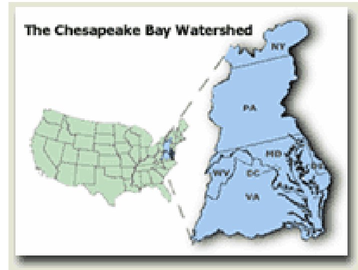
The Impact of Sediment on the Chesapeake Bay and its Watershed

The Chesapeake Bay is a unique treasure to the mid-Atlantic region. The 200 mile long bay is the largest estuary (where fresh and salt water mix) in the United States and supports more than 3,600 species of plants, fish, and animals. The Chesapeake Bay watershed drains 64,000 square miles of all kinds of land uses in six states - New York, Pennsylvania, Maryland, Delaware, Virginia and West Virginia - and the District of Columbia. The 16 million people that live and work in the Bay watershed affect the health of the Bay through their daily activities that washes pollutants, such as sediment, into nearby streams and rivers that serve as a conduit to the Bay.



Sedimentation rates in some areas of the bay have increased four- to five fold since the 1800's in response to timber harvesting and increases in agricultural and urban lands. These changes in land use and the lack of protective environmental practices, have led to excess sediment and nutrients washed into the Bay. When sediment, which is composed of loose particles of clay, silt, and sand, becomes suspended, it makes the water cloudy and reduces the amount of sunlight that reaches the submerged aquatic vegetation (SAV) that provides habitat and stability to the bay. The reduction in water clarity in the Bay has lead to a drastic decline in SAV over the past 30 years and this coupled with poor water quality, leaves the Chesapeake Bay classified as an "impaired water body".

Erosion and sediment transport are natural processes, but in excess are harmful to the streams in the watershed and Chesapeake Bay's plants and animals. Problems associated with excess sediment in the watershed and Bay includes:

- Excessive sedimentation can **degrade stream habitat** and bury benthic (bottom-dwelling) plants and animals, such as oysters and clams.
- Suspended sediment clouds the water, preventing light from penetrating to the leaves and stems of **underwater grasses**, or submerged aquatic vegetation (SAV). Suspended sediment and phytoplankton growth due to excess nutrients have reduced water clarity below the thresholds needed to support SAV.
- **Toxic materials**, potential pathogens, and nutrients may be transported by sediment and contaminate waterways that affect fisheries and other living resources.
- Commercial shipping and recreational boating are threatened by accumulations of sediment that can fill **waterways and ports**, making traffic difficult or hazardous, and requiring dredging.

Why the USGS is Studying Sediment in the Chesapeake Bay and its Watershed

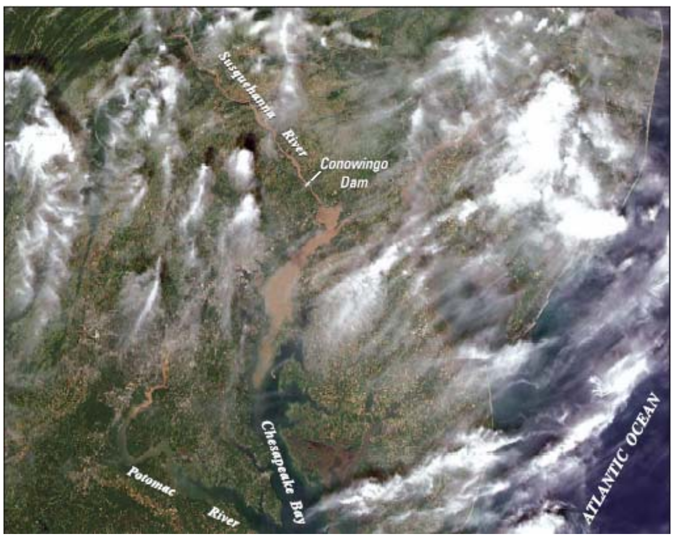
The USGS is working with the Chesapeake Bay Program partners to determine sediment sources, transport, sites of deposition, and relation to water clarity and living resources in various parts of the bay and its watershed so that an effective sediment-reduction strategy can be formulated and implemented. We have synthesized information from the multiple USGS studies to provide this summary related to sediment in the Bay and its watershed. The USGS has multiple studies addressing these issues and more information can be found at: http://chesapeake.usgs.gov/studiesproject.html

