Assawoman Bay Watershed Characterization

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In Support of Worcester County's Watershed Restoration
Action Strategy for Assawoman Bay Watershed

MARYLAND
DEPARTMENT OF THE ENVIRONMENT

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ACRONYMS

303(d) list – List of impaired waters
BIBI – Benthic Index of Biotic Integrity
BMP – Best Management Practices
COMAR – Code of Maryland Regulations
CREP - Conservation Reserve Enhancement Program
CRP - Conservation Reserve Program
CwiC - Chesapeake 2000 Watershed Commitments
EPA – Environmental Protection Agency
EQIP - Environmental Quality Incentive Program
FIBI – Fish Index of Biotic Integrity
FIDS - Forest interior dwelling species
GIS – Geographic Information Systems
IBI – Index of Biotic Integrity
MACS - Maryland Agricultural Cost-Share program
MALPF - Maryland Agricultural Land Preservation Foundation
MBSS – Maryland Biological Stream Survey
MDE – Maryland Department of the Environment
MDNR – Maryland Department of Natural Resources
MET - Maryland Environmental Trust
MGS – Maryland Geological Survey
MPN – Most Probable Number
NPDES - National Pollution Discharge Elimination System
RTE – Rare, Threatened or Endangered species
SAV – Submerged Aquatic Vegetation
SCA – Stream Corridor Assessment
STORET - STOrage and RETrieval
TMDL – Total Maximum Daily Load
USGS – United States Geological Survey
WRAS – Watershed Restoration Action Strategy
WSSC - Non-Tidal Wetland of Special State Concern

INTRODUCTION

Watershed Planning Background

As a foundation for watershed monitoring, analysis and planning, the State of Maryland defined over 130 watersheds that cover the entire State in the 1970s. In 1998, the Maryland Clean Water Action Plan presented an assessment of water quality conditions in each of these watersheds. Based on these assessments, it also established State priorities for watershed restoration and protection. In 2000, the Watershed Restoration Action Strategy (WRAS) Program was initiated as one of several new approaches to implementing water quality and habitat restoration and protection. The WRAS Program solicits local governments to focus on priority watersheds for restoration and protection. Since inception of the program, local governments have received grants and technical assistance for 25 WRASs in which local government, with input from citizens, identifies local watershed priorities for restoration, protection and implementation.

Assawoman Bay WRAS Project

Worcester County, one of five counties participating in the 2005 WRAS program, has selected the Assawoman Bay Watershed (Basin number: 02130102) for restoration and protection. Assawoman Bay Watershed, one of the "Northern Coastal Bays" is protected from the Atlantic Ocean by Fenwick Island (Maps 1 & 2: Deer Creek Watershed and WRAS Project Area). The Assawoman Bay watershed is prioritized in the Maryland Clean Water Action Plan as a Category 1 watershed for restoration, which recognizes the presence of water quality impairments that need improvement (MDNR 1998).

Purpose of the Characterization

In support of the WRAS project, the Watershed Characterization helps to meet several objectives:

- Summarize available information and issues,
- Provide preliminary findings based on this information,
- Identify sources for more information or analysis,
- Suggest opportunities for additional characterization and restoration work,
- Provide a common base of knowledge about the watershed for government, citizens, businesses and other interested groups.

The Watershed Characterization may add to other information gathering efforts that are important for the County's WRAS project:

- Local investigation by the County,
- Reports by the Maryland Department of Natural Resources' (MDNR) Coastal Bays Program,

- Stream Corridor Assessment, in which State personnel physically walk 100 miles of streams and catalogue important issues such as fish blockages, eroded banks, and exposed sewer pipes,
- Synoptic water quality survey in which water samples are collected and analyzed for nutrients and other substances,
- Technical assistance and assessment by partner agencies or contractors.

More Sources of Information

The reference section provides more detailed information that is only very briefly summarized here. The WRAS Program Internet home page has additional information on the program and an index of available electronic copies of WRAS-related documents that can be downloaded free of charge. Available documents include detailed program information, completed WRAS strategies, stream corridor assessments, synoptic surveys and watershed characterizations. Please visit the WRAS Home Page at: http://www.dnr.state.md.us/watersheds/wras/

Additional information on over 130 watersheds in Maryland is available on MDNR's Internet page Surf Your Watershed at: http://www.dnr.state.md.us/watersheds/surf/index.html

The Maryland Clean Water Action Plan is available at: www.dnr.maryland.gov/cwap/

A User's Guide to Watershed Planning in Maryland presents the information and methods necessary for completing a local watershed plan. http://www.dnr.state.md.us/watersheds/pubs/userguide.html

For volunteer opportunities and other information, see the Maryland Coastal Bays Program web site: http://www.mdcoastalbays.org/

WATER QUALITY

Designated Uses For Streams

Maryland's water quality standards address the federal requirements "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" (Clean Water Act, Section 101). Standards have been established to support beneficial uses such as fishing, aquatic life, contact recreation, boating, drinking water supply, and terrestrial wildlife that depend on water. This expanded view of water quality is reflected in current approaches to monitoring, data gathering, and regulation of water bodies as reflected in this watershed characterization.

Streams and other water bodies in Maryland are each assigned a "designated use" in the Code of Maryland Regulation (COMAR) 26.08.02.08. An area's designated use refers to a water body's function. The designated uses are associated with sets of water quality criteria necessary to support the uses. Together, the designated use and the criteria are commonly referred to as "Water Quality Standards". In Maryland's portion of the

Assawoman Bay watershed, all bodies of water are categorized under one of two designated uses:

- Use 1- Recreation and Aquatic Life applies to all surface waters except for those designated as Use 2. (This includes all nontidal water bodies.)
- Use 2- Shellfish Harvesting encompasses all portions of the territorial seas and estuarine portions of bays and tributaries.

Use Impairments

Some streams or other water bodies in the WRAS project area do not meet the full extent of their designated use defined in Maryland regulation. These areas, known as "impaired waters", are tracked by MDE and DNR under Section 303(d) requirements of the Federal Clean Water Act. The impairments for waterbodies in the Assawoman Bay watershed are summarized below. More information on the 303(d) list can be found at: http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/index_new.asp

Bacteria

The Assawoman Bay was included in 1996 303(d) list for impairment associated with fecal coliform bacteria from nonpoint and natural sources. However in 2004, data indicated that the area met approved shellfish standards so the impairment listing for bacteria was removed (MDE 2005).

Dissolved Oxygen

In Maryland's Coastal Bays including Assawoman Bay, dissolved oxygen levels are known to drop below the State standard. The cause is associated with nutrient enrichment and algae over-population in warm months. This dissolved oxygen data is used to support listing impairment by nutrients. Prior to 2002, low dissolved oxygen impairment was listed separately (MDE 1996, 2002).

Nutrients

The Assawoman Bay was included on the 303(d) list for impairments associated with nutrients from nonpoint and natural sources in 1996. Water quality in the Assawoman Bay is affected by freshwater input from the tributaries in the Isle of Wight Bay watershed (MDE 2005).

Total Maximum Daily Loads

Maryland Department of the Environment (MDE) uses the 303(d) list of impaired waters to determine the need for establishing Total Maximum Daily Loads (TMDLs). A TMDL is the maximum amount of pollutant that a water body can assimilate and still meet its designated use. A water body may have multiple impairments and multiple TMDLs to address them. MDE is responsible for establishing TMDLs. In general, TMDLs have two key parts:

1- Maximum pollutant load that the water can accept while still allowing the water body to meet its intended use.
2- Allocation of the maximum pollutant load to point and non-point pollutant sources.

In April of 2002, TMDLs for nitrogen and phosphorus were approved by the U.S. Environmental Protection Agency for five tributaries in the Northern Coastal Bays (MDE 2001). The streams are in the Isle of Wight Bay watershed, adjacent to the Assawoman Bay watershed, and influence the water quality of the Assawoman Bay.

In January 2006, the Department and its contractors began to assemble all of the data in Maryland's Coastal Bays which is presently being analyzed for sufficiency to develop a computer model. Preliminary results indicate that the data, with minimum additional monitoring, are adequate to develop a hydrodynamic/water quality model of the entire Coastal Bays. This work will begin in autumn of 2006. The Department expects to address all of the remaining nutrient impairments in the Coastal Bays by early 2008 (N. Panday, Personal Communication).

Water Quality In Tidal Areas

Overview

Assawoman Bay is polyhaline (18 – 35 parts per thousand (ppt.)) with saltwater input from the Atlantic Ocean flowing through the Ocean City Inlet and the Isle of Wight Bay. The main sources of freshwater come Grey's Creek, Roy Creek in Delaware, from the St. Martins River in the Isle of Wight Bay Watershed and ground water (MDNR Coastal Bays Program, Monthly Monitoring).

Monitoring in the tidal areas of the Assawoman Bay is performed by Maryland DNR, MDE's Shellfish monitoring program and MDE's Field Monitoring Program (In-House Monitoring data) (Map 3: Water Monitoring and Marinas). The MDNR monitoring sites are fixed station monthly monitoring sites. Current data from these sites is available on MDNR's Coastal Bays site: http://mddnr.chesapeakebay.net/sim/dataflow_data.cfm#coastalbays . Data for the MDE Field Monitoring sites for 1998 and 2003 can be found on the Environmental Protection Agency's STORET data site: http://www.epa.gov/storet/dbtop.html . MDE's Beaches Program has a monitoring site on the Ocean side of Fenwick Island, just outside of the Assawoman Bay watershed. Much of the summary of tidal water quality given below has been extracted from Maryland's Coastal Bays: *Ecosystem Health Assessment* 2004 (http://www.dnr.state.md.us/coastalbays/sob_2004.html).

Water Clarity

Good water clarity is necessary for growth of aquatic vegetation. Water clarity is reduced as more suspended sediment, algae and zooplankton occur in the water. Water clarity as measured by Secchi disk should be greater than 0.96 meters or clear to the bottom for good growth of sea grasses. This level should be met for more than 40% of the measurements (Dennison et al. 1993; Stevenson et al. 1993). Water clarity data were available at five monitoring stations in the Assawoman Bay. Data are obtained from these sites monthly but the median chlorophyll *a* concentrations were determined for the seagrass growing season (March – November) for the three-year period from 2001-2003. Sites in the upper bay (XDN7261, XDN6454, XDN5737 and XDN7545 (site in DE, not shown on Map 3)) exceeded the 15µg/L chlorophyll *a* threshold for negative effects on sea grass growth while two stations in the open bay (XDN4851 and XDN3445) met the sea grass objective (median below 15µg/L). Chlorophyll concentrations at all stations were below the 50µg/L threshold for harmful dissolved oxygen effects (Wazniak et al. 2005a).

