Standard Operating Procedure

Turbidity Measurement

Prepared by:

Watershed Planning Program

Division of Watershed Management, Bureau of Water Resources

Massachusetts Department of Environmental Protection

**Commonwealth of Massachusetts**

**Executive Office of Energy and Environmental Affairs**

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Massachusetts Department of Environmental Protection

MassDEP’s mission is to protect and enhance the Commonwealth's natural resources – air, water, and land – to provide for the health, safety, and welfare of all people, and to ensure a clean and safe environment for future generations. In carrying out this mission MassDEP commits to address and advance environmental justice and equity for all people of the Commonwealth; provide meaningful, inclusive opportunities for people to participate in agency decisions that affect their lives; and ensure a diverse workforce that reflects the communities we serve.

Watershed Planning Program

The Watershed Planning Program is a statewide program in the Division of Watershed Management, Bureau of Water Resources, at MassDEP. We are stewards of the water resources of Massachusetts. Together with other state environmental agencies, we share in the duty and responsibility to protect, enhance, and restore the quality and value of the waters of the Commonwealth. We are guided by the federal Clean Water Act and work to secure the environmental, recreational, and public health benefits of clean water for the residents of Massachusetts. The Watershed Planning Program is organized into five Sections that each have a different technical focus under the Clean Water Act: (1) Surface Water Quality Standards; (2) Surface Water Quality Monitoring; (3) Data Management and Water Quality Assessment; (4) Total Maximum Daily Load; and (5) Nonpoint Source Pollution.

Disclaimer

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendation by MassDEP.

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**LIST OF REVISIONS**

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| --- | --- | --- | --- |
| **Rev. #** | **Date** | **Description of Revision(s)** | **Page #s** |
| 0 | 9/2004 | Original draft |  |
| 1 | 4/2009 | Added provisions for calibration and electronic lab notebook documentation | 4-6 |
| 2 | 5/2023 | Revisions throughout; update to use of AQUAfast AQ4500 Turbidimeter; update program name to Watershed Planning Program |  |
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**1.0 SCOPE AND APPLICATION**

This SOP is intended to provide guidance in the measurement of turbidity in surface waters using available Watershed Planning Program (WPP) field/lab turbidimeters.

**2.0 SUMMARY**

Standard procedures for collecting and analyzing turbidity samples using WPP turbidimeters are provided.

**3.0 SAFETY CONSIDERATIONS**

Standard safety considerations for WPP field surveys, as contained in *Sampling Techniques for WPP Surface Water Quality Monitoring (*CN 1.21), apply. There are no SOP-specific, additional safety rules, except to review standard protocols and to consider any project- and/or location-specific safety issues that may exist.

SDS sheets for turbidity standards are located in the Instrument Lab at WPP in Worcester, MA.

**4.0 SAMPLE COLLECTION, PRESERVATION AND HANDLING**

Take water samples consistent with WPP protocols (see *Sampling Techniques for WPP Surface Water Quality Monitoring (*CN 1.21).

The analytical holding time is 48 hours, but samples should be analyzed as soon as possible (i.e., next day and within 24 hours if feasible). Store in dark at 4 deg. C. Remove from fridge for 1-2 hours before analysis.

**5.0 APPARATUS, EQUIPMENT AND MATERIALS**

The following materials are used: i.e.,

AQUAfast QA4500 Turbidimeter

Prepared standards (0.2, 10, 100 and 1000 NTUs)

Sample vials

Manufacturer’s User Guide: https://www.fondriest.com/pdf/thermo\_aq4500\_manual\_09.pdf

**6.0 REAGENTS**

NA

**7.0 CALIBRATION**

Every six months or as needed, the turbidity meter is calibrated using turbidity standards with concentrations of 0.2, 10, 100 and 1000 NTUs. This procedure follows steps outlined in the instrument manual.

**Calibration**: Every six months or as needed.

1. Select the measurement mode: EPA 180 by scrolling up or down until the desired mode is displayed.

2. Press the CAL (#8 key). “H2O INSERT” will be displayed.

3. Insert vial containing DI water and press the YES key.

4. “H2O WAIT” will be displayed and then “1.00 YES?”.

