Region 4 U.S. Environmental Protection Agency Laboratory Services & Applied Science Division Athens, Georgia	
Operating Procedure	
Title: Field Turbidity Measurement	ID: LSASDPROC-103-R6
Issuing Authority: Field Services Branch Supervisor	
Effective Date: April 22, 2023	Review Due Date: November 02, 2025
Method Reference: N/A	SOP Author: Michael Roberts

Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when conducting field turbidity measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters. This Standard Operating Procedure (SOP) is specific to the Field Services Branch (FSB) to maintain conformance to technical and quality system requirements. While this SOP may be informative for other businesses, it is not intended for and may not be directly applicable to operations in other organizations. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

Scope/Application

The procedures contained in this document are to be used by field personnel when measuring turbidity of various, aqueous phase environmental media in the field. On the occasion that LSASD field personnel determine that any of the procedures described in this section cannot be used to obtain turbidity measurements of the media being sampled, and that another method or turbidity measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use.

Note: LSASD is currently migrating to a paperless organization. As a result, this SOP will allow for the use of electronic logbooks, checklists, signatures, SOPs, and forms as they are developed, which will also be housed on the Local Area Network (LAN) and traceable to each project.

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Procedural Section

1. General Information

1.1. Documentation/Verification

1.1.1. This procedure was prepared by persons deemed technically competent by LSASD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the LSASD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.2. General Precautions

1.2.1. Safety

1.2.1.1 Proper safety precautions must be observed when conducting field turbidity measurements. Refer to the LSASD Safety, Health and Environmental Management Program (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.2.2. Procedural Precautions

1.2.2.1 All field turbidity measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the LSASD Operating Procedure for Logbooks (LSASDPROC-010).

2. Quality Control

2.1. All turbidity meters and probes shall be maintained and operated in accordance with the manufacturer's instructions and the LSASD Operating Procedure for Equipment Inventory and Management (LSASDPROC-108). Before a meter or probe is taken to the field, it shall be properly calibrated or verified, according to Sections 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks shall be documented and maintained in a logbook.

2.2. The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

2.3. If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. Field Turbidity Measurement Procedures

3.1. General

3.1.1. Turbidity is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic organisms. Many methods are available for the measurement of turbidity including turbidimeters and optical probes. Turbidity is measured by determining the amount of scatter when a light is passed through a sample.

3.2. Instrument Calibration and Verification

3.2.1. Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies (See Section 3.5 for further discussion). The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within ± 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:

3.2.2. Meter Calibration and Verification

3.2.1.1 HACH 2100Q Turbidimeter:

- Portable turbidimeters are calibrated with Formazin Primary Standards. The manufacturer recommends calibration with a primary standard such as StablCal® Stabilized Standards or with formazin standards every three months.

- Generally only a calibration verification measurement is required in the field; however, if a calibration is needed, record a post calibration reading for each calibration standard used.

3.2.1.2 Meter Verification:

- Push Verify Cal to enter the Verify menu.

- Gently invert the liquid standard several times prior to insertion into meter. Insert the 10.0 NTU (or other defined value) Verification Standard and close the lid.

- Push Read. The display shows "Stabilizing" and then shows the result and tolerance range.

- Push Done to return to the reading display. Repeat the calibration verification if the verification failed. If a meter is unable to pass verification, then that meter will need to be calibrated.

3.2.1.3 Meter Calibration:

- Push the CALIBRATION key to enter the Calibration mode. Follow the instructions on the display. Note: Gently invert each standard several times before inserting the standard and use a non-abrasive, lint-free paper or cloth to wipe off the standards.

- Insert the 20 NTU StablCal Standard and close the lid. Push Read. The
- display shows "Stabilizing" and then shows the result. Record the result.

- Repeat Step 2 with the 100 NTU and 800 NTU StablCal Standard. Record both results.

- Push Done to review the calibration details.

- Push Store to save the results. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

3.2.2 Probe Calibration and Verification

3.2.2.1 The manufacturer's instruction manual should be consulted for specific procedures regarding probe's calibration, maintenance and use. Their calibration must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. The following are basic guidelines for calibration/verification of probes and are provided as an example:

- Turn the meter "ON" and allow it to stabilize
- Immerse the probe in the first standard solution and calibrate the probe against the solution.
- Rinse the probe with de-ionized water, remove excess rinse water and calibrate the probe using additional standards as appropriate.
- Record the standard values used to calibrate the meter.