Dissolved Oxygen

Oxygen is necessary for a healthy ecosystem. Low levels of dissolved oxygen (DO) can impair feeding, growth and reproduction of aquatic life or cause die-offs. DO is often the lowest at night when photosynthesis stops and respiration continues. Fish and crabs often avoid water with low oxygen levels (5 milligrams per liter (mg/l) or lower). State water quality criteria require a minimum DO concentration of 5 mg/l at all times for Use I and Use II Shellfish Harvesting Waters (COMAR). A DO level of 5 mg/l is required for hard clam, alewife, blueback herring, white perch, and striped bass (Funderburk et al. 1991). Blue crabs, bay anchovies and many other species require a minimum of 3 mg/l DO for survival while spot and Atlantic menhaden can survive at 2 mg/l and 1.1 mg/l, respectively (Funderburk et al. 1991). Median summer DO values at all fixed sites for the summer season (July, August and September) for the three year period from 2001-2003 in the Assawoman Bay were above 5 mg/l but minimum daytime values between 3 and 5 mg/l were observed at three stations (Wazniak et al. 2005b).

Chlorophyll (algae)

Chlorophyll *a* is used as a way to measure the size of algae populations. Chlorophyll *a* concentrations greater than 15 micrograms per liter (µg/l) negatively affect seagrasses by blocking more and more light as concentrations increase. At four DNR monitoring stations in the upper Assawoman Bay (XDN7261, XDN6454, XDN5737 and XDN7545 (site in DE, not shown on Map 3)), chlorophyll *a* concentrations were above 15 µg/l therefore interfering with seagrass growth. At two sites in the open bay (XDN4851 and XDN3445) median concentrations were below 15 µg/l. Median chlorophyll *a* concentrations were determined for the seagrass growing season (March – November) for the three-year period from 2001-2003. Concentrations of chlorophyll *a* greater than 50 µg/l are associated with algae populations that are great enough to reduce dissolved oxygen. All sites were below 50 µg/l (Wazniak et al. 2005a).

Nutrients

Nutrient over-enrichment is a major threat to the Coastal Bays. Non-point sources are the main inputs of the nutrients, nitrogen and phosphorus, to the Coastal Bays. Based on monthly data for the three-year period from 2001-2003 from MDNR monitoring stations (five tidal and one nontidal marked with triangles on Map 3) in the Assawoman Bay watershed, the median concentrations of total nitrogen and total phosphorus were unsuitable for seagrass growth (total nitrogen > 0.65 mg/L; total phosphorus > 0.038 mg/L) (Wazniak et al. 2005c).

Sediment Contaminants

Sediments frequently retain traces of contamination by metals, pesticides and other substances that enter surface water. Sediment collected in a dead-end canal in Assawoman Bay contained chlorinated hydrocarbons that are probably remnants from historic inputs (Wells and Hill 2005). The open waters of Assawoman Bay do not contain high levels of contaminants (Wells and Hill 2005). Contamination can contribute to toxicity of the sediment. In 2000 and 2001, the National Coastal Assessment survey sampled Maryland's Coastal Bays and tested the samples for ambient toxicity with a bioassay (survival rate of the amphipod *Ampelisca abdita*). The assay found no detectable toxicity in the sediment at seven sites in the Assawoman Bay (Dawson-Orano and Wazniak 2005).

Total Organic Carbon

Total organic carbon (TOC) in sediments is an indicator of pollution and eutrophication. Higher concentrations suggest a greater tendency toward eutrophication. In Maryland's coastal bays, high TOC is found in the northern bays, which indicates eutrophication problems (Wells 2005).

Bacteria

Bacteria monitoring in the Assawoman Bay watershed is conducted by MDE's Shellfish Monitoring Program and, just outside of the watershed, by MDE's Beaches Program in conjunction with the County Health Department as described below.

Shellfish Certification Division

Maryland Department of the Environment's Shellfish Certification Program is responsible for classifying shellfish harvesting waters to ensure oysters and clams are safe for human consumption. MDE adheres to the requirements of the National Shellfish Sanitation Program (NSSP), with oversight by the U.S. Food and Drug Administration. MDE conducts the shoreline surveys and collects routine bacteria water quality samples in the shellfish-growing areas of Maryland. These data are used to determine the status of the shellfish waters. If the water quality criteria are exceeded, the shellfish areas are closed to harvest. Areas that do comply with criteria remain approved or are reclassified as approved. MDE's Shellfish Certification Division has monitored shellfish growing regions throughout Maryland for the past several decades. Assawoman Bay is part of the Sinepuxent Bay shellfish harvesting area (which also consists of the St. Martin River, Isle of Wight Bay, and the Sinepuxent Bay). Assawoman Bay is bordered by Ocean City on the eastern shore. Ocean City is a large resort community whose population increases significantly during the summer vacation season. Ocean City is served by the Ocean City Wastewater Treatment Plant (WWTP) which discharges to the Atlantic Ocean (Town of Ocean City Wastewater Department). As shown in Map 3, there are five shellfish monitoring stations in Assawoman Bay. The waters of Assawoman Bay are Approved Shellfish Harvesting Areas. The water samples taken from the Assawoman Bay consistently meet the criterion for shellfish harvesting (MDE Shellfish Certification Division).

MDE Beaches Program

The Maryland Beaches Program works with the local government to enhance beach water quality monitoring and improve the public notification process regarding beach water quality. In October 2000, the U.S. Environmental Protection Agency (EPA) passed the Beaches Environmental Assessment and Coastal Health (BEACH) Act and provided funding to improve beach monitoring in coastal states. The state program is administered by MDE; however, the responsibility of monitoring (sampling) and public notification of beach information is delegated to the local health departments. Beaches are used by the public for swimming, surfing, or other similar water contact activities. Indicator organisms, such as Enterococci and *E. coli,* are types of bacteria commonly found in the gut of warm-blooded animals and are used to monitor recent fecal contamination. Swimming advisories are established using water quality indicator bacterial results for single sample maximum, as described in COMAR (26.8.09 and 26.08.02.03-3). The water samples are taken based on a predetermined monitoring frequency. The frequency is established based on potential risk to the swimmer using the data gathered in sanitary surveys. A sample is taken on a pre-selected day and results take approximately 30 hours. If a high count appears, then the managers typically have two options: either resample to reconfirm the high count, or post an advisory. However, most managers will confirm the high count by resampling the very same day. The resample result will be then available within the next 30 hours, at such a point the managers can decide if any action is needed (M. Cora, Personal communication). Elevated counts of bacterial indicator species do not necessarily mean that pathogens are present in significant concentrations in the water body. The current sampling tool (methods) does not offer fast results. EPA is working to develop faster sampling tools. However, no timeframe has been established for the production of the tools (M. Cora, Personal communication).

The Beaches Program monitors six sites on the Ocean side of Fenwick Island (just outside of the Assawoman Bay watershed). There have been no advisories for that area in the last year (M. Cora, Personal communication). Some samples exceeded the single sample maximum of 104 organisms per 100 ml. These sites were tested again soon after and were found to be in compliance (Worcester County Department of Environmental Programs).

Data from Worcester County's Ocean City monitoring sites (not shown on Map 3) can be found at: Worcester County Department of Environmental Programs, Weekly Bathing Beach Water Samples: http://www.co.worcester.md.us/EnvPrograms.htm). More information on the MDE Beaches Program can be found at: (http://www.mde.state.md.us/citizensinfocenter/health/beaches.asp).

Water Quality In Nontidal Areas

Overview

On Maryland's lower Eastern Shore, drainage modifications such as ditching are very common. Many natural streams are altered to speed surface drainage and/or to lower the water table. In some places, natural streams may not exist. Commonly, the nontidal water quality information available does not indicate if the water body sampled is a natural stream or drainage ditch. Therefore, the term stream is used here as a generic term for all nontidal surface water conveyance.

Synoptic Survey

The Synoptic Survey Report, produced by MDE, is a water chemistry analysis (nutrients, temperature, conductivity, pH) on between 30 and 80 sites along nontidal stream corridors in the watershed. Local governments and MDE staff collaboratively choose the sites that MDE will sample. The results of the Survey will be presented in a separate report.

Stream Corridor Assessment (SCA)

The Stream Corridor Assessment (SCA) survey was developed by MDNR's Watershed Restoration Division as a tool to help environmental managers identify environmental problems and prioritize restoration opportunities on a watershed basis. As part of the survey, trained personnel walk the watershed's nontidal stream network and record information on a variety of environmental problems that can be easily observed within the stream corridor. Common environmental problems documented in the survey include: eroding stream banks, inadequate stream buffers, exposed pipes, altered stream channels, fish migration barriers, pipe outfalls, in-stream construction sites and trash dumping locations. The results of the SCA will be presented in a separate report.

Maryland Biological Stream Survey (MBSS)/Stream Waders

The Maryland Biological Stream Survey, started in 1994, samples non-tidal wadable streams in all of the watersheds in the state on a five year rotation. MBSS samples fish, benthic macroinvertebrates, water chemistry and habitat. An index of biointegrity (IBI) is calculated for fish and benthic macroinvertebrates. The IBI score is a quantitative rating of the health of the fish or benthic macroinvertebrate assemblage found at each site. The survey is based on a probabilistic stream sampling approach where random selections are made from all sections of streams in the state that can physically be sampled. The approach supports statistically-valid population estimation of variables of interest (e.g., largemouth bass densities, miles of streams with degraded physical habitat, etc.) (MDNR MBSS). In 2000, MBSS started a volunteer program, Stream Waders, to increase the density of samples taken in sub-watersheds of about 8 sq. miles. Stream Waders sample in the same watersheds as the MBSS program but sample only benthic macroinvertebrates.

In the last cycle of the MBSS program (up to 2004) there were only two Stream Waders samples taken in the Assawoman Bay watershed and none taken by the professional MBSS program. One site was in Back Creek and the other was in a tributary of Bunting Branch (Sussex, DE). Both were rated as poor.

In 2005, MBSS and Stream Waders sampled in the Assawoman Bay watershed. MBSS will present their data in a separate report along with all previous MBSS/Stream Waders data for this watershed. More information on the MBSS/Stream Waders programs can be found at: http://www.dnr.state.md.us/streams/mbss/index.html

Groundwater Quality

The Town of Ocean City's water supply comes from two underground aquifers, the Ocean City Aquifer and the Manokin Aquifer. Twenty-three wells draw from these aquifers and range in depth from 200 feet to more than 400 feet. These deep confined aquifers recharge from outside of Worcester County and contamination from local land practices is low (Town of Ocean City Water Department). The Town government tests the drinking water frequently to guarantee that any contaminants are at a safe level. More information can be found on Ocean City's web site: http://www.town.ocean-city.md.us/Water/AnnualWaterQualityReport.pdf .

Also, a good overview of groundwater in the Coastal Bays watersheds can be found in "Priority Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays", MDE 2004.
http://www.mde.state.md.us/assets/document/wetlandswaterways/CB_all.pdf

Point Sources

Discharges from pipes or other "discrete conveyances" are called "point sources." Point sources may contribute pollution to surface water or to groundwater. For example, wastewater treatment discharges may contribute nutrients that reduce oxygen available for aquatic life. Stormwater discharges may contribute excessive flow of water and/or seasonally high temperatures. Industrial point sources may contribute other forms of pollution. Some understanding of point source discharges in a watershed targeted for restoration is useful in helping to prioritize potential restoration projects.

