Common Water, Common Ground

An Exploration into Watershed Sustainability and Stewardship

Save the Salmon

Curriculum Guide

• Culver Productions and Concord Consortium • 1999

Contents

Common Water, Common Ground

Introduction

Water is essential to nearly all forms of life on earth. About 70% of our planet is covered by water, yet less than 2% of the water on earth is fresh water; the type of water living things need. Common Water, Common Ground is designed to help students learn about our precious fresh water resources, and to help them appreciate how our practices on land affect the quality of the water upon which life depends.

Video and CD-ROM technology anchor the curriculum and provide resources for research into the complex issues surrounding our fresh water resources. CD-ROM technology makes finding information easy for beginning researchers. Students just use the mouse to click on topic headings- pictures, charts, diagrams and articles appear on the computer screen.

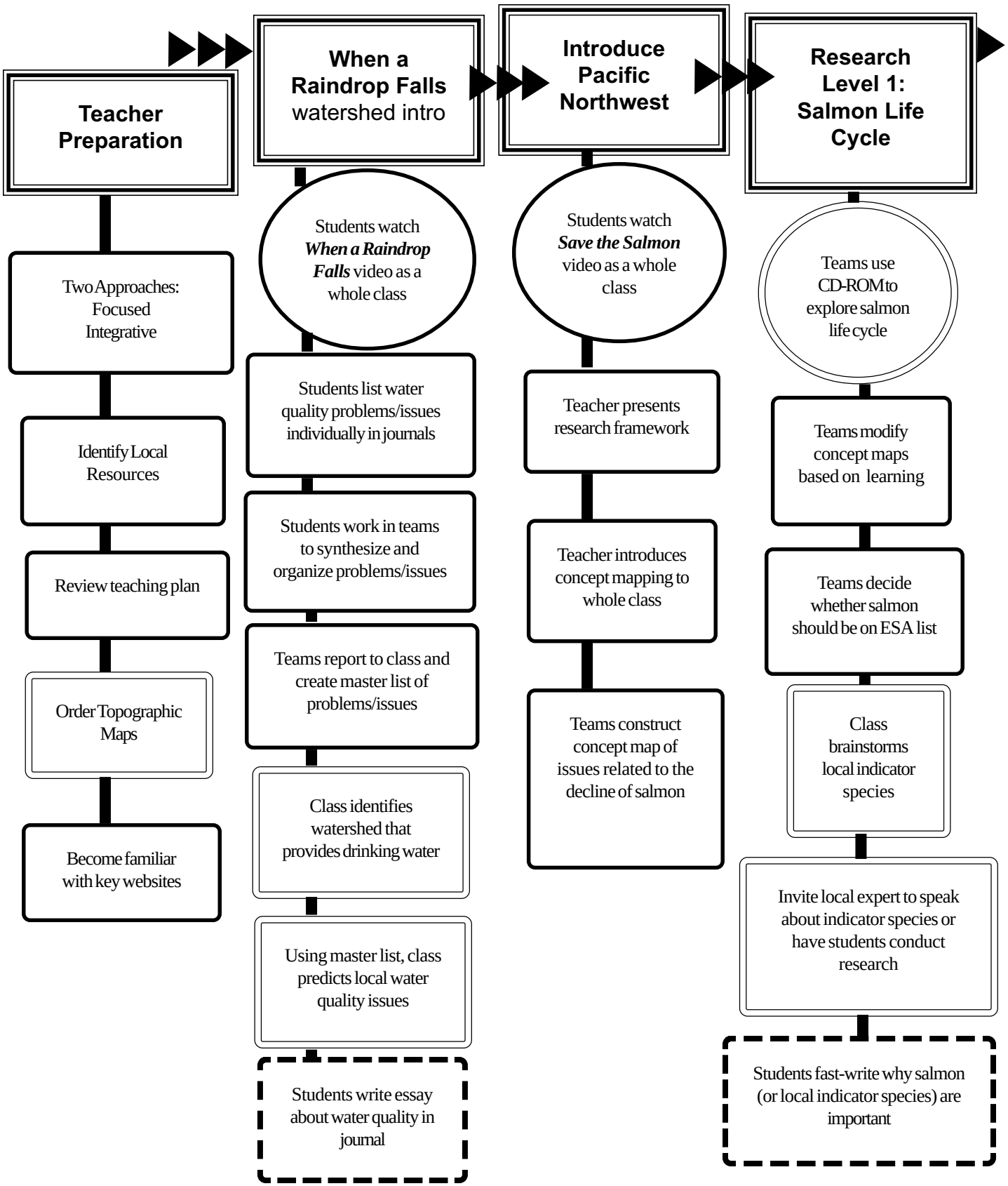
Common Water, Common Ground asks students to focus on water quality issues in the Pacific Northwest. Students learn about water habitats in the Pacific Northwest through a focus on salmon as an indicator species of water quality. When water quality declines in the streams and rivers of this region, so do salmon populations.

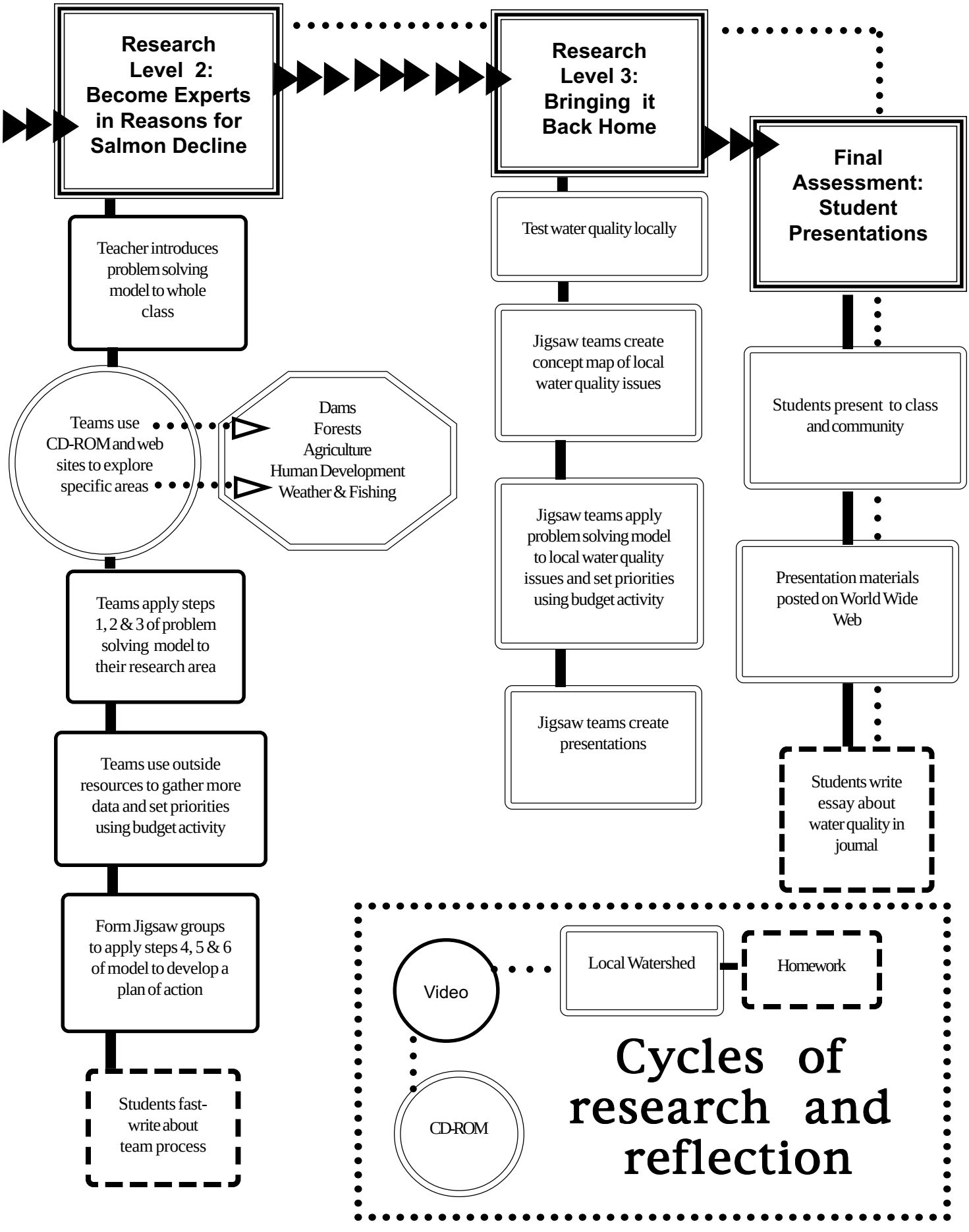
Students connect their studies about the Pacific Northwest with home through investigations into their local watershed. The curriculum first asks students to identify the boundaries and issues of the watershed that provides their drinking water. Students then investigate what has happened in watersheds in another region- the Pacific Northwest. At each level of research, students are asked to engage in activities that will help them connect what they are learning about water quality issues in the Pacific Northwest to issues in their own watershed.

Concept maps and flow charts show how the curriculum can be organized to include research and presentation cycles. Throughout their investigations, students engage in concept mapping to help them think systematically about the many concepts involved in understanding water quality and water habitats. Students also employ strategic planning models to further understand the complexity of the decisions that are made in communities who struggle to balance the importance of water quality against land use considerations.

This curriculum is intended to provide a framework that will assist teachers in developing a curriculum that suits a variety of time and resource constraints. For those who have the time and resources, hands-on investigations, field trips, and guest speakers greatly extend students learning and provide them with valuable connections in the community and natural environment. Suggestions for ways to extend students learning are included throughout this curriculum guide.

