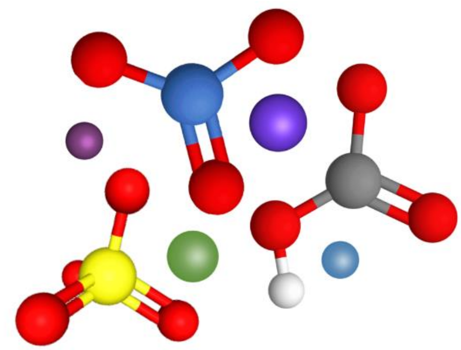
Groundwater Fact Sheet
Salinity



Constituent of Concern
Salinity

Unit of measurement
Total Dissolved Solids (TDS), Electric Conductivity (EC)

Water class in TDS (mg/L)

Freshwater	<1,000
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Highly saline	10,000 to 35,000
Hypersaline	>35,000

TDS for type of water (mg/L) *

Precipitation	10
Lakes/rivers	10 to 200
Groundwater	100 to >50,000
Average Seawater	35,000
Brines	>50,000

Examples of TDS (mg/L) *

Amazon River	40
Colorado River	700
Great Salt Lake	5,000 to 27,000
Mono Lake	81,000

*Average or approximate values.

Summary
Salinity in water is determined by the presence of dissolved particles and ions. The most common ions contributing to dissolved salts are chloride, sodium, nitrate, calcium, magnesium, bicarbonate, and sulfate. Some trace ions like boron, bromide, and iron can also be locally significant.

Two widely used methods for measuring salinity are Total Dissolved Solids (TDS) and Electrical Conductivity (EC). TDS measures all dissolved substances, including organic and suspended particles, reported in milligrams per liter (mg/L). EC, on the other hand, gauges the ability of an electric current to pass through water due to the presence of charged (ionic) particles. It is reported in micromhos per centimeter (µmhos/cm) or microSiemens per centimeter (µS/cm).

For drinking water standards in public supplies, the California State Water Resources Control Board (SWRCB) has set secondary maximum contaminant levels (SMCL). These SMCL are established for taste and odor thresholds. The recommended SMCL for TDS is 500 mg/L (with an upper limit of 1,000 mg/L), and for EC, it is 900 µS/cm (with an upper limit of 1,600 µS/cm). EC and TDS also have short-term SMCL that are generally allowed only under rare circumstances at 2,200 µS/cm and 1,500 mg/L, respectively.

DRINKING WATER STANDARDS[1]

SALINITY

Type	**Agency**	**Recommended**	**Upper**	**Short-term**
Total Dissolved Salts (TDS)	SWRCB[2]	500 mg/L	1,000 mg/L	1,500 mg/L
Electric Conductivity (EC)	SWRCB[2]	900 µS/cm	1,600 µS/cm	2,200 µS/cm

[1]These standards are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These are not considered to present a risk to human health at the SMCL.
[2]SWRCB – California State Water Resources Control Board
[3]Short-term levels are acceptable on a temporary basis pending construction of treatment facilities or development of acceptable new water sources or on a case-by-case basis.

SALINITY IN PUBLIC WATER WELL SOURCES[4]	
Number of active and standby public water wells with TDS above SMCL (> 500 mg/L [5])	2,226 of 8,900 wells tested
Number of active and standby public water wells with TDS above short-term SMCL (> 1500 mg/L)	137 of 8,900 wells tested

[4]Based on 2007-2017 public standby and active well (groundwater sources) data collected by the SWRCB.
[5]Water from active and standby wells is typically treated. Data from private domestic wells and wells with less than 15 service connections are not available.