Many types of point sources operate under permits issued by MDE. MDE's Environmental Permits Service Center (EPSC) data indicate that there are twelve permitted discharges located in Maryland's portion of the Assawoman Bay watershed (Map 4: MDE Permits). One of these, the Ocean City Waste Water Treatment Plant, is listed as a major discharge. The outfall from the Waste Water Treatment Plant goes into the Atlantic Ocean but sludge is treated further then disposed of by land application. In addition, Assawoman Bay receives water from St. Martin's River in the Isle of Wight watershed from tidal movements. Therefore, point source discharges into the Isle of Wight watershed could influence water quality in the Assawoman Bay. Information on the Isle of Wight watershed and permitted point sources in that watershed can be found in the WRAS characterization for the Isle of Wight:
http://dnrweb.dnr.state.md.us/download/bays/iow_char.pdf . More information on

discharge permits can be found on MDE's Customer Service Center web page: http://www.mde.state.md.us/BusinessInfoCenter/enviroPermits/index.asp

Table 1. Assawoman Bay MDE Permits.

Major Municipal Surface Discharge (Sewage Treatment)				
Permit No.	NPDES No.	Facility Name	Address	City
99DP0596	MD0020044	OCEAN CITY WWTP	6405 SEABAY DRIVE	OCEAN CITY

Municipal Surface Discharge (Sewage Treatment)				
Permit No.	NPDES No.	Facility Name	Address	City
04DP3481	MD0069485	LIGHTHOUSE SOUND WTP	12723 ST. MARTINS NECK. ROAD	BISHOPVILLE

Municipal Groundwater Discharge				
Permit No.	NPDES No.	Facility Name	Address	City
01DP3378		SKYLINE POINT	BACK CREEK ROAD @ SELBY ROAD	BISHOPVILLE

General Industrial Stormwater				
Permit No.	NPDES No.	Facility Name	Address	City
02SW1731		OCEAN CITY WWTP	6405 SEABAY DRIVE	OCEAN CITY

General Permits				
Permit No.	NPDES No.	Facility Name	Address	City
00MM8007	MDG498007	GREENMARSH LLC - HABITAT CREATION PROJECT	WILLIAMSVILLE ROAD	BISHOPVILLE
01SI6064	MDG766064	CAPRI CONDOMINIUM	11000 COASTAL HIGHWAY	OCEAN CITY
TBA		MARLIN COVE 1 - POOL 2	106 EDWARD TAYLOR ROAD	OCEAN CITY
TBA		BEACH CLUB CONDOMINIUM	112TH STREET & CHANNEL BUOY ROAD	OCEAN CITY
TBA		LUCAYAN CONDOMINIUM	119 71ST STREET	OCEAN CITY
TBA		VILLA WHITE CONDOMINIUM	404 143RD STREET	OCEAN CITY
02MA9269		ADVANCED MARINA	122 66TH STREET	OCEAN CITY
TBA		LOST COLONY	126TH STREET & TUNNEL AVENUE	OCEAN CITY

Marinas

Discharges of sewage from boats are a concern for water quality because they release nutrients, biochemical oxygen demand and pathogens. These discharges are preventable if a sufficient number of pumpout facilities are locally available and boat operators take advantage of these services. Boat maintenance and operation can also contribute petroleum and other noxious materials to the aquatic environment. This is particularly important in the Northern Coastal Bays because they have been designated as a "No discharge zone" (MDNR, Chesapeake and Coastal Watershed Services). Maryland DNR's Clean Marinas Program encourages marina operators to reduce contamination of the water and certifies those that meet a set of rigorous standards for pollution reduction (MDNR Clean Marinas Program). Assawoman Bay in Maryland has two marinas (Map 3: Water Monitoring and Marinas).

LIVING RESOURSES AND HABITAT

Living resources, including all the animals, plants and other organisms require water to survive. They and their habitats are intimately connected to water quality and availability. Living resources respond to changes in water and habitat conditions in ways that help us interpret the status of water bodies and the effects of watershed conditions. In some cases, water quality is measured in terms of its ability to support specific living resources like submerged aquatic vegetation (SAV) or shellfish. Information on living resources is presented here to provide a gauge of water quality and habitat conditions in the watershed. It is also a potential measure of efforts to manage water quality and watersheds for the living resources that depend on them.

We will provide an overview of the status of living resources in the Assawoman Bay but a more detailed description can be found in "*Maryland Coastal Bays: Ecosystem Health Assessment*" (Wazniak and Hall 2005). The Maryland Biological Stream Survey will provide a current assessment of the status of fish, herpetofauna, and benthic macroinvertebrates of the non-tidal streams in the Assawoman Bay watershed in a separate report. Maryland Department of Natural Resources' Natural Heritage Program has provided a list of rare, threatened and endangered species for the Assawoman Bay watershed which can be found in Appendix A. Species that have not been recorded in 30 years or more are listed as Historical (L. Davidson, personal communication). In addition, a list for each county in Maryland is available on the internet: http://www.dnr.state.md.us/wildlife/espaa.asp .

Blue Crabs

The blue crab, *Callinectes sapidus*, is an important resource in the Coastal Bays and supports a commercial fishery that has averaged between 0.5 and 1.5 million pounds annually since 1990 (Messick and Casey 2005). The population of blue crabs is affected by availability of suitable habitat (SAV beds), low dissolved oxygen levels, and infection by the parasitic dinoflagellate, *Hematodinium perezi*, that kills crabs in late summer and fall. In addition, blue crabs might be affected by competition with non-native green crabs. Information specific to Assawoman Bay is not available for blue crabs but the average size of crabs caught in the commercial fishery has not declined over a thirteen-year period, which suggests that fishing pressure is not excessive (Messick and Casey 2005).

Fish

Current Status

The Coastal Bays support over 140 species of finfish with the most valuable commercial species consisting of summer flounder (*Paralichthys denatus*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), croaker

(*Micropogonias undulatus*), stripped bass (*Morone saxatilis*) and others. Information specific to the Assawoman Bay is limited but commercial landings in Ocean City comprised 12.1 million pounds valued at 8.1 million dollars in 2002 (Casey and Doctor 2005).

Fish kills in the Coastal Bays have generally occurred in dead-end canals where flushing is low and algal blooms frequently happen. The cause of most fish kills appeared to be low dissolved oxygen. Atlantic silverside, *Menidia menidia*, and Atlantic menhaden, *Brevoortia tyrannus*, were the most common species (Luckett and Poukish 2005).

Fish Consumption Advisories

Almost all fish have traces of mercury or PCBs. Maryland Department of the Environment is responsible for determining how much of a given species caught in Maryland's waters can be safely consumed. Although there are no advisories specifically for the Coastal Bays, small and largemouth bass have advisories for all rivers and streams Statewide and there is an advisory against consuming "mustard" from blue crabs (MDE Fish Consumption Advisories). Fish Consumption Advisories by species for the entire State can be found at: http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/home/index.asp .

Fish Blockages

Many fish species migrate between the marine environment and freshwater to complete their life cycles. Anadromous fish, such as American shad, hickory shad and alewife herring, spawn and hatch from eggs in free flowing streams but live most of their lives in estuarine or ocean waters. Catadromous fish, like the American eel, reproduce in the Ocean and mature in estuaries or freshwater. Blockages in streams can inhibit or prevent these fish species from reaching habitats needed for breeding or development. Dams, culverts, and exposed sewer pipes can become barriers to fish migration. MDNR's Fish Passage Program maintains a database of fish blockages and works to eliminate them or provide passage over the barrier. The Fish Passage Program does not list any fish blockages in the Assawoman Bay watershed (MDNR Fisheries, Fish Passage Program). However, barriers to fish migration may be identified in the Stream Corridor Assessment report.

Harmful Algal Blooms

More than a dozen potentially harmful species of algae have been identified in Maryland's Coastal Bays. No evidence of toxicity caused by these algae has been reported. However, these algae are considered harmful because they have the potential to negatively affect human activities or to cause harm to other aquatic life by reducing light and dissolved oxygen levels. Thirteen potentially harmful algae taxa have been identified in the Maryland Coastal Bays: *Aureococcus anophagefferens* (brown tide), *Pfiesteria piscicida* and *P. shumwayae*, *Chattonella* spp., *Heterosigma akashiwo*, *Fibrocapsa japonica*, *Prorocentrum minimum*, *Dinophysis* spp., *Amphidinium* spp., *Pseudo-nitzchia* spp., *Karlodinium micrum*, and two macroalgae genera (*Gracilaria* and *Chaetomorpha*) (Tango et al. 2005). However, the most common in the Coastal Bays is *Aureococcus* *anophagefferens* (brown tide) (Wazniak et al. 2005d). Current information on harmful algal blooms can be found on MDNR's Eyes on the Bay web site: http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm .

Shellfish

A brief overview of the status of some of Assawoman Bay's shellfish stocks will be given here. The Eastern Oyster, *Crassostrea virginica*, has disappeared from the Coastal Bays due to parasites, such as the oyster drill, and disease. The last recorded landings were in 1983 (Tarnowski 2005). The hard clam, *Mercenaria mercenaria*, has supplanted the oyster in commercial landings since the 1960's. Clam densities have been low compared to historic levels but have been fairly stable over the last nine years (Wazniak and Hall 2005). Based on a 2003 survey, bay scallops, *Argopecten irradians*, have been found in all of the Coastal Bays except Newport Bay although in very low numbers (Tarnowski 2005).

Benthic Organisms

Limited monitoring of benthic organisms, specifically bottom dwelling animals, has been conducted in tidal waters of Maryland's Coastal Bays and in nontidal streams/ditches in their watersheds. Assawoman Bay has been monitored as part of larger effort to assess the health of benthic organisms in the open water of the Coastal Bays. Each year from 2000 through 2003, organisms gathered from sample sites were collected and the number and type of species were assessed in a lab. The relative abundance of species was identified and ranked considering the relative occurrence of species tolerant or intolerant to stresses like pollution. The system used for ranking was the Mid-Atlantic Integrated Assessment benthic index, which assigns a number within a range of 1 (most severely degraded) to 5 (most healthy benthic community). Any area ranking between 3 and 5 on the index overall, considering samples taken over several years, meets the goal for a healthy benthic community. All open water sites met the benthic index goal in the Assawoman Bay (Wazniak and Llanso 2005).

In non-tidal streams, the Maryland Biological Stream Survey's Stream Waders volunteer program collected benthic samples from two sites in the Assawoman Bay watershed. One site was in Back Creek and the other was in a tributary of Bunting Branch (Sussex, DE). Both were rated as poor.

Sensitive Species

Sensitive species are generally recognized as being the plants or animals that are most at risk in regards to their ability to maintain healthy population levels. Perhaps the most widely known are the State and Federally-listed Endangered or Threatened animals such as the bald eagle and Delmarva fox squirrel. In addition to animals such as these however, both the United States Fish and Wildlife Service and the Maryland DNR work through their respective Federal and State programs to protect a wide variety of declining non-game animals, rare plants, and the unique natural communities that support them. For the purposes of watershed restoration, it is important to account for the known or potential habitat for sensitive species. Protecting or expanding these habitats helps to conserve biodiversity and is an effective component of a watershed restoration program.

