ESTUARY VALUES AND CHANGES

(Background and Teacher Guide)

Along the shores of the Great Lakes are numerous marshes and estuaries. These wetlands support a great diversity of plant and animal life. Abundant aquatic and terrestrial organisms use areas either on a temporary or permanent basis. Unique wetland habitats support a greater variety of plant and animal life than any other area of equal size in the region.

Estuaries are not easily defined. They have traditionally been characterized as the area where fresh water meets the sea and water levels rise and fall with the tides. Estuaries, however, can be more than just an aquatic interface between fresh water and salt water. In a larger meaning, they are the part of the mouth of a stream in which the water level is influenced by the lake or sea into which the stream flows. The chemical contents of the estuary water [salinity or total dissolved solids] are also between those of the stream and the lake or sea. In this case, they occur where rivers meet freshwater lakes. Many different habitats—marshlands, open water, sand beaches, upland forests, even cities and agricultural fields—can merge at these unique areas.

Terrestrial and aquatic vegetation serve several functions in an estuary. Emergent aquatic plants filter out large quantities of nitrogen, phosphorus, pesticides and silt. Subsequently, some of the nutrients and toxins are taken up by the root systems of these aquatic plants. Without estuaries and marshes acting as a natural buffer zone, even greater quantities of pollution would enter the Great Lakes.

Additionally, plants provide a food source for herbivores and detritus feeders (organisms that feed on dead materials), which are the base of the lake food web. The thick layers of foliage in an estuary provide protective breeding and nursery ground for fish and other aquatic animals. Finally estuaries reduce the harmful flooding effects of storms in the Great Lakes watershed by absorbing large quantities of storm water and then slowly releasing the water into the lakes.

Climate change is predicted to increase lake water evaporation and cause lake levels to lower. If this happens, many estuaries could lose their distinct identities. Only those located where the conditions are compatible with the new shorelines will remain.

The following activities explain some of the beneficial environmental functions wetlands contribute and what may happen to some estuaries as climate change occurs.

Additional Resources for Climate Change Impacts on Estuaries

Climate Change and Great Lakes Wetlands (archived webinar)
http://changingclimate.osu.edu/webinars/archives/2011-11-08

EPA - Climate Ready Estuaries
http://epa.gov/cre

Freshwater Estuaries (video)
http://www.youtube.com/watch?v=Eb3B9VaRVHk

What's an Estuary? Now You Know (video, primarily saltwater focus)
http://www.youtube.com/watch?v=XLumSN4G5P4&feature=youtu.be

National Estuarine Research Reserves
http://nerrs.noaa.gov

Old Woman Creek NERR
http://nerrs.noaa.gov/Reserve.aspx?ResID=OWC

Lake Superior NERR:
http://nerrs.noaa.gov/Reserve.aspx?ResID=LKS

Estuaries 101 Curriculum
http://estuaries.gov

Wonders of Wetlands Curriculum
http://wetland.org/education_wow.htm

Teacher Activity A: What is the ecological role of an estuary?

BACKGROUND

To most people, an **estuary** (es-chew-airy) is a place where freshwater meets the sea. In its broader meaning, an estuary is that part of the mouth of a stream in which the water level is influenced by the lake or sea into which the stream flows. The chemical contents of the estuary water [salinity or total dissolved solids] are also between those of the stream and the lake or sea. The Great Lakes have some estuaries. Old Woman Creek on Lake Erie in Ohio and Lake Superior's St. Louis River in Wisconsin and Minnesota have estuaries that have been set aside by the state and federal governments as "state nature preserves" and "national estuarine research reserves." Why should the government bother to preserve estuaries such as Old Woman Creek and the tip of Lake Superior? There are many reasons:

- The estuaries of the world serve as breeding grounds for many important animals that live in deeper waters.
- An estuary has a wide variety of habitats available for wildlife to use as nesting and feeding sites. Thus, estuaries harbor a lot of diversity.
- The sediments and water of an estuary are places where nutrients are recycled and where the basic things needed for life are made available to a wide variety of organisms.
- Estuaries serve as buffer zones to filter pollutants. Runoff from the land is cleansed before it enters a lake or ocean.
- Estuaries also buffer changes in water level. The effects of flooding and water level changes are lessened as water spreads out in the shallow area of the river mouth.
- Estuaries are "endangered ecosystems." Because of their quiet waters and nearness to lakes or oceans, estuaries are often attractive places for marinas, home sites and tourist developments. Few estuaries still exist in their natural conditions.

An estuary contains some areas that are almost always under water, some areas that are almost always dry land, and some areas between these two extremes. Each of these environments has a set of plants that can survive best under the given conditions. Each set of plants has a special role to play in the estuary and contributes to diversity of both plants and animals there.

Objectives: In this investigation, students will examine some of the characteristics of the estuary at Old Woman Creek, near Huron, Ohio.

The things students learn about this estuary will illustrate the importance of estuaries worldwide.

After completing this investigation, students will be able to:

- Describe the methods used by ecologists to sample populations of plant and animal life in aquatic ecosystems.
- Give a general description of the living communities that are found in different depths of water in an estuary.
- Give examples of how plant communities are important to animal life in an estuary.

Materials:	colored pencils	variety of colors per student/group (green, blue, brown, yellow, red)
	rulers	1 set per student/group

Time required: 1-1.5 class periods

ALLIGNMENT

National Framework for K-12 Science Education:
SEP 4: Analyzing and interpreting data
CC 3: Scale, proportion and quantity
CC 7: Stability and change
Core Idea LS 2: Ecosystems: Interactions, Energy and Dynamics

Great Lakes Literacy Principles:
#2c: Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
#5e,f,h: The Great Lakes support a broad diversity of life and ecosystems.
#6: The Great Lakes and humans in their watersheds are inextricably interconnected.

Climate Literacy Principles:
#3a,c: Life on Earth depends on, is shaped by, and affects climate.
#4a: Climate varies over space and time through both natural and mad-made processes.
#7c,e: Climate change will have consequences for the Earth system and human lives.

ENGAGE

Students look at pictures of estuaries across the United States and propose a definition of an estuary based upon characteristics shared by estuaries in the pictures.

Click through various estuaries at ***http://www.nerrs.noaa.gov/ReservesMap.aspx***. Encourage students to look at the Google maps, the photographs and the brief descriptions of each estuary. As a class or in small groups, have students generate a list of characteristics that are common to all estuaries.

