

Water Resources in a Changing Climate

Note: Prior to delivery of this lesson students should understand the scientific basics of climate change and complete the “Hydrograph Lab” lesson.

Overview: This lesson will investigate the impact of climate change on water resources through calculating the discharge rate of a local stream, and analyzing graphs and data.

Keywords: Climate change, velocity,

Age / Grade Range: 10th-12th

Background: One of the primary rules of ecology is ‘All things are connected’. When teaching about lotic systems, running water systems such as a river, it is important to remember that water connects many parts of an ecosystem together. If water flowing into an ecosystem is altered in any way, there will be consequences. Much like the famous ‘circle of life’ idea, you cannot change one part of an ecosystem and expect the rest of a system to remain static. During this lesson we will explore some of the effects that climate change will have on water resource management. To do this, we first need to examine the science behind climate change.

Climate change is widely accepted as scientific fact (Sudhakara Reddy B. & Assenza G., 2009) and its relation to hydrology is paramount as water is a key element that influences all ecosystems. Currently many researchers are looking into present day and projected trends specific to water resources. As we examine some of this scientific data, it is important to keep in mind that climate change will affect various spatial locations differently. That is to say, Idaho and Florida will experience spatial variability of the affects of climate change. We will specifically be examining a few key changes the Pacific Northwest (PNW) is experiencing and what is expected to change in the future.

One of the focal points of climate science research is examining trends in temperature, and precipitation timing, type, and amount. In the PNW projections suggest that temperature will rise by 1.5-3°C by mid-century (Mote, Salathe, Jr., 2010). Additionally, precipitation is projected to increase overall, but with more precipitation as rain in the winter instead of snow, and less rain overall in the summer (Mote, Salathe, Jr., 2010; Sohrabi M.M., et al., 2012). As a result of these precipitation trends, the hydrology in the PNW is projected to change, with decreased summer streamflow up to 30% by the 2080’s (Wu et al., 2012).

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This has major implications for ecosystems and human uses of water. Idaho receives much of its precipitation in winter in the form of snow that will then melt in the spring. This change in precipitation type in the winter is already visible when we look at databases such as SNOTEL or USGS. These databases show us decades worth of data on temperature, precipitation amounts, and the timing of when the snow melts in springtime.

This timing aspect is an important point to highlight because it affects many facets of human life such as: agriculture, recreation, and municipal water distribution. If these trends continue with peak runoff of water occurring earlier in the spring than in the past we can expect to see expanded growing season lengths, but with less water available in the hotter months of summer. Additionally, we can expect less water in reservoirs and rivers in the summer, which will impact recreational practices (fishing, boating, rafting, etc.) as well as water availability to communities for drinking and taking care of lawns and parks (Farley K., et al., 2011).

These climate change induced hydrological changes are believed to threaten the resilience of watersheds including an increasing population, land use practices, and changes in global climate (Clifton C., et. al., 2010).

**Next Generation
Science Standards &
Common Core:**

HS-LS2.C Ecosystem Dynamics, Functioning and Resilience
HS-ESS2.C The Role of Water in Earth's Surface Processes
HS-ESS2.D Weather and Climate
HS-ESS3.A Natural Resources
HS-ESS3.C Human Impacts on Earth Systems
HS-ESS3.D Global Climate Change

Goals:

1. Students will learn how to measure the discharge (or flow rate) of a local river or stream
2. Students will be able to connect the measurements they take from a local river or stream and compare the data to the SNOTEL and USGS databases to visualize the trends in climate change and water resources management.

Essential Questions:

1. What is discharge and why is it an important measurement of water availability?
2. How do we measure discharge manually?
3. How do the discharge measurements taken locally by students compare to trends visible on USGS databases?

Objectives:

Students will be able to draw meaningful connections between how climate change will impact water resources by locally examining a stream or river and comparing it to government database trends.

Materials:

- Computer
- Internet access
- Access to a small local river or stream
- Discharge data sheet
- Pens/pencils
- 2 pairs of waders/ group of 4-5 students
- 4-6 measuring tapes
- 4-6 yard sticks
- 4-6 stop watches
- 10 oranges to use as 'floats'
- Discharge table for each group of 4-5 students
- Copies of USGS hydrographs for each discharge group

Set up:

Prior to delivery of this lesson students should understand the scientific basics of climate change, greenhouse gas emissions, and complete the "Hydrograph Lab" lesson.