Curriculum Organization




Research Level 2: Become Experts in Reasons for Salmon Decline
Research Level 3: Bringing it Back Home
Final Assessment: Student Presentations
Teacher introduces problem solving model to whole class
Teams use CD-ROM and web sites to explore specific areas
Dams
Forests
Agriculture
Human Development
Weather & Fishing
Teams apply steps 1, 2 & 3 of problem solving model to their research area
Teams use outside resources to gather more data and set priorities using budget activity
Form Jigsaw groups to apply steps 4, 5 & 6 of model to develop a plan of action
Students fast-write about team process
Test water quality locally
Jigsaw teams create concept map of local water quality issues
Jigsaw teams apply problem solving model to local water quality issues and set priorities using budget activity
Jigsaw teams create presentations
Students present to class and community
Presentation materials posted on World Wide Web
Students write essay about water quality in journal
Video
Local Watershed
Homework
CD-ROM
Cycles of research and reflection

Learning Principles

Common Water, Common Ground is designed with certain learning principles in mind:

•Computer and video technology anchor students' learning in real life contexts and provide resources for learning beyond the classroom.

• Research and jigsaw groups provide opportunities for students to learn in depth and to share information.

•Learning and working with others in the community toward a healthy balance between people's needs and environmental considerations will prepare students to be active, knowledgeable citizens.

• Hands-on investigations extend students' learning by building skills in questioning, observing, measuring, analyzing information, and forming conclusions that may lead to further questions.

• Guest speakers and local water quality experts can make water quality issues real to your students. These people have a wealth of highly specialized knowledge- information about the history and issues of the water sheds in your area, information about local water quality indicators, and information about changes in your community that impact water quality.

• Concept maps, strategic planning models, and graphics that detail the sequence of instruction and expectation will assist students to organize information and make connections in order to construct a deep understanding of both science content and social issues.

•Reflection is an important element in learning. Students make journal entries to synthesize information, consider options, and reflect on group process.

• Cooperative groups make it possible for teachers to use a limited number of computers with a larger number of students.

Teacher Preparation

Common Water, Common Ground is designed to make it easy for teachers and students to conduct research by providing a wealth of information on CD-ROM and video tape. Some advance preparation by the teacher will make it possible for students to connect what they are learning about fresh water issues in other watersheds to an important watershed closer to home: the one that provides them with fresh drinking water.

Teachers may choose to have students take a focused approach to their investigations that will take two or three weeks to complete. Students will compare the water quality issues of another region through video anchors and CD-ROM to the issues in their own watershed. The world wide web makes it quick and easy for your students to obtain information about any watershed in the United States.

Suggested extensions to the curriculum will give students the opportunity to take an in-depth approach to their investigations. This approach can take up to six weeks to complete, but will allow students to integrate their understanding into real-life contexts- the same contexts they will live in as adults. When you have students conduct tests on local water ways or water supplies, they can learn basic principles of biology and chemistry as they make sense of the tests. Sampling of indicator species, dissolved oxygen, pH, and temperature will give students data they can use to construct a fairly detailed model of the complex interdependence between life and water quality.

Whether you choose to conduct water quality tests on your local river, or simply surf your watershed on the internet, it is important for students to make connections between water quality issues in other regions and water quality issues at home. Local water utilities and environmental groups can provide information about the source of students' drinking water, and may be able to assist in locating local experts who can share information with students about water testing, indicator species, and local conservation efforts.

Once you know the source of your students' drinking water, you can obtain topographic maps of the watershed that surrounds the water source. These maps can be purchased from the U.S. Geologic Survey, or through local cartographers. Sources for topographic maps are included in the web site bibliography of this guide, and in the resources section of the CD-ROM.

Other key web sites will be very helpful to students as they learn about water quality issues. Review these sites in advance and bookmark them to save precious class time later.

The curriculum organization flow chart suggested in this guide can be modified to meet the needs of your students. Detailed lesson plans offer more information, and include activities to extend students' learning. Review the plans in this guide, then change them as necessary to make them your own.

When a Raindrop Falls
Introduction to Watersheds

Lesson Plans and Extensions

In order to understand the issues surrounding water quality and human impact on water habitats, students must develop an understanding of watersheds. What happens on land will affect the quality of the water that flows into the streams, rivers and lakes that drain the land. Because many students care about the water they drink, investigations into the watershed that supplies their drinking water will be a meaningful way to anchor and connect students' learning about water quality issues to their lives. When students connect the factors that affect the quality of the water they drink with the health of organisms in their own important watershed areas, they can construct a framework that supports their research into water quality issues and their participation in community discussions about water quality. Common Water, Common Ground begins by asking students to identify the watershed that supplies their drinking water, and to think about how practices on land affect water quality.

Teacher Daily Lesson Plans- When a Raindrop Falls

Pre-assessment activity:

As you plan for learning, you may find it helpful to have information about individual students background knowledge or preconceptions. Students may also find it helpful to have something to compare with their final assessment that reveals growth and learning. A homework activity that asks students to draw and/or describe what happens to a drop of water that falls as rain will provide information for both of these purposes.

Day One:

Materials: Videotape: *When a Raindrop Falls,* students' journals

Begin by asking students: Where does your tap water come from? As your class discusses this question, you may find that your students have some surprising ideas. Once students have expressed their ideas, have them watch the video: *When a Raindrop Falls.* The video shows many natural waterways within watersheds, and human activities that depend on or affect water quality. Questions are posed throughout the video (you may wish to stop the video along the way and ask students to respond to or think about some of the questions). At the end of the video, students are asked to engage in two challenges: 1-Identify your watershed and find out where your drinking water comes from; 2- Come up with a list of all of the things that you do that affect water quality and water quantity in your community and around the world (use the video to help in making the list). Before asking students to complete the challenges, engage them in a discussion about what they saw and heard in the video. Ask students if they can answer the question posed in the video: What is a watershed? Since students will be conducting research about their watershed it is important that the teacher does not indicate any one response as correct during the discussion. Tell students that they will need to gather more information in order to fully answer the questions.

After the discussion ask students to write individually in their journals a list of all of the things that affect water quality and water quantity in your community and around the world (they may need to use the video to help in making the list).

Day Two:
Assign students to small groups and ask each group to use the lists that students produced individually the day before to create a list that includes everyone's ideas. It is important that group members talk with each other about the information in the video; some students will notice things that others miss, so the group lists will be longer than the lists made by individual students. Once the students have a list in their small groups, ask each group to share one thing from their list with the class. Go around until no one has anything left on their list that has not been mentioned. Write the list on the board, or on chart paper, or ask a student to record the ideas using a computer, to make a master list for the class.

Ask students to answer individually in their journals the remaining questions posed in the video: What is a watershed? Where is the watershed that supplies your drinking water?

Day Three:
Materials: Topographic maps of the region that supplies your drinking water, highlighting markers, copy paper, information from local water utility about source of drinking water.

Remind students about the questions they answered in their journals on the previous day. Ask students to generate a list of questions or things they will need to know in order to answer the questions. Write their responses on the board. Inform students that each group will conduct research about the watershed that is the source of the school's drinking water (or whatever watershed makes the most sense for your students to research- in many urban areas the watershed that is the source of drinking water is not located within the city).

Students may have identified maps as something that they would need in order to identify their watershed and source of drinking water. If students did not include maps in their list of questions/ things needed, ask them how they think that they could find information about the boundaries of their watershed and allow the students to brainstorm ways to get the information. Students should be able to identify maps as a possible source of information, even if they do not know about topographic maps. Once students have identified maps as a necessary resource, pass out a topographic map of the watershed to each small group of students.

Topographic maps are different from other maps that students may have used before (road maps, political maps) and contain detailed information about the terrain of an area. Topographic maps are necessary because they are the only type of maps generally available that give information precise enough to be used for determining watershed boundaries. Students may not be familiar with topographic maps, however, and may need some instruction in order to make sense of the maps. (Topographic maps show changes in elevation of a terrain, through a series of concentric lines. Areas defined by the same line have the same elevation. Elevation is indicated with numbers at intervals along the lines, the numbers usually refer to feet above sea level. The boundaries of a watershed will be defined by the highest elevations in an area. Waterways (rivers, lakes, streams, creeks) are located in the lowest elevations of an area. The boundaries of a watershed can be determined by locating the waterways in an area and identifying the area between the waterway and the highest elevations in an area.)
If you have them, introduce students to CD-ROM, web site, or text resources that will help them to learn about topographic maps.

Before students can outline their watershed boundaries, you will need to supply them with information about the source of their drinking water. Ask them to identify places where the water may come from on their map. (Topographic maps may contain information about more than one watershed, so students would need to decide what part of the map contains the information they need.) If the information supplied by your water utility indicates that the source of the drinking water is a waterway (river, lake, stream, creek, etc.) ask students to trace the sources of the waterway on the map, and to locate the place where water is removed for purification. If the source of their drinking water is from an underground aquifer or spring, ask students to locate the pump station (usually close to the water tower or purification plant) where the water is removed from the ground.

Once students have located the place where the water is removed for processing, have them identify the highest points of elevation surrounding the water source. These highest points are the boundaries of the watershed. Some watersheds will have a large difference in elevation between lowest and highest points, other watersheds will not have a big difference between these elevations. Because water always flows down hill, rain, and other surface water, will always flow from the highest points to the lowest points of elevation in a watershed.

When students have determined the boundaries of their watershed (or the watershed from which their drinking water is sourced, if different), have them outline the boundaries of the watershed in highlighting marker. If you plan to use the maps again, you may wish to make photocopies of the area in advance of the class and ask students to outline on the copies. You may use copies instead of the actual maps to begin with, but copies will contain less area and may not be ideal for the first part of the activity.

For homework, ask students to write, in their journals, an essay about water quality issues or activities that could affect the quality of their drinking water, based on what they noticed about their watershed.

