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Choptank, Little Choptank and Honga Rivers Water Quality and Habitat Assessment

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Tidewater Ecosystem Assessment

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Information on the water and habitat quality of Maryland's rivers and bays is available due to the hard work of many dedicated staff including:

- staff who are in the field collecting the samples year-round, sometimes under less than desirable weather conditions
- laboratory staff who perform the chemical tests to determine what exactly is in those water samples
- data management staff who collect the resulting information, confirm the accuracy and quality of the data, and organize and maintain the databases and
- analytical staff who interpret the data to answer the question 'how is the river/Bay doing?'

There are too many individuals to directly name from more than 25 years of monitoring, so we simply wish to commend all of them for their commitment to collecting high quality information and making it available and useful to the citizens of Maryland.

Table of Contents

Table of Figures

Table of Tables

Choptank, Little Choptank and Honga Rivers
Water Quality and Habitat Assessment

Overall Condition

Healthy rivers and bays support a diverse population of aquatic life as well as recreational uses, such as swimming and fishing. To be healthy, rivers and bays need to have good water and habitat quality. High levels of nutrients and sediments lead to poor water quality. Poor water quality reduces habitat quality, including water clarity (how much light can get to the bottom) and the amount of dissolved oxygen in the water. In turn, habitat quality affects where plants and animals can live. The Maryland Department of Natural Resources (DNR) is responsible for monitoring water and habitat quality in the Chesapeake Bay and rivers, as well as the health of aquatic plants and animals. DNR staff use this information to answer common questions like "How healthy is my river?", "How does my river compare to other rivers?", "What needs to be done to make my river healthy?" and "What has already been done to improve water and habitat quality in my river?"

How healthy are the Choptank, Little Choptank and Honga Rivers?

Choptank River Water quality in the upper Choptank is poor. Nutrient and sediment loads to the non-tidal waters have increased and nitrogen, phosphorus and sediment levels are too high. Habitat for underwater grasses is fair because water clarity is poor. Algal densities have improved, though this is possibly linked to higher flows in recent years moving algal blooms downstream. Only bottom dissolved oxygen levels are good. Water quality in the shallow water is similar to that in the open water for nitrogen and sediment levels, but phosphorus levels and water clarity differ with location. No underwater grass beds were found in the upper Choptank and phytoplankton (algae and bacteria) and bottom dwelling animal populations are not healthy.

Water quality in the middle Choptank is fair due to high nitrogen levels. Habitat for underwater grasses is poor. P levels have also degraded over the longer term, but sediment levels have improved. Water quality in the shallow waters is much worse at Jamaica Point than at the other stations. Overall, the remaining shallow water areas were similar to the open water for nitrogen and phosphorus levels. No underwater grass beds were found in the middle Choptank and phytoplankton (algae and bacteria) and bottom dwelling animal populations are not healthy. Harmful algal blooms occur in most years.

Water quality in the open waters of the outer Choptank is good due to low nitrogen, phosphorus and sediments levels. Nitrogen and phosphorus levels in the shallow water are similar to the open water but water clarity is lower in some shallow water areas. Summer bottom dissolved oxygen levels are fair but occasionally fell below 3 mg/l. Despite good water quality, underwater grass beds only covered 5% of the area needed to meet the restoration goal and more than half of the habitat for bottom animals was degraded.

Little Choptank Water quality in the open waters of the Little Choptank is currently good due to low nitrogen, phosphorus and sediment levels, but has degraded over the longer term. However, summer bottom dissolved oxygen is often below 3 mg/l. Water quality in shallow water is similar to the long-term open water station. Underwater grass beds have decreased to less than 5% of the area needed to meet the restoration goal and habitat for bottom animals was degraded.

Honga Water quality in the Honga River is good due to low nitrogen, phosphorus and sediment levels. The Honga River is very shallow, and storms can stir up sediments from the bottom and contribute to the poor water clarity. Underwater grass beds only covered 28% of the area needed to meet the restoration goal.

How do the Choptank, Little Choptank and Honga Rivers compare to other Maryland rivers?

The Choptank River and the Little Choptank River are in the ‘Low Urban, High Agriculture’ land use category, and the Honga River is in the ‘Low Urban, Low Agriculture’ category (Figure 1). In the Choptank River overall, nitrogen, phosphorus, sediment and summer bottom dissolved oxygen levels are moderate compared with other high agricultural systems, and water clarity and algal densities are better than other high agricultural systems (Figure 2). This overall comparison does not evaluate the nutrient and sediment levels within each portion of the river (upper, middle and outer), which is discussed more thoroughly in the other portions of the report.

The nitrogen, phosphorus and sediment levels in the Little Choptank River are among the best in all of the Maryland rivers and bays. Algal densities and water clarity are also better than more than half of the other rivers and bays. However, summer bottom dissolved oxygen levels are extremely low and one the worst of any Maryland rivers and bays.

Because no long-term water quality monitoring is done in the Honga River, it is not directly compared to the other Maryland rivers and bays. Information for the shallow-water monitoring program is included in other portions of the report.

Table 1. Summary of trends for non-tidal loadings (1985-2010) and non-tidal water quality parameters trends (1999-2010).

	Loadings			Water Quality		
	Nitrogen	Phosphorus	Sediments	Nitrogen	Phosphorus	Sediments
Non-tidal Choptank River	Increase	Increase	Decrease		Decrease	

Table 2. Summary of tidal habitat quality and water quality indicators. Algal densities, water clarity, inorganic phosphorus and sediments either 'Meet' or 'Fail' SAV habitat requirements (Appendix 5). Dissolved nitrogen levels below the level for nitrogen limitation 'Meet' criteria, otherwise 'Fail' criteria. Summer bottom dissolved oxygen levels above 3 mg/l 'Meet' criteria, otherwise 'Fail' criteria. Annual trends for 1999-2010 either 'Increase' or 'Decrease' if significant at $p \leq 0.01$ or 'Maybe Increase' or 'Maybe Decrease' at $0.01 < p < 0.05$; blanks indicate no significant trend. Improving trends are in green, degrading trends are in red. Nitrogen trends are for total nitrogen, phosphorus trends are for total phosphorus, water clarity trends are for Secchi depth. Depth 'Shallow' is from the shallow water monitoring program, 'Open' is from the long-term monitoring program.

River	Water Depths	Habitat Quality			Water Quality		
		Algal densities	Water Clarity	Summer Bottom Dissolved Oxygen	Nitrogen	Phosphorus	Sediments
Upper Choptank	Shallow	Meet	Fail	Meet	Fail	Fail	Fail
	Open	Meet Decrease	Fail	Meet	Fail	Fail	Fail
Middle Choptank	Shallow	Meet	Fail	Meet	Fail	Meet	Meet
	Open	Meet	Meet	Meet	Fail	Meet	Meet Decrease
Outer Choptank	Shallow	Meet	Fail	Meet	Meet	Meet	Meet
	Open	Meet Maybe increase	Meet	Meet	Meet	Meet	Meet
Little Choptank	Shallow	Meet	Fail	Meet	Meet	Meet	Meet
	Open	Meet Maybe increase	Meet	Fail	Meet	Meet	Meet
Honga River	Shallow	Meet	Meet	Meet	Meet	Meet	Meet

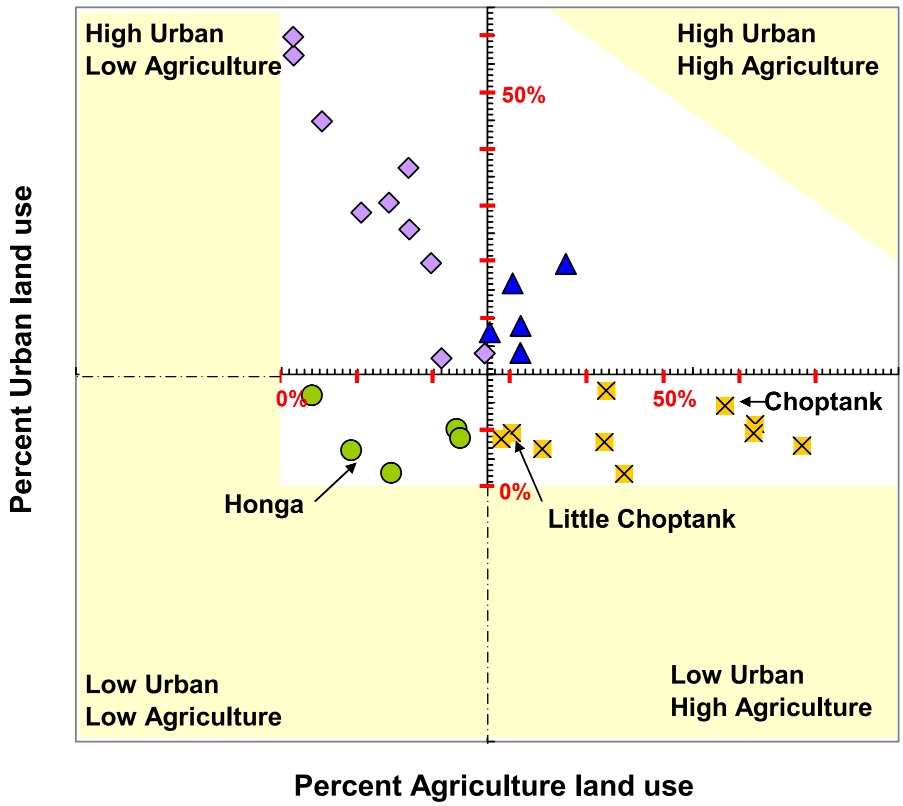

Figure 1. Classification of Maryland rivers and bays by land use.
The medians of all systems percent agriculture and percent urban land use are used to create a grid with four categories. Systems with percent urban less than the median are considered low urban. Systems with percent agriculture less than the median are considered low agriculture. Each system was categorized based on placement on the grid. Note that pale yellow areas are not mathematically possible (i.e. there is not a negative percent agriculture land use, and it is not possible for percent agriculture + percent urban to be greater than 100%). These groupings were used to evaluate each system relative to those other systems with similar land use characteristics.

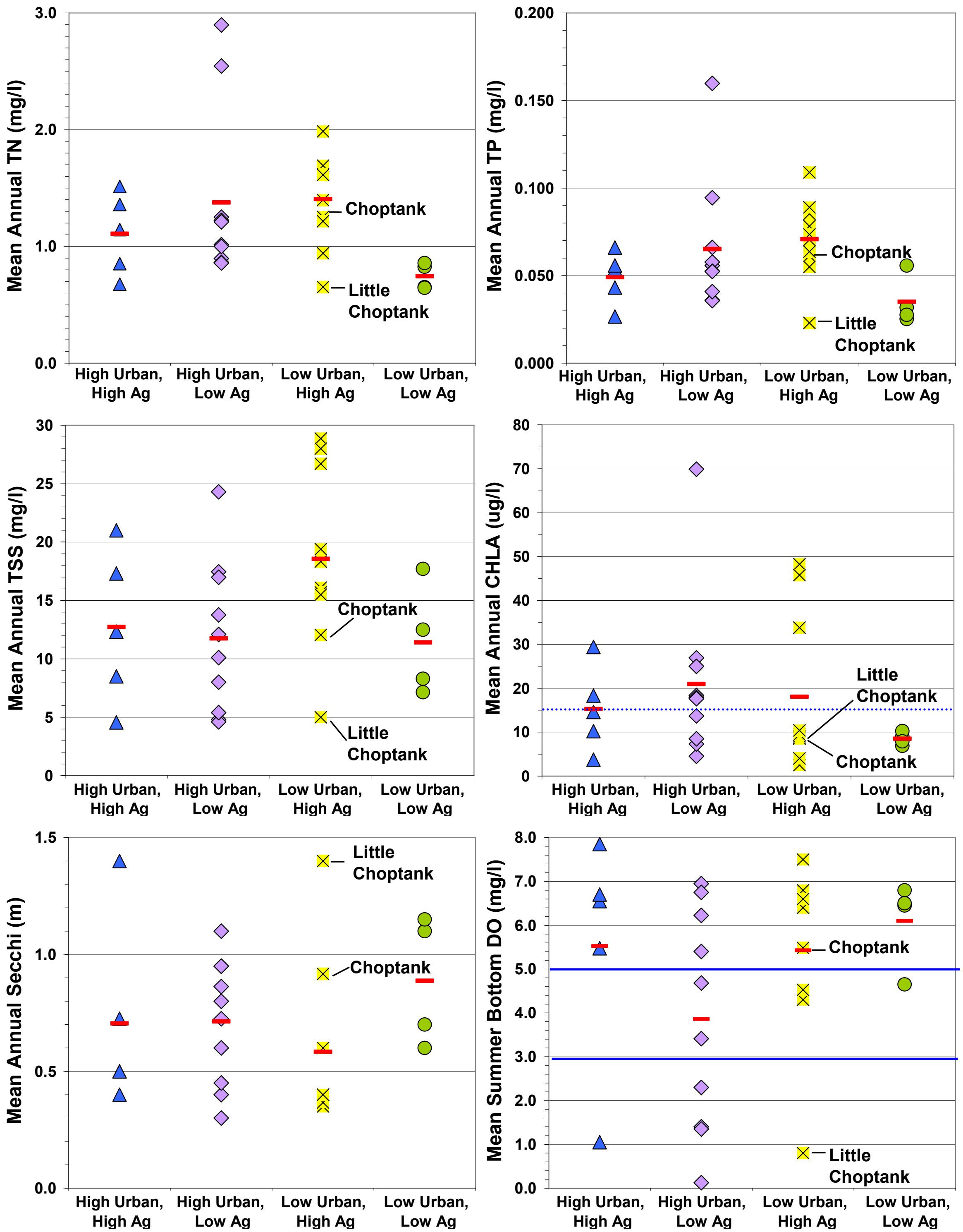

Figure 2. Comparison of the Choptank and Little Choptank to similar rivers.
The mean annual concentration or depth (bottom dissolved oxygen is only summer) for 2008-2010 long-term monitoring data. Red bars indicate the mean of all systems within a category. Reference lines are included on the CHLA and BDO graphs. Water and habitat quality is not measured in the Honga River through the long-term monitoring program so is not compared to the other Maryland rivers and bays.

What needs to be done to make the Choptank, Little Choptank and Honga Rivers healthy?

The most important problems that should be addressed in the Choptank River are nitrogen, phosphorus and sediment loadings from agricultural lands, especially to the upper river. Nitrogen levels in the upper and middle Choptank, water clarity in the upper river and water clarity in shallow water areas throughout the river also need to be improved. Efforts should focus on best management practices specific to agricultural lands. With lower nutrients and sediments, water clarity should improve which will improve habitat quality for underwater grasses. Lower nutrients will also reduce the frequency and duration of harmful algal blooms.

Urban land use in the Choptank watershed has increased by 5% since 2000. As more area is developed, alternatives to conventional building methods and materials should be used to reduce the amount of impervious surfaces and prevent additional degradation of water quality. Also, as more area is developed, management of waste water through waste water treatment plants instead of septic systems is also needed.

The most important problems in the Little Choptank River are low dissolved oxygen levels in the bottom waters and poor water clarity in shallow water areas. High turbidity in the shallow water reduces water clarity even though TSS levels met the habitat requirement for underwater grasses. Agricultural sources of nitrogen, phosphorus and sediment loadings should be reduced to improve water quality. Reductions in nutrients will lead to lower algal densities and further improve habitat quality. Improvements in algal densities will also help to improve the very low dissolved oxygen levels. Improved habitat quality for bottom animals will lead to more diverse and stable populations.

The Honga River watershed is mostly wetlands and forest, so human impacts in this river are minimal. Water and habitat quality is good and maintaining natural land uses will protect the river from degradation.

What has already been done to improve water and habitat quality in the Choptank, Little Choptank and Honga Rivers?

A variety of actions have already been taken to lower nitrogen, phosphorus and sediment loadings from agricultural lands. While specific goals have not been set for this basin, improvements are being made. In 2010 there were more than 30,700 acres of cover crops planted in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on almost 300 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. More than 250 containment structures had been built to store animal wastes to allow these nutrients to be applied to the land in the most effective manner at the appropriate time. More than 16,000 acres of stream buffers were also in place, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

To reduce nutrient inputs from urban lands, additional actions have been taken. These actions include upgrades to wastewater treatment plants, managing stormwater runoff and retrofitting septic systems. Upgrades to the largest wastewater treatment plant that discharges to the Choptank River are under construction and will be completed by the end of 2012. Previous upgrades to the facility have already reduced the nitrogen loadings to one-third and phosphorus levels to one-tenth of previous levels. No major wastewater treatment plants discharge to the

Little Choptank or Honga rivers. Nearly 200 septic system retrofits were completed between 2008-2010, and stormwater retrofits have reduced nitrogen loadings and prevented 2,500 pounds of nitrogen from entering the rivers since 2003.

Maryland also has a number of programs in place to reduce the impacts of continued development and increasing amounts of impervious surfaces. In the Choptank, Little Choptank and Honga river watersheds, Program Open Space projects have conserved more than 100 acres of land for outdoor recreation opportunities. Rural Legacy Program projects have protected more than 3,450 acres, with special focus on areas with important cultural sites and natural resources and to ensure large areas of habitat. Maryland Environmental Trust projects have helped individual land owners protect more than 7,100 acres. Maryland Agricultural Land Preservation Program projects have preserved almost 4,500 acres of agricultural land from development.

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Introduction

Water quality is measured as the level of nutrients and sediments in the water. Habitat quality is determined by how nutrients and sediments impact water clarity, algal populations and bottom dissolved oxygen levels. Habitat quality is also determined by salinity and water temperatures, but these measures are not changed by nutrients and sediments. Habitat quality determines if and where underwater grasses, fish and bottom dwelling animals can live. Reducing the levels of nutrients and sediments is a major focus of restoration efforts. The goal is to reduce nutrient and sediment levels so that habitat quality is improved and high quality habitat is expanded. Assessing water and habitat quality is an important first step in making decisions on what needs to be done to improve water and habitat quality.

Habitat quality can be assessed by looking at the health of the aquatic plants and animals that remain in the same location, such as underwater grasses and bottom dwelling animals. The health of these organisms depends on habitat that is suitable for growth and survival, so healthy organisms indicate healthy habitats. Changes in the populations of these plants and animals can often be linked to specific parts of habitat quality that are poor, such as water clarity or bottom dissolved oxygen. This additional information helps managers better pinpoint what needs to be changed to improve water and habitat quality.

Land use in a watershed is linked to the human population density. Rivers with high urban land uses have higher population densities and more impervious surfaces. Rivers with high agricultural land uses in rural areas have lower population densities and less impervious surfaces. Higher population densities are often linked to management of human wastes through wastewater treatment plants, while septic systems are more prevalent in areas with lower population density. Pollutant loadings from undeveloped lands such as forests are different from loadings from more developed areas. Information on human population and land use help managers decide the best methods for reducing nutrients and sediments going from the land into the water.

The Choptank, Little Choptank and Honga Rivers Water Quality and Habitat Assessment includes a variety of information. Land use data and census data are examined to understand how the watersheds are impacted by human uses. Loadings data is examined to identify how much nutrient and sediment is entering the non-tidal streams from the watershed. Data from long-term non-tidal and tidal water quality monitoring programs are examined for current water and habitat quality and changes over time. Data from monitoring in shallow water habitats are examined to determine water and habitat quality in the areas most important for underwater grasses and the organisms that live there. Data from monitoring of algal populations, underwater grasses and bottom dwelling organisms are examined to determine how well the resulting habitat quality supports healthy plant and animal populations.

Land use and Human population

The Choptank River Basin includes portions of Caroline, Dorchester, Queen Anne's and Talbot Counties (Figure 3). The basin drains approximately 700 square miles in five sub-watersheds. The river originates in Kent County, Delaware, and flows southwest, becoming tidally controlled near Greensboro, Maryland. Larger water bodies in this basin include the Choptank, Little

Choptank, and Tred Avon Rivers and Broad, Harris, and Tuckahoe Creeks. The Honga River is also considered part of this basin. Larger towns include Cambridge, Easton and Denton.

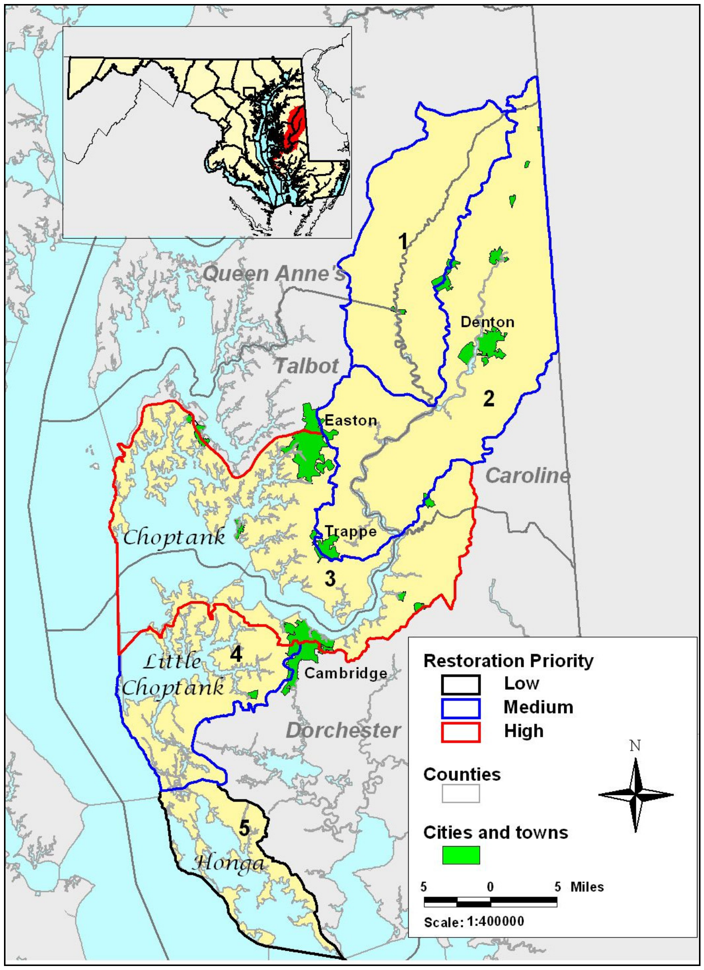

Figure 3. Choptank, Little Choptank and Honga Rivers basin.
Trust Fund Priority Watershed Restoration Priority designation (high, medium, low), county lines and cities/towns are shown. Sub-watersheds (8-digit) are: 1: Tuckahoe Creek, 2: Upper Choptank, 3: Lower Choptank, 4: Little Choptank, 5: Honga.

In 2010 there were approximately 80,000 people living in the watershed.[1] Population density was low (10-100 people per square mile) in much of the basin (Figure 4). A number of smaller areas had moderate densities (100-1,000 people mi^2), and in portions of the towns of Easton and Cambridge population density was the highest (1,000-10,000 people mi^2).

[1] 2010 data from the U.S. Census Bureau available online at http://www2.census.gov/census_2010/04-Summary_File_1/

In 2010, approximately half of the overall basin was in agricultural use.[2] Two-thirds of the land in the Tuckahoe Creek and Upper Choptank watersheds was in agricultural use and one-fourth was forested. The Lower Choptank watershed was half agricultural, and almost a quarter forested and a quarter urban. Almost half of the Little Choptank watershed was forested and almost a third was agricultural. The Honga River watershed was about half wetland and one-third forested. Urban land increased by 4% between 2000 and 2010 in the basin as a whole (Figure 5, Appendix 1). Impervious surfaces covered 4% of the Lower Choptank watershed and were 2% or less in the other watersheds.