Additionally, teachers will need to have a baseline familiarity with USGS website for the 'Elaborate' and 'Evaluate' pieces of this lesson. Data can be tricky to locate when in a pinch, and so it is recommended to identify the specific features you want to have and local area in advance and have the data available on a spreadsheet or document for easy reference.

It is recommended to complete the steps in both the 'Elaborate' and 'Evaluate' sections in advance and print the relevant hydrographs for class usage.

USGS Water Data: <http://waterdata.usgs.gov/id/nwis/rt>

Consider watching this video about students measuring discharge to get a good visual, and showing it to the class :

<http://www.youtube.com/watch?v=yCX7r4c9N9c>

Classroom Time:

About 4 hours, excluding prior lessons needing to be taught.

**Introduction
(Engage):**

Continuing with the climate science unit show video: "Climate Change Impacts on Snow and Water Resources" with Climate Expert Dr. Noah Diffenbaugh (~ 4min)

<http://www.youtube.com/watch?v=sR-XANPItdA>

Activate prior knowledge by asking

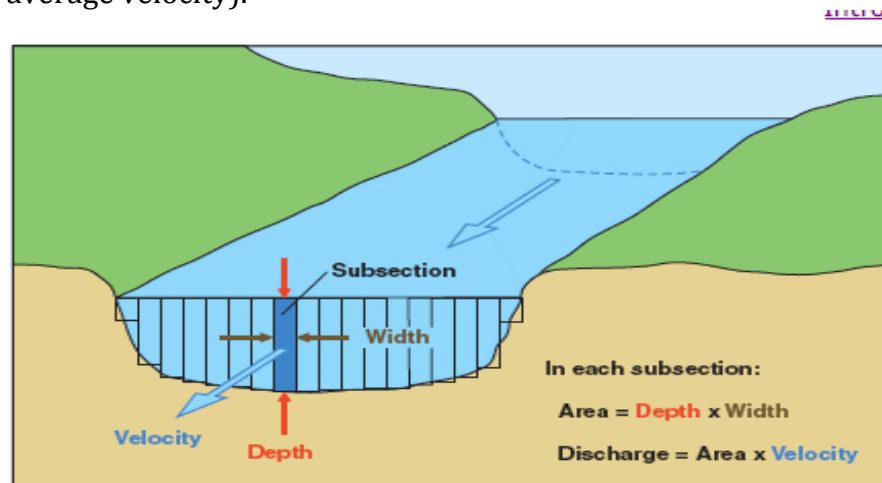
- How will climate change affect water and human access to water?
- Why is it important to consider these impacts?
- How would a change in the type of precipitation impact our community? (Consider factors such as: agriculture, recreation, forest fires etc.)

Intro to Discharge: (10 min)

Explain to the class that today you will be going on a field trip to _____ (insert small local river or stream) to measure the flow rate of the water. The flow rate of a river or stream is also known as 'discharge' can also be thought of as the volume of water flowing through at a given time. Discharge is usually measured in cubic meters per second, however the USGS database we will be using measures and reports data in cubic feet per second, so this activity will take place using the US measuring units (feet).

Show the below diagram, or draw the cross section of a river on a white board. Describe the basic variables needed to calculate the discharge of a lotic system using the drawing or diagram (width of water; average depth, average velocity).

Activity (Explore):



Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

Graphic courtesy of USGS

Divide the students into groups of 4-5 & travel to local river or stream.

How to Measure Discharge: (1.5 hours)

1. Give each group the Discharge Data Table to record their measurements.

2. Start with measuring river width. Have one student from each group wade across the river with one end of the measuring tape while the other end is secured on the opposite bank.
3. Record the width.
4. Next record the depth of your river/stream. This will require one person in waders activity working their way across the river.

NOTE: If your river/stream is less than 15 feet wide take a depth measurement every 1.5 feet. If your river/stream is wider than 5 meters record the depth every meter.

