Washington State Department of Ecology

Environmental Assessment Program

Water Quality Studies Unit

Standard Operating Procedure for Field Measurements of Conductivity/Salinity with a Conductivity Meter and Probe

Version 1.0

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Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)

Environmental Assessment Program, Water Quality Studies Unit

Standard Operating Procedures for Field Measurements of Conductivity/Salinity with a Conductivity YSI Meter and Probe

1.0 Purpose and Scope

1.2 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for Field Measurements of Conductivity/Salinity with a Conductivity YSI Meter and Probe.

2.0 Applicability

2.1 This SOP is to be followed for all field measurements of conductivity or salinity using the YSI 30 meter and probe.

3.0 Definitions

3.1 Conductivity: A measurement of the conductive material in the liquid sample without regard to temperature. Measures the ability of water to carry an electrical current. It is dependent upon the concentration and type (oxidation state and mobility) of ions in the water and the water temperature. Conductivity does not tell us what specific ions are present in water.

3.2 Specific conductance: Conductivity of water expressed at 25°C. Conductivity of water increases with temperature within the range observed in the environment. Conductivity is expressed as milli- or microSiemens/cm (mS/cm or µS/cm) and milli- or micromhos/cm (mmhos/cm or µmhos/cm). 1 µS/cm = 1 µmhos/cm

3.3 Instrument: YSI 30 meter (see figure). (The procedures described also apply to most other instruments, except that calibration procedures will differ – consult manufacturer's instructions.)

3.4 Method: Field measurement with conductivity probe.

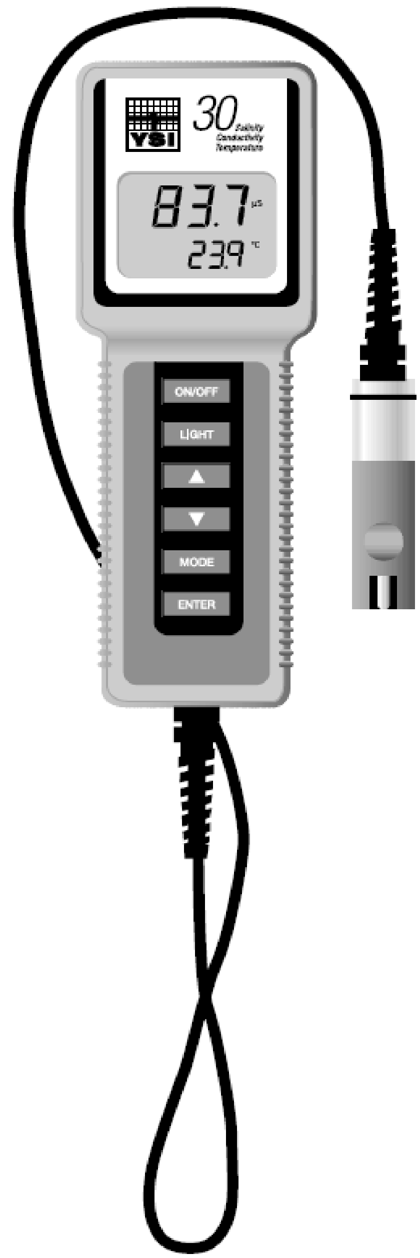
3.5 Precision: Conductivity = ± 1 µmhos/cm @ 25°C
Salinity = ± 0.1 ppt (o/oo)
Temperature = ± 0.1ºC

3.6 Salinity: Measure of the salt concentration of water; higher salinity means more dissolved salts. This meter uses a built-in algorithm to convert conductivity to salinity. The salinity of ocean water is in the range 33-38 ppt, while levels in Puget Sound generally are lower (between 20 and 30 ppt) due to freshwater inputs.

4.0 Personnel Qualifications/Responsibilities

4.1 No special qualifications required.

5.0 Equipment, Reagents, and Supplies



5.1 YSI meter and probe

5.2 Deionized water

5.3 NIST Traceable Calibration Standards (available as "100" (99-109), "1000", or "10,000" µmhos/cm.

5.4 Plastic sample container

5.5 Deionized water squirt bottle

5.6 pH/Conductivity log form

6.0 Summary of Procedure

6.1 Verification and calibration

6.1.1 The YSI30 meter is factory calibrated. However, the calibration should be verified whenever the meter is used as per Method 120.1 (USEPA 1983).

