# Fourth to Sixth Grade River Morphology Unit

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## Unit Overview

The purpose of this unit is to help students develop a conceptual understanding of river morphology. They will look at natural processes (such as the water cycle and flooding) and human uses of the river riparian areas to discover how these interact to modify the stream's composition, channel and aquatic habits. The students' understandings will develop through peer discussions to uncover the essential job of a stream. These discussions will follow hands-on activities which allow students to observe and demonstrate the nature of water flow and deposition. The unit concludes with a reading lesson where students learn about the tribes' restoration efforts. They determine that the river has the capacity to heal itself following a natural process of restoration, but man can make riparian management changes to initiate this opportunity. This reading will spark interest and allows them to generate testable questions they will use to build inquiry investigations. Ultimately this unit has students conduct field studies on riparian zones, river systems, and channel habitats. It prepares them to make critical future decisions for riparian stewardship.

## Unit Objectives and Benchmarks and Standards Addressed

Through the completion of this unit students will:

1. Measure and calculate the area of the school ground. (MT Science *Standard* 1 *Benchmark* 2)
2. Measure the volume and weight of annual rain fall. (MT Science *Standard* 1 *Benchmark* 2)
3. Describe how land use affects groundwater. (MT Science *Standard* 4 *Benchmark* 2)
4. Draw three sites located on a river and compare their features. (MT Science *Standard* 4 *Benchmark* 1)
5. Measure the streams' physical characteristics. (MT Science *Standard* 4 *Benchmark* 2; *Standard* 1 *Benchmark* 2)
6. Graph substrate data. (MT Science *Standard* 1 *Benchmark* 3)
7. Explore how a stream balances sediment and discharge. (MT Science *Standard* 4 *Benchmark* 1; *Standard* 4 *Benchmark* 4)
8. Describe a balanced river channel. (MT Science *Standard* 4 *Benchmark* 1; *Standard* 4 *Benchmark* 4)
9. Make predictions and inferences for an article on river restoration. (MT Science *Standard* 1 *Benchmark* 1)
10. Generate science questions in response to reading about local efforts of stream restoration. (MT Science *Standard* 1 *Benchmark* 1)

## Time/Scheduling

Approximately six class periods will be needed including at least two hours at the river location.

## Resources/materials

- Field journals and pencils
- Meter tape measure

- Local rainfall data
- Project Wild aquatic education activity guide (optional)
- six, one-gallon buckets
- Sand mixture
- Rulers
- six balances
- five pitchers for water
- Paper towels
- Stream table
- June 29, 2005 Missoulian article: "River Gets a Makeover" (Appendix A)
- Sentence strips (Appendix B)

## Lesson #1 - Where does water run off after school

### Summary of the Lesson

Following a unit on the water cycle, this lesson will extend the students' understanding of the relationship between groundwater, runoff, and aquatic habitats. This will create a sound learning progression and allow students to build upon prior knowledge as they start this unit on stream morphology. This lesson is adapted from a Project Wild Aquatic activity.

### Grade Level

4-6th grade

### Approximate time required

One class period

### Unit Objectives and Benchmarks and Standards Addressed

1. Students will measure and calculate the area of the school ground; the volume and weight of annual rain fall. (MT Science *Standard* 1 *Benchmark* 2)
2. Students will describe how land use affects the ground water and runoff between their school and the nearest aquatic habitat. (MT Science *Standard* 4 *Benchmark* 2)

### Resources/materials

- Field journals and pencils
- Meter tape measure
- Local rainfall data
- Project Wild Aquatic education activity guide http://www.dlfaquifer.org/search?q=Salish+Indians
- Shandin Pete's master thesis on the Jocko watershed http://etd.lib.umt.edu/theses/browse/by_author/p.html

### Teacher Preparation

Gather materials and read background information. The Project Wild activity guide will provide more background on sources of pollution if this is your learning objective.

### Background information

Access to a local stream makes this lesson culturally competent. The students will identify local land use patterns and relate family stories representing cultural use of the river. Talk to the students about local and historic rainfall and flooding patterns. Your may want to review Shandin Pete's master thesis to give students an overview of this Confederated Salish and Kootenai tribal member's study on the groundwater of the Jocko River. He gives a nice profile

of the historic geologic record of the Jocko river, and his study compares the conditions of the river from the flood levees of the 1950's to the restoration started in 2002. The summative assessment section in this unit gives more cultural information.

