Lesson Outline for ALEX

General Lesson Information

Title: **Flood Inundation Mapping (FIM)—A Primer**

Overview/Annotation- *A short summary or description of the lesson including activities and science concepts.*

- This lesson will familiarize students with the USGS Flood Inundation Mapper (FIM) in an unplugged manner. A whole class discussion will first take place, discussing FIM in general and then a FIM site in Hattiesburg, MS (for both a non-flood and a flood day). Loss estimate data will be discussed for the flood day. Students will then get into groups with each group being assigned a different FIM site. A number of re-usable handouts will be distributed along with 1 Discussion Sheet per group. Groups will discuss several questions to dig deeper into FIM and flooding.

Setting or format (outdoors, in groups, lab, etc.):

- In groups

Intended group size (if groups are used):

- About 4-5 students each

Intended grade level(s):

- High School: Earth & Space Science
- Could be used for 6^{th} grade Science as well

Approximate Time of Lesson (*Ideally break down into 20-50 minute periods*):

- 50 minutes (ENGAGE 20 minutes, EXPLORE 20 minutes, EXPLAIN 10 minutes)
- [The ELABORATE portion will be a separate lesson plan that has yet to be written]

Researcher Biography

Name & Professional Title:

- Marie E. Wilson
- Education & Outreach Coordinator for the Alabama Water Institute (AWI)

Affiliation:

- Alabama Water Institute at the University of Alabama

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Brief Description of Research Interests:

- I myself am not a researcher, but I work with researchers who use FIM a great deal. CIROH (Cooperative Institute for Research to Operations in Hydrology—one of the 3 groups within AWI) is a consortium of 28 academic, government, and private institutions who conduct research “to improve the understanding of hydrologic processes, operational hydrologic forecasting techniques and workflows, community water modeling, translation of forecasts to actionable products, and use of water predictions in decision making." (https://ciroh.ua.edu/)

- My personal research interests from when I was in undergraduate and graduate school involved aquatic (freshwater) ecology, especially aquatic and riparian macroinvertebrates.

Associated Standards and Objectives

Content Standards- *List Alabama Course of Study Standards that connect to lesson*

Earth & Space Science (High School):

8. Obtain and communicate information to explain different climate regions and their impact on patterns of severe weather.

a. Analyze temperature and precipitation patterns related to factors that influence climate, including proximity to water, topography, elevation, latitude, and orographic effect.

b. Analyze and interpret data to develop predictions about the formation of meteorological events. Examples: severe thunderstorms, hurricanes, tornadoes, floods, droughts, winter storms

c. Communicate scientific information to explain the personal, local, and statewide implications of severe weather events in Alabama.

Science & Engineering Practices (High School):

- Asking Questions and Defining Problems - Formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
- Developing and Using Models - Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Cross-Cutting Concepts (High School):

- Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced, thus requiring improved investigations and experiments. Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Mathematical representations are needed to identify some patterns. Empirical evidence is needed to identify patterns.
- Cause and Effect: Mechanism and Prediction - Empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller-scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects.
- Scale, Proportion, and Quantity - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can be studied only indirectly as they are too small, too large, too fast, or too slow for direct observation. Patterns observable at one scale may not be observable or exist at other

scales. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

- Systems and System Models - Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions (including energy, matter, and information flows) within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Primary Learning Objectives- *Sentences beginning with "Students will be able to…" that describe what students will do in the lesson that relates to how students will be assessed.*

- Students will be able to analyze and interpret data to develop predictions about the formation of meteorological events such as floods.
- Students will be able to communicate scientific information to explain the personal, local, and statewide implications of severe weather events in Alabama.

Additional Learning Objectives- *Any learning outcomes that are not directly related to the content standards but may relate to other local or national standards*

- Students will be able to interpret FIM data from a pre-existing site.
    - Students will be able to explain a hydrograph.
    - Students will be able to identify historical flooding patterns based on FIM library data.
- Students will be able to explain the relationship between historical floods and their impacts on the surrounding ecosystems as well as the human impacts of finances and property.
- Students will be able to relate rainfall amounts to corresponding changes in flood impact extent.
- Students will be able to explain the cause-and-effect relationship between a FIM site's hydrograph, gage height, and current flooding extent.
- Students will be able to identify factors that affect flooding besides precipitation amount.

