The Surge of the Storm
By Margaret Olsen and Katie Greganti

Grade Level: 5-12
Type of Activity: Hands on

Focus Question: How does a hurricane's storm surge of a hurricane affect the low-lying areas along the coast?

**Objectives: The student will:**
1. Investigate the effects of hurricane storm surge on low-lying areas near the coast
2. Determine the distance inland that the storm surge will reach
3. Simulate the destructive force of a storm surge

Materials: (per group)

- Long plastic container such as an under the bed storage container or stream table
- Milk jug or pitcher
- Sand
- Water
- A variety of materials such as Lego blocks, Monopoly houses or other items with which to build houses (such as shells, sticks, rocks, leaves, grass, straws, cardboard, etc.)
- Sponges (to be cut up and placed to represent the marsh)
- Tiny toy animals, people, cars, etc.
- Plastic straws (to place the houses on stilts-optional)
- Block of wood, fan, hair dryer (some source of wave energy)
- Erasable markers
- Paper towels for clean-up

Safety Note: If a hair dryer or fan is used, take special care that they do not come in contact with the water.

Key Words: Hurricane, Storm Surge, Natural disaster, Flooding, Tidal Influences
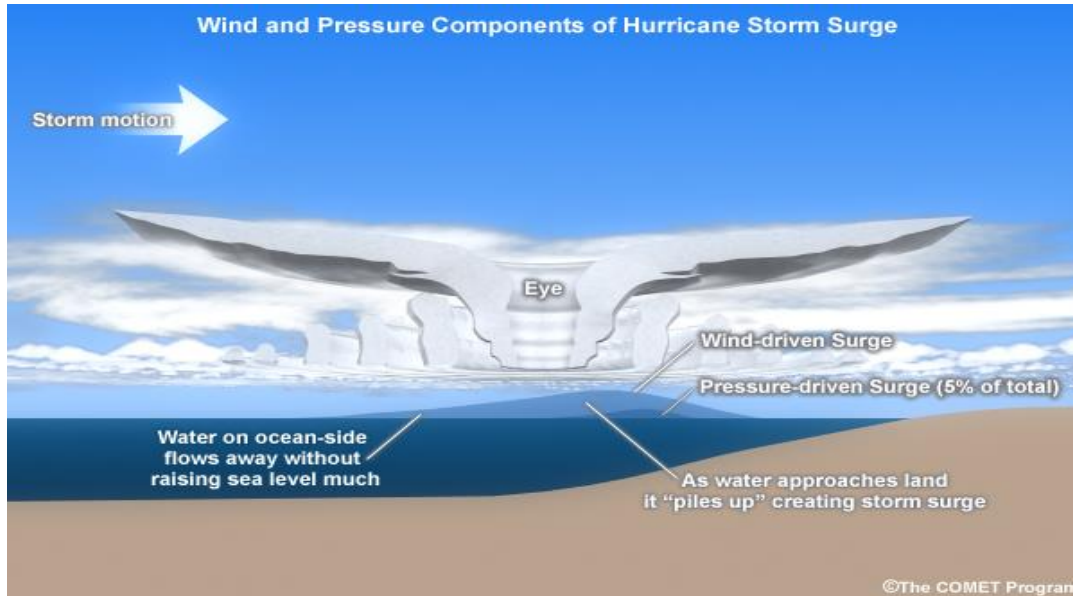
Storm surge graphic depicting wind-drive surge and pressure-driven surge as effects of a hurricane. Image credit:
http://www.nhc.noaa.gov/surge/images/surgebulge_COMET.jpg

A storm surge is a mound of ocean water that moves ashore with a hurricane. It is caused by high winds of a hurricane pushing on the ocean's surface and the low pressure at the hurricane's center. Strong hurricane winds cause ocean water to pile up in a mound under the eye of the storm. A storm surge can increase water levels up to 20 feet higher than normal and can be 50 to 100 miles wide. Though most storm surges are related to hurricanes, some smaller storms can create surges.

Many areas along the southeast coast (the South Atlantic Bight region) have long, gently sloping continental shelves and the water is relatively shallow for miles off the coast. Areas such as this have smaller waves but are susceptible to higher storm surge. This is because in deeper water, the storm surge can be translated down through the ocean. But when a storm surge enters shallow water, there is nowhere for the water to go and it is driven ashore by strong winds of the hurricane. The topography (shape of) the ocean floor, along the coast and the mainland, also will determine the extent of the effect of the surge. Low lying island and mainland areas that are less than a few meters above sea level are at greater risk of inundation by the storm surge. The storm surge and the flooding that it brings are responsible for nine out of ten deaths during hurricanes.

Storm surges cause even greater damage if they occur at high tide when the water level is higher. If a storm surge arrives onshore at low tide, the mound of water may not reach much farther inland than a normal high tide. When a storm surge reaches land during high tide, the ocean is already high on the beach allowing the storm surge to reach further inland towards homes and business.

