U.S. Geological Survey: Impacts of High River Flow and Tropical Storm Isabel on the Chesapeake Bay and its watershed (Updated 10/9/03).

Summary and Highlights:

**Isabel contributed to a near record for river flow into Chesapeake Bay for September 2003. The flow to the Bay during September was 86.9 billion gallons per day (BGD), which was the third highest on record. The record high was 98.3 BGD, recorded in 1975. The September 2003 flow was about 4 times higher than average (21.1 BGD) for September.

**The total amount of water that entered the Bay during Isabel and the subsequent 7 days (September 19-25) was 1,190 billion gallons. This was about 8 times the normal amount of water entering the Bay during a 7-day period in September. The largest amount to enter the Bay during a 7-day period was 4,810 billion gallons, which occurred during tropical storm Agnes in June 1972.

**The near record flow in September contributed to streamflow to Chesapeake Bay to be 56 percent above average during 2003. Since January 2003, 85.1 BGD has entered the Bay compared to long-term (since 1937) average of 54.4 BGD. Near record monthly values have been recorded from June through September. Flow during 2002, which was affected by a drought, was 33.4 BGD.

**For mean monthly flow for 2003 "water year" (October 2002 through September 2003) flow to the Bay was 76.2 BGD, which is the second "water year" since record keeping began in 1937. The highest was during 1972 with 78.1 BGD. The water year represents the natural hydrologic cycle. Streamflow and groundwater levels are generally at their lowest levels at the and of September and the recharge cycle begins again in October. Flow to the Bay in an average water year is 50.8 BGD. In the 2002 water year, the flow to the Bay was 28.6 BGD, reflecting drought conditions.

**The high flow during 2003 and Isabel will cause an increased amount of nutrients, sediment, and other pollutants to enter Chesapeake Bay. The average amounts of sediment, nitrogen, and phosphorous that enter the Bay each year from its three largest rivers are:
Nitrogen: 95,500 tons per year
Phosphorous: 5,450 tons per year
Sediment: 4,000,000 tons per year
The load measured at the river-input stations represents about 60 percent of the total load entering the Bay.

**The large amounts of nutrients transported to the Bay have caused near-record low dissolved oxygen levels. The low dissolved-oxygen levels have caused fish kills in some Bay tributaries.

**The increased amount of nutrient and sediment from rivers also have clouded the waters in the Bay and likely will cause a decrease in the amount of submerged grasses in the Bay next year. There was also a large amount of shoreline erosion during Isabel, which increased the amount of sediment entering the Bay and could cause additional impacts to the underwater

grass beds. The grasses had shown an increase from 1999-2002 due to smaller amounts of nutrients and sediment entering the Bay during the drought.

**Although Isabel contributed additional amounts of nutrients and sediment into rivers that enter the Bay, the impact was less in the fall than if the tropical storm had come during the middle of the summer. During the summer, algal blooms have the lowest dissolved oxygen levels and many grasses are at the height of their growing period. The full extent of underwater grasses lost will not be known until next year when surveys are conducted.

**Nutrient-reduction actions by the Chesapeake Bay Program and jurisdictions in the Bay watershed have slowly lowered nutrient concentrations in many rivers entering the Bay. Therefore, the load during 2003 and Isabel will not be as high because nutrient sources have been reduced.

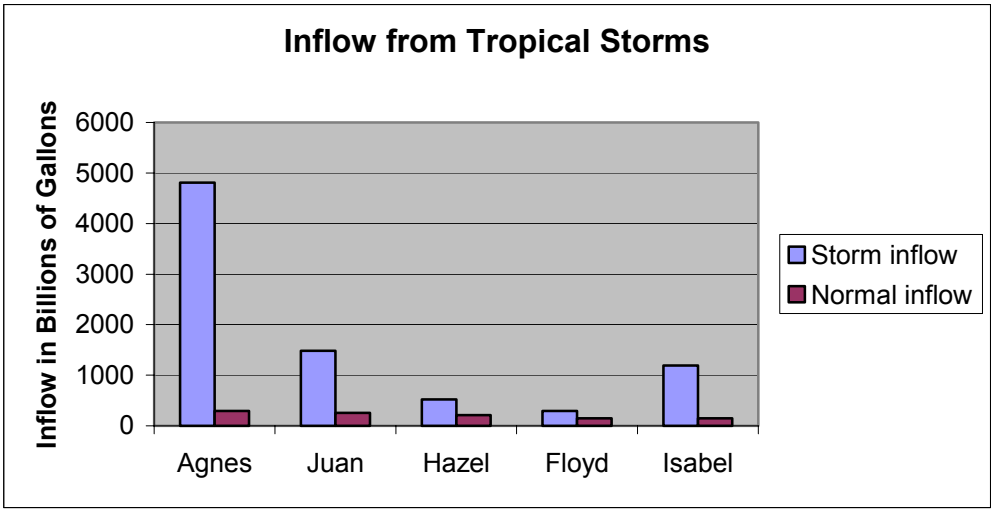
**Further information can be obtained from Scott Phillips, USGS Chesapeake Bay Coordinator, 410 238-4252 or swphilli@usgs.gov. Visit our web site at http://chesapeake.usgs.gov/.

