



One River, Two Floods: The Big Thompson River Floods

Setting the Stage

In 1976, and again in 2013, the Big Thompson River in Colorado experienced major rain-related flooding events that greatly impacted the people and environment of this Front Range watershed.

The 1976 flood resulted in 144 deaths and \$35 million in damage in the Big Thompson drainage. The 2013 Colorado flood caused nine deaths and \$2 billion in damage in the Front Range overall, including two deaths and \$80 million in damage in the Big Thompson drainage.



Aerial scene of Big Thompson Flood of 2013 along Hwy.34.
Photo Credit: U.S. Air National Guard, Capt. Darin Overstreet

Lesson Overview

Students will build understanding about floods in Colorado through the following learning activities:

- *Activity 1 – Engage (10 minutes) An Introduction to Flood Concepts & Case Study*
As a class, watch news clips about floods in Colorado and have a brief class discussion.
- *Activity 2 – Explore (40 minutes) Flood Data Analysis Jigsaw*
In groups, analyze flood information and data to build understanding of the causes, impacts, locations, and frequency of floods.
- *Activity 3 – Explain (50 minutes) Community Flood Risk & Response*
In teams, students create a local news story for their community to share information about flood causes and impacts, and how people prepare for, respond to, and rebound from floods.



Instructional Overview	
Grade Level	Middle School
Instructional Time	100 minutes
Standards Alignment	NGSS: MS-ESS3-2 CDE: MS3.ESS.GLE9
Anchoring Phenomenon	<ul style="list-style-type: none"> • Causes and effects of floods can be identified and measured • Natural factors, such as weather and climate, affect the potential for and severity of floods. • Human impacts and land use changes, such as infrastructure and residential development, affect the impacts of floods.
Driving Question	<ul style="list-style-type: none"> • What are the main causes and impacts of floods? • When and where are floods most likely to occur in Colorado? • What actions should people take before, during, and after a flood?
Learning Goals	<ul style="list-style-type: none"> • Students will understand the basic causes and impacts of floods. • Students will analyze data to build understanding about the location and frequency of floods. • Students will know what actions people take to prepare for, respond to, and rebound from floods.
Materials	<ul style="list-style-type: none"> <input type="checkbox"/> <i>Students:</i> One student handout per student (digital access or printed copy & pencil) <input type="checkbox"/> Individual student computer devices or classroom computer with projector, and internet <input type="checkbox"/> <i>Entire class:</i> For the Activity 2 wrap-up discussion, 12 large Post-Its or pieces of poster size paper, 12 packs of sticky notes, and 12 felt markers <input type="checkbox"/> Materials for Activity 3, depending on the format each group chooses (e.g., poster paper, access to slide presentation and word processing software, audio/video recording, internet, etc.)
Material Preparation	<ul style="list-style-type: none"> <input type="checkbox"/> Print student handouts if needed <input type="checkbox"/> Ensure computer access <input type="checkbox"/> Cue and test web links <input type="checkbox"/> Plan vocabulary integration <input type="checkbox"/> For Activity 2 stations: If internet is available, use student handouts with embedded activity links with student personal devices or two to four shared devices with activity links bookmarked at each station. If internet is unavailable, print two copies of materials located in the MS Flood Resources Folder per station and show video links as a class. Set up two sets of large Post-It or poster size paper, sticky notes, and markers.