Students watch a 3-4 minute video clip introducing wetlands and their components at ***http://www.youtube.com/watch?v=ft_2nj96jLM&feature=related***.

EXPLORE

Students follow instructions to manipulate the map and charts to analyze the vegetation and animals in an estuary.

EXPLAIN

Students answer questions about the types of vegetation and animals in an estuary and their roles in the ecosystem.

Answers to Student Worksheet

1. Marsh, open water and deciduous forest are present within the estuary.
2. Forest plants are rooted in dry soil.
3. Plants could provide nest sites, protection (places to hide), and food for animals.
4. Marsh areas have emergent plants. Some submerged plants are in the open water areas and the marsh.
5. The marsh has the greatest number of animals.
6. Most of the animals are eating or reproducing there.
7. The plants provide food nest sites and protection.
8. Most of the fish listed are plant eaters when they are young. Carp eat plants as adults, too. Songbirds may eat plant seeds.
9. The bottom of the estuary is muddy. This provides the plants with something to hold their roots in place. The plants in the estuary tend to slow down the stream's flow. When water slows down, it cannot carry as much sediment. Much of the stream's load of sediment is, therefore, deposited in the shallow areas where plants are rooted in the water. Pollutants suspended in the water may also be trapped in the estuary this way.
10. An estuary is that part of the mouth of a stream in which the water level is influenced by a lake or ocean into which the stream flows.
11. The water level must have been higher when the picture was taken than when the computer map was made.

EXTEND

Sample extension activities

1. Discuss how the roles of plants might vary in different depths of water in an estuary.
2. Refer to the computer map noting the different types of land uses in the region. What impact could land use have on the estuary? Research examples you can use to support your answer.
3. Look at the map of the Lake Superior National Estuarine Research Reserve at ***http://lsnerr.uwex.edu/maps-data.html***. Compare and contrast the vegetation found at Lake Superior NERR with that found at Old Woman Creek. What land use issues might arise here that would be different from those at Old Woman Creek?

EVALUATE

Sample evaluation questions

1. Define estuary. Where are estuaries found in the Great Lakes? [An estuary is the part of the mouth of a stream in which the water level is infuenced by the lake or sea into which the stream flows. There are many estuaries in the Great Lakes, but Old Woman Creek National Estuarine Research Reserve on Lake Erie and the Lake Superior National Estuarine Research Reserve are recognized nationally.]
2. What are some of the functions served by estuaries that affect an ecosystem? [Estuaries provide breeding, nesting and habitat sites; filter nutrients, sediment and pollutants from water; and lessen the effects of flooding because of water level changes.]
3. Give a general description of the types of plants found in different depths of water in an estuary. [Submerged plants have their roots and leaves under water. Emergent vegetation has roots in water, but leaves and seeds emerge into the air. Some emergent vegetation may float on the surface in deeper water, while be rooted into sediment in shallower waters.]
4. List some ways in which plants are useful to animals in the estuary. Are there ways that animals are useful to plants? [Plants provide a food source for herbivores, omnivores and detritus feeders (organisms that feed on dead materials. The thick layers of foliage in an estuary provide protective breeding and nursery grounds for fish and other aquatic animals. Animal waste, as well as dead and decaying animals are sources of recycled nutrients like nitrogen and phosphorus needed by plants.]
5. Describe a method by which scientists can sample a community. What do you think are the challenges in trying to find a representative sample of all of the organisms in an estuary? [In population sampling, a portion of the organisms in a given area are identified and counted and then an estimate of the total population is made. Satellite imagery and aerial photography can also help scientists determine biodiversity in large areas.]

ADDITIONAL RESOURCES

The Swamp in OSU's Backyard fact sheet: ***http://changingclimate.osu.edu/features/the-swamp/***

Names _____ Period _____

Student Activity A: What is the ecological role of an estuary?

BACKGROUND

To most people, an **estuary** (es-chew-airy) is a place where freshwater meets the sea. In its broader meaning, an estuary is that part of the mouth of a stream in which the water level is influenced by the lake or sea into which the stream flows. The chemical contents of the estuary water [salinity or total dissolved solids] are also between those of the stream and the lake or sea. The Great Lakes have some estuaries. Old Woman Creek on Lake Erie in Ohio and Lake Superior's St. Louis River in Wisconsin and Minnesota have estuaries that have been set aside by the state and federal governments as "state nature preserves" and "national estuarine research reserves." Why should the government bother to preserve estuaries such as Old Woman Creek and the tip of Lake Superior? There are many reasons:

- The estuaries of the world serve as breeding grounds for many important animals that live in deeper waters.
- An estuary has a wide variety of habitats available for wildlife to use as nesting and feeding sites. Thus, estuaries harbor a lot of diversity.
- The sediments and water of an estuary are places where nutrients are recycled and where the basic things needed for life are made available to a wide variety of organisms.
- Estuaries serve as buffer zones to filter pollutants. Runoff from the land is cleansed before it enters a lake or ocean.
- Estuaries also buffer changes in water level. The effects of flooding and water level changes are lessened as water spreads out in the shallow area of the river mouth.
- Estuaries are "endangered ecosystems." Because of their quiet waters and nearness to lakes or oceans, estuaries are often attractive places for marinas, home sites and tourist developments. Few estuaries still exist in their natural conditions.

An estuary contains some areas that are almost always under water, some areas that are almost always dry land, and some areas between these two extremes. Each of these environments has a set of plants that can survive best under the given conditions. Each set of plants has a special role to play in the estuary and contributes to diversity of both plants and animals there.