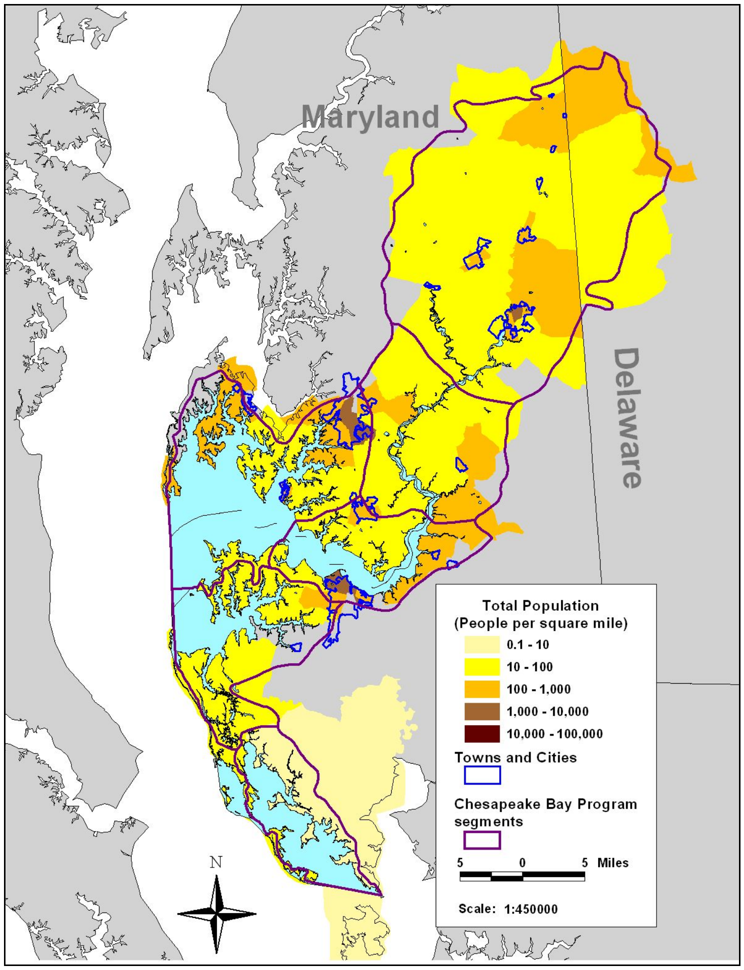

Figure 4. Choptank River basin 2010 Census data for total population by block group. Total population per square mile is shown using a log scale. Differences between the watershed boundaries and the Census Bureau block groups boundaries result in non-exact matching of the population data to the watershed.

[2] Maryland Department of Planning data for 2010 available at http://www.planning.maryland.gov/OurWork/landUse.shtml

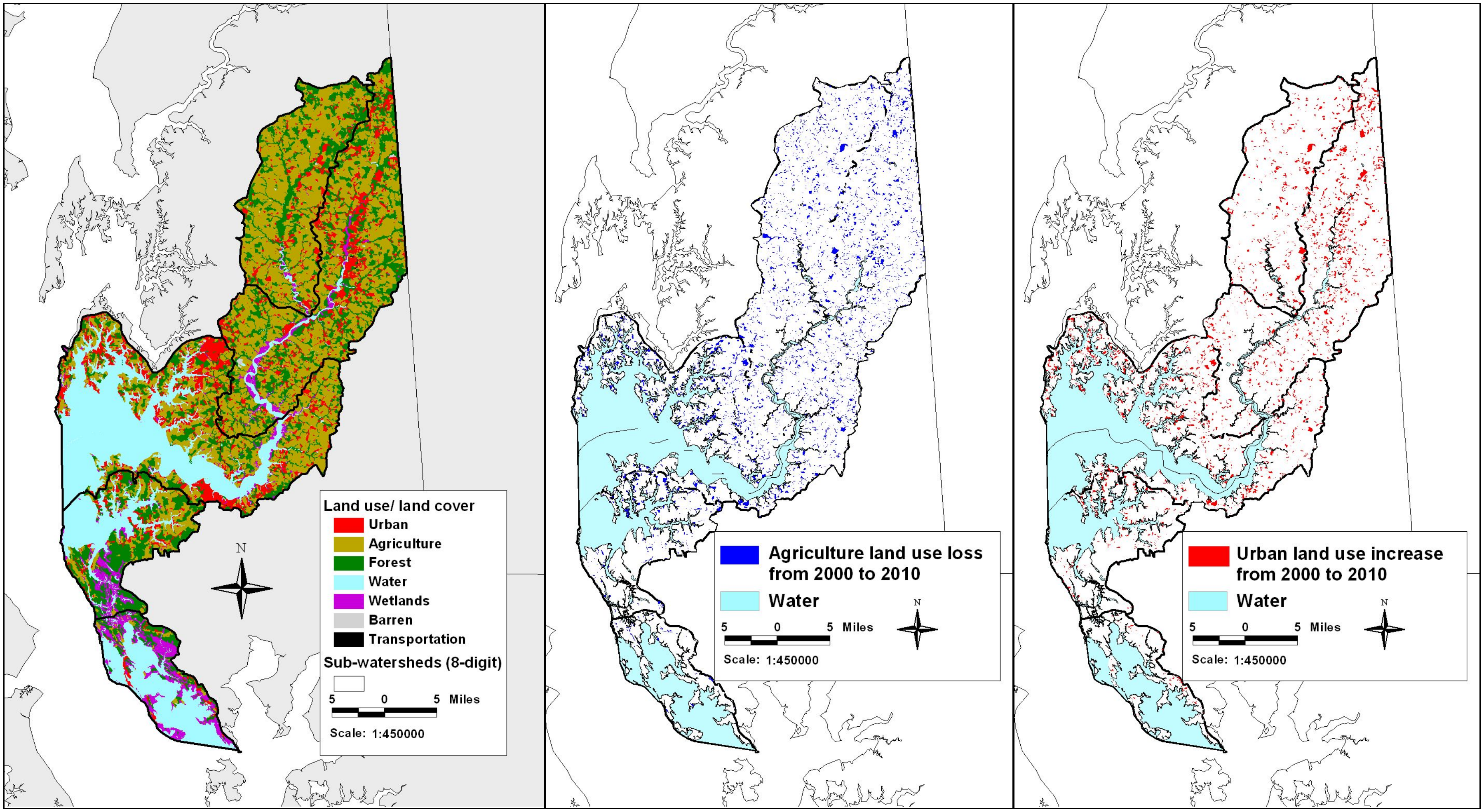

Figure 5. Land use/land cover data for 2010.
See Appendix 1 for detailed land use/land cover information. Left panel shows all land use categories for 2010. Middle panel shows change in agricultural land use in blue. Right panel shows change in urban land use in red.

Stream health is poor in the Lower Choptank and Little Choptank rivers and fair in the Upper Choptank and Tuckahoe Creek watersheds.[3] A Watershed Restoration Action Strategy (WRAS) was developed in 2002 for the upper Choptank watershed.[4] The lower Choptank sub-watershed is a Maryland Trust Fund high priority watershed and the remaining sub-watersheds of the Choptank and Little Choptank rivers are medium priority.[5]

Maryland has a number of programs in place to reduce the impacts of continued development and increasing amounts of impervious surfaces in the Choptank, Little Choptank and Honga rivers. Program Open Space projects have conserved more than 100 acres of land for outdoor recreation opportunities.[6] Rural Legacy Program projects have protected more than 3,450 acres, with special focus on areas with important cultural sites and natural resources and to ensure large areas of habitat. Maryland Environmental Trust projects have helped individual land owners protect more than 7,100 acres. Maryland Agricultural Land Preservation Program projects have preserved almost 4,500 acres of agricultural land from development.

Nutrient and Sediment Loadings

In accordance with the Chesapeake Bay Total Maximum Daily Load (TMDL), Maryland has developed a Watershed Implementation Plan (WIP) for making reductions in nitrogen, phosphorus and sediment loads to the Chesapeake Bay.[7] Maryland is required to reduce loads to Final Target loads by 2025. Maryland's Interim Target loads are set at 60% of the Final Target loads by 2017. Progress toward these Interim and Final Target loads is further broken into 2-year milestone loads. The first of these 2-year milestones is set for July 1, 2011- June 30, 2013.[8]

The Choptank, Little Choptank and Honga Rivers are combined with the other eastern shore rivers into a single category- the Eastern Shore Basin. Final Target Loads for the Eastern Shore Basin are 11.82 million pounds per year of nitrogen, 1.02 million pounds per year of phosphorus and 189 million pounds per year of sediments. The information below is estimated loadings in 2009.

Choptank River

The Choptank River received 2.9 million lbs/yr of nitrogen, 0.27 million lbs/yr of phosphorus, and 30 million lbs/yr of sediment from the surrounding watershed (Appendix 2). Agricultural sources were the largest contributor of nitrogen, phosphorus and sediments to the river as a whole (Figure 6). Agricultural sources were the main contributor of nutrients and sediments in the upper and middle Choptank. Urban runoff was an additional source of phosphorus and

[3] Maryland. Department of Natural Resources data available at www.streamhealth.maryland.gov/stream_health.asp The Honga River does not have steams to evaluate.
[4] Detailed reports are available at http://dnr.maryland.gov/watersheds/surf/proj/wras.html.
[5] Information on Maryland's Trust Fund is available at http://www.dnr.maryland.gov/ccp/funding/pdfs/TrustFundPriorities.pdf
[6] Information on land conservation programs in Maryland is available at http://www.dnr.state.md.us/land/landconservation.asp
[7] Maryland's Phase II Watershed Implementation Plan is online at www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/FINAL_PhaseII_WIPDocument_Main.aspx
[8] Progress toward meeting the 2011-2013 milestones is available on BayStat at www.baystat.maryland.gov/milestone_information.html

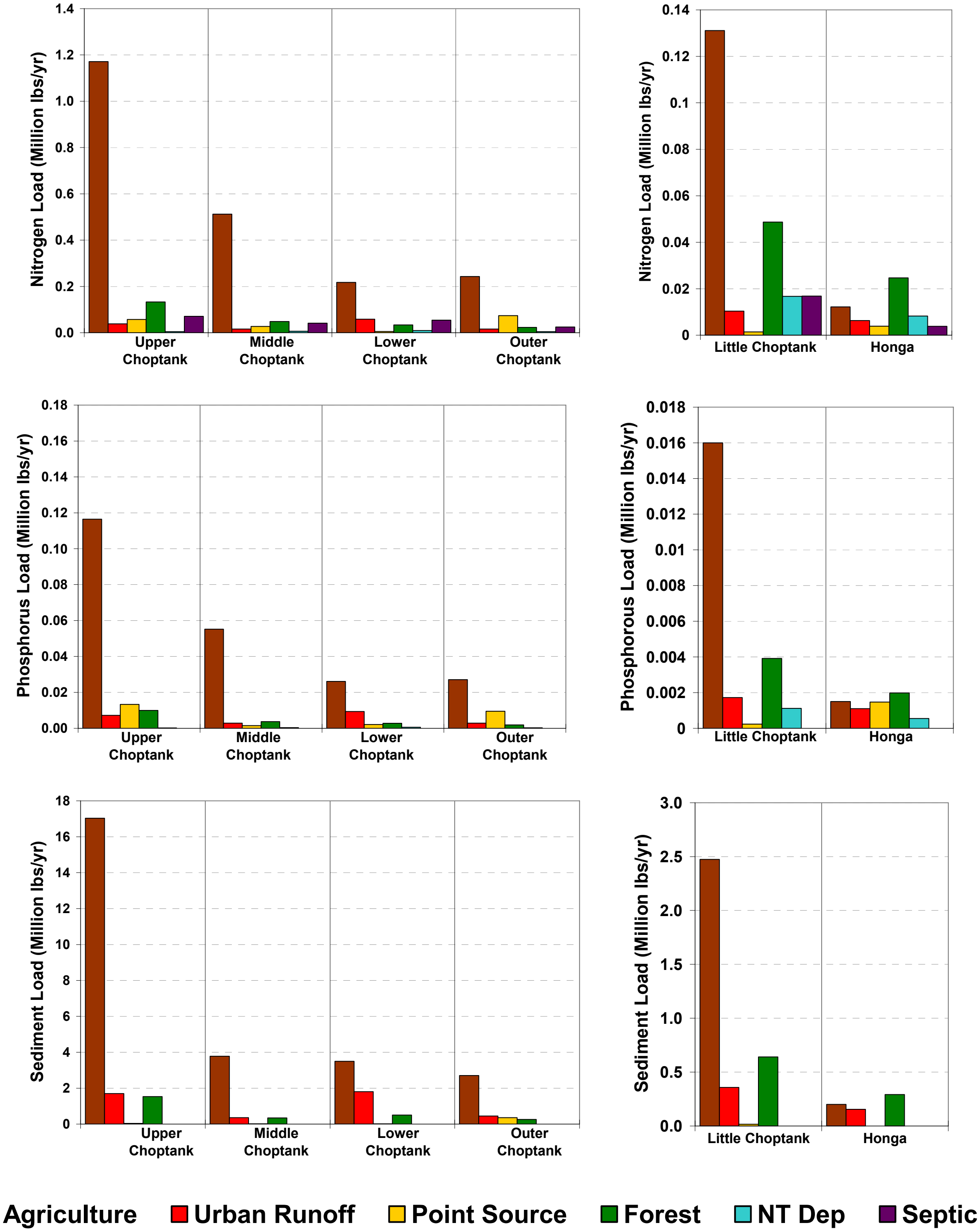

Figure 6. Nitrogen, phosphorus and sediment loadings per year.
Delivered loadings by category in million lbs/yr. Septic is not a source of phosphorus or sediment loadings and water deposition (NT Deposition) is not a source of sediment loadings. See Appendix 2 for additional detail Note that the y-axis differ between the Choptank River graphs on the left and the Little Choptank and Honga River graphs on the right. The TN and TP graphs differ by a factor of 10 and the TSS graphs differ by a factor of 6.

sediments in the lower Choptank, and point sources were a source of phosphorus in the outer Choptank. Approximately half of the total loadings were delivered to the upper Choptank, but on a per acre basis, loadings to the outer Choptank were more than 20 times those of the rest of the river due to the inputs of nitrogen and phosphorus from point sources.

Little Choptank River

The Little Choptank River receives 0.23 million lbs/yr of nitrogen, 0.021 million lbs/yr of phosphorus, and 3.1 million lbs/yr of sediment from the surrounding watershed. Agricultural sources were the largest contributor of nitrogen, phosphorus and sediments (Figure 7). Forest sources also contributed to the nutrient and sediment loadings.

Honga River

The Honga River receives 0.059 million lbs/yr of nitrogen, 0.006 million lbs/yr of phosphorus, and 0.49 million lbs/yr of sediment from the surrounding watershed. Forest sources contributed the most to nitrogen, phosphorus and sediment loadings (Figure 7). Agriculture was also an important nitrogen source. Point sources were as important as agriculture to phosphorus loadings. Urban runoff sources of phosphorus and sediment were also important.

Point Source Loads

Nutrient loadings from point sources (including wastewater treatment plants, WWTPs) are the easiest to measure. Point source loads are often the most cost-effective to manage. A major focus of management actions to reduce nutrient loads has been upgrades to WWTPs. In 2004, Maryland passed legislation creating the Chesapeake Bay Restoration Fund specifically to fund WWTP upgrades to enhanced nutrient removal (ENR).[9] The program is working to complete ENR upgrades to 67 major WWTPs, including three facilities in the Choptank River watershed.[10]

The Cambridge WWTP is the largest facility (8.1 million gallons per day, MGD) and discharges to the main Choptank River. Biological nutrient removal (BNR) was implemented at this facility in mid 2003. ENR construction will begin in mid 2011 and is expected to be complete by the end of 2012.[11] After BNR was implemented, nitrogen loads fell to less than one-third pre-BNR levels, and phosphorus loads dropped to about one-tenth the peak phosphorus loads (Figure 7). Both nitrogen and phosphorus loads were below loading caps post-BNR. Choptank WWTP contributed approximately 55% of the nitrogen and phosphorus loads from WWTPs to the Choptank River.

The second largest facility is the Easton WWTP (4.0 MGD), which also discharges directly to the main river. BNR and ENR upgrades were finished by mid 2007. Total nitrogen and total

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[9] The Chesapeake Bay Restoration Fund collects fees from wastewater treatment plant users to pay for the upgrades. A similar fee is paid by septic system users to upgrade onsite systems and implement cover crops to reduce nitrogen loading to the Bay. For more information on the Chesapeake Bay Restoration Fund see http://www.mde.state.md.us/programs/Water/BayRestorationFund/Pages/index.aspx.

[10] Major wastewater treatment plants (WWTP) are those with greater than 0.5 million gallons per day (MGD) design flow.

[11] BNR technology removes additional nitrogen than traditional methods, bringing nitrogen concentrations in effluent to below 8 mg/l. ENR reduces nitrogen concentrations to below 3 mg/l and phosphorus concentrations to below 0.3 mg/l in effluent.

phosphorus loads were below loading caps following BNR. Easton WWTP contributed approximately 25% of the WWTP nitrogen and phosphorus loads to the Choptank River.

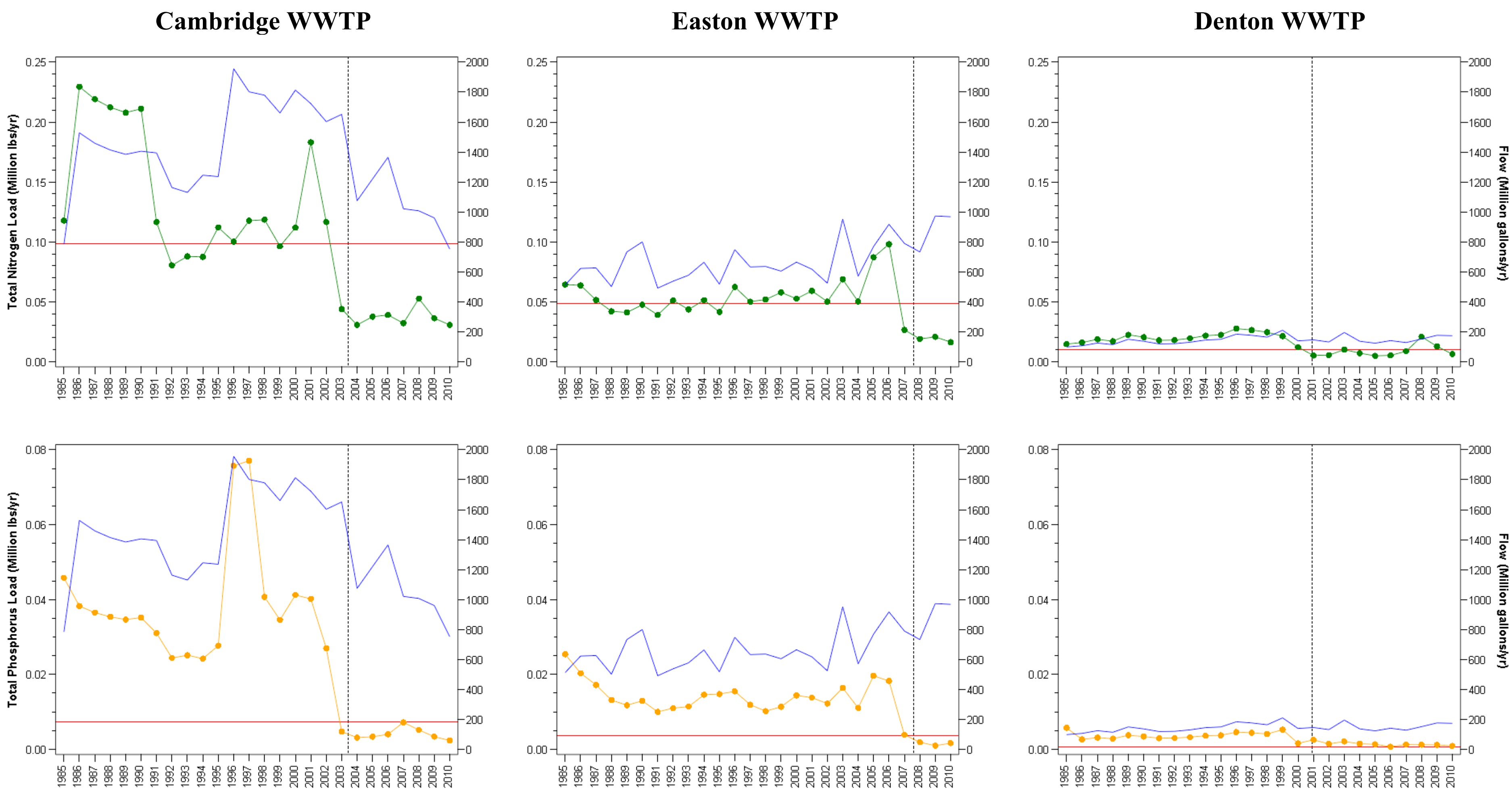

Figure 7. Annual total nitrogen and total phosphorus loadings from WWTPs to the Choptank River.
Top graphs are total nitrogen load (green) and bottom graphs are total phosphorus load (orange) plotted on the left axis.. Blue line on each graph shows total annual effluent flow (right axis). Red horizontal line indicates the loading cap for the facility following implementation of ENR. The dotted vertical line indicates when BNR or ENR was implemented.

The third facility is the Denton WWTP (0.8 MGD), which also discharges to the main Choptank River. BNR upgrades were complete by the end of 2001 and ENR upgrades were complete by the end of 2012. Denton WWTP nitrogen and phosphorous loads were at or below the loading caps following BNR. Denton WWTP contributed approximately 18% of the WWTP nitrogen and phosphorus loads to the Choptank River

Non Point Source Loads

In 1998, Maryland passed the Water Quality Improvement Act, which requires farmers to reduce nitrogen and phosphorus loadings from agricultural lands.[12] Soil Conservation and Water Quality Plans (SCWQPs) are developed to determine what the appropriate actions, or best management plans (BMPs), are for a given area.[13] Each of Maryland's counties has a Soil Conservation District Office with staff to help farmers develop and implement SCWQPs. The total number of BMPs in place in the basin as a whole (not by individual farm) is used to measure progress.[14] In 2010 there were more than 30,700 acres of cover crops planted in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on almost 300 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. More than 250 containment structures had been built to store animal wastes to allow these nutrients to be applied to the land in the most effective manner at the appropriate time. More than 16,000 acres of stream buffers were also in place, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

Water and Habitat Quality

Non-tidal water quality monitoring is done year-round at two stations to characterize conditions in free-flowing freshwater (Figure 9, Appendix 3). The station on the Choptank (ET5.0) has been monitored since 1985. Since 2008, additional sampling is done on Tuckahoe Creek (TUK0181) to assess the impacts of storm flows. Stream gauges are installed at both locations and provide flow data. The USGS uses the flow data and the nutrient data to calculate nitrogen, phosphorus and sediment loadings to the river.[15] The Choptank River (ET5.0) is part of the River Input Monitoring Program (RIM). Trends are calculated for the Choptank River station but not the Tuckahoe Creek station.

Long-term tidal water quality monitoring is done year-round at three stations on the Choptank River and one station on the Little Choptank (Figure 9, Appendix 3). The Honga River is not monitored in the long-term tidal monitoring program, but has been sampled in the shallow-water monitoring program.

For non-tidal and tidal stations, the following parameters were evaluated: total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS). For tidal stations, additional parameters were evaluated: dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (PO_4), algal abundance (as measured by chlorophyll *a*, CHLA), water clarity (as measured with a Secchi disc

[12]For more information, please see the Maryland Department of Agriculture website http://mda2.maryland.gov/resource_conservation/Pages/nutrient_management.aspx
[13] For more information see http://mda.maryland.gov/pdf/scwqplan.pdf
[14] Progress on different BMPs is available at http://www.baystat.maryland.gov/milestone_information.html
[15] For USGS methods see http://md.water.usgs.gov/publications/sir-2006-5178/index.html

and by calculating the percent light through water, PLW), summer bottom dissolved oxygen (BDO), salinity and water temperature.

Assessment methods are described in Appendix 4. Selected graphical results are included with the text. Non-tidal and tidal water quality trends results discussed in the text refer to the 1999-2010 trends. Seasons for 1999-2010 tidal trends are: spring (March-May), summer (July-September)[16] and SAV growing season (Apr-October). Significant trends for 1985-2010 (tidal) or 1986-2010 (non-tidal) are noted in the footnotes. Summary results are presented in Table 1 and Table 2 in the 'Overall Assessment' section. Detailed tabular results are included in the Appendices 6, 7 and 8.

