Impacts of Hurricane Isabel on Maryland's Aquatic Resources: Initial Assessment

Maryland Department of Natural Resources
Resource Assessment Service
October 15, 2003

The Maryland Department of Natural Resources' Resource Assessment Service has conducted preliminary assessments of the effects of hurricane Isabel on water quality, habitat quality, and living resources in the Chesapeake Bay, Coastal Bays, and Maryland's streams. The following is an initial assessment of those impacts. A more detailed assessment of impacts is planned for early 2004.

In brief, initial assessments of the impacts of hurricane Isabel to Maryland's aquatic resources indicate the following.

- **Salinity:** Due to the wet season, salinities throughout Chesapeake Bay were generally lower than normal prior to Isabel. The tidal surge associated with the hurricane immediately resulted in substantial increases in salinity, particularly along the Eastern Shore, but these returned to near normal within about 24 hours.
- **Water Clarity:** The wet season also contributed to poorer than normal water clarity prior to the storm. The tidal surge and high winds associated with Isabel resulted in substantial decreases in water clarity during and immediately after the storm. Water clarity appears to be slowly returning to normal levels.
- **Dissolved Oxygen:** There was a substantial "dead zone" in Maryland's portion of the Chesapeake Bay main-stem prior to the storm, as is typical in late summer. The storm surge and winds associated with Isabel appear to have hastened the normal fall turnover, resulting in increased dissolved oxygen levels in the deep Bay.
- **Nutrients:** Runoff from Isabel undoubtedly flushed nutrients from the watershed into the Bay, however this may be small compared to the amount added to the Bay throughout the wet season. Nutrient impacts will not be known for several months when all analyses are complete.
- **The Bay's Living Resources:** Most Bay organisms are well adapted to temporary fluctuations in water quality, and impacts should be minimal. Bay grass beds appear to have fared well, although there is some concern that seeds may have been buried or washed into deep water. Long-term impacts to bay grasses and oysters will not be evident until next spring and summer. Harmful algal blooms present on the Potomac prior to the storm appear to have been dissipated somewhat by the winds and turbidity.
- **Maryland Streams:** Post-storm sampling of fish and physical habitat at five stream sites revealed no significant impacts beyond those typically associated with a heavy thunderstorm.
- **Groundwater:** Flooding of wells has contaminated many individual drinking water wells. Impacts to deep aquifer wells (which supply most public groundwater sources) are unlikely.

Chesapeake Bay and Coastal Bays

Water quality monitoring was conducted at long-term, fixed stations on the main-stem of the Chesapeake Bay and the tidal Potomac River in the days immediately preceding Isabel in order to assess pre-storm status of salinity, water clarity, dissolved oxygen, and nutrient levels (Figure 1). Similar monitoring was then conducted the week following Isabel to evaluate short-term changes in these parameters resulting from the hurricane. Additionally, water quality mapping (spatially intensive assessments of selected parameters) was conducted pre and post hurricane on the Middle and Magothy rivers. Finally, throughout the duration of Isabel, continuous monitors were in place in many tributaries of the Chesapeake and Coastal Bays (Figure 2). The continuous monitors collect water quality data every 15 minutes on parameters such as salinity, water clarity, and dissolved oxygen. The combination of these three monitoring efforts provides us with an opportunity to access not only pre- and post- Isabel impacts, but also the real-time affects during the storm.

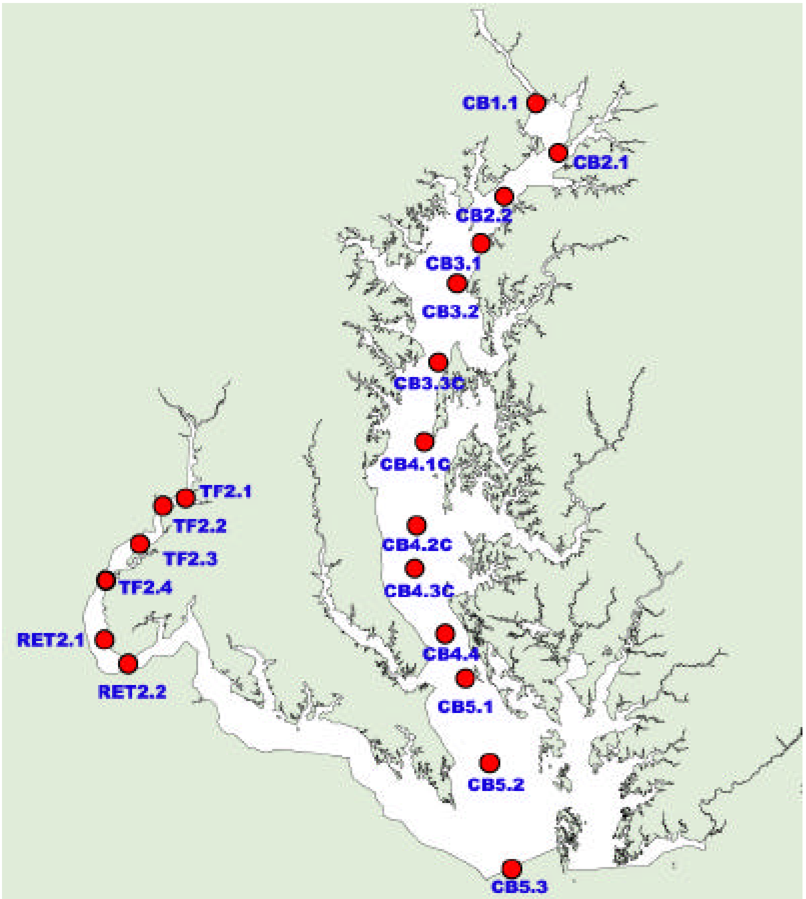


Figure 1. Location of fixed, main-stem Chesapeake Bay and tidal Potomac River stations monitored pre and post Isabel.

Figure 2. Location of continuous monitoring stations in the Chesapeake and Coastal Bays. Information about each station is available at: http://www.eyesonthebay.net/.

Impacts on Water Quality

In general, the short-term impacts of Isabel on water quality were minimal, particularly in comparison to the extremely wet spring and summer. The greatest short-term water quality impacts of hurricane Isabel resulted from the strong tidal surge that moved higher salinity water up the Bay. In the tidal portions of many tributaries, this surge resulted in temporary increases in salinity and decreases in water clarity from sediment resuspension and shoreline erosion. The storm also served to generally increase dissolved oxygen levels in the main-stem of Chesapeake Bay by mixing oxygen poor bottom waters with oxygen rich surface waters. The impact of Isabel on nutrient levels in the Chesapeake and Coastal bays will not be determinable until early 2004 when all samples have been analyzed.

