

Chapter 2

Water Chemistry

- Level 1 Volunteer Water Quality Monitoring Training Notebook -

Chemical parameters play an important role in the health, abundance and diversity of aquatic life. Excessive amounts of some constituents such as nutrients, or the lack of others such as dissolved oxygen, can result in imbalances in water chemistry. Imbalances can degrade aquatic conditions and harm aquatic life. An imbalance in chemical constituents can also make water unsuitable for human consumption, or greatly increase the cost of water treatment before it can be used.

Water Temperature (page 177 *Streamkeepers Field Guide*)

Water temperature is important because most of the physical, chemical and biological characteristics of a river are directly affected by temperature. All aquatic organisms have preferred temperature ranges in which they can survive and reproduce optimally.

Temperature also has an important influence on water chemistry. Rates of chemical reactions generally increase with increasing temperature. Temperature is a regulator of the solubility of gases and minerals (solids) – or how much of these materials can be dissolved in water. The solubility of important gases, such as oxygen and carbon dioxide increases as temperature decreases. In addition certain pollutants become more toxic at increased temperatures.

Temperature Effects

The amount of **dissolved gas in the water**, the **rate of photosynthesis** by algae and other aquatic plants, **and the rate of plant growth** are all affected by temperature. Plant growth increases with warmer temperatures. When plants die, they are decomposed by bacteria, which use up the oxygen. Increased plant growth means more oxygen being removed from the water during the decomposition process.

The metabolic rates of organisms increase with higher temperatures. As respiration and digestion rates increase, fish, aquatic insects and aerobic bacteria need more oxygen to survive.

The sensitivity of organisms is also affected by temperature. Many organisms

require a specific temperature range and changing that range may eliminate some organisms from the ecosystem. Under temperature extremes, organisms may become stressed, which makes them more vulnerable to toxic wastes, parasites and disease.

Human Impacts on Temperature

Riparian cover removal may have a large impact on water temperature by eliminating shade and thereby increasing water temperature.

Soil erosion increases the amount of suspended solids carried by the river. Cloudy water absorbs and holds the sun's heat, which warms the water.

Thermal pollution is water entering the stream that is warmer than the water already present in the river. One source is industries like nuclear power plants which discharge cooling water. Another source is stormwater runoff from heated surfaces, such as parking lots and streets, which get very hot in the summer. Stormwater runoff from these surfaces can reach as much as 120° Fahrenheit.

The Missouri state-wide standard for water temperature is dependent on the designated use for that specific stream. For more information, go to the Secretary of State's website: <http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>.

Dissolved Oxygen (page 170 *Streamkeepers Field Guide*)

Dissolved oxygen (DO) is essential for the maintenance of healthy waterways. The presence of oxygen is a positive sign and the absence of oxygen is a sign of severe pollution. Waters with consistently high dissolved oxygen are considered healthy and stable aquatic systems capable of supporting many different types of aquatic life.

Sources of Dissolved Oxygen

- **Atmosphere.** The air we breathe contains approximately 21% oxygen, which equates to 210,000 ppm oxygen. Most surface waters contain between 5 and 15 ppm dissolved oxygen.

Air: 210,000 ppm

Water: 5 – 15 ppm

NOTE: parts per million (ppm) are equivalent to milligrams per Liter (mg/L)

- **Aeration** from waves and tumbling act to mix atmospheric oxygen with water.

- **Photosynthesis** from algae and other aquatic plants deliver oxygen to water.

Importance of Dissolved Oxygen

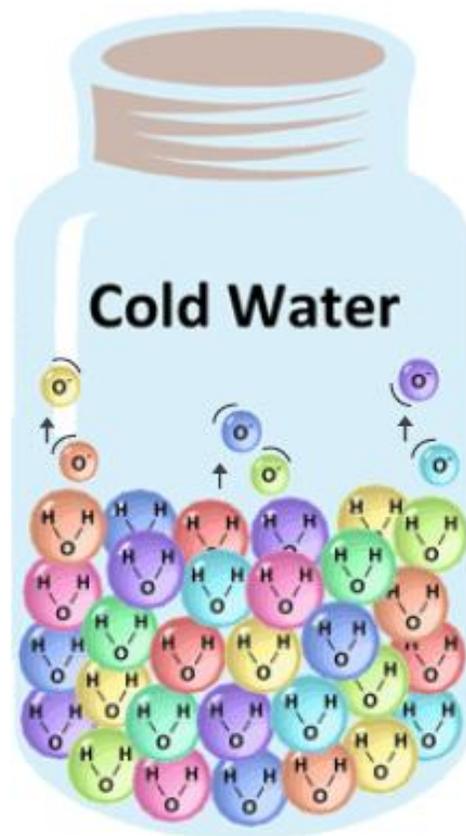
Most aquatic life needs a certain level of dissolved oxygen for survival. A depletion of DO can cause a major shift in the organisms present in a stream from those sensitive to pollution to those tolerant of pollution.

Natural Influences on Dissolved Oxygen

Temperature. Gases like oxygen are more easily dissolved in cool water than warm water. Rivers respond to seasonal changes in the air temperature. Consequently, oxygen levels will be higher in winter than in summer.



* Due to more energy in warm water, water molecules move faster resulting in a lower ability to hold on to oxygen molecules.



* Cold water has lower energy and slower moving water molecules, allowing it to retain oxygen molecules.

Flow. Discharge is also related to an area's climate. Dry periods result in severely reduced flow and increased water temperatures. This combination acts to reduce the dissolved oxygen levels. Precipitation (rain, snow) or melting snows increase flow and the mixing of atmospheric oxygen into the water.

Dissolved or suspended solids. Oxygen dissolves more readily in water that does not contain a high concentration of salts, minerals, or other solids.

Aquatic plants. During daylight hours, dissolved oxygen levels rise due to photosynthesis. Photosynthesis stops as the sun sets, but plant and animal respiration continues to consume oxygen. Just before dawn dissolved oxygen levels fall to their lowest level. Large fluctuations in oxygen from late afternoon to early morning are characteristic of waterways with extensive plant growth.

Human-Caused Changes in Dissolved Oxygen

Removal of riparian corridor vegetation. Lack of shade which causes increased water temperature, and lack of protection from erosion which causes increased solids can work together to reduce oxygen levels.

Organic wastes. These are wastes from the decomposition of dead plants and animals, as well as from the excrement of animals. Organic waste can provide nitrogen and phosphorus which act as fertilizer and stimulate aquatic plant growth. As these plants die, they too become organic wastes. Dissolved oxygen is impacted because aerobic bacteria consume oxygen as they decompose organic matter.

Sources of organic waste:

- Stormwater/Urban Runoff
- Septic systems
- Wastewater treatment plants
- Runoff of manure from animal operations (especially feedlots)
- Discharges from food processing industries

Urban runoff. Rain carries salt, sediment and other pollutants from impervious surfaces (streets, roofs and parking lots) into streams. This raises the total solids in the water and reduces the amount of dissolved oxygen it can hold. In addition, runoff of water from heated surfaces in the watershed, such as streets and parking lots, can cause the stream's

water temperature to rise, and warm water cannot hold as much dissolved oxygen as cooler water.

Dams. Some dams are constructed so that water is released from either the top or the bottom of the reservoir. Although the water on the bottom is cooler than the warm water on top, it may be almost devoid of oxygen as organic matter drops to the bottom and is decomposed by bacteria (using oxygen in the process). The opposite situation can occur when water is released from the top of a dam or spillway. This can cause excessive uptake of air from the atmosphere and results in water that is supersaturated with atmospheric gas.