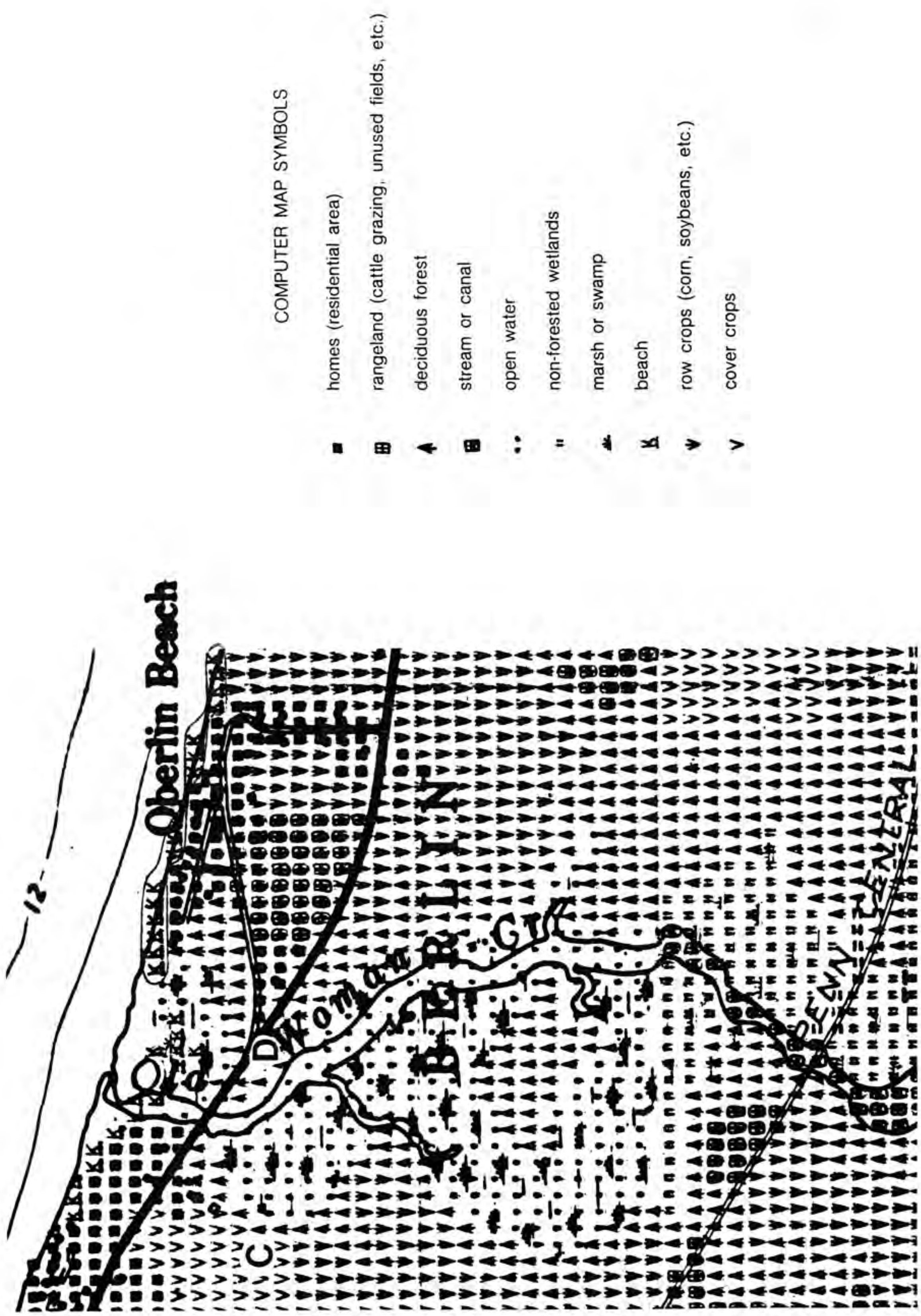
1. Figure 1 is an aerial photograph of the Old Woman Creek estuary, east of Huron, Ohio, on the shoreline of Lake Erie. In this image the opening of the creek is directly in front of the bridge.

Figure 1. Aerial photograph of Old Woman Creek Estuary

2. Figure 2 shows the land use and plant types (called "vegetation") in the same area. Each symbol drawn by the computer stands for the main characteristic of an area equal to about ¼ of an acre. One-quarter of an acre is equal to about 930 square meters, a bit bigger than the average school classroom.

Names ______________________________ Period __________

Figure 2. Computer-generated Map of Old Woman Creek Estuary.



Names _____ Period _____

With your pencil, outline the main parts of the Old Woman Creek estuary on the Figure 2 computer map:

a. Outline the beach area (marked K). One beach that runs along the shore at Oberlin Beach has been outlined as an example. West of Oberlin Beach lies the mouth of Old Woman Creek and another beach begins just west of that. NOTE: The mouth of the creek (where it joins the lake) is drawn in one place near the word "Old," but there is really a sand spit there that shifts back and forth over time. Figure 1, taken at a different time, shows another possible position of the spit.

b. The estuary itself is surrounded almost entirely by deciduous forest (marked with a tree). Look on either side of the creek and find the border of the forest. Draw a line that separates the forest from the estuary. You will also find a patch of forest just below the "B" in BERLIN. Outline this forest with another line.

c. Use colored pencils to shade in the following features:

- Green → forest on border of estuary and on the island
- Blue → the open water of the lake and the main stream channel
- Brown → the marshy and non-forested wetland areas of the estuary
- Yellow → the beach
- Red → residential areas

Sampling the Populations

3. Ecologists use a transect as a way to sample the populations of living things in a community. For example, by naming and counting the plants along a transect, they get an idea of what the whole plant community is like, without counting and naming every organisms in the whole community.

   With your ruler, draw a line straight across Figure 2 between points C and D. This will be called your TRANSECT line.

4. Figure 3 represents your transect line and the plants that might be found along it. It is drawn as a profile so you can tell the location and depth of the water. Figure 3 represents a transect approximately 2.3 times as long as line C-D in Figure 2. That means all its parts are that much bigger.

   Label the parts of Figure 3 to show the type of features (from the computer map) that your transect line crosses. Then turn to the Plant List for a description of the plants.

Answer the following questions using the figures.

1. What three types of features (see the symbols) are now shown to lie within the estuary itself?

2. Which area of the estuary has plants rooted in fairly dry soil?

3. What do these plants provide for the animals that live nearby?

4. What areas have plants with roots submerged (underwater) but leaves emergent (sticking out of the water)? Which areas have plants totally submerged?

Names _____ Period _____

Each of the areas crossed by the transect line is able to support a group of animals. Suppose the area is watched for one week. Figure 4 is a list of the larger animals that might be seen and their activities. Remember, these plant communities and their animal visitors are only being SAMPLED. There are many more organisms in the estuary than we have mentioned here.

5. In which part of the estuary would you find the largest number of animals?

6. What are the two main activities carried on by animals in this area?

7. Look at your answers to questions 5 and 6. Why would an area with many aquatic (water) plants be visited by such a large number of different animals? (Hint: See the list of animal activities in Figure 4.)

8. Perhaps you have listed "eating" in some of your answers above. Which of the animals in Figure 4 might be using the marsh plants as food?

9. What is the bottom of the estuary marsh probably like: muddy or rocky? Why do you think so?

The plants in the estuary tend to slow down the stream's flow. When water slows down, it cannot carry as much sediment. Much of the stream's load of sediment is, therefore, deposited in the shallow areas where plants are rooted in the water. Pollutants suspended in the water may also be trapped in the estuary this way.