Salinity

Salinities along the main-stem of the Chesapeake Bay prior to Isabel were well below the long-term (1985 – 2002) average for September due to the high amount of precipitation the Bay region received throughout the spring and summer of 2003. The tidal surge associated with Isabel increased salinities along the Bay main-stem by up to 5 parts per thousand post-storm ("ppt", fresh water = 0ppt, seawater = 35ppt), but even with this storm associated increase, salinities were still below the long-term average for September (Figure 3). Water quality mapping of the Magothy River pre and post Isabel demonstrated a similar slight increase in salinity several days after the storm (Figure 4). Continuous monitors throughout the Bay generally recorded a substantial increase in salinity during and immediately after the storm, followed by a return to pre-storm, or slightly above pre-storm, levels within approximately 24 hours (see Figure 5 for example). In general, salinity increases were more pronounced in tributaries along the Bay's Eastern Shore (Figure 6). As the storm's tidal surge pushed higher salinity water up the Chesapeake Bay, the earth's rotation deflected the saltier water toward the Eastern Shore, resulting in the higher salinities observed there. One notable exception was at Bishopville in Maryland's Coastal Bays, where a large decrease in salinity was observed that is attributed to high upstream freshwater input (Figure 6). United States Geological Survey stream gage data from nearby Birch Branch at Showell, MD reported a maximum gage height on September 18, 2003 that exceed 8 feet; 4 feet above gage levels in the days prior to Isabel.

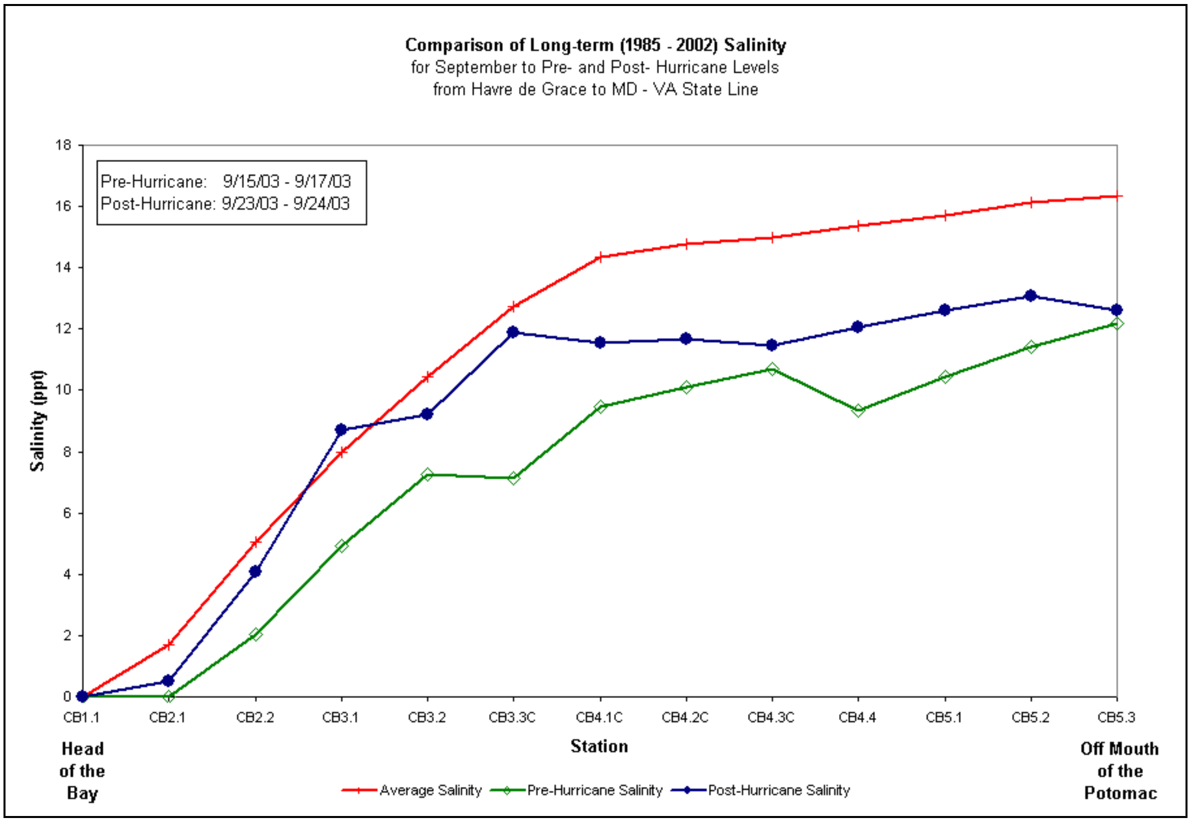


Figure 3. Comparison of long-term main-stem Chesapeake Bay average September surface salinity (1985 - 2002) versus surface salinities pre and post Isabel. The lower than average salinities both before and after the storm reflect the extremely wet 2003 season.

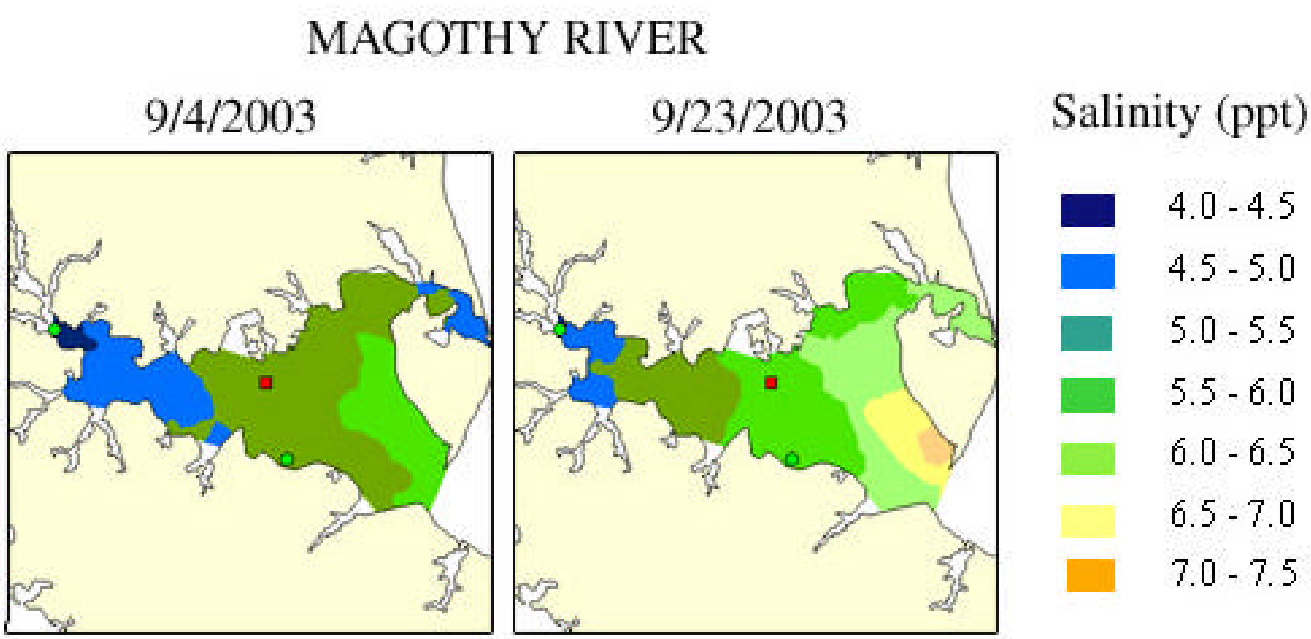


Figure 4. Water quality mapping of surface salinities on the Magothy River pre and post Isabel.

