Water Conductivity Meters

Determining water conductivity is critical to improve the efficiency and precision of electrofishing sampling, for electrode design, and even as an input to deciding which control box model to purchase or which equipment type to use. Water conductivity has much more value than simply a number placed in a table for completeness. Reasonably accurate measurement of water conductivity is essential.

There are two types of water conductivity measures, “ambient” (non-temperature compensated) and “specific” (temperature compensated). In electrofishing, we are interested in the actual water conductivity (“ambient”), not the value that would occur if the water temperature was at some reference, as 25 degrees C (“specific”).

We want an accurate reading conductivity meter, and many of us care about the cost. Luckily, now there are a number of inexpensive options.

Here are a few factors to consider:

- Accuracy
- Cost
- Specific conductivity readout only or does the meter include an option for direct readout of ambient conductivity
- Conductivity ranges available (for freshwaters, we almost always measure in microsiemens/cm (uS/cm)
- Waterproof or not
- Probe directly attached to the meter or on a several foot cable
- If unit measures water temperature, temperature value displayed or not
- Other variables measured as TDS; TDS is not needed for electrofishing and such multiple functionality often makes the meter more expensive

Some examples of meters:

EXtech EC100 Conductivity Meter

Cost: $50 USD

Probe: directly on bottom of meter

Waterproof: Yes

Conductivity ranges: 0 - 1999 uS/cm, 0 – 19.99 mS/cm

Accuracy: + - 1% of full range (so, for the lower 0 - 1999 uS/cm range, that's + - 20 uS/cm)

ATC for specific conductivity; however, the temperature coefficient can be set to zero thereby giving ambient conductivity output.

Hanna Instruments DIST 5 EC/TDS/Temperature Tester

H198311

Cost: $99 USD

Probe: directly on bottom of meter

Waterproof: Yes

Conductivity ranges: 0 - 3999 uS/cm

Accuracy: + - 2% of full range (so, for the 0 - 3999 uS/cm range, that's + - 80 uS/cm)

ATC for specific conductivity; however, the temperature coefficient can be set to zero thereby giving ambient conductivity output.

YSI EcoSense EC300A Conductivity Meter

Cost: $290 USD

Probe: on 4 to 10 m cable

Waterproof: Yes (IP67 rating)

Conductivity ranges: 0 - 500 uS/cm, 0 - 5000 uS/cm, 0 - 50 mS/cm, 0 - 200 mS/cm

Accuracy: + - 1% of reading plus 2 uS/cm for 0 - 500 uS/cm range; + - 1% of reading plus 5 uS/cm

Select either Automatic Temperature Compensated (ATC) for specific conductivity or ambient conductivity

EXtech EC400 Conductivity Meter

Cost: $88 - $105 USD

Probe: directly on bottom of meter

Waterproof: ?

Conductivity ranges: 0 - 200 uS/cm, 200 - 2000 uS/cm, 2 - 20 mS/cm

Accuracy: + - 2% of full range (so, for the 0 - 200 uS/cm range, that's + - 4 uS/cm)

ATC for specific conductivity only; however, also displays water temperature so you could calculate ambient conductivity

Oakton ECTestr 11+ Conductivity Meter

Cost: $90 USD

Probe: directly on bottom of meter

Waterproof: Yes

Conductivity ranges: 0 - 200 uS/cm, 0 - 2000 uS/cm, 0 - 20 mS/cm

Accuracy: + - 1% of full range (so, for the 0 - 2000 uS/cm range, that's + - 20 uS/cm)

ATC for specific conductivity only; however, also displays water temperature so you could calculate ambient conductivity

(Models mentioned do not constitute endorsement. These meters are mentioned for the range of characteristics encompassed and for illustration purposes only).