10. Much of the Old Woman Creek area marked "marsh" on the computer map does not appear that way in Figure 1. An estuary isn't always marshy and a marsh isn't always an estuary. Look back at the introduction and find the "larger meaning" of the term estuary. What is the larger meaning of the term estuary?

11. Based on this definition, why doesn't the Figure 1 photograph show much marshy area?

Names _____ Period _____

Figure 3. Transect and Profile Across Old Woman Creek estuary.

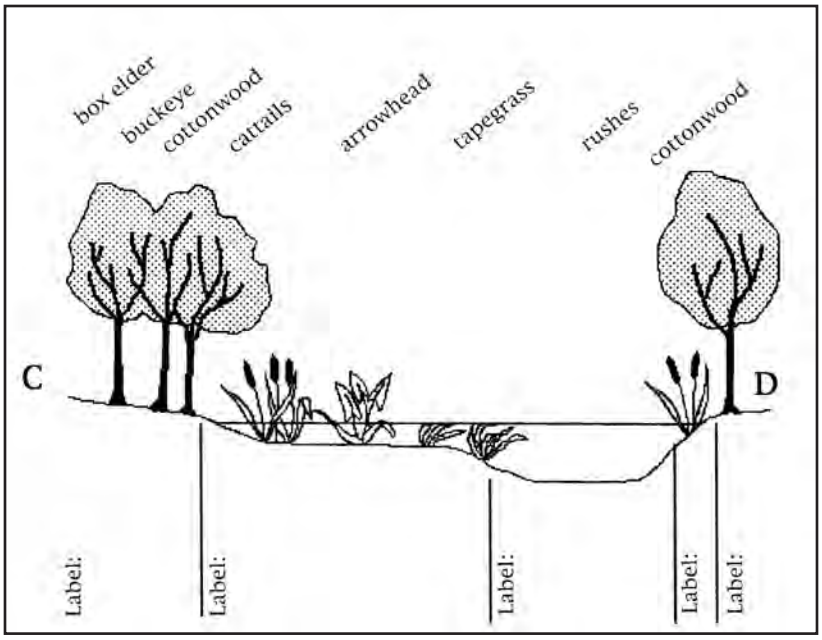


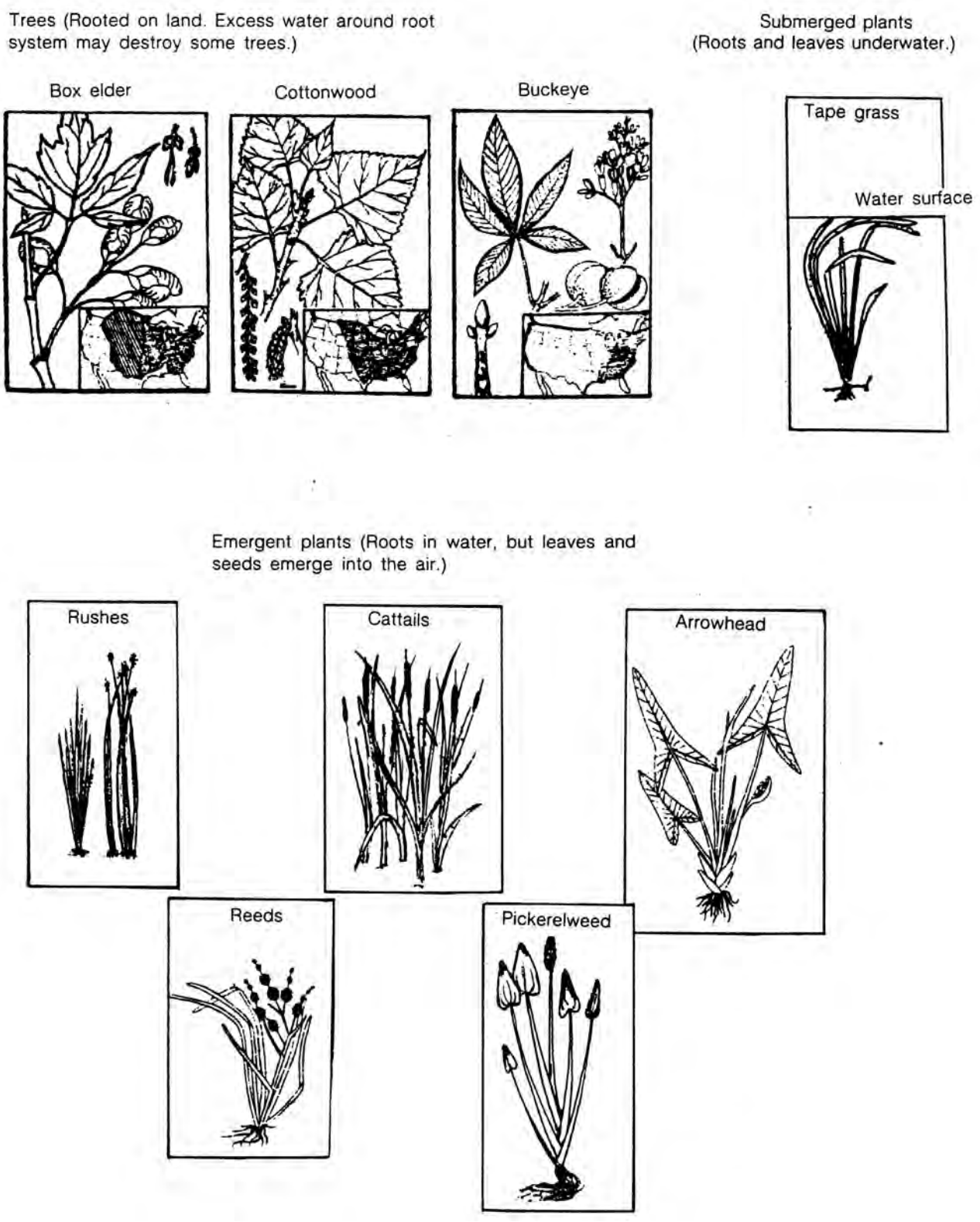
Figure 4. Animals' Use of the Transect Area of Old Woman Creek Estuary.