DNR's Wildlife and Heritage Service identifies important areas for sensitive species conservation in different ways. Several sensitive species overlays are used by the State of Maryland to delineate habitat associated with these species. One overlay is the Sensitive Species Project Review Areas (SSPRA). The SSPRA are buffered areas enclosing ecologically significant areas (areas that harbor or could potentially harbor rare, threatened or endangered species). Map 5, Sensitive Species, shows the locations of sensitive species conservation areas in Maryland's portion of the Assawoman Bay watershed.

There are State and Federal laws and regulations that address land use in areas where listed species occur. In addition, many counties have incorporated safeguards for areas associated with sensitive species into their project and permit review processes as well as adopting specific ordinances in some cases to protect them. In all instances, property owners are encouraged to seek advice on protecting the sensitive species/habitat within their ownership. Property owners and other citizens can help protect sensitive species by obtaining advise from DNR Natural Heritage. Maryland Department of Natural Resources' Natural Heritage Program has provided a list of Rare, threatened and endangered (RTE) species for the Assawoman Bay watershed which can be found in Appendix A. In addition, a list of RTE for each county is available at: http://www.dnr.state.md.us/wildlife/espaa.asp

Chesapeake Bay Critical Area Act

The Chesapeake Bay Critical Area Act, passed in 1984 and later modified to include the Coastal Bays, designated as "Critical Areas" all lands within 1,000 feet of tidal waters or adjacent tidal wetlands (MDNR Critical Areas). The lands contained within this area are subject to development guidelines that attempt to minimize the impacts of development and to preserve valuable natural resources. The local jurisdiction has the duty to enforce its local regulations in these areas but the law also created a statewide Critical Area Commission to oversee the development and implementation of local land use programs in the Critical Areas. More information on Critical Areas can be found at: http://www.dnr.state.md.us/criticalarea/

Submerged Aquatic Vegetation

Submerged Aquatic Vegetation (SAV) is an important indicator of water quality. It is also a critical nursery habitat for many estuarine species such as killifish and minnows. Softshell crabs are known to seek cover in grass beds when they are most vulnerable. Additionally, several species of waterfowl depend on SAV for food when they over-winter in the Mid-Atlantic region (MDNR Bay Grasses).

In the 1930's, a disease eliminated most SAV in Maryland's Coastal Bays (Wazniak et al. 2005e). Map 6, Submerged Aquatic Vegetation, shows SAV acreage in Maryland's part of the Assawoman Bay from 1992 to 2003 based on data provided by Maryland DNR and the Virginia Institute of Marine Science (2002 data are not shown on the map for clarity).

In 1992, there were only four acres of SAV. In 1997, acreage was up to 442 acres. In 2002, there were 406 acres of seagrass in Assawoman Bay. In 2003, coverage was up to 496 acres. SAV tends to grow better on the eastern side of the Bays due to larger amounts of slit on the western side. Salinity is probably a factor, as well, since eelgrass (*Zostera marina*), the most common grass in the Coastal Bays, and widgeon grass (*Ruppia maritima*) thrive in high salinity water (Wazniak et al. 2005e).

LANDSCAPE

Assawoman Bay Watershed, one of the "Northern Coastal Bays", is located in Worcester County and is protected from the Atlantic Ocean by Fenwick Island. The Bay is four miles long and two miles wide with the northern most one-third of the watershed in Delaware. The land area for Maryland's part of the watershed is 6,891 acres (Map 7: Land Use/Land Cover). Assawoman Bay is tidal and opens to the Atlantic Ocean via the Ocean City Inlet. The Assawoman Bay watershed is characterized by low topographic relief, high groundwater tables, poor surface drainage, and sandy soils (MDE 2005).

Land Use

Land use has pronounced impacts on water quality and habitat. A forested watershed absorbs nutrients and slows the flow of water into streams. Roads, parking areas, roofs and other human constructions are collectively called impervious surface. Impervious surface blocks the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surface typically concentrates stormwater runoff, accelerates flow rates and directs stormwater to the nearest stream. Stormwater also brings pollutants and sediments into the Bay and its tributaries. This can cause bank erosion and destruction of stream and riparian habitat. Watersheds with small amounts of impervious surface tend to have better water quality than watersheds with greater amounts of impervious surface. Agricultural land, if not properly managed, can cause substantial increases in nutrients and coliform bacteria in streams. Stormwater from Ocean City flows via a system of underground pipes into the Northern Coastal Bays (Town of Ocean City, Engineering).

Land use in the Assawoman Bay watershed is shown in Map 7 and in the table below. Developed land (28%) is the predominant land use in Maryland's portion of the watershed based on data from Maryland Department of Planning (MDP) 2002. The bulk of the developed land is on Fenwick Island. Forest and brush (25%) and agriculture (24%) cover close to the same land area. Wetlands cover 21% and 2% is barren land.

Table 2: Maryland Land Use Distribution for Assawoman Bay Watershed (MDP data 2002).

Land Use Description	Area (Acres)	Percent of Total
Developed Land	1,934	28
Forest/Brush	1,741	25
Agriculture	1,631	24
Wetlands	1,474	21
Barren Land	111	2
Total land area	6,891	100

Protected Lands

As used in the context of watershed protection and restoration, “protected land” includes any land with some form of long-term limitation on conversion to urban/developed land use. This protection may be in various forms: public ownership for natural resource or low impact recreational intent, private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement, etc. The extent of “protection” varies greatly from one circumstance to the next. Therefore, for some protected land, it may be necessary to explore the details of land protection parcel-by-parcel through the local land records office to determine the true extent of protection.

For purposes of watershed management, an understanding of existing protected lands can provide a starting point in prioritizing potential protection and restoration activities. In some cases, protected lands may provide opportunities for restoration projects because owners of these lands may value natural resource protection or enhancement goals. More information on watershed protection can be found in: *The Practice of Watershed Protection* (Schueler and Holland 2000).

Map 8, Protected Lands, shows the status of protected lands in the Assawoman Bay Watershed. Some land parcels may be affected by more than one type of protection. For example, government-owned parkland may also have a conservation easement on it. State-owned lands make up 126 acres in the Assawoman Bay watershed with nearly all of this acreage on the Mainland. County parks make up 35 acres with two of those acres on Fenwick Island and the remainder on the Mainland. Overall, protected lands make up 2% of the acreage in Maryland’s portion of the Assawoman Bay watershed. At this time, there are no Maryland Environmental Trust (MET) or Maryland Agricultural Land Preservation Foundation (MALPF) easements in the Assawoman Bay watershed.

Soils

Soil type and moisture conditions greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are also one determining factor for water quality in streams and rivers. Soils are an important factor to incorporate in targeting projects aimed at improving water quality or habitat.

Local soil conditions vary greatly from site to site according to published information in SSURGO digital soils data for Worcester County. A summary of this information is shown for the Assawoman Bay watershed in Map 9, Soils. The map aggregates the SSURGO information to help show the distribution of soils important to watershed planning in the watershed:

- Overall, about 1,385 acres (20%) of the watershed is prime agricultural soil that does not require drainage or irrigation. Another 822 acres (12%), requiring either drainage or irrigation, is also potentially prime agricultural soil.

- Nearly 2,990 acres on the mainland and 499 acres on Fenwick Island exhibit hydric characteristics. Hydric soils adjacent to streams or wetlands may offer opportunities for restoration of natural vegetated buffers or wetlands that could intercept nitrogen moving in groundwater before it reaches surface waters.

Green Infrastructure

The Maryland DNR has mapped a Statewide network of ecologically important lands across the State called “Green Infrastructure”. This network is comprised of large blocks of important natural resource lands called hubs and corridors that connect the hubs. These areas are primarily large blocks of contiguous forest but also include wetlands and other naturally vegetated lands. These lands provide significant environmental benefits, such as cleaning the air, filtering and cooling water, and storing and cycling nutrients. Appendix B provides a detailed assessment of the Green Infrastructure in the Assawoman Bay watershed.

Large Forest Blocks

Forest interior dwelling species (FIDS) require large blocks of forest habitat with relatively little influence from open-areas species or from humans. FIDS habitat is a forest block at least 50 acres in size with at least 10 acres of forest interior (forest edge is at least 300 feet away). High quality FIDS habitat is either mature hardwood or mixed hardwood-pine forest at least 100 acres in size of which forest interior habitat comprises at least 25% of the total forest area. This habitat also must contain one or more of the following:

- Contiguous forest acreage of greater than 500 acres;
- Riparian forest bordering a perennial stream or river and, on average, at least 600 feet in width;
- At least one highly area-sensitive species or Black-and-white Warbler, as a probable or confirmed breeder;
- Mature river terrace, ravine, or cove hardwoods, located at least 300 feet from the nearest forest edge;
- At least 5 contiguous acres of old growth forest (as defined in the 1989 MD Department of Natural Resources report "Old Growth Forest Ecosystems")

located at least 300 feet from the nearest forest edge (MDNR Forest Service 2003).

The forest interior assessment map differs from the Green Infrastructure assessment in that forest interior areas are more numerous and more widely distributed because the forest interior size threshold is lower (MDNR Forest Service web site). Map 10, Large Block Forest Habitat, shows that the Assawoman Bay watershed contains 682 acres of high quality FIDS habitat which makes up 39% of the total forest area. Other FIDS habitat occupies 125 acres (7%) and other forest land comprises 934 acres (54%) (MDNR, Natural Heritage Program and MDP 2002).

Wetlands

The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency define wetlands as follows (EPA Office of Wetlands, Oceans and Watersheds web site):

"Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

The Coastal Plain Province likely has the highest diversity of emergent estuarine and palustrine (fresh water) wetland communities relative to other Maryland physiographic regions because the area has both tidal and nontidal freshwater marshes. Wetlands are most abundant in the Coastal Plain due to the low topographic relief and high ground water table characteristic of the region.

<u>Wetland Functions</u>

The State of Maryland Nontidal Wetlands Protection Act of 1989 designates statutory wetland functions which are summarized in the table below from the MDE Wetlands web site and Tiner and Burke (1995).

Table 3. Wetland Functions.