Preparation Information

Total Duration- *How many minutes will the lesson last?*

- 50 minutes

Materials and Resources- *List of materials teacher will need to gather or prepare for lesson*

- ENGAGE (whole class)
    - Image 1: Leaf River "current" stage with historical flood record image
    - Image 2: Leaf River "current" stage with hydrograph image

- Image 3: Leaf River April 15, 1974 flood image
    - Weather Images [These can be used if time permits. Their use is not currently explicitly spelled out in this lesson plan.]
        - Day before "current"
        - Day of "current"
        - Key for 1974 table
        - 3-day table for 1974
- EXPLORE (5 groups of 4-5 each)
    - Copies of 50 historical flood map images (10 per group)
    - Copies of 5 "current" stage with hydrograph images (1 per group)
    - Copies of 5 "current" stage with historical flood record images (1 per group)

Technology Resources Needed- *What technology will teacher and students need for the lesson?*

- None

Background and Preparation- *Description of information (science content, use of materials, etc.) teacher and/or students will need to know prior to this lesson; list steps for any preparation prior to the lesson*

1. All Images can be found here: SciREN_FIM_LessonPlan
2. Fold each group's 10 historical flood FIM images in half so that the historical flood peak record is on one side and the river image is on the other side. Make sure groups complete through #3 on the Discussion Sheet before they unfold the images.
3. Cut the loss estimate tables out (there are 2 per page).

Procedures and Activities

Step-by-step description of lesson that would allow another teacher to successfully complete the lesson (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)

Engagement (sparking interest, introducing phenomenon, engage students' everyday experiences)
ENGAGE – 20 minutes

1. "Today we are going to be talking about a tool that disaster management personnel use to predict, model, and assess flooding. It is a tool provided by the US Geological Survey (USGS), a government agency in the Department of the Interior. The tool is called FIM for short and this stands for Flood Inundation Mapper."
    a. Show the screenshot of the FIM homepage.
        i. "Notice the key in the upper right corner. Each triangle represents a site where FIM data is being collected. What color are most of the triangles' outlines?"
            1. Green
        ii. "What does a green outline indicate?"
            1. No flooding
        iii. "Do you see any other outline colors?"
            1. Yellow and orange

iv. “What do these colors indicate?”
    1. Yellow is action stage and orange is minor flooding
v. “We will delve a bit more into what these different categories mean later.”

b. “Do you see a FIM site in Alabama?”
    i. No
    ii. “There is not a FIM site in Alabama but researchers at the University of Alabama work with other academic institutions that do work at FIM sites located around Kansas City, MO. So, once we break into groups, you will be examining maps from these sites while discussing and making observations about them.”

2. “Now that we have discussed the basics of FIM, I want to pose a question to the class. ‘How do floods affect our lives?’”
    a. Possible answers
        i. Stranded cars
        ii. Destroyed buildings
        iii. Waterborne illnesses
        iv. Toxic chemical spills
        v. Dangerous, murky water
        vi. Deaths and injuries
    b. “These are all great examples of how floods can negatively affect populations of people and the communities in which they live.” Add any points above that students did not mention. “Luckily, by combining weather data with historical flooding data, we can predict floods in the future. FIM helps disaster management personnel and other researchers do just this.”
3. “Now let’s examine the Leaf River in Hattiesburg, MS on February 26, 2025.”
    a. Show *Image 1*
        i. “What is the current stage of the Leaf River?”
            1. 5.73 feet
        ii. “What do you think stage means?”
            1. How high the surface of a river is
        iii. “According to usgs.gov, ‘‘Stage’ is the water level above some arbitrary point in the river’.”
        iv. “What do you notice about the Leaf River in this image?”
            1. It looks like flooding is occurring.
    b. Show *Image 2*
        i. “This is a hydrograph of the Leaf River on February 26, 2025. What do you think a hydrograph shows?”
            1. Water level through time
        ii. “What is being measured on the x-axis?”
            1. Time by day
        iii. “What is being measured on the y-axis?”
            1. Gage height in feet
            2. “How does gage height relate to stage?”
                a. The height of the stream gage determines the stage or water level of the stream.