5. Calculate the average depth.
6. Measure velocity (this will be the trickiest measurement).
 - Measure out a length of the river area you are investigating. A distance of 30 feet is normally long enough and also simplifies the math.
 - You will need two people to wade into the stream/river; one at the upstream end of your measured section and one at the bottom of the measured section.
 - Release the float just a little way upstream of the measured starting point. This allows the float to be moving at the speed of the river when it reaches the start point, rather than starting from stationary.
 - The person upstream will release an object to act as a float (like an orange). It is important to note that when releasing the float to simply let go and not add any additional velocity as it could skew the data.
 - The person downstream should do their best to retrieve the orange but never put themselves in danger.
 - Have one person on shore timing the float's journey down the 30 foot section.
 - Repeat the process at least three times to get a good average velocity measurement. The more time you have to gather multiple velocity measurements, the more accurate the data will be.
7. Calculate the average velocity in two steps.
 - First average the times together.
 - Second calculate the distance over time. Example: if the average velocity is 40 seconds over a 30 foot section calculate: $30/40 = 0.75$ ft/sec
8. Encourage the students to do the calculations in the field for a more

realistic scientific experience.

9. Return to the classroom with the data in hand.

Have each group calculate the discharge of the river using this equation:

$$Q=WDV$$

Where:

Q- discharge; W-width (in feet); D-mean depth (in feet); V-current velocity (in feet/second)

Compare the groups data to one another using a graph or spreadsheet.

Ask:

Explanation

- What are some factors that might affect the discharge of this river/stream? (Climate, vegetation, soil type/geologic factors, terrain, human based activities, etc.)
- How do you think the discharge will vary seasonally?
- Considering water resources in a changing climate how might discharge change over time?

This last question helps to transition into looking at the databases online as they can see visually the changes in discharge overtime.

Comparing group data to USGS yearly data:

Explain to the class that you will be looking at yearly water runoff data and comparing group data to it. This part of the lesson should also activate students' prior knowledge by asking them to remember how to read a hydrograph.

It may also be wise to prepare this hydrograph in advance to save on class time.

Elaboration:

1. Start by opening the link below to the USGS Idaho water page:

<http://waterdata.usgs.gov/id/nwis/rt>

2. Click on the 'Streamflow' link on the center left side of the page under "current conditions."

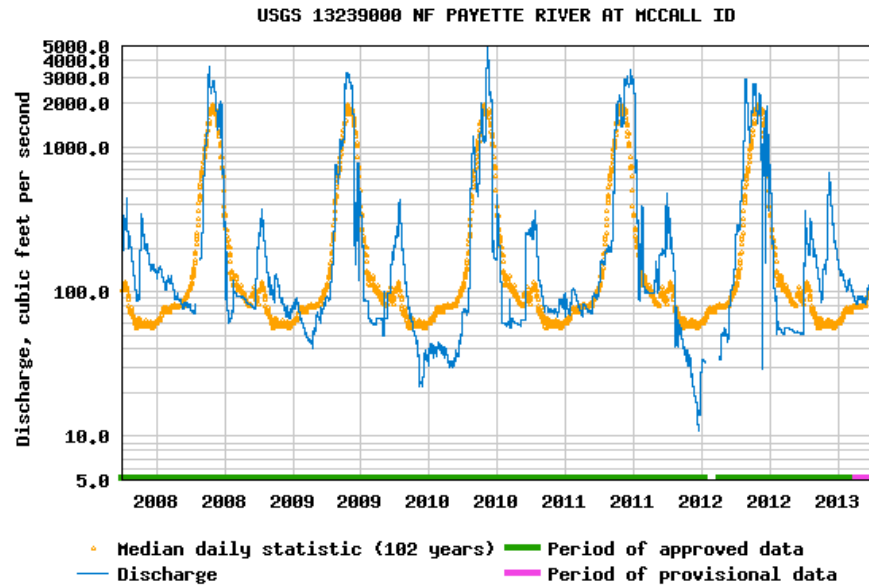
3. This should navigate you to a large table of available sites that measure discharge. Select one near you. For this lesson example we will use the N. Fork of the Payette River at McCall, ID. Click on the numbered station link next to the site you select.

4. Next, you will be presented with the option to graph the discharge (cubic ft/sec) and if you would like to view the gauge height. For this example, we won't look at gauge height.