Animals observed in a typical Great Lakes estuary during one week

			ACTIVITY				
ANIMAL	HOW MANY	AREA	HUNTING	EATING	REPRODUCING	HIDING	OTHER
Raccoon	1	forest edge		X			washing food
White-tail deer	2	forest		X		X	drinking
Fox	1	forest	X	X			
Songbirds	21	forest edge		X	X		nesting
Blacksnake	1	forest	X			X	
American egret	8	forest			X		nesting
American egret	15	marsh	X	X			
Green heron	2	marsh	X	X			
Kingfisher	4	marsh	X	X	X		
Watersnake	1	marsh	X	X			swimming
Seagull	4	marsh		X	X		
Carp	8	marsh		X	X		
Yellow perch	60	marsh		X	X		
Yellow perch	12	open water		X			swimming
Freshwater drum	9	marsh		X			
Gizzard shad	150	marsh			X		swimming
Gizzard shad	30	open water		X			
Clam	17	marsh mud		X	X		
Emerald Shiner	42	open water		X			
Walleye	84	marsh		X	X		

Names _____ Period _____

Figure 5. Macroscopic Plants of the Estuary (Old Woman Creek)



Updated from the activity in ES-EAGLS – *Life in the Great Lakes* © The Ohio State University, 1997

Originally modified from OEAGLES EP-016A, "The Estuary: A Special Place." By Rosanne W. Fortner and Ron Mischler

Teacher Activity B: How do estuaries impact nutrients entering a lake?

BACKGROUND

How do phosphorus and nitrogen get into the Great Lakes? One way is from water runoff. Rainwater falling on farm fields, parking lots, roads and backyards flows into creeks, streams and rivers. The rainwater carries soil, fertilizers and pollution that have washed from the land. You have probably seen how much more water creeks carry just after a storm and how muddy the water looks. Eventually, all this water runs into the lakes, bringing nutrients and other chemicals with it.

Objectives: Students analyze a map and data to learn how estuaries affect nutrient levels as water enters a lake. They make predictions about how the effects of climate change might affect an estuary's ability to improve water quality. After completing this investigation, students will be able to:

- List sources of nutrient inputs to Lake Erie.
- Explain how estuaries can improve water quality.
- Discuss how varying lake levels might affect an estuary's ability to function properly.

Materials:	Nitrate and phosphate data chart [included]	1 per student/group
	Map of Old Woman Creek [included]	1 set per student/group
	Graph paper [included]	1 set per student/group
	Colored pencils (3 colors)	1 per student/group
	2 glass jars, soil, water	1/class demonstration

Time required: 1-2 class periods

ALLIGNMENT

National Framework for K-12 Science Education:
SEP4: Analyzing and Interpreting data
CC3: Scale, proportion and quantity
CC5: Energy and matter: Flows, cycles and conservation
Core Idea LS2: Ecosystems: Interactions, Energy and Dynamics

Great Lakes Literacy Principles:
#1d: The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.
#5f,h: The Great Lakes support a broad diversity of life and ecosystems.
#6d,e: The Great Lakes and humans in its watershed are inextricably interconnected.

Climate Literacy Principles:
#3c: Life on Earth depends on, is shaped by, and affects climate.
#7e: Climate change will have consequences for the Earth system and human lives.

ENGAGE

Students watch a demonstration to visualize how an estuary serves as a filter. Let students know that what they are seeing in the demonstration will help understand what is going on later in the activity. Teachers may want to refer back to the two jars as the lesson progresses.

1. Fill two jars half full of water. Put a handful of soil into each jar.
2. Allow Jar A to be still so the soil settles to the bottom of the jar.
3. Shake Jar B so the water and soil are moving quickly and get mixed together.
4. Pose these questions to students:
    a. Which jar represents water in a creek soon after a storm? [Jar B]
    b. Which jar represents water in a creek when there hasn't been a storm? [Jar A]
    c. Why does creek water look muddy or cloudy after a storm? What has happened? [Following a storm, creek water is muddy from carrying soil and nutrients, and it is moving very quickly.]
    d. How long might it take for creek water to return to a clearer state? [This will vary, but is heavily dependent on the frequency and size of storm events.]
    e. What kinds of things in an ecosystem influence how fast a creek returns to a clearer state? [These will vary, but will include the frequency and size of storm events, the amount of sediment and runoff from solid surfaces, and types and quantities of vegetation in and around a creek.]

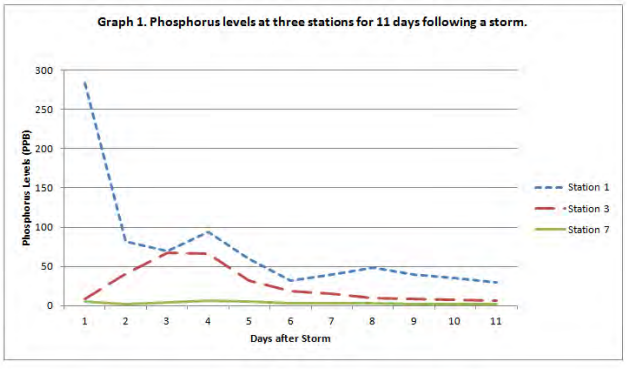
EXPLORE

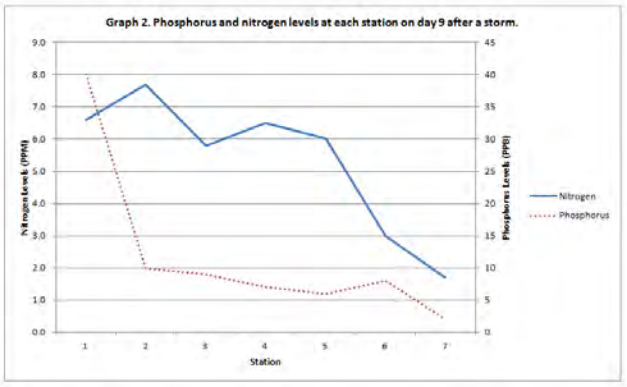
After analyzing a map and graphing data, students draw conclusions about nutrient levels at various points in an estuary.

Teacher's Notes:

- If modifying the activity for lower-level students, consider putting labels and scales on the graph axes before giving the activity to students.
- The best way to construct graph 2 is to label and make a scale for phosphorus on the left Y-axis, and then label and make a scale for nitrogen on the right Y-axis. List the station numbers along the X-axis.

Sample Graphs:





EXPLAIN

Students answer questions comparing and contrasting nitrogen and phosphorus levels at different points in an estuary and at different times. They also make predictions about the effects of severe weather events on nutrient levels and the functioning of an estuary.