Do you know how big your watershed is? After students have identified the boundaries of their watershed, a field trip around and across the boundaries will help them understand the difference between the map and the territory.

If you have access to a school bus or other transportation, drive your students around the boundaries of your watershed so they can see how the water drains through the land following the contours of the terrain to the lowest level, usually a river, lake or stream.

It isn't always possible to drive around the exact boundaries of a watershed, but it is often possible to drive a route that will allow you to identify the boundaries, or take you into another watershed so that students can observe how even slight changes in elevation can affect the course of water as it flows through the land.

If you are near a large park or nature preserve, your students may be able to identify some of the park watershed by walking the nature trails.

Building a three dimensional model of a watershed can help students to more fully understand the concept of watershed. This activity can also help students to gain important map reading and math skills.

Extended unit materials: styrofoam slabs or blocks 1/2 inch thick, utility knives, markers, plasticine, colored cardstock or construction paper, glue.

To begin, students will need to decide how much elevation corresponds to the 1/2 inch slabs. Once whole slab should be used as the base of the model- this base will correspond to the lowest elevation on the map and the other styrofoam pieces will rest on the base. First students will need to find out the highest elevation in the watershed and then decide how many slabs of styrofoam will equal that elevation. Then students will need to determine the lowest elevation in the watershed and draw a corresponding line on the base of the model (the lowest elevation should be where the waterway is located- in the case of underground waterways, students will need to draw a line corresponding to the lowest elevation of the land). Once the lowest elevation has been indicated on the styrofoam base, elevations between lowest and highest will need to be determined as they rise up from the lowest elevation indicated on the base. Slabs are then cut with a utility knife to the desired shape and stacked to the appropriate elevations. Once the styrofoam has been shaped, it will need to be glued together and allowed to dry overnight. This extension activity can be combined with the plans outlined above- students will find it helpful to identify the boundaries of the watershed on a topographic map in order to make the model.

Once the styrofoam has dried, students will cover the top with plasticine clay to form the details of the land. It is important to use only plasticine clay for this project- it is waterproof, easy to mold, and will not dry out. Students will need to carefully consult the topographic map in order to get the land features correctly placed on their model. The plasticine should be used to form the final elevations on the model. This activity should take an entire class period.

Once the top of the model is covered with the plasticine, the sides can be covered with colored cardstock or construction paper to cover the styrofoam sides. If students are making a model that contains an underground waterway, the cardstock should be decorated to indicate the course of the underground waterway.

When students have completed their 3-D watershed models, they can simulate the effects of various practices on the water in a watershed using the model. Students can place sand or soil in an area to simulate a plowed field or construction site where the earth has been disturbed. Water can be poured out of a watering can that has a cap with small holes on the spout to simulate rain. Students can also show how pollutants can enter a waterway by having one student pour a small trickle of water into the model while others place drops of food coloring a points along the waterway. Your students will be able to think of many ways to use the model as a watershed demonstration!

When using the model this way be sure to have some towels ready and place a bucket where the water will run out of the model. Be sure to allow enough time for students to clean up.

Introduce Pacific Northwest

Lesson Plans and Extensions

When students have some understanding of the boundaries and issues of their own watershed, they will move on to research issues surrounding the conservation of many species of Salmon indigenous to the Pacific Northwest. Currently, these species face many challenges to their survival due, in part, to changes in the water quality of their habitat. In order to understand what these changes are and how they impact Salmon, students must develop an understanding of the watersheds that surround the Salmon's immediate water environment. Human activity can affect the quality of the water that flows through a watershed, and have an impact on the health of the organisms that live in the habitats within the watershed. Salmon are sensitive organisms and cannot live outside of a narrow range of water quality indicators. The status of Salmon in a habitat gives information about the health of the watershed environment as a whole. The video, *Save the Salmon,* introduces students to the plight of the salmon, and the plight of communities in the watersheds of the Pacific Northwest as they grapple with balancing human activities and declining salmon populations.

Concept mapping can help students organize information and make connections to build conceptual understanding. If your students are novice researchers, a concept map may help them better understand how their teams will work together to understand the important issues of water quality. A research framework for students is included in this section. It can be used to introduce students to concept mapping while assisting them in understanding the sequence and process they will be expected to follow. If you are going to follow a different plan , you will need to create a research framework that reflects the plan your students will follow.

Teacher Lesson Plans- Introduce Pacific Northwest

This lesson will take one or two days depending on how much time you choose to spend introducing students to concept mapping.

Materials: *Save the Salmon* video, Student research framework.

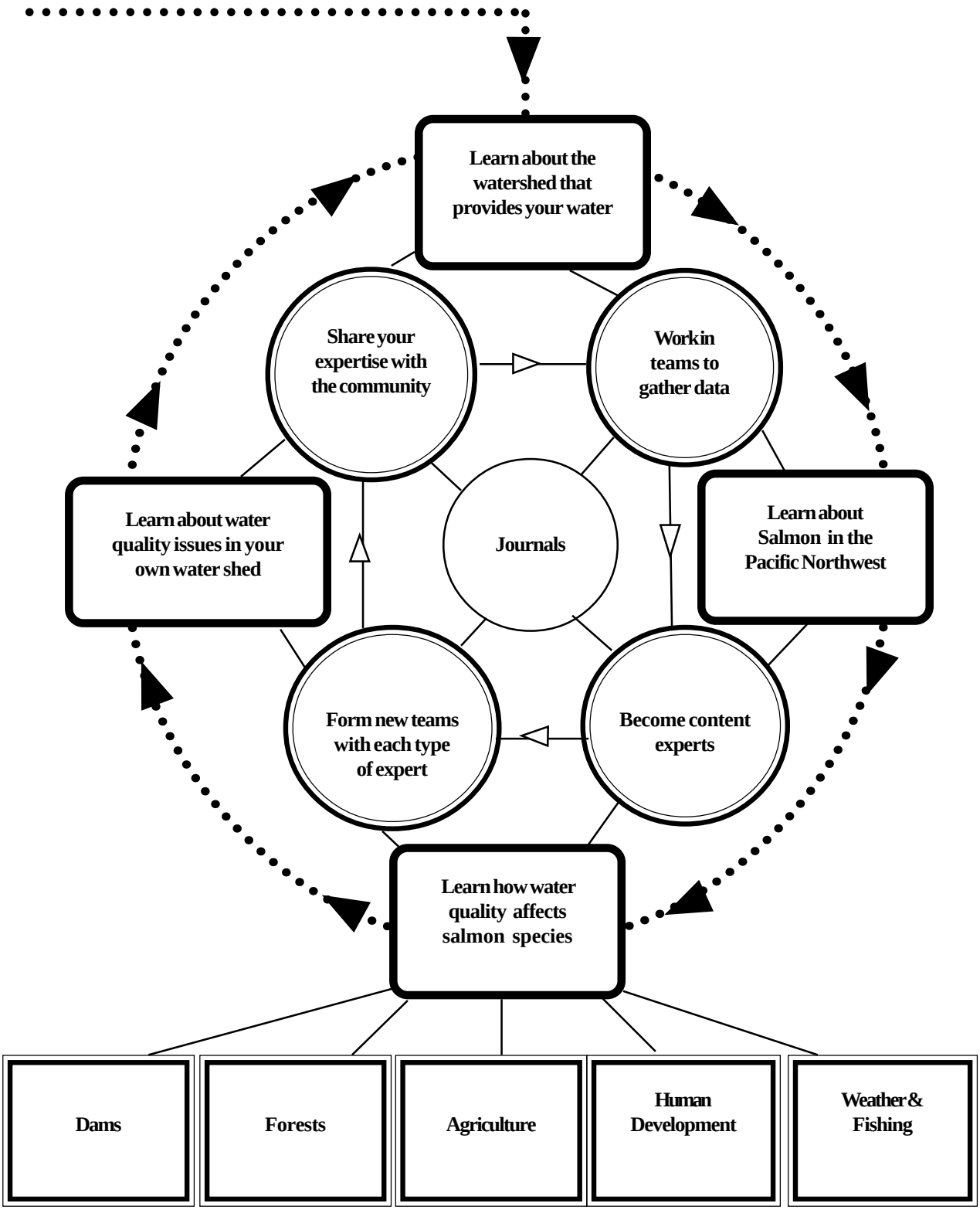
Have students watch the video: *Save the Salmon*. The video shows the journey of Salmon from the viewpoint of the fish. Students may notice that salmon swim against the current. After the video, engage students in a discussion about what they saw, listing any questions they have on the board. Since students will be conducting research about the life cycle of a variety of Salmon species, it is important that the teacher does not indicate students' ideas as correct or incorrect during the discussion. Tell students that they will have the opportunity to gather more information about salmon that may help them answer their questions.

Students with little experience at research will find it helpful to understand what is expected of them. Concept mapping can assist students in organizing information and making connections. A research framework for students is included in this section of the guide. You may use the framework to introduce students to the idea of concept mapping while also making them aware of what they will experience in the cycles of research and reflection ahead.

After introducing the idea of concept mapping to students, ask each group to create a concept map of reasons for the decline of salmon in the watersheds of the Pacific Northwest (they may need to review the video again). The students' maps may be very simple, and may not reflect all of the factors related to salmon decline. Students may need to modify their maps several times in order to construct a detailed understanding.

Once groups are finished, have groups share their maps with the whole class to create a map that includes each groups' ideas. Ask groups to modify their maps to include any new ideas from the other groups. Be sure to have students save their maps so that they can make changes as they learn more about salmon.