Rainfall is one way water re-enters aquatic habitats. Once rain falls upon a surface, water begins to move both laterally outward (taking the path of least resistance) and vertically downward. Lateral movement is runoff and finds its way into streams, rivers, and lakes. Vertical movement seeps down into the soil and porous rock and recharges groundwater supplies.

**Procedure**

1. Engage in a discussion with the class. Ask students the following questions:
   - Explain how groundwater, rain, and the river are connected.
   - Recall any stories from their parents or grandparents on floods of the past.
   - About how much rain do you think it takes to create a flood?
   - How much rain do we get in a year?
   - Where does rain go once it falls?
   - What season do we get the most rain?
   - What other factors influence flooding?
   - How does the ground water come into play?
2. Inform the students that we need a measurement of the playground in order to calculate how much water falls onto our school grounds and recharges the groundwater as it makes it way to the river.
3. Take students out onto the playground with tape measures. Have them run the tape around the perimeter of the school grounds. Use these measurements to get an average width and length to estimate the area of the playground. Explain we are trying to get a workable approximation and that they will need to problem solve how to handle areas that are not part of a rectangular path. Have them write down the measurements to take back into the classroom.
4. Have on hand, your area's annual rainfall as reported by the local television station's weather bureau. For example the annual precipitation in Missoula is 17.04 inches (1.42 ft). Rainfall in this area is fairly evenly distributed throughout the year, but the wettest month is May with an average of 2.38 inches.
5. Help calculate the volume of water our playground produces each year. For example:

| | |
|---|---|
| Playground measures: | 50,000 square feet |
| Annual rain fall: | x 1.42 feet |
| Volume of rain: | 71,000 cubic feet of rain |

6. Next calculate the weight of the rain. Water weighs 62.5 pounds per cubic foot. For example:

   71,000 x 62.5 = 4,437,500 pounds of rain annually.
   This is equivalent to 2,219 tons (when divided by 2,000).

7. This amount is calculated to impress upon the students the remarkable volumes and weights of water moving through the water cycle. A rough equivalent for this weight could be 2,000 bison, but you can also have kids find a different association. Even short periods of rainfall produce amazing amounts of water. Ask them if all this rain eventually finds its way to the aquatic habitat next to the school grounds and what other hydrologic cycle processes explains what happens to the rain.

**Formative Assessment**

Each team generates measurements of the school grounds of workable approximations. **Criteria:** As each group reports the width and length, write the measurements on the board. All groups must be within 20 feet of the correct measurement for each the width and length to earn an "A", 30 feet for a "B" 40 feet for a "C" and 50 feet for a "D".

**Summative Assessment**

Students will create a land use map for their playground that is adjacent to the riparian habitat. This map must show the different types of land usage and disturbances. This map will help students visualize how water flows from higher to lower elevations in a watershed. **Criteria:** The map should include and label: any home sites, business, or industry between their school and the stream; areas where the land had been disturbed. (for example: pavement, gravel, pasture, lawn, roadways, etc.)

Once they have made the map, have them write a paragraph addressing how land use affects runoff and the ground water entering the stream. Some possible answers might discuss the following: that there is more runoff from roadways, grass areas utilize much of the water before allowing vertical movement into porous rock; pavement prevents precipitation from entering the ground water; and the buildings pump ground water from a well which potentially impacts the nearby water source.

**Further cultural information:**
Before assigning this, have students relate family stories on how the river, riparian zone, and the land between the school and the river was used in the past and how it is utilized now. Another point to emphasize is that any waterway can be observed as a multiple use area; humans along with the flora and fauna of the riparian zone are interconnected. Some local examples are:

- Stories telling how there was once a horse race track located on the north edge of Arlee where the housing village is now.
- There were celebration powwow grounds located on both sides of the river.
- Just upstream from the school was a common gathering place. When the weather turned hot, many people would go there to stay cool. They would leave to do chores at home and return in the heat of the day.
- You can also find physical evidence of old dump sites, sweat lodges and family camp sites.
- The following website has photos of Salish encampments: http://www.dlfaquifer.org/search?q=Salish+Indians Curtis, Edward S., 1868-1952, creator, photographer. Library of Congress Digitized Historical Collections: Curtis (Edward S.) Collection (Photographs)

## Lesson #2 - Know your stream

### Summary of the Lesson

Students will monitor the physical characteristics of their stream. They are introduced to the six physical monitoring parameters and will practice using them. These measurements will help them understand basic hydrology and changes in the watershed over time.