ANALYTICAL INFORMATION		
Approved EPA methods	160.1 (TDS)	120 (EC)
Detection range	10 - 20,000 mg/L	Instrument dependent
Notes	Gravimetric method. A well-mixed sample is filtered through a standard glass fiber filter. The filtrate is evaporated and dried to constant weight at 180?C.	Conductivity meter. Samples are preferably analyzed at 25°C or corrections may be applied.
Known Limitations to Analytical Methods	Possible interferences include highly mineralized waters (certain ions may be hygroscopic), samples with high bicarbonate (prolonged drying to ensure that all the bicarbonate is converted to carbonate), and waters with high residue levels (residue will entrap water that will not be driven off during drying)	Instrument must be standardized with Potassium Chloride solution before daily use.
Public Drinking Water Testing Requirements	TDS and EC are unregulated in California. There are no public health goals (PHG) or maximum contaminant level goals (MCLGs) for these constituents because secondary standards are set based on aesthetic concerns. However, Regional Water Quality Control Boards (RWQCB) in California can develop specific Basin Plans outlining water quality goals that may include salinity as EC or TDS.	

Salinity Occurrence

Anthropogenic Sources

Anthropogenic occurrence of salinity may be cause by different sources:

- Agriculture: Evaporation of irrigation water will remove water and leave dissolved salts behind. More salts can be dissolved from soil as irrigation water percolates downward. Besides, plants can naturally increase soil salinity as they uptake water and exclude salts. Application of synthetic fertilizers can increase nitrate concentrations in surface and groundwater. Manure from confined animal facilities is enriched in nutrients and other salts and can also increase salinity levels in receiving waters.

- Municipal: Detergents, water softeners, and industrial processes all use salts. Wastewater discharged to Publicly Owned Treatment Works (POTW) and septic systems is often saltier than the original source water. Discharges from POTWs and septic systems can increase the salinity of receiving water. Overwatering of lawns and residential use can also contribute to salinity.
- Industrial: Many industrial processes can increase salinity in processed wastewater. Cooling towers, power plants, food processors, and canning facilities can contribute to salinity.
- Seawater intrusion: groundwater overdraft has allowed seawater to intrude coastal aquifers that historically contained only fresh water.

Natural Sources

Groundwater contains naturally occurring salts from dissolving rocks and organic material. Some rocks, such as halite, gypsum, and limestones, may dissolve very easily; groundwater in these areas can naturally be of very high salinity.

Occurrence and Transport Characteristics

Salts enter groundwater through dissolution of soil, rock, and organic material. Water is introduced to the soil from irrigation or rain; as the water percolates downwards, it dissolves ionic and non-ionic particles from minerals in the soil column; the percolating water that reaches the underlying groundwater is enriched in salts. Salinity will also increase with time as more minerals in contact with groundwater will dissolve.

The concentration of salts in surface and groundwater can increase in several ways. Increased dissolution can increase salinity levels. Evaporative enrichment is the process of increasing salinity levels in surface or groundwater by removing water via evaporation. For example, irrigation water is often applied to crops during the summer when evaporation rates are highest. As water molecules evaporate into the atmosphere, salts remain behind in the irrigation water. This irrigation water can percolate into the underlying groundwater. If the groundwater is later pumped and used for additional irrigation, the evaporation cycle is repeated, and salinity levels can increase. Dryland salinity affects soils when groundwater is brought to the surface by capillary action; evaporation removes water and leaves salt at the soil surface.

Water uptake by plants can also increase soil salinity. Water percolating through the ground has salts dissolved in it. Plant roots work by taking in water while excluding salts and other non-nutrients. The excluded salts will gradually build up around the roots and must be periodically "flushed" from the root zone to maintain plant health. In natural systems, the types of plants found in a specific environment are adapted for naturally occurring soil salinities. In many agricultural areas, salts are flushed from the soil by applying irrigation water. The salts that are flushed from the soil either enter groundwater or are discharged to surficial drains.

Human activities can also affect salinity levels in ground and surface water. Application of synthetic fertilizers, manures, and wastewater treatment facilities can all contribute salt to surface and groundwater. Nitrogen is a necessary nutrient for plant growth and nitrogen fertilizers are typically in the form of salt and nitrate. If excess nitrate fertilizer is applied to a field, the nitrate not used by plants can dissolve and move to groundwater. Manure from confined animal facilities is enriched in nutrients and other salts and can also increase salinity levels in receiving waters. Domestic wastewater is typically enriched in salts due to household activities such as washing and water softening. Most water treatment facilities cannot remove salt. As a result, discharges from these facilities can increase surface and groundwater salinity.

