The River Mile
Water Quality

Lesson # 3

Water Quality: Turbidity & Conductivity

Developed by the Lake Roosevelt Forum to support "The River Mile" National Park Service Program

Suggested duration: [90 minutes to optional multi day]
Inquiry Question: How do suspended & dissolved substances impact water quality? What role does runoff play in changing turbidity & conductivity**?**
Inquiry Process: Scientific observation
Standards: PS2 & ES2
Formative Assessment: Objective, precise, descriptive, observations using scientific terminology & symbols
Materials: Lesson 2 "dirty" water samples & Water filters Secci disc Turbidity tube Lake or pond water GLOBE Turbidity lab GLOBE Conductivity lab Conductivity test probe Janice Van Cleave's Erosion & Deposition Activities 43, 45,46, & 50
Handouts: Student Handout
Credits/Citations: PP Slides: Lake Roosevelt Forum, NPS and Eric Starkey Van Cleave Earth Science TRM Turbidity Protocol Globe: Turbidity Lab Globe: Conductivity Lab

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Water Quality: Turbidity & Conductivity

INTRODUCTION:
Turbidity measures the cloudiness caused by the presence of suspended solids, such as clay and silt particles from erosion or runoff, re-suspended bottom sediments & microscopic organisms in the water. The greater the amount of total suspended solids in the water (not to be confused with total dissolved solids), the murkier water appears and the higher the measured turbidity.

Turbidity can greatly affect water quality in many ways. Some examples include reducing the amount of light available for plant growth, damaging sensitive gill structures in fish and aquatic organisms, as well as increasing their susceptibility to disease, and preventing proper egg and larval development.

Conductivity and Total Dissolved Solids - Conductivity is a measure of how well water can transmit an electrical current. In the Lake Roosevelt watershed, conductivity is primarily used to determine the mineralization of water (commonly called total dissolved solids). Information from the amount of total dissolved solids can be used to determine changes in water at different times of the year and can also be used to determine certain physiological effects on plants and animals.

STUDENT WORK AND ASSESSMENT
Formative Assessment: Recording detailed observational data

QUESTIONS TO EXPLORE/INSTRUCTIONS/PROCEDURE
1.   Students reflect on experience in Lesson 2: Design a water filter. Why is a system to measure and compare WQ important?
2.   View the WQ Investigation PP (23 slides) as an introduction to Water Quality indicators that will be investigated in Lessons 3-8
3.   Questions for discussion and analysis: How do turbidity and conductivity measures compare on each water sample tested. What are the relationships between turbidity, conductivity, runoff and natural filtration?

Option 1: Use samples of the "dirty" water from Lesson 2. Record observations of the water sample and measure using a turbidity tube. Filter using the student built filters, observe, measure, and compare.

Option 2: Erosion and Deposition Activities 43, 45, 46, & 50 (Van Cleave) as class demonstration or experimental stations

Option 3: Take water samples at one site each month (or seasonally) and compare conductivity.

Option 4: Check conductivity on wind eroded points to see if it differs from non-eroded locations or in coves or streams that feed the body of water. *Note*: *GLOBE lab details are provided in the unit appendices.*

WATER QUALITY: TURBIDITY & CONDUCTIVITY

Name: _____Date: _____

Essential Questions:
   How do suspended & dissolved substances impact water quality?

Inquiry Question:
   What role does runoff play in changing turbidity & conductivity**?**

Objective:
   You will:
   - Record objective, precise, descriptive, observations using scientific terminology
   - Take notes on water quality indicators
   - Measure turbidity & conductivity for a variety of water samples
   - Analyze observational, experimental and statistical data to determine variables

Preparation from Lesson 2:
Think about your experience in Lesson 2 of designing a water filter. Why is a system to measure and compare water quality indicators important?

Think Time:

I think a system for measuring water quality is important because ....

As you watch the Power Point presentation record notes:
Identify key points about each of the following water quality Indicators

TURBIDITY/TRANSPARENCY:

TEMPERATURE:

PH:

DISSOLVED OXYGEN:

DISSOLVED GASSES:

DISSOLVED SOLIDS:

NUTRIENTS (PHOSPHORUS, NITROGEN):

HEAVY METALS:

OTHER IMPORTANT IDEAS:

Turbidity & Conductivity:

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Procedure:

Using a variety of water samples

- ☐ Learn to use the turbidity tube and/or the Secci disc to measure water transparency /turbidity.
- ☐ Learn to use the conductivity meter to measure the total dissolved solids in your water samples.

PROCESS NOTES:		
Turbidity Tube	Secci Disc	Conductivity Meter

1. **Collect observational & statistical data** on turbidity & conductivity from experimental samples

Water Sample	Tap water	Lake/pond or river	Filtered	#43 Run off	#45 Speedy	#46 Wander	#50 Shake Up
Turbidity							
Particulate Matter							
Smell							
Color & Appearance							
Conductivity							

2. **Analyze the data** and experimental procedure to identify variables that impacted water quality.

> **Analysis:** How do turbidity and conductivity measures compare on each water sample tested. Identify dependent & independent variables.