### Grade Level

4-6th grade

### Approximate time required

Two class periods

### Unit Objectives and Benchmarks and Standards Addressed

1. Students will locate the three selected stream monitoring sites on a map and on the ground using a GPS. (MT Science *Standard* 1 *Benchmark* 2)
2. Students will sketch the three stream sites to compare their physical characteristics and utilize the visual survey protocol. (MT Science *Standard* 4 *Benchmark* 1)
3. Students will measure the streams' substrate size, temperature, turbidity, stream flow, and cross section. (MT Science *Standard* 4 *Benchmark* 2; *Standard* 1 *Benchmark* 2)
4. Students will accurately communicate their findings by generating graphs of their data. Benchmark addressed: (MT Science *Standard* 1 *Benchmark* 3)

### Resources/materials

- Montana watercourse volunteer water monitoring training guidebook and data sheets
- electronic copy at www.mtwatercourse.org
- six, one-gallon buckets
- Field journals
- clip board and pencils
- 100 foot tape measure
- Yard stick
- four flags to mark sites
- Tennis ball
- Twine or rope
- Stop watch
- Turbidity tube or transparency
- Waders
- GPS unit
- Topographic map of river area
- Emergency back pack with first aid kit and phone numbers

## Teacher Preparation

Review the section in the "Montana watercourse guidebook" on how to use measurement protocols for the physical characteristics of streams (Page 38-44). Gather and organize all materials needed for field work. Make sure to have emergency contact information for all students going on the outdoor learning experience.

## Background information

Access to a local stream makes this lesson culturally competent. The Jocko River is located entirely on the Flathead Indian Reservation, and because of this has the added cultural components of historical tribal uses, and contemporary river restoration and stewardship techniques. The students will observe the restoration area and notice how the river system compares to areas up and down stream. The CSKT Natural Resource Department can provide more background information about their restoration plans and process. CSKT also have aerial photos showing the historic stream channels of the Jocko River, how it has changed over time, and how it has been restored to closely match the historic footprint and flood plain. Review the field trip safety tips and procedures in the Montana Watercourse guidebook.

## Procedure

**Engage** (day 1)

1. Prior to the field trip, get the landowners permission to collect substrate material (rocks, gravel) to bring back to the classroom. In this case it would be the Tribal Natural Resource Department. The gathered substrate will be used to explore the stream's sediment size and the composition of the sediment in this lesson and in the next lesson to explore the balance of water and sediment.
2. Locate the river on the topographic map and discuss the plan to take measurements of the river's physical features. Introduce students to the measurement protocols and assign groups for doing the field work.
3. Prepare students for the field trip. Demonstrate how to sketch the stream and aquatic habitat. Use photos to show examples of channel shapes, point bars, riffles, pools, rip rap, and woody debris. Explain how they will be graded on accurately including and labeling these features.

**Exploration** (day 2)

1. The class then travels to a local river.
2. Locate on the GPS the first site to observe and make observations discussed in the classroom prior to departure.
3. Students will record the latitude and longitude of three locations (including the location from step #2). Using the visual survey protocol (from the Montana watercourse guidebook), have students draw the river at these three different sites along the river.
4. Make sure that each group, at each station, measures temperature, turbidity, velocity, and draws the stream's cross section accurately.
5. Have students collect samples of substrate at all three locations.

**Explanation** (day 3)

1. In the classroom, after the field trip, the gathered substrate is measured. Demonstrate the protocol for measuring a rock from the guidebook on page 43.
2. Have each group work on their rock samples and then collaboratively compile a large graph on the board. Save the substrate for follow up lessons.
3. Field notes and drawings are used to compare and contrast the three sites on the river. Model this discussion on the board by having one student draw an area of the stream on the board. What characteristics of the stream were different at each location? What did the river do that was the same at each location?

