Teacher Copy, Level 2 Name____________________

DATA Nugget

Float Down the Kalamazoo River

Featured scientist: Leila Desotelle from Michigan State University

Research Background:

Ever since she was a kid, rivers have fascinated Leila. One of her hobbies is to kayak and canoe down the Kalamazoo River in Michigan, near where she lives. For her work, she researches all the living things in the river and how humans affect them. She is especially interested in changes in the river food web, caused by humans building dams along the river, and an oil spill in 2010.

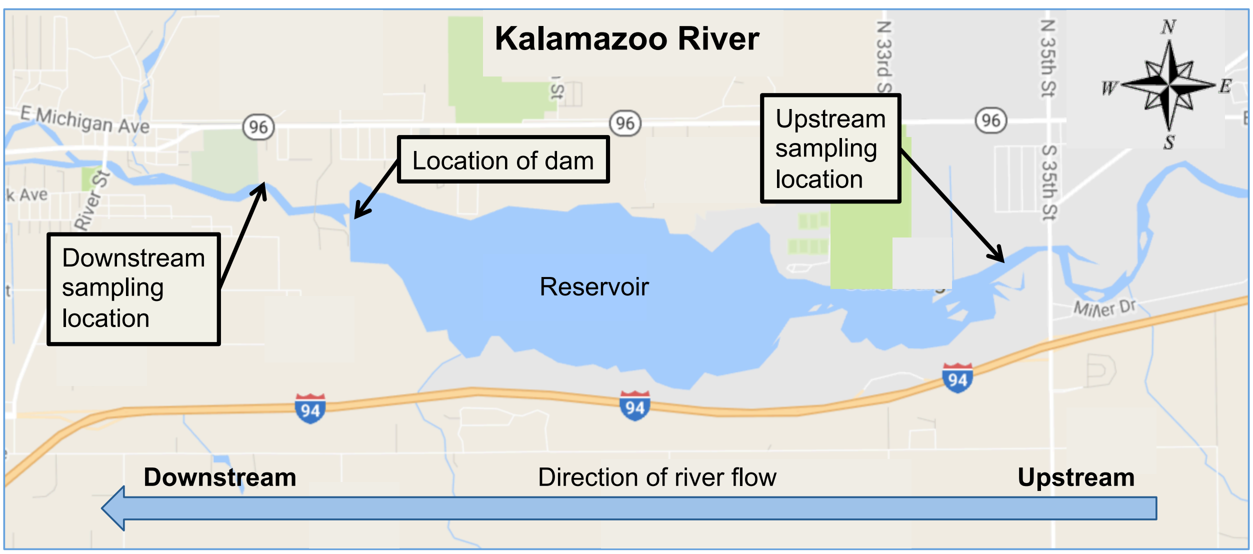
Leila showing off some of the cool invertebrates that can be found in the Kalamazoo River.

Leila knows there is a lot more in river water than what meets the eye! As the river flows, it picks up bits of dead plants, single-celled algae, and other living and nonliving particles from the bottom of the river. The mix of all these particles is called **total suspended solids (TSS)** because these particles are suspended in the river water as it flows. The food web in the Kalamazoo River depends on the particles that are floating in the water. Invertebrates eat decomposing leaves and algae, and fish eat the invertebrates.

A reservoir created by a dam along the Kalamazoo River. When water flows into the reservoir it slows, potentially letting some of the total suspended solids settle to the bottom.

As you float down the river, particles settle to the river bottom and new ones are picked up. The amount of suspended solids in a river is influenced by how fast the water in the river is flowing. The faster the water flows, the more particles are picked up and carried down the river. The slower the water flows, the more particles will settle to the bottom. **Discharge** is a measure of how fast water is flowing. You can think about discharge as the number of cubes (one foot on each side) filled with water that pass by a point every second. During certain times of the year, water flows faster and there is more discharge. In spring, when the snow starts melting, a lot of water drains from the land into the river. There also tends to be a lot more rain in the fall. Things humans build on the river can also affect discharge. For example, we build dams to generate hydroelectric power by capturing the energy from flowing water. Dams slow the flow of river water, and therefore they may cause some of the suspended solids to settle out of the water and onto the bottom of the river.

Leila wanted to test how a dam that was built on the Kalamazoo River influenced total suspended solids. If the dam is reducing the amount of total suspended solids, it could have negative effects on the food chain. She was also curious to see if the dam has different effects depending on the time of year. On eight different days from May to October in 2009, Leila measured total suspended solids at two locations along river. She collected water samples upstream of the dam, before the water enters the reservoir, and samples downstream after the water has been in the reservoir and passed over the dam. She also measured discharge downstream of the dam.