Sediment Sources in the Watershed and Delivery to the Chesapeake Bay

Sediment is generated in the watershed because of natural weathering of rocks and soils, accelerated erosion of lands and streams caused by agricultural and urban development, and resuspension of previously eroded sediments that are stored in stream corridors. Compilations of sediment information lead by the USGS (Langland and Cronin, 2003) indicate the two primary sources of sediment in the watershed are (1) erosion from upland land sources and (2) erosion of stream corridors.

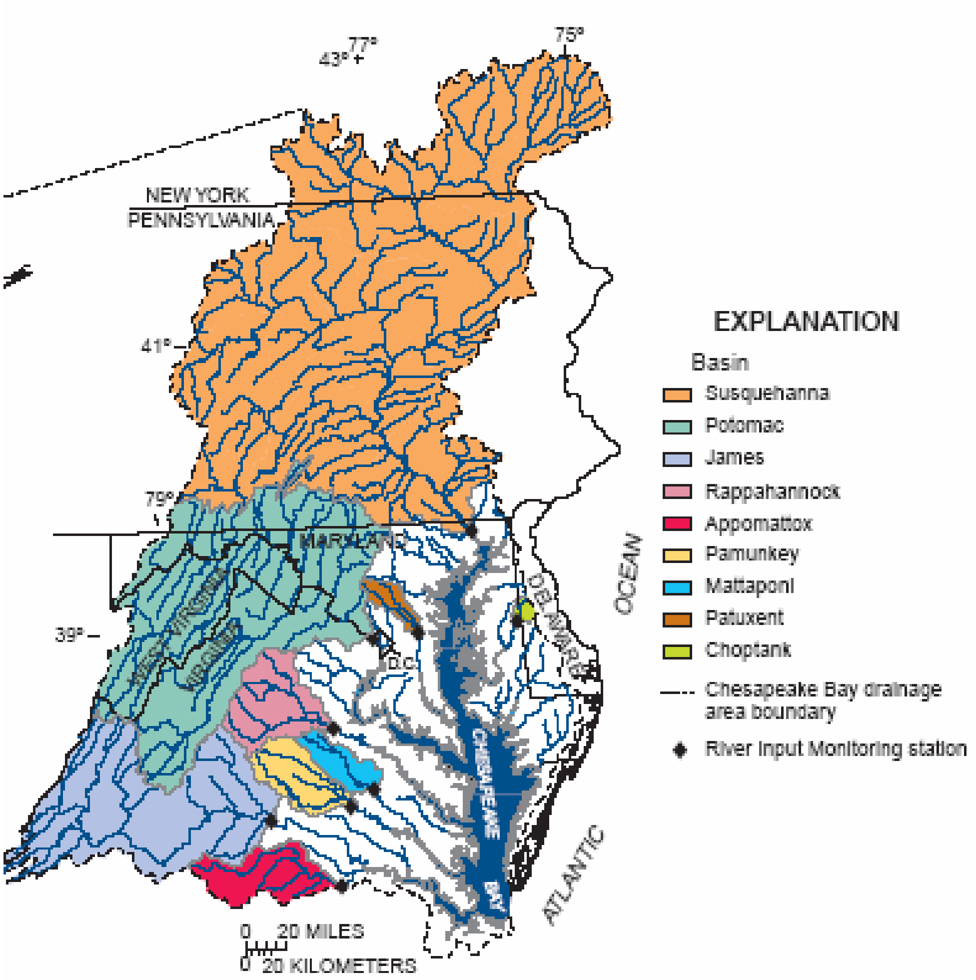
Some findings about sediment in the watershed include:

- For the entire Chesapeake Bay region, river basins with the highest percentage of agricultural land use have the highest annual sediment yields, and basins with the highest percentage of forest cover have the lowest annual sediment yields.
- Urbanization and development can more than double the natural background sediment yield; the increase in sediment yield is highest in the early development stages.
- After development is completed, erosion rates are lower; however, sediment yield from urbanized areas can remain high because of increased stream corridor erosion due to altered hydrology.
- Sediment plays an important role in transporting phosphorus and other contaminants in river systems. The amount of phosphorus depends on the source and on the geochemical reactions affecting phosphorus during transport.
- Most of the sediment from the watershed to the bay is transported when (1) streams reach bankfull conditions, which take place on average every 1-2 years, and (2) during relatively large storm events. Hence, sediment input to the bay potentially can be affected by large-scale patterns of climate change, such as hurricanes and tropical storms. See photo below.

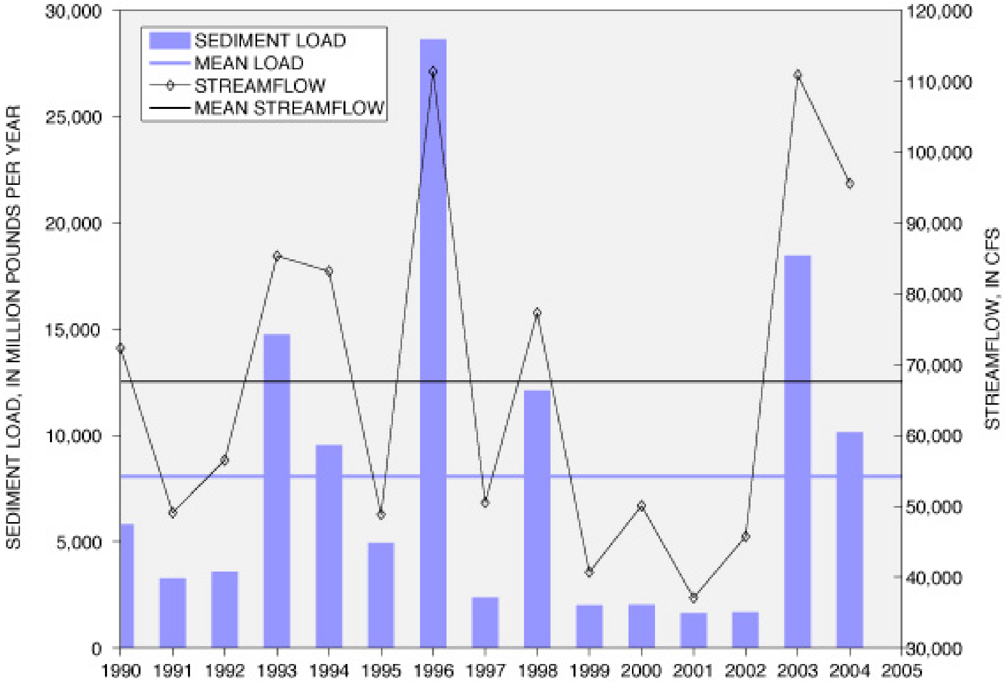


NASA photograph shows the high suspended-sediment concentrations caused by Hurricane Ivan, which affected parts of the Chesapeake Bay Watershed from September 17-18, 2004. Note the brownish turbid waters of the Susquehanna and Potomac Rivers, and the upper Chesapeake Bay.

The USGS has completed recent analysis of the areas of high sediment loads and yields in the Bay watershed (Gellis and others, 2005). Sediment loads (the amount of sediment) to the Bay were highest from the Susquehanna and Potomac Rivers (the locations of these basins are shown below). Also the highest sediment loads for the entire watershed were detected at sites within these two River Basins. In the Susquehanna River some of the highest yields (the amount from a square mile of land) were highest in the Conestoga River Basin, where agricultural is the dominant land use. In the Potomac Basin, some of the highest sediment yields were in streams draining the metropolitan Washington, D.C. area, and these high yield are possibly related to urbanization. More information on sediment loads and yields at over 50 sites in the watershed can be found in the report (http://water.usgs.gov/pubs/sir/2004/5056/SIR2004-5056.pdf).