3.3 Sample Measurement Procedures

3.3.1 Depending on the meter, the sample measurement procedure can differ slightly.

3.3.2 Grab Sample Measurement

3.3.2.1 These procedures should be followed when conducting turbidity measurements of grab samples:

- Collect a representative sample and pour off enough to fill the cell to the fill line (about 15 mL) and replace the cap on the cell.

- Gently wipe off excess water and any streaks from surface of sampling vial.

- Turn instrument on. Place the meter on a flat, sturdy surface. Do not hold the instrument while making measurements.

- Insert the sample cell in the instrument so the diamond or orientation mark aligns with the raised orientation mark in the front of the cell compartment. Close the lid.

- If appropriate, select manual or automatic range selection by pressing the range key.

- If appropriate, select signal averaging mode by pressing the Signal Average key. Use signal average mode if the sample causes a noisy signal (display changes constantly).

- Press Read. The display will show -----NTU. Then the turbidity is displayed in NTU. Record the result to the correct range dependent significant digits as required by EPA Method 180.1 Rev. 2.0 (USEPA, 1993) and SM 2130B (APHA, 1992) (Table 1).

- Rinse the cell with de-ionized water or rinse out with sample water prior to the next reading.

Table 1: Reporting Requirements (APHA, 1992)

Turbidity Range *NTU*	Report to the Nearest *NTU*
0–1.0	0.05
1–10	0.1
10–40	1
40–100	5
100–400	10
400–1000	50
>1000	100

3.3.3 In-Situ Measurement

3.3.3.1 These procedures should be followed when conducting in-situ turbidity measurements:

- Place the probe into the media to be measured and allow the turbidity reading to stabilize. Once the reading has stabilized, record the measurement in the logbook.

- When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational check

3.4.1 Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

3.4.2 While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by ± 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated.

3.4.3 A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

3.5 Units and Application

3.5.1 Due to the availability of various technologies for measuring turbidity, the USGS (United States Geological Survey) in collaboration with ASTM International (American Society for Testing and Materials) has determined that data collected using different methods are not directly comparable and should be reported in units reflecting the specific technology used (USGS 2004; ASTM International 2012) (Table 2).

3.5.2 Measurements taken for regulatory purposes (i.e., National Primary Drinking Water Regulations (NPDWR) monitoring, National Pollution Discharge Elimination System (NPDES) reporting) must be in compliance with EPA approved methods. Approved methods for Clean Water Act programs and Safe Drinking Water Act programs can be found in 40 C.F.R. § 136.3 and 40 C.F.R. § 141.74(a)(1), respectively.

3.5.3 Project leaders should consult the decision tree depicted in Figure 1 to determine the appropriate turbidity method that will meet the project specific Data Quality Objectives. For more detailed information on the different methods and their associated units, refer to the USGS National Field Manual for the Collection of Water-Quality Data, Section 6.7 (USGS 2005) and ASTM designation D7315 (ASTM International 2012). A sensor specific spreadsheet detailing methods and associated units can be found on the USGS Field Manual website under turbidity parameter and methods codes (USGS 2012).

References

APHA (1992). Turbidity: Method 2130B. Standard Methods for the Examination of Water and Wastewater, 18th Edition, pp. 2-11.

ASTM International (2012). D7315-12 Standard test method for determination of turbidity above 1 turbidity unit in static mode: ASTM International, Annual Book of Standards, Water and Environmental Technology, v. 11.01, West Conshohocken, Pennsylvania.

LSASD Operating Procedure for Equipment Inventory and Management, LSASDPROC-108, Most Recent Version

LSASD Operating Procedure for Logbooks, LSASDPROC-010, Most Recent Version

USEPA (1993). Method 180.1: Determination of Turbidity by Nephelometry. Rev. 2.0. Environmental Systems Monitoring Laboratory, Office of Research and Development, Cincinnati, Ohio.

USEPA (2001). Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA.