Scientific Questions: (1) How does the dam influence the amount of total suspended solids present in the river water? (2) Does this effect differ depending on time of year?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Check for Understanding: After reading the introduction, students should be able to:

- Define total suspended solids (TSS), and provide abiotic and biotic examples.
- Describe why suspended solids are important to the river ecosystem and food web.
- Explain the concept of discharge, including how it is measured. What is the relationship between discharge and the speed that water is flowing?
- Explain factors that might cause discharge to vary during different times of the year. For example, snow melt, rain events, drought, etc.
- Explain how discharge affects total suspended solids. The higher the discharge, the faster the water is flowing and the more particles the river water will pick up.
- Describe how dams affect water flow. Upstream of the dam water would be flowing quickly, but slow down as it entered the reservoir created by the dam. Downstream of the dam, water would be flowing more slowly. What does this mean for our predictions about total suspended solids above and below the dam? On the map, students can draw their predictions for where they think water will be moving quickly, discharge will be high, and TSS will be high.
- Understand that water in a river flows from the upstream source to downstream. For the Kalamazoo River, water flows from east to west and empties into Lake Michigan.

Scientific Data:

Use the data below to answer the scientific questions:

Date	**Day of Year**	**TSS** (mg/L) **Upstream of Dam**	**TSS** (mg/L) **Downstream of Dam**	**Discharge** (cubic feet/ second) **Downstream of Dam**
15-May	135	8.3	11.5	972
10-Jun	161	9.6	4.9	1850
30-Jun	181	16.7	8.5	923
15-Jul	196	14.0	8.3	971
30-Jul	211	9.9	18.3	681
15-Aug	227	5.9	17.0	593
30-Aug	242	7.7	13.9	800
30-Oct	272	2.7	4.3	956

Average	9.4	10.8	968.3
Standard Deviation	4.4	5.3	383.8
Standard Error	1.6	1.9	135.7

** Standard deviation (SD) tells us about the amount of variation in the data. A large SD means there is a lot of variation around the mean, while a small SD means the values all fall very close to the mean. Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and the SD. A large SE means we are not very confident, while a small SE means we are more confident.*

Teacher Note – Error Bars: You can have students add error bars to their graphs to deepen this discussion or remove SE or SD from the table for younger students. Error bars based on standard deviation (SD) give us information on the amount of variation in the data. They can be used to draw attention to large or small amounts of variation around the mean. Standard error (SE) is the SD divided by the square root of the study's sample size (SE=SD/√n). Unlike SD, SE reflects the uncertainty in our estimate of the mean. The larger our sample size and the less variation in the data, the more confident we can be in our estimate of the mean. Upper error bars are calculated by adding one SE or SD to the mean, and lower bars are calculated by subtracting one SE or SD from the mean.

Teacher Note: Ask students to consider which variables found in the table would best answer the research questions. The data on discharge is not necessary to address either scientific question; it is there to challenge students to identify the data that helps answer the question and support their claims.

- For the first research question, the location of the stream should be the independent variable because Leila wanted to study the river before and after the dam. The average total suspended solids, therefore, should be the dependent variable.
- For the second research question, the day of the year and location in the river (upstream or downstream of the reservoir) should be the independent variable and the total suspended solids should be the dependent variable. This shows how the TSS changed over the year.

What data will you graph to answer question 1?

Independent Variable: Location in the river (upstream or downstream of dam)

Dependent Variable: Average total suspended solids (TSS) (mg/L)

What data will you graph to answer question 2?

Independent Variable: Day of year and location in the river (upstream or downstream of dam)

