EQUIPMENT AND SUPPLIES 6.7.1

Equipment and supplies commonly used for field measurement of turbidity are listed in table 6.7–1. Before field use of water-quality instruments, become familiar with the manufacturer's instructions for calibration, operation, and maintenance. **Test field instruments before use.**

Table 6.7–1. Equipment and supplies used for measuring turbidity[1]

[≤ , equal to or less than; µm, micrometer; mL, milliliters; in., inch]

- ✓ Turbidimeter or spectrophotometer or submersible-sensor instrument (such as a multiparameter instrument with a turbidity sensor).[2]
- ✓ Turbidity stock solutions and standards:
  - Formazin stock suspension, commercially obtained or prepared with hydrazine sulfate and hexamethylenetetramine chemicals.
  - Manufacturer-provided secondary standards.
- ✓ Sample cells (cuvettes), clear colorless glass (supplied from instrument manufacturer).
- ✓ Debubbler (degassing apparatus, commercially available or self-made).
- ✓ Inert (dry) gas (for example, nitrogen) and gas delivery apparatus; tanks must be fitted with regulators and filter.
- ✓ Sample bottle (preferably a bottle that does not sorb suspended material; if the sample will be stored temporarily, use an amber bottle).
- ✓ Silicon oil, optical grade (with same index of refraction as sample cells; supplied by instrument manufacturer).
- ✓ Paper tissues, extra lint free.
- ✓ Turbidity-free water, deionized water filtered through a ≤ 0.2-µm filter membrane with precision-sized pores.
- ✓ Bottle to hold turbidity-free water, cleaned and rinsed three times with filtered water.
- ✓ Volumetric flask, Class A, 100 mL or 500 mL.
- ✓ Volumetric pipet, Class A, 5.0 mL and pipet filler.
- ✓ Filter flask, 500 mL; filter holder; filter pump, aspirator.
- ✓ Rubber stopper, one-hole, No. 7; tubing, 5/16-in. inside diameter.

[1] Modify this list to meet the specific needs of the field effort.
[2] See text for description of USEPA-approved instrumentation.

Turbidity instruments. Three basic types of instrumentation are used to measure turbidity: turbidimeters (nephelometers), spectrophotometers, and multiparameter instruments with submersible sondes that can accommodate a turbidity sensor (commonly referred to as a turbidity probe). Choice of turbidity instrument depends on site characteristics and intended use of the data in addition to instrument specifications, performance, and reliability.[2]

- If measuring turbidity for regulatory or compliance purposes, the only method approved by the USEPA employs Method 180.1 (STORET NO. 00076) (USEPA, 1979).[3]
- For nonregulatory monitoring purposes, either a submersible sensor that measures turbidity using a near-infrared light source or a spectrophotometer in absorbance mode may be used.
  - Turbidity probes (submersible sensors) are available for multiparameter instruments with pH, temperature, conductivity, and other sensors; this is convenient for monitoring turbidity along with other field measurements. For ground-water studies, multiparameter instruments are available with sondes that can be used in 2-in. diameter wells.
  - Field spectrophotometers can be convenient for qualitative turbidity measurements if additional sample properties will be measured spectrophotometrically.

USEPA-approved specifications for turbidity instruments

- The light source should be a tungsten lamp operated at a color temperature between 2,200 to 3,000 Kelvin.
- The maximum distance traversed by incident and scattered light within the sample tube is 10 centimeters.
- The detector and any filter system are to have a spectral peak response between 400 and 600 nanometers.
- The detector should be centered at an angle of 90 degrees to the incident light path and must not exceed ± 30 from 90 degrees.
- Instrument sensitivity should permit detection of a turbidity difference of 0.02 NTU or less in water with less than 1 NTU.

[2]Turbidity instruments are being developed and improved by several companies; investigate instrument performance and reliability before making an equipment selection.

[3]The USEPA also approves the GLI-2 method turbidity instrument system (a microprocessor-based turbidity system using a pulsed-light, four-beam sensor); the GLI-2 provides stable and reproducible turbidity readings to 0.5 NTU but it is not a portable instrument.

Selected turbidity instruments were tested by the Hydrologic Instrumentation Facility. Referring to table 6.7–2, field tests of the Hach DR 2000™ indicated consistently higher FTU values compared with NTU values measured with the Analite 152™, Hach 2100P™, Hydrolab DataSonde 3™, and YSI 3800™. Not available at the time of testing were either the Hydrolab H20™ or YSI 6000™ multiparameter instruments with turbidity probe or the Analite 156™. Refer to Hydrologic Instrumentation Facility (1994) for test details.

