Lakes, Ponds, and Impoundments

Shallow lakes and impoundments should be sampled at several points and the samples analyzed either as individual samples or as a composite sample. Water quality can vary with depth so deep lakes should be sampled with depth-integrating samplers, or samples should be taken at different depths for analysis as individual or composite samples.

Wells

Because the quality of the water standing in an unused well may not be representative of the quality of the water in the aquifer, a well must be pumped or bailed until the temperature, pH, and specific conductance are constant. Usually the last parameter to attain a reproducible reading and consequently, the most sensitive test for wells, is pH. Standby or little-used wells may require a lengthy period of pumping before the quality of the discharge stabilizes.

It may be impossible to obtain stabilized readings of pH, specific conductance, and temperature — even after lengthy pumping or bailing. If this is the case, a more practical option would be to pump for a specific period of time, say one hour, before collecting the samples.

Perhaps the easiest way to collect samples from existing wells with plumbing is, after sufficient pumping, to take the sample from a faucet or hose. However, if the pump intake is near the water surface or if there are air leaks in the pumping system, dissolved-oxygen contamination may result in the precipitation of metals even before the sample is collected. Water softeners, iron-removal filters, and storage tanks are sources of contamination and chemical change to water from a plumbing system. If it is impossible to avoid them, the installation of observation wells may be necessary. There are few well-defined criteria for sampling wells. Sampling technique will have to be adapted to existing field conditions.

Sample Preparation, Treatment, Documentation, and Field Analysis

Samples must be properly collected, preserved, and identified if they are to serve their intended purpose. Some parameters must be measured in the field; others can be determined in the laboratory.

Sample Preparation

- For suspended solids, cap and chill sample.
- At least two bottles will be needed if both "dissolved" and "total" constituents are to be determined (for example, dissolved iron and total manganese). For the "dissolved" constituents, a small part of the sample must be passed through a 0.45-micron membrane filter as follows:
  - Use a 50-milliliter plastic hand syringe and draw a few milliliters of sample water into the syringe for rinsing. Discard this rinse water.
  - Draw 50 milliliters of sample water.
  - Insert syringe outlet tip into the upper surface of membrane filter holder. Force sample through filter into sample bottle.
- If metals are to be determined, acidify samples immediately with concentrated nitric acid (HNO_3) at the approximate ratio of 1 milliliter of nitric acid per 16-ounce (pint) sample.
- Rinse filter holder and syringe with deionized water.

Recording Field Data and Identifying Sample

The inspector should keep a log or field-data sheet describing in detail the methods used in sample collection and the physical and climatic conditions under which the sample was collected. The log should contain:

- Field data such as pH, visible turbidity, specific conductance, temperature, etc.
- Name or initials of the individual collecting the sample
- Exact sample location (map location, longitude-latitude, or other)
- Date and time of sampling
- General climatic conditions
- Names of any witnesses to the sampling
- Flow rate including a description of the method used to determine it
- Sample identification number
- Name of mine and company.

Sample treatment:

RU—raw, unacidified	FU—filtered, unacidified
RA—raw, acidified	FA—filtered, acidified
RC—raw, chilled	FC—filtered, chilled

The sample container should be labeled with a waterproof marking pen on a pressure-sensitive label. Use permanent gummed labels. The sample container label should contain:

1. Sample identification
2. Time (military)
3. Date of collection
4. Name or initials of the person collecting the sample
5. Sample treatment (preservation)
6. Discharge (ft^3/s or gal./min.)
7. Presence of a calcium-based (or other) treatment system (so that the analyst can determine if there is a potential gypsum suspended-solids problem)
8. Remarks

The name of the coal company and location should not appear on the sample containers; rather, they should be kept in a separate log.

Upon completion of sampling and field-data recording, the samples should be transferred to the laboratory under appropriate conditions. For example, a chilled "C" sample should be shipped in an ice chest. The acid-preserved samples may also be stored in the ice chest as a matter of convenience. A chain of custody form (see Appendix D-11, 12, and 13) should be filled out by the individual doing the sampling and signed by each individual accepting custody of the sample. The samples should be locked in the shipping container or it should be sealed with pressure-sensitive, permanent printed tape to guarantee their security. If sealing tape is used, the laboratory manager responsible for the analysis must sign the chain of custody form stating that the tape sealing the container has not been tampered with.

