Graphic Data & Analyzing Trends in Water Quality

Adapted from *Healthy Water, Healthy People Educators Guide* – www.projectwet.org

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Contents

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Summary
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Vocabulary: best management practices (BMPs), contaminant, nonpoint source pollution, point source pollution, storm water runoff, watershed

Project WET

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Grade Level: 6–8, ages 11-14

Subject Areas: Mathematics, Environmental Science, Language Arts, Geography, Chemistry

Duration:
Preparation: 5 minutes
Activity: 50 minutes

Setting: Classroom

Skills: Interpret, Analyze, Organize, Gather, Communicate, Present, Graph

Objectives

Students will:

- identify significant water quality parameters.
- read and interpret a contour map to determine the characteristics of a watershed.
- discern the value of data from a single sample as compared to data from a series of samples.
- graph, analyze, and summarize both spatial and chronological trends in water quality data.
- compare and contrast the effects of water quality parameters on one another, especially the relationships between temperature and dissolved oxygen, and the relationships between flow and clarity.

Materials

- *Pencils*
- *Graphing paper (or loose-leaf paper if graphing paper is not available)*
- *Copies of **River Watershed Map** Student Copy Page*
- *Copies of **Watershed Data Summaries Worksheet** Student Copy Page*
- *Copies of **River Water Data Cards** Teacher Copy Pages*

Background

Can you imagine living an entire lifetime without ever having a check-up with your doctor? Periodic check-ups can help doctors determine trends in our health and better avoid major health problems. The same is true of watersheds; they too need monitoring over time to assess trends in their health. Like a person who is generally healthy but has suffered a specific injury, say to the knee or shoulder, a river may be generally healthy except for a specific "injured" section such as a stretch contaminated by urban runoff, or one unduly susceptible to high sediment loading in spring. Watersheds need to be monitored in order to preserve their water quality health.

The Environmental Protection Agency (EPA) cites these five major reasons for monitoring a river:

1. to characterize waters and identify changes or trends in water quality over time;
2. to identify specific existing or emerging water quality problems;
3. to gather information to design specific pollution prevention or remediation programs;
4. to determine whether program goals—such as compliance with pollution regulations or implementation of effective pollution control actions—are being met; and
5. to respond to emergencies, such as spills and floods.

Water quality is determined by conducting physical, chemical and biological measurements of a watershed. Chemical measurements include, but are not limited to, pH, dissolved oxygen, nitrates, phosphates, and dissolved solids. Some of the physical parameters often measured are clarity, temperature, discharge (flow rate), and the conditions of stream banks and shoreline. Biological assessments of water health measure the abundance and diversity of aquatic plants and animals.

Many local, state, national and international organizations, have found that if monitoring data is to be useful guidelines must be established and followed. One of the most important guidelines states that strategically collecting numerous data samples that meet chosen objectives is a more effective approach than using data from a single sample, a practice that limits the findings that can be extracted from that data.

For example, it is most valuable to monitor a river several times throughout the year over a period of several years. In doing so, seasonal variations and annual variations can be better understood. This method also provides insight into the impact of pollution, development, and other land uses over time. It is also important that several sites along the length of the river be sampled so land use and environmental variations along the river can be documented.

Finally, the sampling parameters and the associated sampling techniques must be consistent over time and between different monitors. Samples should be collected and analyzed using standardized techniques that are well documented and accepted. These measures ensure that data from one river can be readily compared to data from other rivers and established water quality standards.

This activity focuses primarily on identifying changes or trends in water quality over time. Students will investigate the interactions between several parameters in a river and the ways they affect each other. Specifically, they will notice the relationship between temperature and dissolved oxygen, and between flow and clarity. These relationships are discussed on the following page.

<u>Temperature</u>: Soil erosion causes water to become murky, thereby increasing the absorption of the sun's rays. Thermal pollution—the addition of relatively warm water to a waterway from a power plant or urban runoff from warmed streets and pavement—can increase the temperature of a river.

Temperature has a direct influence on the amount of dissolved oxygen in a river. Generally, warmer waters have lower dissolved oxygen levels than colder waters. Further, aquatic organisms' metabolic rates increase in warm water, consuming even more oxygen from the water. An organism's ability to fight disease, parasites, or pollution is compromised when available dissolved oxygen decreases.

