OBTAINING ACCURATE GROUNDWATER-QUALITY DATA

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PART I. Proper Groundwater Sampling Techniques.

A. Establish sampling objectives.
1. Define the purpose for obtaining the groundwater-quality data.
   a. Baseline quality.
   b. Presence and distribution of pollutants.
   c. Monitoring of changes in response to natural and man-made causes.
2. Determine the area, depth, and general type of groundwater to be sampled.
3. Select which chemical constituents and properties are of interest.
   a. Properties (temperature, specific conductance, pH, Eh, oder, color, turbidity).
   b. Dissolved inorganic constituents.
      (1) Total dissolved solids.
      (2) Major constituents for complete analysis of most natural groundwaters (cations: calcium, magnesium, sodium, potassium; anions: bicarbonate, sulfate, chloride, nitrate; neutral species: silica).
      (3) Minor and trace constituents (examples: fluoride, phosphate, nitrite, boron, heavy metals).
      (4) Dissolved gases (primarily oxygen).
   c. Organic constituents (chemical oxygen demand, biochemical oxygen demand, organic carbon, specific individual or groups of compounds).
   d. Particulate matter.
   e. Microorganisms (bacteriological tests).
4. Determine the accuracy needed in the data.
5. Design a monitoring well system, if needed (see reference 1 for additional information).
   a. Hydrogeologic factors.
   b. Spatial distribution and depths of wells.
   c. Diameter and composition of casing and screen.
   d. Well completion at single versus multiple depth intervals.

   e. Drilling methods (Consider type of formation, depth of well and screened interval, types of constituents to be determined that could be affected by drilling fluids, location of drilling site, design of monitoring well, availability, and cost of drilling equipment).
   f. Well construction (consider difficulty of sampling less permeable zones underlying more permeable horizons).
   g. Well development (best to fully develop immediately after well completion).
6. Design a sampling plan (number of sampling sites and frequency of collection at each site).

B. Prepare for sampling.
1. Determine numbers of samples to be collected (including replicate analyses, storage for possible reanalysis or quality control).
2. Select analytical laboratory for sample analysis (see reference 2).
   a. Predetermine ability to perform required analysis, certification status for required analysis, turn-around time, cost, provision for storage of sample for reanalysis).
   b. Submit reference samples for analysis and evaluate quality of results (see Section D, Part II).
3. Select appropriate containers for constituents and properties to be determined in samples (see references 1, 3, and 4).
   a. Plastic (usually polyethylene) or glass for most inorganic constituents and properties (plastic only for dissolved silica).
   b. Glass for microbiological parameters and most organics.
4. Clean containers appropriately depending on constituents and properties to be determined (see reference 4).
   a. Use detergent and thorough rinsing with deionized or distilled water (acid soaking or rinsing may follow detergent for some purposes such as heavy metals).
   b. Heat glass containers for organics to 300-350°C (about 600°F) for several hours.
   c. Sterilize glass containers for bacteriological tests by heating to 170°C (340°F) for 1 hour.
5. Select sample preservatives depending on constituents to be determined and methods of analysis (see references 1 and 3).
   a. Acids (hydrochloric, nitric, sulfuric) for dissolved metals, nitrogen, and phosphorus species.
   b. Mercuric chloride ($HgCl_2$) for nitrogen and phosphorus species.
   c. Refrigeration (recommended for all samples) or freezing for selected inorganic and organic constituents.
6. Select filtration equipment if field filtration (through 0.45 μm filter) is needed.
7. Prepare equipment for field determination of selected properties and constituents: temperature, pH, Eh, dissolved oxygen, specific conductance, hydrogen sulfide, alkalinity (see reference 4).

8. Obtain portable coolers and coolant (ice for most samples, dry ice to freeze samples for determination of volatile organics).
9. Select and prepare sampling equipment depending on size and depth of wells, and properties and constituents to be determined in samples (see reference 1).
   a. Types of sampling equipment.
      (1) Bailers.
      (2) Suction-lift pumps.
      (3) Portable submersible pumps.
      (4) Air-lift samplers.
      (5) Continuous delivery, squeeze, and piston pumps driven by compressed gases.
   b. Preparation for special purposes.
      (1) Clean appropriately for sampling organics (Pumps may include Teflon or glass).
      (2) Sterilize for bacteriological samples (usually by hypochlorite solutions).

