

Maryland Biological Stream Survey (MBSS) FieldScope Investigations Teacher Notes

The *Maryland Biological Stream Survey (MBSS) FieldScope Investigations* provide an opportunity to explore an authentic scientific dataset using a digital mapping tool developed by National Geographic. These investigations will deepen students' understanding of human impacts on the environment and support Next Generation Science Standards MS-LS-1, MS-LS2-4, HS-ESS3-1, and HS-ESS3-6.

They are appropriate for middle or high school classrooms throughout the Chesapeake Bay Watershed and beyond, as they use Maryland as a case study to understand the relationship between humans and streams. These investigations are not comprehensive curricular units and do not include curricular frameworks, assessment, or extensive teacher notes. Instead they are designed as an introduction to MBSS, preparing students and teachers to explore this rich scientifically-robust environmental dataset. These investigations are also an excellent introduction to conducting local stream investigations using the *Mapping Our Streams with FieldScope* curricular unit.

- Please visit our website to access the *Mapping Our Streams with FieldScope* curricular unit - <http://alese.al.umces.edu> (under the Geospatial Ed: Chesapeake FieldScope tab).
- You can learn more about MBSS at the Maryland Department of Natural Resources website - <http://www.dnr.state.md.us/streams/MBSS.asp>.

MBSS Investigations:

Investigation 1 – What is a watershed?

Investigation 2 – How does impervious surface impact stream health?

Investigation 3 – What is the relationship between nitrate and agriculture?

Investigation 4 – What is the relationship between dissolved oxygen and water temperature?

Investigation 5 – Where are the healthiest streams in Maryland?

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Maryland Biological Stream Survey (MBSS) FieldScope Investigations Overview

In these investigations, you will explore stream health using the Maryland Biological Stream Survey (MBSS) dataset. Maryland Department of Natural Resource scientists collected these data at randomly selected stream sites throughout Maryland.

One way MBSS scientists quantify stream health is by calculating the “benthic index of biotic integrity” or BIBI. This single value captures the diversity of benthic macroinvertebrates that live at a stream site. As their name implies, these are small, spineless organisms that you can see without a microscope. They live on the bottom of streams in many different stream habitats including slow-

moving pools and fast-moving riffles and within the small spaces between rocks, pebbles, wood, and packs of leaves. They include crayfish, insect larva, mollusks, snails, and aquatic worms. Stream macroinvertebrates differ in their sensitivity to changes in their environment caused by pollution and disturbance.

BIBI varies from 1 (unhealthy stream) to 5 (healthy stream). A healthy stream has many different kinds of macroinvertebrates and thus will have a high BIBI. A stream in poor health has fewer types of macroinvertebrates and thus will have a low BIBI.

MBSS Investigation 1: What is a watershed?

In this investigation, you will delineate a watershed for a selected MBSS stream site. Watersheds are very important to studying stream health. They include all the land that impacts a particular stream site. You can draw a watershed for any point on a stream, including your stream site. Complete the investigation with the provided stream site. If possible, repeat with your local site.

1. What area do you think impacts your selected stream site?

- Go to the *Stream Network of a Local Stream Site* map (<http://chesapeake.fieldscope.org/v3/maps/441>). If the *Learn to Use our Map...* window opens, close it. Click on the “i” to close the map’s information window. The red dots represent “participant” data, which were provided by citizen groups and students. Go to *Select Observation Data* above your map. Click in the box next to *Participant Water Quality Data* to deselect it, and then click in the box next to *Maryland Biological Stream Survey* to select it. Click *View Map* to return to your map. Notice now all the MBSS stream sites are shown.
- **Search** for White Sulphur Run Maryland. A red dot without a number will appear on your map marking that location in western Maryland. Zoom all the way in on that location; notice the streams become visible. You are going to investigate the area that impacts the White Sulphur Run MBSS stream site, which is immediately to the west (left) of the dot marking your location. To confirm you are looking at the correct site, click on it and then click on **Show in Table** in the window that opens. The table of MBSS data will appear below your map. The station you clicked on will be highlighted in green at the top of the table. The station name should be White Sulphur Run with an observation date of 1994-12-31. If it is not, click on the map on nearby sites until you find the correct one. Click in the box next to **Table** above your map to close the table once you find the correct stream site.
- Under **Map Layers**, click on *Select new map layers*. On the page of map layers, scroll if necessary and click in the box to **Add Elevation**, and then click **Next**. Click **Show Legend** in the upper right-hand corner of your map to view the *Elevation* layer legend. Then zoom and pan around your area to observe elevation patterns.
- Zoom and pan to see the entire area you believe is impacting this stream site. Under **Draw Tools**, select the **Pencil Tool** and use it to draw a boundary around the area you think is impacting this stream site. In order to draw, be sure to click beside and not on the stream site. If you make a mistake, select the **Erase Tool** and click on the drawing you’d like to erase. After you finish drawing (not before), close the **Draw Tools** panel.