5. Within this same table you will need to select the dates you want to look at. Generally, the more years you can include, the better graph you will have for comparison. For this example, we will be looking at 10/1/2007-3/27/2013. You can also choose your output format: graph; graph with stats; graph without stats; table; or tab separated.
6. An example of the graph with stats output of the N. Fork of the Payette River at McCall, ID. is below:

Discharge, cubic feet per second

Most recent instantaneous value: 116 03-31-2013 09:30 MDT



7. Some important noticeable points are:
- Difference in peak heights across the years. This can be a good reference point when comparing data, especially if this lesson is conducted in the spring (March or April) as this is when most of the runoff is occurring due to snowmelt.
 - Difference in low points. These are normally the late summer early fall months (July-October) when there isn't much precipitation falling and the water coming from snowmelt is finished. This is also the time of year that most people use more water for drinking, pools, lawn care, and hydropower to fuel electricity and air conditioning.
 - The years closest to 2013 have more visible fluctuations than previous years. In this example also notice the low spike between 2012-2013. This hydrograph is good at visually yearly amounts, but isn't the most detailed in terms of monthly runoff.

For this section we will break apart the 2007-2013 hydrograph into years in order to compare discharge fluctuations over time. Due to the number of

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Evaluation:

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hydrographs included, they are listed at the bottom of this section.

To accomplish this task, recall that a water year is October through September. Using the same procedure in the 'Elaborate' section to create hydrographs on the USGS webpage, change only the amount of time you wish to have selected. The graphs below are in the following order: Oct 1 2007-September 30 2008; October 1 2008-September 30 2009; October 1 2009-September 30 2010; October 1 2010-September 30 2011; October 1 2011-September 30 2012.

It is recommended to have created these hydrographs in advance of teaching this activity. Print out a copy of the hydrograph set to each group accompanied by the following questions:

1. How does your collected data compared to the hydrograph from the 2011-2012 water year?
2. If you were to measure discharge again at a different time of year, what would expect to see?
3. What trends do you notice looking at the USGS data related to peak discharge timing and amounts? What trends do you see when looking at low points of the hydrographs?
4. What are some factors that may be responsible for these changes? Please be specific.
5. Do you think climate change is responsible for any of these changes? Please explain.
6. How would a downward trend in discharge affect this area? (Consider dams, wildlife habitat, irrigation, recreation etc.)

Discuss group answers as a class, specifically focusing on question six. Relating discharge to a place-based context is important for students to solidify the concept that water is one of the most important resources available to us.

Additional resources:

Water footprint calculator:

<http://environment.nationalgeographic.com/environment/freshwater/water-footprint-calculator>

Climate data online through NOAA:

<http://www.ncdc.noaa.gov/cdo-web/>

Climate Data Online is an interactive map featuring climatic datasets of historic and recent weather events. Specific datasets include daily, monthly, annual, or marine

data; or choose climate themes such as precipitation, snowfall or temperature.

Climate hot map:

<http://www.climatehotmap.org>

This is a great resource for visually experiencing global effects of climate change with specific focal points including: people, freshwater, oceans, ecosystems, and temperature.