**Elaboration** (day 3 continued)

1. Have the students consider the type of size of substrate in the Jocko River. Ask the following probing questions:
   - What would have to change in our aquarium's substrate in order for it to be more similar to the natural stream?
   - How could the aquarium substrate ever be adequate to support trout spawning?
   - What other factors would we need to consider to create a habitat suitable for trout spawning?
2. Collect data from each group and decide which data to graph to allow comparisons between the sites. Graphing tips are on p. 65-67 of watercourse guidebook. Use the guidebook to reemphasize the importance and purpose of monitoring each physical characteristic of a stream.

**Formative Assessment**

During the field trip, the students will make illustrations that compare three locations on the river. **Criteria:** sketches will include accurate channel shape, riffles, pools, point bars, wetlands, rip rap, woody debris, vegetation and landscape features

**Summative Assessment**

This assessment will include their statements in their science journals on how these locations on the river are similar and different based upon our discussions and illustrations.

## Lesson #3 - How balanced is a river

### Summary of the Lesson

Students will use the substrate gathered at a local stream to explore balance between the stream's sediment load and its discharged water.

### Grade Level

4-6th grade

### Approximate time required

Two class periods

### Unit Objectives and Benchmarks and Standards Addressed

1. Students will explore how to balance sediment and discharge. (MT Science *Standard* 4 *Benchmark* 1)
2. Students will describe a balanced river channel. (MT Science *Standard* 4 *Benchmark* 4)

### Resources/materials

- Six balance scales
- Pitchers of water
- Paper towels
- Stream table
- Sand mixture

### Teacher Preparation

Gather materials and read the background information section of this lesson.

### Background information

Lane's Balance is a model for determining the equilibrium or balance of a river channel. This model determines if the stream's slope and its discharged water are in balance with its sediment load as it affects the amount of sediment deposition, erosion, and flooding.

Stream channels are formed by the flow of water and the load of sediment they carry. The amount of water and sediment moving through a watershed depends on climate and geology.

Impacts of climate and geology:
-Amount of rain and snow, and timing of runoff
-rate of evaporation
-rate of ground water recharge as related to aquifer depth

-stream bank material
-type of vegetation
-rate of erosion
-sedimentation potential
-permeability and porosity of soils
-how quickly bedrock weathers to soil
-water chemistry and biological productivity

Accessing and utilizing a local stream makes this lesson culturally competent. The Jocko River has the added cultural components of historic and contemporary tribal use, contemporary river restoration, and stewardship techniques. This lesson is of particular use for discussing restoration efforts and strategies to create a balanced stream.

## Procedure

### Engage

1. Post the student learning target and read it to the students. "I can describe a balanced river channel."
2. Ask students to list their prior knowledge about: What does it mean when something is balanced? What are the parts of a river system? What can change in a river channel to disrupt balance? (Remind them that aquariums in our classrooms can help them think about streams in nature.)
3. Among the listed parts of a river system, which ones could change or be changed to cause an unbalance? Brainstorm how climate and geology impacts the type of sediment moving through a watershed.
4. Demonstrate the use of a balance scale, including calibration and accuracy. Tell the students we will use a balance scale to create a model for balance. We will use rocks (sediment) to practice making balancing the scale.
5. Students will next place the gathered substrate on a balance scale to create equal weight distribution on the scale. Rearrange the rocks several times. Have them work in partners and make sure everyone has a chance to try balancing the scale using the rocks.

### Explore

1. Give them water and tell them that water is called "discharge," in a river system. Students will be given time to explore how to balance water with sediment using the balance scale. Tell them: Once you have reached a balance, add more water and adjust the rock side to regain balance. Next add more sediment then readjust the water side. Which side is easier to adjust to create a balance on the scale? In nature which would be easier to adjust to balance a stream? Students are modeling balance by using aspects of the stream to create equal distribution of stream material. The misconception may be to think of a stream as a simple rather than complex system.
2. This activity doesn't take very long, so encourage students to create an imbalance that requires adding sediment or water to balance the scale a few times to justify their thinking.
3. Students will use the stream table to explore what happens when the sediment remains constant while the discharge increases, then what happens when the discharge remains constant, while the sediment increases.