2. What is the stream network for your selected stream site?

- As you know, water flows downhill. Determine which direction the stream is flowing at this site by clicking on each side of it and examining the elevation data for those locations.
- Use the elevation data to find every stream that flows down to this site. This is the site’s “stream network.”
- Use the **Flow Path Tool** under the **Draw Tools**, and click on each stream in the site’s stream network to confirm the streams flow through your site.

3. How does FieldScope’s watershed compare to the area you drew?

- The area that positively or negatively impacts a stream site is called its “watershed.” A watershed is all the land that drains water to a point on a stream, lake, ocean, etc. Think of the watershed for this stream site as a bathtub. This stream site is the lowest point—the drain in the bathtub. The boundaries of the watershed are the highest points—the sides of

the tub. Any rainwater that falls on the watershed will flow downhill to this stream site. To compute the watershed for this site, use the **Upstream Area Tool** under the **Draw Tools** and click just downstream of the site (NOTE: the tool will not work if you click right on the site). If your site is difficult to see with the flow paths on your map, you may erase them with the **Erase Tool**.

- Recall the watershed SHOULD include all of the streams AND all of the land that drains to the stream site. Additionally, the watershed SHOULD NOT include any streams or land that does NOT drain to your stream site. In addition, a watershed boundary should NEVER cross a stream except at the stream site where it begins and ends. The FieldScope watershed may have some of these errors. Look at your streams and elevation data and the computed watershed boundary. Do you see any of these errors in your watershed? If so, where are they and where should the correct watershed boundary should be located?
- Compare FieldScope's watershed to the area of impact you drew. How are they the same/different in both size and location?

Investigation 2: How does impervious surface impact stream health?

In this investigation, we will explore the impact of impervious surfaces on stream health. Impervious surfaces are surfaces that do not absorb water. Rain falling on them flows across the surface as “stormwater runoff.” This runoff eventually flows downhill to the nearest body of water. Buildings, roads and parking lots associated with areas of development are all impervious surfaces. Rocky outcrops are an example of a natural type of impervious surface.

We will use six MBSS stream sites as case studies. Three of these stream sites have a high percentage of impervious surface in their watershed (the area that drains to these streams); we will call these “high IS stream sites.” Three of these stream sites have a low percentage of impervious surface in their watershed; we will call these “low IS stream sites.”

1. Where are the three high impervious surface (IS) stream sites?

- Go to the *Impervious Surfaces and Stream Health* map (<http://chesapeake.fieldscope.org/v3/maps/612>). If the *Learn to Use our Map...* window opens, close it. Click on the “i” to close the map’s information window.
- Click the **Show Legend** link in the upper right corner of the map. Notice the dark color marks areas with impervious surfaces (these are dark gray rather than black in the map because they are semi-transparent). Close the legend.
- Find the three MBSS case study sites in areas with high impervious surface compared to the other three case studies. Zoom and pan to determine the nearest city, town or landmark (e.g., park) for each. You may have to go to **Map Layers** and click on the eye (**Layer Visibility**) next to the layer name to hide the *Impervious Surface* layer so you can see the names on the layer beneath it. Don’t forget to make the layer visible again when finished.

2. How much impervious surface is in the watershed of the high IS stream sites?

- Zoom all the way into one high IS stream site and compute its watershed using the **Upstream Area Tool** under the **Draw Tools** (see *MBSS Investigation 1: What is a watershed?* for additional guidance). Then, close the **Draw Tools**. [For additional guidance on watersheds, see *MBSS Investigation 1*]
- Determine the amount of impervious surface in this watershed by clicking the **Data Query Tool**, then **Shape History**, and then the shape that matches your watershed. The amount of impervious in your watershed will be displayed in the *Observation Data* window that opens. Enter this into the table at the end of this investigation.
- Repeat the previous two steps for the other two high IS stream sites. Then calculate the average amount of impervious surface for all three. Enter these values into the table.