The Chesapeake Bay River Input Monitoring (RIM) project was established in the late 1980s to quantify loads and long-term trends of nutrients and suspended sediment entering the tidal part of the Chesapeake Bay Basin from its nine major tributaries (sites shown on map). At the RIM stations, an average of about 8 billion pounds of sediment a year has entered the tidal waters since 1990 (see graph below). The load will vary each year depending on the amount and intensity stream flow that erodes sediment from the watershed and delivers it to the Bay. Another factor that affects sediment to the Bay is the amount that is trapped and eroded from reservoirs on the Susquehanna River.



Annual sediment loads entering the tidal waters at the River-Input stations.

Reservoirs and Sediment Delivery to the Bay

The Susquehanna River is the largest river entering the Chesapeake Bay. A reservoir system on the lower portion of this river affects the amount of nutrients and sediment that reach the bay. The three reservoirs have been filling with sediment since their construction between 1910 and 1931. The trapped sediments are available for delivery to the bay during floods.

Large amounts of sediment and phosphorus are trapped in the reservoir behind the Conowingo dam, which is the last reservoir prior to the Chesapeake Bay. Currently, about 70 percent of the suspended sediment is trapped, 2 percent of the nitrogen is trapped, and 40 percent of the phosphorus is trapped (Langland and Hainly, 1997). Three large floods (June 1972, September 1975, and January 1996) carried about 36 million tons of sediment out of the reservoirs. In September 2004, the flow was also sufficient to scour sediment behind the dam (see photo below).

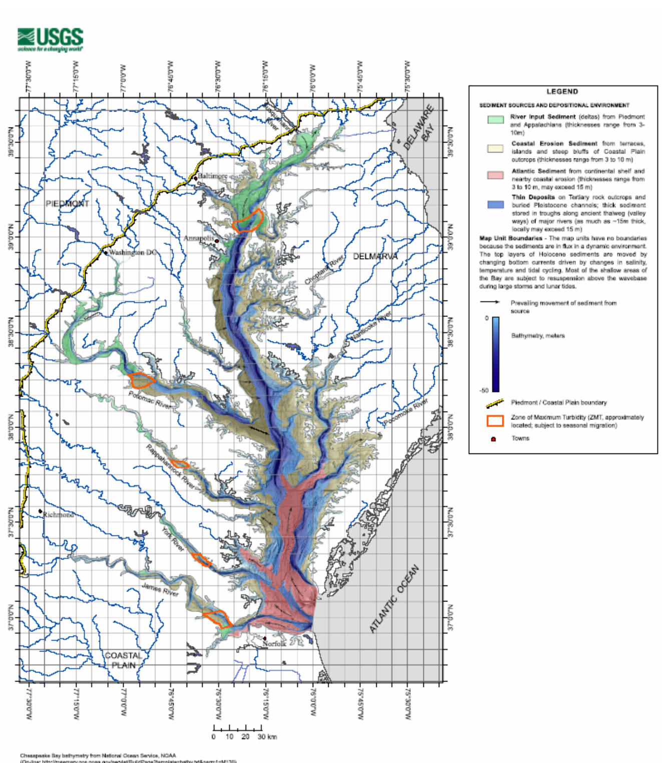
USGS studies have shown that the upper two reservoirs have reached sediment-storage capacity and generally no longer trap large amounts of nutrients and sediments. USGS scientists estimate that the Conowingo reservoir will reach capacity in 20–25 years; this filling will result in an increase in sediment transported to the Chesapeake Bay that will further degrade water clarity and SAV. The time remaining until it becomes filled with sediment depends on factors such as:

(1) land-use and land-management practices,
(2) the amount of rainfall, and
(3) occurrences of large storm events.

Photograph showing the release of water from the Conowingo Dam on the Susquehanna River in Maryland, September 21, 2004 at 10:00 AM as a result of Hurricane Ivan. When this photograph was taken, discharge at the Susquehanna River near Conowingo, Maryland (USGS station number 0157830) was 348,000 cubic feet per second.