<p>Vocabulary</p>	<p><u>Natural hazards</u> are naturally occurring phenomena such as flood, wildfire, extreme heat, or drought, which may disrupt or damage a community.</p> <p><u>Flood</u> is a rising and overflowing of a body of water especially onto normally dry land.</p> <p><u>Flash flood</u> is a local flood of short duration generally resulting from heavy rainfall in the immediate vicinity.</p> <p><u>Streamflow</u> is water flow, or discharge, in a natural channel.</p> <p><u>Discharge</u> is the volume of water that passes a given point in a period of time, which is measured in cubic feet per second (cfs).</p> <p><u>Gage height</u> is measured as the height of the water level relative to a zero point.</p> <p><u>Flood stage</u> is the stage at which a stream will overflow its banks.</p>
<p>Instructional Strategies</p>	<ul style="list-style-type: none"> • Jigsaw (optional, used in Activity 2): A cooperative learning strategy in which each group is responsible for learning one “piece of the puzzle” and then sharing that information with other groups to complete the whole picture. Consider using Activity 3 for students to present the information they learned at their stations. Teachers can choose to use this strategy if time is limited, and stations can be differentiated for different student abilities and levels of teacher assistance. • <u>Mind mapping</u> (optional; used in Activity 2): A creative way to “map out” students’ thoughts and ideas. Similar to a concept map, multiple formats can be used to develop students’ trains of thought and make connections between main ideas or concepts.

<p>Activities</p>	<p>Web Links for Lesson Resources Note: all resources are downloaded as pdfs in the <i>Activity Resources Folder</i></p>
<p>Activity 1</p>	<ul style="list-style-type: none"> • Video: 1976: Deadly Big Thompson flood devastates Colorado https://www.nbcnews.com/nightly-news/video/1976-deadly-big-thompson-flood-d-evastates-colorado-47784003640 • Video: Dramatic images show devastating flooding in Colorado https://www.nbcnews.com/nightly-news/video/dramatic-images-show-devastating-flooding-in-colorado-47907907979
<p>Activity 2</p>	<p>Station 1</p> <ul style="list-style-type: none"> • Text: Colorado Planning for Hazards-- Flood https://www.planningforhazards.com/flood#dd-contents-410 <p>Station 2</p> <ul style="list-style-type: none"> • Data: Flood in Colorado https://www.colorado.edu/climate/extremes/maps/index.html#floods • Data: Flash Flood in Colorado https://www.colorado.edu/climate/extremes/maps/index.html#flashfloods <p>Station 3</p> <ul style="list-style-type: none"> • Data: Big Thompson Watershed topographic map https://drive.google.com/file/d/1g_IME9ef4YuXRvaJyNW0BilZTpcDLBqO/view • Data: Big Thompson Floods of 1976 and 2013 https://drive.google.com/file/d/1wQpwWphObK7EZvnd_akgt7DFjgbzGldh/view <p>Station 4</p>





	<ul style="list-style-type: none"> • Data: 2013 Flood Weather Story https://drive.google.com/drive/folders/16rTlxZBUoXLUiWalGYUzGDgR63e8_EnX <p>Station 5</p> <ul style="list-style-type: none"> • Text: 100-year flood https://www.nbcnews.com/sciencemain/colorado-disaster-what-100-year-flood-it-s-not-what-you-8C11154338 • Data: Hydrograph https://drive.google.com/open?id=1R6SqilEAmvnfl_DrSizdqplshEKZj6cK5zJB6jZVM-7s • Data: Discharge Data https://docs.google.com/document/d/1a5IS4RbzjKt4HlxYZ4KhCB7r8WIV9IM1fnb0sdfat4/edit <p>Station 6</p> <ul style="list-style-type: none"> • Text: Flood Safety, Ready.gov https://www.ready.gov/floods • Text: Flood Safety, Weather.gov https://www.weather.gov/safety/flood
Activity 3	<ul style="list-style-type: none"> • Video: Flood Expert Video https://www.youtube.com/watch?v=loEioPmdfUg&feature=youtu.be • Video: Looking Back at the 2013 Floods https://www.9news.com/video/weather/weather-colorado/looking-back-at-the-2013-floods/73-8245939 • Text: Big Thompson Canyon struck again by tragic flooding https://www.denverpost.com/2013/09/28/big-thompson-canyon-struck-again-by-tragic-flooding/ • Text: Lessons Learned: better notifications, monitoring http://www.reporterherald.com/ci_30190635/lessons-learned-better-notifications-monitoring • Text: The 2013 Flood: A timeline http://www.reporterherald.com/news/colorado-flood/ci_32124713/2013-flood-timeline • Text: A deadly flood that helped improve weather forecasting https://research.noaa.gov/article/ArtMID/587/ArticleID/367/A-deadly-flood-that-helped-improve-weather-forecasting • Text: Recovering after rivers rage https://www.coloradoan.com/story/news/local/2014/09/05/september-flood-anniversary-colorado/15151647/ <p>Optional Resources</p> <ul style="list-style-type: none"> • Data Visualization: NOAA Science on a Sphere-Flood Events https://sos.noaa.gov/datasets/flood-events-2000-2009/