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 LSASD, Athens, GA, Most Recent Version

USGS (2004). Office of Water Quality Technical Memorandum 2004.03: Revision of NFM Chapter 6, Section 6.7- Turbidity, available online at: http://water.usgs.gov/admin/memo/QW/qw04.03.html

USGS (2005). National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A6.7, available online at http://pubs.water.usgs.gov/twri9A.

USGS (2012). Turbidity parameter and methods codes, available online at: https://water.usgs.gov/owq/turbidity/Turbidity_parameter_codes_and_methods_codes_(May2012)%20(2).xlsx

Revision History

History	Effective Date
Replaced Chief with Supervisor; General formatting revisions.	April 22, 2023
LSASDPROC-103-R5, Field Turbidity Measurement, replaces LSASDPROC-103-R4 Title Page: Changed the author from Timothy Simpson to Michael Roberts. Changed the Field Services Branch Supervisor from John Deatrick to Sandra Aker. Deleted Hunter Johnson the as Field Quality Manager. Replaces SESD with LSASD	
LSASDPROC-103-R4, Field Turbidity Measurement, replaces LSASDPROC-103-R3 General: Added to Section 3.6 to include application of various turbidity units and associated methods relative to various applications.	November 03, 2021
Title Page: Changed Enforcement and Investigations Branch to the Field Services Branch and changed the Supervisor from Danny France to John Deatrick. Changed Field Quality Manager from Bobby Lewis to Hunter Johnson. Section 1.4: Added new references cited in Section 3.5 Section 3.2: Added reference to Section 3.5 Section 3.3.1: Added Table 1 outlining reporting requirements. Section 3.5: Introduced different turbidity units associated with various methods and stated importance of using EPA approved methods for regulatory purposes. Also added Figure 1, a decision tree to assist project leaders in selecting the appropriate method to satisfy Data Quality Objectives, and Table 2, outlining technologies, associated units, application, and design.	July 27, 2017
LSASDPROC-103-R3, Field Turbidity Measurement, replaces LSASDPROC-103-R2	January 29, 2013
LSASDPROC-103-R2, Field Turbidity Measurement, replaces LSASDPROC-103-R1	June 13, 2008
LSASDPROC-103-R1, Field Turbidity Measurement, replaces LSASDPROC-103-R0	November 1, 2007
LSASDPROC-103-R0, Field Turbidity Measurement, Original Issue	February 05, 2007

Figure 1: Turbidity Method Decision Tree, adapted from Figure 6.7-2 (USGS 2005)