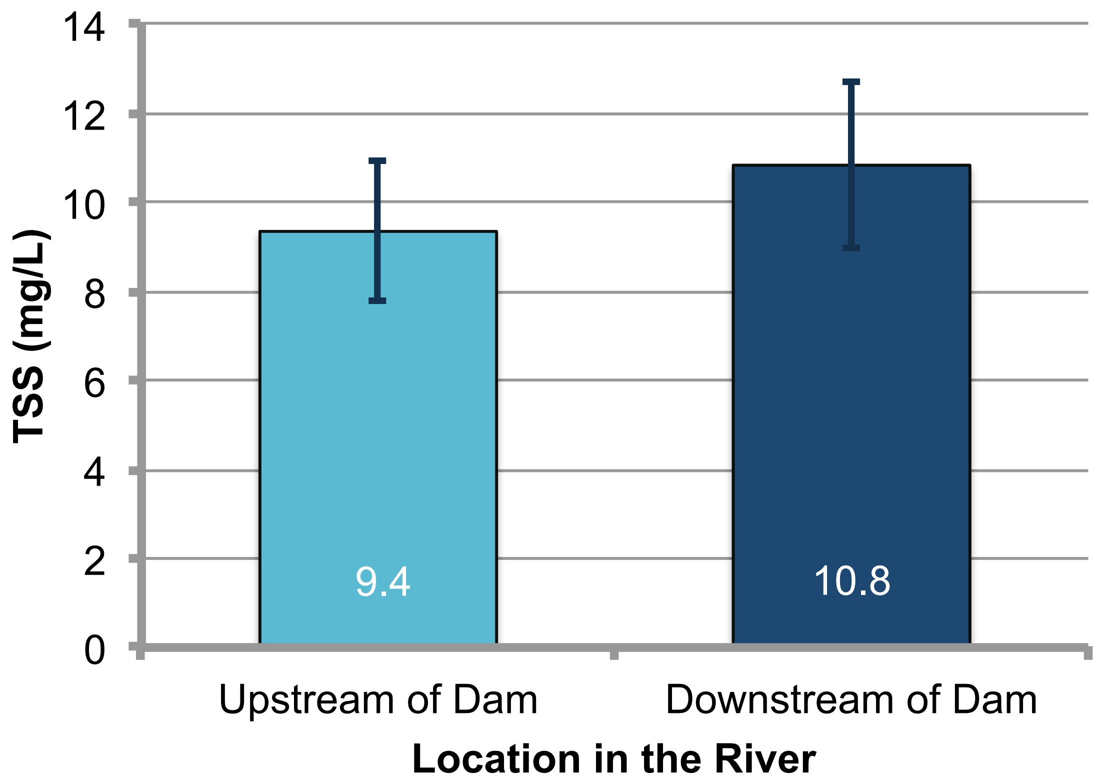
Dependent variable: Total suspended solids (TSS) (mg/L)

Check for Understanding: After taking some time to look at the data table, have students discuss the question, "What type of graphs should we make?" There are many different kinds of graphs, and each is appropriate for different types of data. What type of graph would be most appropriate to make with this data? A line graph is very useful for examining the relationship between two continuous variables (ex. Date, TSS). A bar graph is appropriate for graphing averages for a categorical variable (ex. Average TSS upstream and downstream).

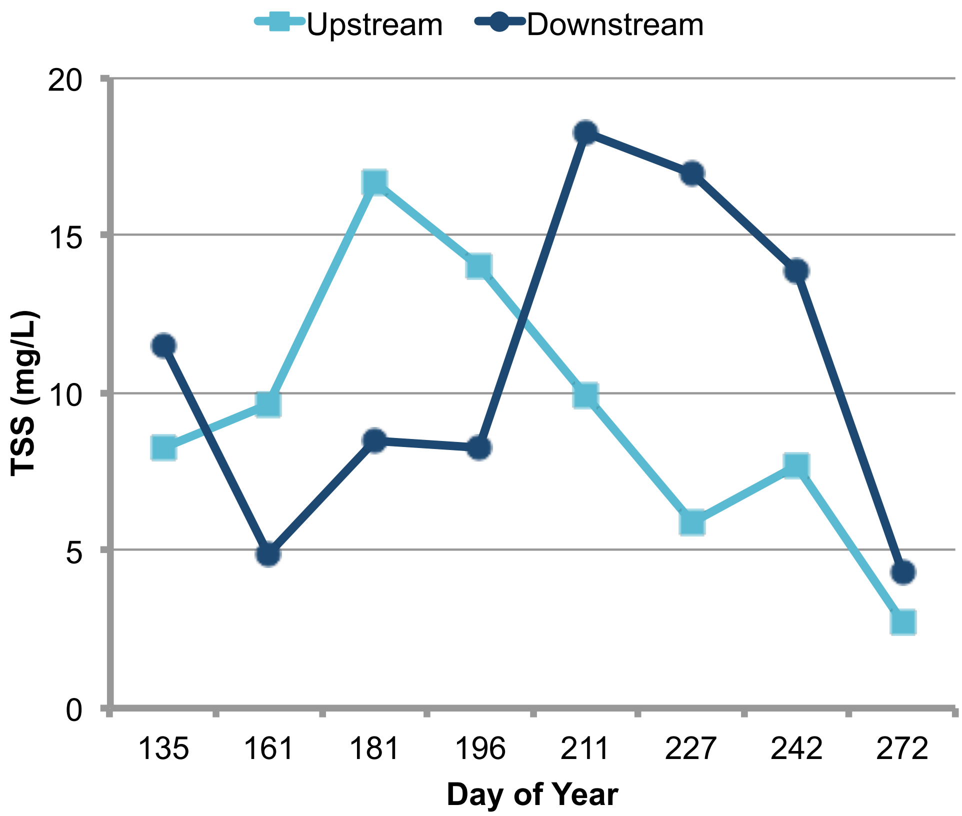
- Bar graphs - suitable for when you have a categorical independent and continuous dependent variable. Used to make comparisons among groups.
- Histograms - suitable for showing the distribution of continuous data. Breaks data into equal intervals.
- Line graphs - suitable for when you have continuous independent and dependent variables, like changes over time. Used to look at trends.
- Pie graphs - suitable for showing data that are parts of a whole.