Remediation and Treatment Technologies

Seawater intrusion can be detrimental to drinking water and irrigation wells and render some areas unsuitable for continued agriculture. To prevent seawater intrusion, some communities have installed subsurface barriers and injection wells to restore or at least lower salinity of groundwater.

In heavy agricultural areas, reduced groundwater pumping reduction may be applied to minimize drought effects and the formation of highly saline groundwater.

Public water works, industrial activities, food processors, and dairies are important parts of the economy and society, but also can all increase salt loads to the State's waters. The following is a list of efforts to address salinity issues:

- National Pollutant Discharge Elimination System (NDPES) and Waste Discharge Requirements (WDR) regulatory programs manage salt impacts to surface water and groundwater.
- Institution of preventative measures by local agencies, such as requiring more efficient water softeners and managing lawn fertilizer application.
- Reducing salt loads from imported irrigation water.
- Development of technical advances in irrigated water and fertilizer application methods.
- Disposal of salts through brine lines, deep injection wells, lined landfills, and evaporation ponds.
- Limiting the use of salt for road de-icing in sensitive areas.

Drinking Water and Wastewater Treatment

The most common and effective way to decrease water salinity is through physical filtration. For example, reverse osmosis systems can remove salt and a wide variety of other contaminants from water.

Water with high concentrations of calcium and magnesium is referred to as 'hard water.' Hard water, which can clog pipes and reduce the lathering action of soaps, may be treated using a water softener that exchanges magnesium and calcium ions for sodium or potassium ions. For the water softener to function properly, the exchange resin must be periodically recharged using highly saline brine. The brine used in the regeneration process is discharged to municipal sewage systems or a septic leach field. Wide-spread use of water softeners has been known to significantly increase salinity levels in wastewater sent to water treatment facilities. As of August 2014, more than 25 communities in the state have banned or greatly restricted the use of salt-based water softeners.

Health Effect Information

High concentrations of salts can damage crops, affect plant growth, degrade drinking water, damage home or industrial equipment and can be a health threat. Most salts do not naturally degrade and can be persistent in groundwater. The economic impact of increased salinity in groundwater and surface water can result in fallowed farmland, unsuitable drinking water, and other environmental issues.

Besides, nitrate, among the most common ions contributing to TDS, is a health concern in drinking water. Methemoglobinemia, or "blue baby syndrome," can affect infants when elevated nitrate levels in drinking water cause a decrease in the oxygen carrying capacity of blood. The current state drinking water standard, 10 mg/L as Nitrogen, is specifically designed to protect infants. High levels of nitrate in drinking water may be unhealthy for pregnant women. Livestock can also be sensitive to high levels of nitrate in their drinking water.

Key Resources

1. California State Water Resources Control Board, A Compilation of Water Quality Goals, 17th Edition, (SWRCB, 2016). http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/docs/wq_goals_text.pdf
2. California State Water Resources Control Board, National Pollutant Discharge Elimination System (NPDES), http://www.waterboards.ca.gov/water_issues/programs/npdes/drinkingwatersystems.shtml
3. California State Water Resources Control Board, Contaminants in Drinking Water. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chemicalcontaminants.shtml
4. United States Geological Survey, Sources of Dissolved Solids in Brackish Groundwater, http://water.usgs.gov/ogw/gwrp/brackishgw/sources.html
5. SUAREZ, D.L., Impact of Agricultural Practices on Groundwater Salinity, Agric., Ecosystems and Environ., 26: 215-227, 1989, Elsevier Science Publishers B.V., Amsterdam-Printed in the Netherlands. https://www.ars.usda.gov/SP2UserFiles/Place/20360500/pdf_pubs/P1043.pdf