3. What is the average and range of BIBI of the high-impervious surface stream sites?

- To view the data collected at a stream site, click on the site in the map, and then click **Show in Table**.
- Scroll over to the “Benthic Index of Biotic Integrity” column, and write down the value in the top row on your table. When finished, click in the box next to **Table** above your map to close the table.
- Repeat the previous two steps for each of the other two high IS stream sites, and then calculate the average and range (highest – lowest number) for the three sites. Write this in the table.

4. Where are the three low IS stream sites?

- Find the three MBSS case study sites in areas with low impervious surface compared to the other three case studies. Zoom and pan to determine the nearest city, town or landmark (e.g., park) for each.

5. How much impervious surface is in the watershed of the low IS stream sites?

- Repeat step 2 using the three low IS stream sites.

6. What is the average and range of BIBI of the low IS stream sites?

- Repeat step 3 using the three low-impervious surface stream sites.

7. How does impervious surface impact stream health?

- Use your data table to explain how impervious surface impacts stream health.

	High IS stream sites	Low IS stream sites
Average % IS in three case study watersheds		
Average BIBI in three case study watersheds		
Range of BIBI in three case study watersheds		

Investigation 3: What is the relationship between nitrate and agriculture?

In this investigation, you will examine how nitrate in stream water varies with the percentage of agriculture in the watersheds of select MBSS stream sites. Nitrate is a common stream pollutant that from lawn and crop fertilizer, animal waste, and other sources.

1. Are there distinct regions with high or low nitrate in streams?

- Go to the *Land Cover and Nitrate* map (<http://chesapeake.fieldscope.org/v3/maps/613>). If the *Learn to Use our Map...* window opens, close it. Click on the “i” to close the map’s information window. On this map, the points provide average amount of nitrate in the stream at each MBSS site.
- Click on *Show Legend* to examine the nitrate scale; close the legend when finished. Are there areas where you see mostly low amounts of nitrate in the stream? Are there areas where you see mostly high amounts of nitrate in the stream? Do you see higher nitrate amounts in areas with more agriculture?

2. What is percentage of agriculture in the watershed of a stream with low nitrate?

- Zoom into one stream site with 0 mg/L nitrate. Use the **Upstream Area Tool** under **Draw Tools** to compute the watershed for that site. [Note: For additional information and guidance on watersheds, see *MBSS Investigation 1: What is a Watershed?*]
- Display the *Land Cover* layer. Under **Data Query Tool**, click on **Shape History**, and then click on the watershed shape in the list. A window will open displaying data for that watershed. Add the percentage of land covered by “cultivated cropland” and “pasture/hay” to calculate the percentage of agriculture in the watershed. Write this down.

3. What is land cover like in the watershed of a stream with high nitrate?

- Zoom in on the stream site with the most nitrate. Compute its watershed, and write down the percentage agriculture in that watershed.

4. What do these data suggest about nitrate and agriculture?

- Review your data and determine what it suggests about how agriculture in an upstream watershed impacts a stream site.
- Here you only had two streams site, so you don’t have much evidence to support your conclusion. What could you do with the MBSS FieldScope data that would provide more evidence?

Investigation 4: What is the relationship between dissolved oxygen and water temperature?

In this investigation, you will examine how dissolved oxygen (DO) in stream water varies with stream water temperature. DO is very important for the survival of fish and macroinvertebrates in a stream. Many factors can affect the amount of DO in stream water. Do you think water temperature affects streamwater DO?

1. What is the relationship between DO and water temperature?

- Go to the *Dissolved Oxygen vs Water Temperature* graph (<http://chesapeake.fieldscope.org/v3/graphs/317>). If the *Learn About the Analysis Tools...* window opens, close it. Click on the “i” to close the map’s information window. This graph displays the amount of dissolved oxygen versus water temperature at a particular stream site. These are “participant” data, which were provided by citizen groups and students.
- Hold the side of your pencil in front of your computer screen so that it covers as many points on the graph as possible (this is called the “best fit line”). Look at the direction your pencil is angled to determine what – if any - relationship exists between water temperature and DO. Is the slope of the best fit line formed by your pencil:
 - angled downward from the upper left of the graph to the lower right? What does that mean?
 - lying flat? What does that mean?
 - angled upward from the lower left of the graph to the upper right? What does that mean?
- Check the best fit line you estimated with your pencil by looking at the computed one. To do this, go to **Data Analysis Tools** and select the option to **Show Correlation & Best Fit Line**
- Aquatic organisms need oxygen in the water. Without considering other factors, would cold water or warm water streams have more oxygen?
- What else might affect the amount of oxygen in streams?