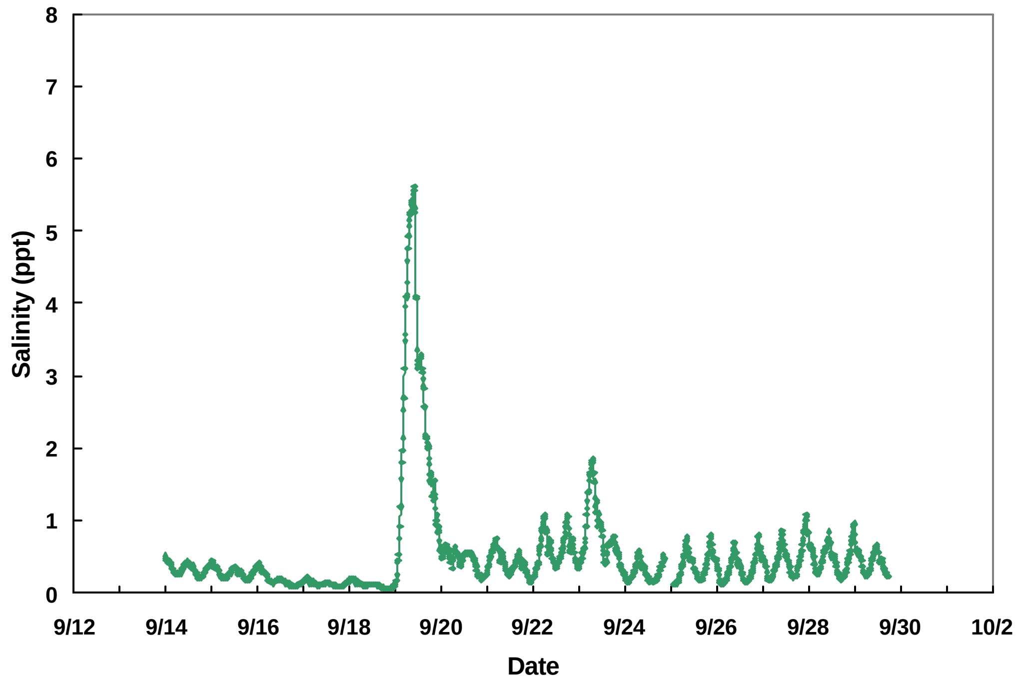


Figure 5. Continuous monitoring salinity data from Deep Landing on the Chester River during hurricane Isabel (September 18 – 19, 2003).

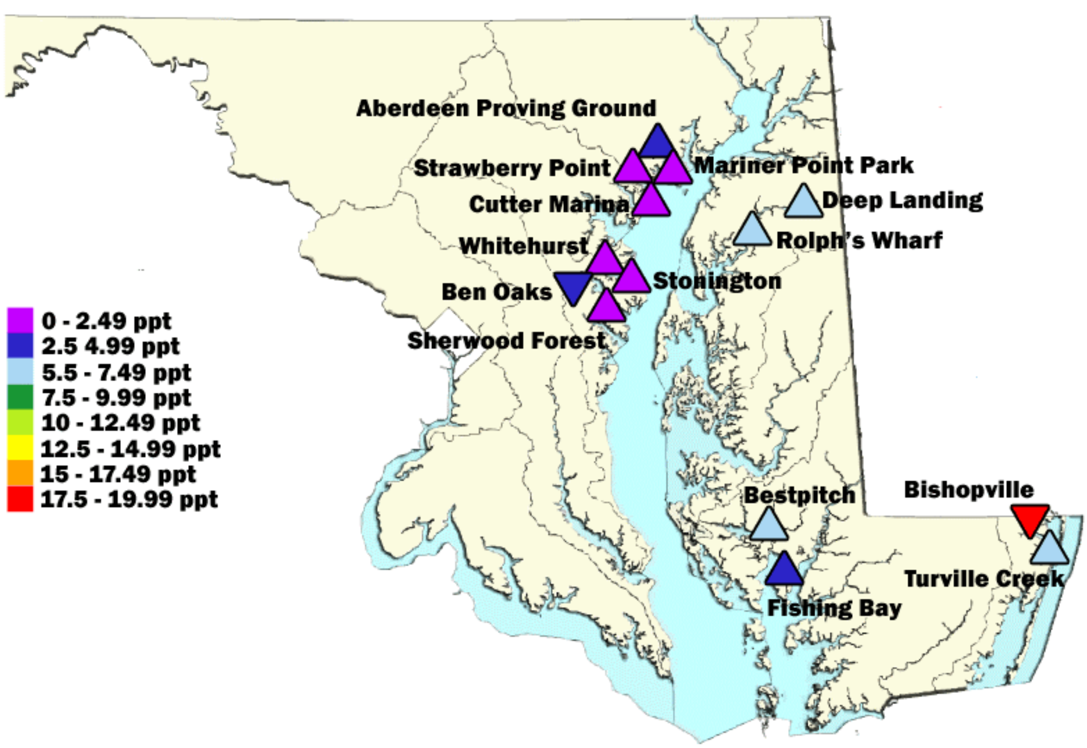


Figure 6. Change in salinity levels from pre- to post- hurricane Isabel from continuous monitoring data. Upward pointing triangles reflect an increase in salinity, downward pointing triangles indicate a decrease in salinity.