Activity 1 (Engage)

Introduction to Flood Concepts & Case Study (10 minutes)

What are the main causes and impacts of floods?

Think: What do you know about floods?

1. What do you know about floods? In one minute, jot down as much information as you know about floods in the “What I Know” section of the KWL Chart on page 2.

Responses vary.

Watch the news stories [1976: Deadly Big Thompson flood devastates Colorado](#) (3:00) and [Dramatic images show devastating flooding in Colorado](#) (3:02) to get a feel for the impacts of floods on people and the environment. As you watch, make mental notes about what you see and hear in the video.



Pair: Discuss your observations and wonderings about the videos with a partner.



2. Write down your observations and questions about floods as a natural hazard in the “What I Wonder” section of the KWL Chart.

Responses vary.

Share: As a class, briefly discuss observations and wonderings about the videos.





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KWL Chart	
1. What I Know	
2. What I Wonder	
What I Learned (Activity 3)	





Activity 2 (Explore)

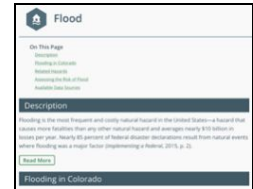
Flood Data Analysis Jigsaw (40 minutes)

Activity 2 is designed as a jigsaw in which students work in small groups to complete the activities at six different stations and then share out. Consider giving the small groups expert names, like “hydrologists,” “emergency managers,” etc. Alternatively, teachers may decide to run some stations as whole-class, teacher-led activities before assigning the remaining stations as a student-led, small-group jigsaw.

Station 1: Colorado Flood Fast Facts

As a flood research team, read the [Colorado Planning for Hazards -- Flood](#) webpage. Write responses to the following questions in your student handout.

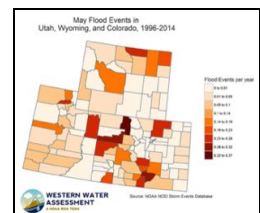
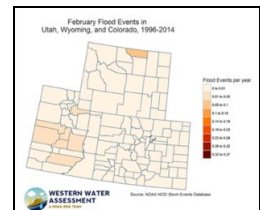
- What are the main causes of floods and flash floods?
Precipitation from storms, runoff, and overflows from dams and other water systems.
- What are the greatest risks that floods pose in Colorado?
Flash floods are the most common. The foothills east of the Rocky Mountains are the most prone to flooding; 20 to 30 major floods occur each year.



Station 2: Location and Frequency of Floods and Flash Floods in Colorado

Select and analyze the Monthly Maps of Significant Weather Events “[Flood](#)” and “[Flash Flood](#)” series to assess the frequency and locations of floods in the state.

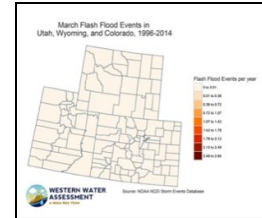
- In Colorado, when does flooding mainly occur (months/seasons)?
Spring and summer (April-September)
- In Colorado, where does flooding mainly occur (geographic area/counties)?
South central Colorado, eastern foothills and western slope





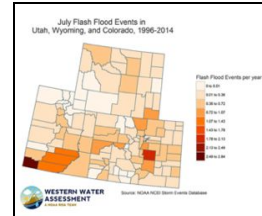
- In Colorado, when does flash flooding mainly occur (months/seasons)?

Summer (June-September)



- In Colorado, where does flash flooding mainly occur (geographic area/counties)?