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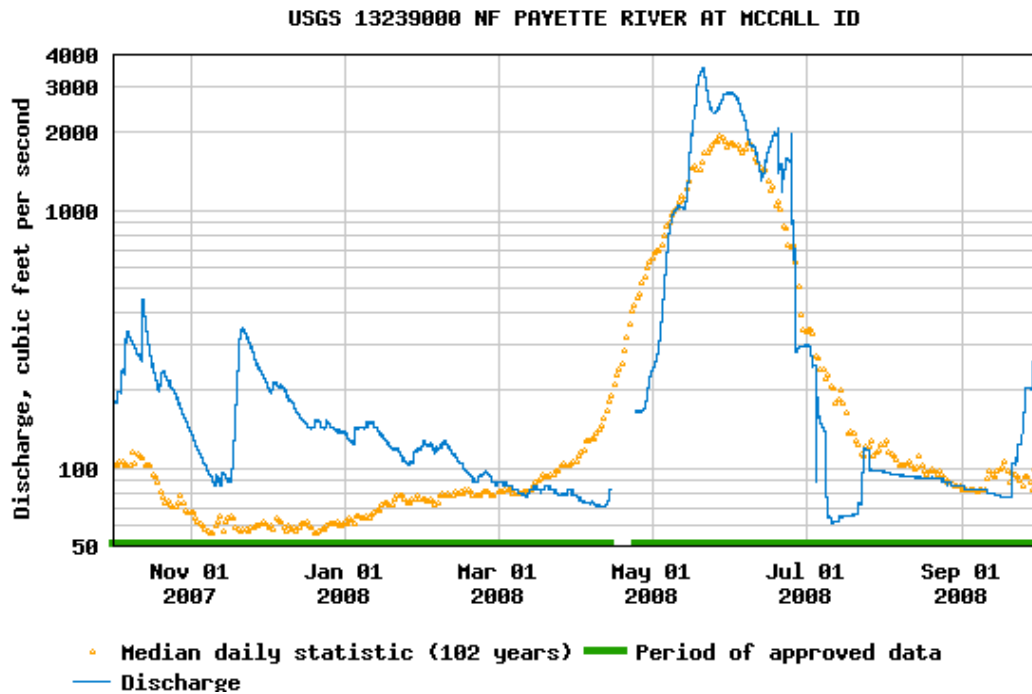
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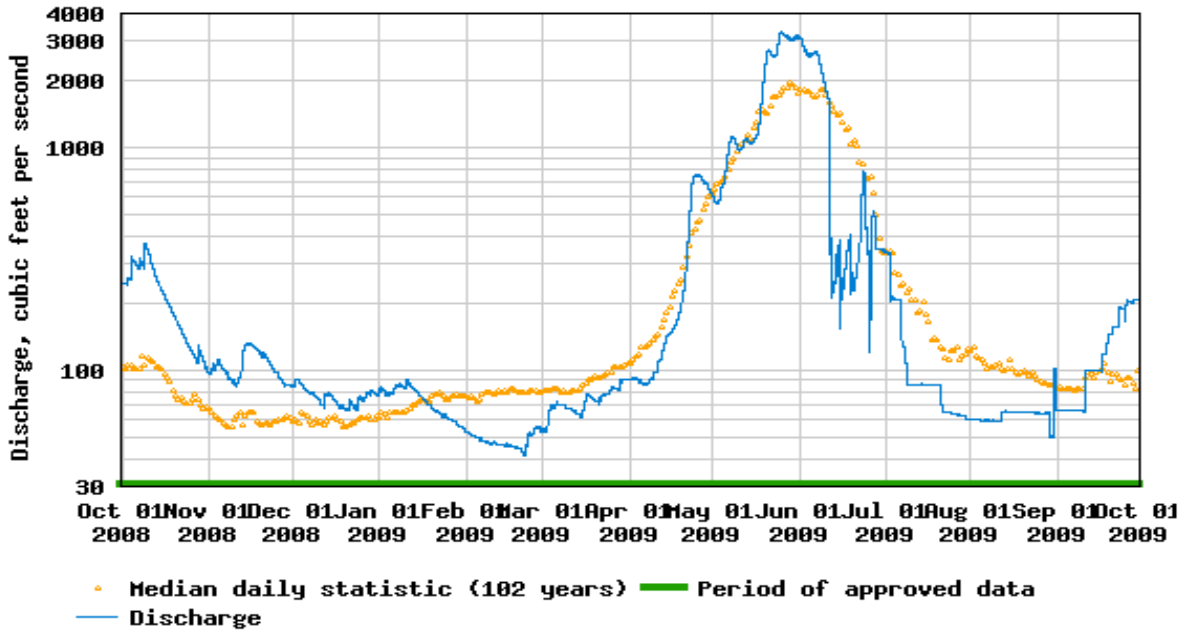
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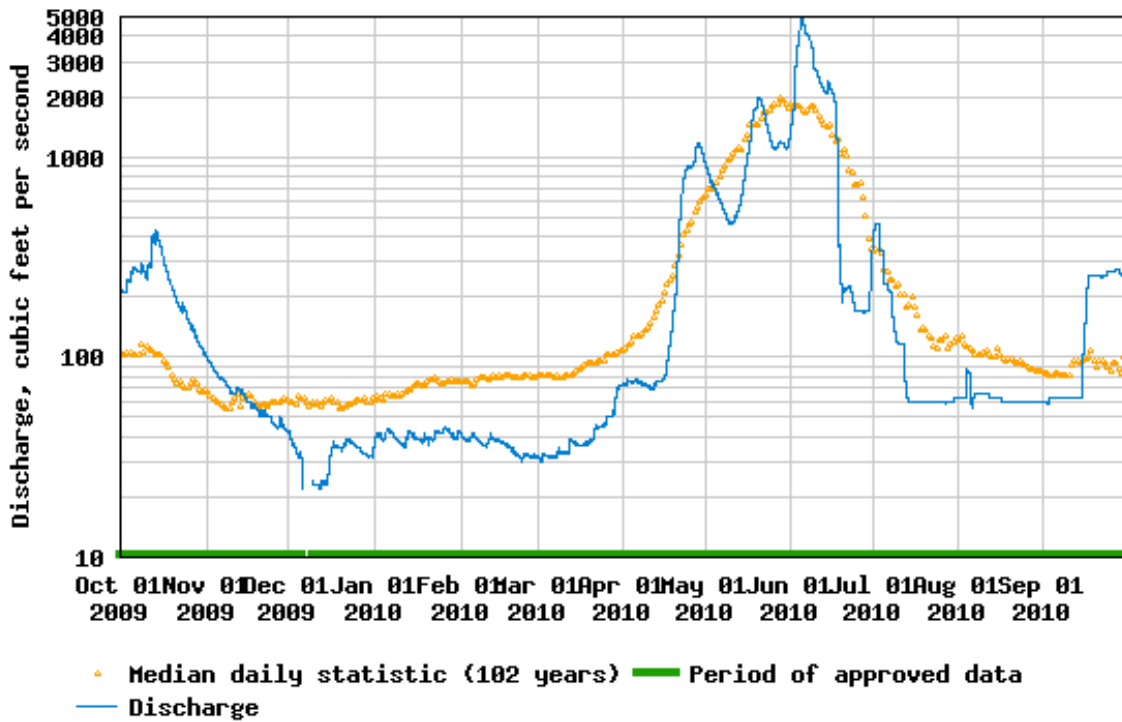
Hydrographs: N. Fork of the Payette River in McCall, ID
Discharge, cubic feet per second

