SAMPLING YOUR ESTUARY
Level IIB WHAT'S IN THE WATER?

Units Level IIB and C work together to guide students in collecting research that will allow them to assess the health of the estuary. These units may be done concurrently or during separate field trips.

GOAL
Students will understand that an estuary is made up of different microenvironments whose plants and animals are dependent on its water quality.

OBJECTIVES, students will…

1. Conduct research to determine differences between the general habitat and water quality in different sections of the estuary.
2. Investigate the cause of habitat and water quality differences and hypothesize their impact on the estuary.
3. Understand the importance of gathering long-term accurate data; will learn how to display the data; and will learn methods of analyzing the data to determine relationships between different parts of the estuary.

SETTING
Field Tour to the estuary

MATERIALS
Materials need for each sampling activity description.
The **WATER QUALITY SAMPLING RESULTS** form is attached to this unit.

OTHER RESOURCES

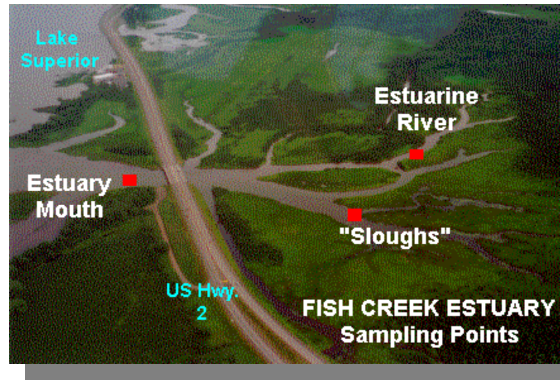
A fun resource that allows students to check biological health of US watersheds can be found at http://www.epa.gov/iwi/

For more information about other water quality sampling procedures:
New York Sportfishing and Aquatic Resources Education Program (SAREP) Instructor Manual, Cornell Cooperative Extension Service,
http://www.dnr.cornell.edu/sarep/publications/pubs.html

A great searchable list of water quality activities:
http://www.uwex.edu/erc/eypaw/

Background

An estuary is comprised of different microenvironments whose plants and animals are dependent on the estuary's water quality. Three easily identified microenvironments include the 1) estuarine river or stream as it enters the estuary, 2) the shallow, slow water "sloughs" or backwaters where the river and lake water mix, and 3) the mouth of the estuary dominated by the Lake.



Example of sampling points used in the Fish Creek Estuary programs

These locations have been selected as sampling points in Level II units because they typically have different water quality and habitat parameters and therefore support different plants and wildlife. Teachers need to help students evaluate if differences in water quality parameters are characteristic for each of the three sampling locations or if they point to potential water quality problems impacting the estuary.

Sampling results at these points, especially if sampling has been conducted over time, can show important changes in the estuary's water quality. Again, teachers will need to help students hypothesize if these changes are due to natural fluctuations or indicate a water quality issue.

Not all estuaries may have water quality problems. Students should understand reasons why sampling and monitoring the estuary is important, even if it there are no current problems. Baseline monitoring overtime can indicate if changes are taking place within the estuary, indicate the source of change, and the potential impact on the estuary.

Discuss who would benefit from the data collected in this effort. (Data collection contributes to understanding the ecosystem and data collection contributes to the analysis of long-term trends.) Reinforce that the data collected in Level IIB and C activities will be used to support hypothesis and solutions students will develop in Level III.

ACTIVITIES

Using the **MASTER ESTUARY MAP** created in Level I Activities, students should select a minimum of 3 sampling sites within the estuary.

These micro-environments within the estuary must be included as sampling points:

1) Along the bank of the estuarine river/stream before it enters the estuary.
2) At the water's edge within the estuary's wetlands or "sloughs".
3) At the mouth of the estuary where it enters & mixes with the Lake.

Other sampling points may be added to this list

Students will be sampling each of these sites for the following water quality parameters:

- ***General Habitat***
- ***Temperature***
- ***Water velocity***
- ***Dissolved Oxygen***
- ***Turbidity***

I. GENERAL HABITAT ASSESSMENT

The following observations will be recorded on page 2 of the **WATER QUALITY SURVEY**

The estuary's habitat functions "holistically". This means that any changes to one part can affect the entire system. Certain land uses affect habitat, water quality, and estuary health. This assessment is a visual evaluation of your observations at the sampling point.