Water Clarity

Hurricane Isabel decreased water clarity (increased turbidity) throughout the Chesapeake and Coastal bays and their tributaries. This decreased water clarity following the storm is attributed to increased sediment input from up-river sources, shoreline erosion, and re-suspension of bottom sediments. The high winds surge associated with the storm resulted in much damage to waterfront property including increased shoreline erosion. The shoreline erosion not only effects the property owners but increases the input of sediments to the Chesapeake Bay.
A common measure of water clarity is "secchi depth", which is the maximum depth at which a standardized white and black disc can be lowered into the water and still seen by eye (i.e. the clearer the water, the greater the secchi depth). The long-term (1985 - 2002) average September secchi depths for the upper tidal Potomac River indicate that the wet 2003 spring and summer had resulted in pre-storm water clarity that was generally worse than the long-term averages. Hurricane Isabel further worsened water clarity in the upper tidal Potomac River (Figure 7). Results from 18 statewide continuous water quality monitors revealed decreases in water clarity in all monitored tributaries (Figure 8). Like the impacts to salinity, continuous monitors generally recorded a substantial decrease in water clarity during the hurricane, followed by a return to pre-storm or slightly poorer than pre-storm conditions within approximately 24 hours (Figure 9).

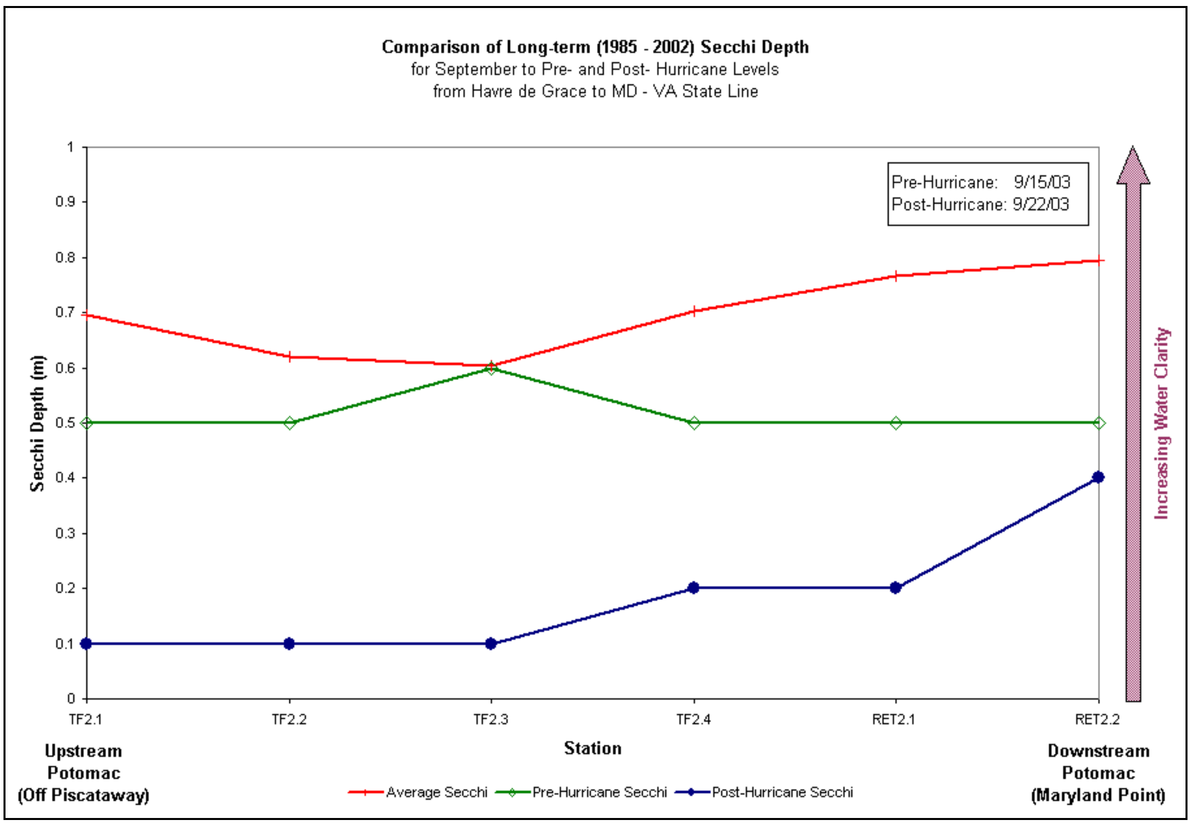


Figure 7. Comparison of long-term main-stem Potomac River average September secchi depths (1985 - 2002) versus secchi depths pre and post Isabel.

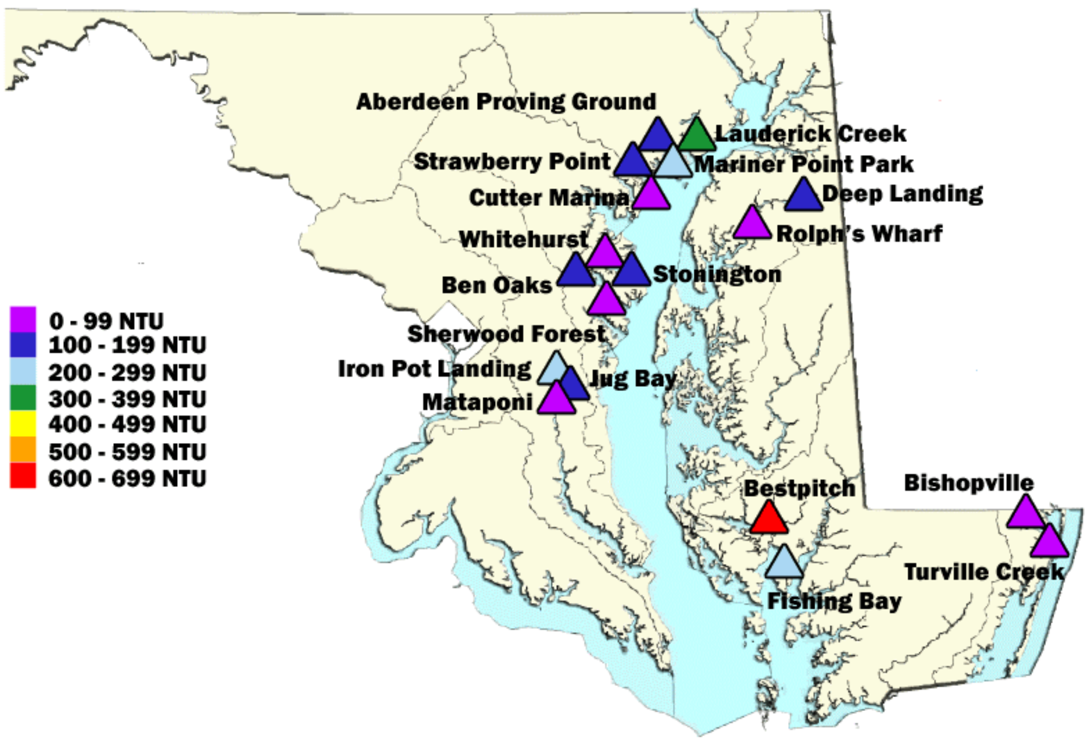


Figure 8. Change in water clarity (turbidity) levels from pre- to post- hurricane Isabel from continuous monitoring data. Upward pointing triangles reflect a decrease in water clarity (i.e. increase in turbidity).