Function	Definition
Ground Water Recharge and Discharge	the capacity of processes in a wetland to influence the amount of water and the rate at which it moves between the ground water system and the surface water system
Stormwater and Flood Control	the capacity of a wetland to store large volumes of water during floods; wetlands modify the flow in streams by decreasing peak discharge (volume of water over a given time) and increasing time of concentration (time between rainfall/flood event and release of water to streams)
Improved Water Quality Toxic Retention Nutrient Removal Transformation	removal of suspended and dissolved solids and nutrients from surface and ground water and conversion into other forms, such as plant and animal biomass or gases
Sediment Stabilization and Retention	the capacity of processes in a wetland to cause the deposition and retention of inorganic and organic sediments from the water column, primarily through physical processes
Aquatic Diversity and Habitat	the capacity of a wetland to produce an abundance and diversity of hydrophytic plant species and communities, and aquatic habitats for animals
Wildlife Diversity and Habitat	the capacity of a wetland to produce large and/or diverse populations of animal species and communities that spend part or all of their life cycle in wetlands

Wetland Categories

Estuarine wetlands are abundant throughout the Coastal Plain. These systems consist of salt and brackish tidal waters and contiguous wetlands where ocean water is at least occasionally diluted by freshwater runoff from the land. These wetlands may extend far upstream in tidal rivers to freshwater areas. Differences in salinity and tidal flooding within estuaries have a significant effect on the distribution of these wetland systems. Salt marshes occur on the intertidal shores of tidal waters in areas of high salinity. Brackish marshes are the predominant estuarine wetland type in Maryland. Estuarine shrub swamps are common along the Maryland coastal zone. Aquatic beds, comprised mostly of submerged aquatic vegetation (SAV), were historically abundant in shallow water zones of Maryland’s estuaries.

Palustrine wetlands are freshwater wetlands that are not associated with flowing water or lakes. In general, palustrine wetlands are associated with freshwater, high water tables, intermittent ponding on land or flood plains. Forested wetlands are the most abundant and widely distributed palustrine wetland type on the Coastal Plain. These wetlands are found on floodplains along the freshwater tidal and nontidal portions of rivers and streams, in upland depressions, and in broad flat areas between otherwise distinct watersheds. Tidal freshwater swamps occur along coastal rivers in areas subject to tidal influence. Emergent wetlands on the Coastal Plain are characterized by a wide range of vegetation, depending on water regime. (Adapted from Wetlands of Maryland, Tiner and Burke, 1995.)

Based on data provided by Maryland DNR, the Federal Emergency Management Agency and the U.S. Fish and Wildlife Service, wetland acreage in the Assawoman Bay, not including open water, is shown on Map 11, Wetlands and Mainland Floodplains, and summarized in the table below.

Table 4. Wetland Types in Maryland's Assawoman Bay Watershed (Published: 1993).

Type of Wetland	Acreage	Percent
Estuarine, Emergent	1,435	52
Estuarine, Forested	9	<1
Estuarine, Scrub/Shrub	23	1
Estuarine, Unconsolidated shore	939	34
Total Estuarine	2,406	88
Marine, Unconsolidated shore	21	1
Palustrine, Emergent	10	<1
Palustrine, Forested	249	9
Palustrine, Scrub/Shrub	1	<1
Palustrine, Unconsolidated bottom	41	1
Palustrine, ditch	20	<1
Total Palustrine	321	12
Total for watershed	2,748	100

Tracking Wetlands

Oversight of activities affecting wetlands involves several regulatory jurisdictions. MDE is the lead agency for the State and cooperates with MDNR, the Army Corps of Engineers and other Federal and local agencies. According to a 1998 report of wetland loss conducted by the Corp of Engineers (USACE, 1998; Spaur et. al., 2001), there has been a 10% loss of salt marsh area in the Coastal Bays since 1900, with losses concentrated in the Northern Coastal Bays. The Northern Coastal Bays (i.e., Isle of Wight and Assawoman Bays) had a loss of 37% salt marsh, or 1,530 acres (MDE 2004). The northern bays, excluding Fenwick Island, had 580 acres of salt marsh loss, concentrated in Ocean Pines and Ocean City North of the inlet. Fenwick Island had 950 acres of salt marsh loss. A large portion of the once extensive zone of emergent salt marsh along the bayside of Fenwick Island is gone. In addition to direct wetland losses, coastal engineering and maintenance of the ocean city inlet may have prevented the natural formation of wetlands in some areas such as the bay side of Fenwick and Assateague (MDE 2004).

MDE tracks State permitting and the net gain or loss of wetlands over time. Maryland's portion of the Assawoman Bay watershed has lost wetlands due to permanent impacts that required permits in both the nontidal and tidal areas: 0.77 acres of nontidal wetlands were lost from 1991 – 2005 (Walbeck 2005) and 0.1 acres of tidal wetlands were lost from 1996 – 2003 (Wazniak and Hall 2005). However, voluntary gains of 92.2 acres of nontidal and tidal wetlands have been acquired in the Assawoman Bay watershed through a variety of programs, such as the NRCS Conservation Reserve Enhancement Program (CREP), from 1998 – 2004 (MDE 2004).

Wetland Restoration

Detailed information on wetlands in the Coastal Bays and recommendations for restoration are provided in MDE's 2004 document, *Priority Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays.* A brief summary of those recommendations will be provided here.

The USACE (1998) and Spaur et al. (2001) targeted the northern coastal bays for salt marsh restoration due to the high amount of historic loss and because the natural process of marsh creation is no longer possible in that region. With little effort, wetlands can be restored in almost any area having hydric soil in the Coastal Bays watershed regardless of the soil organic matter or texture. However, wetland functioning may be higher on certain soil types. Specific locations in the Coastal Bays were selected and prioritized as potential restoration sites based on soil type, drainage, current use and other factors. These sites are described and mapped in MDE 2004 http://www.mde.state.md.us/assets/document/wetlandswaterways/CB_all.pdf.

Floodplains

Map 11, Wetlands and Mainland Floodplains, shows that the 100-year floodplains cover about 2,267 acres in the Assawoman Bay watershed. They extend along all coastal areas of the mainland. In some parts of the mainland, the 100-year floodplain encompasses large areas well inland from the shore of the Bay. Floodplains, particularly those that contain hydric soils, tend to present conditions that limit intensive use. These conditions also present opportunities for maintenance or restoration of natural vegetation, habitat and water quality. Targeting of water quality-related projects, like stream buffers, or habitat-related projects like Green Infrastructure enhancement, should consider local floodplain conditions.

Shoreline and Sea Level Rise

Natural shoreline provides important habitat for fish, shellfish, horseshoe crabs, and birds. Assawoman Bay has about 79% natural shoreline with the remaining 21% being disturbed or protected (riprap, bulkheads, etc.) (Hennessee 2005). Structural shoreline stabilization practices, such as bulkheads and riprap, prevent encroachment from sea level rise that would have resulted in new tidal wetlands (MDE 2004). The average rate of sea level rise along Maryland's coastline has been 3-4 mm/yr, or approximately one foot per century. Such rates are nearly twice those of the global average (1.8 mm/year), a result probably due to substantial land subsidence (Johnson 2000). As sea level rises, marsh can encroach upon drowned mainland and stream valleys. It is now believed that landward marsh migration would not be able to maintain pace with losses due to sea-level rise due to steeper slopes that are now being encountered along the mainland (Hennessee and Stott, 1999). However, since the area is rapidly developing, this landward migration of wetlands is not possible (MDE 2004).

Stream Buffers

Benefits of Stream Buffers

Natural vegetation in stream riparian zones, particularly forest, provides numerous valuable environmental benefits:

- Reducing surface runoff
- Preventing erosion and sediment movement
- Using nutrients for vegetative growth and moderating nutrient entry into the stream
- Moderating temperature, particularly reducing warm season water temperature
- Providing organic material (decomposing leaves) that are the foundation of natural food webs in stream systems
- Providing overhead and in-stream cover and habitat
- Promoting high quality aquatic habitat and diverse populations of aquatic species.

Land Use Adjacent to Streams

Maryland's portion of the Assawoman Bay watershed has about 10 miles of streams. Map 12, Land Use/Land Cover at Stream's Edge, shows the general land use adjacent to these streams using data provided by Worcester County, Maryland Department of Planning, the U.S. Department of Agriculture and the U.S. Geological Survey. This method of assessing buffer condition can be used in the absence of field data collected by stream corridor assessment. The summary table on the map indicates that about 70% (7 miles) of land use at stream's edge is characterized by forest, wetlands and brush. About 20% (2 miles) is agricultural land and less than 10% (<1 mile) is developed land. Working with landowners to increase the amount of native vegetation on their properties might help to stabilize banks and reduce nutrient input to the streams. Also, the agricultural land on hydric soil (1.7 miles) might be used for wetland restoration.

RESTORATION TARGETING TOOLS

Stream Corridor Assessment

Using the Stream Corridor Assessment, valuable information can be compiled to assist in targeting restoration activities. This information will complement existing watershed-related information and may explain cause and effect relationships between what is occurring in the watershed and how those activities are impacting the stream systems. Trained teams walk along streams throughout the Assawoman Bay watershed to identify and document potential problems and restoration opportunities such as pipe outfalls, fish blockages, pond sites, and exposed pipes. Data from the SCA will be provided in a separate report.

Synoptic Survey and MBSS

Based on Synoptic Survey sampling in the Assawoman Bay watershed, MDE staff reported on water quality in non-tidal streams to supplement knowledge of local conditions. Based on selected parameters (dissolved oxygen, nitrogen, phosphorus, pH, conductivity, temperature), the survey findings will help identify problem areas and relative conditions among local streams. It will also help rank subwatersheds by their nutrient load contributions to waterbodies. For the same 2005 sampling sites, the MBSS survey results describe the benthic organism populations in non-tidal streams as a gauge of water quality and habitat conditions. MDNR's report of 2005 findings will include assessment of water quality, benthic organism populations and the potential relationships that may be drawn from the data.

Agricultural Stewardship Programs

The Worcester County Soil Conservation District works with farmers and landowners in the development of Soil Conservation and Water Quality plans that recommend best management practices that will prevent nutrient and sediment impact on surface and ground water. Some of the stewardship practices that can be used are grassed waterways, riparian herbaceous and riparian forested buffers, conservation cover, cover crops, shallow water wildlife areas and grade stabilization structures. The Maryland Agricultural Cost-Share program (MACS), the Conservation Reserve Program (CRP and CREP) and the Environmental Quality Incentive Program (EQIP) are some of the state and federal programs promoted and administered by the Soil Conservation District.

Fish Blockage Removal

Many fish species need to move from one stream segment to the next in order to maintain healthy resilient populations. Blockages in streams can inhibit or prevent many fish species from moving up stream to otherwise viable habitat. The Stream Corridor Assessment will identify potential fish blockage problems. Some blockages to fish movement may be structural components of stream gauging weirs, farm ponds, drainage ditches, etc. If a blockage is found to be in this category, circumstances like requirements for drainage control function and public or landowner needs are considered in determining the potential for a restoration project.

Stream Buffer Restoration

Natural vegetation in stream riparian zones act as stream buffers that can provide numerous valuable environmental benefits such as reducing surface runoff, preventing erosion, and providing overhead cover and habitat.