Water Temperature Effects on Dissolved Oxygen

- As water temperature increases \uparrow , its capacity to dissolve O_2 decreases \downarrow
- As water temperature decreases \downarrow , its capacity to dissolve O_2 increases \uparrow

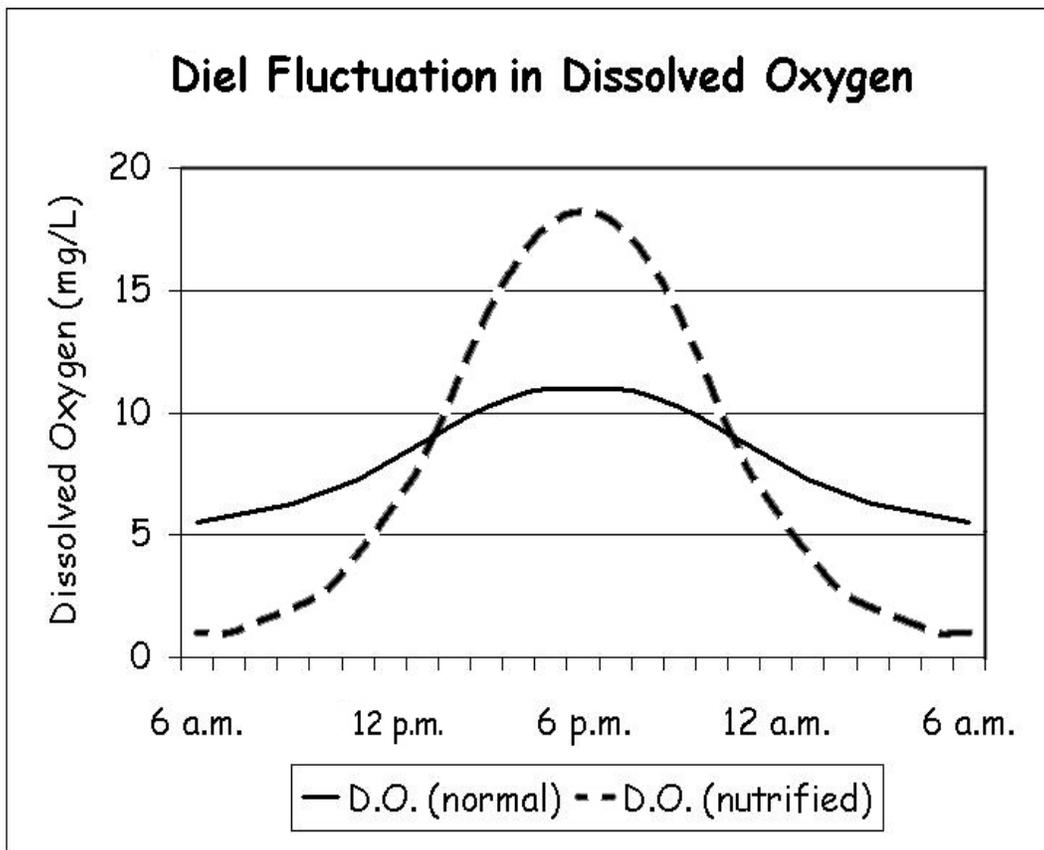
☺ *Therefore, warmer water will not hold as much DO as cold water*

Diel Fluctuation in Dissolved Oxygen

The solid line in the graph represents a normal diel DO fluctuation in late summer. The term “diel” refers to a 24-hour period that usually includes a day and adjoining night. Notice the difference between DO levels at 6:00 A.M. and 6:00 P.M. *Why is the DO lower in the morning and higher in the evening?* In late summer many streams experience an algal “bloom” – a large production of the microscopic plants, called algae, which float suspended in the water and give it its green color. Photosynthesis from algae and other aquatic plants will inflate the amount of oxygen in the stream at peak light – when the sun is highest in the sky during the day. At night the algae and other aquatic plants are not photosynthesizing, and are therefore not producing oxygen.

Plants “respire” both day and night and use oxygen in the process, but as long as the sun is shining, they produce more oxygen via photosynthesis than they are using through respiration.

At the same time, in the summer the water will be warm. Remember that warm water will not hold as much DO as cold water. Therefore, in the summer, streams may have a natural diel fluctuation in DO due to water temperature, algae, and other aquatic plants, and photosynthesis.



The dashed line in the graph represents an extreme diel DO fluctuation in summer. Remember that warmer water increases the metabolic rates of organisms. If the stream lacks a healthy riparian corridor, the water may be hot due to the lack of shade. At night plants do not photosynthesize, so the only source of DO at night in the stream is through physical aeration. *What if it is a slow moving stream with little aeration and an excess amount of nutrients?* An excess of nutrients, like nitrogen and phosphorus, can cause excessive algal growth. So when the sun is shining, this excessive amount of algae pumps a large quantity of oxygen into the water via photosynthesis. Therefore, it follows that they use most of the oxygen at night. Bacteria use oxygen day and night as they decompose dead plants and other organic matter, and the bigger the plant population, the more plants there are to die and decompose. In summary:

- plants are not photosynthesizing at night,
- the water is warm or hot and will not dissolve as much oxygen as a cool stream,
- the metabolic rates of bacteria responsible for decomposing dead organic matter are higher in warm water; and as metabolic rates increase, so does the bacteria's demand for oxygen.

All of these factors together result in more oxygen being used at night than is physically added to the stream via aeration during the night. If these processes occur to extreme levels, subsequent extreme fluctuations in dissolved oxygen, represented by the dashed line on the graph, can occur. Note that the DO level at 6:00 A.M. is within lethal limits for aquatic life.

Dissolved Oxygen Saturation

Saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature, in the absence of other influences. Percent saturation is a more meaningful water quality indicator than a DO reading alone. Dissolved oxygen saturation is a better indicator of whether a DO measurement alone is good or bad.

Think of percent saturation as the amount of oxygen present in the water sample compared to the maximum amount that **could be dissolved at the same temperature**. For example, water is said to be 100% saturated if it contains the maximum amount of oxygen that it can hold at that temperature. A water sample that is 50% saturated only has half the amount of oxygen that it could potentially hold at that temperature. Sometimes water can become supersaturated with oxygen because of rapidly tumbling water.

How is it possible to get a DO saturation greater than 100%? Dissolved oxygen is directly related to the temperature of the water and the atmospheric pressure. For ST VWQMs, atmospheric pressure is not an issue because most volunteers are working close to sea level. The standard temperature for reading DO is normally between 68°F & 72°F (20°C & 22°C), and it is at this temperature that the maximum amount of DO water can hold is considered 100%. We have discussed how oxygen is introduced into the water through photosynthesis of aquatic plants, waves and tumbling action. We have also discussed the fact that cooler water can hold more dissolved oxygen. So if the aquatic plants are producing more O₂ at a faster rate than is being used through respiration, it is possible to get more than 100% O₂ saturation at a given temperature.

Percent saturation values of 80-120% are considered to be excellent and values less than 60% or over 125% are considered to be poor. For instance, a DO reading of 8.0 mg/L could be an excellent result during the summer when water temperatures are high and the water's ability to hold oxygen is low. That same reading, however, could indicate problems if that result were obtained during the winter months when water temperatures are low and

oxygen-holding capacity is high.

A General Rule for Ozark Streams

- > 80% DO saturation reflects healthy DO levels
- < 80% DO saturation reflects water quality impairment

A General Rule for Prairie Streams and Slow Moving Streams

- > 60% DO saturation reflects healthy DO levels
- < 60% DO saturation reflects water quality impairment

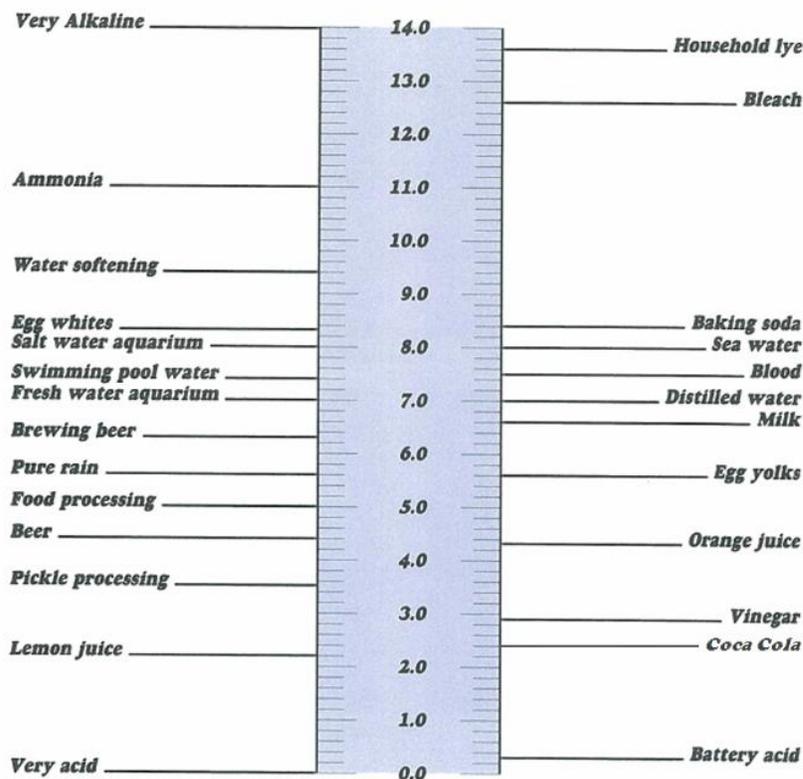
To determine DO percent saturation, refer to the pink *DO Percent Saturation Sheet* at the end of this chapter. Determine DO saturation by cross-referencing your dissolved oxygen results with the water temperature of your stream at the time of DO analysis.