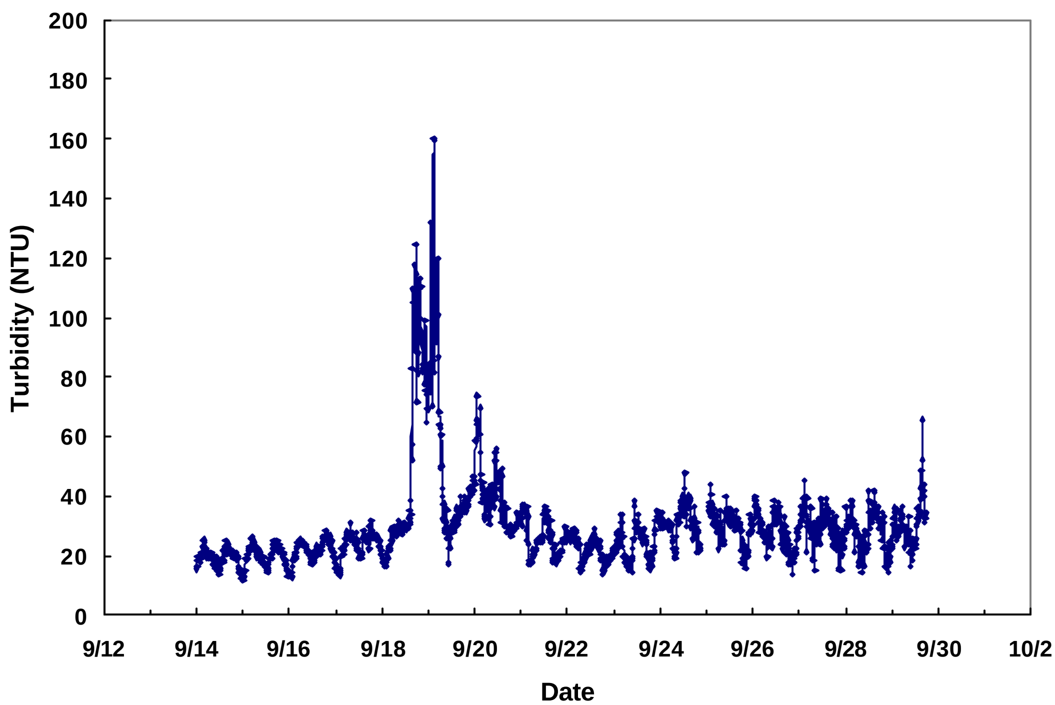


Figure 9. Continuous monitoring water clarity (turbidity) data from Deep Landing on the Chester River during hurricane Isabel (September 18 – 19, 2003). Higher turbidity values indicate lower water clarity.

Historical shorelines have been mapped by DNR's Maryland Geological Survey, and average shoreline erosion rates calculated from these historical data for all of the tidal waters of the state. These erosion rates are averages over long periods of time and, while they incorporate periodic high erosion rates associated with hurricanes such as Isabel, the maps do not show the effects of individual storms or seasons. Shoreline erosion, while it is a continuous process, has highly varying short term rates that respond to seasonal weather conditions including rain, freezing and wind generated waves.

The wind generated waves associated with the storm also served to resuspend or "stir up" the fine muddy sediments that cover much of the bottom of the Chesapeake and its tributaries. Studies of past storm events have shown that suspended sediment concentrations near the Bay bottom are higher than normal after a storm and the bottom material is much easier to resuspend, or erode, for some time following a storm. On each tide cycle sediment is loosed from the bottom and carried upwards a short distance into the overlying water where it can be carried by the tide currents up and down the estuary. Eventually, these sediments are redeposited onto the bottom of the Bay and the amounts in the water column return to more normal levels. Occurrence of this storm in the fall season will allow time over the winter for much of this sediment to be deposited back on the bottom of the Bay. The movement of sediment is part of a relatively normal cycling that occurs on the Bay bottom.

Finally, sediments dredged to maintain the shipping channel that connects to the Chesapeake and Delaware Canal in the northern Chesapeake Bay are placed in sites located near Pooles Island. Surveys of this placed sediment are routinely conducted by RAS/MGS. Surveys were conducted immediately prior to and after the passage of Isabel to examine the amounts of sediment that may have been resuspended and eroded from the site. The data indicated that very little of the deposited sediments were eroded as a result of the storm. Some erosion occurred in the shallowest portions of the placement area, but the quantities of sediment removed were very small.

Dissolved Oxygen

Post-storm dissolved oxygen in the main-stem of the Bay increased at most stations over pre-storm and long-term average levels (Figure 10. This effect was most likely a result of water column mixing caused by wind and wave action. Typically during the summer months, the Bay stratifies (surface and bottom waters do not mix). The excess nutrients added to the Bay from human activities fuels biological, oxygen consuming production that depletes oxygen in the unmixed bottom waters. This reduction in dissolved oxygen produces a "dead zone" within which insufficient oxygen remains to support most aquatic life. A mixing of the Bay's waters typically occurs as water temperature cools in late summer or early fall, however, the tidal surge and wind mixing resulting from hurricane Isabel caused this event to happen with more intensity than it normally would. Interpolated data from the EPA Chesapeake Bay Program shows the spatial extent of this overturn (Figure 11). Although there was a short-term improvement in dissolved oxygen levels in the Bay following the storm as the bottom-level dead-zone was dissipated, increased sediments and nutrients that were delivered to the Bay may have a longer-term negative impact on living resources such as underwater grasses and oyster beds. However, the timing of the storm, arriving in mid September instead of June like hurricane Agnes in 1972, may mitigate these negative impacts from nutrients and sediments.

