirements that are applicable for the location where the sampling is being performed.

1.6 *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 determine the applicability of regulatory limitations prior to use.*

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.26 on Hydraulic Fracturing.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D511 Test Methods for Calcium and Magnesium In Water
D512 Test Methods for Chloride Ion In Water
D516 Test Method for Sulfate Ion in Water
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D858 Test Methods for Manganese in Water
D888 Test Methods for Dissolved Oxygen in Water
D1067 Test Methods for Acidity or Alkalinity of Water
D1068 Test Methods for Iron in Water
D1125 Test Methods for Electrical Conductivity and Resistivity of Water
D1246 Test Method for Bromide Ion in Water
D1293 Test Methods for pH of Water
D1687 Test Methods for Chromium in Water
D1976 Test Method for Elements in Water by Inductively-Coupled Argon Plasma Atomic Emission Spectroscopy
D2330 Test Method for Methylene Blue Active Substances (Withdrawn 2011)[3]
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Gas Chromatography
D2972 Test Methods for Arsenic in Water
D3082 Test Method for Boron in Water
D3223 Test Method for Total Mercury in Water
D3557 Test Methods for Cadmium in Water
D3559 Test Methods for Lead in Water
D3648 Practices for the Measurement of Radioactivity
D3859 Test Methods for Selenium in Water
D3920 Test Method for Strontium in Water
D4191 Test Method for Sodium in Water by Atomic Absorption Spectrophotometry
D4192 Test Method for Potassium in Water by Atomic Absorption Spectrophotometry
D4327 Test Method for Anions in Water by Suppressed Ion Chromatography
D4382 Test Method for Barium in Water, Atomic Absorption Spectrophotometry, Graphite Furnace
D4658 Test Method for Sulfide Ion in Water
D5673 Test Method for Elements in Water by Inductively Coupled Plasma—Mass Spectrometry
D5907 Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water
D5980 Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring
D7315 Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode
D7678 Test Method for Total Petroleum Hydrocarbons (TPH) in Water and Wastewater with Solvent Extraction using Mid-IR Laser Spectroscopy

2.2 *EPA Standards:*[4]

EPA 160.1 Total Dissolved Solids (TDS)
EPA 300.0 Determination of Inorganic Anions by Ion Chromatography
EPA 300.1 Determination of Inorganic Anions in Drinking Water by Ion Chromatography
EPA 310.1 Ortho-Phosphorus, Dissolved Automated, Ascorbic Acid
EPA 310.2 Alkalinity (Colorimetric, Automated, Methyl Orange)
EPA 325.1 Chloride (Colorimetric, Automated Ferricyanide AAI)
EPA 425.1 Methylene Blue Active Substances (MBAS)
EPA 900.0 Gross Alpha and Beta Activity in Water, Official Name: Gross Alpha and Gross Beta Radioactivity in Drinking Water
EPA 903.1 Radium-226 in Drinking Water, Official Name: Radium-226 in Drinking Water (Radon Emanation Technique)
EPA 906.0 Tritium in Drinking Water EPA 908.0 Uranium in Drinking Water-Radiochemical Method
EPA 9030B Acid-Soluble and Acid-Insoluble Sulfides: Distillation
EPA 9034 Titrimetric Procedure for Acid-Soluble and Acid-Insoluble Sulfides
EPA 9056A Determination of Inorganic Anions by Ion Chromatography
RSKSOP-175 Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique (Advisory)
SW846 8015D Nonhalogenated Organics Using GC/FID
SW846 8260C Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
SW846 8270D Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
SW846 6010D Inductively Coupled Plasma-Atomic Emission Spectrometry
SW846 6020B Inductively Coupled Plasma-Mass Spectrometry
SW846 7470A Mercury in Liquid Waste (Manual Cold-Vapor Technique)

2.3 *Federal Standard:*[5]

40 CFR Part 136 Guidelines Establishing Test Procedures for the Analysis of Pollutants

2.4 *Other:*

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[6]
PA DEP 3686 REV 1 Light Hydrocarbons in Aqueous Samples via Headspace and Gas Chromatography with Flame Ionization Detection (GC/FID)

[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.

[5] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cistern, n*—receptacle for the collection or storage of groundwater or rainwater.

3.2.2 *groundwater spring, n*—place where groundwater flows naturally from underground onto the land surface or into a body of surface water.

3.2.2.1 *Discussion*—The occurrence of a groundwater spring depends on the nature of geologic formations, especially permeable and impermeable strata, on the position of the water table, and on topography.

3.2.3 *pitless adaptor, n*—device located below the ground surface used to connect the submersible pump in a water supply well to a pressure tank or other form of water storage.