Common Water, Common Ground



Research Level 1: Salmon Life Cycle

Lesson Plans and Extensions

In order for students to make sense of their research into water quality issues, they will need to understand how scientists evaluate the health of a watershed. Every watershed is a habitat where many species live in balance, if all is well. Some species in a habitat are more sensitive to pollution than others. These species are called **indicator species** by scientists, as the health of these populations reveal much about the health of the watershed. In order for to students to think about water quality issues in their watershed, they will need to understand how organisms can indicate the health of a watershed.

Students can learn a lot about indicator species by researching efforts surrounding the conservation of many species of salmon indigenous to the Pacific Northwest. Salmon are sensitive creatures with a complex life cycle. Many of the challenges to survival faced by salmon are due to changes in the water quality of their habitat. In order to understand how these changes impact Salmon, students must learn about the different species of salmon, and how these species are specifically adapted, through their life cycle, to a particular watershed. As salmon move through their life cycle, human activity can impact salmon at key points in their development. Furthermore, salmon are sensitive organisms and cannot live outside of a narrow range of water quality indicators. Those who seek to save threatened salmon species must understand how the complex life cycle of salmon is affected by activities that affect water quality.

Students will learn about salmon as indicator species in order to think about factors that could impact the quality of the water, and the health of organisms, in their own watershed environments. Ultimately, students will need to identify the indicator species in the water shed that supplies their drinking water. In this section, students will learn about indicator species and water quality testing. One of the best ways to get this information to students is to ask a local expert to speak to the class. Many communities have organizations that test water quality, and members of these organizations are often willing to visit classrooms. The web bibliography in this guide is a great place to begin your search, or contact your local water board.

To install the CD-ROM on your Macintosh computers:

- **Insert the CD-ROM disk into the CD-ROM drive**
- **Use the mouse to double-click on the Set UP Common Waters icon**
- **The software will automatically be installed**
- **When installation is complete, restart your computer**

To launch the program, use the mouse to double-click the salmon icon on the desktop.

Teacher Lesson Plans: Research Level 1: Salmon Life Cycle

This lesson will take 2 class periods.

Day One:

Materials: CD-Rom Disks, students' concept maps, student's journals.

Install the CD-ROM disks on your computers before students arrive. Directions are included in this section for Macintosh and Windows installation. **To exit the CD-ROM program, select Help from the options menu, and then select Quit.**

Begin by asking students to look at the concept maps they created in the previous lesson. Ask them to think about anything that might be missing from their maps, and to think about any questions they may have about salmon and their watersheds. Give each group a few minutes to brainstorm and record their questions, and then have each group report to the whole class.

Assign each group to learn about a different salmon species and their lifecycle, using the CD-ROM on computers. Ask students to keep their questions in mind as they learn about the life cycle of the salmon and to take notes that will help them answer their questions and revise their concept maps. Tell students that they will also need information that will help them decide if salmon need to be protected by the Endangered Species Act. Information about the ESA is included on the CD-ROM, but this information can change due to changes in the status of species populations. For the most up to date information, use the internet to check Endangered Species listings.

When students have completed their research on the computer, ask them to revise their concept maps to include any new information about salmon and water quality. If they found information to answer their questions, have them write it in their journals.

Ask each research group to decide if the species they studied should be listed for protection by the Endangered Species Act. Groups should be prepared to explain their position: if they decide that a species should be protected, they must offer reasons to support their decision.

Alternatively, you may wish to jigsaw the groups (assign one member from each research team to a new group) to decide which, if any, of the salmon species should be listed for protection by the Endangered Species Act. Jigsaw groups can compare the status of the different species, and explain why some species may be better off than others.

To install the CD-ROM on your Windows 95 computers:

- **Insert the CD-ROM disk into the CD-ROM drive**
- **Use the mouse to click "Start" on the taskbar**
- **Click "Run..."**
- **In the dialog box type: D:\SETUP (or replace "D" with the letter of your CD-ROM drive, if different)**
- **Follow the on screen instructions**

To launch the program,-Click "Start" on the taskbar, select "Programs," select "Common Waters" and select "Salmon."

A great extension for this section would be a field trip to an aquarium, a fish hatchery or fish farm, or a natural history museum.

Your students can observe the life cycle of fish when you raise them in your classroom. Some fish are easy to breed in your classroom aquarium. Your public library will have information about how to set up and care for an aquarium, and what type of fish are easy to breed and maintain. Pet stores also provide information about which species of fish would be best for your students to care for and observe.

Day Two:
Materials: Information about indicator species and water quality testing, information about local indicator species, students' journals.

In this lesson, students will learn about indicator species and water quality testing. If you have invited a local expert to speak to the class, you may wish to provide this person with your focus questions in advance and then set up a "panel discussion" where your students ask the expert questions. In the process, the expert can share information about water quality testing and indicator species in your area. Have your students take notes. The guest may also be able to assist students in revising their concept maps.

Below is another way for you, or your guest speaker, to structure a discussion so that students can connect what they are learning about salmon as indicator species in the Pacific Northwest watersheds with the notion of indicator species in the watershed they have mapped.

Begin by asking students to look at the topographic maps that indicate the boundaries of the watershed that supplies their water. Ask students to think about what species live in their watershed that might be affected by the quality of the water. Give students a few minutes to brainstorm in groups and ask them to list as many different species as they can that might live in or around the water in the watershed. Have each group share their list with the whole class.

To install the CD-ROM on your Windows 3.1 computers:

- **Insert the CD-ROM disk into the CD-ROM drive**
- **From the file menu in the Program manager select "Run"**
- **Type: D:\SETUP (or replace "D" with the letter of your CD-ROM drive, if different)**
- **Follow the on screen instructions**
- **The installation program will create a "Common Waters" group in the Program Manager.**

To launch the program,- From the Program Manager, open the program group, select "Common Waters" and double-click on the Salmon icon.

Fast Write Process:
Fast writing is a process similar to free writing. In free writing, there are no rules except that students must write whatever comes to mind for a certain time interval. Students must continue to write until time is up even if they have to change their train of thought.

Fast writing is different from free-writing in that students must write on a topic or question for the selected time interval. Spelling, punctuation and grammar are not important (although appreciated). There are only two rules- what students write must have something to do with the topic or question, and they must write for a certain amount of time.

The fast write process can push students to dig for information, follow an idea, ponder questions or describe a scenario- although sometimes they may write *I don't have anything else to say and I still have 5 minutes to go...*

In any case the fast write process can push students to reveal what they understand, what they don't understand, the limits of their information, and their alternative conceptions. This information can assist teachers in making choices about instruction and sharing information.

After groups have shared their lists, engage the whole class in discussion about the salmon species they have been researching. Below are focus questions to get the discussion started:

• Do you think that the changes in salmon populations indicate any changes in the quality of the water in the Pacific Northwest watersheds?
• How does this happen?

Once students have reasoned about salmon, ask them:
• Which, if any, of the species on our list can give us information about our watershed?
• What could we find out?

Students may reason that some species are sensitive to pollution like salmon, but they may not know what species live in the watershed, and which ones are pollution intolerant. At this point you or your guest would share information with students about local water quality testing and local indicator species.

If a local expert is not available, students can conduct research using text materials or the internet. Depending on the location of your watershed, students may discover that many species of freshwater benthic macroinvertebrates (in other words, insects, mollusks and crustaceans that dwell at the bottom of streams, lakes and rivers) are excellent indicators of water quality.

Students will need to synthesize the information about salmon, indicator species, and water quality testing. For homework ask students to fast write for ten minutes in their journals about:

• Why are salmon, and other indicator species, important to a community?

Research Level 2 :
Become Experts in Reasons for Salmon Decline

Lesson Plans and Extensions

Communities care about water quality for many reasons- water is essential to life, and a watershed that supports a great diversity of life is a healthy watershed. Even though we care about water, many activities in which people engage have a negative impact on water quality. Run off from farms and roads put silt and motor oil in our waters, but we must eat and drive to school and home.

Federal, state and local laws have been passed that regulate anyone who discharges anything into a water way. In addition, everyone is prohibited from dumping certain substances anywhere at all- it is illegal to let even a small amount of motor oil spill on the ground. Yet laws and regulations can not resolve all water quality issues as people continue to develop more of the land.

Every community faces challenges and decisions about the means we use and extent to which we protect our water quality, and none of these decisions are simple or easy. When tough decisions must be faced, a problem solving model can help communities sort out factors and options to make the most informed decisions possible. Saving the salmon in the Pacific Northwest will require people to make changes. What changes would your students suggest?

In the following lessons students will use the CD-ROM program to conduct research about the many factors that contribute to the decline of salmon populations. A problem solving model is included in these plans to help your students organize and make sense of their research. Because these factors are embedded in different contexts, and each may have a different impact on salmon, research groups will complete the first steps in the model and then transform into jigsaw groups to complete the process and come up with a plan that could help save the salmon.

An activity that asks students to set priorities by budgeting a dollar will connect students to the reality of funding water quality efforts and reveal what they consider to be important.

Teacher Lesson Plans- Research Level 2: Reasons for Salmon Decline

These plans will take at least three class periods to complete.

Day one:
Materials: Information about problem solving model, CD-ROM program on computers.

Introduce a problem solving model to students. This section includes one model that you may use; it is suggested that you modify it as makes sense for your students.

It is important that students understand that they will use the model to help them come up with a plan to save the salmon species they decided should be protected under the Endangered Species Act.

Once you have introduced the problem solving model to your students, they will find out that they need to collect, organize and analyze information about what is happening to salmon, and what are the issues at stake for the people who live and work in the watersheds.

Assign each group a topic area to research. Students will use the Common Water, Common Ground CD-ROM and other resources to find out information they will need for the first three steps in the model. Specifically, students will need to find out:

- What human activities are causing problems for salmon species,
- Why those activities are causing problems,
- How those same activities serve people's needs,
- What can be changed, what are the options for doing things differently,
- What laws and regulations are already in place.