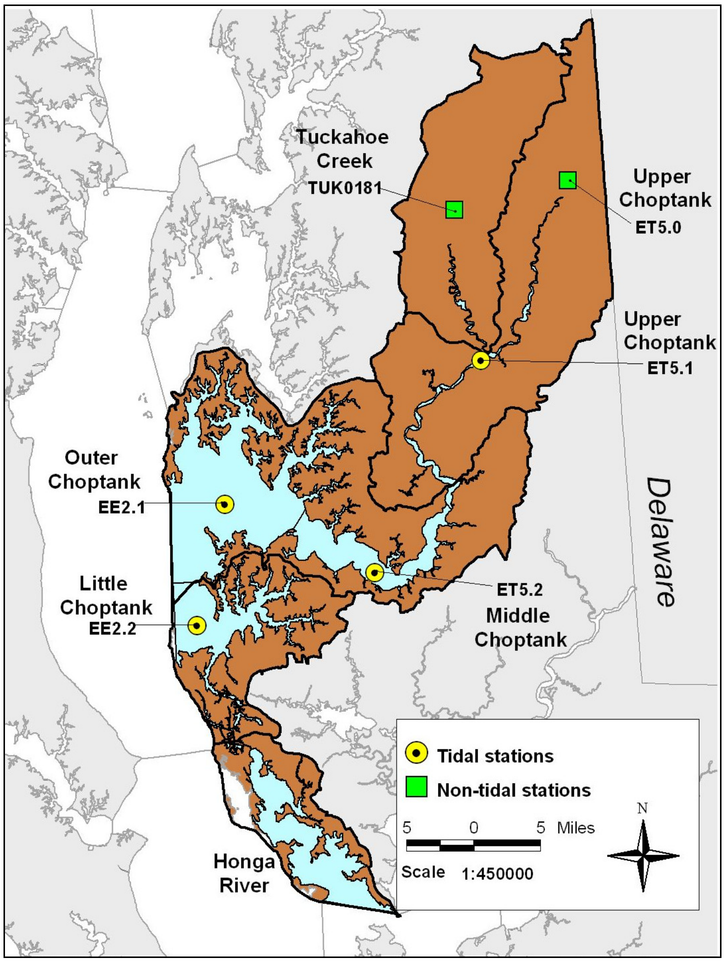

Figure 8. Long-term non-tidal and tidal water quality monitoring stations. Sub-watersheds (8-digit) also shown.

[16] For summer bottom dissolved oxygen analysis, the months used are June-September.

Non-tidal streams

Total nitrogen and total phosphorus loads increased at the Choptank River non-tidal station from 1985-2010 (Figure 10). Sediment load decreased overall from 1985-2010, but increased from 2001-2010 (Figure 11). Sediment loadings for 2010 were the highest measured and total nitrogen and total phosphorus loadings were the second highest even though flow was the sixth highest. TP levels measured in the water decreased.[17]

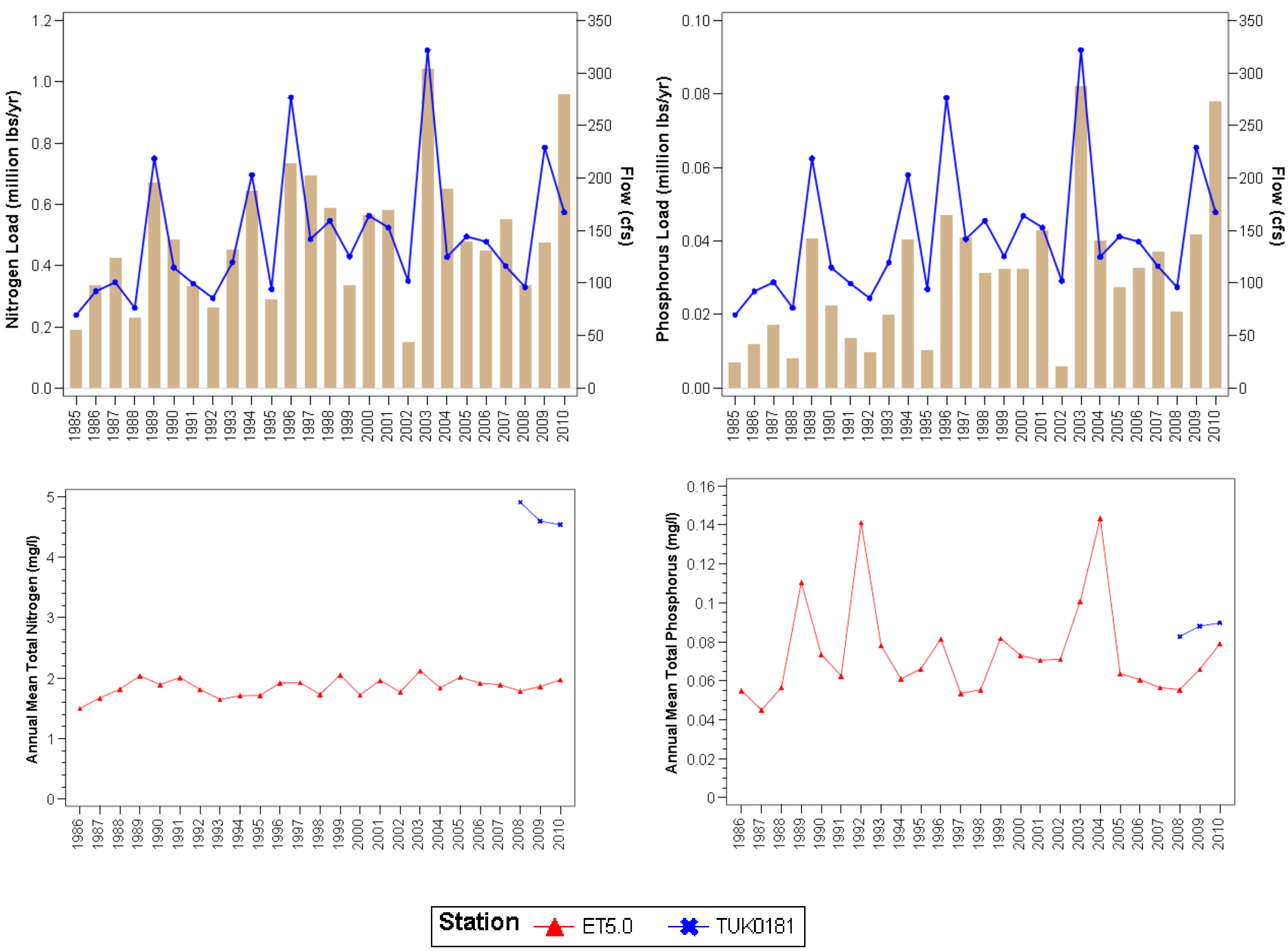

Figure 9. Annual nitrogen and phosphorus load and concentration for non-tidal stations in the Choptank River watershed.
Top graphs show annual nitrogen and phosphorus (tan bars, left axis) and flow (blue line, right axis) for Choptank River near Greensboro. Bottom graphs show annual mean concentrations for total nitrogen and total phosphorus at the Choptank and Tuckahoe Creek stations.

[17] TN levels measured in the water may have increased from 1986-2010 at the Choptank River non-tidal station.

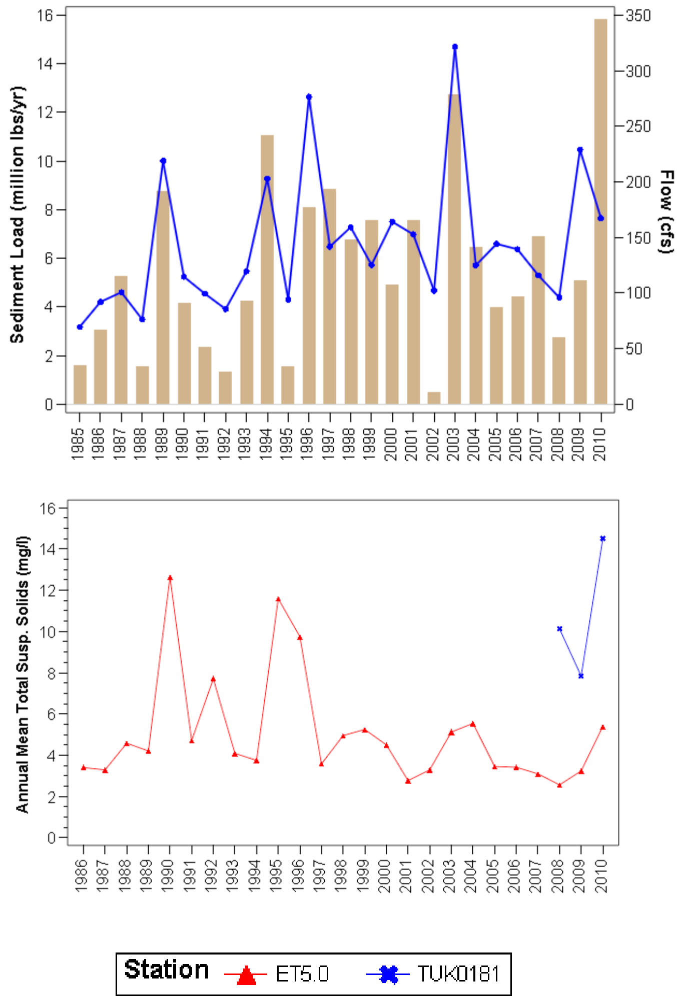

Figure 10. Annual sediment load and total suspended solids concentration for non-tidal stations in the Choptank River watershed.
Top graph shows annual sediment load (tan bars, left axis) and flow (blue line, right axis) for Choptank River near Greensboro. Bottom graph shows annual mean concentrations for total suspended solids at the Choptank and Tuckahoe Creek stations.

Tidal rivers

Choptank River
TN levels were highest in the upper Choptank, and were relatively poor. TN levels in the middle Choptank were relatively poor and relatively good in the outer Choptank (Figure 11).[18] DIN was also highest in the upper Choptank and was relatively poor, but relatively good in the other locations. Middle Choptank DIN levels may have improved in the summer. DIN levels were low enough to allow nitrogen limitation of algal growth in the middle and outer Choptank in summer and fall in many years (Figure 12). Winter DIN concentrations were also low enough for nitrogen limitation to occur in some years.

TP and PO_4 levels were relatively poor in the upper and middle Choptank and relatively good in the outer Choptank. PO_4 levels may have degraded annually, in spring and in the SAV growing season in the upper river, but may have improved in the spring in the outer Choptank.[19] TSS levels were relatively fair in the upper river and relatively good in the middle and outer river. TSS improved annually and in the SAV growing season in the middle river and may have improved in the spring. PO_4 and TSS levels failed to meet SAV habitat requirements in the upper river (Figure 13). PO_4 levels in the middle river were too high in most years but TSS levels met the requirements in all years. Outer river PO_4 and TSS levels met the requirements in all years.

Algal abundance was relatively good at the upper station and improved annually, in spring and in the SAV growing season.[20] Middle Choptank CHLA levels were relatively poor. Outer Choptank CHLA levels were relatively fair but may have degraded annually. Algal densities met the habitat requirement in all years in the outer and middle river, and in 2009 in the upper river.

Water clarity was relatively poor in the upper and middle Choptank and relatively good in the outer Choptank.[21] Water clarity did not meet the SAV habitat requirement in the upper river and middle river, but met the requirements in the outer river in most years.

Summer BDO was good in the upper and outer river and fair in the middle river.[22] However, in most years, summer BDO levels in the middle and outer river dropped below 5 mg/l often and occasionally below 3 mg/l (Figure 14). BDO dropped below 5 mg/l in the upper river in some years. Spring salinity may have decreased in the outer Choptank.[23]

[18] TN concentrations degraded in the upper Choptank and may have degraded in the middle Choptank from 1985-2010, driven by increases in the first half of the monitoring record.
[19] DIN: PO_4 decreased in the middle river from 1999-2010 and ranged from 11-63.
[20] For the 1985-2010 period, CHLA at the upper station improved with a non-linear trend indicates the improvement began in the early 1990s. However, the middle and outer river CHLA levels degraded from 1985-2010.
[21] Middle and outer Choptank water clarity degraded from 1985-2010, but a significant non-linear trend indicates that clarity began to improve in the early 2000s.
[22] Upper river summer BDO degraded from 1985-2010.
[23] Salinity decreased in the river from 1985-2010, with a significant non-linear trend indicating that salinities began to increase in the early 2000s.

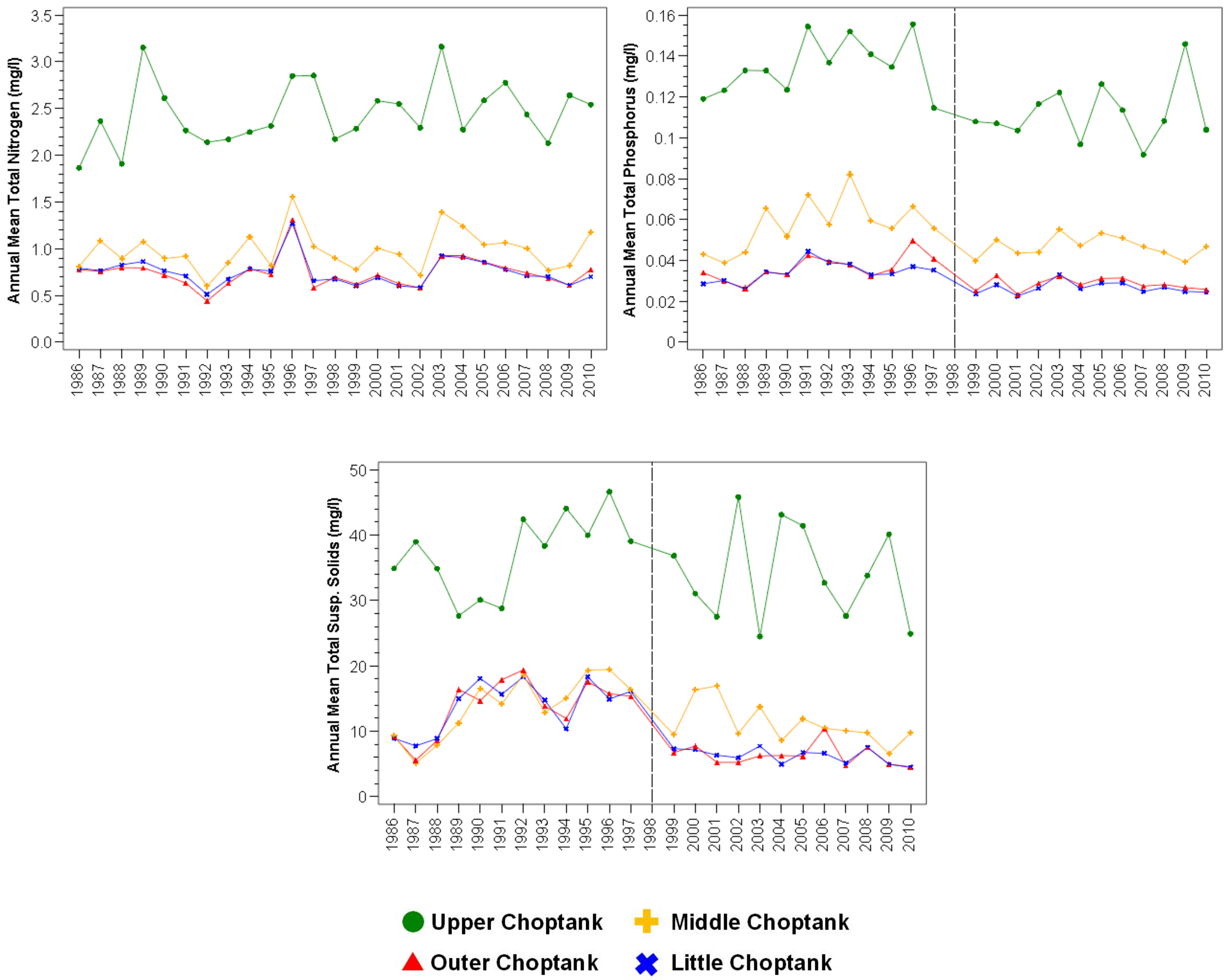

Figure 11. Annual means for total nitrogen, total phosphorus and total suspended solids in the Choptank and Little Choptank rivers.
Dotted line (1998) indicates when the lab change occurred that may have impacted TP and TSS. Caution should be used in making comparisons for TP and TSS from before to after the lab change.

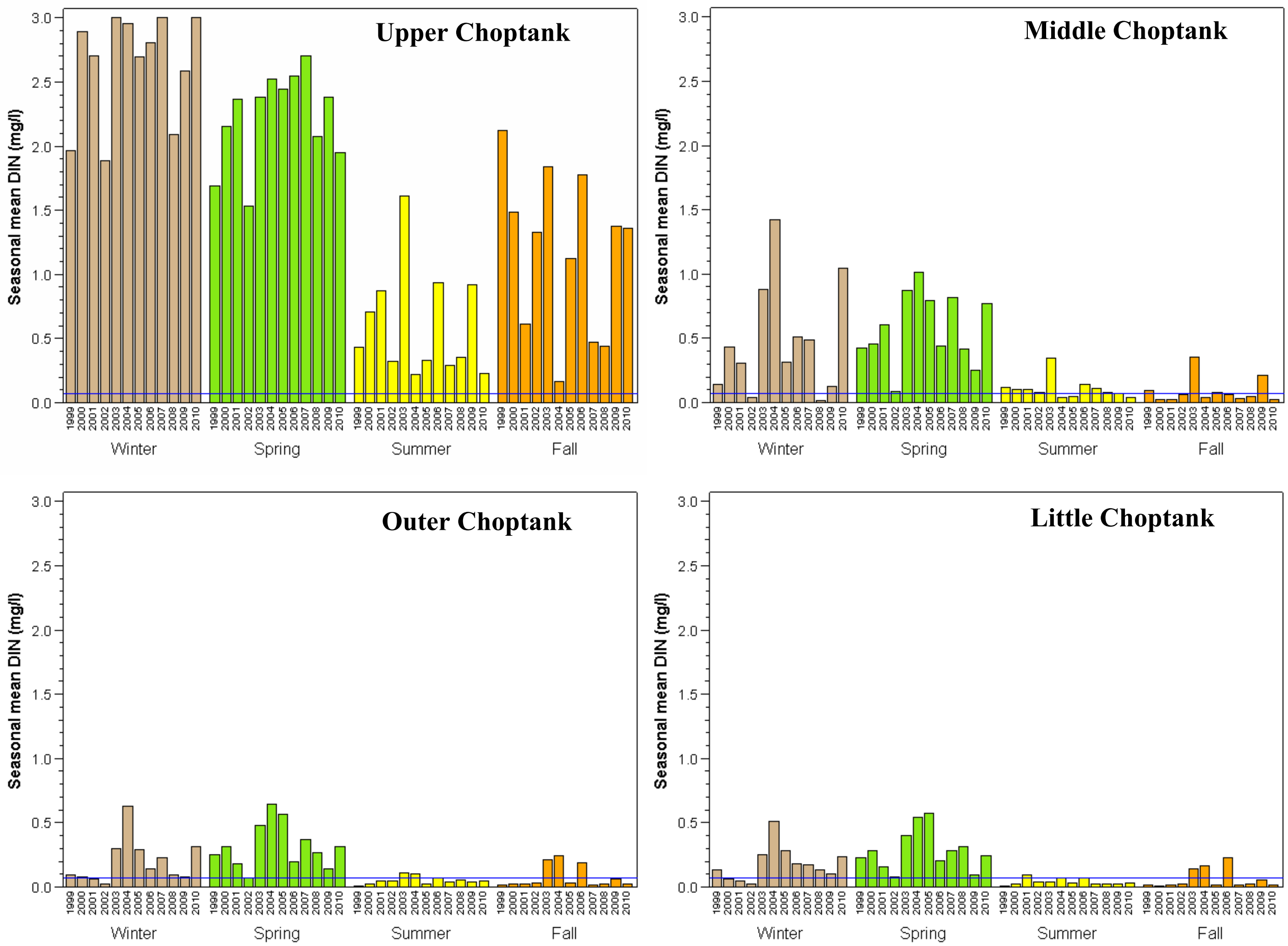

Figure 12. Mean dissolved inorganic nitrogen by season for the Choptank and Little Choptank rivers.
The blue line at 0.07 mg/l indicates the DIN level below which nitrogen limitation likely occurs. Winter season includes December (of the previous year), January and February. Spring season includes March-May. Summer season includes July-August (June is a transition month and not included). Fall season includes October and November. Biological nutrient removal of nitrogen at WWTPs is most effective in warmer months, and seasonal changes in phytoplankton populations (blooms in spring and fall) reduce DIN.

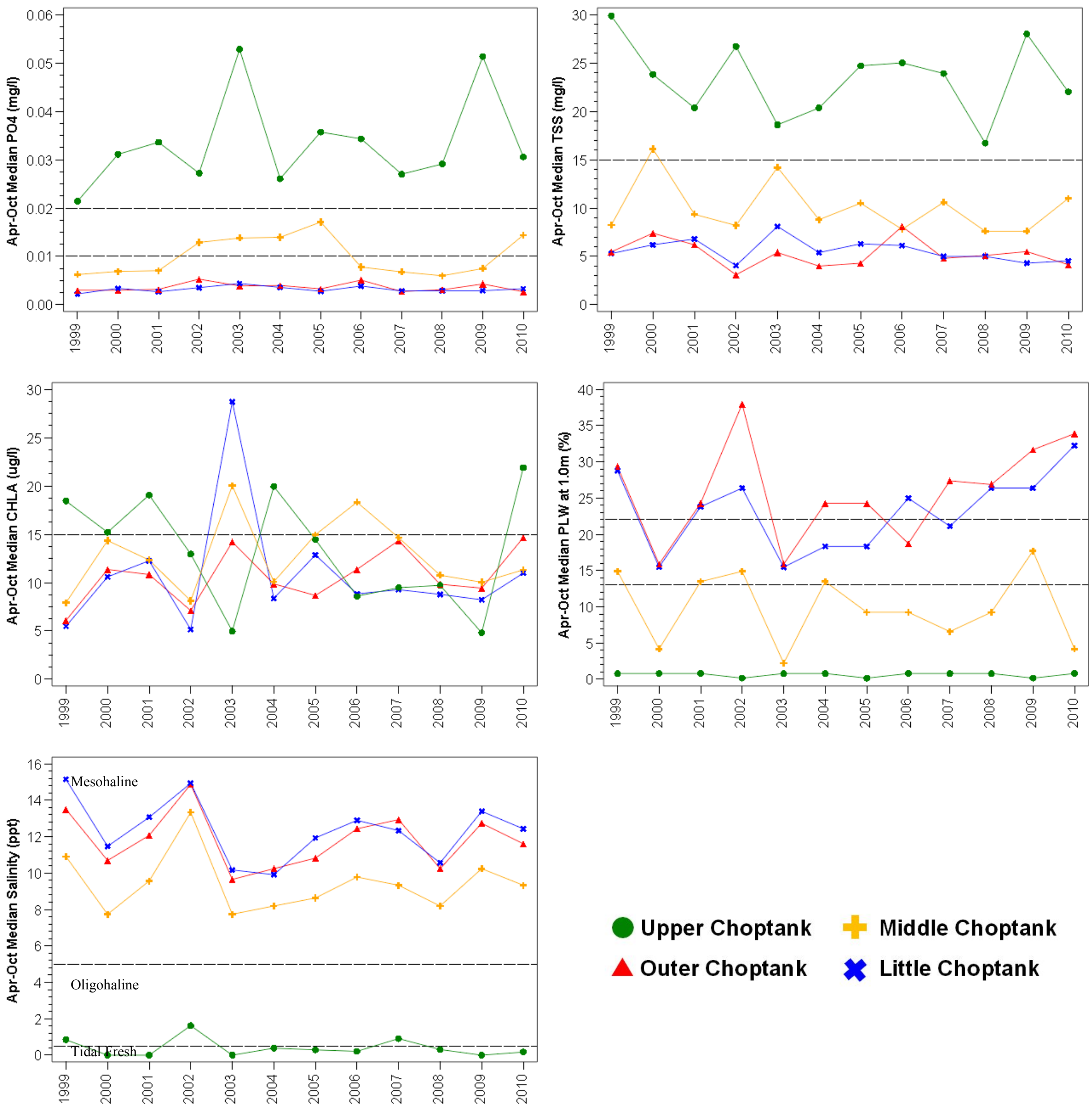

Figure 13. SAV habitat requirement parameters.
SAV growing season (April-October) median values for PO_4, TSS, CHLA, PLW at 1.0m and salinity. Threshold values are shown with dashed lines (Appendix 5). To meet or pass the habitat requirements, levels of PO_4, TSS and CHLA need to be lower than the threshold and PLW needs to be above the threshold. The upper Choptank station needs to meet the tidal fresh/oligohaline thresholds. The other stations need to meet the mesohaline thresholds.