2. How does participant data compare to MBSS data?

- Re-create this graph using MBSS data by clicking the **Select Variables** section above the graph. Under **Data Sources**, deselect *Participant Water Quality Data*, and select *Maryland Biological Stream Survey*. Click **NEXT>** three times to **View Graph**.
- Examine the relationship between water temperature and DO in the MBSS data. How does this relationship compare with the relationship in the participant data you examined in Step 1? If it differs, why do you think this might be?

Investigation 5: Where are the healthiest streams in Maryland?

In this investigation, you will explore how and why stream health varies across Maryland. We consider a stream healthy if it has a BIBI greater than 4.0. We will examine variations in stream health relative to land cover among Maryland's physiographic provinces, which are geographic areas with landforms that are distinct from adjacent regions.

1. What are the physiographic provinces in Maryland?

- Go to the *Land Cover and Physiographic Provinces* map (<http://chesapeake.fieldscope.org/v3/maps/444>). If the *Learn to Use our Map...* window opens, close it. Click on the "i" to close the map's information window. Click *Show Legend* in the upper right-hand corner of your map to view the *Land Cover* layer legend, and look at the land cover patterns across the mid-Atlantic. Are there distinct regions with forest? Agriculture? Development? Close the legend when finished.
- Under **Map Layers**, click on the eye symbol next to *Physiographic Provinces* to display that layer (you may need to zoom in and out a little to see this). Use its legend to identify the different physiographic provinces you see and write them down; and then close the legend.
- Use the **Swipe Comparison Tool** to visually compare the *Physiographic Provinces* and *Land Cover* layers. Does one land cover type seem to be more common in a particular physiographic province? When finished, click *Stop Comparing*.
- Notice the physiographic provinces extend beyond Maryland. To determine land cover type and stream health in each province in Maryland, you must first limit the area of each province to Maryland's boundary. Use the steps below
 - Under **Map Layers**, click *Select new map layers*. In the *Select Map Layers* window, click in the box next to *Land Cover* to remove it and click in the box next to *State Boundaries* to add it. In the *SELECTED LAYERS:* section in the upper right corner, use the up arrow to move *State Boundaries* above *Physiographic Provinces* in the list. Click **Next>** to return to the map.
 - Under **Map Layers**, use the *Transparency* slidebar to increase the transparency of the *State Boundaries* layer so you can also see the *Physiographic Provinces*.
 - Zoom in on the area of Maryland in one of the physiographic provinces. Under **Draw Tools**, use the **Shape Tool** (triangle) to outline the boundary of that physiographic province in Maryland. Click around the border to trace it; double-click to complete the shape. Repeat this for each physiographic province in Maryland. When finished, you will have a total of five shapes; close the **Draw Tools**.

2. What are the dominant land cover types in each physiographic province in Maryland?

- Remove the *State Boundaries* layer from your map, and add the *Land Cover* layer again.
- Under **Data Query Tool**, click on **Shape History** then click on each physiographic boundary shape in the list. A window will open displaying data for that physiographic province in Maryland. For each physiographic province, write down the two land cover types that cover the greatest amount of land and the percentage of land each covers. Also write down the *Number of stations* (listed above land cover data); this is the number of MBSS stations in that area, which you will need for use in the next step.

3. What percentage of MBSS streams in each province in Maryland is healthy?

- Display the *Observation Layer* to view all of the MBSS stations (stream sites).
- To determine the number of healthy MBSS streams in each province in Maryland, first filter all the MBSS sites to display only the healthy ones. To do this, under **Filters**, create a **New Filter** and **Filter by Value**. In the window that opens, select “Benthic Index of Biotic Integrity” as the *Data Variable*. Use the sidebar to *Include Items In Range* 4.00 to 5. Change the *Filter Name* to “Healthy Streams,” and then **Add** it and close the **Filter** tab. Notice how the number of stations decreases by a lot when this filter is applied.
- Next, use the **Shape History Data Query Tool** again to determine the number of MBSS stations with healthy streams in each physiographic province in the state. Write down these values.
- Lastly, for each physiographic province in Maryland, divide the number of MBSS stations with healthy streams by the total number of MBSS stations (from Step 2), and multiply the result by 100 to calculate the percentage of MBSS streams in each province in Maryland that are healthy.51-239

4. Do provinces differ widely in their percentage of health streams? Why do you think?

- Compare the percentage of healthy MBSS streams in each province in Maryland. Are they similar or do some provinces have more or fewer healthy streams than others?
- Look at land cover data in each province and use this information and the stream health to state (1) where the healthiest streams in Maryland are located and (2) why you think they are found there based on land cover?.