Procedure:

1. Read everything under the procedure before beginning this investigation.

2. Obtain all materials

3. Fill one half of the large plastic container or stream table with sand. The sand will represent the land. The now empty part of your container is where the ocean will be.

4. Down the center of the sand create a meandering river by running your finger through the sand – meanders are curves in the river. (you may need to moisten the sand in order to mold it)

5. Near the ocean side of your land, create several smaller, curving waterways that branch off the main river. These are tidal creeks and they should also be curved. They should be deeper at the river's edge and become shallower the farther away from the river they go.

6. On either side of your river (near the ocean side) create low areas in the sand and place pieces of damp sponge in these areas. These are the salt marshes. You may also add freshwater marshes upland from the ocean.

7. At the mouth of river, use some of the sand to create an oval shaped barrier island. This should be several inches toward the ocean from the mouth of the river. The island should not completely block the mouth of the river, (Some of the ocean water should have access to the river)

8. Slowly add water to the ocean side of your container. You should add enough water to surround the island and enter the mouth of the river. Do not completely cover the island.

9. On the island, add some houses (some should be on stilts), hotels, cars, animals, and people.

10. Along the river add towns (houses, factories, cars, animals and people)

11. On the outside of your container, use an erasable marker and place a mark every inch from the ocean edge of the island all the way up the river. The mark at the edge of the island should be the 0 mark. Label each mark 0, 1, 2, 3, etc. where each mark represents one inch).

12. Use the block of wood and very gently tap the water (ocean) by moving it in an up and down motion to create mild waves. If you are using a hair dryer or some other source for wind, turn it on low. Hold the hair dryer or wind source a little distance away from the water so that the wind you produce will be gentle. ***If you are using a hair dryer to create wind, remember to be careful and keep this away from the water.*** Observe what happens to your island and the marshes and mainland behind the island. Record the distance these normal waves are felt inland in the data table in Observations #1. Answer questions # 2 and #3.

13. Next create a mild storm by creating waves with a stronger force. Do this by pushing the block of wood up and down into the water with more force than

before – but not too strongly. If you are using a wind source, increase the speed or move the wind source closer to your model if possible. ***Remember to be careful and do not let the hair dryer too near the water.*** Observe what happens in your model. Record the distance inland the effects of the storm were felt in the data table and answer question # 4, #5 and #6.

14. **Read this part carefully before beginning**!!! Next you are to create a hurricane storm surge. To do this you will need to push water from the ocean onto the island and mainland. Use the block of wood to force the water from the ocean onto the island and mainland.   At the same time, pour additional water into the model to represent the heavy rainfall during a hurricane. If you are using a wind source, turn it on high or move it as close as you can to your model. ***Remember to be careful and keep this away from the water.*** Answer observation question #7.

15. Answer the remaining observation questions and prepare your conclusion.

Observations:

1. Data Table:

Type of disturbance	Distance felt inland
Gentle waves	
Mild Storm waves	
Storm Surge	

2. Describe what happened in your model when you created mild waves (and wind).

3. Which area of your model received the most affect from the waves? Explain why this happened.

4. Describe what happened when you created a mild storm in your model.

5. Which area of your model received the most affect from the waves?

6. Explain how barrier islands help to protect the mainland from the effect of storms.

7. Describe what happened in the model when you created the hurricane storm surge. Explain what happened inland and up the river.

8. Was any area of your model "safe" from the storm surge during your "Hurricane"? Explain your answer.

9. If an evacuation had been ordered, how far should the people travel from the shore in order to be out of harms' way? Support your answer using ideas from the model and further research if necessary.

10. What recommendations would you make to a developer who is interested in building on coastal properties?

11. Discuss the affects of pollutants and runoff from the land on the surrounding aquatic life.

12. Describe how the effects of a storm surge can impact the lives of the people living in that area and the economy of the community.

Conclusions: Discuss what a storm surge is and how it is produced. Include a discussion of how the storm surge of a hurricane affects the low-lying areas along the coast.

Extensions:
1. Repeat the activity to investigate the effects to the surrounding aquatic ecosystems. Devise some means of adding coloring to the water to represent sewage, chemical contamination and runoff. Some suggestions might be to add colored tissue paper under the houses and factories or place small containers of water dyed with food coloring in various places under the sand near some of the houses and factories. You could also add things like dirt, tea leaves or coffee under some areas of the sand to represent siltation. Discuss the affects of pollutants and siltation on the surrounding aquatic life.
2. Have the students create a campaign to educate coastal developers and real estate agents about the hazards of building too close to the ocean.

Websites: NOAA has information and photos related to storm surge. A simple Google search for NOAA Storm Surge will return many results that can provide reference materials for your classroom.