3. **Draw Conclusions:**

> Conclusions: Turbidity, conductivity, runoff, filtration, and motion impact water quality in the following ways:

What is conductivity and why is it important?

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius (25 C).

Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity.

The basic unit of measurement of conductivity is the mho or siemens. Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm). Distilled water has a conductivity in the range of 0.5 to 3 µmhos/cm. The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can range as high as 10,000 µmhos/cm.

Sampling and equipment Considerations

Conductivity is useful as a general measure of stream water quality. Each stream tends to have a relatively constant range of conductivity that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered a stream.

Conductivity is measured with a probe and a meter. Voltage is applied between two electrodes in a probe immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter. The meter converts the probe measurement to micromhos per centimeter and displays the result for the user. NOTE: Some conductivity meters can also be used to test for total dissolved solids and salinity. The total dissolved solids concentration in milligrams per liter (mg/L) can also be calculated by multiplying the conductivity result by a factor between 0.55 and 0.9, which is empirically determined (see Standard Methods #2510, APHA 1992).

Suitable conductivity meters cost about $350. Meters in this price range should also measure temperature and automatically compensate for temperature in the conductivity reading. Conductivity can be measured in the field or the lab. In most cases, it is probably better if the samples are collected in the field and taken to a lab for testing. In this way several teams of volunteers can collect samples simultaneously. If it is important to test in the field, meters designed for field use can be obtained for around the same cost mentioned above.

If samples will be collected in the field for later measurement, the sample bottle should be a glass or polyethylene bottle that has been washed in phosphate-free detergent and rinsed thoroughly with both tap and distilled water. Factory-prepared Whirl-pak® bags may be used.

How to sample

The procedures for collecting samples and analyzing conductivity consist of the following tasks:

TASK 1 Prepare the sample containers

If factory-sealed, disposable Whirl-pak® bags are used for sampling, no preparation is needed. Reused sample containers (and all glassware used in this procedure) must be cleaned before the first run and after each sampling run by following Method A as described in MEthod A in Table 1 in Chapter 5 - Water Quality Conditions.

TASK 2 Prepare before leaving for the sampling site

Refer to section 2.3 - Safety Considerations for details on confirming sampling date and time, safety considerations, checking supplies, and checking weather and directions. In addition to the standard sampling equipment and apparel, when sampling for conductivity, include the following equipment:

⇨ Conductivity meter and probe (if testing conductivity in the field)
⇨ Conductivity standard appropriate for the range typical of the stream
⇨ Data sheet for conductivity to record results
⇨ Be sure to let someone know where you are going and when you expect to return.

TASK 3 Collect the sample (if samples will be tested in the lab)

Refer to Task 2 in Chapter 5 - Water Quality Conditions for details on how to collect water samples using screw-cap bottles or Whirl-pak® bags.

TASK 4 Analyze the sample (field or lab)

The following procedure applies to field or lab use of the conductivity meter.

1. Prepare the conductivity meter for use according to the manufacturer's directions.
2. Use a conductivity standard solution (usually potassium chloride or sodium chloride) to calibrate the meter for the range that you will be measuring. The manufacturer's directions should describe the preparation procedures for the standard solutio n.
3. Rinse the probe with distilled or deionized water.
4. Select the appropriate range beginning with the highest range and working down. Read the conductivity of the water sample. If the reading is in the lower 10 percent of the range, switch to the next lower range. If the conductivity of the sample ex ceeds the range of the instrument, you may dilute the sample. Be sure to perform the dilution according to the manufacturer's directions because the dilution might not have a simple linear relationship to the conductivity.
5. Rinse the probe with distilled or deionized water and repeat step 4 until finished.

TASK 5 Return the samples and the field data sheets to the lab/drop-off point.

Samples that are sent to a lab for conductivity analysis must be tested within 28 days of collection. Keep the samples on ice or refrigerated.
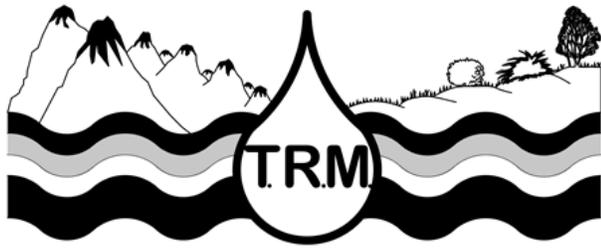
References

APHA. 1992. *Standard methods for the examination of water and wastewater.* 18th ed. American Public Health Association, Washington, DC.

Hach Company. 1992. *Hach water analysis handbook.* 2nd ed. Loveland, CO.

Mississippi Headwaters River Watch. 1991. *Water quality procedures.* Mississippi Headwaters Board. March.
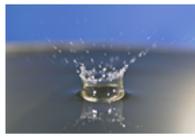
Investigating Water Quality

How is water quality measured?