Dissolved Oxygen (DO): Most aquatic plants and animals, like humans, need oxygen to live. However, aquatic organisms need oxygen that is dissolved in water, and not atmospheric oxygen as humans do. Oxygen becomes dissolved in water in various ways, including tumbling over rocks (whitewater) or falls where water is agitated and atmospheric oxygen is forced into solution. Photosynthesis from aquatic plants also produces dissolved oxygen. While dissolved oxygen is retained in cool water, it is forced out of warmer water. The amount of oxygen dissolved in water peaks in late afternoon when photosynthesis is also at its peak and is lowest just before dawn.

With little agitation and typically higher temperatures, slower-moving, meandering rivers tend to have lower dissolved oxygen levels, while swift, well-aerated streams tend to have a high level of dissolved oxygen. In general, higher dissolved oxygen levels indicate healthier water for aquatic organisms.

Clarity: Clarity refers to how clear water is, or how deep one can see into the water. Relative clarity is measured in centimeters of depth of visibility. Clarity decreases with the increase in levels of suspended solids such as plankton, silt, clay, sewage, organic matter, and industrial waste. Suspended solids are introduced into watersheds by various means. Spring runoff, forest fires, and storms can all increase the rate of erosion and thus the amount of sediment that enters a waterway. Urban runoff, industrial effluent, and wastewater discharge can also contribute suspended solids to a watershed.

Water temperature increases as the clarity of a waterway decreases. When suspended solid levels increase so does the rate of absorption of the sun's rays. Clarity tends to be lowest following storms or during spring runoff when the water carries more eroded sediments and there is an increased disturbance of materials from the stream bottom.

Flow: A river flows at various rates throughout a watershed and throughout the seasons. Flow, or the speed at which water moves past a given point in one second, is typically measured in cubic feet per second or cfs. Both the width of a stream and the depth of its channel play a role in determining flow. Flow tends to be higher in the springtime when storms and snowmelt add volume to rivers. Depending on your geographic location, flows tend to be lower in the winter when much of the precipitation decreases or is frozen as snow.

pH: The landscape in a watershed can influence the pH of its waters. While not directly affected by the other four parameters discussed in this backgroud, pH can be highly influenced by clarity and turbidity. Watersheds that contain bogs, marshes, or pine forests tend to support waters with a lower pH, while sphagnum moss and pine needles are slightly acidic. Decaying vegetation produces organic acids that leach into the ground or join runoff and flow into nearby waters, thus reducing pH. The pH test measures the hydrogen ion concentration and allows us to infer how acidic or basic a substance is. In general, most aquatic organisms can survive in waters between a pH of 5 to 9. Beyond this range, the diversity of species decreases, as pH fluctuations and the associated bioavailability changes will stress or even kill aquatic life.

Understanding the relationships between water quality parameters such as these and how these parameters can change throughout a watershed and over the seasons is an important first step toward understanding the broader scope of watershed monitoring.

Procedure

Warm Up

Discuss why water is monitored. Discuss the four parameters tested in this activity (temperature, dissolved oxygen, clarity, and flow), and the significance of each parameter. For example, why is it important to measure the temperature of water? Why should we be concerned about the rising temperature of a river? How will temperature affect the river and the aquatic organisms that inhabit the river? Discuss the parameter of pH and while it is not tested in this activity it is an important tool for testing water quality. How is pH influenced by some of the other parameters?

Sections of a River

As an extension to this activity have students draw a river diagram and include each of the five sections defined below. Have students label each section. You may also use a diagram or photograph of a local river and have students locate each of the sections. Ask students if they have ever visited one of these locations and what they observed.

Confluence – The flowing together of two or more streams. A point of juncture.

Downriver – Toward or near the mouth of a river; in the direction of the current.

Falls (waterfall) – A steep descent of water from a height; a cascade.

Headwaters – The water from which a river rises; a source.

Midriver – The middle or center of a river.

The Activity

1. Distribute the *River Watershed Map* to each student.

2. (Optional map-reading activity. If your students are skilled at reading topographic contour maps, please skip to Step 3.) Instruct students to locate the contour lines on the map. Contour lines are spaced at twenty-foot intervals and allow the reader to interpret what a three-dimensional landscape looks like using a two-dimensional map. For example, contour lines allow the reader to determine the direction a river flows, where mountains and valleys and even waterfalls are located.

a. Have students place an X on the highest and lowest points on the map.
b. Have the students determine which direction the river is flowing (from highest to lowest elevations). Have them denote this by placing arrows on the map indicating the direction of flow.
c. Have students identify where on the river the waterfall is located. How did they identify this feature? (Two or more contour lines spaced tightly together indicate a very steep slope, or waterfall.)