Answers to Student Worksheet

Analyzing Maps

1. The creek flows north into Old Woman Creek Estuary and then empties into Lake Erie.
2. US Highway 6, Ohio routes 2 and 61, and other roads run through the watershed. There are also several farms. Runoff water from roads and farms will carry pollutants.
3. There are seven water test stations in or near the estuary. Station 1 is closest to where the creek enters the estuary. Station 7 is near the entrance of the creek into Lake Erie.

Analyzing Data

1. Phosphorus levels were highest one day after the storm and lowest 11 days after the storm's onset. At day 1, a lot of runoff water was entering the estuary. This water contained high concentrations of phosphorus. By day 11, there was much less runoff from the storm. Thus, fewer nutrients were being carried into the estuary.
2. Peak phosphorus concentrations occurred on day 3 at Station 3 and on day 4 at Station 6. Stations 3 and 6 are located further downstream in the creek. Water from the creek reaches Station 1 first, then Station 3, then Station 6. Nutrients such as phosphorus being carried by the water reach these stations in the same order.
3. Peak nitrogen concentrations occur at Station 1 on day 4, at Station 3 on day 6, and at Station 7 on day 8. Nitrogen concentrations are following the same general pattern as phosphorus concentrations. The peak concentration of nitrogen occurs at upstream stations before occurring downstream.
4. By day 9, the peaks in phosphorus and nitrogen concentrations have occurred at each of the stations.
5. Phosphorus concentrations on day 9 are highest at Station 1 and lowest at Station 7. This suggests that nutrients are removed as the water passes through the estuary before entering Lake Erie.
6. Nitrogen concentrations are the highest at Station 2 and the lowest at Station 7. Forms of nitrate and phosphate can be dissolved in the water, suspended as particles, or attached to sediments.
7. Following a storm, creek water is muddy from carrying soil and nutrients and it is moving very quickly. As water flows through the estuary, its movement is slowed. Much of the sediment, soil and nutrients in the water settle out as the water slows down. Thus, the water reaching downstream stations is clearer and has lower concentrations of nutrients than the water flowing through the upstream stations.
8. Plants in the estuary need phosphorus and nitrogen as nutrients to grow. Thus, plants in the estuary take up and use phosphorus and nitrogen from the creek water as it passes through the estuary. The plants filter out nutrients that they need from the creek water. This is another reason why fewer nutrients reach the downstream stations.
9. Because of the estuary's filtering action, water entering the lake will contain fewer nutrients than it otherwise would. Many of Lake Erie's water problems result from too many nutrients entering the lake. Estuaries may improve water quality in the lake by reducing the nutrients in it.

EXTEND

"Nutrients in an Estuary" is part of NOAA's *Estuaries 101* curriculum. In this activity, students build a model of an estuary, analyze nitrogen and dissolved oxygen data at various points in an estuary, and use Google Earth to analyze land use in a watershed to determine possible sources of pollutants and sediment entering an estuary. It can be accessed at ***http://estuaries.noaa.gov/Doc/PDF/LS2_NutrientsEstuary.pdf***.

EVALUATE

Sample evaluation questions

1. How do estuaries act as "sinks" and "sponges" to improve the quality of water going through them and reaching a lake? [Plants in the estuary take up and use the nutrients they need from the water passing through the estuary, thus acting as sponges. As water flows through the estuary, its movement is slowed. Much of the soil and nutrients in the water settle out as it slows down. Thus, the wetlands act as nutrient sinks. Estuaries may improve the water quality in the lake by reducing the amount of nutrients entering the lake.]
2. What happens when nutrients are readily available in, or are added to, a lake? [The nutrients act as a fertilizer, allowing plants to grow. Adding nutrients increases plant growth, especially the growth of algae. The algae may be green or blue-green depending on what nutrients are available.]
3. What are some of the human-produced sources of nutrients entering a lake? [Nutrients enter the lake from runoff from farms, parking lots, roads and yards. This runoff contains soil, fertilizers and pollution it has carried from the land.]
4. Think back to the demonstration with the two jars. Which jar could represent station 1? Which jar could represent station 7? How do the jars show how an estuary can act as a filter? [Station 1: Jar B; Station 7: Jar B; The jars represent water clarity and nutrient concentrations as water moves in an estuary. As the water flows through the estuary, its movement is slowed. Much of the sediment, soil and nutrients in the water settles out as the water slows down. Thus, the water reaching downstream stations (leaving the estuary) is clearer and has lower concentrations of nutrients than the water flowing through the upstream stations.]

REFERENCES

Krieger, K. A. 2003. Effectiveness of a Coastal Wetland in Reducing Pollution of a Laurentian Great Lake: Hydrology, Sediment, and Nutrients. *Wetlands*, 23(4): 778-791.

Pinckney, James L. et al. 2001. The Role of Nutrient Loading and Eutrophication in Estuarine Ecology. *Environmental Health Perspectives* 199(5): 699-706.

Niemi, Gerald J et al. 2009. Development of ecological indicators for the U.S. Great Lakes coastal region - A summary of applications in Lake Huron. *Aquatic Ecosystem Health and Management* 12(1): 77-89.

Herdendorf, Charles E. 1991. Recovering from phosphorus enrichment. In, Rosanne W. Fortner and Victor J Mayer (eds.), *The Great Lake Erie*. Ohio Sea Grant. p. 136.

Klarer, D. 1988. "The role of a freshwater estuary in mitigating storm water inflow." OWC Technical Report #5. Huron, OH: ODNR Division of Natural Areas and Preserves.

Leary, Nelson H. 1985. Those summertime blue-greens. *The Conservationist*. July/August, p. 9.

Reutter, Jeffrey M., Frank R. Lichtkoppler and Charles E. Herdendorf. "Lake Erie: Phosphorus and Eutrophication." Ohio Sea Grant Fact Sheet #15.

Name _____ Period _____

Student Activity B: How do estuaries impact nutrients entering a lake?

BACKGROUND

How do phosphorus and nitrogen get into the Great Lakes? One way is from water runoff. Rainwater falling on farm fields, parking lots, roads and backyards flows into creeks, streams and rivers. The rainwater carries soil, fertilizers and pollution that have washed from the land. You have probably seen how much more water creeks carry just after a storm and how muddy the water looks. Eventually, all this water runs into the lakes, bringing nutrients and other chemicals with it. The water in Old Woman Creek runs through the estuary and into Lake Erie.

In this activity, you will analyze maps and data to learn how estuaries affect nutrient levels as water enters a lake. You will also make predictions about how the effects of climate change might affect an estuary's ability to improve water quality.