General Overview

How much water entered the Chesapeake Bay during Isabel and other tropical storms?

Billions of gallons of water a day (BGD) enter the Chesapeake Bay from the rivers draining its 64,000 square-mile watershed. The three largest rivers, the Susquehanna, Potomac, and James, deliver about 50, 25, and 12 percent, respectively, of the total flow into the Bay. Isabel tracked west of the Bay and delivered 1-10 inches of rain across the watershed. An additional rain event on Sept 22-23 delivered another 3-5 inches. The table and graph below shows a comparison of the total amount of water delivered to the Bay during Isabel and several other tropical storms that have greatly impacted the amount of water entering the Bay.

Storm	Date	Total inflow of water (gallons)	Normal inflow of water during these times (gallons)	Tropical storm inflow compared to normal inflow to the Bay
Agnes	June 21-27, 1972	4,810 billon	291 billon	16.5
Juan	Nov 5-11, 1985	1,480 billon	256 billon	5.8
Hazel	Oct. 16-22, 1954	517 billon	210 billon	2.5
Floyd	Sept. 16-22, 1999	291 billon	147 billon	2.0
Isabel	Sept. 19-25, 2003	1,190 billion	147 billion	8.1



How did individual river flows during Isabel compare to historical flows in the major rivers that enter the Bay?

Isabel and the subsequent rainfall on September 22-23, 2003 caused increased river flow (provided in cubic feet per second (cfs)) in all of the major rivers entering the Bay, with a range of 6 to 54 percent of historical river levels (many of which occurred during Agnes in 1972).

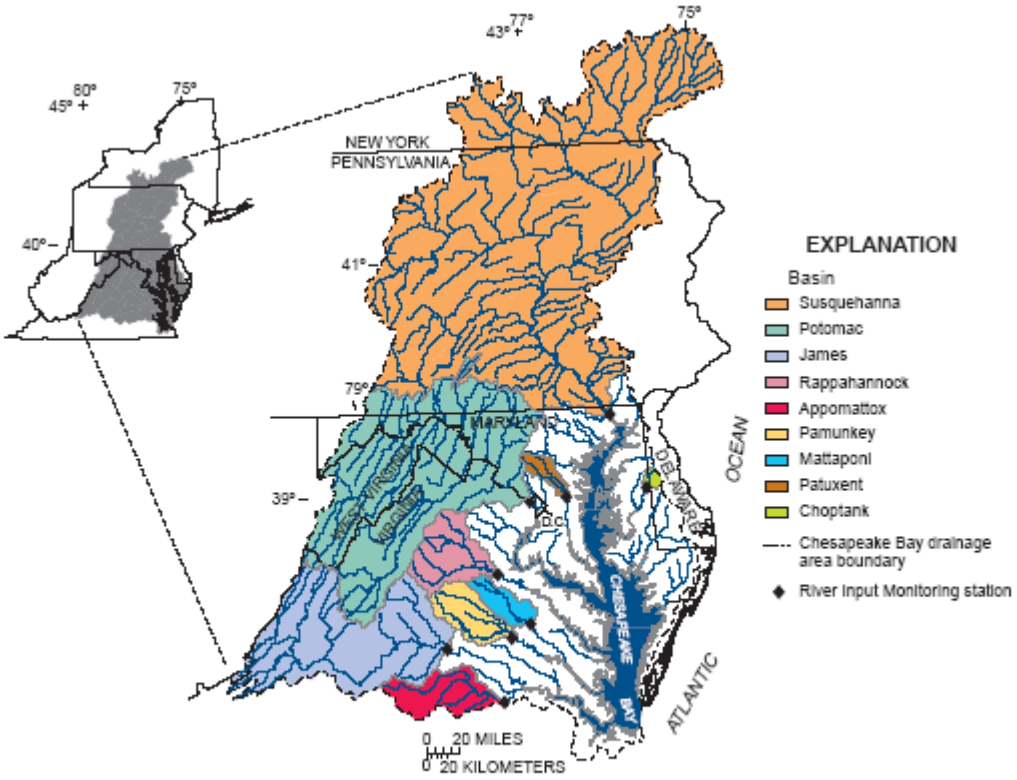


Figure 1. Locations of major river basins and River Input Monitoring stations in the Chesapeake Bay Basin.