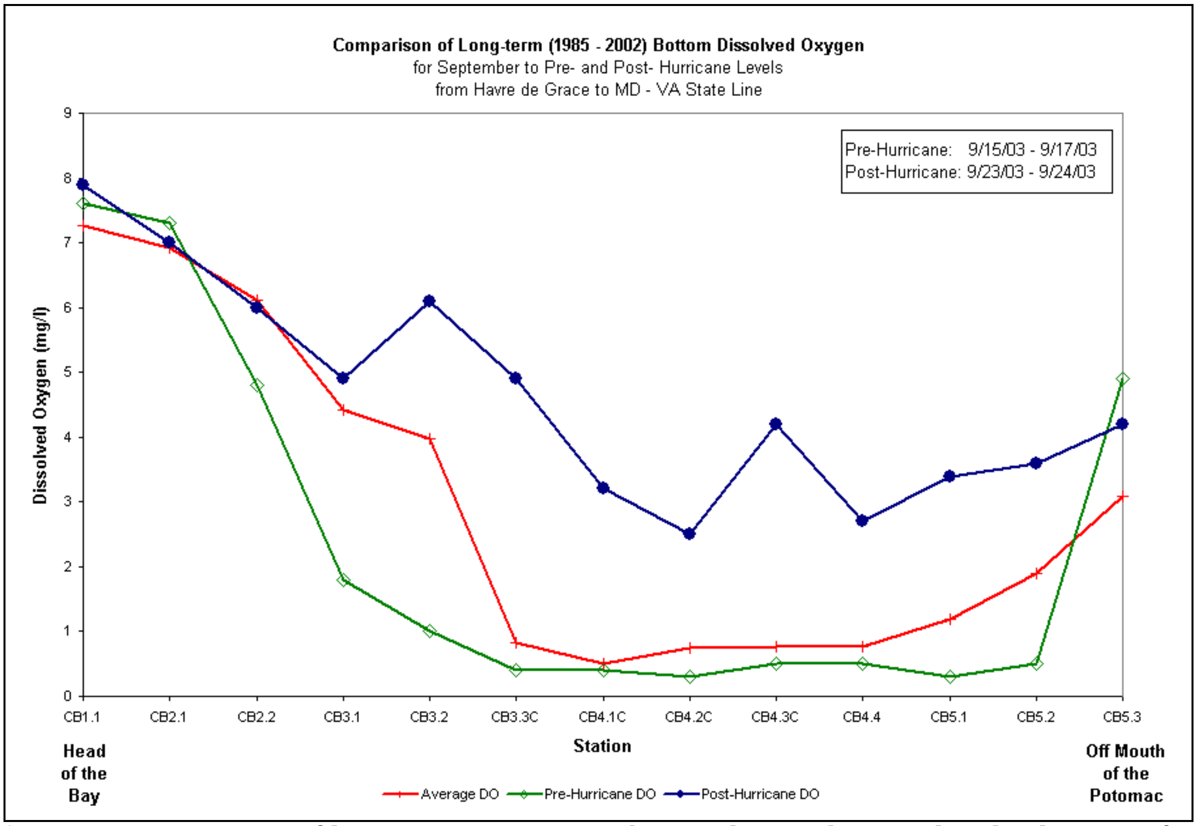
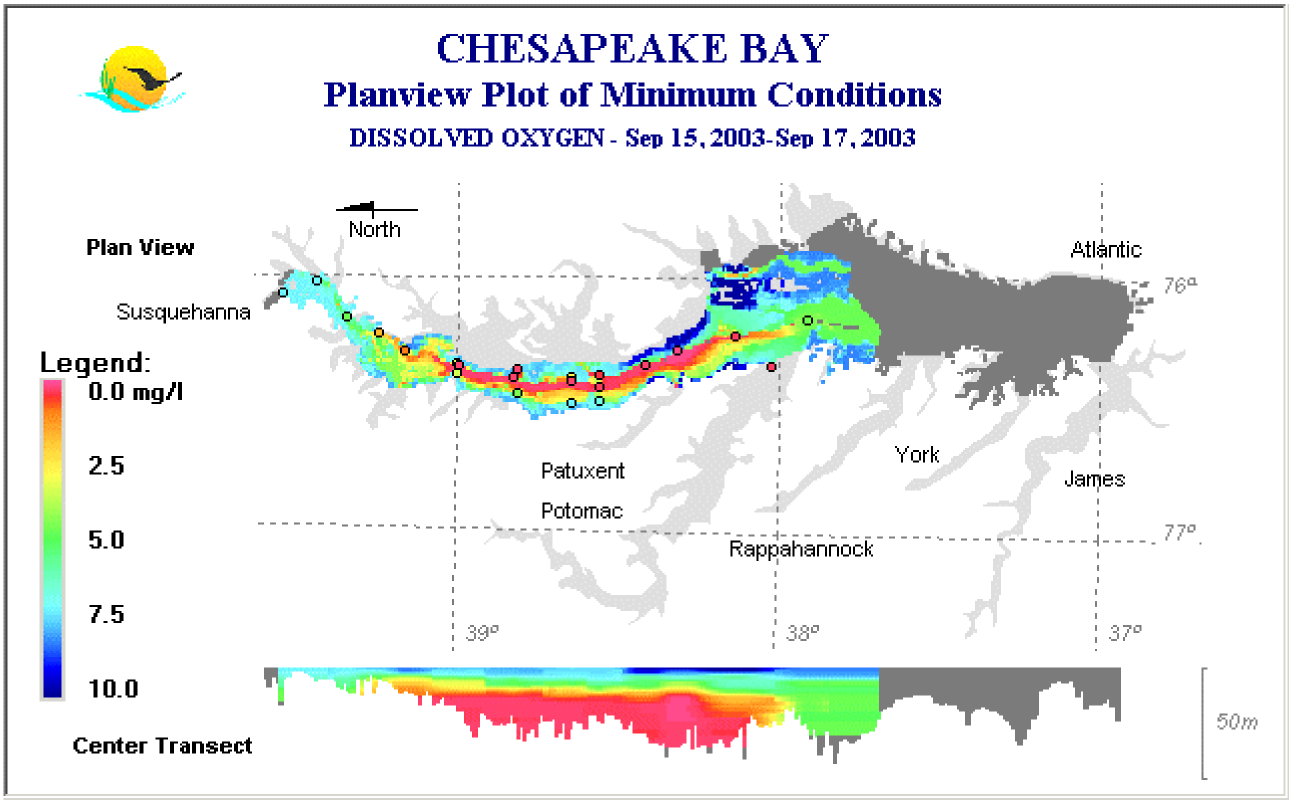


Figure 10. Comparison of long-term main-stem Chesapeake Bay bottom dissolved oxygen for September to pre- and post- hurricane Isabel storm levels.