6.1.2 Rinse the conductivity probe in deionized or tap water.

6.1.3 Rinse with conductivity standard and then place the probe in the standard.

6.1.4 Make sure that the meter is set to read in the non-linear function (nLF) mode for temperature compensation and the reference temperature for the meter is set at 25°C.

6.1.5 For calibration, follow the instrument manual to adjust the cell constant.

6.2 Sample Collection

6.2.1 Conductivity levels are measured directly in-situ or in a sample of the water collected from the source. For freshwater, measurements/samples should be taken from the thalweg of a stream (deepest and fastest portion), in the middle of the water column (at least several inches above the stream bed and below the surface), and, when possible, where the flow is approximately 1 cubic foot per second. For marine waters, measurements/samples should be taken as specified in a Quality Assurance project Plan.

6.3 Sample Measurement

6.3.1 Rinse the conductivity sample container (if used) and conductivity probe with sample water.

6.3.2 Agitate the water in-situ or in a sample container. Turn the meter "ON" and let the meter equilibrate.

6.3.3 Record the conductivity measurement on the Field Data Report Form.

6.3.4 The meter has three modes:

6.3.4.1 **Conductivity** -- A measurement of the conductive material in the liquid sample without regard to temperature.

6.3.4.2 **Specific Conductance** -- Also known as temperature compensated conductivity which automatically adjusts the reading to a calculated value which would have been read if the sample had been at 25º C.

6.3.4.3 **Salinity** -- A calculation done by the instrument electronics, based upon the conductivity and temperature readings.

6.3.5 **Temperature** is displayed in all three modes: conductivity, specific conductance and salinity modes.

6.3.6 Note: The meter displays to the nearest tenth, so in most cases, the measurement needs to be rounded to the nearest whole number. If the tenths digit > .5, round up, < .5, round down, and when = .5 always round to the nearest even number. For example, 103.5 would be rounded to 104 and 62.5 would be rounded to 62.

6.4 Meter/Probe Storage

6.4.1 Rinse Probe with deionized water and store dry.

6.5 Troubleshooting

6.5.1 If you suspect an inaccurate measurement or the conductivity measurement is not within the specified measurement quality objectives, do the following.

6.5.1.1 Make sure the meter is in the non-linear function (nLF) mode for temperature compensation.

6.5.1.2 Change the conductivity standard. Standards should only be used once, because they are easily contaminated. A small quantity of deionized water or even a single drop of pH buffer can have a noticeable impact on the standard. (Since standards are expensive, after the first use of the standard for calibration or verification, the standard can be saved in a marked bottle and reused for rinsing.)

6.5.1.3 Check the battery and the probe connection.

6.5.1.4 Recalibrate the meter. Note this recalibration in the comment portion of the Field Data Report Form.

6.5.1.5 Check the previous conductivity sample and if necessary, revise the recorded measurement.

6.5.2 If these steps do not work, then review the troubleshooting section in the meter instruction manual. If you can not fix the problem, fill out an equipment problem report form when you return from the field and place it and the defective equipment on the Operations Center electronic repair bench. As a courtesy, notify the next person scheduled to use the meter. Make a note in the checkout reservation sheet.

6.6 Total Dissolved Solids (TDS) and Salinity

6.6.1 Although YSI 30 does not give a direct readout for TDS, there are other meters (like YSI 300) that do. When using meter for measuring TDS, care should be taken to interpret the data. The following discussion may be helpful in this regard.

6.6.2 Strictly speaking, salinity and TDS are not the same, although they could be similar for a particular water sample. Measurement of TDS require filtering of a sample and very small particulates that pass through the filter become part of the TDS weight. Therefore, from chemistry point of view salinity and TDS would not be the same. Not all the TDS are ionic in nature. Conductivity meters will only detect mobile charged ions. They will not detect any neutral (uncharged) compounds. Such compounds include sugar, many organics (including many pesticides and their residues). These meters also do not detect macroscopic particulates, as those are too large to move in the electric fields applied. So if you see "rusty" looking water from iron oxide particulates, that won't be measured. Neither will anything else that makes the water look cloudy. Bacteria and viruses also won't be detected.

6.6.3 Conductivity meters are really measuring "total charged particles" in the sample and not "total dissolved solids," i.e. strictly speaking.