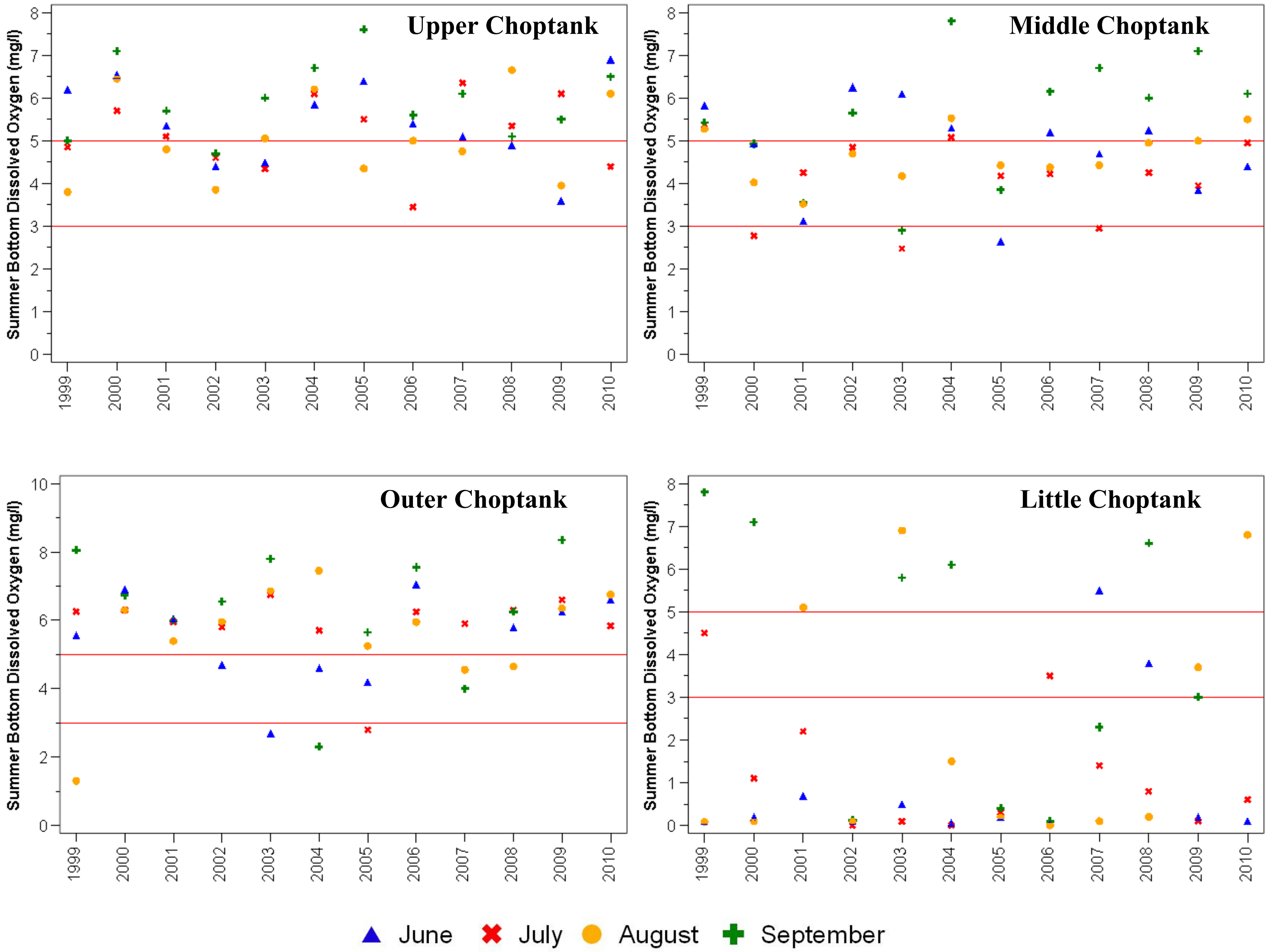

Figure 14. Summer bottom dissolved oxygen levels in Choptank and Little Choptank rivers. Monthly bottom dissolved oxygen levels with threshold values of 5 mg/l and 3 mg/l shown with red reference lines.

Little Choptank

TN, DIN, TP, PO_4 and TSS levels in the Little Choptank were relatively good.[24] DIN levels were low enough in the summer and fall to allow nitrogen limitation of algal growth. PO_4 and TSS concentrations met the SAV habitat requirements.

Algal abundance was relatively good but may have degraded.[25] Water clarity was relatively good.[26] Algal density and water clarity met the SAV habitat requirements. Summer BDO levels were poor.[27] BDO was usually below 5 mg/l in the summer months, and very often below 3 mg/l. Salinity may have decreased annually and in the spring.[28]

[24]TSS degraded and DIN may have degraded in the Little Choptank from 1985-1997.
[25]CHLA degraded from 1985-2010.
[26] Water clarity is good but degraded from 1985-1987 and from 1985-2010. A significant non-linear trend indicates that water clarity began to improve in the early 2000s
[27] Summer BDO may have degraded from 1985-2010

Shallow water

The tidal long-term monitoring program samples at a fixed point that is generally in the center channel and deeper waters of a river. Sampling is done once or twice a month. The strength of this type of monitoring is that the repetition of sampling over many years (more than two decades) measures how water quality has changed over time and in response to management actions, land use changes, etc. However, conditions at the long-term monitoring station may not adequately capture water quality conditions in shallow waters, the river as a whole or on short time scales. The shallow water monitoring program is designed to measure conditions in the areas closest to land that are critical habitat areas, especially in the areas with underwater grass beds. Sampling in a river is done for a 3-year period to determine short-term changes in water quality that occur due to weather, such as between a year with very high rainfall and a year with low rainfall. Some shallow water stations have been monitored for longer periods.

The first part of the shallow water monitoring program uses instruments that stay in the water for extended periods (usually April-October) and collect information every 15 minutes; this is called the continuous monitoring program. Instead of the one or two samples a month typical of the long-term monitoring program, the continuous monitoring program can collect more than 2,800 samples a month.[29] This type of monitoring 1) measures water quality changes that occur between night and day, between days and at longer times spans; 2) determines how long water quality problems persist, such as algal blooms or low oxygen water; and 3) measures water quality changes that occur related to weather events such as storms.

The second part of the monitoring program samples all of the shallow waters of a river (or river segment in larger rivers) once a month from April-October; this is the water quality mapping program. Data is collected nearly constantly as a boat moves along the entire shoreline, so changes in water quality can be measured from one part of the river to another. This data captures water quality in very localized areas and can identify places with better or worse water quality than the river overall. This monitoring is also able to capture changes in water quality related to events that occur in only part of the river such as algal blooms or in response to localized nutrient sources.

A full three-year assessment was completed for all three rivers (Figures 15-16, Appendix 3).[30] The Little Choptank River was monitored from 2005-2007, the Choptank River was monitored from 2006-2008 and the Honga River was monitored from 2008-2010.

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[28] Salinity decreased in the Little Choptank from 1985-2010. A significant non-linear trend indicates salinity began to increase in the early 2000s, following the same pattern as the Choptank River.
[29] Nutrient samples are collected twice a month instead of continuously.
[30] An interactive map of all continuous monitoring stations and complete archived data are available at http://mddnr.chesapeakebay.net/newmontech/contmon/archived_results.cfm. Interpolated maps for all water quality mapping cruises are available on the Maryland Department of Natural Resources "Eyes on the Bay" website http://mddnr.chesapeakebay.net/sim/dataflow_data.cfm

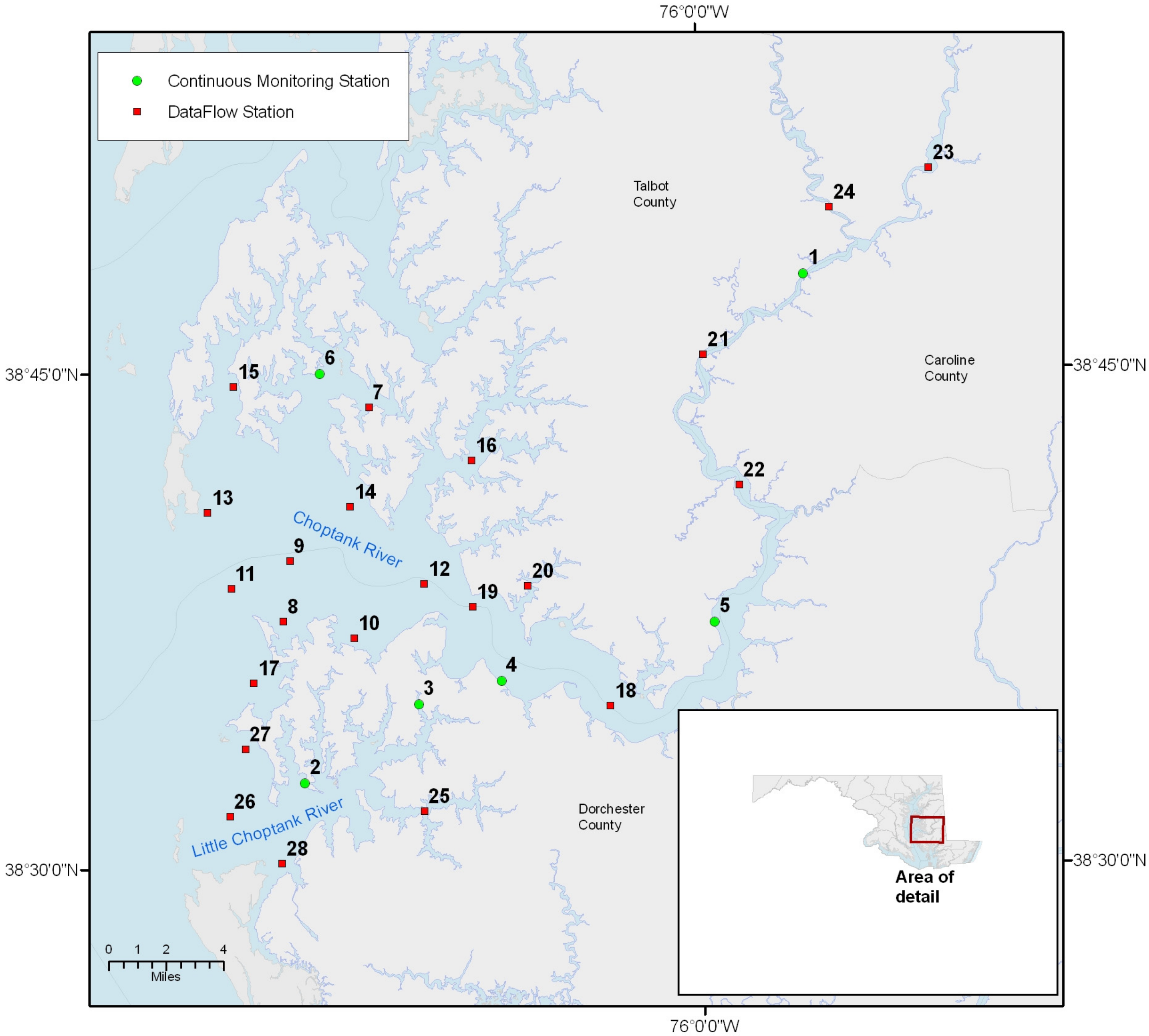

Figure 15. Shallow water calibration stations in the Choptank and Little Choptank Rivers. Green circles show the continuous monitoring locations: 1 Choptank River - High Banks, 2. Little Choptank River - Casson Point, 3-Little Choptank River - Gary's Creek, 4. Choptank River - Horn Point Lab, 5. Choptank River - Jamaica Point, 6. Choptank River - Mulberry Point. Red squares show water quality mapping calibration stations. In the Choptank, these are 7. XFG3973, 8. XEG7539, **9. EE2.1**, 10. XEG6966, 11. XEG8519, 12. XEG8593, 13. XFG0809, 14. XFG0965, 15. XFG4620, 16. XFH2312, 17. XEG5627, **18. ET5.2**, 19. XEH7912, 20. XEH8132, 21. CHO0367, 22. XFI1515, 23. CHO0490, 24. TUK0022. In the Little Choptank these are: 25. XEG1995, **26. EE2.2**, 27. XEG3623, 28. XEG0138. Stations listed in **bold** are also long-term monitoring program stations.

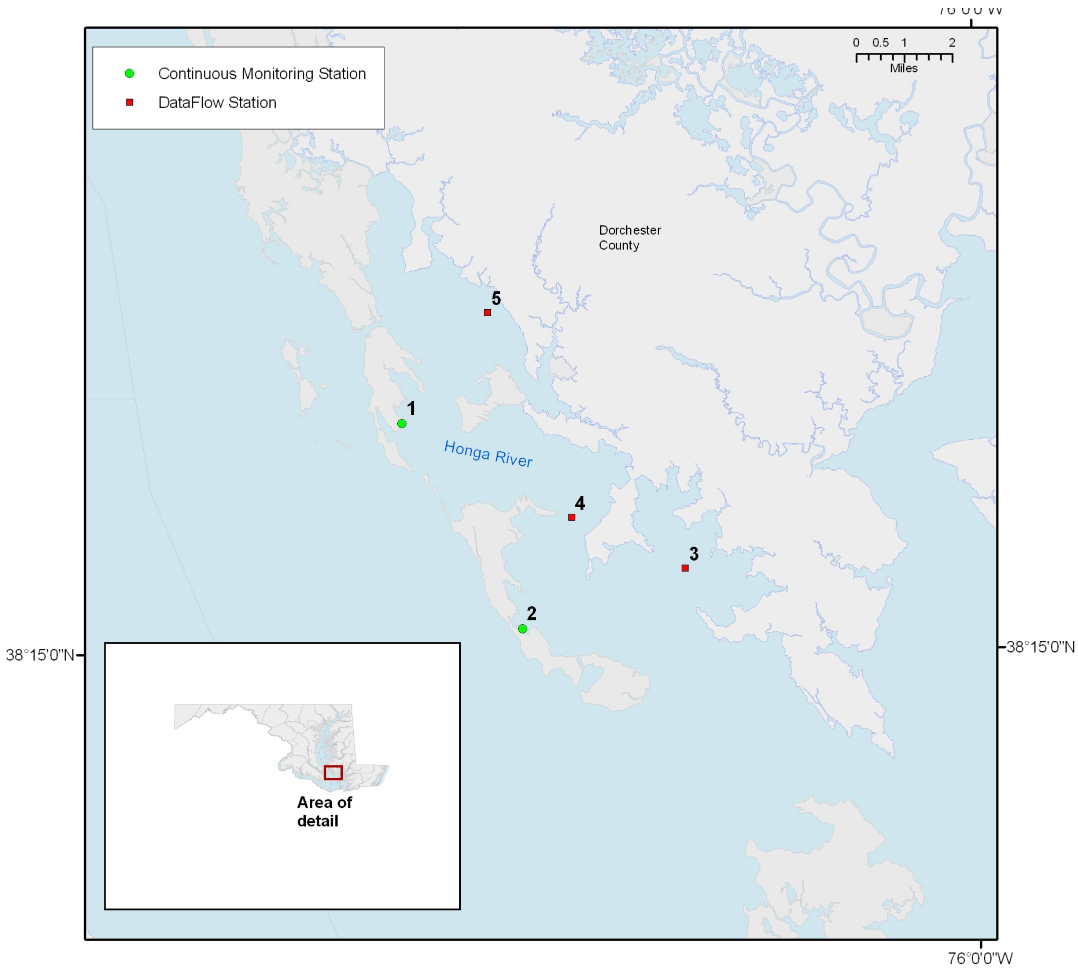

Figure 16. Shallow water calibration stations in the Honga River.
Green circles show the continuous monitoring locations: 1. House Point, 2. Muddy Hook Cove. Red squares show water quality mapping calibration stations: 3. XCH6533, 4. XCH7507, 5. XDG1188.

Current Conditions

Honga River

Continuous monitoring stations were located in the Honga River at House Point and Muddy Hook. Spikes in turbidity at approximately 100 NTU occurred occasionally at both of these stations during 2010 (Figures 17-18). The House Point and Muddy Hook locations have mean low water depths of less than 1 meter and the continuous monitoring sonde at both stations was positioned 0.3 m off the bottom. In general, dissolved oxygen values remained above 5 mg/l for the year at both stations and chlorophyll values remained below 20 µg/l. A large spike in chlorophyll concentrations (>80 µg/l) occurred at Muddy Hook in early August 2010, indicating an algal bloom.

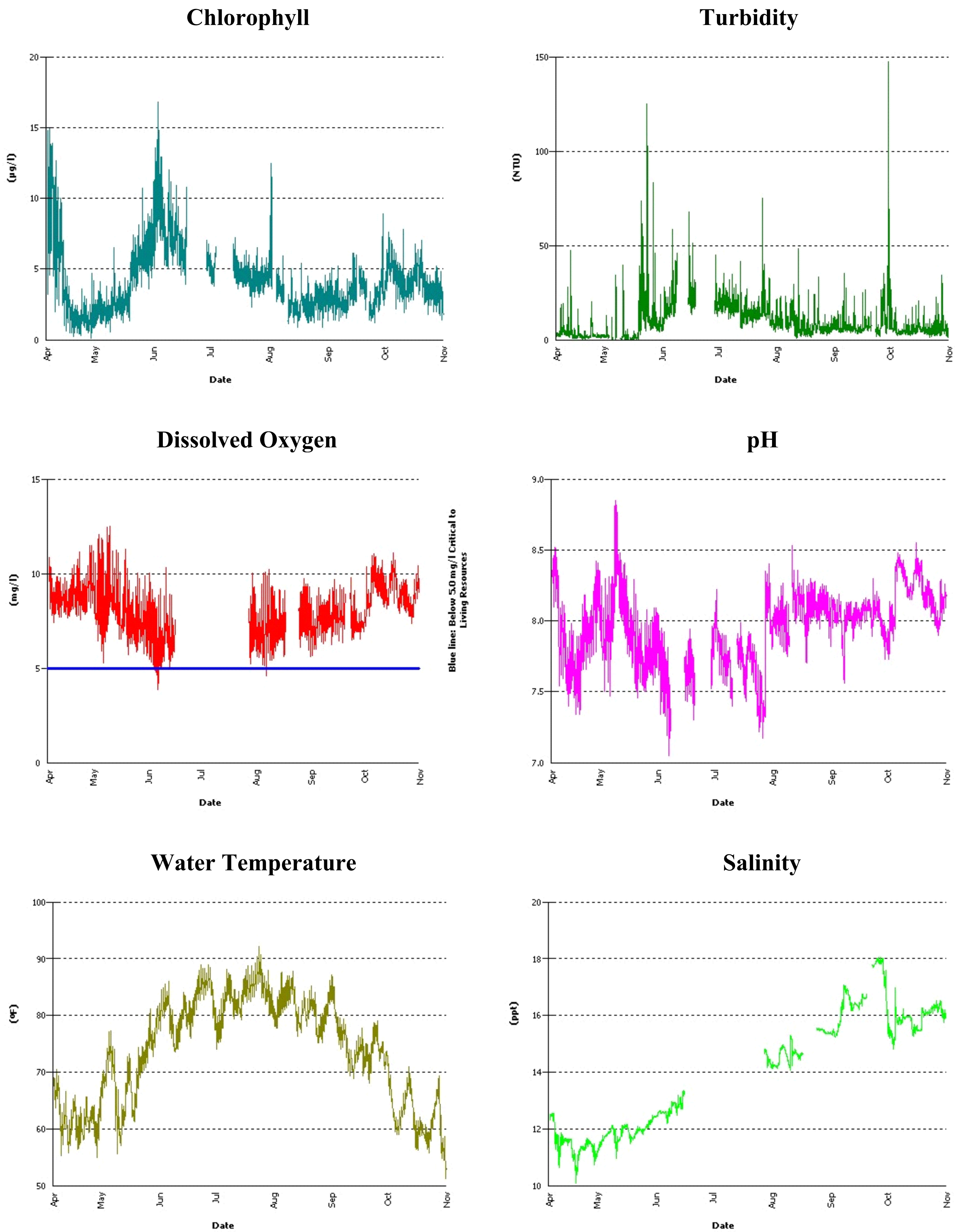

Figure 17. Continuous monitoring results at House Point in 2010.

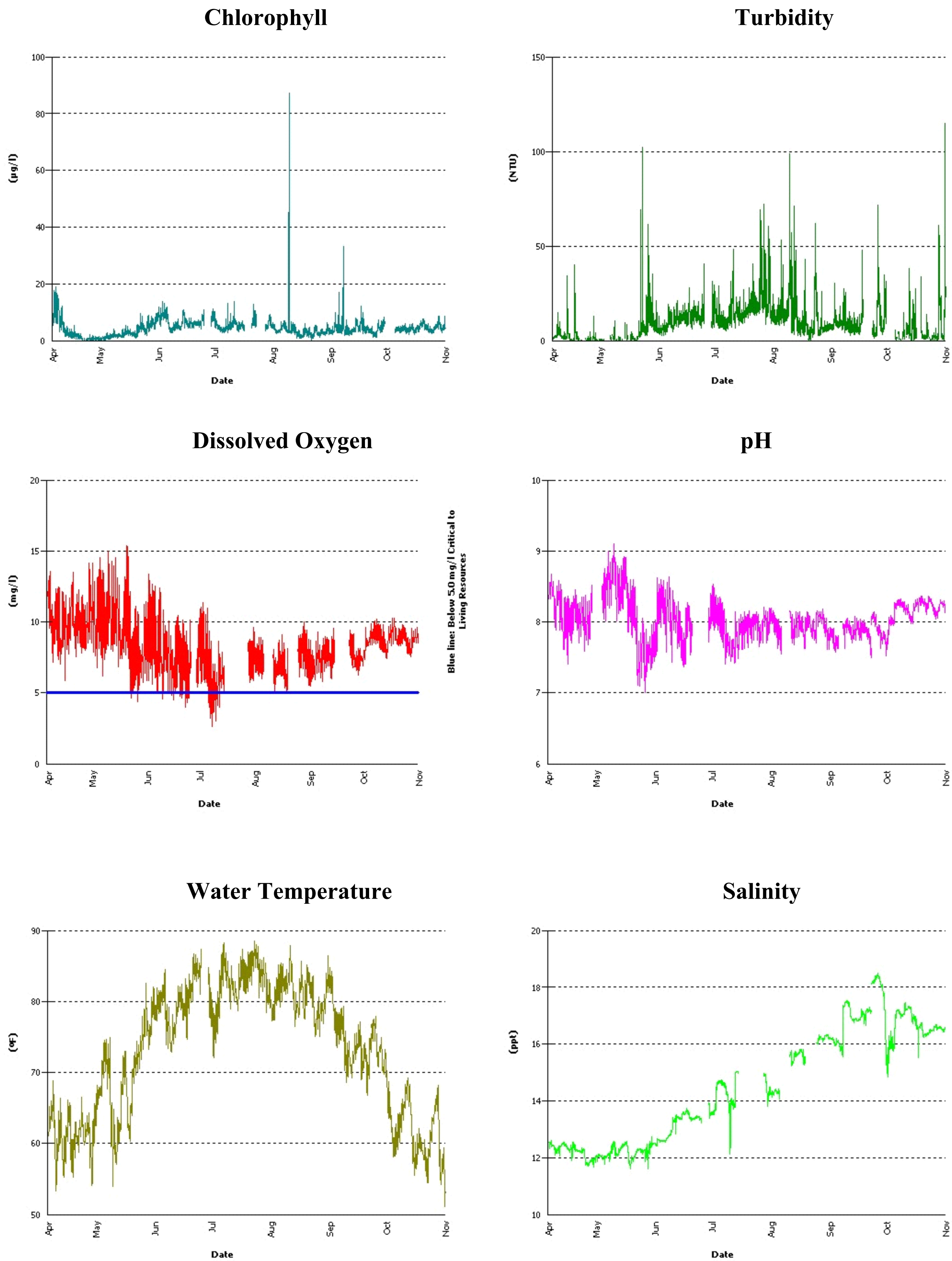

Figure 18. **Continuous monitoring results at Muddy Hook in 2010.**

Due to the shallow water, the turbidity data at these stations may reflect the resuspension of bottom sediments during periods of strong wind or storms. One such storm event was the arrival of Tropical Storm Nicole on September 30, 2010. Data for House Point and Muddy Hook show a sharp decline in salinity and water temperature at this time. Water-quality mapping results for June 3, 2009 in the Honga River (Figure 19) also illustrate the effects of storms on this shallow water system. The June survey was conducted on a day following overnight thunderstorms. The turbidity map shows very turbid waters upstream and along the shoreline of the Honga River, likely due to storm runoff. Also, the heavy rainfall (>1 inch) caused very low salinities (2.5-5.0 ppt) throughout what is normally a mesohaline (5-18 ppt salinity) region.