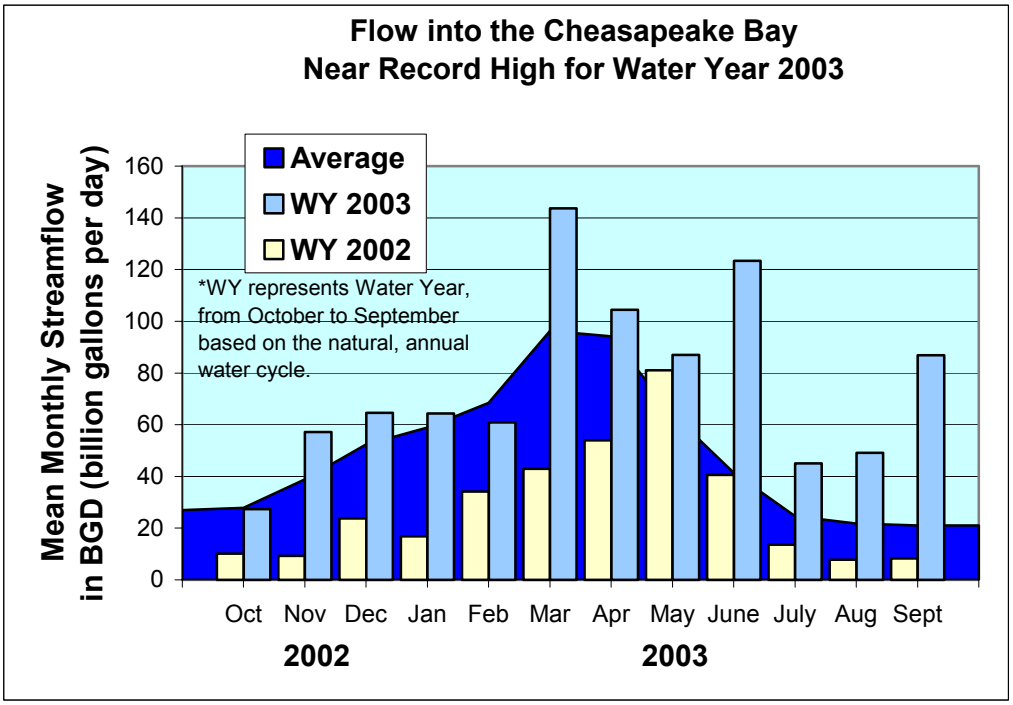
River	Highest Discharge (cfs)	Date	Highest Discharge during Agnes, June 21-27, 1972 (cfs)	Highest discharge during Isabel and following week (Sept 18-25)	Percent of Isabel discharge compared to highest discharge
Choptank near Greensboro, Md.	6,970	8/4/67	2,760	1,290	18%
Susquehanna At Conowingo, Md.	1,130,000	6/24/72 (Agnes)	1,130,000	139,000	12%
Patuxent near Bowie, Md.	11,500	6/6/79	N/A	6,230	54%
Potomac near Washington, D.C.	484,000	3/19/36	359,000	167,000	35%
Rappahannock near Fredericksburg, Va.	140,000	10/16/42	107,000	37,000	35%
Pamunkey near Hanover, Va.	40,300	8/23/69	29,900	13,500	33%
Mattaponi near Beulahville, Va.	16,900	6/25/72 (Agnes)	16,900	2,060	12%
James at Cartersville, Va.	362,000	6/22/72 (Agnes)	362,000	89,800	25%
Appomattox at Matoaca, Va.	40,800	10/7/72	22,800	19,600	48%

How much water has entered the Chesapeake Bay during 2003?
Isabel contributed to a near-record amount of water entering Chesapeake Bay during September. The flow to the Bay during September was 86.9 BGD, which was the third highest on record. The record high was 98.3 BGD, recorded in 1975. The September 2003 flow was about 4 times higher than average (21.1 BGD) for September.

The near-record flow in September contributed to streamflow to Chesapeake Bay being 56 percent above average during 2003. Since January 2003, 85.1 BGD has entered the Bay compared to an average of 54.4 BGD. Near-record monthly values have been recorded from June through September. Flow during 2002, which was affected by a drought, was 33.4 BGD.

For the 2003 water year (October 2002-September 2003), flow to the Bay was 76.2 BGD, which is second highest water year since record keeping began in 1937. The highest was during 1972 with 78.1 BGD. The water year is October through September and represents the natural

hydrologic cycle. Flow to the Bay in an average water year is 50.8 BGD. In the 2002 water year the flow to the Bay was 28.6 BGD, reflecting drought conditions.



How much nutrients and sediment enter the Chesapeake Bay?