An estuary is a healthy, dynamic place. Wildlife find shelter and food near and in its water. Vegetation grows along its banks and in its water. Some plants may shade the estuary, cooling its waters. Others grow on its bottom and help filter pollutants and sediments. Within the estuary's waters fish, insects, and other tiny creatures that need certain water temperatures, velocity, and dissolved oxygen to survive. Many land use activities can alter the estuary's characteristics, changing its habitat and the plants and animals that can live there.

Measuring Habitat

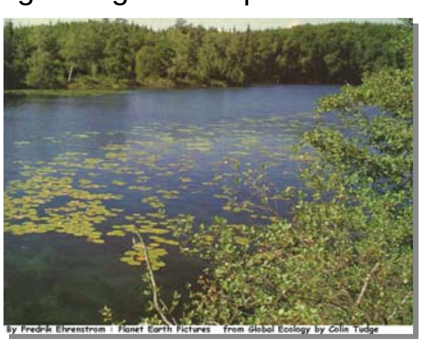
Habitat Assessment
Materials Needed:
Habitat Check List –see Water Quality Survey
Pens/pencils

To conduct a Habitat Assessment, you will be making observations within the "riparian zone"-- the land between the water's edge and the land.

Observe the following characteristics of the riparian zone at your sampling point and record them on the **WATER QUALITY SURVEY**. Refer to the survey for choices for these habitat measurements:

A. Riparian Zone Vegetation:

Trees, bushes, shrubs, tall grasses, sedges, characterize a healthy riparian zone and other plants that help stop pollution from flowing into the estuary. They also provide food and shelter for wildlife. The characteristics of the riparian zone will vary between different parts of the estuary. What is the dominant form of vegetation growing in the riparian zone at each sample site?



Natural riparian zones include trees, shrubs, grasses or other native plants that help filter pollutants.

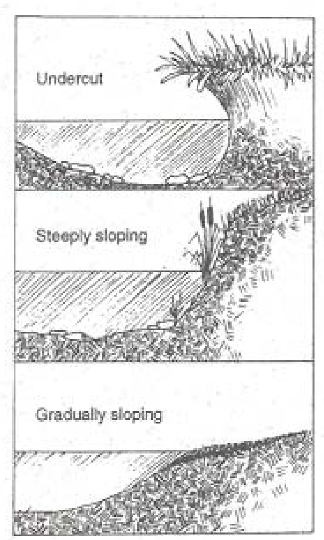
Unnatural vegetation in riparian zones, such as cultivated lawns, do little to filter pollutants and sediment from running into the estuary

B. **Bank Characteristics**

The shape and condition of the bank between the land and water can give clues to the types of land uses within the watershed. It also indicates if water velocity is high and causes erosion. What shape is the estuary's bank at this sampling point?

BANK CHARACTERISTICS

An Undercut Bank (above) rises vertically or overhangs the river/stream. This type of bank generally provides good cover for aquatic invertebrates and fish. It is resistant to erosion. This bank usually has good vegetative cover to help stabilize the bank and prevent erosion. However, if the bank is seriously undercut from flooding, it can collapse.



A Steeply Sloping Bank (middle) slopes at more than a 45-degree angle. It is very vulnerable to erosion.

Gradually Sloping Bank (lower) has a slope of 30-degrees or less. It is very resistant to erosion, but provides little cover for fish or aquatic insects.

Artificial Banks (not shown) include ditches, concrete embankments, and other man-made structures. Most are extremely susceptible to erosion.

The gradually sloping riparian zone of the lower Kakagon/Bad River Sloughs is more resistant to erosion.

The steeply sloping banks along the Sioux River are vulnerable to erosion that can lead to sediment deposits in the Sioux River Estuary.

