Electrical Conductivity/Salinity Fact Sheet

What is Electrical Conductivity/Salinity/TDS?

Solids can be found in nature in a dissolved form. Salts that dissolve in water break into positively and negatively charged ions. Conductivity is the ability of water to conduct an electrical current, and the dissolved ions are the conductors. The major positively charged ions are sodium, (Na^{+}) calcium (Ca^{+2}), potassium (K^{+}) and magnesium (Mg^{+2}). The major negatively charged ions are chloride (Cl^{-}), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^{-}). Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity, although they are very important biologically.

Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related. The salts in sea water are primarily sodium chloride (NaCl). However, other saline waters, such as Mono Lake, owe their high salinity to a combination of dissolved ions including sodium, chloride, carbonate and sulfate.

Why is it Important?

Salts and other substances affect the quality of water used for irrigation or drinking. They also have a critical influence on aquatic biota, and every kind of organism has a typical salinity range that it can tolerate. Moreover, the ionic composition of the water can be critical. For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration.

Conductivity will vary with water source: ground water, water drained from agricultural fields, municipal waste water, rainfall. Therefore, conductivity can indicate groundwater seepage or a sewage leak.

How is it Measured?

Conductivity is measured by a probe, which applies voltage between two electrodes. The drop in voltage is used to measure the resistance of the water, which is then converted to conductivity. Conductivity is reciprocal to resistance and is measured in the amount of conductance over a certain distance. The conductivity unit has been called “mho” because it is the inverse of “ohm”, the resistance unit.

The basic unit is "mho/cm", otherwise known as 1 Siemen. However, this unit does not really occur in water and we are using one thousandth (mili-) or one millionths (micro-) of it for natural waters (1000 milimhos and 1,000,000 micromhos are equal to one mho). The useful unit for seawater is milimhos/cm (mS); ocean waters are around 55 mS. The useful unit for freshwater is micromhos/cm (umhos/cm, or uS); tap water ranges between 50 and 800 uS (depending on the source). Because electrical conductivity greatly depends on temperature, scientists use the term "specific conductivity" if the value has been corrected to reflect the measurement temperature (see IP-3.1.3 for more detail about temperature and conductivity).

Salinity can be measured using a hydrometer or a refractometer. The hydrometer measures specific gravity which can then be converted to salinity. The refractometer measures the ability of the water to refract light. Scientists also measure salinity by determining the amount of chlorine in seawater. Salinity can also be measured gravimetrically (i.e., as the weight of the total dissolved solids per a given volume of water). The results are usually expressed in grams/liter (g/l) or parts per thousand (ppt) for sea water (Pacific Ocean water are around 32 g/l in winter). In freshwater the term "total dissolved solids" (TDS) is often used for the same thing instead of "salinity". Useful TDS units are milligrams/liter (mg/l) or parts per million (ppm). See IP-3.1.3 for more detail about the relationship between the different methods.

What Affects it in Water?

1. Rain! In pristine environments, rainwater conductivity equals zero (i.e., the rain is essentially distilled water). Rain falling into a waterbody, or rain runoff flowing into it, will decrease conductivity/salinity.
2. Minerals: Soil and rocks release ions into the waters that flow through or over them. The geology of a certain area will determine the amount and type of ions. Spring water typically shows higher conductivity than inland rain water.
3. Ocean Spray: The salinity/conductivity of coastal rivers is influenced by sea spray that can carry salts into the air, which then fall back into the rivers with rainfall.
4. Tides and mixing zones: In flat areas, water at the river mouths are often salty because of salt water intrusion during high tides. The flow of rivers into estuaries can greatly affect salinity as well as the location of the estuarine mixing zone. This is very important to the survival of estuarine organisms.
5. Evaporation: Evaporation and loss of fresh water will increase the conductivity and salinity of a waterbody. Warm weather can even increase ocean salinity.

What are the Typical Ranges?

Conductivity of Water

Water Type	Conductivity (umhos/cm)
Distilled water	0.5 - 3.0
Melted snow	2 - 42
Potable water in U.S.	30 - 1500
Freshwater streams	100-2000

The table above shows some ranges of conductivity values you might encounter in the field. Conductivity can be much higher than the maximum values shown above under special conditions in some waters, for examples:

- rivers or drainage ditches dominated by subsurface agricultural return flows,
- ephemeral streams or pools late in the season,
- tidally influenced coastal waters, and
- naturally saline or brackish lakes or ponds

The salinity of some naturally saline waters is indicated in the following table:

Salinity of Water

Water Type	Salinity (g/l)
Sea water	33 - 37
Salton Sea	46
Mono Lake	90

What are the Water Quality Benchmarks?