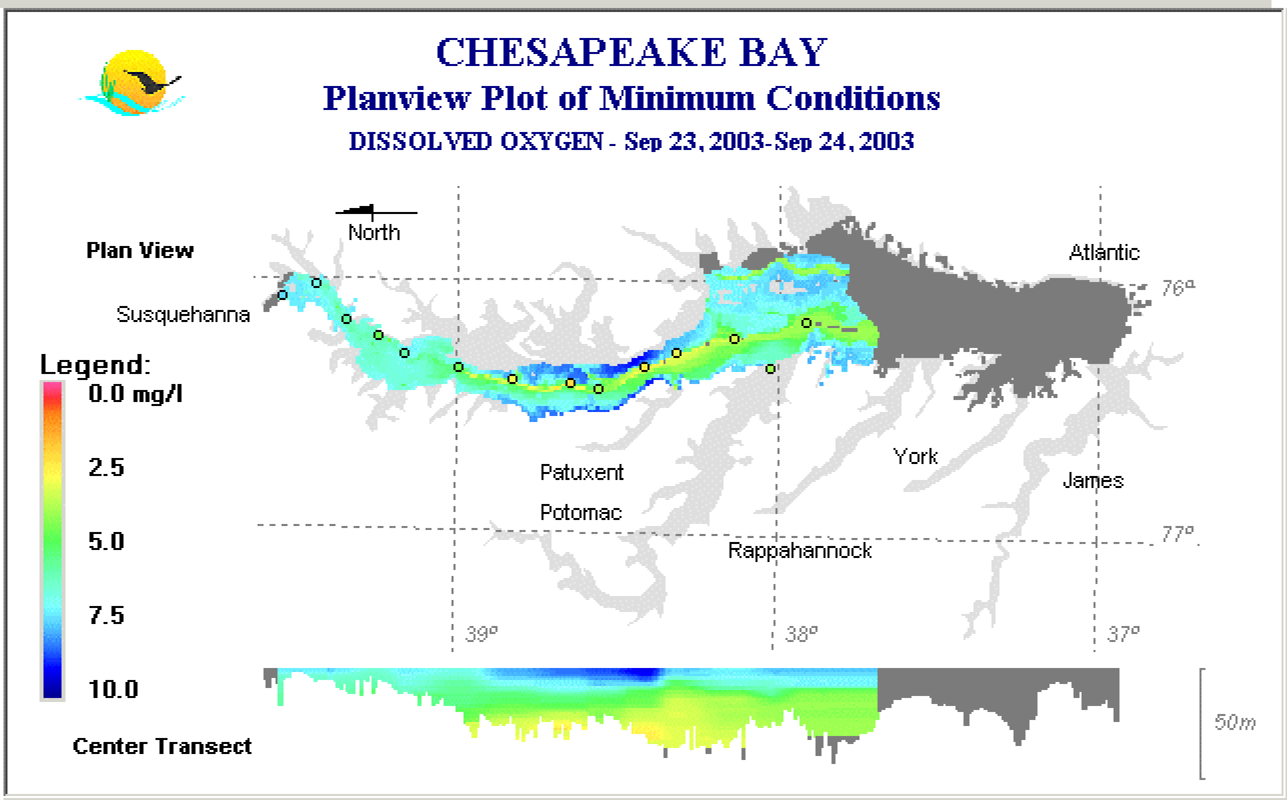


Figure 11. Interpolated plot of minimum dissolved oxygen conditions in the Chesapeake Bay before (top) and after (bottom) Hurricane Isabel. Graphic provided courtesy of the EPA Chesapeake Bay Program.

Nutrients

Any rainstorm washes sediment and nutrients into the Bay. Hurricane Isabel was not a major rain producer compared to other hurricanes that have impacted the region. However, the high rainfall of the past year resulted in saturated ground conditions so that much of the rain that fell during Isabel ran off into the rivers and streams that feed the Chesapeake Bay. One likely result of this runoff was an increase in nutrient delivery to the Chesapeake. The late season timing of the storm, relative to warm weather periods when primary productivity is high, may serve to lessen the impacts of the delivered nutrients. The amount of nutrients added to the Bay as a result of Isabel will not be determined for several months when sample analysis is complete.

Impacts on the Bay's Living Resources

Most mobile organisms that inhabit estuaries such as the Chesapeake and Coastal bays are well adapted to rapid changes in salinity and temperature, and therefore impacts from Isabel are likely to be minimal. Non-mobile organisms such as bay grasses and oysters are generally more susceptible to these impacts. Conclusive data on the impacts to these organisms will not be available until annual surveys are conducted in the spring and summer of 2004.

Anecdotal information from a variety of sources surveying underwater bay grass (Submerged Aquatic Vegetation or "SAV") beds bay-wide, suggests that the short-term impacts of Isabel on bay grasses were minimal. Most bay grass beds that have been visited to date are still intact and appear healthy. There are reports that some of the fouling algae that typically cover bay grass blades, thereby reducing light from reaching the plants, may actually have been cleaned off by the intense wave action. There is some concern, however, about the potential long-term impacts. Several bay grass species are currently going to seed, and it is possible that the seeds may have been buried by the increased sedimentation or flushed out into deep water.

Microcystis is a blue green harmful algae that blooms in the fresh, nutrient enriched portions of the Bay in summer and fall. It has the ability to produce toxins that may cause health problems in humans and animals that swim in or drink water from blooms. In 2003 and previous years, blooms of *Microcystis* have resulted in several beach closures. In the first week of September, the Smith Point region of the Potomac River was the focus of a major *Microcystis* bloom, defined by concentrations over 2 million cells/ml. Bloom conditions were observed at lower but significant levels from Indian Head to Morgantown days before Isabel arrived. Initial post-hurricane sampling by the Departments of Natural Resources and Environment indicates that *Microcystis* was still present on the river, but at significantly reduced levels. Cell counts at Smith Point were down to only 53 cells/ml. Cell counts were higher downstream at Smith Point (21,960 cells/ml), but still below pre-hurricane bloom levels. It is possible that the combination of intensive mixing, increased turbidity, and increased salinity combined to reduce the bloom. It is also possible that some of the bloom was flushed further downstream. Department of Natural Resources crews are continuing to conduct follow-up monitoring.

There are also concerns about the impacts of oil, gasoline, nutrients and herbicides that have been washed into many of the tributaries. These potential long-term impacts may not be known until next year.

Maryland Streams

Stream flows throughout the region have been above normal in every month except two during 2003. Near-record monthly flows were reached in June through September. Several rivers in Maryland reached flood stage during September, including the Potomac and Monocacy. Monthly record flows were set on the Youghiogheny River in Garrett County, and on the Choptank and Pocomoke rivers on the Eastern Shore.

The Department of Natural Resource's Monitoring and Non-tidal Assessment Division (MANTA) of the Resource Assessment Service has been conducting the Maryland Biological Stream Survey (or MBSS) since 1995. Each year, about 250 freshwater stream sites across the state are sampled in spring and summer to assess the ecological health of these important tributaries to the Chesapeake Bay. In July and August 2003, the MBSS crews had completed the summer sampling period that is focused on the fish community and the physical habitat, thereby providing pre-storm conditions. Post-storm impacts were assessed by re-sampling five of these sites (Figure 12).