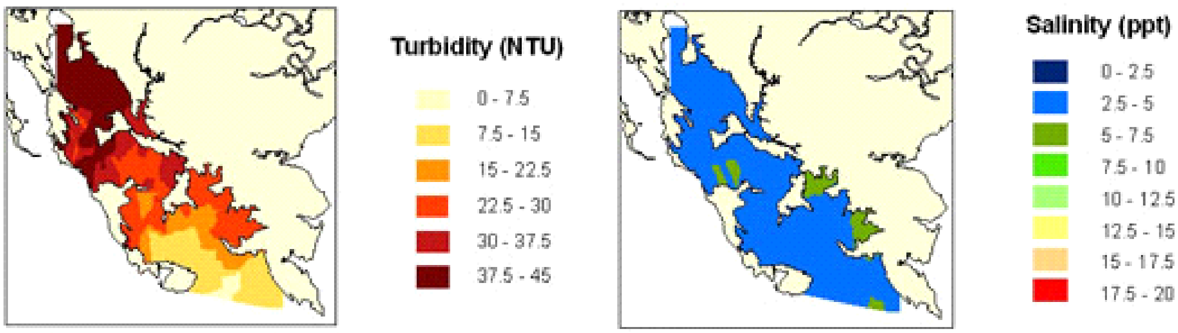

Figure 19. Water quality mapping survey results for the Honga River, June 2009.

Temporal and Spatial conditions

Water and habitat quality in the shallow water was evaluated in two ways. The first was a temporal assessment. High temporal frequency data from the continuous monitoring program were used to determine how often water quality met conditions needed for healthy habitats. Percent failures are defined as the percent of values in each year that did not meet the water quality thresholds (see Appendix 4 for methods). Chlorophyll and turbidity measurements collected during the SAV growing season (April through October) and summer dissolved oxygen values (June through September) were included in the analysis. The percent failures for all stations are shown in Appendix 9.

The second method was a spatial assessment. The nutrient data collected at continuous monitoring and water quality mapping calibration stations for April-October were compared to the SAV habitat requirements (Appendix 9). Water quality and habitat conditions were also compared between the shallow water stations and the long-term station.

Choptank

In the Choptank River, dissolved oxygen levels at all stations were above the 3.2 mg/l dissolved oxygen threshold more than 90% of the time, and several stations had years during which the dissolved oxygen concentrations never dropped below 3.2 mg/l (Appendix 9). For chlorophyll, failure of the 15 µg/l threshold at all stations was always less than 25%. In contrast, turbidity exceedences were more common. Downstream stations (Horn Point Lab, Mulberry Point) had turbidity values greater than 7 NTU between 40-70% of the time. Turbidity exceedences at the upstream stations in the Choptank (High Banks, Jamaica Point) were even more frequent. Virtually all of the turbidity readings at High Banks and Jamaica Point were above 7 NTU.

In 2008, the shallow waters in the upper Choptank only met the CHLA habitat requirement, with the exception of TUK0022 which failed all five habitat requirements (Table 3). In 2006-2008, the station farthest upstream (CHO4090) had significantly higher Secchi depths and lower PO_4 levels than the rest of the stations in the upper Choptank (Appendix 9). The stations were similar for DIN, TSS and CHLA levels.

Water quality in the shallow waters of the middle Choptank was better than the upper Choptank for TSS and PO_4 at all but one station. Only Jamaica Point failed to meet the SAV habitat requirements for TSS and PO_4 in 2008. All of the locations met the CHLA habitat requirement in 2008, but only XEH8132 met the DIN requirements. In 2006-2008, Jamaica Point TSS, DIN and PO_4 levels were significantly higher and Secchi depths were significantly lower than the rest of the middle Choptank stations. Water quality at the rest of the stations in the middle Choptank were similar with the following exceptions: 1) TSS levels at Horn Point were significantly higher that at the downstream station (XEH7912) and the long-term station, and 2) Secchi depth was significantly higher at the downstream station than at the station in La Trappe Creek (XEH8132).

Most of the shallow waters of the outer Choptank met the CHLA, TSS and PO_4 habitat requirements in 2008, but several locations failed to meet the DIN and Secchi depth requirements. In 2006-2008, Secchi depths were highest in Trippe Bay (XEG5627) and at the long-term station, and significantly lower in the creeks and at Mulberry Point. TSS levels at Mulberry Point were significantly higher than the rest of the stations in the outer Choptank. CHLA levels in the Tred Avon River were significantly higher than in Trippe Bay and at Mulberry Point, and CHLA levels at the long-term station were also significantly higher than at Mulberry Point.

Little Choptank

At Gary's Creek, less than 3% of dissolved oxygen values were below the 3.2 mg/l threshold during the years 2005-2007. At Casson Point, the dissolved oxygen concentrations never dropped below 3.2 mg/l. For chlorophyll, failure of the 15 µg/l threshold at Gary's Creek and Casson Point was less than 37% and 12%, respectively. The downstream station (Casson Point) had turbidity values greater than 7 NTU between 40-70% of the time. Greater than 80% of observations at Gary's Creek failed the turbidity threshold.

In 2005-2007, shallow waters in the Little Choptank met the CHLA, DIN and PO_4 habitat requirements (Appendix 9). Casson Point (XEG2646) and Gary's Creek (XEG4991) failed to meet the TSS habitat requirement, but the remaining stations met the requirement. TSS and PO_4 levels at Gary's Creek were significantly higher than at all other stations, but the remaining stations were not different from each other or the long-term station.[31] Only DIN levels at Gary's Creek were significantly higher than the other stations and the long-term station. Secchi depths were significantly different between some of the stations and four stations were significantly lower than at the long-term station; Gary's Creek had the lowest Secchi depths.

[31] TN and TP levels in the Little Choptank at Gary's Creek were also significantly higher than the other stations.

Table 3. Shallow-water monitoring data compared to SAV habitat requirements in the Choptank River for 2008.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling. Station names in **bold** are continuous monitoring stations, and station names in *italics* are water quality mapping calibration stations.

	Station		Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth	
Upper Choptank	*CHO0490*		23	2008	7.3	MEET	22.7	FAIL	1.288	FAIL	0.0242	FAIL	0.5	FAIL
	TUK0022	*Tuckahoe Creek*	24	2008	18.9	FAIL	41.0	FAIL	1.296	FAIL	0.0337	FAIL	0.4	FAIL
	CHO0417	**High Banks**	1	2008	12.7	MEET	38.0	FAIL	1.011	FAIL	0.0382	FAIL	0.3	FAIL
	CHO0367		21	2008	9.0	MEET	21.3	FAIL	0.609	FAIL	0.0532	FAIL	0.4	FAIL
	XFI1515		22	2008	8.2	MEET	27.0	FAIL	0.391	FAIL	0.0485	FAIL	0.4	FAIL
Middle Choptank	**XEI7405**	**Jamaica Point**	5	2008	9.2	MEET	25.0	FAIL	0.164	FAIL	0.0269	FAIL	0.4	FAIL
	ET5.2	*long-term*	18	2008	11.7	MEET	7.6	MEET	0.111	FAIL	0.0065	MEET	0.8	FAIL
	XEH5622	**Horn Point Lab**	4	2008	9.0	MEET	14.0	MEET	0.113	FAIL	0.0060	MEET	0.8	FAIL
	XEH8132	*La Trappe Creek*	20	2008	11.1	MEET	13.5	MEET	0.063	MEET	0.0027	MEET	0.7	FAIL
	XEH7912		19	2008	11.7	MEET	5.6	MEET	0.077	FAIL	0.0031	MEET	1.1	MEET
Outer Choptank	*XEG8593*		12	2008	11.1	MEET	5.7	MEET	0.103	FAIL	0.0043	MEET	1.1	MEET
	XFH2312	*Tred Avon R*	16	2008	10.2	MEET	7.6	MEET	0.059	MEET	0.0035	MEET	0.7	FAIL
	XEG6966		10	2008	8.5	MEET	8.4	MEET	0.042	MEET	0.0024	MEET	0.9	FAIL
	XEG7539		8	2008	9.0	MEET	9.6	MEET	0.033	MEET	0.0032	MEET	0.9	FAIL
	EE2.1	*long-term*	9	2008	10.6	MEET	5.2	MEET	0.071	FAIL	0.0029	MEET	1.2	MEET
	XFG0965	*Broad Creek*	14	2008	8.5	MEET	5.5	MEET	0.084	FAIL	0.0034	MEET	1.0	MEET
	XFG3973	*Edge Creek*	7	2008	9.2	MEET	12.4	MEET	0.048	MEET	0.0027	MEET	0.7	FAIL
	XFG5054	**Mulberry Pt**	6	2008	7.5	MEET	16.0	FAIL	0.045	MEET	0.0033	MEET	0.7	FAIL
	XFG4620	*Harris Creek*	15	2008	7.5	MEET	10.4	MEET	0.087	FAIL	0.0028	MEET	0.7	FAIL
	XFG0809		13	2008	7.9	MEET	14.4	MEET	0.070	MEET	0.0031	MEET	0.8	FAIL
	XEG8519		11	2008	9.9	MEET	6.8	MEET	0.056	MEET	0.0033	MEET	1.0	MEET
	XEG5627	*Trippe Bay*	17	2008	7.8	MEET	6.4	MEET	0.044	MEET	0.0042	MEET	1.2	MEET

Honga

Of the three river systems in this basin, the Honga River exhibits the best water quality with the least percent failures for dissolved oxygen, chlorophyll, and turbidity (Appendix 9). Dissolved oxygen values in the Honga River rarely dropped below 3.2 mg/l, chlorophyll values exceeded 15 µg/l less than 5% of the time, and turbidity values less than 7 NTU approximately 50% of the time.

The percent failure analysis determines how often dissolved oxygen levels were below healthy levels, but not how long at any one time dissolved oxygen levels are dangerously low. This is important because most benthic animals and fish can survive in low dissolved oxygen for short periods but not extended periods. A special study of the continuous monitoring data from Maryland rivers, including the data for the Honga River, (Muddy Hook Cove, XCG5496) data for 2010) found that periods of dissolved oxygen levels below 3.2 mg/l at different locations lasted from as little as 15 minutes to as long as 2.5 days.[32] The longest continuous period of extremely low dissolved oxygen at Muddy Hook Cove was 3 hours. The total amount of time in 2010 with extremely low dissolved oxygen levels was 5 hours out of 172 days, or 0.1% of the time. Dissolved oxygen levels at House Point were never below 3.2 mg/l in 2010. Dissolved oxygen levels fell below 5 mg/l only 2% of the time at Muddy Hook and only 0.3% of the time at House Point.

In 2008-2010, the shallow waters in the Honga River met the CHLA, DIN and PO_4 requirements but failed to meet the Secchi depth requirement (Table 4).[33] TSS levels met the requirements except at House Point (XCG9168). The water quality was not different between any of the stations with the exception of Secchi depths at Muddy Hook, which were significantly lower than the other stations.

Table 4. Shallow-water monitoring data compared to SAV habitat requirements in the Honga River for 2008-2010.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling. Station names in **bold** are continuous monitoring stations, and station names in *italics* are water quality mapping calibration stations. DIN and PO_4 levels were not measured in 2010.

Station		Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth	
XDG1188		5	2008	6.0	MEET	12.5	MEET	0.048	MEET	0.0032	MEET	0.60	FAIL
			2009	5.2	MEET	11.1	MEET	0.024	MEET	0.0020	MEET	0.70	FAIL
			2010	9.3	MEET	14.6	MEET				MEET	0.90	FAIL
XCG9168	**House Point**	1	2008	7.2	MEET	20.0	FAIL	0.042	MEET	0.0030	MEET	0.70	FAIL
			2009	6.4	MEET	17.0	FAIL	0.021	MEET	0.0028	MEET	0.75	FAIL
			2010	9.4	MEET	17.8	FAIL				MEET	0.60	FAIL
XCH7507		4	2008	11.1	MEET	10.7	MEET	0.073	FAIL	0.0034	MEET	0.90	FAIL
			2009	6.1	MEET	6.4	MEET	0.025	MEET	0.0032	MEET	1.00	MEET
			2010	10.0	MEET	10.4	MEET				MEET	0.80	FAIL
XCG5495	**Muddy Hook**	2	2008	7.5	MEET	15.6	FAIL	0.032	MEET	0.0029	MEET	0.70	FAIL
			2009	5.1	MEET	10.9	MEET	0.020	MEET	0.0028	MEET	0.90	FAIL
			2010	8.8	MEET	14.6	MEET				MEET	0.60	FAIL
XCH6533		3	2008	7.6	MEET	7.2	MEET	0.036	MEET	0.0030	MEET	0.90	FAIL
			2009	5.6	MEET	4.4	MEET	0.016	MEET	0.0039	MEET	1.20	MEET
			2010	5.8	MEET	8.3	MEET				MEET	0.90	FAIL

[32] Boynton et al (2011) available online at
http://www.gonzo.cbl.umces.edu/documents/water_quality/Level1Report28.pdf
[33] The only failure of the DIN threshold was at XCH7507 in 2008, but the levels were borderline.

Health of Key Plants and Animals

Phytoplankton

Phytoplankton (generally algae) are the primary producers in the Chesapeake Bay and rivers and the base of the food chain. Routine samples collected in the long-term tidal and shallow water monitoring programs estimate the abundance of algae but can not determine the health of the population overall. As part of a supplemental program, since 1985 the overall phytoplankton community was sampled at the upper Choptank and middle Choptank long-term tidal water quality stations in spring and summer. The phytoplankton index of biotic integrity (PIBI) assesses the health of the community. [34] A PIBI score of greater than 3 is considered meeting the goal for phytoplankton community health criteria. Spring PIBI scores in the upper Choptank were generally better than the summer scores, although the only score to meet the goal was in summer 2006 (Figure 20). [35] The spring and summer scores in the middle Choptank were higher than in the upper Choptank, but very few years met the goal. There was no change in the upper Choptank PIBI scores, but the middle Choptank scores but degraded in summer and may have degraded in spring from 1985-2010.

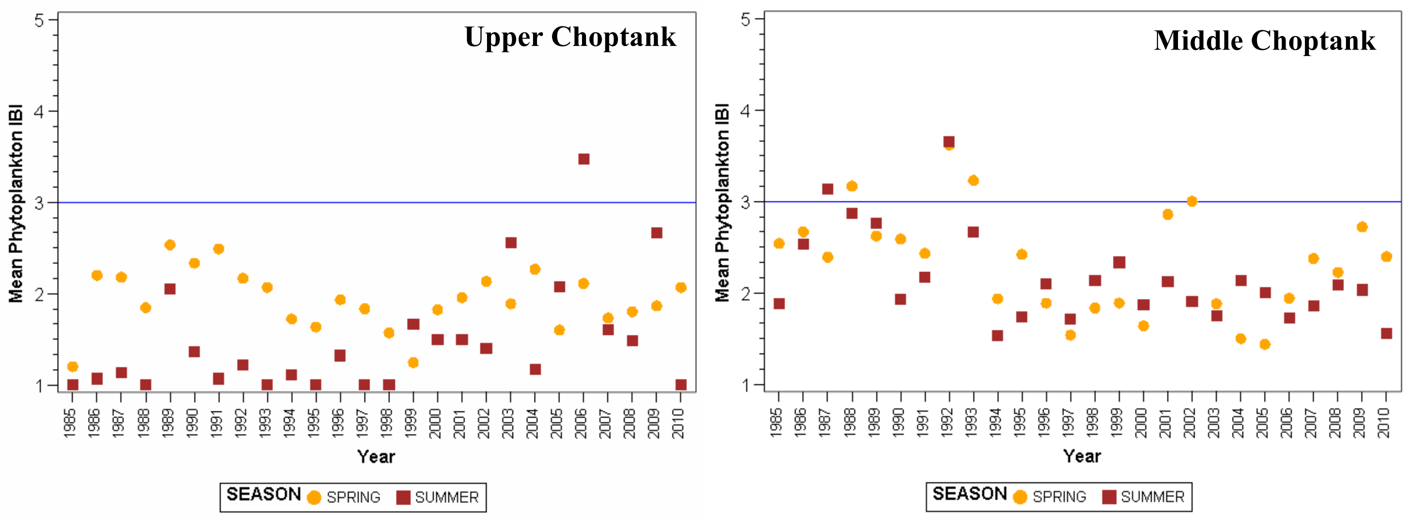

Figure 20. Spring and summer Phytoplankton Index of Biotic Integrity (PIBI) scores 1985-2010.

Harmful Algal Blooms (HABs)

High algal density (algal blooms) can degrade habitat quality. Blooms of certain species of phytoplankton (harmful algae) can also degrade habitat quality. Routine samples collected in the long-term tidal and shallow water monitoring programs can not distinguish between good and harmful algae. Additional samples are taken at some locations to determine what algal species are present and in what densities. When a bloom occurs, samples are taken to test for the presence and levels of toxins, which can be released by some types of harmful algae.

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[34] Methods for calculation of the PIBI are available at www.chesapeakebay.net/.../indicator_survey_phyto_ibi_2011_final.docx

[35] PIBI scores calculated by J. Johnson, Interstate Commission on the Potomac River Basin/Chesapeake Bay Program.

Fortunately, of the more than 700 species of algae in Chesapeake Bay, less than 2% of them are believed to have the ability to produce toxic substances.[36]

Blue-green algae are generally smaller cells and not as nutritious and edible to small animals (zooplankton). Blooms of blue-green algae look like blue-green paint floating at or near the water surface (Figure 21). Blue-green algae can only live in low salinity waters. Some species of blue-green algae (*Microcystis* and *Anabaena*) can produce a toxin that is released into the water. Contact with or ingestion of water containing high toxin levels can cause human health impacts (skin irritation, gastrointestinal discomfort), and can be harmful or even fatal to livestock and pets.

Blooms of some species of dinoflagellates are known as 'mahogany tides' because the color of the algae and the density of algae in the bloom make the water appear brown or reddish-brown (Figure 21). These conditions are most often caused by blooms of *Prorocentrum minimum*. While *Prorocentrum* frequently blooms in the spring, blooms have been observed in Maryland waters in all seasons. These algae do not produce a toxin, but the magnitude of the bloom can harm fish and shellfish by replacing more nutritious algae, depleting oxygen in the water column or clogging gills. The darkened waters can also reduce the light reaching underwater grasses.

Other harmful algal species can lead to fish kills. *Karlodinium venificum* can release a toxin that harms fish, and densities above 20,000 cells/milliliter can be acutely toxic to fish. Extremely low dissolved oxygen is often the result of the abrupt die off of a bloom, when the process of decomposing the large amount of plant material uses up the oxygen in the water. The combination of the toxin and low dissolved oxygen can lead to fish kills.

Figure 21. Harmful algal blooms.
Left panel: Blue-green algae bloom. Right panel: 'Mahogany tide' bloom.

A recurring type of HAB in the Choptank River are 'mahogany tides'. In July 2008, a fish kill in middle Choptank was associated with a bloom of *Karlodinium venificum*. Blooms of *K. venificum* occurred at the same time in the Miles River and Tred Avon River.

[36] Information on Harmful Algal Blooms is available at http://mddnr.chesapeakebay.net/eyesonthebay/habs.cfm

Underwater grasses

Water quality determines the distribution and abundance of underwater grasses (submerged aquatic vegetation, SAV). For this reason, SAV communities are good barometers of the health of the tidal rivers and bays. SAV beds are also a critical nursery habitat for many bay animals. Similarly, several species of waterfowl are dependant on SAV as food when they over-winter in the Chesapeake region. SAV distribution is determined through the compilation of aerial photography directed by the Virginia Institute of Marine Science (VIMS).[37]

Choptank

SAV has never been reported in the tidal fresh or oligohaline regions (above Bow Knee Point) of the Choptank River. In past years, very small amounts of SAV have been mapped by the VIMS aerial survey in the area extending from Bow Knee Point to Castle Haven Point (mesohaline region), well below the SAV restoration goal. Ground-truthing by citizen volunteers in the Bow Knee Point and Chancellor Point areas has found horned pondweed, an early season species typically missed by the summer aerial survey.

SAV distribution has been variable but declining overall in the outer Choptank River since peaking in 1997 with 6,900 acres. SAV coverage was 6,584 acres in 2002 (Figure 22). Acreage has declined since then, falling to 461 acres in 2008. There was a slight increase in 2009 when VIMS mapped 649 acres of SAV, but acreage fell again in 2010 to 404 acres, which represents only 5% of the 8,184 acre restoration goal (Figure 23). Most of the SAV beds were found near the mouths of Broad and Irish Creeks and in Harris Creek and the Tred Avon River. Ground-truthing by staff from the University of Maryland's Horn Point Environmental Laboratory, U.S. Fish and Wildlife Service and NOAA found widgeon grass, horned pondweed, sago pondweed and redhead grass.

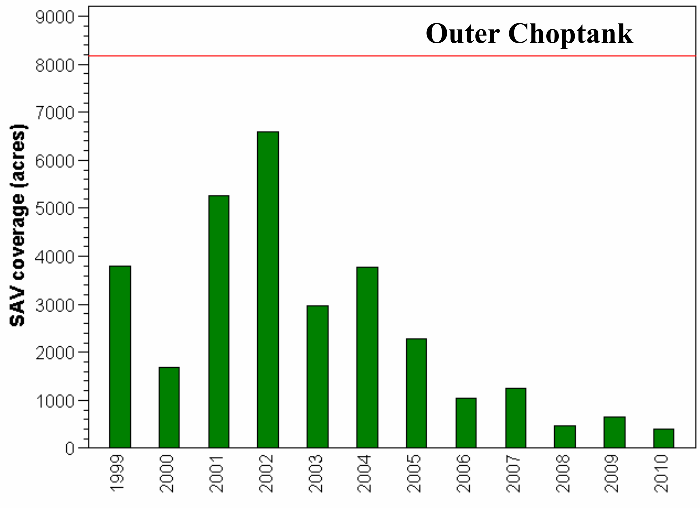
Little Choptank

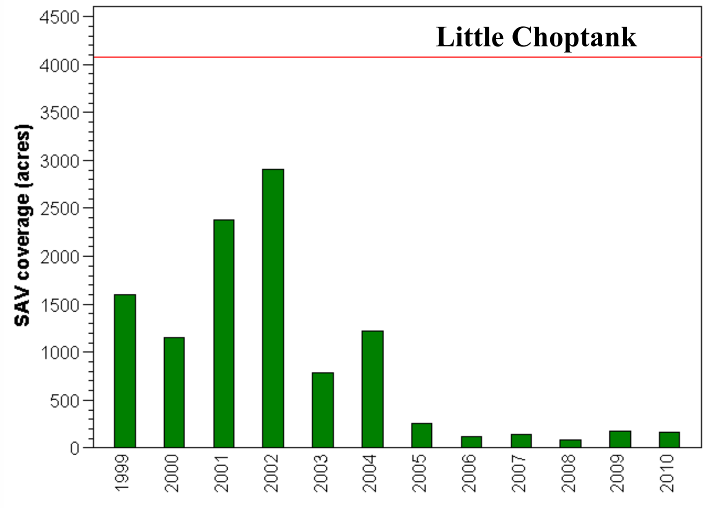
SAV coverage increased from 1999 to 2002, with a high of 2,905 acres in 2002, or 71% of the goal. Acreage has since declined, with less than 175 acres of SAV mapped in 2006-2010. Most of the beds are found in Brooks Creek near Casson Point and in Oyster Cove near Taylor Island.

