Hurricane!

Time: 1 class period
National Benchmarks: Benchmarks 5A: Diversity of Life; 5D Interdependence of Life; 5E: Flow of Matter and Energy; 9B:Symbolic Relationships; 9D:Uncertainty; 12B:Computation and Estimation; 12D:Communication Skills; 12E:Critical-Response Skills.
National Science Content Standards: *Science as Inquiry: A*; *Life Science: C*: Biological Evolution; The Interdependence of Organisms; Matter, Energy, and Organization in Living Systems; *Science and Technology: E:* Abilities of Technological Design; Understandings about Science and Technology; *Science in Personal and Social Perspectives: F:* Population Growth; Natural Resources: Environmental Quality; Natural and Human-induced Hazards; Science and Technology in Local, National, and Global Challenges
New York State Standards: 1, 2, 4, 5, 6, 7

Objective: Students will know how a large storm affects the flow of water in streams and be able to create a graph that explains their answers to this question.

Lesson Outline:
1. Students view images of past hurricanes, discuss personal experiences
2. Students read flood article
3. Students use data to discover the effects of 2 flooding storms on streams
4. Students think about the impact of global warming on hurricanes

Materials: Worksheet, excel data, flood article (attached), Hurricane! video by NOVA (optional)

Engage: View video of Hurricane! by NOVA, or one of the recent documentaries about Hurricane Katrina. Show photos of recent flooding in Dutchess County. Encourage students to share their personal experiences and thoughts.
Explore: Students will begin by reading a background article (attached at the end of this lesson plan) on the impacts of flood events based on a local flood in Dutchess County in April, 2007. This can be given for homework the day before or done in class.

Then, students will use data from 2 different floods to explore the changes that occur to streams during and after a flood. Students will use the Hurricane Floyd data set as well as data from the April 2007 storm to understand the impact of a flood on local waterways, creating two different graphs based on these data. Students should pay particular attention to the amount of time it takes different types of rivers to recover to normal flow after a storm of this magnitude. There is also an extension that provides historical peak flow data from Wappinger Creek at Red Oaks Mill, giving students a chance to see the difference between the two storms and other historic flood events.
Explain: Predictions from the 2007 Intergovernmental Panel on Climate Change (IPCC) indicate that large, flooding storms will increase in frequency in northeastern North America. These types of storms could be hurricanes, nor'easters, blizzards and large storms in general. It isn't clear yet whether hurricanes will increase in number. The number of hurricanes varies from year to year and ocean to ocean, but on average, there are about 6 hurricanes in the Atlantic Ocean each year. With warming ocean waters, scientists predict an increase in the intensity of

hurricanes in the years to come, but as of 2007, it isn't clear if the frequency of hurricanes is increasing. Hurricane frequency and intensity varies on a natural cycle of 20-30 years. Nevertheless, flooding storms can be devastating. In this lesson, students will investigate 2 different flooding storms in Dutchess County. These 2 storms occurred at different times of the year. This made a tremendous difference in the impact of the 2 storms. In addition, the precipitation that caused these floods occurred over different time scales. Normally a precipitation event causes stream flow to increase rapidly and then decrease in a skewed fashion, resulting in a prolonged 'tail' of flow as the stream recovers. The Hurricane Floyd flood shows this pattern, but the April 2007 flood does not. The April storm occurred during a time when the ground was saturated. There was no room for additional moisture in the ground or in the water table. The April 2007 storm was a nor'easter that fell as rain as opposed to snow. Future global change may bring more of these late season nor'easters that in past years would have fallen as snow. The September 1999 storm occurred after a long summer. There was plenty of room in the soil and groundwater to absorb this large event. Thus, the peak flows and resulting devastation from the April event surpassed the September event, even though there was more rain in the September 1999 event.

Basin	**1975-1989**	**1990-2004**
East Pacific	36	49
West Pacific	85	116
North Atlantic	16	25
Southwestern Pacific	10	22
North Indian	1	7
South Indian	23	50

The number of Category 4 or 5 hurricanes increased between the periods 1975-1989 and 1990-2004. (Adapted from Webster et al., 2005). NASA Earth Observatory website, http://earthobservatory.nasa.gov/ .

Students should read about predictions of storm intensity under various global warming scenarios. "Confronting Climate Change in the Northeast" by the Union of Concerned Scientists includes two relevant sections: pgs 15-31 explains the impacts on coastal systems, while pgs 62-65 explains the impacts on water in the northeast. The report can be downloaded at: http://www.northeastclimateimpacts.org/ . Students can also use NASA's Earth Observatory article on hurricanes to gather more information: http://earthobservatory.nasa.gov/Library/Hurricanes/hurricanes_1.html .

Extend: Students can research the relationship between land use and storms, specifically the connections between the 2006 tsunami and loss of mangroves as well as Hurricane Katrina and wetland loss.

Evaluate: Students should submit their graphs and the answers to the accompanying questions.

Answers: **Part 1: Reading**

1. It was the 3rd largest flood on Wappinger Creek since 1928.
2. The size of a flood depends on the amount of rain, how much vegetation is in the area, and whether the ground is already saturated from previous rainfall.

3. Human factors that contribute to flooding include increasing impervious surfaces, reducing wetlands, and preventing water from moving naturally as it floods by building barriers.
4. Preventing future floods is possible by reducing the amount of development that takes place in flood-prone areas, increasing vegetation along stream banks, and allowing streams and rivers to move in a natural manner.