- **NOTE:** Remember that you must have taken the stream water temperature at the time of the DO analysis to determine DO percent saturation.
- **NOTE:** Mathematical calculation of saturation (page 175 *Streamkeepers Field Guide*)

Missouri's state-wide standard for DO is a minimum of 5 mg/L for all streams.

pH or Parts Hydrogen (page 165 *Streamkeepers Field Guide*)

Water (H₂O) contains both H⁺, Hydrogen ions and OH⁻, hydroxide ions. "pH" is an abbreviation for the French expression, "Pouvoir Hydrogene," meaning "the power of Hydrogen." It measures the H⁺ ion concentration of substances and gives results on a scale from 0 to 14. Water that contains equal numbers of H⁺ and OH⁻ ions is considered neutral (pH 7). If a solution has more H⁺ than OH⁻ ions, it is considered **acidic and has a pH less than 7**. If a solution contains more OH⁻ ions than H⁺ ions, it is **considered basic with a pH greater than 7**.



Source: Hach Co. "Water, Water Everywhere"

The pH scale is logarithmic. Thus, it is important to **remember that every one-unit** change on the pH scale is a ten-fold change of the sample. As you go up and down the scale, the values change in factors of ten. A one-point pH change indicates the strength of the acid or base has increased or decreased tenfold; a 2-point change indicates a 100-fold change in acidity or basicity, and a 3-point change in pH indicates a 1000-fold change.

Examples:

- An increase in pH from **7.0 to 8.0** means the water is **10 times more basic**.
- An increase in pH from **7.0 to 9.0** means the water is **100 times more basic**.
- An increase in pH from **7.0 to 10.0** means the water is **1,000 times more basic**.

Changes in Aquatic Life

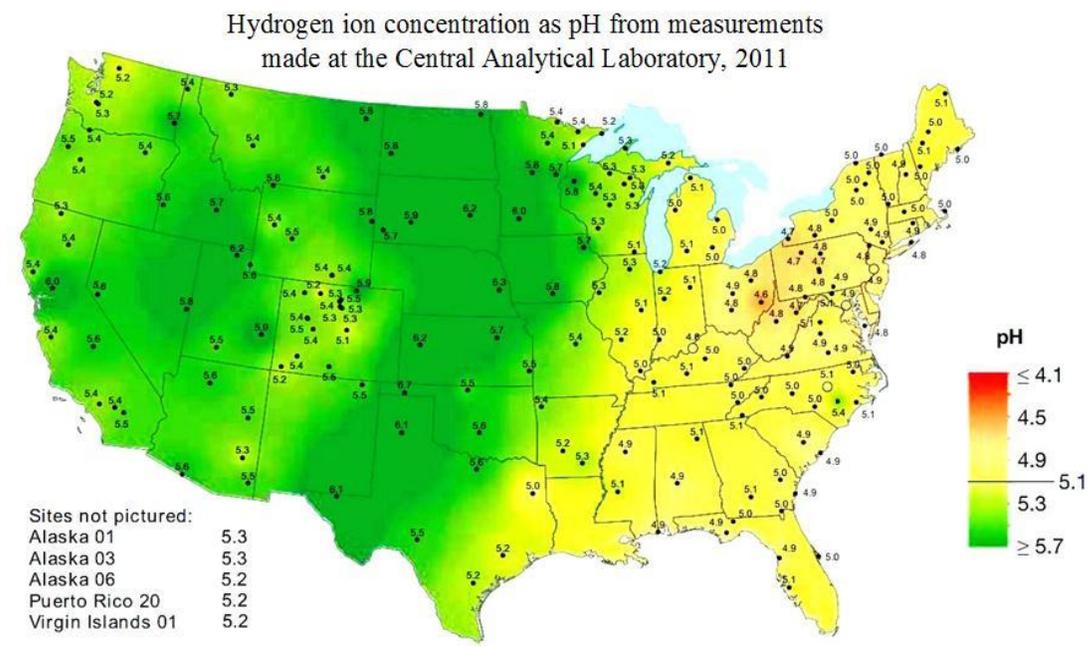
Most organisms have adapted to life in water of a specific pH and may die if the pH changes even slightly. **At extremely high or low pH values (11.0 or 4.5) the water becomes lethal to most organisms** (reference Table 9 on page 167 of the *Streamkeeper's Field Guide*). pH is also important because of how it affects other pollutants in the water. Waters that are very acidic can cause metals such as zinc, aluminum, and copper to be released into the water column. The metals can then be taken up and accumulated in the food

chain. Metals in the water such as copper and aluminum can accumulate on the gills of fish or cause deformities in young fish, reducing their chance of survival. Ammonia compounds convert to a toxic form in water that is basic. The more basic the water, the more toxic is the ammonia that is present.

Human-Caused Changes in pH

In the United States the pH of rivers is usually between 6.5 and 9.0. Rain water is normally acidic with a pH of around 5.6. Increased amounts of nitrogen oxides (NO_x) and sulfur dioxide (SO_2), primarily from automobile and coal-fired power plant emissions, are converted to nitric acid and sulfuric acid in the atmosphere resulting in **acid rain or acid snow**. In many areas of the United States the local geology strongly influences the acidity of the local water. In the northeastern United States the geology of the substrate is granite, which has very little neutralizing capacity. **If limestone or dolomite is present, which is the case in much of Missouri, the alkaline (basic) limestone and dolomite neutralizes the acid rain before it can have a negative impact on the water quality of lakes and streams.**

Missouri's state-wide standard for pH is a minimum of 6.5 and a maximum of 9.0 for all streams.



National Atmospheric Deposition Program/National Trends Network, 2011
<http://nadp.sws.uiuc.edu>

Conductivity (page 181 *Streamkeepers Field Guide*)

All liquid solutions conduct electricity to some degree. The measurement of water's ability to conduct electricity is called **conductivity**, or *specific conductance*, and is measured in a unit of current, or flow of electricity called micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$; the symbol " μ " represents "micro"). It is the opposite of electrical *resistance*, which is measured in ohms. Pure water is not a good conductor of electricity. Conductivity of water is determined by the amount of solids that are dissolved in the water. Rainfall, interacting with the atmosphere, vegetation, rocks and soil, is the major source of dissolved solids in streams. Groundwater entering streams is another source. Water is uncommonly good at dissolving a wide variety of materials. It is the medium that allows the necessary biochemical reactions in organisms to proceed. Water carries needed minerals and nutrients to living organisms and transports wastes away.

Seven common substances make up about 99% of the dissolved solids in streams. In their approximate order of abundance in Missouri waters, these include:

- Bicarbonate
- Calcium
- Magnesium
- Sulfate
- Chloride
- Sodium
- Potassium

It is not surprising that the three most abundant dissolved substances come from the dissolution of limestone and dolomite, Missouri's most abundant rocks. The remaining one percent of dissolved substances can vary considerably, but can include nitrates, different metals, ammonia, phosphorus, and manmade compounds such as pesticides and fuels. **There is no water quality standard for conductivity because it is a general indicator of water quality. However, a large change in conductivity values or readings greater than 1200 $\mu\text{S}/\text{cm}$ may indicate a need for further investigation. Conductivity can tell us the amount of solids dissolved in the water, but does not tell us what kind of dissolved solids are present. Unexplained changes in conductivity can indicate problems in the watershed.**

Conductivity may vary primarily due to the influence of rainfall or snowmelt. Precipitation is low in dissolved solids and an unimpacted stream, which has recently

received rainfall, will have a lower conductivity value. The conductivity values below are typical readings for various waters and geographic regions.

Typical Conductivity Readings

Missouri River at St. Joseph Conductivity is high in the Missouri River since it drains all of the water for 420,300 square miles.	400-750 $\mu\text{S}/\text{cm}$
Grand River near Sumner	350-550 $\mu\text{S}/\text{cm}$
Pomme de Terre near Polk	250-450 $\mu\text{S}/\text{cm}$
Big Piney at Devil's Elbow	200-350 $\mu\text{S}/\text{cm}$
Little Ditches near Rives	85-580 $\mu\text{S}/\text{cm}$
Jacks Fork at Alley Spring	230-350 $\mu\text{S}/\text{cm}$
Pickle Creek at Hawn State Park Pickle Creek is located in Hawn State Park near Ste. Genevieve, which is in a geologic region that consists of granite. Granite does not dissolve as easily as limestone, so the amount of natural dissolved minerals and nutrients is very low in the waters of this ecoregion.	40-60 $\mu\text{S}/\text{cm}$
Municipal wastewater treatment plant effluent The conductivity of wastewater tends to be very high since most plants do not treat wastewater for dissolved solids. The most common and abundant dissolved solid that may pass through the plant is sodium chloride, the salt that we ingest. Salt is a good electrical conductor.	800-2000 $\mu\text{S}/\text{cm}$
North and west Missouri shallow groundwater Groundwater in North Missouri is high in salt (dissolved minerals) since the aquifer rests on an ancient seabed.	800-2000 $\mu\text{S}/\text{cm}$

Source: USGS, 2010

Chlorides

Chloride is one of the major components of road salt, also known as rock salt. The use of road salt has been implicated in the elevation of chloride and sodium levels in surface and groundwater as well as in the surrounding environment. Sources of chloride run off are roads, parking lots, airports, drains, ditches, salt storage piles, garages, truck washing areas, and sites where snow is piled as well as waste water treatment facilities, industrial and natural sources. It is estimated between 10 and 20 million tons of road salt is used nationally each year.