Use the maps and data table provided at the end of the activity.

Analyzing Maps

1. Use Google Maps to view Old Woman Creek. Look at the land surrounding the creek. All the land within the dotted line on Figure 1 is the watershed of Old Woman Creek. Water from this land runs off into Old Woman Creek, then through Old Woman Creek Estuary, before reaching Lake Erie. A watershed is all of the land drained by a creek, stream or river. From the satellite image, are there any roads or farms in the Old Woman Creek watershed? How might these affect the water entering the creek?

2. The numbers on the map shows places in the estuary where scientists have tested the creek's water to see how much phosphorus and nitrogen it contains. How many test stations are located in or near the estuary? Which station is nearest to the lake? Which is nearest where the creek enters the estuary?

Name _____ Period _____

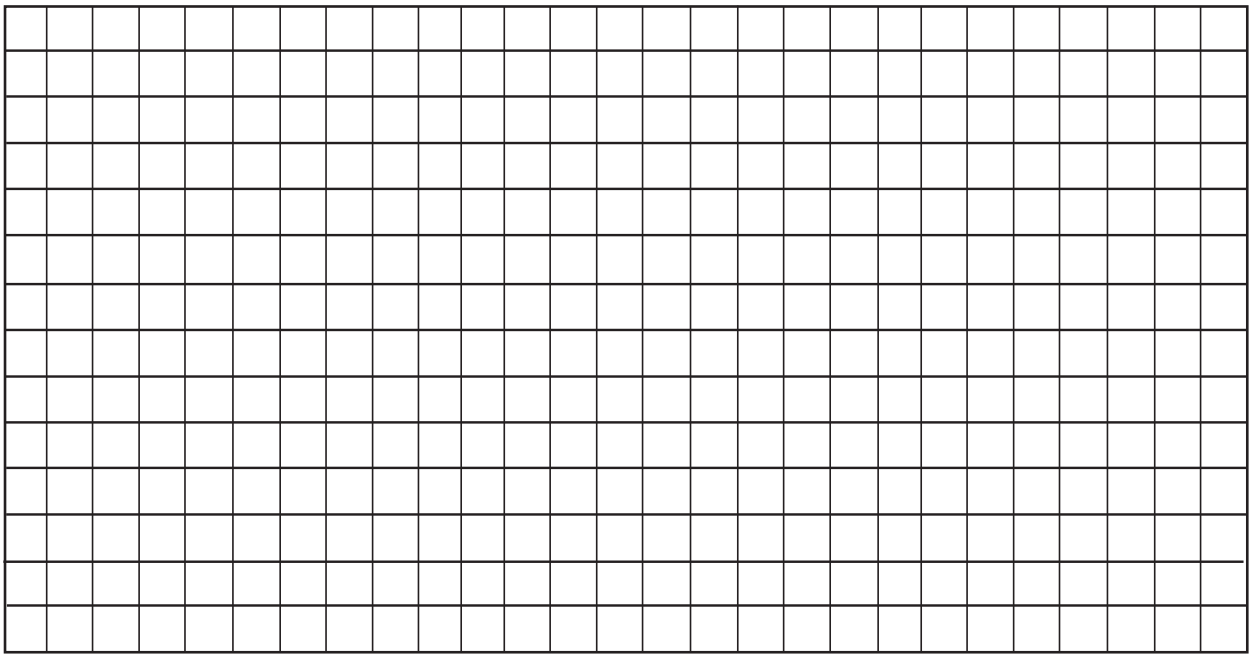
Analyzing Data

Construct two graphs.

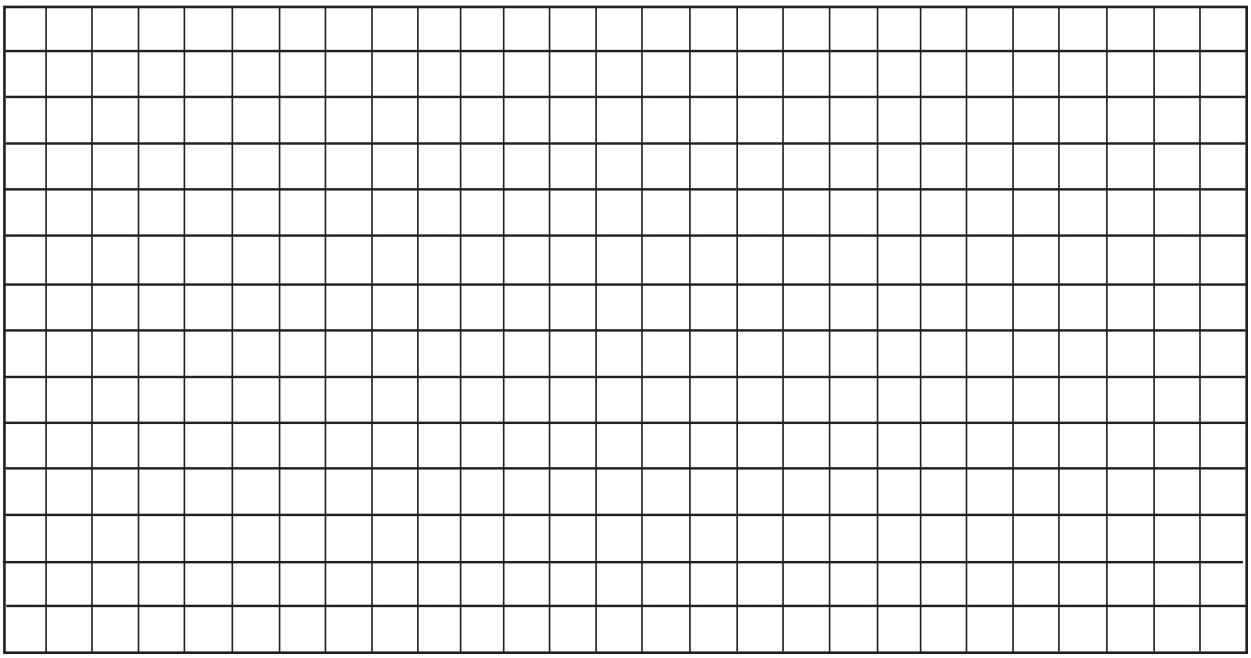
First, graph the concentrations of phosphorus at Station 1, Station 3 and Station 7 in the estuary for each day after the storm from day 1 to day 11. Make a line graph and remember to add a key to identify your lines.