Most recent instantaneous value: 116 03-31-2013 09:30 MDT

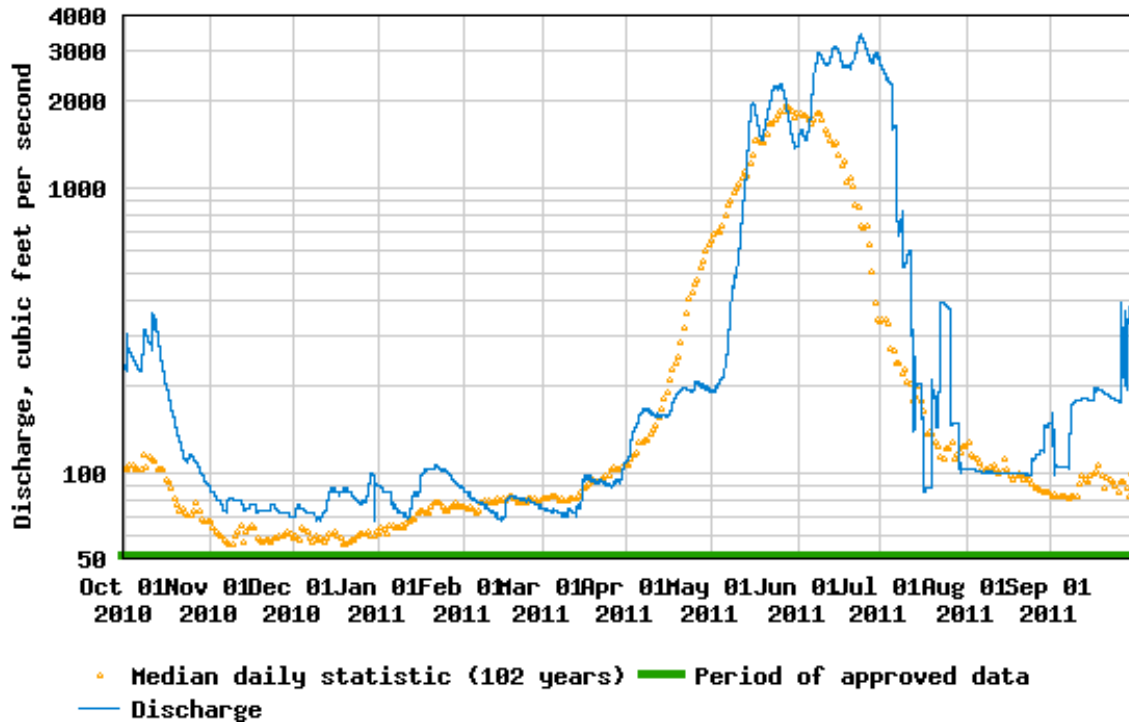




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