Headwater Streams

Headwater streams are the smallest and most numerous in Maryland watersheds and, unlike larger streams, they intercept all of the surface runoff within the watersheds that they drain. Also, these streams at the "top" of the watershed are the type and size that are most affected by development. In addition, for many watersheds, headwater streams drain the majority of the land within the entire watershed; therefore, stream buffers restored along headwater streams tend to have greater potential to intercept nutrients and sediments than stream buffers placed elsewhere. The nutrient removal function of headwater streams buffers with their associated springheads provides water supply benefits. In targeting stream buffer restoration projects, giving higher priority to headwater streams is one approach to optimizing nutrient and sediment retention. Restoring headwater stream buffers can also provide habitat benefits that can extend downstream of the project area. Forested headwater streams provide important organic material, like decomposing leaves, which "feed" the stream's food web. They also introduce woody debris which enhances in-stream physical habitat. The potential for riparian forest buffers to significantly influence stream temperature is greatest in headwater regions. These factors, in addition to positive water quality effects, are key to improving aquatic habitat.

Optimizing Water Quality Benefits by Combining Priorities

Strategic targeting of stream buffer restoration projects may promote many different potential benefits. To maximize multiple benefits, site selection and project design need to incorporate numerous factors. For example, finding a site with a mix of attributes like those in the following list could result in the greatest control of nonpoint source pollution and enhancement to living resources:

– land owner willingness / incentives,
– marginal land use in the riparian zone,
– headwater stream,
– hydric soils,
– selecting appropriate woody/grass species,
– adjacent to existing wetlands / habitat.

Additionally, selecting restoration projects that are likely to produce measurable success is an important consideration in prioritizing projects for implementation. In the early stages of a watershed restoration program, measurable water quality improvement can be one of the strongest ways to demonstrate project success. In general, targeting restoration projects to one or a few selected tributaries or small watersheds will tend to offer the greatest probability of producing measurable water quality improvement.

Wetland Restoration

Wetlands serve important environmental functions such as erosion control, habitat and nursery areas for many organisms and nutrient uptake/recycling. However, most watersheds in Maryland have significantly fewer wetland acres today than in the past. This loss due to draining, filling, etc. has led to habitat loss and negative water quality impacts in streams and bays. Reversing this historic trend is an important goal of wetland restoration. Staff from MDE's Waterways and Wetlands Program and WRAS can provide assistance to local governments in targeting wetland restoration efforts.

Land Preservation/Protection Programs

Numerous land preservation programs exist that can assist land owners and local governments office in their efforts to protect and restore the watershed. A few have been mentioned in this document already: Conservation Reserve Enhancement Program (http://www.fsa.usda.gov/dafp/cepd/crep.htm), Maryland Agricultural Cost-Share program (http://www.mda.state.md.us/pdf/MDA_MACS_bro_proof4.pdf), and the Environmental Quality Incentive Program (http://www.nrcs.usda.gov/PROGRAMS/EQIP/). In addition the Maryland Environmental Trust (MET) (http://www.dnr.state.md.us/met/) and the Maryland Agricultural Land Preservation Foundation (MALPF) (http://www.malpf.info/) offer assistance to landowners.

POTENTIAL BENCHMARKS FOR WRAS GOAL SETTING

Several programs designed to manage water quality and/or living resources have existing or proposed goals that are relevant to setting goals for the Assawoman Bay Watershed Restoration Action Strategy (WRAS). The goals from these other programs tend to overlap and run parallel to potential interests for developing WRAS goals. Therefore, to assist in WRAS development, selected goals from other programs are included here as points of reference.

Water Quality Standards and TMDLs

Water quality standards represent minimum legal goals for managing the physical, chemical and biological integrity of the Nation's waters. Achieving these standards will necessitate the restoration and protection of habitat and living resources within the watershed.

In order to meet water quality standards, Total Maximum Daily Loads (TMDLs) have been established for pollutants in many impaired waterbodies. TMDLs represent pollutant loading goals. In watershed management plans designed to implement TMDL goals, Best Management Practices (BMPs) are often included. BMPs are management practices (such as nutrient management) or structural practices (such as terraces) designed to reduce the quantities of pollutants. Thus, water quality standards, TMDLs, and BMPs reflected in implementation plans provide a set of benchmarks, which are linked together via a systematic water quality management framework.

Existing water quality impairments, water quality goals, and loading goals for the Assawoman Bay are documented in the TMDL(s) for that waterbody. Watershed plans should focus on implementation actions that have a high likelihood of improving these specific water quality impairments.

Water Quality Improvement Act of 1998

The Water Quality Improvement Act of 1998 presents many challenges for agriculture in Maryland. It represents a major change in our approach to controlling agricultural nutrient pollution. The Act requires nutrient management plans for both nitrogen and phosphorus for virtually all Maryland farms. The Maryland Agricultural Water Quality Cost-Share (MACS) Program offers cost-share assistance for the development of nutrient management plans. The Manure Transport Program helps poultry, dairy, beef and other livestock producers cover the costs of transporting excess manure identified by their nutrient management plans off their farms. Implementation of projects assisted by this funding has the potential to move nutrients to sites where they are needed and reduce nutrient input to Maryland's waters (University of Maryland 1998; Maryland Department of Agriculture 2003).

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APPENDIX A: Current Rare, Threatened, and Endangered Species of Assawoman Bay Watershed (02130102) (MDNR Natural Heritage Program, 2005)

Scientific Name	Common Name	G-rank	S-rank	MD	Fed.
Caretta caretta	Atlantic Loggerhead Turtle	G3	S1B	T	LT
Circus cyaneus	Northern Harrier	G5	S2B		
Gymnopogon brevifolius	Broad-leaved Beardgrass	G5	S1	E	
Prunus maritima	Beach Plum	G4	S1	E	
Rynchops niger	Black Skimmer	G5	S1B	E	

OTHER Biological Resources of Concern to DNR's Wildlife & Heritage Service:

Colonial Waterbird Nesting Colony

Forest Interior Dwelling Species Habitat

Historical Rare, Threatened, and Endangered Species of Assawoman Bay Watershed (02130102) 2005

Agalinis fasciculata	Fascicled Gerardia	G5	S1	E
Aster concolor	Silvery Aster	G5	S1	E
Buchnera americana	Blue-hearts	G5?	SH	X
Carex silicea	Sea-beach Sedge	G5	S1	E
Charadrius melodus	Piping Plover	G3	S1B	E
Cicindela lepida	Little White Tiger Beetle	G4	S1	E
Coelorachis rugosa	Wrinkled Jointgrass	G5	S1	E
Desmodium rigidum	Rigid Tick-trefoil	GNRQ	S1	E
Desmodium strictum	Stiff Tick-trefoil	G4	S1	E
Eleocharis albida	White Spikerush	G4G5	S2	T
Fuirena pumila	Smooth Fuirena	G4	S2S3	
Fundulus luciae	Spotfin Killifish	G4	S2?	
Honckenya peploides	Sea-beach Sandwort	G5	S1	E
Leptochloa fascicularis	Long-awned Diplachne	G5	SU	
Panicum flexile	Wiry Witch-grass	G5	S1	E
Panicum oligosanthes	Few-flowered Panicgrass	G5	S2S3	
Paspalum dissectum	Walter's Paspalum	G4?	S2	T
Pituophis melanoleucus	Northern Pine Snake	G4	SH	
Pycnanthemum setosum	Awned Mountain-mint	G3?	S3.1	T
Rhynchospora torreyana	Torrey's Beakrush	G4	S2	T
Schwalbea americana	Chaffseed	G2	SX	X
Spiranthes odorata	Sweet-scented Ladys' Tresses	G5	SH	X
Sterna antillarum	Least Tern	G4	S2B	T
Triglochin striata	Three-ribbed Arrow-grass	G5	S1	E
Xyris smalliana	Small's Yelloweyed-grass	G5	S1	E

EXPLANATION OF RANK AND STATUS CODES FOR RTE LIST

January 26, 2003
(From MDNR Natural Heritage Program)

The global and state ranking system is used by all 50 state Natural Heritage Programs and numerous Conservation Data Centers in other countries in this hemisphere. Because they are assigned based upon standard criteria, the ranks can be used to assess the range-wide status of a species as well as the status within portions of the species' range. The primary criteria used to define these ranks are the number of known distinct occurrences with consideration given to the total number of individuals at each locality. Additional factors considered include the current level of protection, the types and degree of threats, ecological vulnerability, and population trends. Global and state ranks are used in combination to set inventory, protection, and management priorities for species both at the state as well as regional level.

GLOBAL RANK

G1 Highly globally rare. Critically imperiled globally because of extreme rarity (typically 5 or fewer estimated occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 Globally rare. Imperiled globally because of rarity (typically 6 to 20 estimated occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 Either very rare and local throughout its range or distributed locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; typically with 21 to 100 estimated occurrences.
G4 Apparently secure globally, although it may be quite rare in parts of its range, especially at the periphery.
G5 Demonstrably secure globally, although it may be quite rare in parts of its range, especially at the periphery.
GH No known extant occurrences (i.e., formerly part of the established biota, with the expectation that it may be rediscovered).
GU Possibly in peril range-wide, but its status is uncertain; more information is needed.
GX Believed to be extinct throughout its range (e.g., passenger pigeon) with virtually no likelihood that it will be rediscovered.
G? The species has not yet been ranked.
_Q Species containing a "Q" in the rank indicates that the taxon is of questionable or uncertain taxonomic standing (i.e., some taxonomists regard it as a full species, while others treat it at an infraspecific level).
_T Ranks containing a "T" indicate that the infraspecific taxon is being ranked differently than the full species.

STATE RANK

S1 Highly State rare. Critically imperiled in Maryland because of extreme rarity (typically 5 or fewer estimated occurrences or very few remaining individuals or acres in the State) or because of some factor(s) making it especially vulnerable to extirpation. Species with this rank are actively tracked by the Natural Heritage Program.
S2 State rare. Imperiled in Maryland because of rarity (typically 6 to 20 estimated occurrences or few remaining individuals or acres in the State) or because of some factor(s) making it vulnerable to becoming extirpated. Species with this rank are actively tracked by the Natural Heritage Program.
S3 Rare to uncommon with the number of occurrences typically in the range of 21 to 100 in Maryland. It may have fewer occurrences but with a large number of individuals in some populations, and it may be susceptible to large-scale disturbances. Species with this rank are not actively tracked by the Natural Heritage Program.
S3.1 A species that is actively tracked by the Natural Heritage Program because of the global significance of Maryland occurrences. For instance, a G3 S3 species is globally rare to uncommon, and although it may not be currently threatened with extirpation in Maryland, its occurrences in Maryland may be critical to the long-term security of the species. Therefore, its status in the State is being monitored.
S4 Apparently secure in Maryland with typically more than 100 occurrences in the State or may have fewer occurrences if they contain large numbers of individuals. It is apparently secure under present conditions, although it may be restricted to only a portion of the State.
S5 Demonstrably secure in Maryland under present conditions.
SA Accidental or considered to be a vagrant in Maryland.
SE Established, but not native to Maryland; it may be native elsewhere in North America.
SH Historically known from Maryland, but not verified for an extended period (usually 20 or more years), with the expectation that it may be rediscovered.
SP Potentially occurring in Maryland or likely to have occurred in Maryland (but without persuasive documentation).
SR Reported from Maryland, but without persuasive documentation that would provide a basis for either accepting or rejecting the report (e.g., no voucher specimen exists).
SRF Reported falsely (in error) from Maryland, and the error may persist in the literature.
SU Possibly rare in Maryland, but of uncertain status for reasons including lack of historical records, low search effort, cryptic nature of the species, or concerns that the species may not be native to the State. Uncertainty spans a range of 4 or 5 ranks as defined above.
SX Believed to be extirpated in Maryland with virtually no chance of rediscovery.
SYN Currently considered synonymous with another taxon and, therefore, not a valid entity.
SZ A migratory species which does not inhabit specific locations for long periods of time.
S? The species has not yet been ranked.
-B This species is migratory and the rank refers only to the breeding status of the species. Such a migrant may have a different rarity rank for non-breeding populations.