The high flow during 2003 and Isabel caused an increased amount of nutrients, sediment, and other pollutants to enter Chesapeake Bay. The amount, or load, of pollutants to the Bay is influenced both by the amount of water entering the Bay and the nutrient and sediment concentrations in the water. The USGS, working in cooperation with the Maryland Department of Natural Resources and Virginia Department of Environmental Quality, has collected samples from the major rivers to determine the nutrient and sediment concentrations and estimate loads.

The average amount of sediment, nitrogen, and phosphorus that enter the Bay each year from its three largest rivers is:
Nitrogen: 95,500 tons per year.
Phosphorous: 5,450 tons per year
Sediment: 4,000,000 tons per year.

What are the potential impacts of nutrients and sediment being delivered to the Bay?
The large amount of rain caused an increase in nutrients and sediment in streams and rivers throughout the Bay watershed. Excess nutrients entering the Bay during the spring and summer cause algal blooms that consume oxygen as they decay and result in fish kills. The increased sediment can bury underwater grasses or cloud the light conditions in the Bay, which impedes

their growth. Underwater grasses are important because they provide habitat for crabs and food for waterfowl. The increased river discharge also affects the salinity in the Bay, which in turn impacts underwater grasses, oysters, and crabs. Some specific impacts from Isabel include:

Conditions during Isabel have caused a large increase in sediment delivery to the Bay that will impact underwater grasses.

Sediment enters the Bay from erosion of several sources: (a) shorelines (b) land surface, (c) stream banks, and (d) reservoirs. During Isabel shoreline erosion was probably the greatest source of sediment to the Bay due to the storm surges and waves. This will have a direct impact on the underwater grasses that are adjacent to the shoreline. Sediment from the major rivers will have some impact on the grasses but less than some previous storms such as Agnes. The full extent of underwater grasses lost will not be known until next year when surveys are conducted.

Agnes contributed to a loss of almost 2/3 of the underwater grasses in the Bay during the early 1970s. Losses of underwater grasses during Agnes occurred mostly in the western shore tributaries and the Susquehanna Flats. The losses were related to sediment from the rivers and scouring of sediment from the Conowingo reservoir. There was not a large amount of shoreline erosion during Agnes because winds had declined by the time the storm reached the Bay.

During Isabel, very little sediment was eroded in the reservoirs of the Susquehanna River system and delivered into the Bay. The water in the Susquehanna has to reach a rate of about 400,000 cfs for scour of the bottom sediment in reservoirs to occur. During Isabel and subsequent rainfall on September 22-23, the rate reached 139,000 cfs.

Large amounts of sediment were eroded from the Conowingo reservoirs during January 1996, during the melting of snow from the blizzard of that month. During the January 1996 storm, a total of 2 to 5 inches of snowmelt combined with 2 to 5 inches of rainfall to cause widespread flooding. The January storm transported roughly 3 times the amount of freshwater, 6 times the amount of phosphorus, 3 times the amount of nitrogen, and 17 times the amount of sediment to the Chesapeake Bay than is typically transported during an average January.

Isabel has caused an increase in the amount of nutrients entering the Bay, contributing to already low dissolved-oxygen levels.

High river flow during 2003 has contributed nutrients to the Bay, causing near-record low dissolved oxygen levels. The low dissolved-oxygen levels have caused fish kills in many Bay tributaries. While Isabel contributed additional nutrients into the Bay, the impact will be less now than if the tropical storm had come during the middle of the summer. The fall is generally not a time of high nutrient runoff from agricultural and suburban lands because crops and plants have used much of the fertilizer and manure that was applied in the spring. Additionally, once nutrients enter the Bay, the conditions for algal blooms and subsequent loss of dissolved oxygen are not as favorable during the fall as during the summer. The waters in the Bay have begun to cool so there is more mixing and better exchange of oxygen throughout the Bay's water column.

Most importantly, nutrient-reduction actions by the Chesapeake Bay Program and the jurisdictions in the Bay watershed have slowly lowered nutrient concentrations in many rivers

entering the Bay. Therefore the load during 2003 and Isabel was not as high as if could have been if these actions had not been taken.

What are the current flow conditions of streams and rivers in the Bay watershed?
Many streams are already above average due to the heavy rainfall in 2003. A map of the levels in streams in the Mid-Atlantic, based on real-time data collection by the USGS, can be viewed at: http://water.usgs.gov/waterwatch/.

The three largest rivers in the Chesapeake Bay also have real-time data collection. View the current conditions for the:

Susquehanna
01576000 Susquehanna River at Marietta, PA

Potomac
01646500 POTOMAC RIVER NEAR WASH, DC LITTLE FALLS PUMP STATION

James
02035000 JAMES RIVER AT CARTERSVILLE, VA