Eastern foothills and plains, western slope



Station 3: Visual Comparison of Big Thompson Flood Events

As a flood research team, review the topographic map of the [Big Thompson Watershed](#) and the [Big Thompson Floods of 1976 and 2013](#) infographic. Record observations about the trends and patterns noted in the student handout.

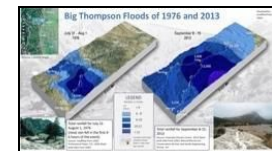
- Describe the general topography of the Big Thompson River watershed.

The topography is a mountainous, steep, and narrow canyon, which runs east-west from Estes Park to Loveland, Colorado. A fork of the river comes in from the north from Glen Haven and joins at Drake (the confluence).



- Compare and contrast the amounts of precipitation and locations of precipitation for the 1976 and 2013 floods (note: read the descriptions below the images, too).

1976 Flood: Less total rainfall concentrated in a smaller area, but it fell over a shorter period of time (2 days; most rain fell in 4-6 hours); higher peak streamflow at Drake and Sylvan Dale Ranch.



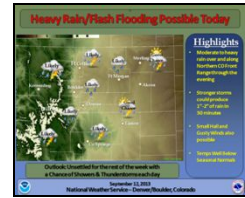
2013 Flood: Greater rainfall over a larger area, which fell over a longer period of time (7 days); lower peak streamflow at Drake and Sylvan Dale Ranch.





Station 4: The 2013 Flood Weather Story

Look over the National Weather Service's [Weather Story forecasts](#) from September 10-22 about the 2013 Colorado Front Range Flood, which included the Big Thompson River.



11. On what date was the first flash flood warning issued for the Front Range? When was the last flash flood warning for this area?

The first flood warning was issued on September 12, 2013. The last flash flood warning was on September 16, 2013.

12. On what date(s) and in what general location (in relation to key cities) did severe flooding occur? Why do you think severe flooding occurred in this area?

Severe flooding occurred on September 14 and 15, 2014. The area with severe flooding was from the Boulder area north to just south of Fort Collins (Loveland is included) and east beyond Fort Morgan in the plains. The flood waters flowed down the river canyons in the Front Range to the plains and the amount of water was more than the rivers and streams could hold; the ground was saturated with rainwater so the extra water could not be absorbed (the rockslide and mudslide warnings are due to water-saturated ground).

13. Describe the pattern and location of the flooding between September 17 and September 22, 2013, during the Weather Story forecasts.

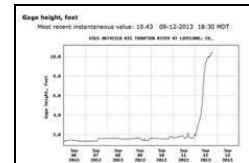
The Front Range had flood advisories from September 17 through September 18, and then the flood threat ended. The eastern plains and the northeastern corner of the state had flood warnings from September 17 through September 21; there was a flood advisory in the northeastern corner of the state on September 22, 2013.



Station 5: The 2013 Big Thompson Flood Hydrograph

Analyze the [graph](#) about the 2013 Big Thompson Flood and the [data table](#) about the Big Thompson River discharge rates.

14. What data is the graph illustrating? What is the *independent variable* and its units? What are the *dependent variables* and their units? Hint: How is time displayed? What does gage height refer to?



The graph shows the gage height, or stage, of the Big Thompson River at Loveland, Colorado, during the flood.

Independent variable: Time (24-hour unit intervals)

Dependent variables: Gage height (in feet)

15. Describe the general pattern of the data shown on the graph.

The gage height of the river was consistently about 1 foot until the water level increased very rapidly starting on September 12, 2013. The gage height was over 10 feet and still increasing but then stopped before September 13, 2013 (due to the gage being destroyed).

16. Flood level on the Big Thompson River is at a depth of 5 feet of water. Looking at the graph, approximately when did the Big Thompson River exceed its flood level?

About 6 a.m. on September 12.

17. What information is the data table providing? What do “cfs” units measure? Compare and contrast the cfs values for average discharge rate and flood level discharge rates for the Big Thompson River.