Draw your graphs below: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.

Graph 1



Graph 2



Interpret the data:

Make a claim that answers each of the scientific questions.

(1) When comparing upstream of the dam to downstream, there was not a difference in the average total suspended solids (TSS) present in the river water.

(2) In both locations, the amount of TSS varied through time. Upstream, TSS were highest on June 30th, while downstream TSS were highest on July 30th.

What evidence was used to write your claims? Reference specific parts of the table or graphs.

(1) The average TSS was slightly higher downstream (10.8 mg/L) compared to upstream (9.4 mg/L). Considering the variability in the data (TSS ranges from 2.7-18.3, and large SD and SE bars), this is a very small difference.

(2) Upstream of the reservoir, total suspended solids were highest on June 30th at 16.7 mg/L. Downstream of the reservoir, total suspended solids were highest on July 30th at 18.3 mg/L.

Total suspended solids were lowest at the end of October both upstream, at 2.7 mg/L and downstream, at 4.3 mg/L.

At certain times of the year (Days: 135, 211, 227, 242, 272), TSS downstream of the reservoir were higher, and at other times of the year, there were more TSS upstream of the reservoir (Days: 161, 181, 196).

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how dams could impact the amount of suspended solids in the water.

(1) Even though the average TSS downstream was slightly higher than upstream, this small difference is likely not large enough to have an effect on the river ecosystem. The range in TSS over several different sampling dates indicates that the river naturally has much higher and lower TSS than both the averages, so the difference of 1.4 mg/L is not significant. This means that the dam does not have an effect on the amount of particles that are suspended in the water as the water flows out of the reservoir. We would need more information to confirm that the dam slows down the water (discharge data before and after the reservoir).

(2) When we look at the TSS upstream and downstream and how it changes over time, we can see that there are differences between the two locations in the river that were not clear when we just looked at averages. The relationship between day of year and total suspended solids varies depending on the location in the river. In both locations along the river, total suspended solids varied through time (the line goes up and down).The relationship was not as simple as thinking about certain events that happen in different seasons. There were no sampling points in March or April, when most of the snow was probably melting and contributing water to the river. In the fall (October), when it was predicted there could be more rain that drained into the river, increasing discharge and increasing TSS, we see that the total suspended solids was actually at the lowest over the year. There does not seem to be a straightforward pattern with TSS upstream and downstream over the dates sampled here.

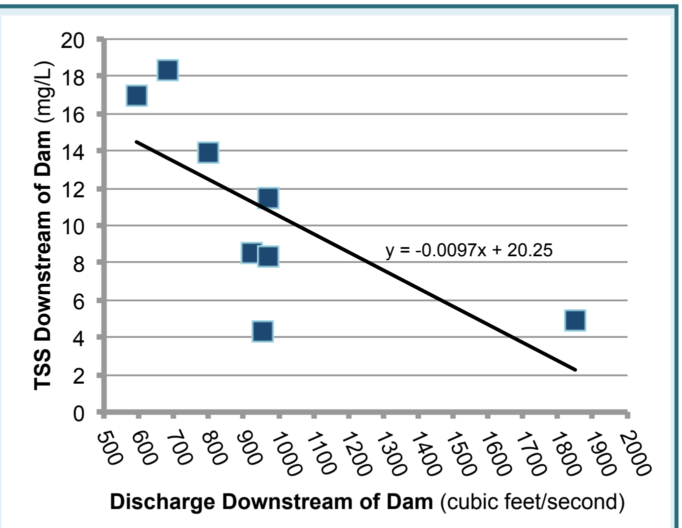
What do the data from this study tell us about Leila's hypothesis?