6.6.4 Metcalf and Eddy (1991) states that "the electrical conductivity (EC) of water is used as a surrogate measure of total dissolved solids (TDS) concentration. Dissolved solids and total dissolved solids are terms generally associated with fresh water systems and consist of inorganic salts, small amounts of organic matter, and dissolved materials (Sawyer,1960). The equivalent terminology in Standard Methods is filterable residue (Standard Methods,1998). Salinity is an oceanographic term, and although not precisely equivalent to the total dissolved salt content it is related to it (Capurro, 1970). For most purposes, the terms total dissolved salt content and salinity are equivalent."

6.6.5 Conductivity typically has a strong linear relationship to TDS. The YSI-300 estimates TDS based on the following relationship: TDS (g/L) = conductivity (mS) x 0.65, where 0.65 is a default factor used by some instruments, (the range is 0.3 to 1.00). The most accurate factor depends on ion "signature" of the specific water body, and a site-specific relationship can be determined from Conductivity measurements and laboratory TDS.

6.6.6 However, the salinity is internally calculated using the following relationships (Standard Methods, 1998):

$$S = a_0 + a_1 R_t^{1/2} + a_2 R_t + a_3 R_t^{3/2} + a_4 R_t^{2} + a_5 R_t^{5/2} + \Delta S$$

where

$$\mathrm{R}_t = \frac{\mathrm{C\ (sample\ at\ t)}}{\mathrm{C\ (KCl\ solution\ at\ t)}}$$

C = conductivity
t = temperature

$$\Delta S = \left[\frac{t - 15}{1 + 0.0162\,(\mathrm{t} - 15)}\right](b_0 + b_1 R_t^{1/2} + b_2 R_t + b_3 R_t^{3/2} + b_4 R_t^{2} + b_5 R_t^{5/2})$$

$a_0 = 0.0080$	$b_0 = 0.0005$
$a_1 = 0.1692$	$b_1 = 0.0056$
$a_2 = 25.3851$	$b_2 = 0.0066$
$a_3 = 14.0941$	$b_3 = 0.0375$
$a_4 = 7.0261$	$b_4 = 0.0636$
$a_5 = 2.7081$	$b_5 = 0.0144$

6.6.7 Additional formulations exist for salinity measurements below 2 ppt (Standard Methods, 1998).

7.0 Records Management

7.1 Not Applicable

8.0 Quality Control and Quality Assurance Section

8.1 The meter is factory calibrated and ready for use, but procedures are available for recalibration. Nonetheless, the QAPP should specify procedures to verify meter accuracy. Typically, meter readings should be verified against two standards that reflect the range of conductivity expected in the field. Failure to meet accuracy targets with standard checks would indicate that recalibration is needed. Conductivity is generally a robust parameter, so the frequency of standard checks can be as frequent as before and after each survey, but monthly may be adequate depending on data quality objectives.

8.2 Meters can also be field-verified by collecting samples for laboratory analysis of conductivity.

8.3 The results of recalibration are recorded on the Meter Calibration Log Form (Appendix D). If the meter will not calibrate properly or if the standard check is off by more than the specified measurement quality objectives, then see Troubleshooting in Procedures above. Also, be sure to code the data with a "J", and note meter problems on the form.

9.0 Safety

9.1 When measuring conductivity/salinity, as with all activity associated with water bodies, be aware of your surroundings. Select an area in which you feel safe and secure both from water and land hazards.

9.2 For further field health and safety measures, please refer to the EAP safety manual.

10.0 References

10.1 Capurro, L.R.A., 1970. Oceanography for practicing engineers. Barnes and Noble Inc., New York.

10.2 USEPA. 1983. Methods for Chemical Analysis of Water and Wastewater. EPA/600/4-79/020.

10.3 Metcalf and Eddy. 1991. Wastewater Engineering

10.4 Sawyer, C.N., 1960. Chemistry for sanitary engineers. McGraw-Hill , New York.

10.5 Standard Methods. 1998. 20th edition. APHA, AWWA, and WEF

10.6 YSI 30 instrument manual. http://www.ysi.com/extranet/EPGKL.nsf/447554deba0f52f2852569f500696b21/90a0378150c2d2dd85256a1f0073f295/$FILE/030136D.pdf

10.7 YSI 300 instrument manual. http://www.ysi.com/extranet/EPGKL.nsf/447554deba0f52f2852569f500696b21/90a0378150c2d2dd85256a1f0073f295/$FILE/605369B.pdf