3. Drawing on what the students know about water flow, have them label the appropriate sampling sites with the following terms: *Headwaters, Confluence, Midriver, Falls, Downriver.*

4. *Distribute a different River Water Data Card to each student.* Ask them to study their card and locate their site on the map.

5. Distribute a copy of the *Watershed Data Trends Worksheet* to each student. Under the *Single Sample* section, ask students to write a brief summary of what they have learned about the water quality at their site. (They should only be able to state how the water at their monitoring site sample looked at that time, not any broader inferences about the river.)

6. Have selected students read their paragraphs and discuss the value of the information on the card. What other information about the river is needed to write a more complete paragraph?

7. Have students break into groups representing the five sections of the river, Headwaters, Confluence and so on through Midriver, Falls, and Downriver.

8. Instruct students to graph the data for their group. They should create a total of four graphs of data, one each for Temperature, Dissolved Oxygen, Clarity, and Flow. The parameter measured should be on the y-axis (vertical axis), and the seasons should be along the x-axis (horizontal axis). Their graphs should illustrate the seasonal temperature changes of the river at their site.

9. Instruct each group to write a paragraph describing what they know about the entire river based on the data they graphed at their sampling site and then record the group paragraph under the *Sampling Site* section of their *Watershed Data Trends Worksheet.*

10. Ask groups to share their summaries with the class. What other information would they like to help them understand the water quality of the River?

11. Reshuffle students into four groups representing each of the four seasons: winter, spring, summer, fall. All of the students with spring cards will form a "spring group" while all of the students with a winter sampling card will form a "winter group" and so on.

12. Have students graph each parameter along the y-axis and their sampling site along the x-axis. The groups should again have the same four graphs, one for each parameter, which allows them to interpret how each parameter changes as they follow the river down the watershed during their respective season.

13. Instruct the groups to write a paragraph describing what they know about the river based on the seasonal data they graphed. Record this paragraph under the Seasons section of the ***Watershed Data Trends Worksheet.***

Wrap Up

Have students review their summary paragraphs and then read aloud selected ones to the class. Instruct students to write a final summary paragraph (under the *Project Summary* section) explaining how their site changed both spatially (along a watershed) and chronologically (through the seasons). What patterns or relationships were revealed from the spatial interpretation of the parameters? What patterns or relationships were revealed from the chronological interpretation of the parameters? Ask students to compare these summary paragraphs with their single sample paragraph based on their individual card.

Have students discuss the benefits of long-term data (a monitoring project) over a single monitoring event (a single sample). Why is it important to monitor a river over a long period of time? Discuss monitoring a river over time, and then monitoring an entire watershed over time. Which would be most valuable? What are some limitations of both? (e.g., money, time, accessibility to each site, weather, etc.)

Assessment

Have students:

- identify important water quality parameters and their significance (***Warm Up***).
- read and interpret a contour map to determine the characteristics of a watershed (**Steps 2-3**).
- discern the value of data from a single sample and that from a series of samples of stream monitoring data (**Steps 4-13; *Wrap Up***).
- graph, analyze, and summarize chronological and spatial water quality data for several parameters (**Steps 8-12**).
- compare and contrast the effects of water quality parameters on one another, especially the relationships between temperature and dissolved oxygen, and the relationships between flow and clarity (***Wrap Up***).

Extensions

Challenge students to use all the clues provided (temperature, elevation, etc.) to determine where this river may be located. Have them list their evidence and defend their prediction. The data is fabricated, but the data resembles that of a state in the northern latitude of the United States or a Canadian province.

Research the watershed monitoring being conducted in your area. Invite a watershed monitoring coordinator or water quality district representative to demonstrate water quality monitoring equipment and methods, or to discuss water quality issues in your area.

Resources

Ebbing, D. 1990. *General Chemistry, Third Edition*. Boston, MA: Houghton Mifflin Co.

Mitchell, M., and W. Stapp. 1997. *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools*. Dubuque, IA: Kendall/Hunt Publishing Co.

United States Department of Agriculture. 1991. *Water Quality Indicators Guide: Surface Waters*. Washington, D.C.: U.S. Government Printing Office.