5. If the standard is 1.00, insert standard vial and press the YES key. (If standard is another value, press the 6 or 3 key, “CHANGE?” will be displayed. Press the YES key. “STD VAL?” will be displayed. Enter value of standard using numeric keypad. Press the YES key to accept.)

6. Repeat step 5 for each additional standard (10, 100, 1000).

7. When the calibration is complete the AQ4500 will proceed to the measure mode.

**Calibration Check**: monthly/quarterly

1. Insert the CAL 1 standard (0 NTU) into the sample chamber.

2. Press down the vial until it slides fully into the instrument. Cover the vial using the vial cover.

3. Select the measurement mode.

4. Press the MEAS (#9 key). Wait 5-10 seconds for internally averaged result.

5. The meter will display the results. Record the reading.

6. Repeat the calibration check for CAL 2, CAL 3, CAL 4, and CAL 5 calibration standards.

7. If the displayed results are within 10% of the nominal NTU value of the standard or the precision criteria required by your method, the calibration check passed, and the meter is now ready for measurement.

**8.0 ANALYTICAL PROCEDURE**

**SETUP:**

1. Retrieve samples and allow to come to room temperature; transfer sample custody by signing the Chain of Custody.
2. Record sample information the Turbidity printed worksheet (large binder): OWMID, lab numbers, date/time collected. Add lab numbers for a lab blank (LB) and lab duplicate (LD) and record the OWMID of the sample being used as a duplicate.
3. Set up the electronic workbook: Save a copy (“save as”) of the Color Turbidity Workbook Template from OneDrive ([WPP Lab SOPs and Results 2023](https://massgov-my.sharepoint.com/:f:/r/personal/james_meek_mass_gov/Documents/Monitoring/Targeted%20Monitoring%202023/WPP%20Lab%20SOPs%20and%20Results%202023?csf=1&web=1&e=CbQwXh)) with the new batch number as the file name. Check the Turbidity binder for the next batch number. Turbidity batch numbers are designated “TCyy-xx” with yy = year and xx = batch number. (E.g., TC23-01)
4. Turn on Turbidimeter and check battery condition. If low (<20%), replace batteries (4 AA batteries).
5. Check the measurement mode = EPA 180.1 (if not, change using SETUP key. See Field and Laboratory Operations Coordinator.)
6. Lab QC for each batch: Run lab blank (DI water) first, and one lab duplicate (select one of the field samples to run a second time) per batch or one per every ten samples for larger batches.

**MEASUREMENTS:**

1. Use gloves.NEVER TOUCH (OR SCRATCH!) THE VIALS WITH BARE HANDS! ALWAYS USE KIM WIPES.
2. Run the lab blank (DI water) first following Steps 9-14 (below). The blank should be ≤ 0.02 NTU. If the blank is > 0.02 NTU, check that the vial is clean (or switch vials), and retest before continuing measurements for the regular samples. If the problem persists, talk with the Field and Laboratory Operations Coordinator.
3. **Rinse** the turbidity vial: 2 rinses DI water and one rinse with the sample.
4. **Mix** the field sample gently but thoroughly to disperse the solids immediately before pouring.
5. **Pour** the sample into the vial up to the fill-line and recap. Wait until all bubble disappear.
6. **Wipe** the vial clean with Kimwipes. Place the vial in the measurement sample chamber, lining the triangle on the vial with the notch (red arrow in picture). And cover the sample well with the well cap.
7. **Take the reading**: press the “avg” (4) key to activate the averaging feature, press “meas” (9) to take the measurement. (Averaging will stay active until you press the “avg” key again.)
8. **Record** the reading on the worksheet.
9. Repeat Steps 8-13 to analyse all samples.
10. After last sample, review lab sheet to ensure that all sample and analysis information has been recorded.
11. When done, turn unit off and clean up work area.
12. Enter raw results and related information into the electronic Turbidity worksheet. The e-lab sheet will automatically incorporate any dilution factors and will apply rounding rules and significant figures for the final result.
13. Once the final values are calculated, transfer final e-results back to the paper raw lab sheet. Save the manual lab sheet (bench sheet) in the lab binder for turbidity.

**9.0 QUALITY CONTROL and REPORTING**

For each lab batch, run the following QC samples (in addition to field QC samples) at approx. 1 per every 10 samples: lab blank (run as first sample), and a lab duplicate.