**Explain**

1. Review the learning target. They should now be able to explain that a balanced river channel is one that has balanced amounts of substrate and discharge. Ask the following question and discuss: What happens to a river if there is not a balance between its substrate and discharge?
2. Go go over the list of impacts to a balanced river as described in the background section of this lesson plan.
3. Have the students generate examples of several geological and climate impacts.

**Elaborate**

1. Set up stream tables and ask students to use them to demonstrate how a stream's energy moves water and carries sediment through a watershed. Encourage them to investigate the interaction of variables, like volume of water, substrate, slope, etc.
2. Have students make predictions about outcomes and formulate hypotheses afterward from their findings.

**Formative Assessment**

Teacher writes the responses to the questions from the engage part of the lesson on a chart. Students write responses to questions in the exploration phase in their journals.

**Summative Assessment**

Following the explain part of the lesson, have the students choose two impacts to describe what happens in nature to a stream. Then have them write a description of a balanced river channel.
**Criteria:** Student can accurately explain two of the impacts.

## Lesson #4 - The restoration story of the Jocko River

### Summary of the Lesson

Students will prepare for future investigations in riparian habitats by reviewing what is happening at a local restoration area. They read about the restoration process and generate questions of interest for future inquiry investigations.

### Grade Level

4-6th grade

### Approximate time required

One class period

### Unit Objectives and Benchmarks and Standards Addressed

1. Students will draw on background knowledge to make predictions and inferences related to a newspaper article on river restoration. (MT Science *Standard* 1 *Benchmark* 1; MT Reading *Standard* 1 *Benchmark* 1)
2. Students will generate science questions in response to reading about local efforts of stream restoration. (MT Science *Standard* 1 *Benchmark* 1; MT Reading *Standard* 1 *Benchmark* 1)

### Resources/materials

- June 29, 2005 Missoulian article: "River Gets a Makeover" (Appendix A)
- Cut sentence strips (Appendix B)

### Teacher Preparation

Download the article from the Internet. You may rewrite the article to meet the reading level of your students. Make sentence strips by typing out phrases from the article that give insight into important points. You will need half as many phrases as you have students: two students will have the same phrase.

### Background information

In 2004, the Confederated Salish and Kootenai Tribes restored a section of the Jocko River. They hope their efforts will help lead to the return of the large migratory bull trout that once used this stream. The newspaper article used in this lesson will introduce students to the concept of river restoration and bull trout habitat. The article discusses how much of the Jocko doesn't need this much help.

Accessing and utilizing a local stream makes this lesson culturally competent. The Jocko River has the added cultural components of historic and contemporary tribal uses, contemporary river

restoration and stewardship techniques. The article references how a historic flood event in 1948 and aerial maps from the 1930's were used by tribal scientists to make restoration decisions. This lesson is of particular use for discussing restoration efforts to create a healthy stream. The section chosen for restoration was one of the most disturbed.

## Procedure

1. Pass out the sentence strips. Have students mingle around the room sharing their phrases with others. Students will discuss what they think the article might be about as they read the phrases to each other.
2. In small groups of 4-5 students discuss what they presume the article is about. Write these predictions down.
3. Then a student from each group reports to the whole group how they reached their predictions.
4. Each student reads the article individually. Students will highlight where they recognize the phrases used for the group work.
5. Reread and generate a list of questions the article causes them to wonder about.
6. As a class group give examples of the questions generated by reading the article.

## Formative Assessment

Student-generated questions can be reviewed for misconceptions or areas of interest. This information can help guide further instruction.

The teacher writes the questions from article on a chart and reviews them to determine an essential question for investigation. For example: Will the bull trout return to the Jocko River? This type of question can be posed to help students think of what we need to know in order to answer this question. Write down some ideas of research to develop background knowledge on. When students come up with questions that can be investigated, help turn them into a question for future scientific inquiry to be conducted in the field.

## Summative Assessment

Following a guided practice for developing an investigable question, the students are required to write a question of their own. **Criteria:** Interview each student to determine proficiency. An advanced student can discuss how their question could be answered by describing a possible investigation. A proficient student can determine that the question is not testable, but can with some prompting turn it into one that can be tested. A novice student generates a question that is not testable or has great difficulty even when prompted to recognize the difference between an investigable question and one that cannot be answered by investigation.