3.2.3.1 *Discussion*—This device serves to protect the wellhead from freezing conditions and may center the submersible pump in the well.

3.2.4 *point-of-entry treatment (POET) system, n*—or whole house or building treatment systems, treats all water entering the building.

3.2.4.1 *Discussion*—These systems are typically situated in the basement of a home or building or in a vault within proximity to the home or building.

3.2.5 *point-of-use (POU) system, n*—treats water at the point where it is used.

3.2.5.1 *Discussion*—These systems are typically situated under kitchen or bathroom sinks or both or in closets/cabinets in proximity to kitchens or bathrooms.

3.2.6 *pressure tank, n*—closed vessel used to store water from a supply well or spring under pressure for use within a home or building.

3.2.6.1 *Discussion*—Typically "bladder" pressure tanks are used in association with supply wells and springs; these tanks contain a rubber bladder filled with air that is used in association with a pressure switch to regulate the pressure of the water in the tank.

3.2.7 *water softener, n*—water treatment system that substitutes sodium ions for ions that cause water to be "hard," in most cases, calcium and magnesium ions and having a cation resin in the sodium form that removes cations such as calcium and magnesium from water and releases another ion such as sodium.

3.2.7.1 *Discussion*—Water softeners are also used to remove iron, manganese, some radiological materials, nitrate, arsenic, chromium, selenium, and sulfate.

4. Significance and Use

4.1 A supply well provides groundwater for household, domestic, commercial, agricultural, or industrial uses.

4.2 Using a standardized protocol based on an existing industry standard or approved regulatory methods and procedures to collect water samples from a supply well is essential to obtain representative water quality data. These data can be critical to efforts to protect water uses, and human health, and identify changes when they occur. Use of this guide will help the project team to design and execute an effective water supply sampling program.

4.3 It is important to understand the objectives of the sampling program before designing it. Water supplies may be sampled for various reasons including any or all of the following:

(1) baseline sampling before an operation of concern,
(2) periodic sampling during such an operation,
(3) investigative responses to perceived changes in water quality, or
(4) ongoing monitoring related to known or potential groundwater constituents of concern in the area.

Sampling programs should be based on these objectives and be developed in coordination with the prospective laboratory(ies) to ensure its procedures, capabilities, and limitations meet the needs of the program, protect human health and fulfill regulatory requirements.

5. Well Purging and Sampling Requirements

5.1 *Sampling Equipment:*

5.1.1 Gas or multiple meters to provide, at a minimum, information on lower explosive limits for combustible gases and oxygen levels to be used for atmospheric screening;

5.1.2 Sample containers, made of compatible materials, preservatives appropriate for the sampling to be performed, labels, and chain-of-custody forms (COCs).

5.1.3 Field notebook, preferably with waterproof, numbered pages or electronic equivalent such as a tablet.

5.1.4 Schedule and contact information for the properties (locations) to be sampled and contact information for laboratory and carrier/shipping company (if used).

5.1.5 Area maps, including GPS coordinates of well(s).

5.1.6 Large cooler and bagged ice for storing all samples and a mini cooler that can be brought inside the home/building to put samples directly on ice after collection and gallon and quart size zip-lock bags in which to put sample containers, ice, and COC, and trash bags for site-derived waste.

5.1.7 Intrinsically safe flashlight or headlamp (sample ports are commonly located in low light areas).

5.1.8 Pan or other secondary containment system to catch any water that may have dripped during sampling. Make sure cleanup is performed after sampling is complete.

5.1.9 Safety equipment including: gloves (work and latex or nitrile), safety glasses, shoes with slip resistant soles, clean rags or towels, pails and buckets, basic tool kit, first aid kit, and fire extinguisher.

5.1.10 Specific health and safety plan.

5.1.11 Watch or wristwatch with second hand, or a digital timer, and graduated container to calculate flow rate and volume.

5.1.12 Supplies need to include apparatus used to measure field parameters such as pH, turbidity, specific conductance, and dissolved oxygen.

5.1.13 Digital Camera.

5.2 *Field Visit and Sample Collection*—After arrangements with the property owner or responsible party have been made, the following steps should be taken:

5.2.1 Confirm location and note time of arrival, weather conditions, including barometric pressure, and all onsite personnel.

5.2.2 Provide the property owner/occupant an explanation of the work to be undertaken, how long it is expected to take, and what the owner/occupant can expect. Provide identification (for example, personal identification badge (with photograph) and a card or letter that can be provided to the property owner/occupant with the appropriate contact information).