Honga River

Honga River had impressive gains in SAV coverage from 1984 until 1993, at which time the abundance (4,560 acres) was near the goal of 7,761 acres. After 1993 SAV coverage declined precipitously to a low of 782 acres in 1998, and has been recovering since. The 2002 coverage was up to 6,320 acres, the highest ever recorded, but coverage declined to 2,844 acres in 2003 (Figure 21). In 2010, SAV coverage declined to 2,175 acres, 28% of the restoration goal (Figure 24). Previous ground-truthing has found widgeon grass and horned pondweed in this region.

[37] Reports detailing methodology and annual SAV coverage are available at www.vims.edu/bio/sav . Details on species of SAV discussed in this report can be found at www.dnr.maryland.gov/bay/sav/key





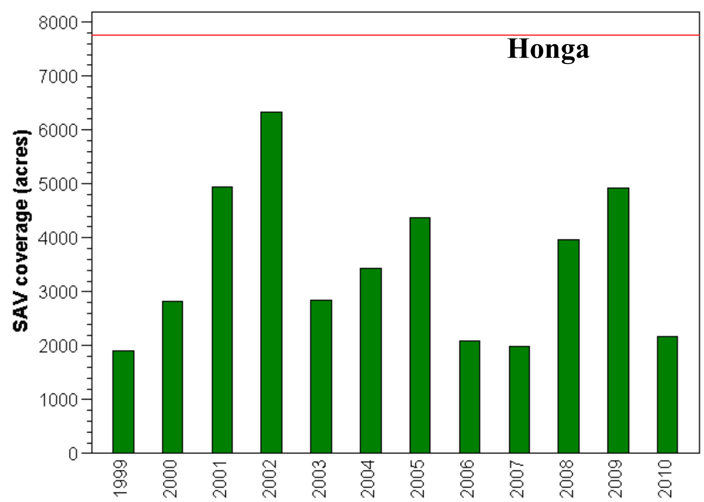


Figure 22. SAV coverages in the outer Choptank, Honga and Little Choptank Rivers 1999-2010. Outer Choptank data is for segment Mesohaline 1 (see Figure 22). SAV data provided by the Virginia Institute of Marine Science. Red line shows the restoration goal for each river.

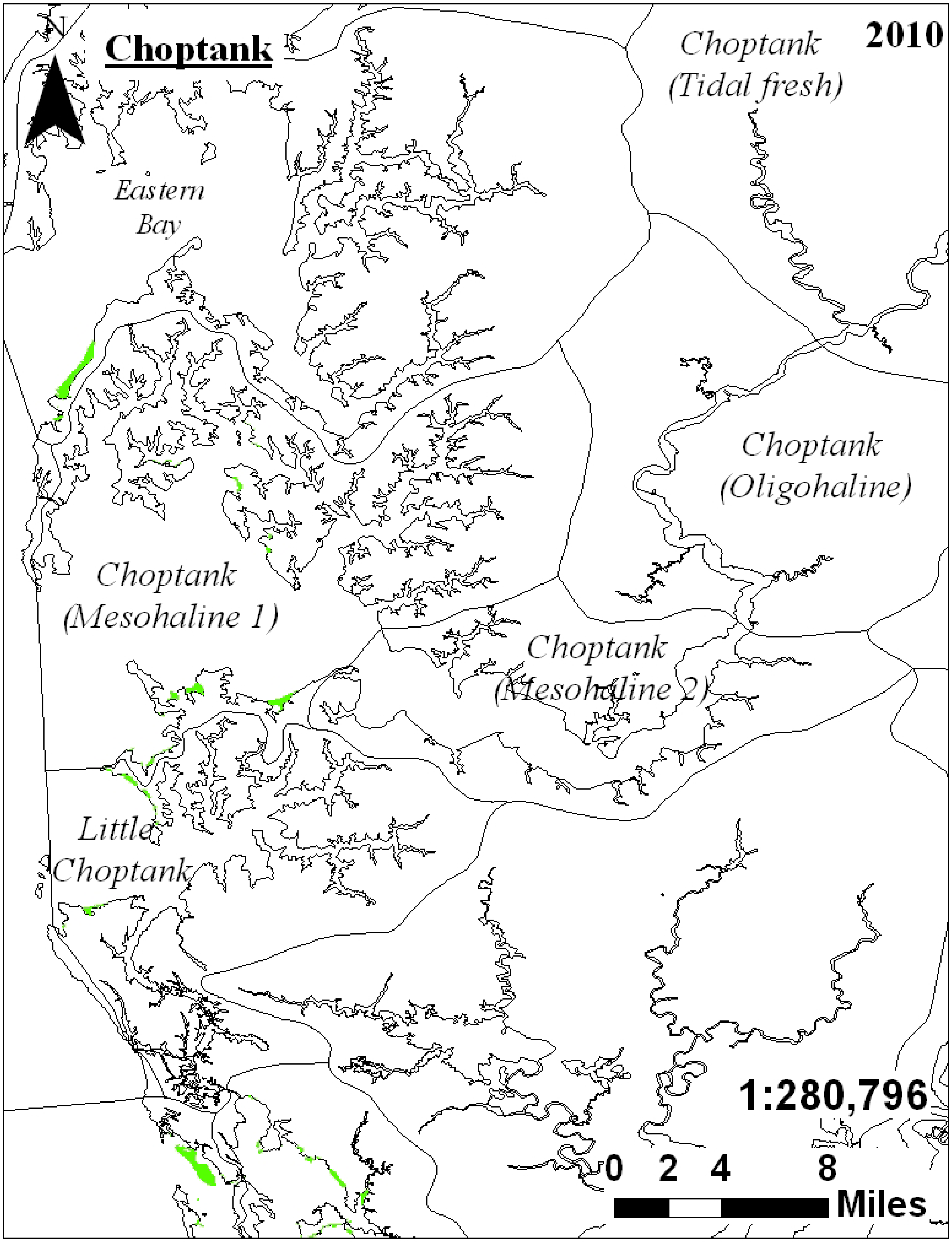


Figure 23. SAV beds (in green) in the Choptank and Little Choptank in 2010.
SAV data provided by the Virginia Institute of Marine Science.

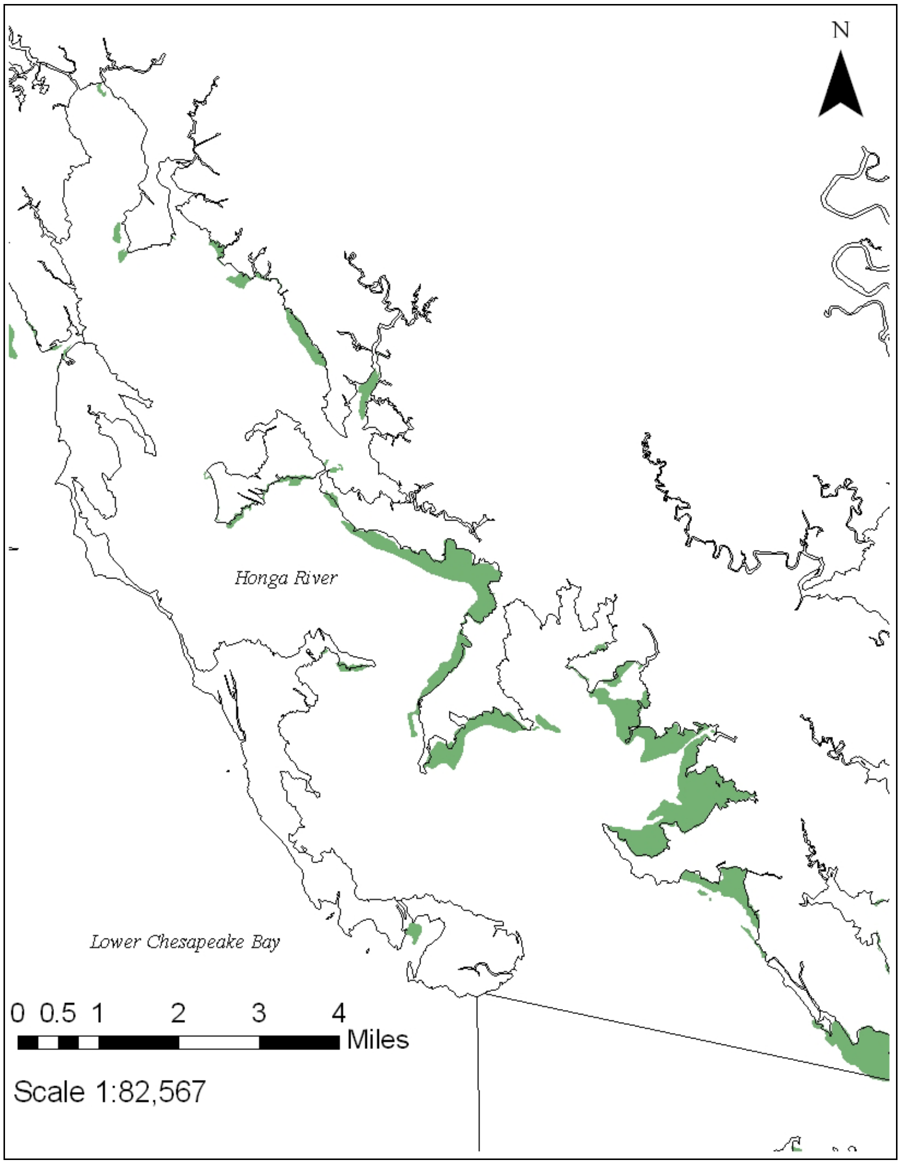


Figure 24. SAV beds (in green) in the Honga River in 2010.
SAV data provided by the Virginia Institute of Marine Science.

Benthic animals

Benthic animals are the animals that live in or on the bottom of the bay. To determine the health of benthic communities, samples are collected in the summer at one long-term benthic monitoring station in the upper Choptank and one in the middle Choptank River near the long-term tidal water quality monitoring stations. The Choptank River stations have been monitored since 1984. Starting in 1994, samples were also collected from all of the rivers and mainstem Bay each year from randomly selected locations. Within the eastern shore rivers there are not a fixed number of samples each year in any particular river and each river is not sampled in every year. Larger rivers end up with more samples collected over time. The benthic index of biotic integrity (BIBI) assesses the health of the benthic community.[38] A BIBI score of greater than 3 is considered meeting the goal for benthic community health.

In 2008-2010, benthic animal community health was degraded in the upper Choptank, and only marginal in the Middle Choptank. No trends were found. During this time period, 19 random samples were collected in the Choptank River (Figure 25). Of these samples, 21% (4 samples) were severely degraded, 26% (5 samples) were degraded, 21% (4 samples) were marginal and 32% (6 samples) meet or exceed the restoration goal. The Little Choptank was sampled 7 times, 4 samples were severely degraded or degraded and only one sample met the restoration goal. The Honga was sampled only twice, and both samples were marginal. The results indicated that 84% of the total benthic habitat was degraded in 2008, 65% in 2009 and 69% in 2010.[39] Poor benthic community health in the eastern shore rivers results from low dissolved oxygen levels and high nutrient and sediment loadings.[40] Severely degraded conditions are likely due to prolonged low oxygen conditions that decrease the number of benthic animals. Degraded conditions are more often due to high nutrients, high levels of organic matter in the sediments and the absence of low dissolved oxygen conditions.

[38] Methods for calculation of the BIBI are available at http://www.baybenthos.versar.com/DsgnMeth/Analysis.htm#BIBI.
[39] Annual reports for 2008, 2009 and 2010 are available online at http://www.baybenthos.versar.com/referenc.htm.
[40] See Annual reports, section 4.

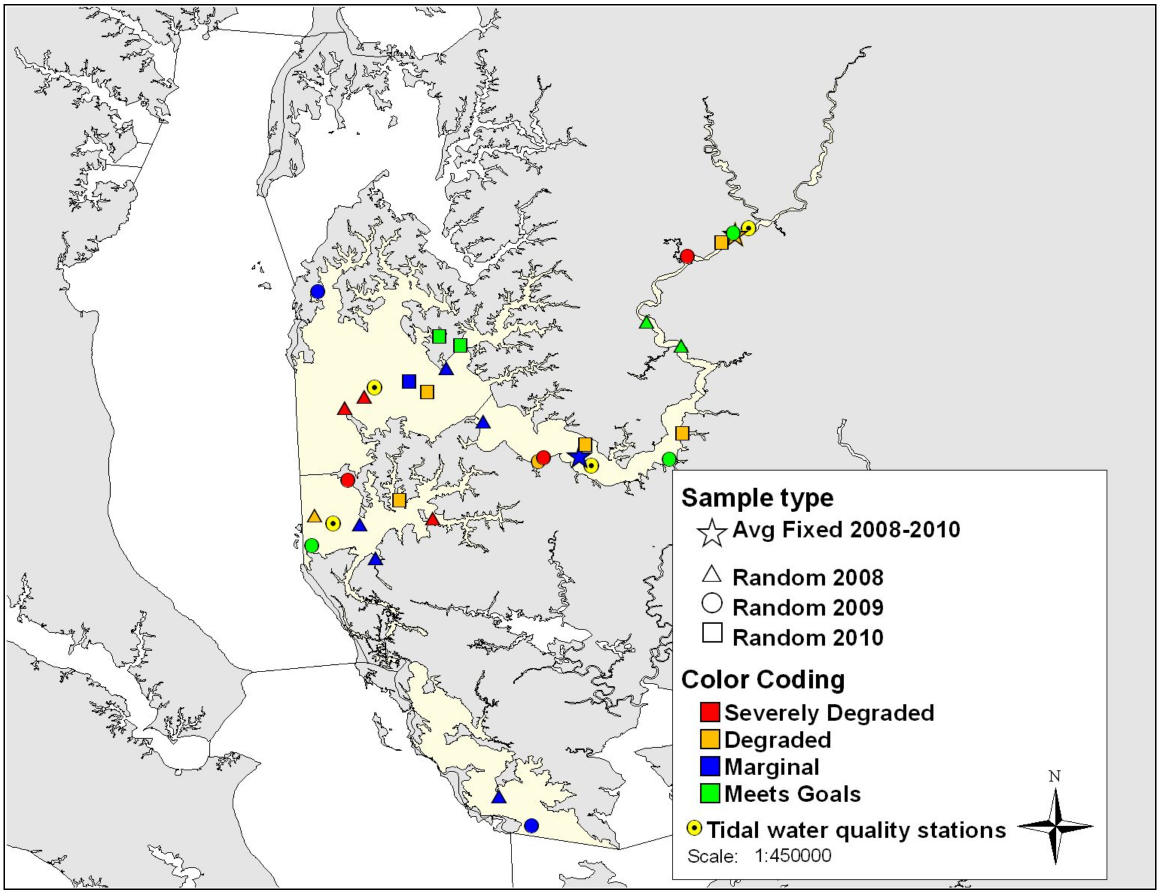


Figure 25. Benthic Index of Biotic Integrity results.
Random samples were collected at 22 locations in 2008-2010. Yellow circles show locations of long-term tidal water quality monitoring stations. A BIBI score of 3 or greater Meets Goals. BIBI scores of 2.7-2.9 are Marginal, 2.1-2.6 are Degraded and less than 2.1 are Severely Degraded.

Summary of Water and Habitat Quality Conditions

Information on current water and habitat quality and the changes through time is needed to assess the health of a river. Many types of information are needed to most completely understand the current conditions. In some instances the assessment is straight forward and all of the information indicates both good water quality and healthy habitats. Most often, some aspects of the overall picture indicate good conditions and other aspects indicate poor conditions. The summary presented here is intended to best represent an overall condition. This is a simplified version and can not capture all the detail presented in the previous sections of this report. Informing the public about the overall health of a river is often best done with a summary of all of the data. Management decisions can benefit from both the summarized and the detailed information.

Choptank River

The Choptank River is divided into three regions- upper, middle and outer. The lower Choptank sub-watershed is a high priority for restoration efforts through Maryland's Trust Fund Program, and the upper two sub-watersheds are moderate priority. Stream health is fair in the Tuckahoe Creek and upper Choptank sub-watersheds, but poor in the Lower Choptank sub-watershed. Human population density is mostly low, but is moderate in small areas. Agricultural land uses cover more than 50% of the basin, and impervious surfaces cover 4% of the land area. Agricultural sources are the largest contributors of nitrogen (N), phosphorus (P) and sediments (S) loadings. Urban runoff is also a source of S and P. In the outer Choptank, point sources are also important to P loading.

Upper Choptank

N and P loads to the non-tidal waters increased from 1985-2010, while sediment loads decreased. However, S loads increased from 2001-2010. S loadings for 2010 were the highest measured and N and P loadings were the second highest even though flow was the sixth highest. P levels measured in the non-tidal water decreased.

Tidal water monitoring at the long-term station found poor and worsening water quality due to increases in N levels and maybe P levels over the longer term. N and P levels were relatively poor. S levels were relatively fair, but were not low enough to meet the habitat requirement for underwater grasses. Algal densities were relatively good and have improved, though this is possibly linked to higher flows in recent years moving algal blooms downstream. Water clarity was poor and did not meet habitat requirement for underwater grasses, but bottom dissolved oxygen levels were good.

Water quality in the shallow water was similar to that in the open water for N and S levels, while there was more variation in the P levels and water clarity. Water clarity and P levels were best at the station farthest upstream but P levels were still too high at this location. Water quality in Tuckahoe Creek was poor.

Continuous monitoring at High Banks found that turbidity levels almost always exceeded the threshold, but chlorophyll levels were below the threshold 90% of the time. Dissolved oxygen levels fell failed to meet the threshold more than 7% of the time in 2006, but always met the criteria in 2007 and 2008.

No underwater grass beds were found in the upper Choptank. The health of algal populations was poor and the health of bottom animal populations was marginal.

Middle Choptank

Water quality in the middle Choptank was poor due to N and P levels that were too high and poor water clarity. N levels may have improved in the summer, though levels were still too high for nitrogen limitation to occur. N, P and algal densities degraded over the longer term. S levels improved. Summer bottom dissolved oxygen levels were fair but occasionally fell below 3 mg/l. N levels degraded over the longer term.

Water quality in the shallow waters was very different at Jamaica Point than at the other stations. N, P and S levels at Jamaica Point were too high to meet the habitat requirements for underwater grasses. Overall, the remaining shallow water areas were similar to the open water for N and P, though N levels were only low enough to meet habitat requirement at station XEH8132. Sediment levels at Horn Point were also higher than at the long-term open water station.

Continuous monitoring at Jamaica Point found that turbidity levels almost always exceeded the threshold but chlorophyll levels were lower than the threshold more than 90% of the time. Dissolved oxygen levels were only rarely less than 3.2 mg/l. Turbidity levels at Horn Point were above the threshold 40-60% of the time, while chlorophyll levels were above the threshold approximately 25% of the time in 2006-2007. Dissolved oxygen levels at Horn Point were less than 3.2 mg/l less than 3% of the time.

No underwater grass beds were found in the middle Choptank. The health of algal populations was poor and degraded. Bottom animal populations were healthy at the long-term station but overall most of the bottom area habitat was degraded.

Outer Choptank

Water quality in the open waters of the outer Choptank was fair due to high algal densities. N levels were low enough for N limitation to occur. P levels met habitat requirements for underwater grasses and may have improved in the spring. Algal densities degraded over the longer term. N and P levels in the shallow water were similar to the long-term open water station, but water clarity was lower in some areas relative to others. Summer bottom dissolved oxygen levels were fair but occasionally fell below 3 mg/l.

Continuous monitoring at Mulberry Point found that turbidity levels exceeded the threshold 40-70%of the time but chlorophyll levels were below the threshold more than 85% of the time. Dissolved oxygen levels were only rarely less than 3.2 mg/l.

Underwater grass beds only covered 5% of the area needed to meet the restoration goal. More than half of the habitat for bottom animals was degraded.

Little Choptank

Land use in the Little Choptank River watershed is half forest and approximately one-third agriculture. Less than 2% or the watershed is covered with impervious surfaces. The watershed is a medium priority for restoration efforts through Maryland's Trust Fund Program, and stream health is poor. Agriculture is the largest source of N, P and S, and forest also contributes to the loads.

Water quality in the open waters of the Little Choptank was relatively good but has degraded over the longer term. N levels were low enough for N limitation to occur. P and S levels met habitat requirements for underwater grasses. However, summer bottom dissolved oxygen was often below 3 mg/l. Water quality in shallow water was similar to the long-term open water station.

Continuous monitoring at Casson Point found that turbidity exceeded the threshold at least 60% of the time but chlorophyll levels were lower than the threshold at least 90% of the time. Dissolved oxygen levels were never less than 3.2 mg/l. Turbidity levels at Gary's Creek failed to meet criteria more than 80% of the time, and chlorophyll levels exceeded the threshold 30-40% of the time. Dissolved oxygen levels were less than 3.2 mg/l less than 3% of the time.

Underwater grasses are much lower than in than in the early 2000s, but have small increases in 2009 and 2010. Most of the grass beds are found in Brooks Creek near Casson Point and in Oyster Cove near Taylor Island.

Honga

Land use in the Honga River watershed is half wetland and approximately one-third forest. Less than 2% or the watershed is covered with impervious surfaces. Forest was the largest source of N, P and S loads. Agriculture also contributed to N loads and urban run-off contributed to P and S loads.

There is not a long-term monitoring station in the Honga River. Shallow waters in the Honga River met all of the SAV habitat requirements except for House Point (XCG9168), which failed to meet the TSS requirement. The water quality was not different between any of the stations with the exception of water clarity at Muddy Hook, which was significantly lower than the other stations. The Honga River is very shallow, and storms can stir up sediments from the bottom and contribute to the poor water clarity.

Continuous monitoring at House Point found that turbidity exceeded the threshold 50-60% of the time but chlorophyll levels were lower than the threshold at least 95% of the time. Dissolved oxygen levels were never less than 3.2 mg/l. Turbidity levels at Muddy Hook exceeded the threshold 30-50% of the time, but chlorophyll levels were almost always below the threshold and dissolved oxygen levels were almost never less than 3.2 mg/l

In 2010, underwater grass beds covered 28% of the area needed to meet the restoration goal, only one-third of the amount present in 2002.