Second, graph the concentrations of phosphorus and nitrogen at each station in the estuary on day 9. Make a bar graph and remember to add a key to identify your lines. Note: nitrogen and phosphorus are not measured in the same units.

Graph 1. Phosphorus levels at three stations for 11 days following a storm.



Graph 2. Phosphorus and nitrogen levels at each station on day 9 after a storm.



Name _____ Period _____

Questions

1. At Station 1, how many days after the storm were phosphorus levels the highest? When were phosphorus levels the lowest? How can you explain this?

2. What day did peak phosphorus concentrations (highest) occur at Station 1? Station 3? Station 7? What relationship do you see between station locations and the time when phosphorus concentrations peaked at those locations? Suggest an explanation for this trend.

3. On what day do the peak concentrations of nitrogen occur at each station? Does it seem that the peak nitrogen concentrations are following the same kind of pattern the peak phosphorus concentrations showed?

4. By day 9, have the peaks in phosphorus and nitrogen concentrations occurred at all seven stations?

5. For Day 8, at which station are phosphorus concentrations the highest? At which station are they the lowest? What might this suggest about the action of the estuary on water flowing through Old Woman Creek?

6. At which station are nitrogen concentrations the highest? At which are they the lowest?

7. Where do you think estuary water will be the muddiest? Where will it be the clearest? What is one reason why phosphorus and nitrogen levels are lower at Station 7 than at Station 1?

8. The estuary has many plants growing in it. How might the plants affect the nutrients reaching each station?

9. How might an estuary's action as a sink and sponge for nutrients affect the lake into which the creek empties?

Name _____ Period _____

Figure 1. The Old Woman Creek Watershed with Water Test Stations

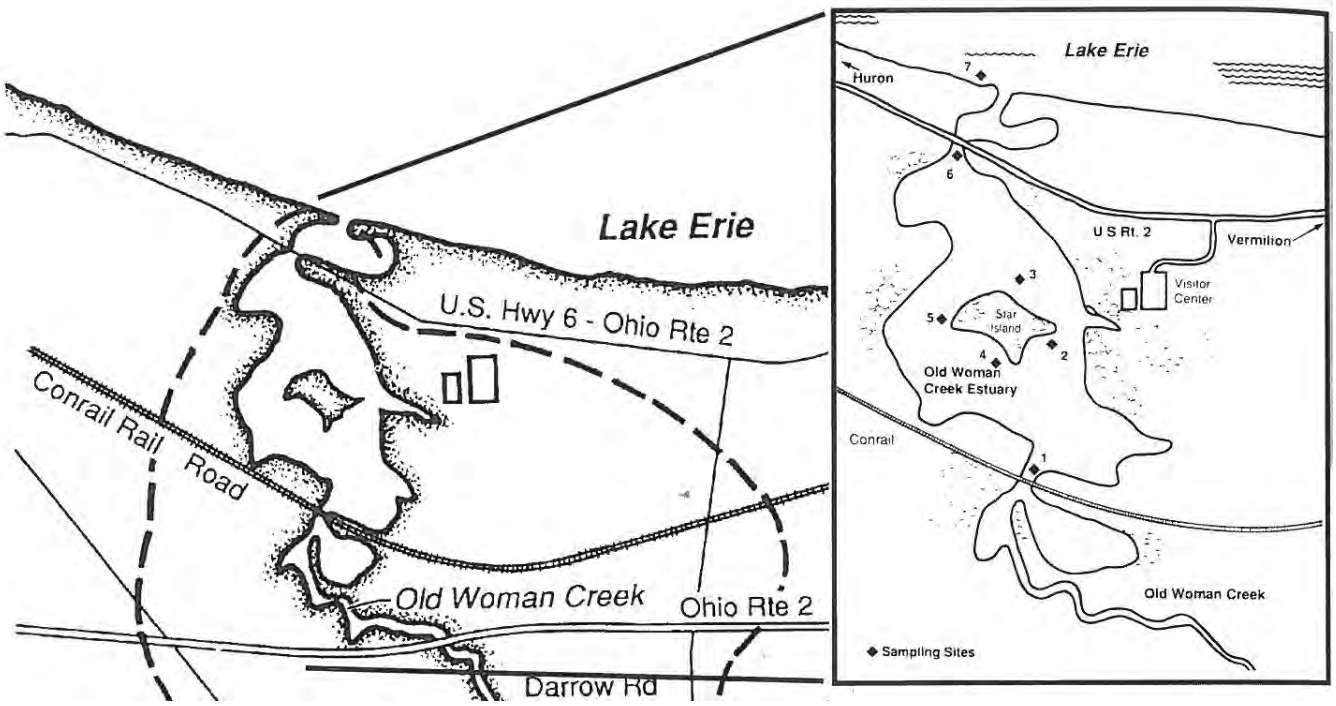


Figure 2. Changes in nitrate (nitrogen) and phosphate (phosphorus) concentration in water at sites along Old Woman Creek following a storm.

Station	NITROGEN LEVELS (PPM) DAYS AFTER STORM										
	1	2	3	4	5	6	7	8	9	10	11
1	283	82	70	94	60	32	40	49	40	35	30
2	104	97	79	79	50	35	21	12	10	7	3
3	9	41	67	66	32	19	15	10	9	8	7
4	9	7	35	28	29	11	11	10	7	5	3
5	8	11	10	22	20	16	12	10	6	3	2
6	9	5	10	26	19	11	10	10	8	6	5
7	5	2	4	6	5	3	3	3	2	2	2
Station	**PHOSPHORUS LEVELS (PPB) DAYS AFTER STORM**										
	1	2	3	4	5	6	7	8	9	10	11
1	6.5	6.9	9.7	12.4	10.5	9.5	7.8	6.5	6.6	6.5	6.6
2	1.5	3.3	6.1	8.7	9.0	10.1	9.0	8.0	7.7	6.5	5.9
3	0.4	1.9	2.8	7.6	5.4	9.9	8.0	6.8	5.8	4.1	2.3
4	0.2	0.3	2.4	3.3	5.1	8.8	8.7	8.4	6.5	4.8	2.2
5	0.2	0.8	0.6	2.6	4.9	9.7	7.8	6.9	6.0	4.1	2.3
6	0.5	0.5	2.0	3.4	3.4	3.4	3.3	3.3	3.0	2.7	1.7
7	0.9	1.0	1.1	1.4	1.6	1.7	2.0	2.1	1.7	1.5	1.2

Updated from the activity in *GLIMCES* © The Ohio State University, 1995