The mouth of the Whittlesey Creek Estuary was "channelized" or straightened in the 1940's. This is an example of an artificial stream bank modification. Changing natural bank structure often results in increased erosion. Note the plume of sediment deposited at the mouth of the estuary.

C. Bottom Characteristics

Observe that the bottom of the estuary is composed of at the sampling point and record your findings. Characteristic types are listed on the survey.

D. General Water Characteristics

Observe and record the following observations at your sampling point:

Water Velocity: The speed or "velocity" that water flows through the estuary determines which plants and animals will live there. If water flows too quickly, some organisms can't hold on to rocks and plants and will be flushed downstream. If the water flows too slowly, it will warm up and there will not be enough oxygen mixed into it to allow many organisms to live.

Presence of pools, riffles, runs: Differences in water depths offer a greater variety of habitats for a greater number of species.

Presence of rooted aquatic plants: Rooted aquatic plants provide food and shelter for aquatic organisms. They can also indicate if there is water quality problem, too. Excessive or unnatural amounts of plants may indicate that too many nutrients are being flushed into the estuary.

Presence or absence of algae: Algae are simple plants that live mainly on the water. They provide food for animals low on the food chain. Algae may be green, brown, or other colors. It may grow on submerged roots and logs or float on the surface. Excessive algae growth may indicate that pollutants, such as fertilizers, are entering the estuary.

Water Appearance: Note any the colors and odors of the water at the sampling point.

II. WATER QUALITY PARAMETERS

The following observations will be recorded on page 2 of the **WATER QUALITY SURVEY**

A. WATER VELOCITY

Water velocity is the speed that water moves over a designated point. It is usually expressed as feet per second.

Velocity is directly affected by the amount of water running off the watershed and flowing into the estuary. It can be influenced by weather, changing each season as rainfall or snowmelt increases run-off into the estuary. It also can be affected by diversion of water from a river for irrigation, power generation, or industrial purposes. Different parts of the estuary will have different water velocity rates.

Water velocity is important because it influences water quality and the living organisms that inhabit the estuary. The speed that water flows through each part of the estuary influences the following characteristics of it:

What kinds of organisms live there
Some organisms are adopted to faster flowing water than others

The amount of sediment or silt that is deposited or flushed downstream
Faster moving water "flushes" sediments downstream. The faster a stream flows, the more sediment it can carry.

The amount of oxygen in the water
Faster flowing water generally has higher levels of oxygen than slower moving water

Measuring Water Velocity:

> **Water Velocity**
> Materials Needed:
> *An orange or tennis ball*
> *Tape measure*
> *Stopwatch and calculator*

1. Put a marker at your sampling point. This will be the starting point.

2. Mark off second point 10 feet downstream from the first marker. Make this the finish line. In some places within an estuary, it may be difficult to determine which direction is "downstream" without careful observation.

3. Designate someone as the timekeeper.

4. Place (don't throw) the orange in the water, in line with the first marker. The timekeeper starts the watch as soon as the orange is released.

5. Record the time (to the nearest $1/10^{th}$ second) that it takes for the orange to pass the second marker.

6. Calculate the water velocity using this formula:

   Distance/Time = Velocity

7. Repeat the velocity test 3 times. Average the results of the velocity experiments and record the average velocity for your sampling point on your Water Sampling Form.

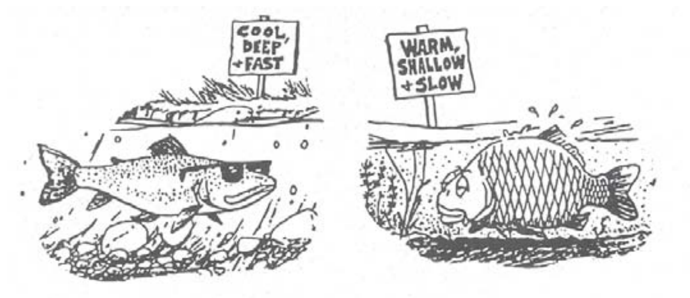
B. TURBIDITY

Turbidity is a measure of water clarity. Turbid means "murky". Turbidity is a useful indicator that runoff from non-point sources like construction sites, farm fields, logging, industrial discharge or other natural or non-natural activities is entering the estuary.