5.2.3 Document information from property owner including comments on water quality and water usage the day of the sampling.

5.2.4 Record the well permit number if one has been issued (check with local authorities), and refer to D5980 for further information on pulling monitoring well permits that show the depth of the well and the location of the screened interval.

5.2.5 Sketch the area including the location of the supply well(s) and photo-document with a digital camera, and sketch location in logbook. Be aware that a property may have more than one supply well or other water sources. It is important to understand and document the uses of these supply sources (for example, drinking and agricultural) and understand and document if they are connected to the system being sampled (into one pressure tank or separate pressure tanks); this will allow the sampling team to choose the correct sample location(s) and the source of the sample.

5.2.6 As appropriate, photograph features on the property (buildings, septic systems, wells, surface water, chemical storage areas, fuel tanks, vehicle and equipment storage/parking areas, visual surface staining, signs of stressed vegetation, and cracks in foundation) and the water delivery system (pressure tank, water treatment equipment, wellhead and pump, sampling port, and floor drain if present). All photographs should have a date/time stamp and be annotated to where the photograph was taken.

5.2.7 Locate the water shutoff valve. It is critical this step is undertaken before starting any purging or sampling to reduce any potential damage if a leak or break does occur.

5.3 *Determining Sample Locations*—Samples should be collected as close to the water well as possible; however, the actual water supply well should only be accessed by a licensed plumber or similarly qualified individual as contaminants can be introduced if this work is undertaken by untrained personnel. The sampling team should not remove well caps, plugs, or ports from water supply wells, unless permissible by applicable statue or regulations.

5.3.1 The sampling team should review the water system configuration to determine the closest water tap to the water source; this is commonly, but not always, a drain port on the front near the base of the bladder/pressure tank. Care should be taken to ensure the valve is operational. Do not force valves open. Treatment systems and exact sample locations should be documented. Samples should be collected before the water reaches any treatment systems. Collecting treated water should be avoided since it will not be representative of actual inflow conditions. Usually, water treatment systems are designed to allow temporary bypass flow without alteration to the system itself. If the sample is collected after treatment, it should be noted in the field notebook.

5.3.2 Water lines should be traced to determine exactly what is being sampled (for example, water from pressure tank, water treated through a treatment system). The sampling team should not alter the piping or water delivery system in any way, including turning treatment systems off or removing tubing or both; however, if the sampling team needs to take a sample through existing tubing, this should be noted.

5.4 *Purging and Sampling of Supply Wells*—Stagnant, non-representative water should be purged from the water supply system before samples are collected to ensure that the sample is representative of actual well conditions. The convention of purging monitoring wells of three well volumes before sampling is not necessarily applicable to nor practical for supply wells. Supply wells may contain hundreds of gallons of water, the purging of which would be time-consuming, potentially detrimental to the well pump, may result in short-term depletion of the property owner's water supply, could overfill septic systems if discharged to a sink, and increase electric utility cost to the property owner. Additionally, while monitoring wells tend to remain stagnant for long durations, supply wells are commonly pumped more frequently. Thus, it is important to purge the plumbing system but not necessarily the supply well. An unused or infrequently used supply well may require a greater purge volume. The water supply system should be purged until two times the holding tank volume is removed or field parameter measurements stabilize. This ensures water is coming from the well and not just residual water in the plumbing system.

5.4.1 Holding tank volumes are commonly listed on the side of the pressure tank, or can be determined based on the dimensions of the tank or both. A good rule of thumb is to listen for the bladder/pressure tank switch to click, which indicates that the bladder/pressure tank is filling with water from the well.

5.4.2 Field parameters, including temperature, pH, specific conductance, dissolved oxygen, color/appearance, and flow rate should be recorded at established sample time intervals (every 3 to 5 min) during purging with instruments calibrated in accordance with manufacturer specifications. This is most accurately and efficiently accomplished with flow-through cells equipped with probes for temperature, pH, and specific conductance. When the field parameters vary less than ±10 % in replicate measurements for dissolved oxygen and specific conductance, ±0.2 pH units, and ±10 NTUs for turbidity, the well is adequately stabilized. Purging may be terminated 30 minutes following removal of two holding tank volumes should parameter stabilization not be achieved. In this case at least one casing volume should be removed. This sample may not reflect groundwater conditions, because it may consist only of water from the well casing, which has been in the well casing for an unknown period of time. Barometric pressure and field temperature should also be recorded.

5.4.3 The sampling team should establish whether the well has deliverability problems and if a drawdown would be objectionable to the well user. In such a case, it may be acceptable to obtain a sample before purging, prior to removal