So you have 25 students and only 8 computers? Research rotations can give every student time on the computer.

Rotations can be structured to meet your needs. Arrange for students to use several different sources of information in groups. For example, while two groups use the CD-ROM program on the computers, two groups read articles about conservation efforts, and another group watches a video related to their research focus. The groups switch, after a certain amount of time, until each group has completed all of the activities.

How you structure the time will depend on your schedule and your students needs. If you have a long block of time, you may allow 30 minutes for each activity and students will complete three activities in one morning or afternoon. You may devote an entire class period to each rotation- three research activities would take 3 days for the class to complete.

Environmental Problem Solving Model:

When people have tough problems, it sometimes helps to have a problem solving model that allows the community to work together in steps toward solutions. Below are some steps you can use to come up with a plan to help save the salmon.

Step 1: Recognize the problem. If you don't know what the problems are, you cannot figure out how to solve them later. In this step you list the problem or problems that you want to solve. In this step, you also want to think about what is causing the problem.

Step 2: Decide what information you need. People often need more information to solve problems. If you think you know what is causing a problem, do you have evidence to support your ideas? What are the facts, and what are your assumptions? In this step you list what you know (facts and evidence), what you think might be true, but are not sure about (assumptions), and what questions you have about the problem. What information do you need in order to think of a plan to save salmon?

Step 3: Work together to collect and understand as much information as possible. Lots of information is available about salmon and water quality. Once you know what your questions and assumptions are, you can find out what others have learned about water quality issues. This information will help you to examine your assumptions, support your ideas, and better understand the problems so you can think about solutions that will work.

Step 4: Look at the problem from different perspectives. In order to really understand a situation, we need to understand how everyone is affected. In solving environmental problems, we must consider how we balance the impact we have on the environment with our needs as people. If everyone's perspective is considered, we have a better chance of finding solutions that will meet everyone's needs.

Step 5: Decide what your goals and options are. In order to come up with a plan, you must first decide what you can do. What can be changed? What are the options? What are the laws that apply to the situation and how does that affect what can be done? You probably cannot solve all of the problems at once, but you can choose something that can be done if you know what your options are.

Step 6: Develop and carry out your plan. Once you have decided what you can do, you must decide how you will accomplish your plan. Sometimes people need help from the entire community in order to carry out the plan. What will you plan to help save the salmon? Who will need to help? What will it cost?

You will learn a lot if you look back at how this process worked for your group. How did you work together? If you get to carry out your plans, did you accomplish your goals? Did your goals change as you learned new information?

Day Two:
Materials: Problem solving model, CD-ROM program on computers, students' journals, PNW water quality budget activity pages.

Have students use the computers and any text or video resources you have to continue to gather and analyze information on their research topic area. Have them make notes in their journals, and be sure to remind them that they will need their notes in order to share information in their jigsaw group later. If you have time, you may choose to give students more than one day for research. When students have some information, have them use it to work through the first three steps in the problem solving model.

Once students wrap up their research and first three steps of the problem solving model, have groups or individuals complete the budget activity included in this section. The page can be copied for students to use. This activity will be more meaningful to students if they are able to work with actual coins as they figure out their budget.

Tell students that they must also be able to defend their choices about the money should be spent. For example, students that conducted research in human development may decide to spend 25 cents on cleaning up industrial pollution, 25 cents on stopping air pollution, 25 cents on sustainable cities and 25 cents on community education about water quality issues. Students must explain why they think these would be good choices, and include information about what they think would be done with the funds.

Day Three (or at the end of their research):
Materials: Problem solving model, students' journals and notes.

Assign students to jigsaw groups by combining one student from each research group into a new group. Jigsaw groups will share information in order to come up with a plan to save salmon species, using steps 4, 5, and 6 of the problem solving model. Challenge your groups to consider the feasibility of their plans as they brainstorm options. Students may wish to use their concept mapping skills to document their group's plan. Have each group share their plans with the whole class.

For homework ask students to fast write in their journals about how their research and jigsaw teams worked together. What worked well? What was challenging? What changes would you make?

Pacific Northwest Water Quality Budget

It takes resources to improve water quality. Imagine that one dollar represents the money your group has to work with in order to improve water quality and save the salmon in the Pacific Northwest. How will you spend that dollar? Will you use all of the money for one big project, or do you think it would be best to spend it on several smaller projects? In the space below, use words, or make a chart or graph that shows how you think the money should be spent, and explain your reasons for each choice.

Research Level 3 : Bringing it Back Home

Lesson Plans and Extensions

Learning about water quality issues in other places can help students appreciate the complexity of water quality issues at home. In some areas the issues are similar to those in the Pacific Northwest, and in some areas the issues are somewhat different. In order for students to understand the water quality issues in their own watershed, they will need to find out what tests are conducted in their watershed, and what those tests reveal about the quality of the water.

Many options are available for students to find out about local water quality testing. If you have the time and resources, students can test the water quality in your watershed themselves. This takes quite a bit of time and preparation, although many resources exist that can assist your students in learning how to test water quality. Visiting a local stream or river and testing the water can deepen students understanding and appreciation of the complex factors that impact watersheds and influence the quality of the water upon which all life depends. Students enjoy the opportunity to get out in nature and test water quality, and because they are working in a real context, and looking for real problems, they are motivated to learn how water quality tests work, and what they reveal about the watershed.

A field trip to a local lake or river might be more that your classes can manage. Why not test the drinking water at school? How about bottled water? If you have access to a pond or river, bring in a sample of that water to compare to the tap and bottled water. Water testing kits can be obtained that make it simple to test water for a number of water quality indicators.

Information about the results of water testing in your watershed can be found on the “Surf your watershed” website. Even if your students conduct water quality tests, they will need to know what previous tests have determined about water quality in order to think about the issues and problems in the watershed. Many problems are revealed through trends over time, as water quality indicators decline.

Guest speakers and local water quality experts can make water quality issues real to your students. These people have a wealth of highly specialized knowledge- information about the history and issues of the water sheds in your area, information about local water quality indicators, and information about changes in your community that impact water quality. Invite them into your classroom, in person or through e-mail correspondence,

The same problem solving model students used to develop a plan to save the salmon can be used to help resolve water quality issues in their own watershed. Students cannot resolve water quality issues all by themselves, they will need to find ways to get others involved. Student presentations will demonstrate what students have learned about water quality, and can be structured to educate others in the community about water quality issues. Students can create a brochure, a radio or television program, or a web site to educate an audience about water quality issues.

Today it is easier that ever for your students to learn about water quality testing. Because many school groups are interested in monitoring local water quality, you will find a wealth options for testing water quality with your students. If you decide to take your students out in nature to test water quality in your local watershed, they will need to prepare in advance for the experience. A number of curricula have been developed to teach students about field testing for water quality. Several curricula are available through the Earth Force Global Rivers Environmental Education Network. This organization also provides affordable, nontoxic kits that contain everything you need to test your local water for many water quality indicators.

You can connect with the Earth Force website at: **www.earthforce.org** or E-mail them at: **green@earthforce.org** An address and phone number for this organization can be found in the bibliography of this guide.

The following activity can be used to test water quality in your classroom, either to prepare for a water testing field trip or to replace the field trip altogether. The materials for this activity can be obtained through Earth Force. Depending on your circumstances, you may choose to select a few tests for a large number of water samples, or to order kits that will allow students to perform 8 different tests on a smaller number of water samples.

Materials: Field Manual for Global Low Cost Water Quality Monitoring (or other field reference text- see bibliography), 1 or 2 Green Low-Cost Water monitoring kit(s) for each class, and at least three different water samples for each group (fresh water from nature, tap water and bottled water; or samples from others sources of your choice). If you choose to order single tests, be sure to include tests for: Dissolved oxygen/biological oxygen demand, nitrate, phosphate, pH, and coliform bacteria.

Assign each small group to conduct one test on each of the three samples of water. Have students record the results of each test. Once tests are complete, have students create a chart that compares the results of each test for the three samples. Ask students to explain what the results tell them about each type of water. What indicators are similar among the samples? What indicators are different? If students get results that seem unusual according to ranges listed in the field manual, have the group repeat the tests.

If you have more than one class, compare the results for each test across classes. This way students can come to appreciate that the results of some tests can vary widely, depending on the samples and test conditions. Other test results may not vary much among the samples.

Once students have analyzed and discussed the results of their tests, have them compare the results to the baseline data from local water quality tests. This data can be found on-line through the world wide web at: **www.epa.gov/surf2**

Teacher Lesson Plans- Research Level 3: Bringing it back home

The time these plans will take depends on how much time students spend on each activity. Adjust the time frame to suit your plans.

Day one:

Materials: Materials to test water quality or information about local water testing, students journal.

Have students find out about water quality testing in the watershed that provides their water. If possible, have students conduct tests on the water themselves and then use the internet to find out the results of local efforts to monitor water quality. Students may not be able to conduct every test themselves, since some require special resources. Students should be able to find information on the internet about the status of indicator species in their watershed (in some locations this is a water quality index rating based on sampling of macroinvertebrate populations). Students can also find out about dissolved oxygen levels, pH levels, turbidity, fecal coliform levels, and information about levels of toxic contaminants or heavy metals in the water.

Ask students to record information about the results of water quality tests in their journals.

Day two:

Materials: Student's journals and notes about water tests.

Ask students to work with their jigsaw groups to create a concept map of water quality issues in their watershed. Have each group share their map with the class and combine each groups' ideas into a "master map" created by the whole class.

Day three:

Materials: Problem solving model, "master concept map" of local water quality issues, students' journals and notes, local water quality budget activity pages.

Ask students to work in their jigsaw groups to apply the steps of the problem solving model to at least one of the water quality issues in the master concept map. Have students complete the budget activity as a group and include it in their plan.