Soil that enters and mixes with the water is called sediment. It is the chief culprit in making the water turbid. Turbidity can also be caused by suspended materials like small particles of algae floating in the water. Excessive algae growth may indicate that nutrients from farm fields, lawns/gardens, or even natural sources are running into the stream and fertilizing the growth of too much algae in the estuary.

All streams and estuaries have some level of turbidity. Fish and aquatic life have evolved over time to adapt to different levels of turbidity. What causes problems is when unusual changes in turbidity happen AND when these changes last for long periods of time. Fish are especially stressed when they have to live in highly turbid water for a long period of time. Fish eggs are ten times more sensitive to turbidity than adult fish.

Water turbidity also influences what fish are present. Bass and other species that depend upon good vision to capture their food may be replaced by bullhead and other fish that feed by touch and odor if waters are constantly murky from sedimentation. Turbidity, caused by excess algae, may indicate that oxygen levels are depleted. In this low-oxygen environment only fish, like carp and members of the catfish family, can survive.



In zebra mussel-infested waters, the clarity of the water may be improved dramatically due to the capacity of these organisms to filter huge amounts of water. Unfortunately zebra mussels filter out beneficial microorganisms and create a clear, but sterile aquatic environment.

The turbidity of the water within the estuary influences it in the following ways:

Turbid water keeps sunlight from reaching aquatic plants
Sediment and suspended materials can block sunlight from reaching down into the water, interfering with photosynthesis of aquatic plants.

Turbid water is warmer than clear water and has less oxygen in it
Sediment and suspended materials in the water absorb the sun's heat and warm the water. The warmer the water, the less oxygen it can hold. This directly affects the numbers and types of plants and animals that can live in turbid waters.

Turbidity
Materials Needed:
Secchi Disk and rope
Yardstick

Measuring Turbidity

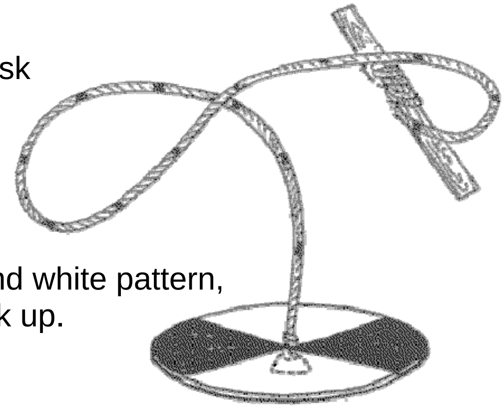
There are several ways of measuring turbidity. Using a Secchi Disk is the most common. Instructions on how to make a Secchi Disk, if one is not available to your class, are included in this unit.

Secchi disks are often available to loan from Wisconsin Dept. of Natural Resource Offices, University water quality labs and field stations.

Using the Secchi Disk

1. Hold onto the stick and rope, and lower the Secchi disk into the water until you can no longer see the painted surface.

2. Using the marks on the rope, determine how deep the Secchi disk is when you lose sight of the black and white pattern, or the depth at which it reappears as you bring it back up. This depth in inches is your measure of turbidity.



Secchi Disk

If the water is very shallow and it is impossible to lower disk to the point where the pattern disappears, record the maximum depth (in inches) to which you can lower the Secchi Disk. This depth is your measure of turbidity.

Record the turbidity measurement for your sampling point on the **WATER QUALITY SAMPLING RESULTS** form

C. TEMPERATURE

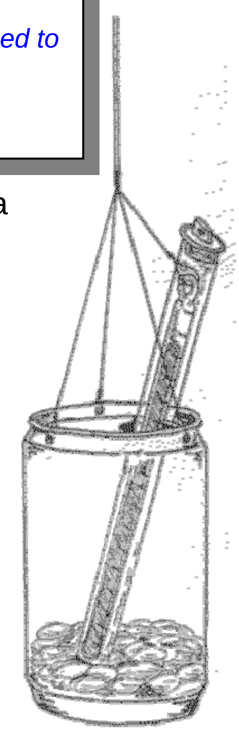
Temperature
Materials Needed:
Thermometer or weighted thermometer
Yardstick or heavy string attached to the thermometer

You can measure water temperature easily in shallow water or at the surface using a weather thermometer tied to a string. However, water temperature in deeper water generally differs from that of surface water.