When my co-instructor, Jan Dean, and I are trying to find less expensive but accurate testing equipment, whether water conductivity meters, pocket scopemeters, or current clamps, we test their accuracy. The tests are either by standards or by comparison to more expensive meters. With water conductivity meters, we use standards. Standards can be purchased, or made by you. Here's an equation for making up water conductivity standards using table salt provided by A. Lawrence ("Larry") Kolz:

NaCl (mg/L) = (Cw + 3.667)/1.9861; R^2 = 0.99

where,

NaCl = sodium chloride (table salt with or without iodine)

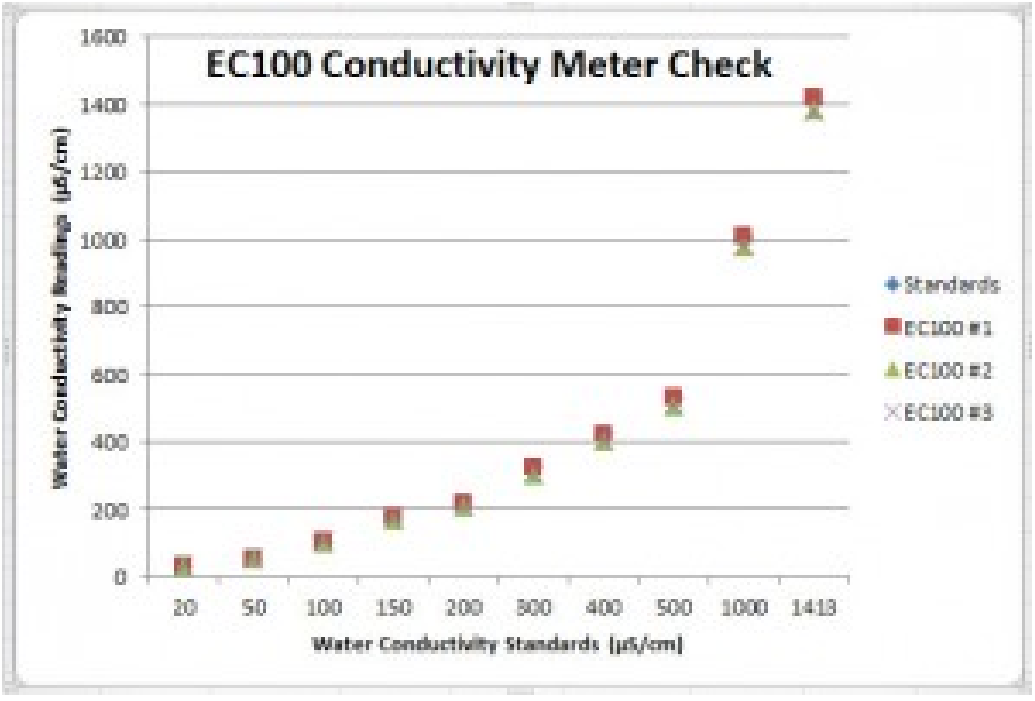
Cw = water conductivity (uS/cm) at 25 degrees C.

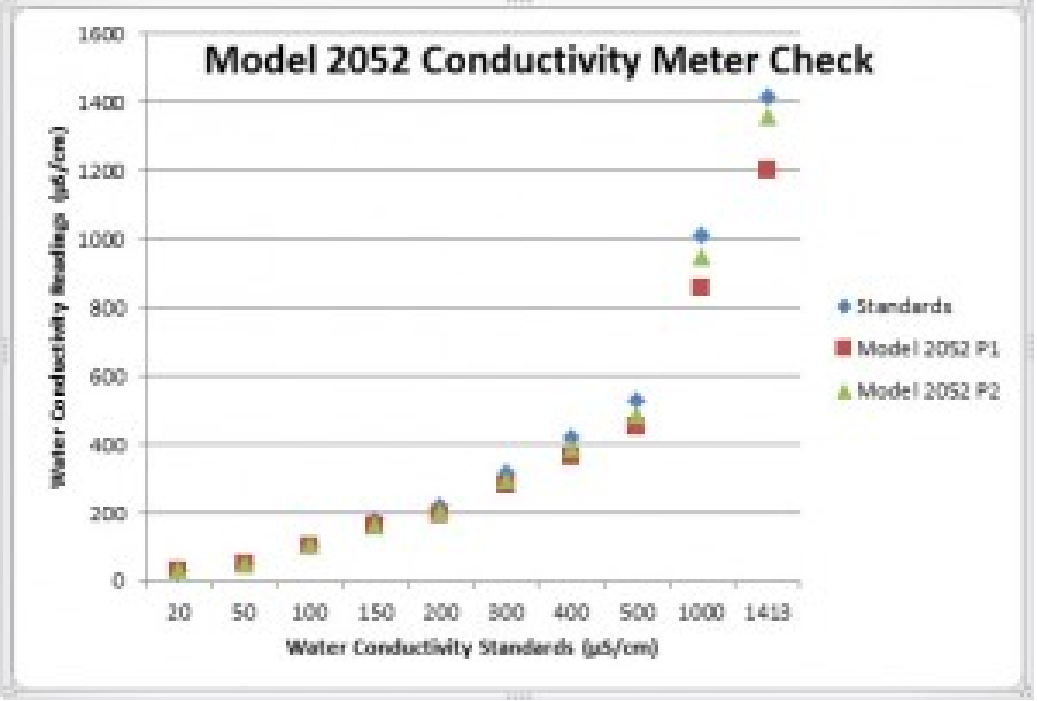
To use this equation, just plug in the value of water conductivity you want for a standard and the result is NaCl in mg you'll need to add to a liter of distilled water. You'll also need an accurate gram balance and a volumetric flask.