2013 Big Thompson River Discharge	
Streamflow	Rate (cfs=cubic feet per second)
Average flow	72.5 cfs
Average peak flow	1700 cfs
Average 100-year flood peak flow	7360 cfs
1976 flood peak flow	8710 cfs
2013 flood peak flow	18,400 cfs

The data provide information about different streamflow and discharge rates (e.g., average and flood levels). Units of cfs measure the rate of water flowing in “cubic feet per second.” Floods have a higher cfs value than the average flow rate of the river.

18. What is the average discharge rate for the Big Thompson River? How do the 1976 and 2013 flood discharge rates compare to the average peak flow rate and 100-year flood peak flow rates?

Both the 1976 and 2013 floods exceeded the average peak flow. The 1976 flood peak flow rate was almost 1500 cfs greater than the 100-year flood peak flow rate, and the 2013 flood peak flow rate was about 9 times greater than the 100-year flood peak flow rate. For the Big Thompson River, the 2013 flood had the highest discharge rate (about





2.5 times greater than the 100-year flood average peak flow, about 10 times greater than the average peak flow rate, and more than twice the rate of the 1976 flood). The average flow is very low and the average peak flow is much lower than the highest flood discharge rates.

Station 6: Flood Safety

Read the [Floods Ready.gov](https://www.floodsready.gov) webpage and the National Weather Service [Flood Safety](#) plan.

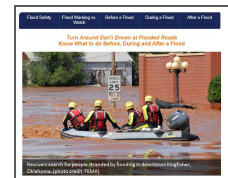
19. What does “Turn Around, Don’t Drown!” mean? Why is trying to cross or drive through a flooded area a risk?

“Turn around, don’t drown!” means to not enter or attempt to enter a flooded area (e.g. road). Floodwaters one foot deep or less can sweep people off their feet, move cars, etc.



20. If you live in an area at risk of floods, what should you and your family do to prepare? In the event of a flood warning, what should you do to protect yourself and others with you?

Have an emergency and evacuation plan in place and listen to alerts. Move to high ground; do not enter flood waters; stay off bridges and away from fast-moving flood waters; follow evacuation orders; stay in a safe place until flooding is over; etc.





Activity 2 Wrap Up Discussion

Have a 10-minute [mind mapping](#) session or consensus discussion session about your findings and learning from the activity sections. Start the class mind map with “Flood” labeled in the center of a large Post-It, poster paper, or shared digital document.

As a class, briefly share findings for stations to check and correct your responses, as needed, and add key information to the drought mind map.

Collect student handouts and/or have them digitally share their copy with you. Student handouts will be used for Activity 3, and it is important for students to have complete and correct responses to communicate information.

Suggested discussion questions:

- What are key factors about the causes and impacts of floods?
- In which locations and at what time of year do most floods occur in Colorado?
- How should people prepare for and respond to be safe in the event of a flood?

Activity 3 (Explain)

Community Flood Risk & Response (50 minutes)

What action should people take before, during, and after a flood?

For Activity 3, students will work in new groups, or hazard expert teams. Each hazard expert team is made up of one student from each of the jigsaw groups, so that the team consists of students that collectively completed each of the Activity 2 stations. The goal is to have an expert from each station in order to communicate key flood information to your (or another) community that faces flood risk and/or has experienced a flood in the past.

In addition to using their student handouts, use Activities 3.1 and 3.2 as models and to develop their ideas about how floods affect communities. See Activity 3.3 for the final product instructions (summative assessment for the lesson).





Activity 3.1 Flood Expert Interview (5 minutes)

First, watch the short interview with Jeff Lukas, a flood expert with Western Water Assessment (WWA). WWA is part of the Cooperative Institute for Research in Environmental Sciences, which is based at the University of Colorado Boulder. Jeff talks about many of the concepts that you learned in the previous activities, and that you will present in this activity.