Answers: **Part 3: Questions**

1. Hurricane Floyd dropped 171.5 mm of rain on 9/16/1999, and the April 2007 storm dropped 76 mm on 4/15/07 and 56 mm on 4/16/07, for a combined total of 132 mm.
2. For Hurricane Floyd, peak flow occurred right after midnight on Sept. 17th, with the discharge at 320 cubic feet per second. It remained high for about one hour, beginning to recede around 1:30am.
3. For the April 2007 flood, peak flow occurred at 6:30am on April 16th, with the discharge rate at 1854 cubic feet per second. However, there was a second peak of 1789 cfs at 8:30 am that same morning.
4. Before the Hurricane Floyd flood event, the discharge rate varied between 4 and 11 cfs. Before the April 2007 flood, discharge rate varied between 57 and 147 cfs.
5. Although Hurricane Floyd dumped more rain on the region, there was significantly more stream flow during the April 2007 flood. Due to the time of year (April), the ground was already saturated with moisture and couldn't absorb any more rainfall. Consequently, the rain ran off into the streams and caused a larger flood event than the rainfall during Hurricane Floyd.
6. The curves differ in that the Hurricane Floyd stream returned to normal more slowly than the April 2007 stream. Since the land was able to retain more rainfall in September, the flooding in September was less severe, and it allowed the water to enter the stream channel in a slower, more controlled manner. The April 2007 flood occurred quickly, but it was also over very quickly.

Part 4: Historical Change

1. The peak flow was much higher in 1938 and 1955.
2. The flood in 1938 was a hurricane that occurred in September, killing more than 50 people in New York and causing billions of dollars in damage (in today's dollars). The 1955 flood was also a result of a hurricane, and caused a lot of damage around the Northeast.

Part 5: Future Change

1. The scientific name for a hurricane, regardless of its location, is *tropical cyclone.* In general, a cyclone is a large system of spinning air that rotates around a point of low pressure. Only *tropical* cyclones, which have warm air at their center, become the powerful storms that are called hurricanes.
2. On average, there are between 16-25 hurricanes in the North Atlantic each year.
3. The number of hurricanes has been increasing. The evidence to support my answer comes from the NASA Earth Observatory website.

4. Based on the climate change report, there will be more intense storms in the future. This will cause damage to coastal areas, eroding beaches, damaging homes and communities, and potentially causing damage to fisheries. There will be less water available during the summer, and rain will fall in a more unpredictable pattern. Less snowfall means less runoff in the spring. More precipitation events will occur as rain instead of snow, which has consequences not just for hydrology but also for some plants, which rely on a blanket of snow as an insulator.
5. Free response answer.

Comments:

References: NASA Earth Observatory website, http://earthobservatory.nasa.gov/ .

Northeast Climate Impacts Assessment: http://www.northeastclimateimpacts.org/

Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Sunday, April 22, 2007
Flooding is caused by more than just rainfall

By Dave Strayer
For the Poughkeepsie Journal

Last week, heavy rainfall and wet soils combined to create floods throughout the mid-Hudson Valley. Standing water closed more than 60 roads, including parts of the Taconic Parkway.

According to the United States Geological Survey, it was the third-largest flood on Wappinger Creek since 1928, and the fifth-largest on the Ten Mile River since 1930.

At its peak, Wappinger Creek had risen 13 feet above typical summer levels, and was carrying 87,000 gallons of water over the dam at Red Oaks Mill every second. We can expect to see a flood this size every 15-30 years.

What determines the size of a flood? To begin with, the harder it rains, the bigger the flood. However, peak flows last week were almost twice as large as in the flood of October 2005, even though we had much less rain (5.2 inches in two days) than in October 2005 (8 inches in a day, and 13 inches in a week). Rainfall alone doesn't determine the size of a flood.

Several other factors contribute to flood severity. Actively growing plants take up about half the rainfall in a typical summer. As a result, it takes more rain to cause a flood in summer than in winter or spring.

The weather leading up to a storm can also affect flooding. Lack of growing vegetation and wet ground from earlier rain and snow added to the severity of last week's flood.

The human factor

Human activities also contribute to flooding. Impervious surfaces such as parking lots, roadways and roofs cause water to run rapidly into streams. Careless construction or land management can cause excess sediment to enter streams, filling up stream beds and making them more prone to flooding.

As was apparent to anyone out driving in last week's flood, artificial barriers to water flow (inadequate culverts, roadways) can cause local flooding.

It is normal for streams to flood. Streams mold their channels to carry the water and sediments they receive from the landscape. A typical stream in our region has a floodplain that contains water periodically during wet periods. Streamside plants benefit from the rich soils deposited by floodwaters. Fish and other animals that use floodplains for feeding or breeding also depend on this regular cycle of flooding.

Preventing streams from rising into their floodplains can cause ecological damage and increase flood severity downstream.

Floodplains and wetlands help ensure against severe floods. By absorbing and slowly releasing water, these areas allow floodwaters to work their way downstream gradually, instead of arriving in a single, devastating pulse.

Economic damages from flooding can be reduced if homes and businesses are kept away from floodplains and stream banks. Uses such as hiking trails, pastures or recreational fields may be appropriate for floodplains, as long as we recognize they will occasionally flood.

Although it might seem logical to head off floods by dredging, straightening stream channels or building levees, such projects can actually worsen the problem.

By preventing water from spreading out onto the floodplain and speeding the movement of water downstream, these projects can exacerbate downstream flooding - helping you but hurting your neighbors. These projects can also destabilize stream channels, causing erosion, sediment problems and ecological damage for years. Problems are not limited to the project area, but can extend for long distances up and downstream.

Preventing flood damage requires management of entire watersheds, not just stream channels. Dutchess County is fortunate to already have management plans for Wappinger and Fishkill Creeks, which could serve as the basis for such planning.

Dave Strayer is a freshwater ecologist at the Institute of Ecosystem Studies in Millbrook.