Table 6.7–2. Measurement range and laboratory test results of selected turbidity instruments

[This table is meant to serve as a guide by which study criteria for turbidity instruments can be developed. Instruments listed were tested by the USGS Hydrologic Instrumentation Facility (HIF) unless otherwise noted. Turbidity instruments are being improved and new instruments are in development. NTU, nephelometric turbidity units; <, less than; ±, plus or minus; >, greater than; ~, approximately; %, percent; FTU, Formazin turbidity units; ≤, less than or equal to; YSI, Yellow Springs Instrument Company, Inc.; ISO, International Standards Organization]

Instrument	Measurement range	Percent difference from NTU standards
Hach 2100P™. (Handheld portable tubidimeter; 0.01 NTU resolution.)[1]	<10 to 1,000 NTU	~5%, 20 to 950 NTU
Hach Ratio/XR™. (Flowthrough cell, bench turbidimeter—can be adapted for field with a generator; 0.001 NTU resolution on 0–2 scale.)[1]	0 to 2,000 NTU	<5%, 20 to 950 NTU
Hydrolab DataSonde 3™ (DS-3)[2]. (Multiparameter, submersible instrument with internal logging and electronic communications capabilities.)	0 to 1,000 NTU	<2%, 40 to 950 NTU >10%, 20 NTU
YSI 3800™. (Multiparameter, submersible; 1 NTU resolution.)	0 to 1,000 NTU	≤3%, 40 to 950 NTU > 10%, 20 NTU
YSI 6000™. (Multiparameter, submersible instrument with internal logging and electronic communications capabilities; probe equipped with mechanical wiper.) [2]	0 to 1,000 NTU	Manufacturer specifications (not tested by HIF): ±5% of reading or 2 NTU (whichever is greater)
Analite 152™ and 156™. (Fiber optic portable nephelometer with wand-type sensor, 1-foot long.) [2]	<10 to >30,000 NTU	~5% or less, 400 to 950 NTU
Hach DR2000™. (Spectrophotometer; readings in FTU.)	0 to 450 NTU	5% or less, 20 to 400 NTU

[1]Meets USEPA regulatory specifications for turbidity measurements, has 90-degree hatchure and visible radiation.
[2]Hydrolab DataSonde3™, Analite 152™ and 156™, YSI 6000™ (not tested), and Hydrolab H20™ (not tested) use infrared technology. Instruments that conform to ISO 7027 criteria for backscatter angle of 90 degrees include the YSI 6000™, Hydrolab DS-3™, and Hydrolab H20™.

The method used for sample handling falls into three general categories, as dictated by instrument capabilities: (1) manual (discrete) sample, using a cuvette-based instrument, with sample decanted into a sample cell (cuvette); (2) pumped sample, in which a sample is pumped through a "flowthrough cell," which is a turbidity-sensor-containing cuvette that is an internal part of the instrument; and (3) direct determination, by positioning a turbidity probe either in situ or into a flowthrough chamber that receives pumped sample (see NFM 6.0).

Turbidity-free water. Turbidity-free water is used for preparation of turbidity standards and is prepared by filtering either sample water or deionized water (DIW) through a 0.2-µm or smaller pore-sized membrane. Turbidity-free water is recommended instead of unfiltered DIW for preparation of standards.

Turbidity standards. USEPA (1979) guidelines recommend monthly preparation of the stock turbidity suspension for the calibration standard, and daily preparation of the standard turbidity suspension at the dilutions needed (see 6.7.2). Formazin stock solution is available commercially.

Debubbler/degassing system. Bubbles in the sample will give false turbidity readings. A debubbler or degassing system is required if sample contains effervescing gases. The equipment plumbing must be set up to maintain a constant head, resulting in constant velocity through the turbidimeter's flowthrough cell. When using a turbidity probe within a flowthrough chamber, it might be necessary to direct debubbled water through the chamber.

- Obtain a debubbler from the instrument manufacturer, or construct one as shown on figure 6.7–2 in section 6.7.3.
- Probe-based instruments are available with a wiper mechanism that clears bubbles from the optical surface of the submersible sensor (probe).

Instruments with gas-sweep capacity. Condensation must be removed or reduced throughout turbidity determination. Some flowthrough-cell instruments have the capacity to continuously sweep the sample compartment with dry gas, reducing condensation on the sample cell; otherwise, condensation is to be removed manually every few minutes.

MAINTENANCE, CLEANING, AND STORAGE 6.7.1.A

Check manufacturer's instructions for instrument maintenance, cleaning, and storage. **Test equipment before each field trip and record all repairs in the instrument log book.** Manufacturer's instructions and the log book should accompany the instrument at all times.

Turbidity instruments. Protect instruments from extreme temperatures. Shield the instrument LED display panel from direct sunlight. If a bench-top turbidimeter gets wet, allow it to dry thoroughly before the next use (field turbidimeters are constructed to withstand moisture). Check and replace batteries routinely.

Sample cells (cuvettes). Handle and store sample cells in a manner to prevent dirt, scratches, or other damage. Follow instrument manufacturer instructions for the maintenance of sample cells. Keep sample cells scrupulously clean, inside and out. After each use, (1) wash with nonphosphate laboratory detergent, (2) rinse repeatedly with deionized water until all detergent residue is removed, and (3) allow cells to air dry in a dust-free environment.

Submersible turbidity probe. Exercise care that optical surfaces of probes are not scratched during cleaning, operation, or storage. Scratched or damaged probes must be replaced. Keep optical surfaces free of all foreign material by wiping with moist lens-cleaning paper or cloth.

Standard solutions. Discard turbidity standards with elapsed expiration dates. Protect turbidity standards from extreme temperatures. Never pour used standard or a portion of unused standard back into its original (stock) container.

Keep sample cells scrupulously clean and free of scratches.