If the class will be measuring the temperature of deeper water, consider building a "weighted thermometer" using the instructions included in this unit.

Measuring Temperature

1. Lower the thermometer weighted thermometer into the water and let it remain there for five minutes, at the depth that you wish to measure.



A Weighted Thermometer

2. While waiting to bring the weighted thermometer out of the water, one of the club members can record the depth at which the temperature is being taken.

3. Bring the can to the surface quickly and read the thermometer. Make sure that the tip of the thermometer is in the water in the can when you measure the temperature.

4. Record the temperature of the water on the **WATER QUALITY SAMPLING RESULTS** form. Be sure to convert all temperatures to Celsius. A conversion chart is printed attached to this unit.

Temperature Tolerance Levels of Selected Aquatic Organisms

Greater than 68-degrees F:	Much plant life, many warm water fish diseases, bass, crappie, bluegill, carp, catfish present
Upper Range (55-68-degrees F)	Some plant life, some fish disease. Salmon, trout, stonefly nymphs, mayfly nymphs, caddisfly larvae, water beetles, water striders
Lower Range (Less than 55-degrees F)	Trout, caddis fly larvae, stonefly nymphs, mayfly nymphs

D. DISSOLVED OXYGEN (DO)

Oxygen is a gas that is important to all life. The air that we breathe contains about 20% oxygen. Fish and other aquatic life also need oxygen to live, but they don't breathe air like we do. The kind of oxygen that they use is dissolved in the water, and is in a much smaller concentration than is in the air. Fish use their gills to take this oxygen from the water and pass it into their bloodstreams where it can be used by muscles and other organs. Some insects have a type of gills that do this, too. Other insects can absorb the oxygen in the water directly through their body surfaces.

There are several ways that oxygen gets dissolved in water. Green plants in the water produce oxygen in a process called photosynthesis. Photosynthesis requires sunlight, so plants produce oxygen only during the day. Oxygen also gets into water as it mixes with the air, or when oxygen is “tossed” into the water as it tumbles over stones or down a river’s rapids. The amount of oxygen that is dissolved in water varies a great deal, depending on the size and depth of the river or lake or stream, the flow rate and temperature of the water, the time of year, and the levels of pollutants that are in the water.

The oxygen content of water can change over the course of the day, especially in estuary backwaters. There are two major causes for this natural fluctuation. Water warms up as the sun shines on it. Warmer water holds less DO. However, something else is happening. Microscopic green plants, or plankton, produce oxygen through photosynthesis during sunny days. By late in the afternoon, levels may be extremely high.

At night, photosynthesis stops. Plants stop adding oxygen to the water. DO levels tend to crash because plants, bacteria, and aquatic organisms now must use up the DO that the photosynthesis process put into the water during the day in order to survive.

Effects of Temperature on DO
The maximum amount of oxygen that water can hold depends on the water temperature.
The cooler the water, the more oxygen it can hold.
The warmer the water is, the less oxygen it will hold.

Dissolved oxygen can be also be depleted by these types of pollutants:

Manure entering waterways is flushed downstream and can "fertilize" an estuary .

Pollutants that contain high levels of organic matter (manure, sewage)

Bacteria in the water decompose organic matter, such as manure or inadequately treated wastewater. Decomposition cleans up the water, but also-uses up dissolved oxygen in the process.

Pollutants that are high in nutrients (fertilizers, phosphorus based soaps)

These pollutants promote the excessive growth of plants by fertilizing them. The plants may produce oxygen during the day but use up large amounts at night, causing dramatic variations in DO levels. When the plants die, they sink to the bottom and decompose. The decomposition process depletes DO.

Effect of DO on Estuary Species
Each type of aquatic organism has a threshold dissolved oxygen level below which it cannot survive. Because these levels vary from species to species, the types of organisms found in a particular body of water provide a living index of water quality.