Day four:

Tell students that their plan will need to include a way to share what they have learned about water quality issues in their watershed with others in the community. Students will need to select a goal, an audience, and a format for their presentations. Have students work together in their jigsaw groups to create their presentations.

Is there an organization working to implement a watershed plan in your area? If so, you have a valuable resource for helping your students can find out what it means to develop and implement a watershed plan. Most groups will be glad to share their plans with your students, and some groups my have educational materials that pertain specifically to your watershed. Ask if someone could come and speak to your students- many groups make education and public awareness of water quality issues a priority.

Local Water Quality Budget

It takes resources to improve water quality. Imagine that one dollar represents the money your group has to work with in order to improve water quality in your watershed. How will you spend that dollar? Will you use all of the money for one big project, or do you think it would be best to spend it on several smaller projects? In the space below, use words, or make a chart or graph that shows how you think the money should be spent, and explain your reasons for each choice.

Final Assessment : Student Presentations

Lesson Plans and Extensions

Assessment of student understanding is important and the plans in this guide provide many opportunities to assess what your students are learning as they create concept maps and apply a problem solving model to water quality issues. These types of assessment tend to be informal and give you plenty of opportunities to question students and provide them with feedback about their ideas. This type of informal assessment may be used to obtain grades along the way as students complete their assignments.

Final presentations by students will serve to focus their learning about water quality, help them to feel that they are creating solutions, and give you, classmates, and others in the community a chance to provide feedback about their ideas. Your assessment practices and strategies will depend on your circumstances and resources, but student presentations can provide a wealth of information about student understanding.

Presentations can take a variety of forms, limited only by your resources and your students' imaginations. How about a radio commercial? A investigative report for a television journal? A handbook on water quality that helps younger students learn how to conserve water resources? A web site with links to water quality and conservation information and organizations?

Whatever is chosen, criteria for evaluation must be clear to students. Present students with your criteria as they begin to plan their presentations. It is important for students' presentations to include information about each area of research (the impact of dams, forestry, agriculture, human development, weather and fishing) and how their plan addresses these areas (or does not address the research area and why). Students will also need to consider any laws and treaties that affect their plans and to include this information in their presentations.

Teacher Lesson Plans- Final Assessment: Student Presentations

The time these plans will take depends on how many groups will present information and how the information will be presented. Adjust the time frame according to your actual plans.

Day one:

Materials: Students' notes and journals and any other materials or equipment necessary for their presentations.

Have students share their presentations in what ever way makes sense for your classes. You may wish to invite local water quality experts, parents, or others in the school or community to attend.

Day two:

If you have a web site for your school or classroom, students can post information from their presentations on the web site to educate others in the community about water quality issues. If students have chosen to present information in a form that is not suitable for posting on the web (or if a web site is not available to your students), think about other ways that students can share their information with the community.

After students have shared their presentations, ask them to write an essay about water quality issues in their journals for homework. What are the important issues in their watershed? What will it take for the community to resolve these issues? What can each student do to help improve water quality?

Post Assessment:

Ask students to draw and/or describe what happens to a drop of water that falls as rain. This will give information about how students' thinking has changed since the pre-assessment.

Internet Resources

The World Wide Web is a fantastic resource for you and your students. URLs can be found on the CD-ROM program in addition to those on this page.

Surf your watershed: **www.epa.gov/surf2**

EPA Maps on Demand: **www.epa.gov/enviro/html/mod/index.html**
(This site is a source of GIS maps)

Environmental Protection Agency homepage: **www.epa.gov/**

EPA Office of Wetlands, Oceans, and Watersheds: **www.epa.gov/owowwtr1/**

EPA Non-point Source Pollution Control Program: **www.epa.gov/OWOW/NPS/**

EPA Browse by Topic: **www.epa.gov/epahome/browse.htm**

U. S. Fish and Wildlife homepage: **www.fws.gov**

U.S. Endangered Species List: **www.fws.gov/r9endspp.html**

World Wildlife Federation homepage: **www.panda.org**

Endangered Species Wetlands Report: **www.eswr.com**

List of water quality monitoring programs: **www.sfei.org/**

Natural Resources Conservation Service: **www.nrcs.usda.gov/**

Earth Force Global Rivers Environmental Education Network (Eathr Force GREEN):
www.earthforce.org

National Science Standards

Common Water, Common Ground helps students learn about water quality issues. These lessons address many of the National Science Standards. How the different sections of the curriculum address the Science Standards are outlined below.

Lessons about watersheds and the impact of human activity on water quality can address a number of Science Education Standards.

The National Science Education Standards, as recommended by the National Research Council, that apply to this section of the curriculum are: Unifying Concepts and Processes; Standard A- Science as Inquiry; Standard B- Physical Science; and Standard C- Life Sciences; Standard D- Earth Science; and Standard F- Science in Personal and Social Perspectives.

Unifying Concepts and Processes
Five Unifying Concepts and Processes are addressed by this curriculum.

1. Systems, Order and Organization- During this unit, students will learn that a watershed is a highly organized system of biological and chemical components that interact to maintain a dynamic equilibrium. The equilibrium in a watershed directly affects the health and biodiversity of the waterways that lie at the bottom of the watershed. This tension between factors that cause organization and disorder within this complex system ultimately determine the health of all of the organisms in the watershed. Water quality indicators such as: water temperature, pH, dissolved oxygen content, bacteria, and biodiversity of organisms will reflect the status of this balance. Because many substances, harmful to aquatic life-forms, enter rivers and waterways from point and non-point sources, the watershed as a whole system must be taken into consideration when thinking about the impact of human activity on water quality.

Students will also be asked to think about the impact of certain human choices on the quality of water in watersheds around their community, and beyond their community. Students will learn that all watersheds are connected by the water that flows from the continental divide to the oceans. Global water quality can be affected by the choices students make locally because, ultimately, we all live downstream.

2. Evidence, Models, and Explanation- Students will be required to conduct research to gather information about the watershed surrounding the source of their drinking water, and the factors that can impact the water's quality. The research will be used to identify the boundaries of the watershed and, in the extended lesson, to create a model of the watershed. This research will also assist students in understanding and explaining the numerous and varied opportunities for substances to end up in the waterways that flow through the low points of the watershed. Students will be required to explain: the physical features of the watershed; what substances might enter the water as it drains through the watershed; where the substances might enter the water, both from point and non point sources; how the substances could affect the quality of the water that drains through the watershed.

3. Constancy, Change and Measurement- Students will learn that a watershed is a dynamic system that changes over time and in response to the action of water, among many factors, as it flows through the system. Students will learn that some aspects of the watershed change constantly in small increments, but that the physical laws that describe the behavior of water do not change. Water continually changes the shape of the landforms in a watershed in small ways, but water always behaves in predictable ways in response to those changes; it always runs downhill and seeks it own level. Furthermore, a watershed is defined by the flow of water as it drains from the surrounding land into the waterway located along the lowest points in the watershed. Sometimes the waterway is located underground, sometimes it is located at the surface of the land.

Students will learn that when certain substances enter water, they change the quality of water in a variety of ways. Some substances (motor oil, pesticides) directly affect the chemical composition of the water, and may prove difficult (or impossible) to remove from the water by normal methods of purification. Other substances do not affect the chemical composition of the water and change the quality of water indirectly (organic material increases the amount of bacteria living in the water by providing the microorganisms with additional food). These substances are easier to remove from water through normal purification methods. Some substances (such as dirt and silt from plowed fields, or eroded land areas) entering the water can change the watershed in drastic ways, but do not pose much of a problem for water purification.

Measurement is a key concept in this unit. Students will need to use mathematical skills to identify the boundaries of the watershed and/or create the watershed model. Vertical and horizontal relationships and scale, and making accurate metric measurements are important mathematical concepts developed in this unit.

4. Evolution and Equilibrium- Equilibrium is an important concept in understand watersheds. Equilibrium in the watershed is affected by natural conditions and human activities within the watershed. A delicate balance between the amount and quality of the water flowing through the watershed, and the plants, animals, oxygen, temperature, nutrients and bacteria exist in every healthy watershed. Students will learn that a certain balance, or equilibrium, is necessary to support a wide variety of life in a watershed, and that the variety of life in the watershed is an indication of the quality of the water that comes from the waterways at the bottom of the watershed.

5. Form and Function- Students will learn that the shape of the land determines the way that water will flow through the watershed. As water changes the shape of the land, the watershed boundaries will shift, but the form of the land defines the course that water will take as it runs downhill in response to gravity. The forms of the land determine the organization of the waterways in a watershed system.

Science Education Standard A- Science as Inquiry

Science as inquiry is an important aspect of this unit, and a determining principle in the organization and selection of students' activities. The activities in this unit will develop students' ability to conduct inquiry and help them build understandings that they will need in order to conduct further scientific inquiry in the subsequent curriculum.

The unit addresses the inquiry standards as specified below.

1. Identify questions and concepts that guide scientific research- In any study of the natural environment, the questions that guide research must be grounded in the features of the natural

environment under study. Students must identify those features of the environment that impact their investigations. Before students can investigate the impact of human activities on the organisms that live in an aquatic environment, they must first identify the limits and features of the environment. The concept of watershed provides an important foundation for students' further investigations about the relationship between water quality and the health of organisms in a water habitat.

2. Design and conduct scientific investigations- This unit is organized around research conducted by students to identify the watershed that is the source of their drinking water, and to identify factors that can affect water quality in a watershed. During the course of the unit, students will be asked to use data in the form of topographic maps, apply logic to the analysis of the maps, and outline or construct a model of the watershed based on the maps. Students will be asked to conduct research into ways that human choices and activities impact water quality, and to explain where those activities might take place in the watershed.