So, here's an example where I tested two meter models, one a newer Extech EC100 and my old (and discontinued) EC Model 2052.

Using Larry's equation, I made up nominal standards of 20, 50, 150, 200, 300, 400, 500, and 1000 uS/cm. To this series I added two commercially made standards, 100 and 1413 uS/cm. I calibrated the Model 2052 but had trouble calibrating the EC100. I tested three individual EC100 meters and one Model 2052. I ran two tests on the Model 2052, each with a different probe.

What I found out:





Larry's equation seemed to work well except for the 20 uS/cm standard. I suspect that standard was actually around 30 uS/cm since all tests were reading about 30 uS/cm. I think this was a result of my measurement error making the standard. I already was cutting the amount of NaCl in half since I was using 0.5 liter volumetric flasks. My recommendation for mixing low conductivity standards is to mix up a larger volume of standard, at least one liter.

Percent error for each meter or meter/probe combination was (excluding the 20 uS/cm standard) were:

EC100 #1 = 5.7%

EC100 #2 = 2.3%

EC100 #3 = 3.0%

Model 2052 probe #1 = 8.7%

Model 2052 probe #2 = 4.1%

My conclusions are that

- the low cost meter (EC100) had an accuracy acceptable for use in electrofishing sampling;
- with time, probes can degrade and are often enclosed such that you cannot perform periodic maintenance; and
- although not as complete, the same assessment would have resulted by using only the 100 and 1413 uS/cm standards.

My recommendations are that

- conductivity meters/probes should be periodically evaluated for accuracy; and
- buy inexpensive meters and discard when their accuracy becomes unacceptable or buy meters that have probes that can be maintained or separately purchased when accuracy declines.

In addition, I checked the EC100 to verify that by setting the temperature coefficient from 2.0% to 0.0% resulted in a direct reading of ambient conductivity. Jan Dean did the same verification test with his Hanna Instruments DIST 5 EC/TDS/Temperature Tester. We both found that yes, by setting the temperature coefficient to 0.0%, the meters provide a direct readout of ambient conductivity.

Wrapping up, you may have a situation where you wish to convert historical specific water conductivity data to ambient or you have a conductivity meter that only reads specific. The following equation converts specific water conductivity to ambient:

$$Ca = Cs \times 1.02^{(Ta - Ts)}$$

where,

Ca = ambient water conductivity in uS/cm

Cs = specific water conductivity in uS/cm

Ta = ambient temperature, the water temperature at the sample site (in degrees C)

Ts = specific or reference temperature of the conductivity meter, commonly 25 degrees C

Note: the "1.02" term changes conductivity 2% for every degree C the site water temperature differs from the specific temperature of the meter. A value of 2% for surface water is commonly used and appeared to be valid in my study and work done by Jan Dean over a range of water temperatures typically encountered in electrofishing sampling. Since there may be some error or variance in the percent change, it is always better to measure ambient water conductivity directly if possible.