The data that Leila collected in this year do not support her hypothesis that dams affect the river by slowing down the water and allowing more suspended solids to settle out of the water. The data show that the average total suspended solids upstream and downstream of the river are very similar. Additionally, at several points throughout the year, the TSS at the downstream location had more TSS than the water collected at the upstream location.

What conclusions can we draw from Leila's research? Discuss the limitations on what we can say, based on these data. What future data could be collected to address these limitations?

See Teacher Note below.

Teacher Note: Interestingly, Leila predicted (based on reading other published scientific research) that there would be a positive relationship between discharge and total suspended solids in the river. As an exercise, you can have the students graph a scatter plot showing the relationship between discharge downstream of the dam and TSS downstream of the dam. The graph to the right shows the negative relationship.



Have a classroom discussion to explore ideas behind why this relationship is not reflected in the data from this study. The main reason is that these data were measured about every two weeks from May-October in a single year. Weather events may impact the relationship between discharge and TSS greatly, so sampling over several years would give us a better idea of what this relationship looks in this area under different conditions. The point sampled for discharge is from a small section of the river, and in an area that may be affected by the dam. When scientists synthesize data on discharge and TSS in many spots along many rivers at many different times of the year and under many different conditions, then the general pattern of increased total suspended solids with higher discharge can be seen.

Additionally, looking at the recorded weather events for this year may help explain some of the points we see. Was there a rain event around June 10th that caused the discharge to be so much higher? If we continued to look at these sites for several years, documenting differences in average rainfall around each sampling date, could that help explain the results from this study?

A limitation of the data in this experiment is we only have discharge data for downstream of the dam. Having information on the discharge downstream as well as upstream of the reservoir would tell us if the dam is changing the relationship between TSS and discharge from positive to negative. It could be that there is a funnel effect, and the water leaving the reservoir is not any slower than the water upstream of the reservoir. Or, perhaps the reservoir does slow water discharge, but the dam increases TSS because it churns the water up as it flows over the dam. This could be studied by taking TSS and discharge measurements at a more fine spatial scale – some upstream and downstream in the river, some in the reservoir, and some right at the dam.

<u>Your next steps as a scientist</u>: Science is an ongoing process. What new question do you think should be investigated?

`See Teacher Note below.`

Teacher Note: Student responses may vary, and they will probably generate a wide diversity of questions for in this system. You can have a class discussion where you jot down all the questions up on the board. Be prepared to ask your students to clarify or justify another student's response in a class discussion. Do students see any ways to improve each other's questions? Are some questions untestable? Remember, if your class wants to send their questions about the study system to Leila, the scientist studying the Kalamazoo river, they can email them to datanuggetsk16@gmail.com!

The data from this study did not support Leila’s hypothesis; the dam had no effect on total suspended solids (TSS) (TSS was the same upstream and downstream of the reservoir). In small groups, have students discuss why they think average TSS was unaffected by the dam, and why there are differences upstream and downstream of the dam depending on the time of year. Have students think about the natural process (and human caused processes) that may add suspended solids to a river at different times of the year. Also consider how long it may take some of these solids to float down the river and move from upstream to downstream.

In future research, Leila planned to look into what causes the differences in TSS over time and why these vary upstream and downstream from the reservoir. However, an oil spill in the Kalamazoo river in 2010 put a halt to her research on this subject! Leila shifted the focus of her research to study the effects of the oil spill on the Kalamazoo river food web, but once the oil is cleaned up she can return to her original questions.

It would be interesting to look at what makes up the TSS at the two different sites. TSS is a mix of biotic and abiotic particles, and a similar TSS value does not mean the composition is the same. Maybe the upstream location has more sediment that has been carried down the river. Once this sediment enters the reservoir, it may settle out. However, the reservoir might provide a better habitat for algae to reproduce because of the slow-moving water and increased exposure to the sun. This means that the TSS composition at the downstream location could be more algae than sediment. These differences could have impacts on the river food web. Similarly, scientists could look at how differences in TSS affect invertebrate communities in the river that rely on suspended algae and leaf tissue for food. Scientists could collect data on the invertebrates present in the river along with TSS measurements to see if higher TSS leads to increased invertebrate abundances and diversity.