-N This species is migratory and the rank refers only to the non-breeding status of the species.
Such a migrant may have a different rarity rank for breeding populations.

STATE STATUS

This is the status of a species as determined by the Maryland Department of Natural Resources, in accordance with the Nongame and Endangered Species Conservation Act. Definitions for the following categories have been taken from Code of Maryland Regulations (COMAR) 08.03.08.

E Endangered; a species whose continued existence as a viable component of the State's flora or fauna is determined to be in jeopardy.

I In Need of Conservation; an animal species whose population is limited or declining in the State such that it may become threatened in the foreseeable future if current trends or conditions persist.

T Threatened; a species of flora or fauna which appears likely, within the foreseeable future, to become endangered in the State.

X Endangered Extirpated; a species that was once a viable component of the flora or fauna of the State, but for which no naturally occurring populations are known to exist in the State.

* A qualifier denoting the species is listed in a limited geographic area only.

PE Proposed Endangered; a species whose continued existence as a viable component of the State's flora or fauna is determined to be in jeopardy.

PT Proposed Threatened; a species of flora or fauna which appears likely, within the foreseeable future, to become endangered in the State.

PX Proposed Endangered Extirpated; a species that was once a viable component of the flora or fauna of the State, but for which no naturally occurring populations are known to exist in the State.

PD Proposed to be deleted or removed from the State Threatened & Endangered Species list.

FEDERAL STATUS

This is the status of a species as determined by the U.S. Fish and Wildlife Service's Office of Endangered Species, in accordance with the Endangered Species Act. Definitions for the following categories have been modified from 50 CRF 17.

LE Taxa listed as endangered; in danger of extinction throughout all or a significant portion of their range.

LT Taxa listed as threatened; likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

PE Taxa proposed to be listed as endangered.

PT Taxa proposed to be listed as threatened.

C Candidate taxa for listing for which the Service has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened.

APPENDIX B

Green Infrastructure

Green Infrastructure Assessment
For Worcester County, Maryland
Including
The Coastal Bays Watershed
And
The Pocomoke River Watershed

August 2005

Maryland Department of Natural Resources

Watershed Services, Ecological Analysis Center
Kenneth E. Shanks

Introduction

Worcester County encompasses the entire Coastal Bays watershed in Maryland and a large portion of Maryland's Pocomoke River watershed. In the Coastal Bays watershed, Worcester County is drafting or has completed watershed management strategies for all subwatersheds including Assawoman Bay, Chincoteague Bay, Isle of Wight Bay, Newport Bay, and Sinepuxent Bay. Additionally, the County is working toward adoption of an updated Comprehensive Plan in 2005 that will address all areas in both the Coastal Bays and Pocomoke River watersheds. To support there County efforts, this Green Infrastructure assessment is offered to provide technical information to assist in local management decisions and prioritization for implementation.

Across Maryland, including the watersheds mentioned above, large blocks of natural resource lands provide valuable water quality and habitat benefits. These areas are primarily large blocks of contiguous forest and large areas of tidal/nontidal wetlands and other naturally vegetated lands. In general, actions taken to prevent conversion of these areas to other land uses, to avoid fragmentation, and to restore areas that have been cleared or filled will contribute significantly to maintaining and improving water quality in this watershed and to conserving Maryland's biodiversity.

To assist in protection and tracking of natural resource areas that are important at the landscape scale, Maryland Department of Natural Resources (DNR) mapped a statewide network of ecologically important lands collectively called "Green Infrastructure." This Green Infrastructure provides the bulk of the state's natural support system. It delivers ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, protecting areas against storm and flood damage, and maintaining hydrologic function.

Green Infrastructure, as defined by DNR represents natural resource conditions on the ground. In general, the Green Infrastructure network is comprised of large blocks of ecologically important natural resource lands called hubs and corridors that link the hubs. Hubs contain one or more of the following:

- Areas containing sensitive plant or animal species;
- Large blocks of contiguous interior forest (at least 250 contiguous acres, plus the 300 foot transition zone);
- Wetland complexes with at least 250 acres of unmodified wetlands;
- Streams or rivers with aquatic species of concern, rare coldwater or blackwater ecosystems, or important to anadromous fish, and their associated riparian forest and wetlands; and
- Conservation areas already protected by public (primarily DNR or the federal government) and private organizations like The Nature Conservancy or Maryland Ornithological Society.

For more information on how Maryland's Green Infrastructure was identified and previously published reports that reflect conditions in the 1990s, see www.dnr.maryland.gov/greenways/

Local Findings

During the 2005 work to update its County Comprehensive Plan, Worcester County is considering the concept of Green Infrastructure as a potential element for incorporation in the Plan. DNR supports County efforts to incorporate the Green Infrastructure concept into local management and decision-making processes like comprehensive planning and watershed planning. This Green Infrastructure assessment presents Statewide assessment and regional priorities recommended by DNR to assist the County's exploration of local Green Infrastructure interests. DNR encourages efforts by local government to generate local priorities for Green Infrastructure management and protection.

Throughout Maryland, new development, land management changes and other on-the-ground activities are changing Green Infrastructure in measurable ways compared to conditions in the 1990s when it was originally identified. Until a fully updated Green Infrastructure assessment can be performed to comprehensively account for these changes, an interim approach has been devised to gauge current conditions in the Green Infrastructure. The interim approach employs the Green Infrastructure boundaries for hubs and corridors, as defined in DNR's original analysis, like cookie cutters on Maryland Department of Planning 2002 land use data. The boundaries of the hubs and corridors serve as benchmarks to gauge expansion or contraction of the Green Infrastructure area. This approach is one way to acknowledge land use changes that have occurred within Maryland's Green Infrastructure since it was initially identified.

Findings for the coastal drainage area are drawn from the map *Green Infrastructure - 2002 Coastal Bays Watershed*:

- Natural vegetation, including forest and wetland, accounts for about two-thirds of the area within the Green Infrastructure hubs and corridors.
- The category called "other", including beach and water within the hubs and corridors, covers about one-fifth of their area.
- Gaps in the Green Infrastructure that are in agricultural use encompass 11% and 13% of the hubs and corridors respectively.
- Gaps in the Green Infrastructure that are developed cover about two percent of the hubs and corridors.

Findings for the eastern side of Worcester County are drawn from the map *Green Infrastructure -2002 Pocomoke River Watershed*:

- Forest and wetland accounts for 84% of the Green Infrastructure hubs within the Pocomoke River watershed. Overall, forest is the dominant Green Infrastructure feature.
- Gaps in the Green Infrastructure that are in agricultural use encompass 14% and 29% of the hubs and corridors respectively.

- Gaps in the Green Infrastructure that are developed cover about 1% and 3% of the hubs and corridors respectively.

Change Over Time

Using the same approach described for 2002 data, the existing Green Infrastructure hub and corridor boundaries are applied like cookie cutters on Maryland Department of Planning 1973 land use data. This approach is employed based on the assumption that at least as much Green Infrastructure was present in these areas two or three decades prior to the original Green Infrastructure assessment. However, this approach cannot account for loss of an entire Green Infrastructure hub or corridor that may have occurred between the early 1970s and the middle 1990s.

By comparing the land use differences within the hub and corridor boundaries for 1973 and 2002, an estimate of land use change in the hubs and corridors for over nearly 30 years can be generated. Several findings from the comparison are summarized below.

The map *Green Infrastructure – 1973 Coastal Bays Watershed* shows land use nearly 30 years prior to the 2002 data. A comparison of the data in the two maps for the Coastal Bays watershed was performed. It was found that about 766 acres of land in Green Infrastructure hubs was developed between 1973 and 2002, which covers about 1% of the hubs in aggregate. This development in hubs represents a loss of natural value in the hubs. During the same period, about 644 acres of land in corridors was developed, which is nearly 8% of the total area identified as corridors. This rate of development indicates a loss of connectivity between Green Infrastructure hubs.

The map *Green Infrastructure – 1973 Pocomoke River Watershed* also shows previous land use conditions. In the Pocomoke River watershed within Worcester County, about 784 acres of land in Green Infrastructure hubs was developed between 1973 and 2002, which covers about 0.7% of the hubs in aggregate. During the same period, about 255 acres of land in corridors was developed, which is nearly 3% of the total area identified as corridors.

Overall, the loss of Green Infrastructure to development in both the Coastal Bays watershed and in the Pocomoke River watershed is slow. However, the rate of loss in the Coastal Bays watershed appears to be greater due to proximity to Ocean City and Route 50 corridor.

Interpreting Hub Ranking

The map *Green Infrastructure Hub Rank* shows that there are numerous Green Infrastructure hubs in Worcester County based on DNR's original assessment. All of these hubs identified in Maryland's Green Infrastructure are important in the State's network of natural resource areas from the perspective of the statewide analysis that was used to identify the hubs.

The ecological values associated with each hub differ in ways that can be used to compare and prioritize them for potential management action. The “Eco-Region Percent Rank” shown in the map presents one of many possible views for comparing the hubs. To interpret this ranking effectively, it is important to understand what it represents. It is a scale from 1 to 100 that incorporates measurements of on-the-ground conditions like size for the contiguous area, sensitive species, vegetation conditions and many other measures related to ecological condition. In general, larger hubs are ranked closer to “1” and smaller hubs are ranked closer to “100”. The relative size of the GI hubs is one measure of their importance regionally in Maryland network of natural areas. The smaller hubs are important on the local scale by contributing to conditions in local streams. Numerous other measurements of environmental integrity also contribute to this ranking.

For all hubs, two important management objectives generally apply:

- Maintaining/enhancing integrity of the large block natural area already in the hub.
- Maintaining/enhancing connectivity between two or more hubs so that they can function collectively in the natural resource network.

For larger hubs, maintaining hub integrity tends to be relatively important. For smaller hubs, enhancing connectivity, i.e. allowing two hubs to function as one larger hub, is an increasingly important management objective.

Local Hub Findings

Findings for individual Green Infrastructure (GI) hubs are presented in three tables at the end of this section. The Table 1 includes a simple description and a suggested name for each hub based on one or two attributes identified during the analysis including park names, stream names or nearby roads. Table 2 summarizes the kinds of protection identified in the hub that could affect potential for land use conversion to development within the hub. Table 3 summarizes several types of natural resource conditions or presence of areas designated in State regulation.