3. Formulate and revise scientific explanations and models using logic and evidence- Students will need to organize and display their data about the watershed. They will need to use the data about the watershed as evidence for their explanations about activities that can affect water quality in the watershed. The unit will result in the creation of a conceptual, and if extended, physical model of a watershed.

Students' explanations about the impact of natural conditions and human activities on the watershed may be revised as students' understanding develops through their investigations into the relationship between water quality and the status of organisms in a water habitat, in the subsequent curriculum.

4. Communicate and defend a scientific argument- In this unit students will be required to develop and follow a procedure for communicating information about a watershed. Students will be required to give an explanation of the concept of watershed orally and with a visual representation. Students will be asked to defend their predictions about the impact of human activities on a watershed based on their explanations and visual representation or physical model.

5. Understandings about scientific inquiry- Through the activities in this unit, students will inquire about how a watershed system functions. The activities will allow students to develop conceptual understandings that will guide later inquiries. Scientific knowledge about watershed systems will influence the design and interpretations of students' subsequent inquiries into the relationship between the status of organisms in a water habitat and water quality.

Students will need to apply mathematical principles as a part of their inquiry into the concept of watersheds. Students will need to use math skills to understand the data on the topographic maps and to create the visual representation or physical model of the watershed. The models and explanations must be logically consistent, and abide by the rules of evidence as provided by the data on the maps.

Standard B- Physical Sciences
As a result of their activities in this unit, students will develop an understanding of the nature of chemical reactions, motions and forces, and conservation of energy and the increase in disorder in a watershed. The unit addresses these standards as specified below.

1. Chemical Reactions- Chemical reactions can have a profound impact on water quality in a watershed. Many human activities provide opportunities for chemical reactions to occur in a watershed, some with disastrous consequences.

2. Motions and forces- Gravitation is the force that compels water to run downhill. Students will learn that gravity is the most important force with regard to the behavior of flowing water, and that gravity causes water to continuously flow through and between watersheds.

3. Conservation of energy and the increase in disorder- As water changes the features of a watershed, matter and energy are conserved. As human activities release substances into the environment, those substances are not destroyed, but are dispersed into the watershed and carried in the water as it flows, ultimately, to the ocean. Substances that disperse as molecules or very small particles (chemicals, oil) will be able to contaminate (or affect the order of) watersheds far from the original source. Substances that disperse as relatively large particles (dirt, silt) are more likely drop out of the water and tend not to affect watersheds very far beyond the point of entry.

Standard C- Life Sciences
As a result of their activities in this unit, students will develop an understanding of interdependence of organisms; and matter, energy, and organization in living systems. The unit addresses these standards as specified below.

1. Interdependence of organisms- The atoms and molecules in a watershed cycle among the living and nonliving components of the watershed. Water flows in one direction in a watershed- down. Everything that gets in the water from above flows down with the water, and affects the quality of the water to a greater or lesser extent. Human beings live with in the world's watersheds. Increasingly, humans affect the quality of the water in a watershed as a result of population growth, technology, consumption, and uninformed choices. The impact of human activities threatens the stability of many watershed systems, and if not addressed, watersheds will be irreversibly affected.

2. Matter, energy and organization in living systems- The distribution and abundance of organisms and populations in a watershed system are limited by the ability of the watershed to recycle materials. When natural conditions or human activities place materials in the watershed that are beyond the limits of what can be recycled, water quality suffers. This is particularly true of organic matter, and organic chemicals released into the watershed.

Standard D- Earth Science
As a result of their activities in this unit, students will develop understandings about energy in the earth system, geochemical cycles, and the evolution of the earth system. The unit addresses these standards as specified below.

1. Energy in the earth system- Gravity is a major source of energy in a watershed. It is the energy that causes water to flow through the system.

2. Geochemical cycles- Water is one of the most abundant and important chemical compounds on earth. Reservoirs of this chemical exist is the ocean, seas, lakes, rivers and their tributaries, ground watertable, and atmosphere. A watershed defines the boundaries and the direction of f flow of these important chemical reservoirs on earth. Movement of water and other matter between these reservoirs is driven by the earth's gravitational and energy and weather systems.

3. The evolution of the earth system- Interactions between the solid earth, fresh water reservoirs, atmosphere and organisms in a watershed result in the ongoing evolution of the watershed. We can observe some of the changes on a relatively brief time scale (erosion of land that has been disturbed), but many processes take place over much longer periods of time (a shift in the course of a river).

Standard F- Science in Personal and Social Perspectives

As a result of their activities in this unit, students will develop understandings about Natural Resources, Environmental Quality, Natural and Human-Induced Hazards, and Science and Technology in Local, National and Global Challenges. The unit addresses these standards as specified below.

1. Natural Resources- Students will learn that human populations use water and other natural resources in order to maintain and improve their existence. All water used by human populations comes to us through a given watershed. Human populations depend on a particular watershed in order to have water for many purposes. Students will learn that human populations can place severe stress on a watershed through the consumption of water, and through the disposal of waste water and pollutants. A watershed has limited potential for renewing water resources, and a limited ability to neutralize pollution as it enters the watershed.

2. Environmental Quality - Students will learn that watersheds are natural ecosystems and provide an array of basic processes that affect humans. Natural processes within watersheds are vital to the renewal of water resources through the hydrological cycle. Natural processes within watersheds are vital to the recycling of nutrients. The disposal of waste, especially waste water, can greatly impact the health of a watershed and the quality of the water that flows through the watershed. Materials from human societies can affect the natural cycles within a watershed. These changes may be detrimental to both humans and other organisms that depend on the quality of water in a watershed.

3. Natural and Human-Induced Hazards - Students will learn that human activity can cause changes in a watershed. These changes can be slow and progressive, yet still result in tremendous problems within a watershed. Some of the changes in a watershed can bring benefits to human society, but involve risks to the watershed. Benefits and risks can be assessed to some extent, yet scientists and engineers may not always be able to accurately predict the impact of human activity upon a watershed.
4. Science and Technology in Local, National and Global Challenges - Students will learn that people must make informed decisions about activities that affect watersheds. In order to know what activities will be harmful to a given watershed, an understanding of the basic concepts and principles of science should precede debate about the economics or politics of human activities. Human activity can have a major effect on other species within a watershed. Human activity can also have a major effect on the quality of the water that flows through a watershed, and so impact the quality of the water that is necessary to human life. Human activity within a watershed can result in changes to the chemical composition of the water that flows through the watershed. Some of these changes are difficult or impossible to reverse, and may continue to impact water quality within a watershed for generations.

Study of the life cycle of salmon can address a number of National Science Education Standards. How these standards apply to this curriculum are detailed below.

The National Science Education Standards, as recommended by the National Research Council, that apply to this curriculum are: Unifying Concepts and Processes, and Standard C- Life Sciences.

Unifying Concepts and Processes
Five Unifying Concepts and Processes are addressed by this lesson. Specifically these are:

1. Systems, Order and Organization- During this lesson, students will learn that salmon are complex organisms and, as such, demonstrate an ordered, organized system. The life cycle of salmon is a complex system with definite boundaries (salmon have specific needs regarding temperature, dissolved oxygen, and food requirements), components (salmon move through a number of very different habitats during their life cycle), resource flow (salmon ultimately give back everything they take from their habitats to nourish the next generation of salmon) and feedback (salmon endure many natural transitions to complete the cycle of their life, including a change from fresh to salt water that requires a period of adjustment in an estuary before they are able to swim out to sea. Furthermore, current theories about salmon hold that the fish rely on subtle electromagnetic feedback from the environment to locate their original spawning grounds).

2. Evidence, Models, and Explanation- Students will be required to conduct research to gather information (observations and data collected by field scientists) about the life cycle of the salmon. They will use this information to create a conceptual model of the life cycle of the salmon This model will be useful explanation that will assist students in understanding the challenges faced by salmon in adapting to a changing environment.

3. Constancy, Change and Measurement- The life cycle of salmon is an excellent study of constancy within change. Salmon endure numerous changes in their life cycle. Yet these changes always occur in the exact same order for each generation of any particular salmon species. The dangers and difficulties naturally experienced by individual salmon result in a stronger species. Salmon are both prey and predator throughout their life cycle. Their life cycle consists of an arduous journey through far flung habitats that always ends at the same place it began. The life cycle of salmon demonstrates a pattern wherein matter and energy are transferred and changed. Ultimately the sum of this matter and energy remain the same as the salmon return all they have taken from the environment to their original spawning grounds ensuring the continuation of their species.

4. Evolution and Equilibrium- In this curriculum, students will learn that some modern salmon species are over two million years old, yet the fossil record shows that salmon have existed on this planet for some fifty million years, changing dramatically over time. Modern salmon have adapted to different watershed habitats, known as runs, such that the salmon in each run is considered to be a different race within its broader species. This is because salmon species must return to their original spawning grounds through the same path that they departed. If a salmon is taken from its run, it will become confused, easy prey for larger predators.

It is believed that salmon run to the sea because ancient salmon species evolved in a fresh water habitat that was periodically covered by glaciers. The ice cover forced the salmon out into the ocean. When the ice retreated, the salmon returned to the freshwaters of their birth.

Salmon are able to change so much in just a few generations that geneticists favor them for studies in mutation and adaptation. It is possible that the incredible changes that Salmon naturally experience during the course of their life cycle have evolved them to be not only hardy, but mutable as well.

Equilibrium is an important concept in the life cycle of salmon. Salmon have evolved to require certain watershed conditions, especially with regard to temperature, dissolved oxygen, and water quality. Current changes in many salmon runs are stretching the limits of these highly mutable species.