Appendix 1

Land use/Land cover for 2000 and 2010 and Amount of Impervious Surface

Land-use/Land-cover 2000 and 2010 from the Maryland Department of Planning. 2010 data available at www.planning.maryland.gov/OurWork/landUse.shtml. 2000 data available from Maryland Department of Planning, Planning Data Services, (410) 767-4450. Use codes from the Maryland Department of Planning Land Use/ Land Cover Classification Definitions (http://www.planning.maryland.gov/PDF/OurWork/LandUse/AppendixA_LandUseCategories.pdf). Impervious surface calculated from definitions in Cappiella and Brown, Urban Cover and Land Use in the Chesapeake Bay watershed, Center for Watershed Protection, 2001, as referenced in Table 4.1 of a User's Guide to Watershed Planning in Maryland, http://dnr.maryland.gov/watersheds/pubs/userguide.html

Sub-watershed	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Tuckahoe Creek	AGRICULTURE	105.64	**69%**	101.60	**67%**	4.04	3%
	BARREN LAND	0.00	0%	0.05	0%	-0.05	0%
	FOREST	40.37	**26%**	38.81	**25%**	1.56	1%
	URBAN	5.50	4%	11.20	7%	-5.69	-4%
	WETLANDS	1.18	1%	1.00	1%	0.18	0%
	IMPERVIOUS SURFACE	1.03	1%	1.28	1%	-0.25	0%
Upper Choptank	AGRICULTURE	147.47	**59%**	141.27	**57%**	6.20	3%
	BARREN LAND	0.17	0%	0.60	0%	-0.43	0%
	FOREST	72.99	**29%**	66.44	**27%**	6.55	3%
	URBAN	21.12	8%	33.57	13%	-12.46	-5%
	WETLANDS	7.56	3%	7.66	3%	-0.11	0%
	IMPERVIOUS SURFACE	4.27	2%	4.88	2%	-0.61	0%
Lower Choptank	AGRICULTURE	103.67	**58%**	94.16	**52%**	9.51	5%
	BARREN LAND	0.04	0%	0.40	0%	-0.36	0%
	FOREST	40.99	**23%**	39.29	**22%**	1.71	1%
	URBAN	30.13	17%	40.90	**23%**	-10.77	-6%
	WETLANDS	4.94	3%	4.86	3%	0.08	0%
	IMPERVIOUS SURFACE	6.87	4%	7.80	4%	-0.93	-1%
Choptank overall	AGRICULTURE	356.78	**60%**	337.03	**57%**	19.75	3%
	BARREN LAND	0.21	0%	1.05	0%	-0.84	0%
	FOREST	154.35	**26%**	144.53	**24%**	9.82	2%
	URBAN	56.76	10%	85.67	14%	-28.92	-5%
	WETLANDS	13.68	2%	13.53	2%	0.15	0%
	IMPERVIOUS SURFACE	12.18	2%	13.96	2%	-1.79	0%

Sub-watershed	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Little Choptank	AGRICULTURE	23.98	**32%**	22.21	**30%**	1.76	2%
	BARREN LAND	0.01	0%	0.01	0%	0.00	0%
	FOREST	35.93	**48%**	35.49	**48%**	0.44	1%
	URBAN	4.96	7%	7.34	10%	-2.38	-3%
	WETLANDS	9.38	13%	9.26	12%	0.13	0%
	IMPERVIOUS SURFACE	0.83	1%	0.80	1%	0.03	0%
Honga River	AGRICULTURE	3.12	9%	3.21	9%	-0.09	0%
	BARREN LAND	0.13	0%	0.11	0%	0.02	0%
	FOREST	12.18	**33%**	12.05	**33%**	0.12	0%
	URBAN	1.96	5%	2.49	7%	-0.53	-1%
	WETLANDS	19.06	**52%**	18.59	**51%**	0.47	1%
	IMPERVIOUS SURFACE	0.40	1%	0.39	1%	0.01	0%

Appendix 2

Delivered Loads to the Choptank, Little Choptank and Honga Rivers
Phase 5.3 2009 Progress Run 8/25/2010

Chesapeake Bay Program. Accessed January 10, 2012 from
http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044
File
(ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase53_Loads-Acres-BMPs/MD/
Load_Acres_MDWIP_08252010.xls)

Loadings by Land Use and Segment
Loadings > 20% are in **bold typeface.**

River	Category	N load (Million lbs per yr)	% Total N Load	P load (Million lbs per yr)	% Total P Load	Sed load (Million lbs per yr)	% Total Sed Load
Upper Choptank	Agriculture	1.171	**79%**	0.1165	**79%**	17.03	**84%**
	Point Source	0.057	4%	0.0133	9%	0.04	<1%
	Septic	0.070	5%				
	Urban Runoff	0.038	3%	0.0072	5%	1.70	8%
	Forest	0.133	9%	0.0099	7%	1.53	8%
	Non-tidal Water Deposition	0.004	<1%	0.0002	<1%		
	Total Load	**1.474**		**0.1472**		**20.30**	
Middle Choptank	Agriculture	0.512	**79%**	0.0552	**87%**	3.78	**84%**
	Point Source	0.027	4%	0.0015	2%	0.02	<1%
	Septic	0.041	6%				
	Urban Runoff	0.015	2%	0.0028	4%	0.36	8%
	Forest	0.048	7%	0.0038	6%	0.35	8%
	Non-tidal Water Deposition	0.007	1%	0.0004	1%		
	Total Load	**0.651**		**0.0637**		**4.51**	
Lower Choptank	Agriculture	0.217	**58%**	0.0261	**64%**	3.50	**60%**
	Point Source	0.005	1%	0.0021	5%	0.01	<1%
	Septic	0.054	14%				
	Urban Runoff	0.058	15%	0.0093	**23%**	1.81	**31%**
	Forest	0.034	9%	0.0028	7%	0.51	9%
	Non-tidal Water Deposition	0.009	2%	0.0006	2%		
	Total Load	**0.378**		**0.0409**		**5.82**	
Outer Choptank	Agriculture	0.243	**63%**	0.0271	**65%**	2.71	**72%**
	Point Source	0.074	19%	0.0095	**23%**	0.36	10%
	Septic	0.025	6%				
	Urban Runoff	0.016	4%	0.0029	7%	0.46	12%
	Forest	0.023	6%	0.0019	4%	0.26	7%
	Non-tidal Water Deposition	0.005	1%	0.0003	1%		
	Total Load	**0.384**		**0.0417**		**3.79**	
Entire Choptank	Agriculture	2.143	**74%**	0.2249	**77%**	27.02	**79%**
	Point Source	0.163	6%	0.0263	9%	0.43	1%
	Septic	0.190	7%				0%
	Urban Runoff	0.127	4%	0.0223	8%	4.32	13%
	Forest	0.238	8%	0.0183	6%	2.64	8%
	Non-tidal Water Deposition	0.025	1%	0.0015	1%		
	Total Load	**2.887**		**0.2934**		**34.42**	

Loadings by Land Use and Segment
Loadings > 20% are in **bold typeface.**

River	Category	N load (Million lbs per yr)	% Total N Load	P load (Million lbs per yr)	% Total P Load	Sed load (Million lbs per yr)	% Total Sed Load
Little Choptank	Agriculture	0.131	**58%**	0.0160	**70%**	2.47	**71%**
	Point Source	0.001	1%	0.0002	1%	0.02	<1%
	Septic	0.017	7%				
	Urban Runoff	0.010	5%	0.0017	7%	0.36	10%
	Forest	0.049	**22%**	0.0039	17%	0.64	18%
	Non-tidal Water Deposition	0.017	7%	0.0011	5%		
	Total Load	**0.225**		**0.0230**		**3.49**	
Honga	Agriculture	0.012	**21%**	0.0015	**23%**	0.20	**31%**
	Point Source	0.004	7%	0.0015	**22%**	0.00	
	Septic	0.004	6%				
	Urban Runoff	0.006	11%	0.0011	17%	0.15	**24%**
	Forest	0.025	**42%**	0.0020	**30%**	0.29	**45%**
	Non-tidal Water Deposition	0.008	14%	0.0005	8%		
	Total Load	**0.059**		**0.0066**		**0.65**	

Appendix 3

Station names and locations.

Long-term non-tidal and tidal water quality stations

Station Name	Location/Depth	Latitude/ Longitude (NAD83 DMS)	Characterizes
TUK0181	Tuckahoe Creek - Crouse Mill Road near Ruthsburg, MD	38° 59.831’ N 75° 47.186’ W	Free flowing freshwater, flow gauge
ET5.0	Choptank River at Red Bridge near Sewell Mills	38° 58.028’ N 75° 56.587’ W	Free flowing freshwater
ET5.1	Upper Choptank River 200 yds upriver from Ganey’s Wharf, downstream of confluence with Tuckahoe Creek; 6.0 m.	38° 48.387’ N 75° 54.582’ W	Tidal fresh
ET5.2	Lower Choptank River, midriver 50yds NNE of G l, W of Rt 50 bridge at Cambridge; 11.0 m.	38° 34.839’ N 76° 03.520’ W	Lower Estuarine
EE2.1	Choptank embayment between Todds Point and Nelson Pt; 8.0 m.	38° 39.295’ N 76° 15.855’ W	Embayment
EE2.2	Little Choptank River mid-channel West of Ragged Point, W of Buoy Fl g 3; 14.0 m.	38° 31.566’ N 76° 18.245’ W	Embayment

Shallow-water monitoring stations and dates

Waterbody	Segment	Station Name	Station	Years deployed	LAT (NAD83)	LONG (NAD83)
Choptank River	CHOTF	High Banks	CHO0417	2006 – 2008	38° 47.865' N	75° 55.893' W
		Additional water quality mapping calibration stations	CHO0490	2006 – 2008	38° 51.036' N	75° 50.982' W
			CHO0367	2006 – 2008	38° 45.450' N	75° 59.802' W
			XFI1515	2006 – 2008	38 41.484' N	75 58.452' W
			TUK0022	2006 – 2008	38° 49.872' N	75° 54.858' W
	CHOMH2	Jamaica Point	XEI7405	2006 – 2008	38° 37.354' N	75° 59.469' W
		Horn Point Lab	XEH5622	2006 – 2008	38º 35.610' N	76º 07.725' W
		Additional Water quality mapping calibration stations	ET5.2	2006 – 2008	38° 34.842' N	76° 03.522' W
			XEH7912	2006 – 2008	38° 37.878' N	76° 08.814' W
			XEH8132	2006 – 2008	38° 38.490' N	76° 06.666' W
	CHOMH1	Mulberry Point	XFG5054	2006 – 2008	38° 44.961' N	76° 14.638' W
		Additional water quality mapping calibration stations	XFG3973	2006 – 2008	38° 43.938' N	76° 12.750' W
			XEG7539	2006 – 2008	38° 37.470' N	76° 16.128' W
			EE2.1	2006 – 2008	38° 39.294' N	76° 15.858' W
			XEG6966	2006 – 2008	38° 36.954' N	76° 13.404' W
			XEG8519	2006 – 2008	38° 38.484' N	76° 18.138' W
			XEG8593	2006 – 2008	38° 38.568' N	76° 10.680' W
			XFG0809	2006 – 2008	38° 40.782' N	76° 19.038' W
			XFG0965	2006 – 2008	38° 40.926' N	76° 13.512' W
			XFG4620	2006 – 2008	38° 44.598' N	76° 17.994' W
			XFH2312	2006 – 2008	38° 42.312' N	76° 08.808' W
			XEG5627	2006 – 2008	38° 35.598' N	76° 17.298' W
Little Choptank River	LCHMH	Gary's Creek	XEG4991	2005 – 2007	38° 34.930' N	76° 10.927' W
		Casson Point	XEG2646	2005 – 2007	38° 32.562' N	76° 15.353' W
		Additional water quality mapping calibration stations	XEG1995	2005 – 2007	38° 31.698' N	76° 10.746' W
			EE2.2	2005 – 2007	38° 31.566' N	76° 18.246' W
			XEG3623	2005 – 2007	38° 33.606' N	76° 17.640' W
			XEG0138	2005 – 2007	38° 30.138' N	76° 16.248' W
Honga River	HNGMH	House Point	XCG9168	2008 – 2010	38° 19.144' N	76° 13.173' W
		Muddy Hook	XCG5495	2008 – 2010	38° 15.409' N	76° 10.439' W
		Additional water quality mapping calibration stations	XCH6533	2008 – 2010	38° 16.477' N	76° 06.686' W
			XCH7507	2008 – 2010	38° 17.419' N	76° 09.288' W
			XDG1188	2008 – 2010	38° 21.140' N	76° 11.169' W

Appendix 4

Water and Habitat Quality Data Assessment Methods

Loadings
For USGS methods see http://md.water.usgs.gov/publications/sir-2006-5178/index.html

Current condition- Status
Tidal station nutrient concentrations and physical properties were evaluated to determine the current health of the rivers (status). Relative status was determined for total nitrogen (TN), dissolved inorganic nitrogen (DIN), total phosphorus (TP), dissolved inorganic phosphorus (PO_4), total suspended solids (TSS), algal abundance (as measured by chlorophyll *a*, CHLA) and water clarity (as measured with a Secchi disc) for the 2008-2010 period. For status calculation methods see http://mddnr.chesapeakebay.net/eyesonthebay/documents/ICPRB09-4_StatusMethodPaperMolson2009.pdf.

Results for some parameters are compared with established threshold values to evaluate habitat quality. Summer bottom dissolved oxygen (BDO) is compared to US EPA Chesapeake Bay dissolved oxygen criteria for deep-water seasonal (June- September). Summer dissolved oxygen is considered healthy if levels are 5 mg/l or greater and impaired if levels are less than 3 mg/l. For more details see www.chesapeakebay.net/content/publications/cbp_13142.pdf. DIN is compared to a nitrogen limitation threshold value of less than 0.07 mg/l (Fisher and Gustafson 2002, available online at http://www.hpl.umces.edu/gis_group/Resource%20Limitation/2002_report_27Oct03.htm#es). Submerged aquatic vegetation (SAV) growing season median concentrations for 2008-2010 for PO_4, TSS, CHLA and percent-light through water (PLW) are compared SAV habitat requirements (Appendix 5) using the methods of Kemp et al. (2004) available online at http://archive.chesapeakebay.net/pubs/sav/savreport.pdf

Change over time- Trends

Nutrient concentrations and physical properties were evaluated to determine progress toward improved water quality (trends). For trends calculation methods see http://mddnr.chesapeakebay.net/eyesonthebay/documents/stat_trend_hist.pdf. For non-tidal water quality stations, concentrations of TN, TP and TSS were evaluated. For tidal water quality stations, the following parameters were evaluated: TN, DIN, TP, PO_4, TSS, algal abundance (as measured by chlorophyll *a*, CHLA), water clarity (as measured with a Secchi disc), summer BDO, salinity and water temperature. In order to understand results in the primary parameters, additional parameters were examined including nitrate-nitrite (NO_{23}), ammonium (NH_4) and ratios of nutrient concentrations (TN:TP, DIN:PO_4) that may explain more about nutrient use by aquatic plants and limitations of available nutrients.

Non-tidal water quality data was tested for linear trends for 1999-2010 and 1986-2010. Tidal water quality data were tested for linear trends for 1985-1997, 1999-2010 and 1985-2010. Tests for non-linear trends were also done for 1985-2010 with the tidal water quality data. Trends are significant if $p \leq 0.01$; also included in the discussion are trends that 'may be' significant when $0.01 < p < 0.05$. Due to a laboratory change in 1998 that affects the tidal water quality data, a step trend may occur for TP, PO_4 and TSS. For these parameters, trends are determined for 1985-1997 and 1999-2010 only.

In addition to annual trends for the various time ranges above, tidal water quality data was tested for seasonal trends for 1999-2010. Seasons tested were spring (March-May), summer (July-September) and SAV growing season (April-October).

Shallow water Temporal Assessment (Percent failure analysis)

Continuous monitoring data were compared to water quality thresholds. Measurements of dissolved oxygen taken during the months of June through September were compared to the USEPA threshold value of 3.2 mg/l for shallow water bay grass use (instantaneous minimum). This time period was used because the summer months typically experience the lowest dissolved oxygen levels and are the most critical for living resources. Chlorophyll and turbidity measurements collected during the SAV growing season of April through October were compared to threshold levels of 15 µg/l and 7 NTU, respectively. Values above these levels can inhibit light penetration through the water column and impact growth of underwater grasses. Percent failures are defined as the percent of values in each year that did not meet the water quality thresholds.

Shallow water Spatial Assessment

Algal density, sediment and nutrient samples were collected from calibration sites on water quality mapping cruises, some of which were also at continuous monitoring sites. In addition, samples were collected at the continuous monitoring sites when the equipment was serviced (approximately every two weeks). All data for a station (water quality mapping calibration and continuous monitoring calibration) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median. Note that the long-term stations include data from long-term and water quality mapping sampling. The median CHLA, TSS, PO_4 and DIN levels and Secchi depths for the April-October SAV growing season were compared to the habitat requirements in the same manner as the long-term tidal data (Appendix 5).

Non-parametric one-way ANOVAs were used to determine if there were differences between stations (SAS Institute software). Where a significant difference was present, a Tukey's Studentized Range (HSD) test was performed to determine which stations were different from each other. Tests were considered significant at $p < 0.05$.

Appendix 5

Submerged Aquatic Vegetation Habitat Requirements

Submerged Aquatic Vegetation (SAV) habitat requirements by salinity regime (from Habitat Requirements for Submerged Aquatic Vegetation in Chesapeake Bay: Water Quality, Light Regime, and Physical-Chemical Factors. W. M. Kemp, R. Batiuk, R. Bartleson, P. Bergstrom, V. Carter, C. L. Gallegos, W. Hunley, L. Karrh, E. W. Koch, J. M. Landwehr, K. A. Moore, L. Murray, M. Naylor, N. B. Rybicki, J. C. Stevenson and D. J. Wilcox. Estuaries. 2004. 27:363–377 available online at http://archive.chesapeakebay.net/pubs/sav/savreport.pdf.).

SAV growing season for all three regimes in Maryland is from April-October. Median seasonal values are compared to the listed habitat requirement to determine if water quality is suitable for SAV growth and survival. Note that the dissolved inorganic nitrogen (DIN) requirement for mesohaline waters exceeds the 0.07 mg/l level where nitrogen limitation of algal growth likely occurs. The more stringent nitrogen limitation DIN level is used for interpretation of habitat quality instead. Due to issues with the model calibration, instead of Percent light at leaf (PLL) water clarity is assessed with percent light through water (PLW) at 1.0 meter depth (L. Karrh, personal communication). PLW can be calculated for the long-term stations that were sampled from 1985-2010. For all stations, Secchi depth can also be used to estimate PLW (L. Karrh, personal communication).

Salinity Regime (ppt)	Water Column Light Requirement (PLW) (%) or Secchi Depth (m)	Total Suspended Solids (mg/l)	Plankton Chlorophyll-*a* (µg/l)	Dissolved Inorganic Nitrogen (mg/l)	Dissolved Inorganic Phosphorus (mg/l)
Tidal Fresh <0.5 ppt	>13% or 0.725 m	< 15	< 15	Not applicable	< 0.02
Oligohaline 0.5-5 ppt	>13% or 0.725 m	< 15	< 15	Not applicable	< 0.02
Mesohaline 5-18 ppt	>22% or 0.97 m	< 15	< 15	< 0.15 (Nitrogen Limitation < 0.07)	< 0.01

Appendix 6

Long-term annual trends results from non-tidal water quality stations.
Trend results from 1999-2010 and 1986-2010.

Data is from the surface. Red colored results indicate degrading conditions. Green colored results indicate improving conditions. Grey shading of the 1985-2010 Linear Trend results indicates the non-linear trend is significant and the linear trend results should not be reported. For trends significant at $p \leq 0.01$, results are abbreviated as INC (increasing), DEC (decreasing), U (u-shaped non-linear trend) and INV-U (inverse u-shaped non-linear trend). For trends significant at $0.01 < p < 0.05$, NT (no trend) precedes the abbreviation. NT alone indicates trend is not significant at $p < 0.05$.

Station	PARAM	1999-2010 Linear	1986-2010 Linear	1986-2010 non-linear	Non-linear date
ET5.0	TN	NT	NT INC	NT	
	TP	DEC	NT	NT	
	TSS	NT	NT	NT	

Appendix 7

Current status and long-term annual trends results from the tidal water quality stations. Trend results from 1985-1997, 1999-2010 and 1985-2010

Data is from the surface layer with the exception of dissolved oxygen, which is from the bottom and the trends are for summer only (June-September). Red colored status and trends results indicate poor or degrading conditions. Green colored status and trends results indicate good or improving conditions. Blue colored status indicates fair status. Blue colored trends indicate decreasing trends where a qualitative assessment (improving or degrading) is not applicable; purple colored trends indicate increasing trends in the same parameters. Grey shading of the 1985-2010 Linear Trend results indicates the non-linear trend is significant and the linear trend results should not be reported. For trends significant at $p \leq 0.01$, results are abbreviated as IMP (improving), DEG (degrading), INC (increasing), DEC (decreasing), U (u-shaped non-linear trend) and INV-U (inverse u-shaped non-linear trend). For trends significant at $0.01 < p < 0.05$, NT (no trend) precedes the abbreviation. NT alone indicates trend is not significant at $p < 0.05$. '*' indicates trend could not be determined due to a high percentage of data that was below laboratory detection limits.

Param	Station	Initial 2-yr Median	2008-2010 Median	2008-2010 Status	1985-1997 Linear Trend	1999-2010 Linear Trend	1985-2010 Linear Trend	1985-2010 Non-Lin Trend	Non-linear inflection
TN	**ET5.1**	1.568	2.302	**POOR**	**DEG**	NT	**DEG**		
	ET5.2	0.688	0.824	**POOR**	NT	NT	NTDEG		
	EE2.1	0.705	0.636	**GOOD**	NT	NT	NT		
	EE2.2	0.825	0.652	**GOOD**	NT	NT	NT		
DIN	**ET5.1**	0.693	1.573	**POOR**	**DEG**	NT	Not evaluated due to lab change		
	ET5.2	0.163	0.106	**GOOD**	NT	NT			
	EE2.1	0.168	0.078	**GOOD**	NT	NT			
	EE2.2	0.142	0.040	**GOOD**	NT DEG	NT			
TP	**ET5.1**	0.138	0.115	**POOR**	NT	NT	Not evaluated due to lab change		
	ET5.2	0.052	0.045	**POOR**	**DEG**	NT			
	EE2.1	0.042	0.024	**GOOD**	NT	NT			
	EE2.2	0.025	0.023	**GOOD**	NT	NT			
PO4	**ET5.1**	0.026	0.030	**POOR**	NT	NTDEG	**DEG**	**U**	Dec-93
	ET5.2	0.018	0.006	**POOR**	NT	NT	SLOPE=0	**U**	Jul-01
	EE2.1	0.005	0.003	**GOOD**	*	NT	*		
	EE2.2	0.005	0.003	**GOOD**	*	NT	*		
TSS	**ET5.1**	38.0	23.4	**FAIR**	NT	NT	Not evaluated due to lab change		
	ET5.2	8.5	7.5	**GOOD**	**DEG**	**IMP**			
	EE2.1	8.5	5.3	**GOOD**	**DEG**	NT			
	EE2.2	8.0	5.0	**GOOD**	**DEG**	NT			
CHLA	**ET5.1**	20.4	5.4	**GOOD**	NT	**IMP**	**IMP**	**INV-U**	Aug-92
	ET5.2	6.6	10.5	**POOR**	**DEG**	NT	**DEG**		
	EE2.1	5.8	9.8	**FAIR**	NT	NTDEG	**DEG**		
	EE2.2	7.0	8.8	**GOOD**	NT	NTDEG	**DEG**		
SECCHI	**ET5.1**	0.3	0.4	**POOR**	SLOPE = 0	NT	NT		
	ET5.2	1.1	0.9	**POOR**	**DEG**	NT	**DEG**	**U**	Nov-02
	EE2.1	1.5	1.5	**GOOD**	**DEG**	NT	**DEG**	**U**	Jan-02
	EE2.2	1.7	1.4	**GOOD**	**DEG**	NT	**DEG**	**U**	Jun-01
DO	**ET5.1**	5.7	5.4	**GOOD**	NT	NT	**DEG**		
	ET5.2	5.3	4.8	**FAIR**	NT	NT	NT		
	EE2.1	6.3	6.2	**GOOD**	NT DEG	NT	NT		
	EE2.2	2.6	0.8	**POOR**	NT DEG	NT	NTDEG		

Param	Station	Initial 2-yr Median	2008-2010 Median	2008-2010 Status	1985-1997 Linear Trend	1999-2010 Linear Trend	1985-2010 Linear Trend	1985-2010 Non-Lin Trend	Non-linear inflection
WTEMP	ET5.1	16.9	16.4	INC	NT	NT	NT		
	ET5.2	18.4	15.4	INC	NT DEC	NT	NT		
	EE2.1	18.1	13.6	INC	NT DEC	NT	NT		
	EE2.2	15.6	14.7	INC	NT	NT	NT		
SALINITY	ET5.1	1.3	0.0	DEC	SLOPE = 0	NT	SLOPE=0	U	Jun-01
	ET5.2	11.8	9.9	DEC	DEC	NT	DEC	U	Sep-00
	EE2.1	14.0	13.0	INC	DEC	NT	NTDEC	U	Jul-00
	EE2.2	14.8	13.5	INC	DEC	NTDEC	NT	U	Nov-00
NH4	ET5.1	0.080	0.087	POOR	NT	NT	Not evaluated due to lab change		
	ET5.2	0.038	0.022	GOOD	NT IMP	NT			
	EE2.1	0.039	0.018	GOOD	NT	NT			
	EE2.2	0.026	0.010	GOOD	NT	NT			
NO23	ET5.1	0.595	1.520	POOR	DEG	NT	Not evaluated due to lab change		
	ET5.2	0.083	0.078	GOOD	NT	NT			
	EE2.1	0.093	0.050	GOOD	NT	NT			
	EE2.2	0.080	0.023	GOOD	NT	NT			
TN:TP	ET5.1	26	39	NOD	NT	NT	Not evaluated due to lab change		
	ET5.2	32	44	DEC	NT DEC	NT			
	EE2.1	37	54	INC	NT	NT			
	EE2.2	65	57	INC	NT	NT			
DIN:PO4	ET5.1	75	80	DEC	NT	DEC	Not evaluated due to lab change		
	ET5.2	29	43	DEC	NT	NT			
	EE2.1	74	53	DEC	NT	NT			
	EE2.2	59	31	DEC	NT	NT			

Appendix 8

Seasonal trends results for long-term tidal water quality data from 1999-2010.