b. A gage is a tool used to measure stream stage

iv. "You noticed that the water seems to be overflowing the banks a bit but look at the hydrograph and ask yourself, 'Is it flooding?'"
   1. No
   2. Not enough to warrant any action
   3. Not enough to activate disaster management personnel
   4. Not enough to activate any sort of warning system

v. "Where is the line on the hydrograph?"
   1. In the gray area

vi. "What does the key indicate that this gray area means?"
   1. Below Action

vii. "The yellow Action Stage is still much higher up on the hydrograph. What might this indicate about some of the areas around this river?"
   1. They are marshy/swampy
   2. There are floodplains

c. "Now take a closer look at the land a bit further out from the river. What do you see surrounding the Leaf River?"
   i. Buildings
   ii. Trees
   iii. Roads

d. "Take a minute to think about the buildings you see. How much danger do you think these buildings are in regarding possible flooding (Action Stage or above)?"
   i. Not much
   ii. A lot
   iii. I do not know

4. "Now let's take a look at *Image 3*. This is the Leaf River on April 15, 1974."
   a. "Is the river still confined to swampy areas close to the riverbanks?"
      i. No
   b. "What is the peak gage height on this day?"
      i. 34.03 feet
   c. "Take a look at the hydrograph in the upper left corner of the inset box. What color is the hydrograph where this gage height sits?"
      i. Purple
   d. "What Stage of flooding does purple indicate?"
      i. Major Flood Stage
   e. "What has happened to the buildings and roads surrounding the Leaf River that you identified earlier?"
      i. Many of them have flooded
      ii. Water now covers them
   f. "Is everything that is now blue on the map completely under water?"
      i. No
      ii. The blue just indicates where water is on the ground
   g. "What measurement is missing from this data and why would this particular measurement be important?"
      i. Depth of the water on the ground.

ii. Knowing the depth of the water at different points far from the river would help disaster management personnel determine the extent of need and damage.

h. "Before I ask the next set of questions, I want to make the important point that in regard to loss estimates, we have just that...estimates. This is general loss estimate data for specific stream stages not specific floods. And regarding this particular flood, there is no loss estimate data for a stream stage this high. In other words, we have to imagine that the loss caused by this flood was actually more than the highest estimates we have."
   i. "Consider all the buildings that you noticed earlier. How much do you think the flood's damage to the buildings cost?"
      1. > $97,426,000
   ii. "Consider the contents of these buildings. How much do you think the flood's damage to these contents cost?"
      1. > $135,573,000
   iii. "Consider this damage. What do we call the stuff left behind after a disaster that is now unusable?"
      1. Debris
   iv. "Debris can be so extensive that we measure it in tons. How much debris in tons do you think resulted from this flood?"
      1. > 10,265,189 tons
   v. "Now let's consider the entire damage cost. How much do you think the total cost was for this disaster?"
      1. > $408,506,000

5. Wrap up any discussion of what has been covered so far.

Main activity (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)

EXPLORE – 20 minutes

1. "Now we are going to break into groups of 4-5 and explore historical flooding of 5 different FIM sites—1 site per group."
   a. Groups
      i. 1 – Missouri: Blue River at Stadium Drive in Kansas City, 06893578
      ii. 2 – Missouri: Blue River at 12th Street in Kansas City, 06893590
      iii. 3 – Missouri: Blue River at Kansas City, 06893500
      iv. 4 – Kansas: Indian C at State Line Rd, Leawood, 06893390
      v. 5 – Missouri: Blue River at Blue Ridge Blvd Ext in Kansas City, 06893150
   b. "Each group will have the following for their assigned FIM site."
      i. 1 FIM image of each of 10 historical floods (these images will be folded so that you do not know which historical flood you are looking at)
      ii. 1 image of weather data the day before the flood
      iii. 1 image of weather data the day of the flood
      iv. 1 FIM image of a non-flood day in February 2025 with the historical flooding record

v. 1 FIM image of a non-flood day in February 2025 with the associated hydrograph
vi. 1 image of weather data the day before the non-flood day
vii. 1 image of weather data the day of the non-flood day
viii. 1 loss estimate table

2. "You are going to be going through the tasks and questions on the handout in your groups. You will have 20 minutes to work on this."