A simple chemistry test for dissolved oxygen (DO) can give you clues about the health of an estuary. In general, the higher the DO, the more different species of plant and animal life the water can support. Low dissolved oxygen levels indicate pollution, either from an organic source such as manure or insufficiently treated wastewater, or from a nutrient (fertilizer) source that causes excess growth of aquatic plants.

Dissolved oxygen concentrations in lakes and wetlands normally range from 0 to 18 parts per million (ppm). Young fish and fish eggs, as well as insect life, are especially sensitive to dissolved oxygen levels. Many adult fish like salmon and trout cannot survive unless DO levels are above 7 parts per million. Levels below 4 parts per million indicate that there is likely a pollution problem.

A difference of two or three parts per million of oxygen can mean the difference between life and death to many aquatic creatures. Immature developing aquatic insects such as stonefly nymphs, water pennies and many mayfly nymphs need high levels of dissolved oxygen for survival. These insects make up part of the diet of some fish. If the insects cannot survive in a stream or pond, what happens to the fish that would eat them?

Measuring Dissolved Oxygen

Dissolved Oxygen
Materials needed:
Dissolved oxygen test kit.
If available, use a Hach Kit for DO tests.

Thermometer, watch to record time
Plastic gloves and safety goggles

Hach Kits can be ordered from
http://www.hach.com/

Hach Water Sampling Kit

This unit includes a factsheet that gives procedures for testing DO levels using a Hach Kit and a Level of Oxygen Saturation Chart.

After completing DO tests, write results on the **WATER QUALITY SAMPLING RESULTS** form for the sampling site.

The sampling protocol for this unit was taken from the UW-Wisconsin, Water Action Volunteer Program. For more information visit http://clean-water.uwex.edu or call 608-262-3346 and ask for publication #GWQ026- “Volunteer Monitoring Factsheet Series” for a complete guide to water quality sampling.

Collecting the Sample

These directions, with some minor modifications, are written for the Hach water testing kit for dissolved oxygen.

Remember that photosynthesis and respiration will continue after a sample is collected, so water can gain or lose oxygen while sitting in the sample bottle. Therefore, you should begin D.O. testing immediately upon reaching the shore after you have collected the sample.

Think Like A Scientist!

Follow the directions VERY CAREFULLY! Accuracy is a must for valid data comparisons.

1. Use bottle with the stopper included in the Hach kit.
2. Immerse thermometer in water for about two minutes, record temperature.
3. Collect your sample in roughly one-foot deep, normally moving water.
4. Facing downstream, slowly lower the bottle so opening of the bottle faces you and water current is entering bottle.
5. Allow the bottle to fill with water gradually, avoiding air bubbles.
6. Bottle should be submerged for two to three minutes.
7. Cap bottle while still submerged.
8. When lifting out of water, look for bubbles. If you see any, take another sample using the same procedure.

Testing for Dissolved Oxygen

Note: If you see any air bubbles trapped in the sample bottle during steps 2-6, discard the sample and start over.

1. Put on protective gloves and safety goggles. If your skin comes in contact with any powder or titrant, rinse the area liberally with water.
2. Remove the stopper and add the contents of D.O. powder pillow #1 (manganous sulfate powder) and D.O. powder pillow #2 (alkaline iodide azide powder) to the sample.
3. Insert the stopper, being careful not to trap an air bubble and shake *vigorously,* holding on to the top. If oxygen is present, a brownish-orange floc will form.
4. Allow the sample to stand until the floc settles halfway. Shake the bottle a second time and allow the floc to settle halfway again.
5. Remove the stopper and slowly add the contents of D.O. powder pillow #3 (sulfamic acid), taking care not to displace any floc.
6. Stopper and shake vigorously to dissolve the floc. Shake and wait until all the floc is dissolved. The yellow color is from iodine. This is called the prepared sample. Prepared samples can be stored in the dark for a short time if it is more convenient or comfortable to return to your home/school to complete the analysis.
7. Transfer ***two*** plastic measuring tubes full of prepared sample to the square glass mixing bottle (your Hach kit instructions probably say one measuring tube full). Two measuring tubes allows you to determine D.O. to the nearest 0.5 mg/L instead of 1 mg/L .
8. *a.)* Holding the dropper vertically, add one drop at a time of sodium thiosulfate standard solution titrant (some kits use PAO titrant instead of sodium thiosulfate) to the square mixing bottle, and count each drop. *b.)* Swirl the solution after each drop. *c.)* Continue adding sodium thiosulfate drops until the