Chloride is soluble and can enter surface and groundwater easily. Although non-toxic at low levels, elevated levels of chloride in waterbodies can have a detrimental effect on freshwater ecosystems. At high levels, chloride is toxic to freshwater organisms. High levels of chloride can also lead to density stratification in lakes and ponds, resulting in oxygen depletion and fish kills. High chloride concentrations can restrict water use for consumption

in domestic and public supply wells, and affect the quality necessary for many industrial uses. Use of water with high chloride concentration for irrigation can damage crops directly through burning of tissue or indirectly by changing the soil structure, which can cause fields to be damaged beyond use or repair.

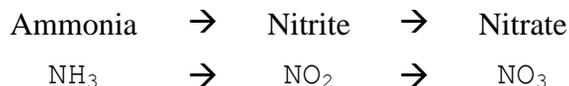
If you live in an urban area where roads and/or parking lots are heavily salted, or near an airport or other source of possible chloride contamination, you may wish to inquire with program staff about monitoring your stream for chlorides. Monitoring usually takes place from October through February.

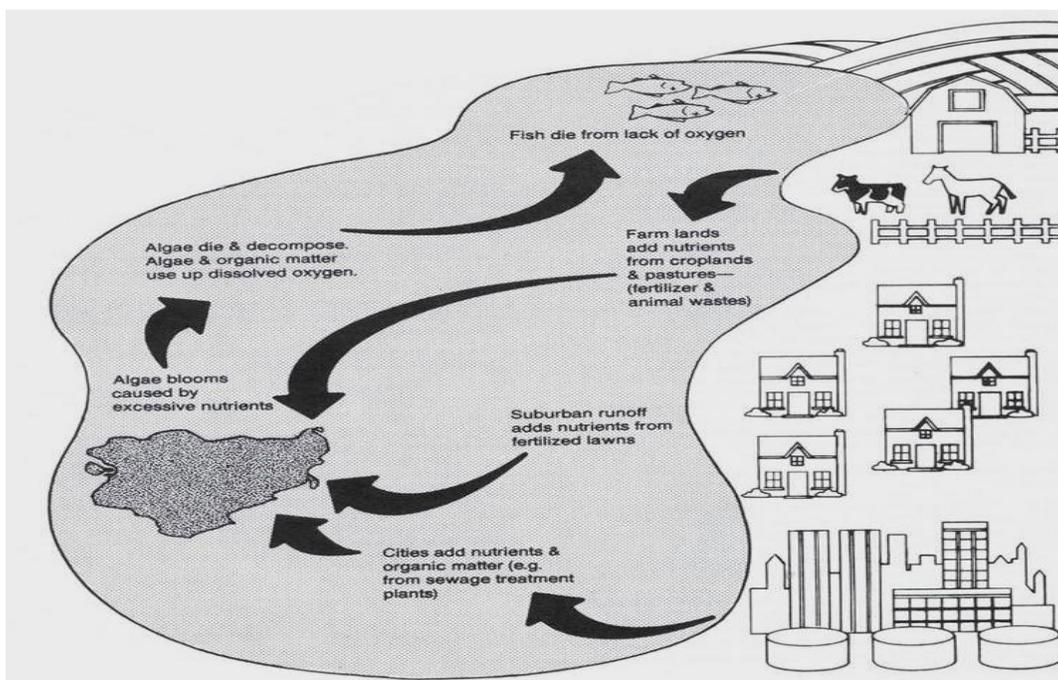
Missouri water quality standards establish the following limits on chloride:

<u>Beneficial Use</u>	<u>Acute toxicity</u>	<u>Chronic toxicity</u>
Aquatic life	288 mg/l	178 mg/l
Drinking Water	250 mg/l (maximum standard)	

Nitrates and Ammonia (Nitrogen on page 179 *Streamkeepers Field Guide*)

Nitrogen is an essential plant nutrient required by all living plants and animals for building protein. **All organic (living) matter contains nitrogen.** In aquatic ecosystems, nitrogen is present in different forms. The usable forms of nitrogen for aquatic plant growth are ammonia (NH₃) and nitrate (NO₃). Excess amounts of nitrogen compounds can result in unusually large populations of aquatic plants and/or organisms that feed on plants. For instance, some algal blooms are a result of excess nitrogen entering the stream. **As aquatic plants and animals die, bacteria break down the organic matter. Ammonia (NH₃) is oxidized (combined with oxygen) by bacteria to form nitrites (NO₂) and nitrates (NO₃).**





Source: NRCS "Water Quality Indicators Guide: Surface Waters"

The cycle for breaking down organic matter (both the biological process and the chemical process) uses up the oxygen present in the water.

Impacts on Nitrogen Levels

Natural

- **Leaf fall** – When trees shed their leaves in the fall and the leaves drop into the stream, nitrate levels naturally become elevated as a result of decomposition of organic matter.
- **Organic decay** – Since all living matter is composed of nitrogen, decomposition of organic matter other than leaves may cause elevated nitrate levels.

Manmade

- **Poorly functioning septic systems** may leak nitrogenous waste into streams. Wastewater from treatment plants may be high in nitrogen since most treatment plants do not remove nitrates.
- **Storm drains** may carry wastes from pets, fertilizer, broken sewer lines and septic systems.

Combined Sewer Overflows (CSOs) are waste water systems designed to combine

with the stormwater system during high flows to bypass wastewater treatment plants. These antiquated systems were originally designed this way as an attempt to avoid overwhelming the wastewater treatment plants. It has long been recognized that these systems were a bad idea because they allow too much untreated water to enter streams. These systems were designed in the early 1900s and can still be found in existence in Kansas City, St. Louis, Sedalia, St. Joseph and Moberly. The estimated cost to fix Kansas City's CSOs is about \$1 billion, which is why these big systems have not been replaced.

Runoff from animal production in feedlots and runoff from wastes improperly applied to the land may enter a stream.

Runoff from lawn fertilizers may enter a stream if fertilizer is improperly applied or if there is an immediate rainfall event after fertilizer application.

Septic systems are a common wastewater treatment method in many areas. Instead of centralized wastewater treatment plants, which exist in most urban settings, people with septic systems have individual wastewater treatment. A septic system is comprised of a main pipe from the house to the septic tank, and a number of pipes with holes in them leading from the septic tank. These pipes are arranged in a grid that usually lies over stone and gravel and is called a "drain field." Wastes from the toilet, kitchen sink, bathtub, and washing machine flow through an underground pipe to a septic tank. In the septic tank solid matter settles out and floating grease may be skimmed off. The remaining liquid enters the drain field through the holes in the pipes and trickles through the stone, gravel and soil.

In properly functioning systems, soil particles remove nutrients, like nitrates and phosphates, before they reach groundwater or surface water. People who fail to periodically pump out their septic tank may allow their tanks to overflow with solids. This results in wastes going directly to the drain field instead of settling in the tank. The drain field becomes plugged and the liquid wastes are no longer filtered through the soil. **In this condition, household sewage may pool on the ground and enter surface water through runoff.**

NOTE: *The Volunteer Water Quality Monitoring Program measures "Nitrate as Nitrogen" ($\text{NO}_3\text{-N}$) and "Ammonia as Nitrogen" ($\text{NH}_3\text{-N}$).*

NITRITES + NITRATES as NITROGEN in mg/L

<u>River</u>	<u>Average Value</u>	<u># of Samples</u>	<u>Range</u>
Mississippi	2.39	n = 10	0.56 – 4.53
Chariton	0.73	n = 14	0.38 – 1.43
Pomme de Terre	0.15	n = 14	0.02 – 0.81
Jacks Fork	0.35	n = 10	0.31 – 0.39

Source: USGS, 2010

There are currently no numeric nutrient standards for streams. DNR has recently developed nutrient standards for Missouri's lakes and reservoirs, and is in the process of developing similar nutrient standards for Missouri streams.

Ammonia (NH₃) is the only nutrient that is directly toxic to aquatic life.

However, the toxicity of ammonia is dependent on the pH and the temperature of the water.

Toxicity - What is Toxicity?*

Toxicity: The potential of a test material to cause adverse effects on living organisms. Generally it is a poison or mixture of poisons. Toxicity is a result of *dose or exposure concentration and exposure time.*

Acute Toxicity: Relatively “short-term lethal” (deadly) or other effect, usually defined as occurring within 4 days for fish or macroinvertebrates.