Field Analyses

Temperature

Water temperature is important because it may indicate thermal pollution and it influences other physical, chemical, and biological activities in water. Gas-diffusion rates, chemical-reaction rates, and the settling velocity of particles are just a few of the many important variables that are related to water temperature. In addition, temperature differences between different water sources and seasonal variations of temperature make temperature useful in hydrologic investigations, particularly those that involve the mixing of groundwater and surface water.

For economy and ease of use, the liquid-in-glass thermometer is recommended for field use. A pocket-sized thermometer protected by a metal case is recommended. A mercury-filled stem, with a yellow or red background is desirable. To eliminate the problem of column separation, it is best to use a thermometer with gas-filled capillary.

Most thermometers shipped from the manufacturer are not highly accurate. Before each new thermometer is issued for field use, it should be checked for accuracy. This is done by comparing the field thermometer to a precise instrument such as an ASTM calibration thermometer at three points. The comparison is usually made in a water bath to eliminate erratic readings. Any thermometer found to be off by more than 0.5°C should be rejected.

Temperature data are generally reported in degrees Celsius, generally to the nearest 0.5°. The following formulae can be used to convert between the Fahrenheit and Celsius scales:

$$°C = 5/9\ (°F - 32) = (°F - 32)/1.8$$
$$°F = 9/5\ °C + 32 = 1.8°C + 32$$

Temperature measurements should be made directly in the source if possible. Water in wells, mine shafts, and underground-mine effluents presents special problems and the measurements obtained will be less than the ideal. Unusual circumstances, such as standing water, plumbing, or treatment facilities, that may affect temperature should be noted. The following steps should be taken when making temperature measurements:

- Check thermometer for liquid-column separation.
- Immerse bulb into source.
- Allow the reading to stabilize.
- Read temperature with bulb immersed (removing the bulb from water can result in rapid temperature changes).
- If temperature cannot be measured in the source, collect at least an 8-ounce bottle or cup of water and measure the temperature immediately. Keep bottle out of the sun and wind while measuring.
- Return thermometer to protective case.

pH

Because the pH of some samples can change in a short time, ideally it should be measured in the field with a reliable instrument or field test kit. At least two different methods may be used to determine the pH of water.

Colorimetric Measurement. A wide variety of chemical reagents that display color changes over narrow ranges of pH changes are used as indicators to show the approximate pH of the solution. Field kits can be used to estimate the pH of colorless, nonturbid, well-buffered water solutions, provided the reagents are fresh. The reliability of indicators for most mine-drainage testing is poor. Field data obtained with colorimetric kits may indicate possible violations; however, it will still be necessary to perform the analysis in the field with a reliable pH meter or collect a sample for laboratory analysis. Litmus paper and other chemically treated papers can also be used to indicate the approximate pH of a solution.

pH Meter. The pH meter used in conjunction with a glass electrode and reference electrode (or a combination glass plus reference electrode) develops a voltage potential in response to the hydrogen-ion activity without interference from most other ions. This method of measurement has become the standard for accurately determining pH in the field and laboratory.

It is important that semiannual maintenance and calibration be provided for all pH meters. If the pH meter is properly maintained and calibrated, field values obtained by the inspector should be acceptable in litigation.

Calibration of Meter. Before calibration of a new or untested meter, test meter response by making a 3-buffer check using solutions of pH 4, 7, and 10. Place electrode in the pH 7 buffer and adjust "standardize" knob to make meter read 7. Rinse the electrode with distilled water, dry with soft tissue, and place it in pH 4 buffer solution; the meter should read approximately 4. Rinse and dry again and place electrode in pH 10 buffer solution; meter should read approximately 10.

Calibrate meter and electrode according to manufacturer's instructions using two buffer solutions (for example 4 and 7, or 7 and 10). Use last the buffer having a pH nearest that anticipated for the sample. To avoid contamination of buffers, calibration and meter checks should be conducted in buffer solution in separate containers, such as small disposable paper cups. Buffer solutions should be discarded after use. Proceed to calibrate as follows:

- Check battery.
- Expose filling opening to atmosphere by uncovering opening during measurements.
- Place function switch on "standby" or "ready".
- Measure temperature of buffers.
- Set temperature compensator to temperature of buffers.
- Rinse electrode with deionized or distilled water thoroughly before placing it in a different buffer or into the sample.
- If the approximate pH of sample *is* known (based on field-kit or multi-range pH paper results), place electrode in a buffer solution having pH near that anticipated for the sample. Turn function switch to "measure." Adjust meter to read pH of buffer by turning "standardize" knob. Repeat this procedure using another buffer to closely "bracket" the anticipated pH of the sample, this time adjusting the meter reading with the "slope" knob (or equivalent) until the meter reads the pH of this second buffer.
- If the pH range of the sample is *not* known, place electrode in pH 7 buffer. Turn function switch to "meas-

ure." Adjust meter to read pH 7 by turning "standardize" knob. Then, place electrode in the sample to determine an "anticipated" or "approximate" pH value for that sample.