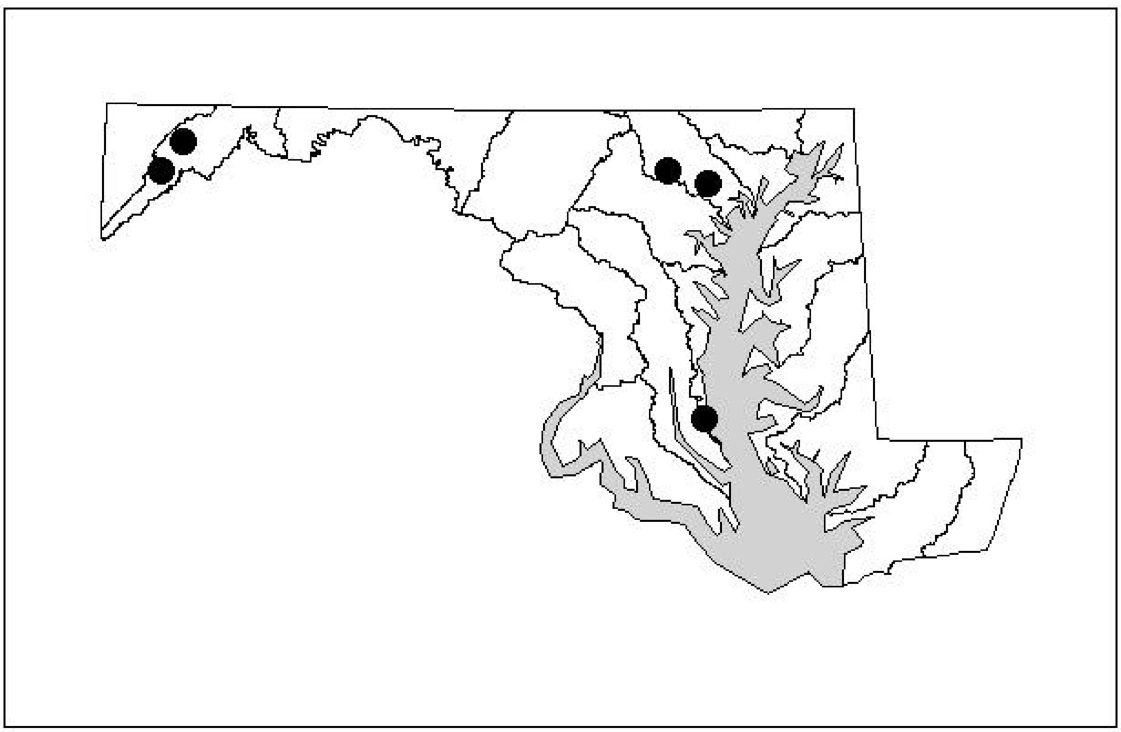


Figure 12: Freshwater stream sites sampled to assess impacts of Hurricane Isabel

Post-Isabel Stream Monitoring Results

To conduct this post-Isabel assessment, MANTA's field crews sampled one 1st order stream in the Coastal Plain (Governor's Run, Calvert County), one 1st and one 2nd order stream in the Piedmont (Baisman Run and Minebank Run, Baltimore County), and two 2nd order streams on the Appalachian Plateau (Savage River and Crabtree Creek, Allegany County). Baisman Run, Savage River, and Crabtree Creek are high quality Sentinel Sites for the MBSS that drain predominantly forested watersheds. Minebank Run drains a heavily-urbanized watershed and is known to exhibit extremely flashy flows after rain events. Governor's Run drains directly into the Chesapeake Bay and was selected for resampling because it might have been influenced by the Isabel-related storm surge. If so, freshwater fish inhabitants of Governor's Run could have been inundated by salty Bay water.

MBSS field crews sampled these five freshwater streams as soon after Isabel departed as current velocities, water depths, and turbidities would allow. Crew safety was our first priority. Sampling efficiency with electrofishing gear is greatly reduced when turbidity levels are high and crew visibility is impaired. Monitoring criteria used to assess Isabel impacts on streams were fish species composition/relative abundance and physical habitat conditions. An overview of MANTA's monitoring results is presented below.

Neither the fish community nor the physical habitat in Governor's Run, a small Coastal Plain stream on Maryland's western shore, were impacted by either the storm surge or elevated stream flows associated with Isabel. Anecdotal information from residents in the area suggested that the upstream intrusion of the storm surge did not reach much further in Governor's Run than the normal high tide level. Only two fish species were collected: American eel and blacknose dace. Both are hardy, pollution tolerant, and abundant in many Maryland streams.

The fish community and physical habitat in the two Piedmont streams, Baisman Run and Minebank Run, also showed no detectable changes that could be associated with Isabel. Flows in both streams responded to rainfall from Isabel by peaking on September 19-20, but then quickly returned to near baseline flows by September 21. Peak Isabel flows were lower than other peak flows that occurred in these streams in prior months, and also lower than the peak flows on September 23 associated with the significant rain event of September 22-23. Therefore, in these two Piedmont streams, rainfall associated with Isabel produced just one more period of elevated stream flows in a very wet year that included several such periods of elevated streams flows----some lower, some about the same, and some higher than what Isabel produced.

Elevated stream flows associated with Isabel and two significant rain events soon after combined to make it impossible for the field crews to sample the two MBSS streams in western Maryland until October 9 when flows finally returned to near baseline conditions. No significant changes in the fish communities were observed, when compared to pre-Isabel sampling conducted in July. Minor changes in the physical habitat included streambed scouring, loss of woody debris and one large overhanging tree, and formation of new depositional areas in the stream channel. These changes are all consistent with elevated flow events, but it is impossible to associate them specifically with Isabel. September 2003 was one of the wettest Septembers on record throughout Maryland. Two significant rain events preceded the arrival of Isabel on September 18-19, and two events occurred within about a week after Isabel.

Future Stream Monitoring

The fifth and last year of the second statewide round of the Maryland Biological Stream Survey will be completed in 2004. About 220 randomly-selected stream sites across the state will be sampled in spring and summer to assess chemical, biological, and physical habitat conditions. The three Sentinel Sites described above plus an additional 20-22 Sentinel Sites will also be sampled next year. Therefore, DNR will be collecting a large amount of monitoring data in freshwater streams in 2004 that will be analyzed to evaluate any prolonged or delayed impacts of Isabel and the extremely-wet 2003 on fish, benthic macroinvertebrates, and their habitats.

Groundwater and Surface Waters

Many individual wells in flooded areas were overtopped by Chesapeake Bay waters and the wells have been reported to be contaminated. Local and State health authorities are working to assist homeowners to identify and decontaminate these wells. Oil tanks and septic fields that were damaged or destroyed during the flooding of low lying areas may have contributed to the contamination of ground water in the water table aquifer, but are unlikely to have impacts on deeper aquifers in which public water supply wells are located. Conditions of the public water supply wells are routinely monitored to insure potable water for the citizens of Maryland.

The US Geological Survey as part of the cooperative agreement with the DNR Maryland Geological Survey actively monitors springs, streams and water table wells throughout the state. This monitoring effort will assist in determining any long term effects of contamination on the ground and surface waters in the State.