**Appendix A – Missoulian Article**

*Missoulian - Western Montana's News Online*

# Jocko River gets a makeover

By PERRY BACKUS of the *Missoulian*

ARLEE - The Confederated Salish and Kootenai Tribes want migrating bull trout to slow down, take a look around and maybe settle in for a long stay in the Jocko River near Arlee. And they're in the process of making some major improvements to the local accommodations.

The tribes are in the middle of a multi-year project to restore a short section of river just outside town as part of a larger plan to improve habitat and water quality along the 22-mile stretch of the Jocko from Arlee down to the Clark Fork River. Over time, they hope the efforts will help lead to the return of the large bull trout that once migrated from the far reaches of the Clark Fork drainage.

On Tuesday, experts on an intensive river restoration effort near Arlee gathered along the Jocko to talk about the effort with members of the Flathead Reservation Fish and Wildlife Board. The 9,000-foot "demonstration reach" is within a short walk of town. Following a huge flood in 1948 that threatened the town, residents of the valley shored up the river's banks. Over the years, the channel was straightened and dikes were built to protect nearby structures. Along the way, the river lost the characteristics bull trout need to survive.

Last year, the tribes started work to change that. Using funds obtained through a 1998 settlement with the Atlantic Richfield Co., with a financial assist from the Environmental Protection Agency and the U.S. Fish and Wildlife Service, officials started an ambitious project to change the course of a river. Using aerial maps from the 1930s, they found the old riverbed that wound its way back and forth across the valley. The plan called for rebuilding that old riverbed and encouraging the water to take a different route.

The first year, the tribes focused on the first 4,000 feet. Last summer, they fired up excavators and other heavy equipment and went to work creating floodplains and rebuilding the riverbed. Using river-building skills developed over decades, they built meanders, installed strategic log jams and planted thousands of new trees, bushes and sedges. When they were finished, they'd raised the riverbed up somewhere between 3 and 4 feet.

And then the rains came this spring. On the first weekend of June, everyone held their breath as a 10-year flood swept down over all their hard work. As it turned out, there was no need to worry. The flood left behind a smattering of stumps, driftwood and other debris, but no significant damage to the new riverbed.

"We'd normally like to wait for a few years to allow vegetation to take hold on the floodplain areas, but it didn't work out that way this time around," said Les Evarts, the tribal fisheries program manager. "We were all certainly gratified to see how well this worked."

Just downstream from phase one was a different story. The section of the river slated for the next bit of work was a mess. Riverbanks had fallen away. Huge pine trees lay scattered about.

A 200-foot section of a dike near the Jocko River Trout Hatchery was simply gone. "It just unraveled," said Evarts. "It doesn't take a rocket scientist to know that amount of erosion is going to have some serious impacts downstream."

If he had his choice, Evarts would just as soon take a hands-off approach to river restoration. He's seen what nature can do if given a chance. "Rivers are very resilient," he said.

The riparian area along the river has bounced back in places where management changes have provided an opportunity. But where man's work has left a lasting scar, nature can only do so much. The section of river near Arlee is a good example.
"This is one of the most disturbed sections along the river. It's very erosive and it would probably take generations for it to repair itself," said Evarts. "Most of the Jocko doesn't need this much help. What we've had to do here is very heavy handed."

And very expensive. Evarts says the first phase may cost somewhere close to $1 million. "This isn't a standard stream job," he said "We're testing a lot of different techniques here. The Arco settlement requires that this work translate into more riparian habitat. One-third, maybe as much as half of the cost, is for revegetation.

"It's a big price tag, but it's a demonstration project and we want it to shine," said Evarts.

There's still a lot to learn, and Evarts said the river will surely teach them a trick or two. "We make a lot of good guesses and maybe we get it right," he said. "Hopefully our guesses are good enough to get it started in the right direction."

Reporter Perry Backus can be reached at 523-5259 or at pbackus@missoulian.com

## Appendix B - Sentence strips

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over the years, the channel was straightened

dikes were built to protect nearby structures

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project to change the course of a river

the old riverbed that wound its way back and forth

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