- Complete calibration by "bracketing" the approximate pH value of the sample.

When only occasional pH measurements are made, calibrate the instrument before each measurement. When frequent measurements are made, the meter calibration should be checked at least twice a day. If the meter is drifting appreciably it will need to be recalibrated more frequently — or it may need new electrodes. In all cases where readings indicate a violation, it is advisable to calibrate the instrument and double-check readings.

Measurement of pH.

- Place electrode into sample to a depth of approximately 1 inch.
- Measure temperature.
- Set temperature compensator to temperature of sample.
- Turn function switch to "measure."
- Allow meter readout to stabilize. This may take several minutes if the electrodes are old.
- Record pH to nearest 0.1 pH unit.
- Rinse electrode with deionized water.
- Cover electrode with protective cap of water or pH 7 buffer.

If litigation is anticipated, repeat measurement (record all readings; do not average values).

Precautions.

- Never remove electrode from buffer or sample unless meter is in "standby" or "off" position. To do so may polarize the electrodes, permanently damaging them and resulting in unstable meter readings.
- Dirty connectors on pH electrodes may result in erroneous readings; do not handle the plug; if it is dirty, clean it with ethanol or isopropyl alcohol.
- Static electricity on meter face may be reduced by an antistatic cloth such as those used on phonograph records. If problem continues, check for broken or loose cable-shield wire.
- Keep electrode filled with the recommended solution to within ½ inch of filling opening. Do not substitute a filling solution of different chemical composition made for another electrode. Keep the fill hole closed when the electrode is not in use to prevent evaporation of the filling solution.
- Keep electrode tip moist by filling the provided rubber cap with either pH 7 buffer solution or deionized water. If the tip dries out, soak it in pH 7 buffer solution for 24 hours.
- Never immerse the electrode to such a depth that the surface of the filling solution is below that of the test solution.
- The temperature compensator on most meters must be set for the temperature of the sample that is being measured; however, on several brands of cheap meters the "temperature" compensation knob is also used as a "slope" knob to calibrate the meter to the second buffer. When these meters are used the buffers must be at the same temperature as the water being sampled. This can be accomplished by immersing the container of buffer in the stream being sampled until the temperatures are similar.
- Do not let the electrodes freeze.
- Avoid contamination of buffer. Use a separate container (cup) and discard it after use.
- Broken or scratched electrodes can give erroneous readings.
- Do not leave meter exposed to extreme weather conditions.

Iron (total)

Generally, field determination of iron with a portable kit is not reliable and, at best, the test result should be considered only an indicator. If a violation is suspected a raw acidified (RA) sample should be collected and preserved according to the method outlined in Appendix D7.

Manganese (total)

Most field procedures for the determination of total manganese are not very precise but they can indicate the presence or absence of manganese. A raw acidified (RA) sample for laboratory determination of total manganese should be collected and preserved according to the method outlined in Appendix D7.

Suspended Solids

There is no practical field method for determining suspended solids. Therefore, if a violation is suspected it will be necessary to collect a raw, chilled (RC) sample according to the method outlined in Appendix D6.

Specific Conductance

Because it is easy to measure, the inspector may find specific conductance useful in estimating the concentration of dissolved solids in water. For example, it can be used to determine the progressive dilution of an effluent downstream or possibly to aid in identifying the source of abandoned mine drainage or "breakthrough" water from an underground mine.

Rather precise field measurements of specific conductance can be made with a specific conductance meter. Most conductance meters are an adaptation of the Wheatstone resistor bridge with built-in circuitry capable of converting resistance values (ohms) to conductivity values (mhos). Most natural waters have a conductivity of much less than 1 mho, and to avoid decimals, values are usually reported in micromhos—the observed value in mhos times 1,000,000. Most field instruments are calibrated in micromhos, though some older models may be graduated in millimhos (mhos times 1000) or even in megohms.