United States Environmental Protection Agency. 1996. *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. Washington, D.C.: U.S. Government Printing Office.

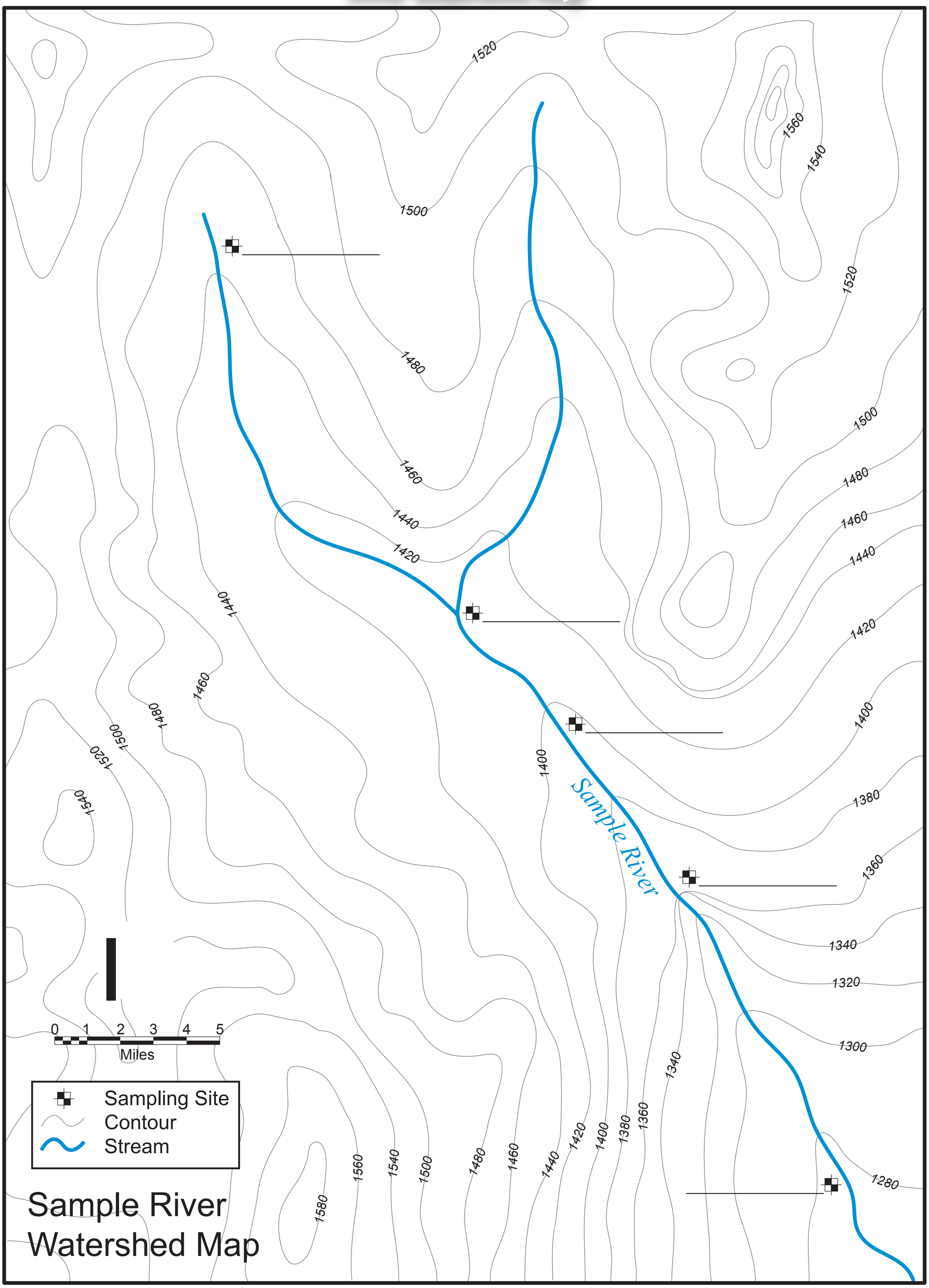
Yates, S. 1991. *Adopting a Stream: A Northwest Handbook*. Seattle, WA: University of Washington Press.

Websites

United States Environmental Protection Agency. *Monitoring Water Quality*. http://www.epa.gov/OWOW/monitoring/monintro.html.