Manufacturer specifications for turbidity are as follows:

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| **Analyte** | **Units** | **Expected Range** | **Accuracy (+/-)** | **Resolution** | **Overall Precision (RPD)** |
| Turbidity | NTUs | 0-100 | 1% of full scale (0-10)  5% of full scale (0-100)  10% of full scale (0-1000) | 0.1% of range | 10% |

**Estimated detection and reporting limits**:

0-10 RANGE LIMITS:

Instrument detection limit (est.): 0.01 NTUs

Lowest reference standard used: 0.02 NTUs

Method detection limit, MDL (est.): 0.2 NTUs

Reporting detection limit, RDL (est.): 0.5 NTUs

**Auto-Reporting Rules:**

All values less than 0.2 NTU are reported as “<MRL”. Estimated Method Detection Limit or MDL= 0.1 NTU. Designated Reporting Limit or RL= 0.2 NTU.

Auto-Reporting Rules: round based on Standard Methods.

1. For all reported values from 0.2 to 10 NTUs, report data to the nearest 0.1 NTU.
2. For all values between 10 and 40 NTUs, report data to the nearest 0.5 NTU.
3. For all values between 40 and 100 NTUs, report data to the nearest 1 NTU.
4. For all values between 100 and 500 NTUs, report data to the nearest 5 NTUs.
5. For all values between 500 and 1000 NTUs, report data to the nearest 10 NTUs.

**Record Keeping:**

Hard-copy workbook: *(during the analysis)* Record all data in the paper lab notebook, AND

Electronic workbook: *(during and immediately following analysis)* When sample analysis is complete, transcribe raw data from the paper lab notebook to the electronic notebook. The e-notebook is set up to make final calculations automatically (blue shaded areas). Once these values are calculated, transfer final results to the paper lab notebook and add paper lab sheet to the color lab worksheet binder. Save the final e-notebook spreadsheet as (read-only) "lab batch ID" (e.g., "TC09-12") designed file folder (see Field and Laboratory Operations Coordinator).

**10.0 INTERFERENCES**

* scratched or dirty glass
* foam or air bubbles
* true color (resulting in low bias)
* coarse sediment (resulting in large fluctuation in readings)

1. **PREVENTIVE MAINTENANCE**

* Keep vial cover in place at all times to prevent water/dust from contaminating the optical well.
* Keep vial clean and unscratched. Wash with soft cloth and detergent periodically. Replace as necessary.

1. **CORRECTIVE ACTIONS**

Take the following corrective actions as needed:

* Replace sealed standards that are no longer consistently accurate due to scratched glass, beyond expiration date or other reason.
* Replace scratched sample vials with new ones.
* Review usage of instrument and discuss with appropriate staff re: any defects due to misuse.
* Re-train staff as needed

1. **WASTE AND POLLUTION PREVENTION**

Consider the following in order to minimize waste:

* Continue to use sealed factory NTU standards, not formazin preparations.

**14.0 REFERENCES**

* EPA 600/R-93/100 Methods for Determination of Inorganic Substances in Environmental Samples, 1993.
* Thermo Scientific Orion AQUAfast AQ4500 Turbidimeter User Guide 2009 (downloaded from https://www.fondriest.com/pdf/thermo\_aq4500\_manual\_09.pdf)
* Standard Methods for the Examination of Water and Wastewater, , APHA/AWWA/WEF, 23rd edition
* ASTM D-1889-00 Standard test method for Turbidity in Water, 2003

**15.0 DEFINITIONS/ACRONYMS**

NTU: Nephelometric turbidity units

**16.0 APPENDICES**

Appendix A: by reference CN 95.8 – SOP Analysis for Turbidity QUICKGUIDE

Appendix B: DRT-15CE Turbidimeter Calibration Form

**APPENDIX A**

Turbidimeter

# Calibration Form

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QC Check Staff: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Calibration Standards Used:

Reference SOPs: EPA 180.1; SM 2130B; WPP Lab Turbidity SOP (CN 95.2) and Quick Guide (CN 95.8)

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| Standard Used | “True” NTUs | Reading | Difference | Comments |
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