- "Hello, I'm a single drop of H_2O (water) but you can call me Splash. The River Mile Program put me at the center of their logo because they know that without me there is no life on Earth. I'm not being fresh... just stating the facts. They asked me to help you understand conditions that impact water quality. Together we'll ask important questions, do some tests, record and analyze data, and look for answers to our questions.
- Are you ready? All the other drops are anxious to show you around, so let's jump in!"

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- "People rarely think of us as individual drops because we have amazing properties that hold us together in bodies of water such as the Spokane River, the Columbia River, and Lake Roosevelt. Even when it rains we appear to be connected."
- "We drops are so popular that everything seems to get carried away with us. If you aren't sure just think about what happens to homes, trees, cars and people when the river floods."

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- "With so many other substances dissolving or being suspended in water, our quality is being questioned.
- The first thing people notice is whether or not we look clean coming out of the faucet and then they sip a few drops to see if we taste good. But there is so much more to our story."

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- Scientists from the Environmental Protection Agency (EPA), the Washington State Department of Ecology (DOE), the United States Geological Society (USGS), The Department of Fish and Wildlife Services, Bonneville Power Admin., Teck Cominco, Canada and fish biologists, from the Spokane Tribe of Indians and the Colville Confederated Tribes all conduct tests to see if we drops are healthy and safe for humans, animals, and fish to consume and use. Believe me they get pretty personal but it's ok they do want me to be healthy.

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Scientist take water samples and use high tech probes to test and measure water for...

- **Turbidity/Transparency**
- **Temperature**
- **pH**
- **Dissolved Oxygen**
- **Dissolved Gasses**
- **Phosphates**
- **Nitrates**
- **And more...**

You can do some tests with simple materials and compare your results with data from other sources.

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- **Turbidity** measures the cloudiness caused by the presence of suspended solids, such as clay and silt particles from erosion or runoff, re-suspended bottom sediments & microscopic organisms in the water.

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- The greater the amount of total suspended solids in the water (not to be confused with total dissolved solids), the murkier it appears and the higher the measured turbidity.

- Turbidity can greatly affect water quality in many ways. Some examples include reducing the amount of light available for plant growth, damaging sensitive gill structures in fish and aquatic organisms, as well as increasing their susceptibility to disease, and preventing proper egg and larval development.

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Water Quality: Transparency

- **The Secchi disk** - is used to measure how deep a person can see into the water of lakes and large rivers. It is generally an 8-inch diameter metal disk painted in alternate black and white quadrants. The disk is lowered into the water until the observer loses sight of it. The disk is then raised until it reappears. The depth of the water where the disk vanishes and reappears is the Secchi disk reading. Secchi Disk measurements are important to understanding how water clarity may be affected by algae and sediment at different times of the year.

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- Turbidity can also be measured by using a turbidity tube. You can see the miniature secchi disc located in the bottom of the tube. Sample water is added to the turbidity tube and then slowly removed until the black and white pattern is visible.

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- **Temperature** - Certain types of fish like rainbow trout, kokanee salmon and aquatic organisms need cold water temperatures to thrive. Temperature is monitored to observe changes from month to month, season to season, and overall trends from year to year. Temperature may also directly affect the amount and location of aquatic plant growth.

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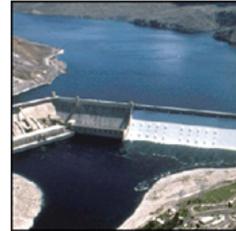
- Scientists studied the Columbia and Snake system to understand what causes increased temperatures. They analyzed everything from climate change to paper mills.

- They found that the biggest influence on temperature is hydroelectric reservoirs. Scientists estimate that the reservoir (Lake Roosevelt) behind Grand Coulee can increase water temperature in the Columbia River by as much as 6 degrees Celsius above natural conditions, the most of any of the facilities. Hydroelectric facilities are grouped into the category of non-point source pollution. Other examples of non-point source pollution are erosion and removal of shading vegetation next to waterways.

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Water Quality: Temperature

Max. Effect on Temperature in the Columbia/Snake Rivers from Various Sources

- Understanding water quality indicators is complex. Turbidity, transparency, temperature ....what else?

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- **pH** – Is the measurement for how acidic or basic something is. pH is measured on a scale from 0 to 14, with 7 being neutral. Fresh water generally has a pH between 6.0 and 8.5. If the pH of water becomes too high (basic) or too low (acidic), aquatic organisms begin to die. At extremely high or low pH levels all aquatic life will die. pH is probably the single most important factor initiating all chemical reactions in water.

pH	6.2	6.8	7.2	7.8	8.4
	VERY LOW	LOW	← OK →		HIGH

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- **Total Dissolved Gasses** (TDG) When water plunges over a waterfall and into a deep pool, it takes air bubbles with it. The high pressure causes the bubbles to change into a solution. This mixes with the normal water, so now the water is supersaturated with gases, primarily nitrogen (70%). It's kind of like putting the fizz into soda pop.

- So if you're looking at a beautiful waterfall, you may be seeing TDG supersaturation happening as a normal part of nature. And if you're looking at water falling over the spillway of a dam, you may be seeing it as part of what humans create. For a full explanation of the process check out http://lrf.org/TMDL2print.html.

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