Seasonal trends results for surface data from 1999-2010. Color codes and abbreviations are the same as used in Appendix 7.

param	station	ANNUAL Jan-Dec	SPRING Mar-May	SUMMER Jun-Sep	SAV Apr-Oct
TN	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
DIN	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NTIMP	NT
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
TP	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
PO4	ET5.1	NTDEG	NTDEG	NT	NTDEG
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NTIMP	NT	NT
	EE2.2	NT	NT	NT	NT
TSS	ET5.1	NT	NT	NT	NT
	ET5.2	**IMP**	NTIMP	NT	**IMP**
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
CHLA	ET5.1	**IMP**	**IMP**	NT	**IMP**
	ET5.2	NT	NT	NT	NT
	EE2.1	NTDEG	NT	NT	NT
	EE2.2	NTDEG	NT	NT	NT
SECCHI	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
WTEMP	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NT	NT	NT
	EE2.2	NT	NT	NT	NT
SALINITY	ET5.1	NT	NT	NT	NT
	ET5.2	NT	NT	NT	NT
	EE2.1	NT	NTDEC	NT	NT
	EE2.2	NTDEC	NTDEC	NT	NT

Appendix 9

Shallow water monitoring data for the SAV growing season.

Continuous monitoring data for the years 2005-2010. Instantaneous measurements of dissolved oxygen taken during June through September were compared to threshold value 3.2 mg/l. Chlorophyll and turbidity measurements collected during the SAV growing were compared to threshold levels of 15 µg/l and 7 NTU, respectively. The percent of values in each year that did not meet the water quality thresholds are presented as "percent failures".

Station	Location	Year	Dissolved Oxygen Thresholds % < 3.2 mg/l	Chlorophyll Thresholds % > 15 ug/l	Turbidity Thresholds % > 7 NTU
CHO0417	*Choptank River* High Banks	2006	7.70	7.10	99.98
		2007	0.00	8.79	99.90
		2008	0.00	11.50	99.27
XEI7405	*Choptank River* Jamaica Point	2006	0.00	16.12	97.22
		2007	0.20	15.22	96.46
		2008	0.00	6.49	94.81
XEH5622	*Choptank River* Horn Point Lab	2006	0.88	26.06	63.98
		2007	2.40	24.47	51.89
		2008	0.41	2.68	39.20
XFG5054	*Choptank River* Mulberry Point	2006	0.06	9.14	43.90
		2007	0.03	12.47	69.61
		2008	0.01	0.04	54.17
XEG4991	*Little Choptank River* Gary's Creek	2005	1.32	34.63	83.03
		2006	2.86	28.02	80.97
		2007	0.01	36.92	94.03
XEG2646	*Little Choptank River* Casson Point	2005	0.00	0.52	64.91
		2006	0.00	2.63	58.41
		2007	0.00	11.54	67.72
XCG9168	*Honga River* House Point	2008	0.00	4.75	55.16
		2009	0.00	0.78	49.08
		2010	0.00	0.06	46.69
XCG5495	*Honga River* Muddy Hook	2008	0.11	1.68	49.08
		2009	0.00	0.81	26.80
		2010	0.22	0.99	51.68

< 10 % failure

40 - 70 % failure

10 - 40 % failure

> 70 % failure

Spatial Assessment

Shallow water monitoring data for 2008-2010 compared to SAV habitat requirements in the Honga River.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling. In 2010, DIN and PO_4 was not measured at some stations.

Station	Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		DO mg/l		Salinity	Salinity Zone	TN mg/l	TP mg/l	Wtemp °C
		2008	6.0	MEET	12.5	MEET	0.048	MEET	0.0032	MEET	0.60	FAIL	7.5	MEET	11.6	MH	0.762	0.0290	23.2
XDG1188	**5**	2009	5.2	MEET	11.1	MEET	0.024	MEET	0.0020	MEET	0.70	FAIL	7.4	MEET	14.5	MH	0.660	0.0257	23.4
		2010	9.3	MEET	14.6	MEET				MEET	0.90	FAIL	7.5	MEET	14.1	MH			24.9
		2008	7.2	MEET	20.0	FAIL	0.042	MEET	0.0030	MEET	0.70	FAIL	7.9	MEET	12.3	MH	0.750	0.0379	22.1
XCG9168 House Point	**1**	2009	6.4	MEET	17.0	FAIL	0.021	MEET	0.0028	MEET	0.75	FAIL	8.6	MEET	14.6	MH	0.673	0.0357	23.5
		2010	9.4	MEET	17.8	FAIL				MEET	0.60	FAIL	8.2	MEET	14.3	MH			24.7
		2008	11.1	MEET	10.7	MEET	0.073	FAIL	0.0034	MEET	0.90	FAIL	7.4	MEET	11.9	MH	0.664	0.0249	22.1
XCH7507	**4**	2009	6.1	MEET	6.4	MEET	0.025	MEET	0.0032	MEET	1.00	MEET	7.3	MEET	15.3	MH	0.561	0.0245	22.8
		2010	10.0	MEET	10.4	MEET				MEET	0.80	FAIL	7.1	MEET	14.5	MH			24.6
		2008	7.5	MEET	15.6	FAIL	0.032	MEET	0.0029	MEET	0.70	FAIL	7.3	MEET	12.4	MH	0.722	0.0343	21.2
XCG5495 Muddy Hook	**2**	2009	5.1	MEET	10.9	MEET	0.020	MEET	0.0028	MEET	0.90	FAIL	9.1	MEET	15.0	MH	0.620	0.0264	22.5
		2010	8.8	MEET	14.6	MEET				MEET	0.60	FAIL	7.8	MEET	14.7	MH			24.4
		2008	7.6	MEET	7.2	MEET	0.036	MEET	0.0030	MEET	0.90	FAIL	7.7	MEET	11.9	MH	0.686	0.0296	22.2
XCH6533	**3**	2009	5.6	MEET	4.4	MEET	0.016	MEET	0.0039	MEET	1.20	MEET	7.7	MEET	15.1	MH	0.591	0.0237	23.4
		2010	5.8	MEET	8.3	MEET				MEET	0.90	FAIL	7.6	MEET	14.5	MH			25.1

Shallow water monitoring data for 2005-2017 compared to SAV habitat requirements in the Little Choptank River.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling.

River	Station		Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		DO mg/l		Salinity	Salinity Zone	TN mg/l	TP mg/l	Wtemp °C
Little Choptank River 2005-2007	XEG1995		25	2005	9.3	MEET	11.3	MEET	0.019	MEET	0.0057	MEET	0.50	FAIL	7.7	MEET	10.4	MH	0.844	0.0514	25.7
				2006	7.5	MEET	9.0	MEET	0.032	MEET	0.0053	MEET	0.60	FAIL	7.9	MEET	11.0	MH	0.715	0.0489	22.7
				2007	13.8	MEET	12.4	MEET	0.034	MEET	0.0037	MEET	0.50	FAIL	7.1	MEET	11.9	MH	0.840	0.0471	27.5
	XEG4991	Gary's Creek	3	2005	12.5	MEET	27.3	FAIL	0.023	MEET	0.0068	MEET	0.40	FAIL	7.2	MEET	9.5	MH	1.062	0.0743	25.9
				2006	11.7	MEET	33.3	FAIL	0.018	MEET	0.0075	MEET	0.40	FAIL	7.1	MEET	11.1	MH	1.042	0.0878	22.7
				2007	12.5	MEET	31.2	FAIL	0.015	MEET	0.0036	MEET	0.40	FAIL	6.8	MEET	11.9	MH	1.034	0.0737	24.8
	XEG2646	Casson Point	2	2005	8.2	MEET	18.7	FAIL	0.053	MEET	0.0027	MEET	0.50	FAIL	7.3	MEET	11.2	MH	0.828	0.0372	25.2
				2006	10.5	MEET	17.9	FAIL	0.021	MEET	0.0036	MEET	0.60	FAIL	7.8	MEET	12.8	MH	0.813	0.0343	22.2
				2007	8.5	MEET	18.6	FAIL	0.038	MEET	0.0030	MEET	0.60	FAIL	7.3	MEET	12.9	MH	0.859	0.0349	23.9
	XEG0138		28	2005	10.0	MEET	16.5	FAIL	0.020	MEET	0.0025	MEET	0.50	FAIL	7.0	MEET	11.9	MH	0.827	0.0302	23.5
				2006	12.0	MEET	11.5	MEET	0.053	MEET	0.0035	MEET	0.80	FAIL	7.8	MEET	12.9	MH	0.827	0.0276	21.2
				2007	9.0	MEET	8.0	MEET	0.021	MEET	0.0040	MEET	0.80	FAIL	7.1	MEET	12.9	MH	0.809	0.0320	25.9
	EE2.2	long-term	26	2005	12.0	MEET	6.3	MEET	0.047	MEET	0.0028	MEET	1.00	MEET	8.5	MEET	11.9	MH	0.746	0.0279	23.7
				2006	9.9	MEET	6.3	MEET	0.058	MEET	0.0036	MEET	1.10	MEET	8.2	MEET	13.1	MH	0.780	0.0320	23.2
				2007	9.0	MEET	3.6	MEET	0.025	MEET	0.0032	MEET	1.20	MEET	8.2	MEET	13.0	MH	0.669	0.0296	23.0
	XEG3623		27	2005	8.7	MEET	17.0	FAIL	0.062	MEET	0.0033	MEET	0.90	FAIL	7.6	MEET	11.9	MH	0.757	0.0270	23.6
				2006	8.4	MEET	6.0	MEET	0.052	MEET	0.0048	MEET	0.90	FAIL	9.1	MEET	13.5	MH	0.705	0.0283	21.7
				2007	5.4	MEET	6.4	MEET	0.021	MEET	0.0023	MEET	1.10	FAIL	7.6	MEET	13.1	MH	0.741	0.0243	25.1

Shallow water monitoring data for 2006-2008 compared to SAV habitat requirements in the upper and middle Choptank River. All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling.

River	Station		Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		DO mg/l		Salinity	Salinity Zone	TN mg/l	TP mg/l	Wtemp °C
Upper Choptank River 2006-2008	CHO0490		23	2006	10.5	MEET	13.3	MEET	1.123	FAIL	0.0208	FAIL	0.40	FAIL	6.2	MEET	0.0	TF	1.887	0.0937	22.1
				2007	3.4	MEET	18.5	FAIL	1.119	FAIL	0.0248	FAIL	0.50	FAIL	5.1	FAIL	0.0	TF	1.804	0.0825	25.4
				2008	7.3	MEET	22.7	FAIL	1.288	FAIL	0.0242	FAIL	0.50	FAIL	5.7	MEET	0.0	TF	2.013	0.0842	23.9
	TUK0022	*Tuckahoe Creek*	24	2006	8.5	MEET	18.8	FAIL	1.361	FAIL	0.0261	FAIL	0.40	FAIL	5.7	MEET	0.0	TF	2.187	0.0983	22.6
				2007	9.7	MEET	21.3	FAIL	1.066	FAIL	0.0237	FAIL	0.40	FAIL	6.0	MEET	0.4	OH	1.689	0.0794	25.4
				2008	18.9	FAIL	41.0	FAIL	1.296	FAIL	0.0337	FAIL	0.40	FAIL	6.3	MEET	0.0	TF	2.141	0.1147	23.8
	ET5.1	long-term	near 1	2006	8.6	MEET	25.0	FAIL	1.054	FAIL	0.0343	FAIL	0.40	FAIL	5.5	MEET	0.2	OH	2.009	0.1128	23.1
				2007	9.5	MEET	23.9	FAIL	0.775	FAIL	0.0270	FAIL	0.40	FAIL	6.2	MEET	0.9	OH	1.403	0.0758	22.7
				2008	9.7	MEET	16.7	FAIL	0.996	FAIL	0.0291	FAIL	0.40	FAIL	6.5	MEET	0.3	OH	1.895	0.0946	25.3
	CHO0417	High Banks	1	2006	10.5	MEET	33.0	FAIL	1.039	FAIL	0.0370	FAIL	0.30	FAIL	5.4	MEET	0.5	OH	1.910	0.1365	22.6
				2007	11.6	MEET	43.5	FAIL	0.479	FAIL	0.0299	FAIL	0.30	FAIL	6.2	MEET	2.1	OH	1.464	0.1146	25.3
				2008	12.7	MEET	38.0	FAIL	1.011	FAIL	0.0382	FAIL	0.30	FAIL	6.6	MEET	0.9	OH	2.007	0.1330	23.9
	CHO0367		21	2006	8.2	MEET	18.5	FAIL	1.019	FAIL	0.0465	FAIL	0.40	FAIL	5.2	MEET	1.8	OH	1.746	0.1053	22.4
				2007	9.0	MEET	29.0	FAIL	0.670	FAIL	0.0412	FAIL	0.30	FAIL	6.1	MEET	3.1	OH	1.262	0.0920	25.0
				2008	9.0	MEET	21.3	FAIL	0.609	FAIL	0.0532	FAIL	0.40	FAIL	6.5	MEET	3.0	OH	1.314	0.1042	22.8
	XFI1515		22	2006	6.5	MEET	20.0	FAIL	0.432	FAIL	0.0516	FAIL	0.40	FAIL	6.9	MEET	3.6	OH	1.244	0.1098	22.6
				2007	12.0	MEET	30.2	FAIL	0.207	FAIL	0.0374	FAIL	0.30	FAIL	6.3	MEET	4.8	OH	0.944	0.0945	25.0
				2008	8.2	MEET	27.0	FAIL	0.391	FAIL	0.0485	FAIL	0.40	FAIL	6.5	MEET	5.3	MH	1.136	0.0923	22.7
Middle Choptank River 2006-2008	XEI7405	Jamaica Point	5	2006	18.7	FAIL	27.5	FAIL	0.314	FAIL	0.0388	FAIL	0.40	FAIL	7.1	MEET	7.0	MH	1.174	0.0966	23.6
				2007	10.5	MEET	25.9	FAIL	0.106	FAIL	0.0213	FAIL	0.35	FAIL	7.5	MEET	8.6	MH	0.924	0.0869	24.6
				2008	9.2	MEET	25.0	FAIL	0.164	FAIL	0.0269	FAIL	0.40	FAIL	8.1	MEET	6.5	MH	0.945	0.0878	22.1
	ET5.2	long-term	18	2006	13.5	MEET	10.5	MEET	0.154	FAIL	0.0115	FAIL	0.70	FAIL	6.7	MEET	9.5	MH	0.964	0.0530	23.0
				2007	13.5	MEET	10.4	MEET	0.083	FAIL	0.0063	MEET	0.70	FAIL	7.1	MEET	9.3	MH	0.880	0.0520	24.2
				2008	11.7	MEET	7.6	MEET	0.111	FAIL	0.0065	MEET	0.80	FAIL	7.0	MEET	8.6	MH	0.819	0.0447	22.1
	XEH5622	Horn Point Lab	4	2006	10.1	MEET	13.2	MEET	0.091	FAIL	0.0088	MEET	0.60	FAIL	6.2	MEET	11.2	MH	0.973	0.0585	22.9
				2007	10.9	MEET	15.5	FAIL	0.102	FAIL	0.0041	MEET	0.60	FAIL	6.1	MEET	10.7	MH	0.836	0.0534	23.7
				2008	9.0	MEET	14.0	MEET	0.113	FAIL	0.0060	MEET	0.80	FAIL	7.7	MEET	9.6	MH	0.826	0.0481	21.3
	XEH8132	*La Trappe Creek*	20	2006	19.4	FAIL	10.0	MEET	0.032	MEET	0.0063	MEET	0.60	FAIL	7.3	MEET	10.4	MH	0.927	0.0428	23.2
				2007	10.2	MEET	13.6	MEET	0.038	MEET	0.0039	MEET	0.60	FAIL	6.7	MEET	9.9	MH	0.878	0.0621	25.6
				2008	11.1	MEET	13.5	MEET	0.063	MEET	0.0027	MEET	0.70	FAIL	7.4	MEET	9.7	MH	0.785	0.0462	23.4
	XEH7912		19	2006	10.5	MEET	6.0	MEET	0.096	FAIL	0.0040	MEET	0.80	FAIL	8.7	MEET	11.3	MH	0.849	0.0351	22.8
				2007	9.9	MEET	7.5	MEET	0.030	MEET	0.0025	MEET	1.00	MEET	7.2	MEET	10.6	MH	0.857	0.0367	23.9
				2008	11.7	MEET	5.6	MEET	0.077	FAIL	0.0031	MEET	1.10	MEET	7.6	MEET	9.8	MH	0.698	0.0351	21.6

Shallow water monitoring data for 2006-2008 compared to SAV habitat requirements in the outer Choptank River.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling.

River	Station		Map #	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		DO mg/l		Salinity	Salinity Zone	TN mg/l	TP mg/l	Wtemp °C
Outer Choptank River 2006-2008	XEG8593		12	2006	9.6	MEET	6.0	MEET	0.137	FAIL	0.0035	MEET	0.90	FAIL	7.9	MEET	11.6	MH	0.830	0.0364	23.2
				2007	12.3	MEET	4.8	MEET	0.066	MEET	0.0041	MEET	1.00	MEET	7.8	MEET	11.4	MH	0.881	0.0341	23.9
				2008	11.1	MEET	5.7	MEET	0.103	FAIL	0.0043	MEET	1.10	MEET	7.4	MEET	10.0	MH	0.708	0.0318	22.0
	XFH2312	*Tred Avon R*	16	2006	17.0	FAIL	8.0	MEET	0.021	MEET	0.0048	MEET	0.70	FAIL	7.3	MEET	10.6	MH	0.864	0.0445	23.0
				2007	8.7	MEET	8.0	MEET	0.073	FAIL	0.0033	MEET	0.60	FAIL	6.6	MEET	10.6	MH	0.860	0.0452	24.8
				2008	10.2	MEET	7.6	MEET	0.059	MEET	0.0035	MEET	0.70	FAIL	7.5	MEET	10.6	MH	0.750	0.0356	23.8
	XEG6966		10	2006	13.2	MEET	8.0	MEET	0.039	MEET	0.0033	MEET	0.80	FAIL	9.1	MEET	11.9	MH	0.831	0.0342	23.1
				2007	9.6	MEET	7.2	MEET	0.053	MEET	0.0039	MEET	0.90	FAIL	7.9	MEET	11.8	MH	0.836	0.0316	24.1
				2008	8.5	MEET	8.4	MEET	0.042	MEET	0.0024	MEET	0.90	FAIL	7.8	MEET	10.2	MH	0.686	0.0362	21.6
	XEG7539		8	2006	13.5	MEET	7.6	MEET	0.036	MEET	0.0037	MEET	0.90	FAIL	8.9	MEET	12.3	MH	0.788	0.0363	23.3
				2007	8.4	MEET	5.6	MEET	0.060	MEET	0.0029	MEET	1.00	MEET	7.2	MEET	12.3	MH	0.669	0.0305	23.9
				2008	9.0	MEET	9.6	MEET	0.033	MEET	0.0032	MEET	0.90	FAIL	8.0	MEET	10.4	MH	0.699	0.0305	21.9
	EE2.1	**long-term**	9	2006	15.3	FAIL	6.0	MEET	0.041	MEET	0.0043	MEET	1.00	MEET	9.0	MEET	12.7	MH	0.785	0.0370	23.3
				2007	9.0	MEET	4.4	MEET	0.056	MEET	0.0029	MEET	1.20	MEET	7.9	MEET	12.5	MH	0.810	0.0296	22.7
				2008	10.6	MEET	5.2	MEET	0.071	FAIL	0.0029	MEET	1.20	MEET	7.5	MEET	10.1	MH	0.667	0.0285	23.4
	XFG0965	*Broad Creek*	14	2006	13.8	MEET	8.0	MEET	0.029	MEET	0.0040	MEET	0.90	FAIL	8.3	MEET	11.8	MH	0.765	0.0348	22.3
				2007	5.2	MEET	7.0	MEET	0.053	MEET	0.0034	MEET	0.80	FAIL	7.5	MEET	11.5	MH	0.735	0.0312	24.1
				2008	8.5	MEET	5.5	MEET	0.084	FAIL	0.0034	MEET	1.00	MEET	7.8	MEET	10.1	MH	0.666	0.0288	23.1
	XFG3973	*Edge Creek*	7	2006	12.3	MEET	8.8	MEET	0.030	MEET	0.0038	MEET	0.60	FAIL	7.7	MEET	11.4	MH	0.746	0.0356	22.7
				2007	10.2	MEET	8.0	MEET	0.052	MEET	0.0040	MEET	0.60	FAIL	6.9	MEET	11.0	MH	0.849	0.0291	24.8
				2008	9.2	MEET	12.4	MEET	0.048	MEET	0.0027	MEET	0.70	FAIL	7.3	MEET	10.4	MH	0.777	0.0310	24.8
	XFG5054	**Mulberry Pt**	6	2006	10.2	MEET	12.2	MEET	0.038	MEET	0.0043	MEET	0.65	FAIL	7.4	MEET	11.5	MH	0.770	0.0433	22.5
				2007	6.6	MEET	20.5	FAIL	0.057	MEET	0.0032	MEET	0.60	FAIL	6.7	MEET	11.2	MH	0.823	0.0380	24.7
				2008	7.5	MEET	16.0	FAIL	0.045	MEET	0.0033	MEET	0.70	FAIL	7.6	MEET	10.7	MH	0.747	0.0337	23.2
	XFG4620	*Harris Creek*	15	2006	11.2	MEET	8.8	MEET	0.041	MEET	0.0033	MEET	0.70	FAIL	7.4	MEET	11.4	MH	0.819	0.0360	23.4
				2007	7.5	MEET	9.3	MEET	0.120	FAIL	0.0037	MEET	0.60	FAIL	7.4	MEET	11.4	MH	0.854	0.0407	24.4
				2008	7.5	MEET	10.4	MEET	0.087	FAIL	0.0028	MEET	0.70	FAIL	7.4	MEET	10.4	MH	0.709	0.0428	24.2
	XFG0809		13	2006	17.9	FAIL	12.8	MEET	0.036	MEET	0.0036	MEET	0.70	FAIL	7.6	MEET	11.7	MH	0.794	0.0415	22.4
				2007	6.0	MEET	7.9	MEET	0.075	FAIL	0.0041	MEET	0.70	FAIL	7.9	MEET	12.7	MH	0.851	0.0279	21.0
				2008	7.9	MEET	14.4	MEET	0.070	MEET	0.0031	MEET	0.80	FAIL	7.3	MEET	10.4	MH	0.800	0.0337	22.1
	XEG8519		11	2006	15.6	FAIL	7.6	MEET	0.079	FAIL	0.0058	MEET	1.00	MEET	8.6	MEET	13.1	MH	0.840	0.0339	23.0
				2007	6.5	MEET	8.0	MEET	0.041	MEET	0.0031	MEET	0.90	FAIL	7.2	MEET	12.6	MH	0.763	0.0292	23.4
				2008	9.9	MEET	6.8	MEET	0.056	MEET	0.0033	MEET	1.00	MEET	8.0	MEET	9.9	MH	0.657	0.0363	21.7
	XEG5627	*Trippe Bay*	17	2006	10.2	MEET	5.3	MEET	0.115	FAIL	0.0032	MEET	1.00	MEET	8.7	MEET	12.6	MH	0.707	0.0276	22.5
				2007	6.6	MEET	2.4	MEET	0.048	MEET	0.0025	MEET	1.20	MEET	8.6	MEET	13.4	MH	0.632	0.0237	22.4
				2008	7.8	MEET	6.4	MEET	0.044	MEET	0.0042	MEET	1.20	MEET	7.8	MEET	10.2	MH	0.810	0.0331	23.0