Chronic Toxicity: Toxicity involving a stimulus that lingers or continues for a long period of time. A chronic toxic effect can be measured in terms of reduced growth, reduced reproduction, etc., in addition to death.

* From Standard Methods for the Examination of Water and Wastewater, 19th Edition 1995

Ammonia Toxicity Tables

It is important to note that ammonia levels are not usually a problem in most Missouri streams. However, current wisdom is that ammonia may be the cause of Missouri's native mussel and clam species' decline in population. Because this may be the case, tighter ammonia restrictions are being placed on wastewater treatment plants as permits are renewed. Since ammonia kits are very expensive, the VWQM Program only provides kits to volunteers sampling in areas where ammonia levels could become a problem, (e.g., below waste treatment plants or below hog and poultry operations).

To determine the toxicity of ammonia, a measurement of water temperature and pH must have been made at the time of the ammonia analysis. You will find the Water Quality Standards at the Secretary of State's Website:

<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf>

Ammonia Nitrogen is one of the Numeric Criteria listed in the rules. The majority of these criteria (also called standards) can be found in Tables A and B in the rules at 10 CSR 20-7.031. Criteria for acute and chronic Total Ammonia Nitrogen are found in Tables B1 (acute) and Tables B2 and B3 (chronic) – see below.

Note: The following paragraph pertains to Table B1 specifically: Before you can look up your stream's *Acute Criteria for Total Ammonia Nitrogen*, you must first know your stream's official "beneficial uses," which are found in "*Table H – Stream Classification and Use Designations.*" Descriptions of the uses listed at the bottom of Table H (e.g., IRR = Irrigation, CLF = Cool Water Fishery, WBC = Whole Body Contact Recreation) can be found at 10 CSR 20-7.031(1)(C) in the rules. **If you want to look this type of information up, but don't have a copy of the rules, or just have trouble reading the rules, please feel free to contact any one of the trainers that work for the Department of Natural Resources and ask for help (a complete list of trainers can be found in the Appendix of this notebook).**

These tables can be used to determine the chronic or acute toxicity of ammonia in your stream by cross-referencing the pH of the stream with the water temperature or designated use of the stream. The toxicity of the ammonia is any value above the cross-referenced number. For example, for water with a pH 7.6, the acute criteria for a stream designated as a "Cold Water Fishery" is 11.4 mgN/L. An ammonia nitrogen value above 11.4 mgN/L is considered toxic.

Note: all water bodies are assumed to have "early life stages present" (and so Table B3 would be used), unless a special study documenting the absence of early life stages is approved. Only in that case would Table B2 be used.

AMMONIA as NITROGEN in mg/L

River	Average Value	# of Samples	Range
Mississippi	1.27	n = 10	0.72 – 3.3
Chariton	1.5	n = 14	0.49 – 4.6
Pomme de Terre	0.28	n = 14	0.16 – 0.46
Jacks Fork	0.08	n = 10	0.05 – 0.1

Source: USGS, 2010



Table B1. Acute Criteria for Total Ammonia Nitrogen (mg N/L)

pH	Cold-Water Fisheries ⁽¹⁾	Cool & Warm-Water Fisheries ⁽²⁾
6.5	32.6	48.8
6.6	31.3	46.8
6.7	29.8	44.6
6.8	28.1	42.0
6.9	26.2	39.1
7.0	24.1	36.1
7.1	22.0	32.8
7.2	19.7	29.5
7.3	17.5	26.2
7.4	15.4	23.0
7.5	13.3	19.9
7.6	11.4	17.0
7.7	9.6	14.4
7.8	8.1	12.1
7.9	6.7	10.1
8.0	5.6	8.4
8.1	4.6	6.9
8.2	3.8	5.7
8.3	3.1	4.7
8.4	2.5	3.8
8.5	2.1	3.2
8.6	1.7	2.6
8.7	1.4	2.2
8.8	1.2	1.8
8.9	1.0	1.5
9.0	0.8	1.3

Table B2. Chronic Criteria for Total Ammonia Nitrogen (mg N/L): Early Life Stage absent⁽³⁾⁽⁴⁾

pH	Temperature (°C)																
	0-7	8	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30
6.5	10.8	10.1	9.5	8.9	8.3	7.8	7.3	6.8	6.4	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	10.7	9.9	9.3	8.7	8.2	7.7	7.2	6.7	6.3	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	10.5	9.8	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	10.2	9.5	8.9	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	9.9	9.3	8.7	8.1	7.6	7.2	6.7	6.3	5.9	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	9.6	9.0	8.4	7.9	7.4	6.9	6.5	6.1	5.7	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	9.2	8.6	8.0	7.5	7.1	6.6	6.2	5.8	5.4	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	8.7	8.2	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	8.2	7.7	7.2	6.7	6.3	5.9	5.6	5.2	4.9	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	7.6	7.2	6.7	6.3	5.9	5.5	5.2	4.8	4.5	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	7.0	6.6	6.2	5.8	5.4	5.1	4.8	4.5	4.2	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	6.4	6.0	5.6	5.3	5.0	4.6	4.3	4.1	3.8	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	5.8	5.4	5.1	4.7	4.4	4.2	3.9	3.7	3.4	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	5.1	4.8	4.5	4.2	4.4	3.7	3.5	3.2	3.0	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	4.5	4.2	3.9	3.7	3.5	3.2	3.1	2.8	2.7	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	3.9	3.7	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	3.4	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	2.9	2.7	2.5	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	1.4	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1



Table B3. Chronic Criteria for Total Ammonia Nitrogen (mg N/L): Early Life Stages present ⁽⁵⁾

pH	Temperature (°C)									
	0	14	16	18	20	22	24	26	28	30
6.5	6.6	6.6	6.0	5.3	4.6	4.1	3.6	3.1	2.8	2.4
6.6	6.5	6.5	5.9	5.2	4.6	4.0	3.5	3.1	2.7	2.4
6.7	6.4	6.4	5.8	5.1	4.5	3.9	3.5	3.0	2.7	2.3
6.8	6.2	6.2	5.7	5.0	4.4	3.8	3.4	3.0	2.6	2.3
6.9	6.1	6.1	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2
7.0	5.9	5.9	5.3	4.7	4.1	3.6	3.2	2.8	2.4	2.1
7.1	5.6	5.6	5.1	4.5	3.9	3.5	3.0	2.7	2.3	2.0
7.2	5.3	5.3	4.9	4.3	3.7	3.3	2.9	2.5	2.2	1.9
7.3	5.0	5.0	4.6	4.0	3.5	3.1	2.7	2.4	2.1	1.8
7.4	4.7	4.7	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.7
7.5	4.3	4.3	3.9	3.4	3.0	2.6	2.3	2.0	1.8	1.6
7.6	3.9	3.9	3.6	3.1	2.7	2.4	2.1	1.9	1.6	1.4
7.7	3.5	3.5	3.2	2.8	2.5	2.2	1.9	1.7	1.5	1.3
7.8	3.1	3.1	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1
7.9	2.8	2.8	2.5	2.2	1.9	1.7	1.5	1.3	1.1	1.0
8.0	2.4	2.4	2.2	1.9	1.7	1.5	1.3	1.1	1.0	0.8
8.1	2.1	2.1	1.9	1.6	1.4	1.2	1.1	1.0	0.8	0.7
8.2	1.7	1.7	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6
8.3	1.5	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
8.4	1.2	1.2	1.1	1.0	0.9	0.7	0.7	0.6	0.5	0.4
8.5	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
8.6	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
8.7	0.7	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2
8.8	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2
8.9	0.5	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2
9.0	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

- (1) *Salmonids present*: $CMC = [0.275 / (1 + 10^{7.204 - pH})] + [39.0 / (1 + 10^{pH - 7.204})]$
- (2) *Salmonids absent*: $CMC = [0.411 / (1 + 10^{7.204 - pH})] + [58.4 / (1 + 10^{pH - 7.204})]$
- (3) Without sufficient and reliable data, it is assumed that Early Life Stages are present and must be protected at all times of the year.
- (4) Early Life Stages absent
 $CCC = [0.0577 / (1 + 10^{7.688 - pH})] + [2.487 / (1 + 10^{pH - 7.688})] * 1.45 * 10^{0.028 * (25 - \text{MAX}(T, 7))}$
- (5) Early Life Stages present
 $CCC = [0.0577 / (1 + 10^{7.688 - pH})] + [2.487 / (1 + 10^{pH - 7.688})] * \text{MIN}(2.85, 1.45 * 10^{0.028 * (25 - T)})$

Phosphorus (page 180 *Streamkeepers Field Guide*)

Phosphorus is also a plant nutrient. Phosphorus is most readily available to plants as **orthophosphate**, a reactive form of phosphorus commonly referred to as **PO₄ (phosphate)**. In nature it is generally present in very low levels measured in tenths or hundredths of mg/L.