Wrap up and Reflection (wrap up activity, reflecting on learning, informal assessments of student learning)
EXPLAIN – 10 minutes

1. "We are going to spend the last few minutes of class sharing the answers you discussed as groups about your FIM site's historical flood records."
2. (Note: The big missing factor to mention and briefly discuss from #10 on the handout is topography. Other factors include: new zoning laws between floods, new land developments between floods, soil saturation, soil type, season, permeability of surfaces in the area, etc.)

Final product/Summative evaluation (e.g. quiz, presentation, essay, etc., may occur during a later class period)
BELL-RINGER for next class period: [Display the 3 FIM images from the Leaf River in MS, along with the weather data from both time points.] Describe the patterns you see between the weather data and each stage level. What other factors may be at play in the flooding or non-flooding you are seeing?

Attachments- *Any materials for the lesson such as video links, worksheets, etc., listed here*

- USGS Flood Inundation Mapper - https://fim.wim.usgs.gov/fim/
- Images (separated into folders for ENGAGE & EXPLORE) - SciREN_FIM_LessonPlan

Flood Inundation Mapper Discussion Sheet
Names:
Date:

1. Examine the non-flood day images from February 2025. Look at the hydrograph and think about how the stage on this day is associated with the appearance of your river on this day. What is the stage in feet? ________ What is the date? ____________________

2. Using the historical flood record on the non-flood day image, estimate the stage for each historical flood below (place this number in front of the /).
   a. Date: _________________ Stage: _________/__________
   b. Date: _________________ Stage: _________/__________
   c. Date: _________________ Stage: _________/__________
   d. Date: _________________ Stage: _________/__________
   e. Date: _________________ Stage: _________/__________
   f. Date: _________________ Stage: _________/__________
   g. Date: _________________ Stage: _________/__________
   h. Date: _________________ Stage: _________/__________
   i. Date: _________________ Stage: _________/__________
   j. Date: _________________ Stage: _________/__________

3. Lay out the folded historical flood images in front of you. Notice that each image has a number. These numbers do not correspond to the chronological order of these floods. Consider the stages you estimated above (in #2) and the extent of each image's flood. Now place the number (or numbers if the stages are very similar and you cannot differentiate) of each image next to the letter above (in #2) corresponding to the image's historical flood date.

4. Now that you have done your best to match the floods to their dates/stages, unfold each image.

5. Take a look at the stage noted on each image's historical flood chart. Write in the exact flood stages to the right of the /s in #2 above.

6. Were your guesses close? __________ What do you think may have led to some of the mismatches? ____
   ____
   ____
   ____
   ____

7. Do all of the matches make sense now that you know which image goes with which historical flood? Why or why not? ____
   ____
   ____
   ____
   ____

____
____

8. Now look at the weather data for each historical flood. You have data for the day of the flood and data for the day before the flood. How do weather patterns around the times of the historical floods inform the hydrographs, the gage heights, and the extent of the floods? ____
____
____
____
____
____
____

9. Now take a look at your loss report table. Remember these are estimates for specific gage heights or stages, not exact measurements for each historic flood. Do you think the numbers in this table are close to accurate? __________ Did you notice any similar stage historical floods that had different patterns of flooding extent? ___________ With this in mind, do all floods of similar stages have the exact same damage extent? ____________ Explain your thought process: ____
____
____
____
____
____
____

10. What are other factors that need to be taken into account to best predict flooding and the damage flooding can cause? List at least 3 (Hint: There is one absolutely critical aspect that we have not covered today.)
    a. ________________________________
    b. ________________________________
    c. ________________________________

Group 1: Loss Estimates - Missouri: Blue River at Stadium Drive in Kansas City, 06893578

Date	**Stage (ft)**	**Total Loss ($)**	**Building Loss ($)**	**Content Loss ($)**	**Total Debris (tons)**
Aug 31, 2003	26	104,583,000	25,208,000	36,719,000	286,982
May 19, 2004	28	119,582,000	29,434,000	41,358,000	311,357
Jun 4, 2005	27	112,012,000	27,404,000	39,114,000	296,636
May 7, 2007	28	119,582,000	29,434,000	41,358,000	311,357
Jul 30, 2008	27	112,012,000	27,404,000	39,114,000	296,636
Jun 14, 2010	32	158,370,000	39,232,000	53,344,000	371,770