Sediment Sources and Deposition in the Bay

For the Bay, major sediment sources include: riverine, shoreline, ocean, and biological production. These sources, along with resuspension of existing sediment, contribute to sediment deposition and associated poor water clarity in the Bay. Documenting the relation among sources, transport, and deposition in the bay is critical to successfully developing sediment reduction strategies to meet water clarity standards. The USGS has prepared additional products showing sediment sources into tidal waters of the Bay (see map below).



The USGS has mapped sediment sources near the Bay. This map delineates sediment from rivers, coastal erosion, and the Atlantic Ocean. Highlighted in red is the area of maximum turbidity (**Newell and others**). It is available online at: http://pubs.usgs.gov/of/2004/1235/

USGS studies have shown that:

- The Susquehanna River is the dominant source of sediment in the **northern** part of the bay
- Shoreline erosion and influx from the ocean is the dominant source in the **southern** bay
- Sediment accumulation is lowest in the **central** bay segment. As much as 18 and 22 percent of suspended material in the central Bay came from skeletal material and organic production and as much as 52 percent came from shoreline erosion.
- Sedimentation in the deep bathymetric channels of the bay tends to be faster than in the shallow water areas.
- Little or no sediment is exported from the bay to the adjacent ocean except during extreme climate events causing high freshwater inflow from the watershed. This reflects the overall sediment trapping nature of the entire bay system. During extreme weather events, such as Tropical Storm Agnes, or sustained periods of high freshwater inflow, substantial amounts of sediment can be exported into the main stem bay.

Implications for restoration of the Chesapeake Bay and its watershed

There were several implications about restoration of the Chesapeake Bay and its watershed from these studies and they include:
-Both nutrient and sediment reductions will be needed to improve water clarity in the Bay;
-Different strategies will be required to reduce sediment since its sources and transport are different from nutrients; and
-Because of the long travel times for sediment, management actions to reduce sediment in the watershed will help local streams but may take decades or longer to improve water clarity in tidal waters. Therefore management actions for sediment should consider targeting near-shore areas.

The USGS is conducting additional studies of sediment sources and transport to help resources managers better target restoration activities to reduce sediments to streams and the Chesapeake Bay.

Resources:

Summary of Suspended-Sediment Data for Streams Draining the Chesapeake Bay Watershed, Water Years 1952–2002 *By* Allen C. Gellis, William S.L. Banks, Michael J. Langland, *and* Sarah K. Martucci, USGS Scientific Investigation Report 2004-5056: http://water.usgs.gov/pubs/sir/2004/5056/SIR2004-5056.pdf

Changes in Streamflow and Water Quality in Selected Nontidal Sites in the Chesapeake Bay Basin, 1985-2003 *By* Michael J. Langland, Scott W. Phillips, Jeff P. Raffensperger, and Douglas L. Moyer, USGS Scientific Investigations Report 2004-5259: http://water.usgs.gov/pubs/sir/2004/5259/

A summary report of sediment processes in Chesapeake Bay and watershed edited by Michael J. Langland and Thomas Cronin, Water Resources Investigation 2003-4123: http://pubs.er.usgs.gov/pubs/wri/wri034123

Distribution of Holocene Sediment in Chesapeake Bay as Interpreted from Submarine Geomorphology of the Submerged Landforms, Selected Core Holes, Bridge Borings and Seismic Profiles *By* Wayne L. Newell, Inga Clark, *and* Owen Bricker, USGS Open-File Report 2004-1235: http://pubs.usgs.gov/of/2004/1235/

Langland, M.J., and Hainly, R.A., 1997, Changes in bottomsurface elevations in three reservoirs on the Lower Susquehanna River—Implications for nutrient and sediment loads to Chesapeake Bay: U.S. Geological Survey Water-Resources Investigation Report 97–4138, 34 p.

For further information see the USGS Chesapeake Bay WWW site: http://chesapeake.usgs.gov/

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