Phosphorus occurs naturally in rocks and enters the water column through the natural weathering of rock. Phosphorus binds readily with soil particles. Soil must be highly saturated with phosphorus before excess amounts are detectable in shallow groundwater, which will eventually enter streams where it can have negative impacts.

In many instances phosphate can be the nutrient that limits plant growth (called “primary productivity”). This occurs when phosphorus is less abundant in surface water than nitrogen. Even small increases in the amount of phosphorus entering a stream can have a large impact. If point source or nonpoint sources of pollution are high in phosphate, they can over-stimulate the growth of all types of aquatic plants.

Sources of Phosphorus in Streams

Natural

- **Rock and Soil** – Phosphate enters water naturally through the weathering of rock.
- **Organic** – Since all living matter is composed of phosphorus (and other compounds), most of the phosphate is bound in bacteria and algae.

Manmade

- **Runoff from animal production** – Phosphorous wastes from animal feedlots can contribute to phosphate loading in streams.
- **Wastewater from treatment plants** – Wastewater may be high in phosphorus since most treatment plants do not remove phosphates.
- **Poorly functioning septic systems** – Waste from septic systems may reach streams.
- **Runoff from fields and lawns** – Many people fertilize their lawns in urban areas. Rainfall events that follow fertilizer application can result in runoff that is high in phosphorus.

- **Storm drains** – Storm drains may carry lawn fertilizer and pet waste, or runoff from broken wastewater lines and septic systems.
- **Combined Sewer Overflows (CSOs)** – These systems caused excessive algal blooms in Lake Erie in the 1960s. Most of the CSOs that entered Lake Erie have been fixed.

PHOSPHATE (PO₄) in mg/L

<u>River</u>	<u>Average Value</u>	<u># of Samples</u>	<u>Range</u>
Mississippi	0.11	n = 10	0.05 – 0.19
Chariton	0.03	n = 14	0.008 – 0.04
Pomme de Terre	0.02	n = 14	0.004 – 0.08
Jacks Fork	<0.02	n = 10	0.01 – 0.02

Source: USGS, 2010

There are currently no numeric nutrient standards for streams. DNR has recently developed nutrient standards for Missouri’s lakes and reservoirs, and is in the process of developing similar nutrient standards for Missouri streams.

Turbidity (page 182 *Streamkeepers Field Guide*)

Turbidity measures the clarity of water. Water with low turbidity is clear while water with high turbidity is cloudy or murky. Suspended matter, such as soil particles and plankton such as algae, most often cause cloudy or murky water. Turbidity is measured in NTU’s (Nephelometric Turbidity Units) which quantifies of the amount of light scattered by suspended material in the sample.

Impacts from High Turbidity Levels

- Sediment can block out light needed by aquatic vegetation.
- Suspended particles can increase water temperature.
- Sediment can bury fish eggs and benthic invertebrates.
- Sediment can fill in interstitial spaces, eliminating habitat

Thus by measuring turbidity, you can evaluate whether excessive soil erosion or algal growth is occurring. Previously discussed methods for measuring nutrient (Nitrogen and

Phosphorus) loads can determine if a stream is at risk for excessive algal growth. However, **some measurement of suspended solid matter is necessary in order to evaluate the level of soil erosion.** Areas where turbidity monitoring is particularly valuable include:

- **Areas being developed** where a great deal of construction and land disturbance is occurring.
- **Downstream from quarries and gravel mining operations.** These activities can result in fine particles entering a stream and smothering habitat.
- **Agricultural areas that have not adopted best management practices** to prevent soil erosion.

Interpreting the Data

The water chemistry and biological data can show variation between streams in a general area, and even for the same location. There are seasonal variations and even time of day variations. In reviewing the data there are several questions that can be asked, and the answers will provide some clues in assessing the overall ecological health of the stream.

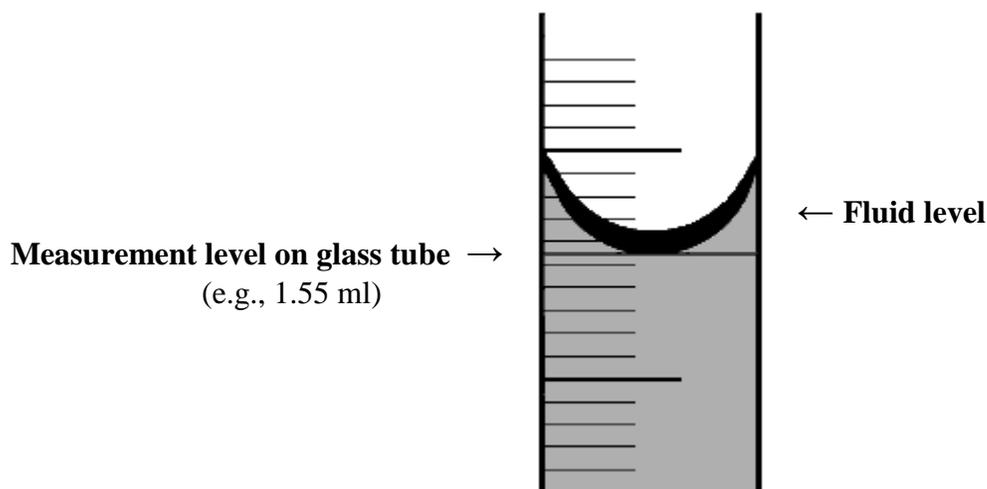
1. Does the stream meet the **minimum** standards for water quality? The water quality standards are state rules established by the Missouri Clean Water Commission and set the minimum requirements for water quality for all waters of the state. A comparison of data against these minimum criteria will show whether there are any serious violations of the state standards.
2. After a volunteer has been monitoring a stream for a period of time, they will begin to be able to recognize changes that are out of the normal variation (e.g., those caused by changing seasons). If a volunteer *does* notice a change, they should ask themselves if the change appears to be significant enough to cause impacts on water quality problems. If so, DNR staff should be notified so the problem can be addressed.
3. Are there readily apparent sources (either point or nonpoint) for the impacts that are seen? Are these sources similar to the types of activities that are regulated through permits (point sources), or are they sources that might be improved by voluntary

actions? Examples of voluntary actions include addressing a litter problem by organizing a litter pickup, or addressing a variety of nonpoint sources of pollution by planting trees in a riparian zone to act as a filter buffer for a stream.

*** Don't forget to review your data sheets and calibrate your meters the night before going to the field! ***

Definitions for Chemical Kits

- **Reagent** – a substance that, because of the reactions it causes, is used in analysis and synthesis.
- **Meniscus** – the convex lower surface of a column of liquid, the curvature of which is caused by surface tension.



Chemical Waste

Waste reagents and liquid from Nitrate analyses must be containerized separately in the container supplied by the Program (e.g., a cubitainer) or a well-rinsed, heavy-walled detergent or bleach container. **DO NOT** use milk or soda containers – the plastic is too thin and will eventually fail. Waste may be turned in to Program Staff at a ST VWQM workshop or to a DNR or MDC Regional Office (see map in *Appendix*).

It is critical that you mark waste bottles with the contents (i.e. Nitrate Waste) and do not mix the waste products from different chemical tests. If you do not separate and label wastes, the DNR Environmental Services Program lab must treat the waste as if it contains a variety of chemicals which is time consuming and expensive. Also **DO NOT** put any waste materials in your waste container other than those generated from the nitrate tests performed by volunteer monitors! Adding other unrelated wastes (e.g., petroleum products) can be dangerous, and as mentioned earlier, will increase the time and handling costs for staff at DNR's lab in order to properly dispose of as hazardous waste.

Expiration Dates for Kit Chemicals

pH: The pH 7.0 (yellow) and pH 10.0 (blue) Buffer Solutions are used to calibrate the pH meter. The solutions should have the expiration date printed on the side of bottle. *When properly stored, these solutions should be good until expiration dates.* Over time, trace CO₂ from the air will leach into the bottles forming carboxylic acid, which will cause shifting pH values and the acid consumes buffering capacity. This is especially evident in the pH 10.0 buffer solution where an open beaker can become more acidic over the course of a few hours (*Molecular Biology Problem Solver* by Alan S. Gerstein). Do NOT put solution used for calibration back in the bottle or you risk contamination. These are salt solutions so **used or expired solution can be poured down the drain.** Contact Program Staff for replacement chemicals.

Conductivity: The clear Sodium Chloride Standard Solution is used to calibrate the conductivity meter. This solution has the expiration date printed on the bottle. *When properly stored, indoors at room temperature, the solution should be good until expiration*

dates. DO NOT put solution used for calibration back in the bottle or you risk contamination. It is a salt solution, so **used or expired solution can be poured down the drain**. Contact Program Staff for replacement chemicals.