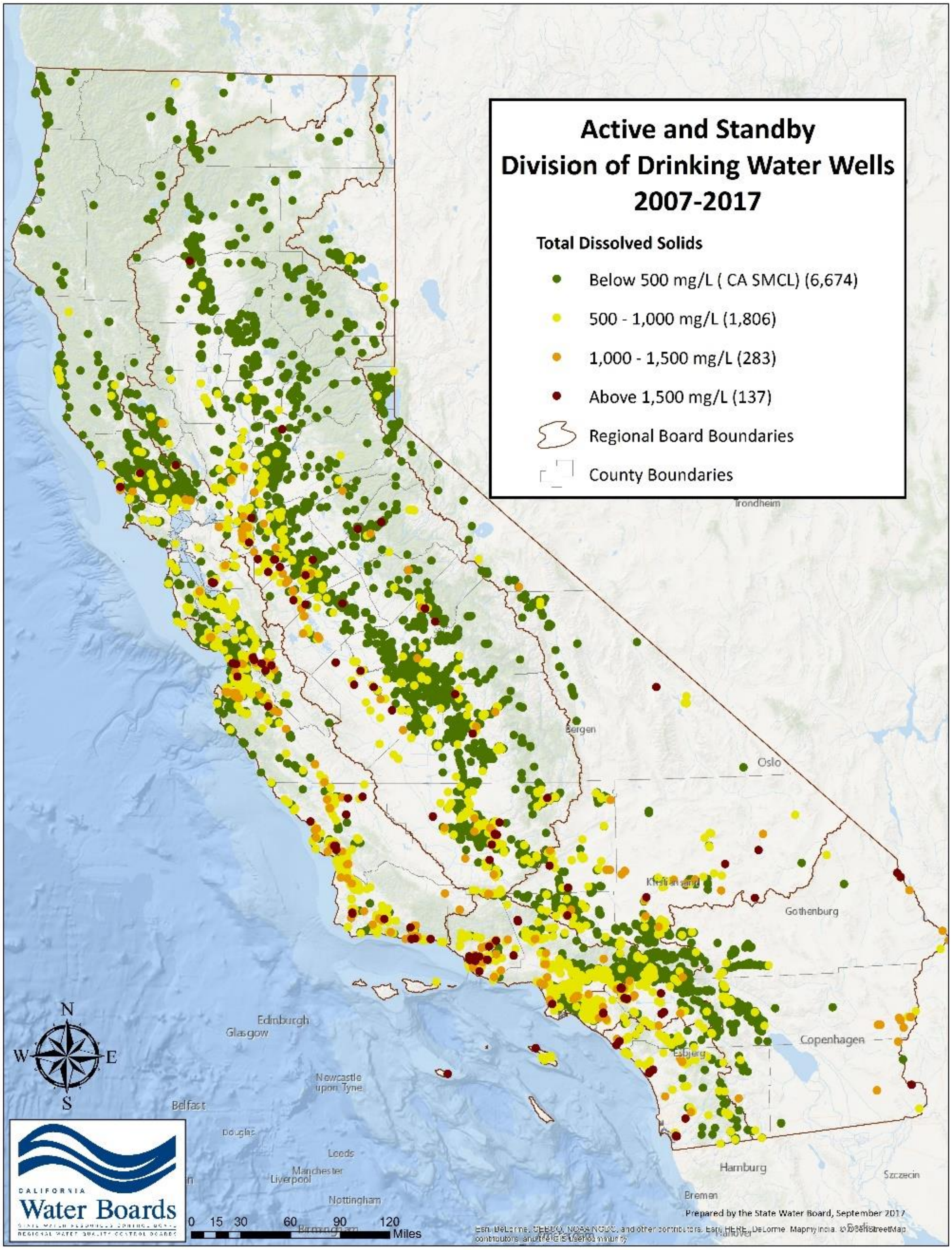


Figure 1. Active and standby public drinking water wells with relative TDS concentrations, 2007-2017, 8,900 wells tested. Source: GAMA GIS.