C. Collect samples.
1. Correctly identify the site and record location, depth, date, etc. in field notes.
2. Select sampling point, if necessary (as near to well head as possible) avoiding treatment such as water softeners in supply systems or fertilizer and pesticide addition to irrigation waters).
3. Pump well for period needed to obtain representative sample.
   a. For first samples collected from a monitoring well, pump 4-10 casing volumes and determine certain properties (such as temperature, pH, and specific conductance) until stable readings are obtained.
   b. For subsequent samples from a monitor well, pump a volume that will completely flush pumping system and remove stagnant water in casing.
   c. Pump a water-supply well for an appropriate time depending on previous pumping, being aware that different pumping stresses may cause quality variations if well is open to more than one aquifer horizon or upconing could draw in water of different quality.
4. Correctly label containers and record all sampling information in field notes.
5. Filter sample, if needed.
6. Fill container completely or to a level dependent on preservative present or to be added, add preservative, and seal container.
7. Store in portable cooler.
8. Determine selected properties and constituent concentrations in field on separate portion of sample collected at the same time as preserved sample (see reference 5).

PART II. Verification of Analytical Data

A. Control quality of field measurements through use of pH buffers, specific conductance standards, etc. in field (see reference 5).

B. Record chain of custody of samples from field to laboratory.

C. Establish laboratory quality-control program if in-house laboratory is used (see reference 4).

D. Monitor analytical results for quality assurance (see references 2 and 4).
   1. Submit standard reference or control samples (about 5 percent of total samples) to assess accuracy of data.
      a. Prepare or obtain standard reference solutions appropriately preserved and submit with groups of samples.
      b Collect a large amount of selected representative samples, properly preserve and store, and submit periodically with groups of samples. Also submit these to high quality laboratories such as in the U.S. Geological Survey and Environmental Protection Agency, state agencies (for example, the Department of Health and Environment and the Geological Survey in Kansas), or research laboratories (for example, the Desert Research Institute).
   2. Submit replicate samples (about 5 percent of total) to assess precision.
   3. Evaluate quality of data.
      a. Consistency of results relative to field measurements.
      b. Calculations for estimating data quality.
         (1) Charge-balance calculation for dissolved inorganic species (error less than a few percent for good analyses).
         (2) Measured hardness compared with hardness calculated from separate calcium and magnesium determinations.
         (3) Measured total dissolved solids compared with computed sum of constituent concentrations.
         (4) Measured total dissolved solids compared with solids estimated from specific conductance measurement.

References

In addition to the following references, articles in Ground Water Monitoring Review may be of interest for specific applications.

1. Scalf, M.R., J. F. McNabb, W.J. Dunlap, R.L. Cosby, and J.S. Fryberger, 1981, Manual of ground-water sampling procedures: U.S. Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, 93 p., NTIS No. PB82-103045. (Also available from National Water Well Association, 500 W. Wilson Bridge Rd., Worthington, Ohio 43085).

2. Keith, S.J., S.G. Wilson, H.R. Fitch, and D.M. Esposito, 1983, Sources of spatial-temporal variability in ground-water quality data and methods of control. Ground Water Monitoring Review 3 (2): 21-32.

3. U.S. Government, 1979, Chemical quality, Chapter 5, National Handbook of Recommended Methods for Water-Data Acquisition: Prepared by Federal agencies of U.S. under sponsorship of U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., 196 p.

4. Friedman, L.C. and D.E. Erdmann, 1982, Quality assurance practices for the chemical and biologicaal analyses of water and fluvial sediments, Chapter 6, Book 5, Laboratory Analysis, Techniques of Water Resources Investigations: U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., 181 p.

5. U.S. Government, 1980, Groundwater, Chapter 2, National Handbook of Recommended Methods for Water-Data Acquisition: Prepared by Federal agencies of U.S. under sponsorship of U.S. Geological Survey, U.S. Government Printing Office, Washington, D.C., 149 p.

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