May 31, 2013	27	112,012,000	27,404,000	39,114,000	296,636
Aug 22, 2017	35	187,254,000	47,388,000	63,483,000	430,497
Oct 8, 2018	29	127,514,000	31,584,000	43,857,000	329,507
Jul 4, 2024	26	104,583,000	25,208,000	36,719,000	286,982

Group 2: Loss Estimates - Missouri: Blue River at 12th Street in Kansas City, 06893590

Date	Stage (ft)	Total Loss ($)	Building Loss ($)	Content Loss ($)	Total Debris (tons)
Aug 13, 1982	21	3,894,000	754,000	1,763,000	334
Jun 6, 2001	22	4,576,000	898,000	2,072,000	428
Jun 16, 2009	19	2,635,000	536,000	1,248,000	272
May 31, 2013	24	6,238,000	1,226,000	2,936,000	516
May 17, 2015	20	3,228,000	628,000	1,476,000	286
Aug 27, 2016	22	4,576,000	898,000	2,072,000	428
Aug 22, 2017	31	11,457,000	2,610,000	5,427,000	1,193
Oct 8, 2018	26	7,784,000	1,583,000	3,756,000	704
May 29, 2020	23	5,365,000	1,055,000	2,464,000	488
Jul 4, 2024	23	5,365,000	1,055,000	2,464,000	488

Group 3: Loss Estimates - Missouri: Blue River at Kansas City, 06893500

Date	Stage (ft)	Total Loss ($)	Building Loss ($)	Content Loss ($)	Total Debris (tons)
Nov 17, 1928	39	499,918,000	45,516,000	81,814,000	279,135
Apr 23, 1944	36	431,456,000	31,571,000	74,131,000	203,593
Jul 11, 1951	38	490,569,000	42,123,000	80,458,000	255,118
Jul 31, 1958	38	490,569,000	42,123,000	80,458,000	255,118
Sep 13, 1961	44	573,359,000	67,095,000	91,726,000	413,748
Sep 13, 1977	35	408,305,000	27,964,000	72,014,000	174,510
Jun 9, 1984	37	463,779,000	36,291,000	77,863,000	219,974
May 15, 1990	41	526,440,000	54,081,000	85,111,000	331,238
Jun 14, 2010	37	463,779,000	36,291,000	77,863,000	219,974
Aug 22, 2017	42	545,023,000	58,767,000	87,587,000	351,990

Group 4: Loss Estimates - Kansas: Indian C at State Line Rd, Leawood, 06893390

Date	Stage (ft)	Total Loss ($)	Building Loss ($)	Content Loss ($)	Total Debris (tons)
Mar 4, 2004	23	7,407,000	1,364,000	2,745,000	52,723
Aug 27, 2006	22	6,443,000	1,138,000	2,355,000	44,514
Jul 30, 2008	25	9,767,000	1,911,000	3,609,000	67,239
Jun 14, 2010	26	11,986,000	2,338,000	4,211,000	81,657
May 6, 2012	22	6,443,000	1,138,000	2,355,000	44,514
May 31, 2013	24	8,513,000	1,624,000	3,170,000	59,811
Jul 20, 2015	23	7,407,000	1,364,000	2,745,000	52,723
Aug 22, 2017	28	18,523,000	3,781,000	6,408,000	140,713
Oct 8, 2018	23	7,407,000	1,364,000	2,745,000	52,723
May 28, 2020	22	6,443,000	1,138,000	2,355,000	44,514

Group 5: Loss Estimates - Missouri: Blue River at Blue Ridge Blvd Ext in Kansas City, 06893150

Date	Stage (ft)	Total Loss ($)	Building Loss ($)	Content Loss ($)	Total Debris (tons)
May 19, 2004	39				
Jun 4, 2005	37	2,868,000	594,000	995,000	83,231
May 7, 2007	34	1,277,000	237,000	424,000	39,686
Jun 4, 2008	37	2,868,000	594,000	995,000	83,231
May 31, 2013	37	2,868,000	594,000	995,000	83,231
May 17, 2015	32	661,000	133,000	240,000	20,450
Aug 22, 2017	40	6,012,000	1,306,000	2,153,000	177,190
Oct 8, 2018	38	3,443,000	729,000	1,212,000	100,322
May 28, 2020	37	2,868,000	594,000	995,000	83,231
Jul 4, 2024	34	1,277,000	237,000	424,000	39,686