Conductance is dependent upon water temperature, and by convention, values are adjusted to 25°C. (In most solutions an increase of 1°C increases conductance by about 2 percent). Many field instruments have temperature compensators, either automatic or manual. If this feature is not built into the instrument, it is necessary to use a temperature-adjustment graph or the temperature factors given in Table 1 to adjust the values to 25°C.

Specific-conductance electrodes should be rinsed occasionally in a hydrogen peroxide solution or a weak acid solution (5 percent) to prevent debris and algae from accumulating. It is a good practice to provide semiannual maintenance and calibration services for all conductance meters in use.

Calibration of Meter and Measurement of Specific Conductance Using Meter With Manual Temperature Compensation.

- Check battery.
- Measure temperature of standard.
- Set temperature compensator to temperature of standard.
- Check instrument against at least two known standards before every field trip.
- Rinse electrode with sample water.
- Return electrode to sample for temperature equilibration.
- Measure temperature of sample.
- Set temperature compensator to temperature of sample.
- Read conductance according to manufacturer's instructions.
- Keep removing and reinserting the probe until two consecutive readings are in exact agreement. Air bubbles trapped in the probe will give erroneous readings.
- Record specific conductance in micromhos at 25 °C to two significant figures. Examples: Measured value of 1926 is reported as 1900; measured value of 48.6 is reported as 49.
- Remove probe from sample and rinse thoroughly with deionized or distilled water.
- If the specific conductance meter does not have temperature compensation then the readings must be corrected to 25 °C in accordance with instructions given in Table 1.

Table 1. Temperature factors for correcting conductivity data from meters without temperature compensating devices to the standard temperature of 25 °C. Electrical conductivity @ 25 °C = measured electrical conductivity x temperature factor for the temperature at which the conductance was measured.

°C	*Temperature Factor*	°C	*Temperature Factor*
0	1.87	16	1.25
1	1.82	17	1.19
2	1.76	18	1.16
3	1.71	19	1.14
4	1.66	20	1.11
5	1.61	21	1.09
6	1.57	22	1.06
7	1.53	23	1.04
8	1.49	24	1.02
9	1.45	25	1.00
10	1.41	26	0.98
11	1.37	27	0.96
12	1.34	28	0.94
13	1.31	29	0.92
14	1.28	30	0.91
15	1.25		

Precautions.

- Gently agitate electrode in sample to eliminate air bubbles.
- Allow water temperature and electrode temperature to equalize.
- Make temperature correction (Automatic or manual compensator or by table).
- Make sure electrode is clean.
- Do not leave meter exposed to extreme weather conditions.

Discharge (flow)

The inspector may find it desirable to measure streamflow at the time of water-quality sampling. The streamflow data could be useful in evaluating the water quality data and assessing any violations.

The Price current meter is a commonly used instrument for measuring stream velocity. The meter assembly consists of a cup wheel rotating about a vertical axis and tail vanes to keep the meter headed into the current.

The flow of water causes the cup wheel to turn. The number of revolutions, which is directly related to the velocity of the stream, is signaled to a set of earphones or a counter by electrical contacts powered by a battery.

To measure velocity, set the meter at a desired depth and start the counter if there is one, or start a stop watch on an initial signal (click) of the rotor. The next click is counted as one. Count the number of clicks for at least 40 seconds. After the number of revolutions and time have been determined, the stream velocity is obtained from a calibration chart furnished with the meter. For high velocities, the meter can be set to click on every fifth revolution. The number of revolutions then would be 5 times the number of clicks.

In shallow water the meter may be attached to a rod for wading measurements. In rivers and streams that cannot be waded, the meter is suspended from a bridge or boat by a cable. In that case a weight will be needed to keep the meter as nearly vertical as possible.

If the stream is over 2.5 feet deep, measurements should be taken at 2/10 and 8/10 of the depth of the stream. The average of these two measurements is nearly equal to the mean velocity in a vertical section. A single measurement at 6/10 depth is taken for streams less than 2.5 feet in depth.

Streamflow measurement is made by determining the mean velocity in a number of partial sections across the total cross section of a stream. For small streams, flowing less than 2 cubic feet per second, a minimum of three partial sections should be used. Each partial section should contain approximately the same flow. In general, for larger streams, each partial section should contain no more than 5 percent of the total flow. Stated differently, very large streams should be divided into at least 20 partial sections.