Dissolved Oxygen Kit: All Dissolved Oxygen Reagents have an expiration date printed on each of them. Please check the date each time you monitor. If they are past the expiration date, unused packets can be disposed of in the trash and replacements requested from Program Staff. Waste or expired Sodium Thiosulfate from the dissolved oxygen tests should **not** be combined with the nitrate waste. DO kit test waste can be poured into any plastic container and disposed of at home down the drain.



Nitrate Test Kit: The Nitrate Reducing Reagent is the little brown glass bottle has an expiration date printed on the label. It will often expire within a year, so it is critical to make note of the expiration date before sampling. If the reagent has passed its expiration date, or is no longer dry and powdery, it will no longer provide a viable result and should not be used. **Do not throw it away! This reagent contains cadmium and must be disposed of properly as hazardous waste.** Please return it to the Program or turn it in to Program Staff at a workshop and request a replacement. Keeping the cap tightly taped will help keep out moisture that will ruin the reagent. The Mixed Acid Reagent also has an expiration date printed on the bottle. **Please containerize the waste reagent from this kit separately.** **When you receive your cubitainer, mark it as Stream Team Nitrate Waste with a permanent marker.**

Read the Material Safety Data Sheets (MSD sheets) and note precautions and spill procedures. MSD sheets are required by law to inform individuals about the hazardous nature of any chemicals with which they may come into contact. Keep the MSD sheets handy in case of spills or accidents. Teachers should keep MSD sheets in the kits at all times and keep a copy on file at their school. Additional copies of MSD sheets are posted on the Stream Team Website (<http://www.mostreamteam.org/datasheets.asp>).

METHODS AND TECHNIQUES FOR FIELD CHEMISTRY

pH Pen Key Points

1. After receiving a new pH pen, fill the cap with about 2 cm of tap water. Recap the tester and soak sensor for one hour. This will activate the sensor and hydrate the bulb. Rinse cap and sensor with tap water before calibrating.
2. Always use 2-point calibration. Calibrate the pH meter to 7.0 with the yellow pH 7.0 Buffer Solution, and to 10.0 with the blue 10.0 Buffer Solution prior to each sampling event, within 12 hours before you sample. If the bulb is dry, the meter will not work properly. If even after soaking, the meter doesn't work properly, follow troubleshooting procedures outlined under Chemical Monitoring Procedures in this notebook's *Appendix*.
3. To calibrate, turn the meter on by pressing the  button.
 - Pour a small amount (about 2 cm) of yellow 7.0 Buffer Solution and blue 10.0 Buffer Solution into two separate clean dry cups.
 - Rinse the meter with distilled water or tap water and gently blot the end dry with a paper towel.
 - Submerge the meter in the 7.0 Buffer Solution and stir gently. Wait for displayed value to stabilize at or near 7.0.
 - Press the "cal" button to enter calibration sequence. "Cal" will flash momentarily and then show a flashing default reading.
 - Press the "hold/ent" button to confirm reading. Rinse the meter with distilled water or tap water and gently blot the end with a paper towel.
 - Submerge the meter in the 10.0 Buffer Solution. Once the reading stabilizes to 10.0, press "cal" to abort the calibration process and return to measurement mode. Calibration is now complete.
 - After calibrating the pH pen, **turn off the pen**, replace the cap, and discard the used calibration solution. Do not put used solution back in the bottle or you risk contamination. It is a salt solution, and can go down the drain.

Note: the tester will automatically turn off after 8.5 minutes of non-use to conserve batteries.
4. Never submerge the meter over the cap line either during calibration or during stream monitoring. Water may damage the electronics if submerged.

5. When storing the meter, dampen a small piece of paper towel with the yellow pH 7.0 Buffer Solution and place in the bottom of the cap. This will help keep the bulb hydrated in between uses.
6. Please note that the Stream Team Program does NOT provide replacement batteries for the Oakton ECO pH Testr 2. This meter takes A76 micro-Alkaline batteries, which can be found at any large multi-purpose or hardware store.

Conductivity Pen Key Points

1. After receiving a new conductivity pen, remove the electrode cap and soak that end of the pen for about 2 minutes in alcohol to remove oils. As with the pH pen, do not submerge the meter over the cap line. Add 2 cm of tap water or calibration standard to the cap (approximately ½ full) and recap. Allow meter to soak for at least 15 minutes to condition and hydrate the probe. Rinse cap and probe and continue with calibration procedure.
2. Always calibrate the conductivity meter with the Sodium Chloride Standard Solution prior to each sampling event within 12 hours before you monitor. It should be calibrated to read $1000 \mu\text{S}/\text{cm} \pm 10 \mu\text{S}/\text{cm}$.
3. To calibrate, use the following instructions (which are also located inside the conductivity pen package):
 - Switch unit on using the  key and dip sensor into calibration standard. Wait for reading to stabilize.
 - Press “cal” to begin calibration. Display will show “CAL” briefly and will blink the default reading.
 - If the meter does not automatically read 1000, press the “hold/ent” button until the blinking value matches the value of the calibration solution.
 - If you accidentally overshoot 1000, continue to press the “hold/ent” button past the maximum value to continue with the lowest adjustable value.
 - When meter reads 1000, release the “hold/ent” button to accept calibration value. After a few seconds of no button press, “Ent” will flash on the screen.
 - Press “cal” to return to measurement mode. The meter is now calibrated.

Note: the tester will automatically turn off after 8.5 minutes of non-use to conserve batteries

4. After calibration or stream monitoring, turn the pen off. The meter can either be stored with a small amount of calibration solution to keep the probe conditioned, or stored dry and re-conditioned before the next use (recommended for long-term storage).
5. Do not put used solution back in the bottle or you risk contamination. It is a salt solution, and can go down the drain.
6. Please note that the Stream Team Program does NOT provide replacement batteries for the ECO EC Low Testr. Just like the ECO pH Testr, this pen also takes A76 micro-Alkaline batteries.

Dissolved Oxygen Kit Key Points

1. Always rinse all sample containers, including lids and caps, with stream water at least three times before collecting a sample.
2. The directions for the DO kit say to “hold the dissolved oxygen bottle under the water for several minutes and stopper the bottle under the water.” It is not necessary to hold the collection bottle under water for a full minute. It’s more important to make sure to collect the sample while holding the bottle completely under water. Stopper the bottle underwater and once you lift it out of the water, be sure to leave some water around the rim at the top of the stopper. This will come in handy if you have to pull the stopper out slightly to release any trapped air bubbles.
3. Possible Interferences: In some cases, the floc will not settle as expected if water temperatures approach freezing or due to interference from high chlorides. Floc exposed directly to the air might react with the Dissolved Oxygen 3 Reagent Powder Pillow to form a black, tar-like residue that is extremely difficult to remove. If the floc fills the bottle to the stopper after shaking vigorously the first time, shake the

bottle vigorously a second time and wait five minutes. If the floc still fills the bottle to the stopper, discard the sample water and reagents, rinse the bottle thoroughly with sample water three times, and begin the test again. If the floc still fills the bottle to the stopper after thorough rinsing, repeated vigorous shaking, and waiting five minutes, DO NOT add Dissolved Oxygen 3 Reagent Powder Pillow. Discard the sample and make a note on the Water Chemistry Data Sheet that the DO floc would not settle.

4. When finished with the DO analysis, wrap a small piece of paper towel around the stopper before returning it to the DO bottle. This will prevent the stopper from becoming stuck in the bottle.
5. Always wear gloves and safety glasses when conducting a DO or nitrate analysis since the chemicals are acidic. DO Reagents #1 and #2 have iodine in them, which is a hazardous skin irritant.
6. DO test waste should be containerized separately from nitrate test waste. DO waste can be either disposed of on the ground (away from the stream) or placed in a plastic container and poured down the drain at home.

Nitrate Kit Key Points

1. Always wear gloves and safety goggles when performing a nitrate analysis.
2. Always rinse all sample containers, including lids and caps, with stream water at least three times before collecting a sample.
3. The nitrate-reducing reagent contains cadmium, a hazardous heavy metal. Do not inhale or ingest this compound.
4. Ignore the instructions to use the multiplier in the last step.

5. Containerize all nitrate waste analyses separately in the container supplied by the Program or a heavy-walled detergent or bleach container.
6. If your nitrate reducing agent has passed its expiration date, or is no longer dry and powdery, it is no longer good to use. Please send it back to the Program and request a replacement.