Water quality benchmarks (including criteria, objectives, targets, standards, action levels, limits, etc.) are developed **for individual parameters** to protect the environment and the human users, based on what is perceived as or known to be harmless or safe. Each of these benchmarks has a different meaning and a different use; some are generic and some are specific to a given waterbody or to a given legal process.

A Water Quality Objective (WQO) is a law or regulation that “factors in” three elements:

the beneficial designated use or uses of a particular waterbody, the generic water quality criteria that are necessary to protect these types of beneficial uses, and an anti-degradation statement. Most of the WQOs refer to the average or to the median of several measurements rather than to a single value (e.g., they would specify a "50% upper limit" which is defined as the 50 percentile value of monthly means for a calendar year). In addition, WQOs change over time as we learn more about the effects of each parameter and the ecological requirements of the organisms we are trying to protect.

In California, each of the Regional Water Quality Control Boards (Regional Board) develops a Basin Plan for the Region and keeps updating it over time. The Plan includes a list of water bodies and associated beneficial uses for each. The Plan also has the water quality objectives developed for the Region. As you may have gathered, the WQOs for conductivity vary from Region to Region. In some cases, there are no objectives for conductivity, but there are for total dissolved solids (TDS). If you want the latest value, please be sure to contact the Regional Board in your area. Some examples are provided below.

The following examples were taken from Basin Plans in 1996 and are applicable to surface waters only (excluding the Pacific Ocean).

North Coast (Region1): There are numerical objectives for conductivity in the Basin Plan. The objective is specific to the water body. It is expressed as a number that should not be exceeded, either the 90% upper limit or the 50% upper limit. The 50% upper limit ranges in value from 100 to 1300 umhos/cm, depending on the water body.

San Francisco Bay (Region 2): The narrative objective states that, "Controllable water quality factors shall not increase the total dissolved solids or salinity of waters of the state so as to adversely affect beneficial uses, particularly fish migration and estuarine habitat". There is also a conductivity objective for agricultural supply water, and a total dissolved solids objective for the Alameda Creek watershed.

Central Coast (Region 3): There are no objectives for conductivity. However, there are objectives for total dissolved solids. The TDS objectives range from 150 to 1400 mg/l depending on the water body.

Los Angeles (Region 4): There are no objectives for conductivity. However, there are objectives for total dissolved solids. The TDS objectives range from 225 to 2000 mg/l depending on the water body.

Central Valley (Region 5): The objectives are specific to the water body. They are expressed as either a 90% upper limit, a 50% upper limit, a running average for a specific period of time, or a median value. The objectives are designed to protect fish and wildlife in the Sacramento-San Joaquin Delta. Conductivity objectives are also established to protect the quality of water used for irrigation.

Lahontan (Region 6): The mean annual electrical conductivity of Lake Tahoe shall not exceed 95 umhos/cm at 50 degrees F at any location in the Lake. For other water bodies, there are objectives for conductivity or TDS.

Colorado River Basin (Region 7): There are no objectives for conductivity. However, there are waterbody-specific objectives for TDS which range from 2000 to 4000 mg/l as an annual average.

Santa Ana (Region 8): There are no objectives for conductivity. However, there are waterbody-specific objectives for TDS which range from 110 to 2000 mg/l.

San Diego (Region 9): There are no objectives for conductivity. However, there are waterbody-specific objectives for TDS which range from 300 to 2100 mg/l. These concentrations are not to be exceeded more than 10% of the time during any one year period.

Sources and Resources

This Fact Sheet is implemented by the Clean Water Team (CWT), the Citizen Monitoring Program of the California State Water Resources Control Board. This fact sheet has been revised by CWT from an original document authored by Gwen Starrett, former State Coordinator for Citizen Monitoring. Please contact your Regional CWT Coordinator for further information and technical support.

For an electronic copy, to find many more CWT guidance documents, or to find the contact information for your Regional CWT Coordinator, visit our website at www.swrcb.ca.gov/nps/volunteer.html

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