The flow in any partial section is equal to the area of that section times the mean velocity of the section: $q = av$

Where:

q = discharge in any partial section
a = cross-sectional area of partial section
v = mean velocity in partial section

The total discharge of the stream is the sum of the discharges in the partial sections: $Q = q_1 + q_2 + q_3 + \ldots q_n$

Where:

Q = total discharge of stream

q_1 = discharge of stream section 1

q_2 = discharge of stream section 2

q_n = discharge of last stream section.

The following characteristics should be sought when selecting a reach of stream for discharge measurement:

- A straight reach with the velocity threads parallel to each other
- Stable streambed free of large rocks, weeds, brush, or other obstructions that would create turbulence
- A flat streambed profile to minimize vertical components of velocity.

Effluents or streams too small to be measured with a current meter may sometimes be accurately measured volumetrically with a bucket and timer. Results obtained in gpm (gallons per minute) may be converted to ft^3/s as follows:

Cubic feet/sec = gpm $\times$ 2.228 $\times$ 10^{-3}

Inspectors are not normally equipped to measure large streams. If such measurements are needed, get help.

Sampling Equipment

Many varieties of field-testing equipment, sampling devices, and sample containers are in use by State and Federal agencies. The purpose of this section is to describe basic items. Many years of field experience by Federal agencies such as the U. S. Geological Survey, Environmental Protection Agency, and Federal Highway Administration have shown the items described here to be satisfactory. The following discussion is for identification purposes only. It does not imply endorsement nor does omission of certain brands imply that they are unsatisfactory.

Field-testing Equipment

The instability of certain chemical and physical constituents in natural water and waste water makes it desirable that some measurements be made on site or shortly after sample collection. Inspectors should know the operation and field use of these types of equipment:

pH meter
pH field testing kit (indicator only)
Specific conductance meter
Thermometer
Alkalinity kit
Acidity kit
Iron kit (indicator only)

These items must be transported and handled with care. Even though some have been designed for field use, they are subject to damage from shock, dust, and moisture. Use cushioned, waterproof carrying cases with all of these instruments.

Each instrument should be given frequent periodic calibration and maintenance. Meters measuring pH are routinely calibrated against standard buffered solutions; specific conductance meters are calibrated against a standard resistor or a standard potassium chloride solution.

Check all instruments frequently for corrosion on terminals and batteries and for moisture and dust on controls and circuitry. Because testing kits are subject to contamination and decomposition of reagents, keep glassware scrupulously clean and reagents freshly stocked from a quality-controlled supply.

Sampling Devices

The contaminants in water associated with mining operations are present in both liquid and solid states. To be representative, a water sample from a mining area must contain liquid water, dissolved solids, and undissolved solids in proportion to their occurrence in the source. Undissolved solids may include both suspended solids, such as clay, and transported solids, such as sand. The devices described in this section will provide a practical means of obtaining a representative sample with a minimum of effort.

Suspended-Sediment Samplers

An inspector will rarely need to sample streams so large as to require special depth-integrating samplers, but such devices may be needed to sample larger impoundments.

The Federal Inter-Agency Sedimentation Project of the Inter-Agency Committee on Water Resources, St. Anthony Falls Hydraulic Laboratory, has developed standard samplers and methods. The two depth-integrating samplers most likely to be used by inspection personnel are the US-DH-48 and the US-DH-59.

The US-DH-48, which is suitable for wadable streams at least 3.5 inches deep, consists of an aluminum casting and glass or plastic bottle. The sample is collected through a brass or Teflon nozzle. The sampler weighs about 4½ pounds and is held by a 3- or 4-foot rod.

The US-DH-59, which is used for larger streams that cannot be waded, is heavier and can be suspended by rope from a bridge or boat. The body consists of a bronze casting, weighing about 24 pounds. The DH-59 has a choice of nozzle sizes, depending upon flow velocity.

If Teflon nozzles and gaskets are used, both the DH-48 and DH-59 are suitable for collecting the kinds of samples upon which most inorganic, organic, and physical tests can be made.

Most discharges from mine sites will not be deep enough to permit use of these samplers. Neither will discharges move fast enough (1.5 ft/sec or more) for the standard suspended-sediment samplers to fill properly.

Bottle

Open-mouth bottle samples can be taken when stream velocities are low (less than about 2 feet per second) and the flow is tranquil, when only fine silt- and clay-sized particles are in suspension, and suspended-solids concentrations do not vary greatly either vertically or laterally. Standard suspended-sediment samplers do not fill properly at velocities less than about 1.5 ft/s.

Open-mouth bottle samples should be depth-integrated. A depth-integrated sample is one in which all depths acces-