[Flood Expert Video](#)

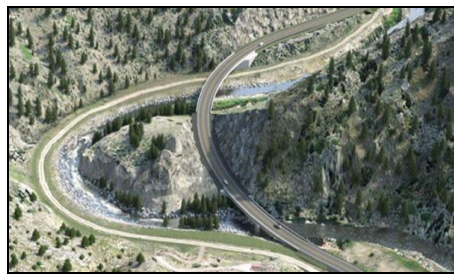
Activity 3.2 Big Thompson Flood Virtual Diary (10 minutes)

Next, watch the short video and read one item from the virtual diary on how people and communities prepared for, responded to, and rebounded from the devastating Big Thompson floods.

- Video: [Looking Back at the 2013 Floods](#) (2:12)
- Reading (select one):
 - [Big Thompson Canyon struck again by tragic flooding](#)
 - [Lesson Learned: better notifications, monitoring](#) article and [photos](#)
 - [The 2013 Flood: A timeline](#) article and [photos](#)
 - [A deadly flood that helped improve weather forecasting](#)
 - [Recovering after rivers rage](#)



A man stands on the bank of the Big Thompson River in front of a huge debris field at the mouth of the 20-mile-long Big Thompson Canyon (Photo: *Denver Post*).



Post-flood bridge repair at Horseshoe Curve, Big Thompson River. This part of Highway 34 was washed out in the 1976 and 2013 floods. (Photo: *Kiewit Infrastructure Company*)





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Activity 3.3 Local Flood News Story (35 min)

Prompt: Create a local news story in a format of your choice (see options below), that summarizes important information for people in your community to be “flood wise” before, during, and after a flood.

The format choices for the local flood news story include:

- Newspaper article with one picture and one graph or map (one page)
- Radio story (2-3 minute in length)
- Video newscast (2-3 minute in length)

Follow the steps in the table below to create your news story. Be creative, but accurate.





Local Flood News Story Instructions	
<p>1) KWL Chart “What I Learned” (see page 2)</p> <p><input type="checkbox"/> Check when completed</p>	<p>As a group, reflect on what was learned in Activities 1, 2, and 3. Then independently complete the “What I Learned” section of your KWL Chart (see page 2 of the student handout) to summarize your learning. Use these prompts to reflect on what you learned:</p> <ul style="list-style-type: none"> • What important things do you now know about floods that you didn’t know before? • What should people do to be “flood wise” before, during, and after a flood?
<p>2) Choose a Format</p> <p><input type="checkbox"/> Check when completed</p>	<p>As a team, choose one of the following formats for your group’s Local Flood News Story:</p> <ul style="list-style-type: none"> • Newspaper article with one picture and one graph or map (one page) • Radio story (2-3 minutes in length) • Video newscast (2-3 minutes in length)
<p>3) Create a Draft</p> <p><input type="checkbox"/> Check when completed</p>	<p>Referring to notes and responses in your student handout, make a quick draft of your group’s product ideas. Your team’s news story should summarize and share information about:</p> <ul style="list-style-type: none"> • Causes and impacts of floods in Colorado • Locations and times of higher flood risk in Colorado • How to prepare for a flood • How to respond and stay safe during a flood • Describe how people and communities rebound from flood
<p>4) Create the Final Product</p> <p><input type="checkbox"/> Check when completed</p>	<p>Create your team’s Local Flood News Story. Remember to keep your product brief and summarize these key elements for your community audience:</p> <ul style="list-style-type: none"> • What are causes and impacts of floods in Colorado? • Which regions and times of the year have higher flood risk in Colorado? • How can people prepare before a flood? • How should people respond to stay safe during a flood? • What are some ways that people and communities have rebounded after a flood?
<p>Lesson Rubric</p>	<p>Refer to the rubric to help you assess Activity 3.</p>





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Teacher Guide
Middle School
Hazard Lesson: Flood

If there is extra time, participate in a [class gallery walk](#), where your team shares what they have learned about how people and communities prepare for, respond to, and rebound from floods.

Presentations will vary; they may be assigned as homework, if needed.

Post presentations in the classroom and/or online for hosting the class gallery walk.



These materials were developed by CIRES Education & Outreach at CU Boulder.
<https://cires.colorado.edu/outreach/projects/HEARTForce>