5. Form and Function- In this lesson, students will learn that the form of an individual salmon changes dramatically over the course of its life. These changes are a reflection of how a salmon must function in different environments at different points in the life cycle. Salmon eggs become tiny fish called alevin. Alevin hide among the gravel and consume a yolk sac that remains from to egg to nourish them through this period. The function of the salmon at this point relies on its form- the tiny salmon needs to be able to hide from predators while growing large enough to become a predator itself. The form of the alevin yolk sac facilitates this function.

Male salmon transform dramatically during the return to their spawning grounds. Some grow fearsome looking fangs that help them compete with other males for the privilege of fertilizing the eggs of females. This form facilitates the male salmons' function in this point of the life cycle. As camouflage against predators, all members of many salmon species change dramatically in appearance during the return to their spawning grounds.

Standard C- Life Sciences
As a result of their activities in this lesson, students will develop an understanding of biological evolution; interdependence of organisms; and behavior of organisms. The lesson addresses these standards as specified below.

1. Biological evolution- the evolution and adaptations of the salmon are inexorably connected to the life cycle of the salmon. To answer questions concerning the life cycle, students must gather evidence about the conditions in which salmon species have adapted and evolved. (See Unifying Concepts Standard 4, above, for a more detailed discussion of this life science standard.)

2. Interdependence of organisms- Salmon species have the potential to produce populations of infinite size, but many factors naturally limit the size of any salmon species. Salmon are both predator and prey at every stage in their life cycle. Furthermore, many organisms depend on the decaying remains of spawned out salmon, including the next generation of salmon. In order to answer questions concerning the life cycle of salmon, students must gather evidence about the interdependence of organisms that are both predator and prey to salmon. Students must also learn about reasons many salmon species die after spawning.

3. Behavior of organisms- Salmon have nervous systems that generate behavior. In order to answer questions and formulate explanations and models about the life cycle of Salmon, students must gather evidence about the nervous systems of Salmon and its relationship to Salmon behavior. Many theories about the means salmon use to locate their runs and return to their spawning grounds have to do with their nervous system. Salmon have very sensitive sense organs based on specialized cells

that detect light, sound, and specific chemicals that enable them to monitor what is going on in the environment around them. Salmon possess an acute sense of smell; they are able to detect one part in one trillion. Other, less understood, attributes of their nervous system may enable salmon to detect subtle changes in the electromagnetic fields of their run. All of these factors may be involved in the mysterious ability of salmon to return home.

Lessons about water quality testing can address a number of Science Education Standards. How these standards apply to this curriculum are detailed below.

The National Science Education Standards ,as recommended by the National Research Council, that apply to this curriculum are: Unifying Concepts and Processes; Standard A- Science as Inquiry; Standard B- Physical Science; and Standard C- Life Sciences.

Unifying Concepts and Processes
Four Unifying Concepts and Processes are addressed by the lessons in this section. Specifically these are:

1. Systems, Order and Organization- During this lesson, students will learn that water quality monitoring makes use of a highly organized system of chemical and observational tests to arrive at an overall picture of a river's health and biodiversity. This complex system measures definite boundaries (a specific water habitat), components (tests measure water temperature, pH, dissolved oxygen content, organic pollutants, inorganic pollutants, toxic pollutants, bacteria, and biodiversity), resource flow (many substances both necessary and harmful to aquatic life enter and leave rivers through a number of physical and biological mechanisms, and from point and non-point sources) and feedback (the results of some tests will inform the results of other tests; an example of this is: A decrease in the diversity of a river's benthic macroinvertebrates can explained by low levels of dissolved oxygen in that river. If levels of dissolved oxygen are normal, other factors in river system must be tested to determine the cause of the decline).

2. Evidence, Models, and Explanation- Students will be required to conduct research to gather information about the tests scientists use to monitor water quality. The results of these tests supply evidence about the quality of a water habitat. Students will learn what the tests measure, how they work, what scientific principles inform the tests, what the test results tell us about the quality of a water habitat, and how aquatic life forms respond to changes in the variables measured by the tests.

3. Constancy, Change and Measurement- Inferences drawn from the results of many water quality tests rely on observing patterns in nature to determine normal fluctuations in the habitat as measured by the tests. A range of results will occur depending on the variable being measured and natural changes in the physical and biological characteristics of the habitat (examples of this type of test are: dissolved oxygen, temperature, and biodiversity of benthic macroinvertebrates). Baseline data must be collected over a period of time to determine what are normal ranges in a habitat. Field scientists compare the results of any given test to the baseline data to determine if the result indicates a problem or is reflective of natural fluctuations in the habitat. The results of these tests often show that matter and energy are transferred, changed, and recycled in somewhat predictable patterns over time in a healthy water habitat. Ultimately, in a healthy habitat, the sum of this matter and energy remain the same.

On the other hand, some tests measure variables wherein any significant change is indicative of a problem (examples are the tests for toxic pollutants). When the results of this type of test indicate a problem, other tests can begin to indicate results out of normal ranges.

In order to realize what it means to monitor water quality, students must understand that constancy for certain water quality indicators is represented by a range of values while constancy in other indicators is represented by an absolute value.

Measurement is a key concept in this curriculum. Each water quality test uses a different type of measurement tool and results are quantified in different types of units. Some tests indicate precise results, others generate indices from representative samples. Students will learn the units of measure used to quantify and interpret results, and make inferences about the impact on Salmon and other aquatic life forms of changes that may be indicated by water quality tests.

4. Evolution and Equilibrium- Equilibrium is an important concept in water quality monitoring. Equilibrium in the habitat is the condition being monitored by most water quality tests. A delicate balance between plants, animals, oxygen, temperature, nutrients and bacteria exist in every healthy habitat. Monitoring these factors gives information about the balance, or equilibrium, necessary to support a wide variety of life in a habitat.

Salmon have evolved to require certain watershed conditions, especially with regard to temperature, dissolved oxygen, and other water quality indicators. Current changes in some Salmon runs are such that many species who have evolved in a particular habitat are unable to adapt to new conditions and are now threatened or extinct.

Science Education Standard A- Science as Inquiry

This curriculum is organized around research conducted by students to create a plan for improving water quality in the Pacific Northwest, and in their own watershed. Initially students will be asked to gather evidence, apply logic, and propose an explanation about how changes in water quality indicators impact Salmon species. These explanations may need to be revised and/or extended in order to formulate a model that will allow students to understand factors in a healthy habitat and how those factors can change to upset the balance of all life in the habitat.

Students will need to recognize and analyze alternative explanations and models because many water quality indicators have a variety of options available with regard to principles, tools, and units of measurement. Students will need to decide which testing devices should be preferred according to scientific, or other types of practical, criteria.

Students will be required to explain water quality tests are conducted in their watershed, what those tests reveal about the watershed, and formulate a plan for improving water quality in their area.

Standard B- Physical Sciences
As a result of their activities, students will develop an understanding of structure and properties of matter; chemical reactions; and conservation of energy and the increase in disorder. The lesson addresses these standards as specified below.

1. Structure and properties of matter- In order to understand the scientific principles behind water quality tests, students must learn that the properties of water reflect the nature of the interactions among its molecules , which are determined by the structure of the water molecule. Students must also learn about the nature of dissolved gasses and the impact of changes in temperature on the physical state and the saturation point of dissolved oxygen in water.

2. Chemical reactions- Many water quality tests depend on chemical reactions to produce results. Water reacts with many every day trash items to produce metal oxidation, which can become inorganic pollution. pH is a factor measured by water quality tests to determine the acidity of the water. Many organisms, including Salmon, cannot tolerate ph above or below a certain range. Students will need to possess some understanding of chemical reactions in order to explain these water quality tests.

3. Conservation of energy and the increase in disorder- In order to explain a number of water quality tests, students must understand that energy is transferred in a river system, but it is not created or destroyed. The many interactions in a Salmon run result in a decrease in order in physical systems. Energy from the sun and the actions of many life forms result in an offsetting increase in order in the system. This is why a healthy water habitat must achieve a state of dynamic equilibrium that supports a wide variety of life forms to make use of solar energy and recycle decomposing material.

Standard C- Life Sciences
As a result of their activities in this lesson, students will develop an understanding of biological evolution; interdependence of organisms; and matter, energy, and organization in living systems. The lesson addresses these standards as specified below.

1. Biological evolution- the evolution and adaptations of the Salmon are inexorably connected to the conditions found in the Salmon's habitat. To answer questions concerning the impact of changes in these conditions on Salmon, students must gather evidence about the conditions in which Salmon species have adapted and evolved. (See Unifying Concepts Standard 4, above, for a more detailed discussion of this life science standard.)

Benthic macroinvertebrate diversity testing is based on a system that classifies these animals into categories based on their ability to tolerate different types of pollution. Although this is different from taxonomical classification, this classification reflects the ability of some species to adapt to a wide range of conditions while others are unable to adapt and, therefore, die.

2. Interdependence of organisms- Salmon species have the potential to produce populations of infinite size, but many factors naturally limit the size of any Salmon species. Many of these factors are monitored by water quality testing. Furthermore, many factors are interrelated such that one change in the habitat can cause a change in several conditions that are monitored. In order to formulate a plan to monitor the quality of a water habitat, students must gather evidence about the

interdependence between organisms and the physical characteristics of the habitat. Students must understand how oxygen, carbon, and energy flow from photosynthetic organisms to herbivores to carnivores to decomposers in a Salmon run.

3. Matter, energy, and organization in living systems - In order to formulate a plan to improve the quality of a water habitat, students must realize that living systems require a continuous input of energy to maintain their physical and chemical organizations. This energy ultimately derives from the sun and is brought into water habitats through photosynthesis. Photosynthesis is also responsible, in part, for the input of dissolved oxygen into a water habitat. High levels of dissolved oxygen are necessary to maintain a wide diversity of water life and are essential to the survival of Salmon.

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