Objective:

Students will understand the difference between turbulent (rough, fast) and laminar (smooth, slow) flow in liquid substances. Students will understand these two types of flow in terms of rivers.

Background information:

Laminar flow: flow of a fluid that is smooth, slow, and does not mix with itself
Turbulent flow: flow of a fluid that is rough, fast, mixes together, and is characterized by eddies, rapids, etc.

Liquids can flow in two different ways. (I will use water as an example of a liquid throughout this lesson). Sometimes water flows without any disturbance from its environment or itself. This happens, for example, when a slow stream of water is released from a kitchen tap. If water flows slowly and is not disturbed, its flow is called laminar. From a tap, water does not rush against itself (water remains translucent), and the air surrounding it does not disturb the stream. (see Fig 1). Laminar flow does not happen naturally very often because the conditions for its existence are not often available. More often in nature, we witness turbulent flow. Turbulent flow occurs when water moves quickly and runs into many rough obstacles. Using the previous example, turbulent flow will occur if the water is released very quickly from the faucet, and will remain turbulent as the water hits the bottom of the sink and splashes around. The water rushes against itself as well as its rough surroundings, the sink. (see Fig.1).
We can see turbulent and somewhat laminar flow in rivers. As water rushes against itself as well as against the river bottom and banks, we can see features such as ripples, waves, rapids, and eddies. These features are a result of the rough objects the water pushes against. Over time, the water will erode these rough surfaces. A river that was once very turbulent will slowly work its way toward laminar flow. Note that the smoother flow of water in the river is not perfectly laminar, but simply more laminar than the turbulent rapids. Here is a video that highlights both kinds of flow found in a river. https://www.youtube.com/watch?v=LXsNZ-ZL3f88

The following page explores laminar vs. turbulent flow from a more in-depth scientific perspective:
Alignments to Utah’s Core Curriculum:

6th grade: Standard 4, Objective 3
7th grade: Standard 2, Objective 1
8th grade: Standard 1, Objective 3; Standard 4, Objective 4

Materials:

- 2 cookie sheets
- modeling clay or poster tack
- dirt, rocks, sticks, grass, or other natural items
- 1 gallon of water or a hose
- plastic tub for water capture (or perform demonstration outside)
- Observation notebook

Procedure:

1. Before class, prepare your 2 cookie sheets. The first sheet will remain as it is: nothing more than a smooth cookie sheet (no cookie crumbs allowed!). The second will be decorated with many natural objects to serve as obstructions and features in a riverbed. Using modeling clay or poster tack, attach many natural objects to the surface of the cookie sheet. Make it as dirty and natural as you like!
2. Instruct the class of the differences between laminar and turbulent flow. Provide definitions and begin a discussion about flow in rivers.
3. First demonstrate laminar flow. Hold the empty cookie sheet at a downward angle into the plastic tub (or the ground, if you’re outside). Slowly pour water over the cookie sheet. Ask students to tell you what they see, and have them explain their thought processes.
   - Is there any turbulence?
   - Is this perfectly laminar?
   - Why is this flow laminar?
4. Second, demonstrate turbulent flow by holding the second cookie sheet at a downward angle into the tub (or ground). Quickly pour water over the second sheet. Ask the students what they see now, and require explanation.
   - Is the water flowing smoothly?
   - Did some of your features fall off and slide away with the water?
   - Was there splashing?
   - Why is this flow turbulent?

5. Explain that the cookie sheet is like the riverbed. One river bed has been eroded and produces smooth flow (cookie sheet 1), and another river bed is filled with natural obstacles and produces turbulent flow (cookie sheet 2).

6. Show the class the video of the river (see Background Information). Ask them to point out the parts of the river that are more turbulent, and the parts that are more laminar.
   - Can they explain why the surface of the river is smoother in some places than others?

7. Take students outside to a nearby stream, river, canal, or other flowing water feature. Ask them to observe the river very closely and write down their observations in notebooks.
   - Where is the river turbulent? Where is it more laminar?
   - What sound does turbulent water make compared to the sound of laminar water?
   - How is the color of turbulent water different than the color of laminar water?
   - What shapes do the different flows make?

8. In their observation notebooks, ask them to draw the outline of the riverbanks and any river features (rocks, fallen trees, bushes) for as far as they can see. Ask them to imagine sending a tennis ball down the river. Starting upstream, have them draw a path that the ball might take down the river, drawing straight lines through laminar parts and squiggly lines through turbulent parts. Ask them to draw several of these paths, starting at different parts of the upstream cross-section. Once they are done, they should have a map of flow lines for that section of river!
An example of river flow lines. http://www.oakton.edu/user/4/billtong/eas100lab/rivrprof.gif

Discussion:
Ask students the following questions, and probe them to explain their reasoning. Ask students to make predictions about the following questions. Then look to the activity extension to find the answers!

How do you think your flow lines will change in the next month? Year? 10 years?
Why does turbulent flow cause erosion?
Why does turbulent flow produce more sound than laminar flow?

If the river were filled with maple syrup instead of water, how would the flow you observed change? What effect would the maple syrup have on the river bed?

How do you think river turbulence affects fish and other animals that live in the river?
Rocks and trees can create turbulence in rivers, but what else can create turbulence in water? Are these bad things?

Activity Extension:
Ask students to do some research to answer any questions they may have. The following links will be helpful to them (and you!) in solving the problem!


Lesson plan created by Lexie Wilson, School Programs