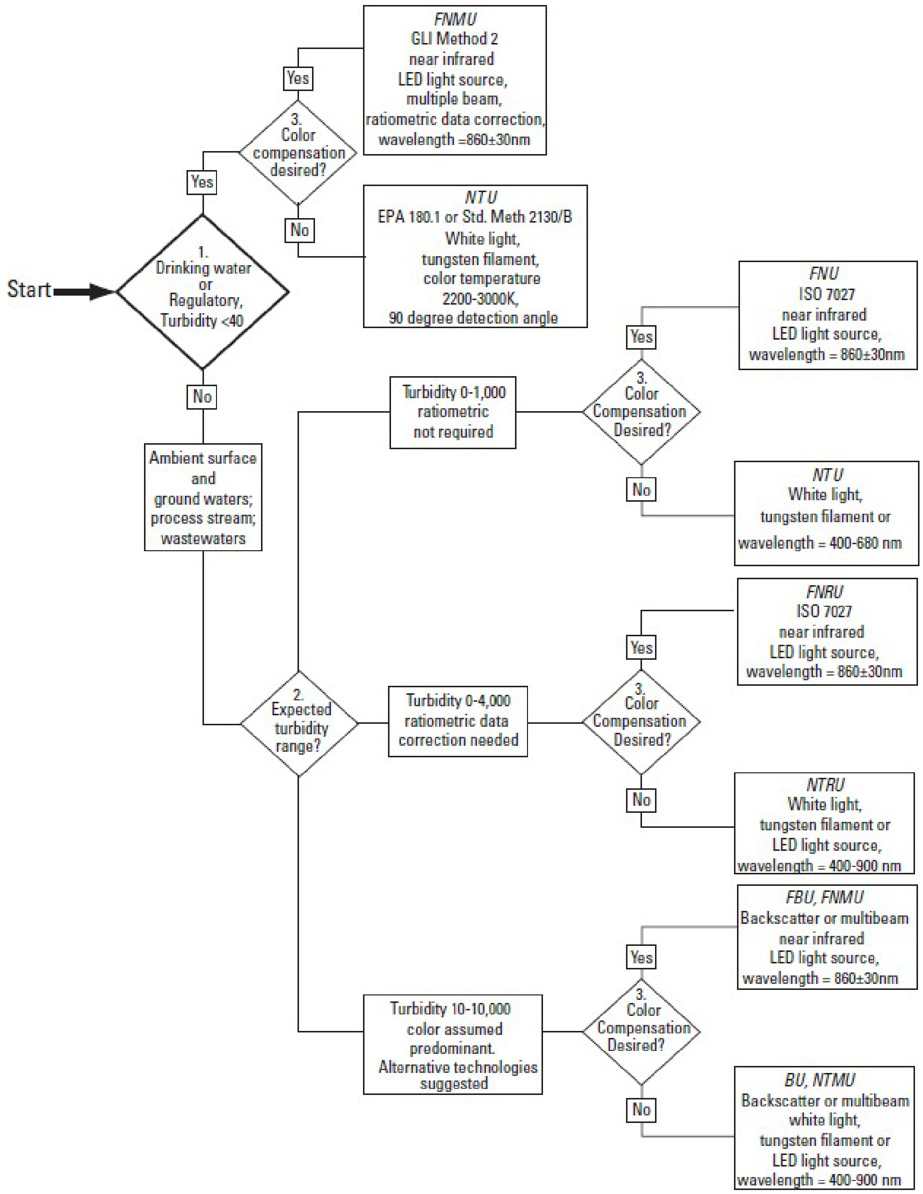

Table 2: Turbidity Technology, Units, Application, & Design (adapted from ASTM International 2012)

Design and Reporting Unit	Prominent Application	Key Design Features
Nephelometric non-ratio (NTU)	White light turbidimeters. Comply with USEPA Method 180.1 for low level turbidity monitoring.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.
Ratio White Light turbidimeters (NTRU)	Complies with ISWTR regulations and Standard Method 2130B. Can be used for both low and high level measurement.	Used a white light spectral source. Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.
Nephelometric, near-IR turbidimeters, non-ratiometric (FNU)	Complies with ISO 7027. The wavelength is less susceptible to color interferences. Applicable for samples with color and good for low level monitoring.	Detector centered at 90° relative to the incident light beam. Uses a near-IR (780–900 nm) monochromatic light source.
Nephelometric near-IR turbidimeters, ratio metric (FNRU)	Complies with ISO 7027. Applicable for samples with high levels of color and for monitoring to high turbidity levels.	Uses a near-IR monochromatic light source (780–900 nm). Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.
Surface Scatter Turbidimeters (NTU)	Turbidity is determined through light scatter from or near the surface of a sample.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.
Formazin Back Scatter (FBU)	Not applicable for regulatory purposes. Best applied to high turbidity samples. Backscatter is common with but not all only probe technology and is best applied in higher turbidity samples.	Uses a near-IR monochromatic light source in the 780–900 nm range. Detector geometry is between 90° and 180° relative to the incident light beam.
Backscatter Unit (BU)	Not applicable for regulatory purposes. Best applied for samples with high level turbidity.	Uses a white light spectral source (400–680 nm range). Detector geometry is between 90° and 180° relative to the incident light beam.
Formazin attenuation unit (FAU)	May be applicable for some regulatory purposes. This is commonly applied with spectrophotometers. Best applied for samples with high level turbidity.	Detector is geometrically centered at 0° relative to incident beam (attenuation). Wavelength is 780–900 nm.
Light attenuation unit (AU)	Not applicable for some regulatory purposes. This is commonly applied with spectrophotometers.	Detector is geometrically centered at 0° relative to incident beam (attenuation). Wavelength is 400–680 nm.
Nephelometric Turbidity Multibeam Unit (NTMU)	Is applicable to EPA regulatory method GLI Method 2. Applicable to drinking water and wastewater monitoring applications.	Detectors are geometrically centered at 0° and 90°. An instrument algorithm uses a combination of detector readings, which may differ for turbidities varying magnitude.