NOTE: Expired Nitrate Reducing Reagent and Nitrate test waste related to the Volunteer Water Quality Monitoring Program must be turned in to Department of Natural Resources or Missouri Department of Conservation Regional Offices (see maps in the *Appendix* of this notebook). Be sure to indicate you are with the Stream Team Program or the offices may not accept your chemical waste. Always label any waste reagents as directed. You may also turn in Stream Team equipment you no longer choose to use. They will make sure any returned equipment gets back to the Program to recycle for future use. You may also call the Program and request a prepaid mailing label to return equipment. Please do not return items such as expired calibration solutions or reagents that can be thrown in the trash or poured down the drain.

D.O. Percent (%) Saturation Sheet

Temp
(C)

D.O. (mg/L)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15*
0	7%	14%	21%	27%	34%	41%	48%	55%	62%	68%	75%	82%	89%	96%	103%
1	7%	14%	21%	28%	35%	42%	49%	56%	63%	70%	78%	85%	92%	99%	106%
2	7%	14%	22%	29%	36%	43%	51%	58%	65%	72%	80%	87%	94%	101%	109%
3	7%	15%	22%	30%	37%	45%	52%	60%	67%	74%	82%	89%	97%	104%	112%
4	8%	15%	23%	31%	38%	46%	53%	61%	69%	76%	84%	92%	99%	107%	115%
5	8%	16%	24%	31%	39%	47%	55%	63%	71%	78%	86%	94%	102%	110%	118%
6	8%	16%	24%	32%	40%	48%	56%	64%	72%	80%	88%	97%	105%	113%	121%
7	8%	17%	25%	33%	41%	50%	58%	66%	74%	83%	91%	99%	107%	116%	124%
8	8%	17%	25%	34%	42%	51%	59%	68%	76%	85%	93%	101%	110%	118%	127%
9	9%	17%	26%	35%	43%	52%	61%	69%	78%	87%	95%	104%	113%	121%	130%
10	9%	18%	27%	35%	44%	53%	62%	71%	80%	89%	98%	106%	115%	124%	133%
11	9%	18%	27%	36%	45%	54%	64%	73%	82%	91%	100%	109%	118%	127%	136%
12	9%	19%	28%	37%	46%	56%	65%	74%	84%	93%	102%	112%	121%	130%	139%
13	10%	19%	29%	38%	48%	57%	67%	76%	86%	95%	105%	114%	124%	133%	143%
14	10%	19%	29%	39%	49%	58%	68%	78%	87%	97%	107%	117%	126%	136%	146%
15	10%	20%	30%	40%	50%	60%	70%	79%	89%	99%	109%	119%	129%	139%	149%
16	10%	20%	30%	41%	51%	61%	71%	81%	91%	102%	112%	122%	132%	142%	152%
17	10%	21%	31%	41%	52%	62%	73%	83%	93%	104%	114%	124%	135%	145%	155%
18	11%	21%	32%	42%	53%	63%	74%	85%	95%	106%	116%	127%	138%	148%	159%
19	11%	22%	32%	43%	54%	65%	76%	86%	97%	108%	119%	130%	140%	151%	162%
20	11%	22%	33%	44%	55%	66%	77%	88%	99%	110%	121%	132%	143%	154%	165%
21	11%	22%	34%	45%	56%	67%	79%	90%	101%	112%	124%	135%	146%	157%	169%
22	11%	23%	34%	46%	57%	69%	80%	92%	103%	115%	126%	138%	149%	161%	172%
23	12%	23%	35%	47%	58%	70%	82%	93%	105%	117%	129%	140%	152%	164%	175%
24	12%	24%	36%	48%	60%	71%	83%	95%	107%	119%	131%	143%	155%	167%	179%
25	12%	24%	36%	49%	61%	73%	85%	97%	109%	121%	133%	146%	158%	170%	182%
26	12%	25%	37%	49%	62%	74%	87%	99%	111%	124%	136%	148%	161%	173%	185%
27	13%	25%	38%	50%	63%	75%	88%	101%	113%	126%	138%	151%	164%	176%	189%
28	13%	26%	38%	51%	64%	77%	90%	102%	115%	128%	141%	154%	166%	179%	192%
29	13%	26%	39%	52%	65%	78%	91%	104%	117%	130%	143%	156%	169%	183%	196%
30	13%	27%	40%	53%	66%	80%	93%	106%	119%	133%	146%	159%	172%	186%	199%
31	13%	27%	40%	54%	67%	81%	94%	108%	121%	135%	148%	162%	175%	189%	202%
32	14%	27%	41%	55%	69%	82%	96%	110%	124%	137%	151%	165%	179%	192%	206%
33	14%	28%	42%	56%	70%	84%	98%	112%	126%	140%	154%	168%	182%	196%	209%
34	14%	28%	43%	57%	71%	85%	99%	113%	128%	142%	156%	170%	184%	199%	213%
35	14%	29%	43%	58%	72%	87%	101%	115%	130%	144%	159%	173%	188%	202%	216%
36	15%	29%	44%	59%	73%	88%	103%	117%	132%	147%	161%	176%	191%	205%	220%
37	15%	30%	45%	60%	75%	89%	104%	119%	134%	149%	164%	179%	194%	209%	224%
38	15%	30%	45%	61%	76%	91%	106%	121%	136%	151%	166%	182%	197%	212%	227%
39	15%	31%	46%	61%	77%	92%	108%	123%	138%	154%	169%	184%	200%	215%	230%

*** If D.O. is greater than 15 mg/L then use the formula
on pg. 175 in your Stream Keepers Field Guide:**

$$\frac{\text{Actual Dissolved Oxygen (mg/L)}}{\text{Max Oxygen Concentration at Water Temp}}$$



WATER CHEMISTRY REFERENCE TABLE

Use this table as a guide as you interpret your water quality field data. Remember that each aquatic system is different, so this table is only a guide, not a hard fast rule!

WATER PARAMETER TESTED	WHAT IT MEASURES	NATURAL READINGS	CAUTIONARY READINGS (could be a problem)	POSSIBLE SOURCES/ INFLUENCES	REMEDIES
Water Temperature	average amount of heat in the water	0° - 34°C (32° - 93°F)	above 32°C (90°F) above 24°C for smallmouth bass/goggle eye streams (84°C) above 20°C for trout streams (68°C)	<ul style="list-style-type: none"> - thermal discharges (e.g., industrial, waste water treatment plants) - increased turbidity - solar heat (e.g., loss of shade in riparian areas) - heated runoff from impervious surfaces (e.g., asphalt, concrete) 	<ul style="list-style-type: none"> - discharges adhering to limits set in permits/regulations - increased riparian (stream side) shade - decrease impervious surfaces (i.e., revegetate watershed)
Dissolved Oxygen	amount of oxygen dissolved in the water	<p>natural readings: 5 – 15 mg/L (milligrams per liter) or more than 80% dissolved O₂ % saturation in Ozark streams and more than 60% dissolved O₂% saturation in prairie streams or streams with no aeration</p> <p>cautionary readings:</p> <ul style="list-style-type: none"> - below 6 mg/L cold water <i>Standards</i> violation - below 5 mg/L cool and warm water <i>Standards</i> violation - 3 - 5 mg/L (40% - 80%) causes stress resulting in abnormal feeding, reduced reproduction - < 3 mg/L (<40%) results in death in most species - 0 mg/L = anoxic 		<ul style="list-style-type: none"> - atmosphere via aeration (e.g., wind, running water) - photosynthesis by algae and other aquatic plants 	<ul style="list-style-type: none"> - can control quantity of algae by limiting nutrients (N, P) entering the water - reduce water temperature
pH	acid/base of the water	generally 6.5 – 9.0	below 6.5 above 9.0	<ul style="list-style-type: none"> - acid rain - industrial pollution - chemical spills 	<ul style="list-style-type: none"> - pollution controls - pH moderation by addition of acid or basic compounds
Nitrates	organic matter or fertilizer materials in water	0.0 – 2.0 mg/L	consistent readings above 2 mg/L	<ul style="list-style-type: none"> - human sewage - industry output - domestic use of detergents - fertilizer (urban and agricultural) - animal wastes 	<ul style="list-style-type: none"> vegetated riparian zones limit usage of agricultural and yard fertilizers properly maintained septic systems
Phosphates	organic matter or fertilizer materials in water	0.0 – 0.2 mg/L	consistent readings above 0.2 mg/L	<ul style="list-style-type: none"> - animal wastes - fertilizer - domestic use of detergents - industry output 	<ul style="list-style-type: none"> vegetated riparian zones agricultural waste management limit use of agriculture and yard fertilizers
Turbidity	clarity of the water	highly variable measured in Nephelometric Turbidity Units (NTUs)	increasing turbidity measurements in a waterbody over a period of time	<ul style="list-style-type: none"> - sediment, usually from increased surface runoff (e.g., off construction sites, cropland) - excessive algae growth - watercraft traffic 	<ul style="list-style-type: none"> sediment controls riparian zones to reduce nutrients watercraft speed limits