—continued on next page

Procedure *(continued)*

sample is a very light yellow. *d.)* Add 3 to 4 drops of starch solution. The prepared sample will turn blue from the added starch solution. If you do not have starch solution, proceed with the next step but be aware that your sample will turn from yellow to colorless instead of blue to colorless. *e.)* Continue adding drops, mixing and counting until the prepared sample turns from blue (or yellow) to colorless (the end point). Often this is just one or two more drops, so be careful.

9. The dissolved oxygen content of the water in mg/L is the total number of drops of titrant used to get to the endpoint divided by two if two measuring tubes of prepared sample were used. If only one measuring tube of prepared sample was used, the dissolved oxygen content is equal to the number of drops of titrant. *Example:* If you used two tubes of sample, you need to divide by two (13 drops divided by two tubes = 6.5 mg/L). If you only used one tube of sample, it's the actual number of drops of titrant used (6 drops with one tube = 6 mg/L).

10. Report dissolved oxygen (mg/L) and temperature on the record form.

11. Use instructions and chart below to convert D.O. to % saturation. Report % saturation on the record form.

Temperature Conversion Chart

Fahrenheit	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Celsius	.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5	5.6	6.1	6.7	7.2	7.8
Fahrenheit	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Celsius	8.3	8.9	9.4	10	10.6	11.1	11.7	12.2	12.8	13.3	13.9	14.4	15	15.6
Fahrenheit	61	62	63	64	65	66	67	68	69	70	71	72	73	74
Celsius	16.1	16.7	17.2	17.8	18.3	18.9	19.4	20	20.6	21.1	21.7	22.2	22.8	23.3
Fahrenheit	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Celsius	23.9	24.4	25	25.6	26.1	26.7	27.2	27.8	28.3	28.9	29.4	30	30.6	31.1

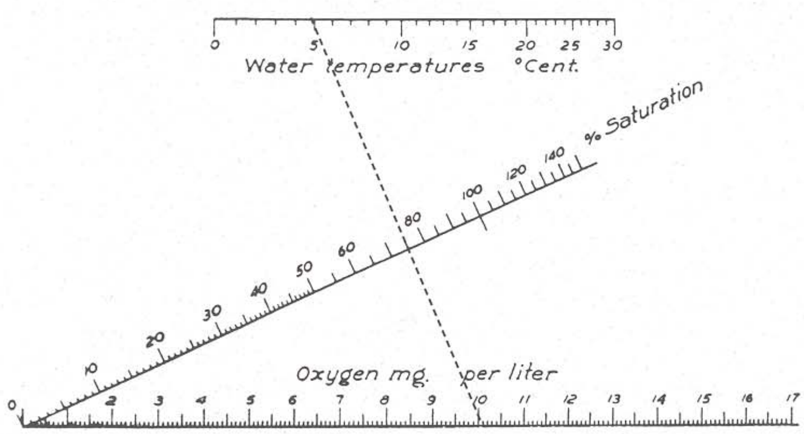


Figure 9. Level of oxygen saturation chart.

How to Find Percentage of Saturation: *Using a straight edge, find your water temperature (convert from Fahrenheit if necessary using above chart). Align with the Oxygen mg/Liter scale. The percentage of saturation is on the same line. For example, 5°C with 10 mg/L of oxygen aligns with 75% saturation, which is your answer.*

Water Action Volunteers is a cooperative program between the University of Wisconsin-Extension and the Wisconsin Department of Natural Resources. For more information, contact the Water Action Volunteers Coordinator at 608/264-8948.

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