United States Geologic Survey. *National Water Quality Monitoring Council Work Plan*. http://water.usgs.gov/wicp/acwi/monitoring/nwqmc_wkpln.html.

River Watershed Map



River Water Data Cards

Headwaters:
Date: January 5

Conditions: River is partially frozen; clear day.

Temp: .5° C
DO: 14.5 mg/L
Clarity: 48 cm
Flow: 800 cfs

Headwaters:
Date: April 7

Conditions: River is at high flows due to spring runoff.

Temp: 4.4° C
DO: 14.5 mg/L
Clarity: 6 cm
Flow: 2000 cfs

Headwaters:
Date: July 6

Conditions: Hot and humid, but the trees over the river offer shade.

Temp: 12.8° C
DO: 12mg/L
Clarity: 26 cm
Flow: 1200 cfs

Headwaters:
Date: October 9

Conditions: Cool, fall day; leaves falling in the water.

Temp: 10° C
DO: 13 mg/L
Clarity: 33 cm
Flow: 750 cfs

Confluence:
Date: January 5

Conditions: The combined flows keep the river free of ice.

Temp: .5° C
DO: 14.5 mg/L
Clarity: 46 cm
Flow: 1600 cfs

Confluence:
Date: April 7

Conditions: Spring rains have led to high runoff.

Temp: 4.4° C
DO: 14.5 mg/L
Clarity: 5 cm
Flow: 4000 cfs

Confluence:
Date: July 6

Conditions: Much of the bank is showing due to low flows.

Temp: 11.7° C
DO: 11.5 mg/L
Clarity: 20 cm
Flow: 2000 cfs

Confluence:
Date: October 9

Conditions: Cool temperatures; leaves are changing colors.

Temp: 9.4° C
DO: 12 mg/L
Clarity: 32 cm
Flow: 1500 cfs

Midriver:
Date: January 5

Conditions: Small ice sheets float by as you conduct your sampling.

Temp: 1.7° C
DO: 12 mg/L
Clarity: 42 cm
Flow: 1600 cfs

Midriver:
Date: April 7

Conditions: Sediment levels are high due to the high flows.

Temp: 7.2° C
DO: 13 mg/L
Clarity: 8 cm
Flow: 4000 cfs

Midriver:
Date: July 6

Conditions: Algae is beginning to grow along the edges of the river.

Temp: 16° C
DO: 8 mg/L
Clarity: 17 cm
Flow: 2000 cfs

Midriver:
Date: October 9

Conditions: The water feels cool to the touch as fall approaches.

Temp: 11° C
DO: 9 mg/L
Clarity: 24 cm
Flow: 1500 cfs

River Water Data Cards

Falls:	Falls:	Falls:	Falls:
Date: January 5	Date: April 7	Date: July 6	Date: October 9
Conditions: Churning water at the falls keeps ice from forming on the river.	Conditions: High flows have almost washed out the falls.	Conditions: Swimmers frequent the pool below the falls in summer.	Conditions: Low autumn flows greatly reduce the size of the falls.
Temp: 2.8° C	Temp: 8.9° C	Temp: 18.3° C	Temp: 12.8° C
DO: 13 mg/L	DO: 2.2 mg/L	DO: 9 mg/L	DO: 10 mg/L
Clarity: 32 cm	Clarity: 8 cm	Clarity: 11 cm	Clarity: 18 cm
Flow: 1600 cfs	Flow: 4000 cfs	Flow: 2000 cfs	Flow: 1500 cfs
Downriver:	**Downriver:**	**Downriver:**	**Downriver:**
Date: January 5	Date: April 7	Date: July 6	Date: October 9
Conditions: Winter winds blow strong, keeping the river free of ice.	Conditions: Brown, turbid water from high flows.	Conditions: Dark, deep, and warm water slowly passes by your site.	Conditions: The water seems clearer now than in the summer.
Temp: 3.3° C	Temp: 10° C	Temp: 22.8° C	Temp: 15° C
DO: 6 mg/L	DO: 7 mg/L	DO: 3 mg/L	DO: 4 mg/L
Clarity: 32 cm	Clarity: 8 cm	Clarity: 11 cm	Clarity: 18 cm
Flow: 1600 cfs	Flow: 4000 cfs	Flow: 2000 cfs	Flow: 1500 cfs

Watershed Data Summaries Worksheet

Single Sample
Sampling Site
Seasons
Project Summary