Findings that apply to more than one hub in Worcester County are summarized in the following list:

- The majority of land in GI hubs within Worcester County is privately owned. Most of this private land does not have protection from conversion to development or other land uses. Only the GI hub on Maryland’s portion of Assateague Island is completely protected from conversion to developed uses.
- Forest interior, floodplain and sensitive species habitat is found in most Green Infrastructure hubs.
- Wetland of Special State Concern, which are identified in State regulation and require wetland permits to include particular requirements, are found in over one third of the Green Infrastructure hubs.

Table 1. Green Infrastructure Hub Rank For the Coastal Bays Watershed Scale for Rank is from 1 (important larger hubs) to 100 (also important but smaller hubs)		
Map Key	Percent Rank	Green Infrastructure Hub Description
1	0.9	Cypress Swamp Vicinity south and west of Pocomoke City.
2	1.7	Nassawango Creek vicinity including large areas west of Snow Hill, west of Rt 12 and north of Rt 113. Includes parts of Worcester and Somerset Counties.
3	3	Assateague Island in its entirety.
4	4.7	Upper Nassawango Creek vicinity northeast of Rt 12 and northwest of Rt 354 including parts of Worcester and Wicomico Counties.
5	5.2	Upper Chincoteague mainland along Chincoteague and Newport Bays between Snow Hill and Berlin.
6	5.6	Johnson Bay / Brockanorton Bay vicinity from the Stockton area to near Tanhouse Creek including Vaughn WMA.
7	6.5	Pocomoke River vicinity from Snow Hill through Ninepin Branch to Rt 374.
8	9.1	Upper Pocomoke River vicinity from Rt 374 to Rt 50.
9	11.2	Tanhouse Creek vicinity including the area of natural vegetation between the two higher-ranked mainland hubs.
10	11.6	Northern Pocomoke River from Rt 50 north into Delaware.
11	21.1	Corkers Creek vicinity south of Rt 113.
12	25.4	Headwaters of Herring Creek and Ayer Creek east of Berlin.
13	29.3	Big Mill Pond hub (natural area in the Big Mill Pond watershed.
14	31	Purnell Bay hub (around bay and extending toward Stockton)
15	34.1	St. Martins Neck vicinity between the St. Martin River and Assawoman Bay.
16	35.3	Big Bay Point Islands.
17	41.4	Pikes Creek upstream of Rt 12 (north of Stockton)
18	47	Hancock Creek hub (south of Stockton)
19	47.8	Pilchard Cr. Hub (east of Pocomoke City between Rt 113 & Rt 366
20	48.3	Mills Island
21	49.6	Rowley Creek headwaters (east of Gridletree)
22	53.4	Poplartown Branch headwaters (upstream of Rt 113)
23	53.9	Sinepuxent Mainland near Snug Harbor
24	55.2	All the small islands in Brockanorton Bay that are not already included in another hub.
25	55.6	Assawoman Bay’s western shore hub north of Greys Creek
26	56.9	Longridge Swamp hub east of Whaleyville.
27	62.1	Spring Hill Branch headwaters.
28	64 - 76	Herring Creek vicinity including three small hubs
29	72.4	Wagram Creek vicinity.

Table 2. Protection Summary For Green Infrastructure Hubs In Worcester County Based On DNR GIS Data Available In August 2005

Map Key Hub #	Public Ownership			Private Ownership				
	Federal Park	MD DNR Land	County Park	Ag Easmt	Rural Legacy		MET Easmt	Other Conserv Easmt
					In Area	Easmt		
1	-	Y	-	-	-	-	-	-
2	-	Y	Y	-	-	-	-	Y
3	Y	Y	-	-	-	-	-	-
4	-	Y	-	-	-	-	-	Y
5	-	Y	-	-	-	-	-	-
6	-	Y	-	-	A	Y	Y	-
7	-	Y	Y	Y	-	-	-	-
8	-	Y	-	-	-	-	-	-
9	-	-	-	-	P	-	Y	-
10	-	Y	-	-	-	-	-	-
11	-	Y	Y	-	P	Y	-	-
12	-	-	Y	-	-	-	-	-
13	-	Y	-	-	-	-	Y	-
14	-	-	-	-	A	Y	Y	-
15	-	Y	-	-	-	-	-	-
16	-	-	Y	-	-	-	-	-
17	-	Y	Y	-	A	-	-	-
18	-	-	-	-	A	Y	Y	-
19	-	Y	-	-	-	-	-	-
20	-	-	-	-	A	-	-	-
21	-	-	-	-	A	Y	-	-
22	-	-	-	-	-	-	-	-
23	-	-	Y	-	-	-	-	-
24	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-
26	-	Y	-	-	-	-	-	-
27	-	-	-	-	P	Y	-	-
28	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-

Key: Y – Yes, characteristic is present.
A – All of the hub has this characteristic.
P- Part of the hub has this characteristic.
"-" The characteristic was not identified in the hub.
MET – Maryland Environmental Trust.

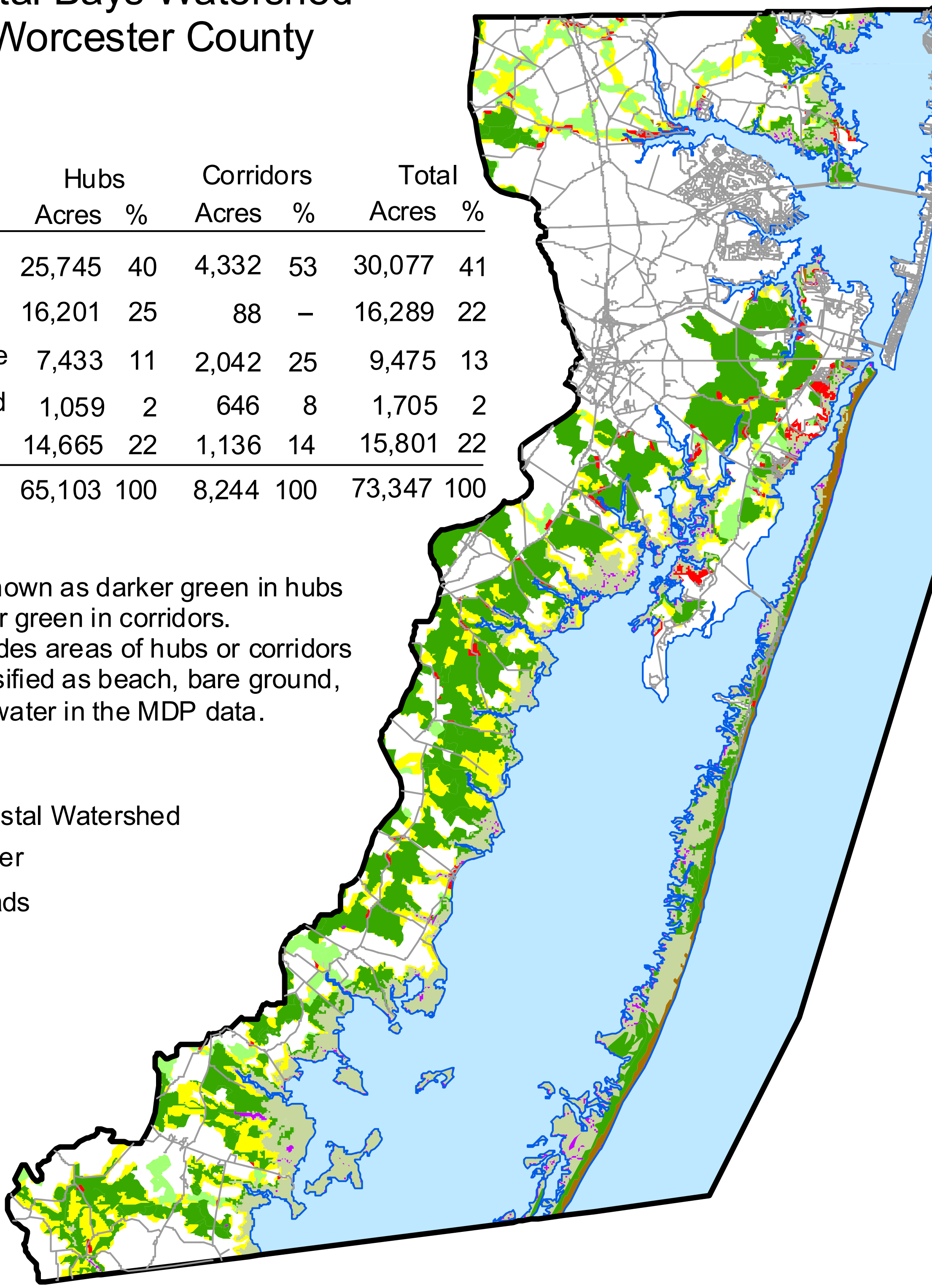
Table 3. Resource Summary For Green Infrastructure Hubs In Worcester County Based On DNR GIS Data Available In August 2005				
Map Key Hub #	Forest Interior	Floodplain	SSPRA	WSSC
1	Y	Y	Y	Y
2	Y	Y	Y	Y
3	-	Y	Y	-
4	Y	Y	Y	Y
5	Y	Y	Y	Y
6	Y	Y	Y	Y
7	Y	Y	Y	Y
8	Y	Y	Y	-
9	Y	Y	Y	Y
10	Y	Y	Y	Y
11	Y	Y	Y	-
12	Y	Y	Y	-
13	Y	-		
14	Y	Y	Y	
15	Y	Y	Y	-
16	-	Y	Y	-
17	Y	-	Y	Y
18	Y	Y	Y	Y
19	Y	Y	Y	-
20	-	Y	Y	-
21	Y	-	Y	-
22	Y	-	-	-
23	Y	Y	-	-
24	-	Y	Y	-
25	-	Y	Y	-
26	Y	-	-	-
27	Y	-	Y	-
28	Y	Y	Y	-
29	Y	Y	-	-

Key: Y – Yes, characteristic is present.
"-" The characteristic is not identified in the hub.
SSPRA – Sensitive Species Project Review Area. Sensitive species are found within the envelop encompassed by this area but the entire envelop is not sensitive species habitat.
WSSC – Wetlands of Special State Concern.

Green Infrastructure - 2002
Coastal Bays Watershed
In Worcester County

Land Use	Hubs Acres	Hubs %	Corridors Acres	Corridors %	Total Acres	Total %
Forest*	25,745	40	4,332	53	30,077	41
Wetlands	16,201	25	88	–	16,289	22
Agriculture	7,433	11	2,042	25	9,475	13
Developed	1,059	2	646	8	1,705	2
Other	14,665	22	1,136	14	15,801	22
Total	65,103	100	8,244	100	73,347	100

"Forest" is shown as darker green in hubs and as lighter green in corridors.
"Other" includes areas of hubs or corridors that are classified as beach, bare ground, wetlands or water in the MDP data.



Coastal Watershed
Water
Roads

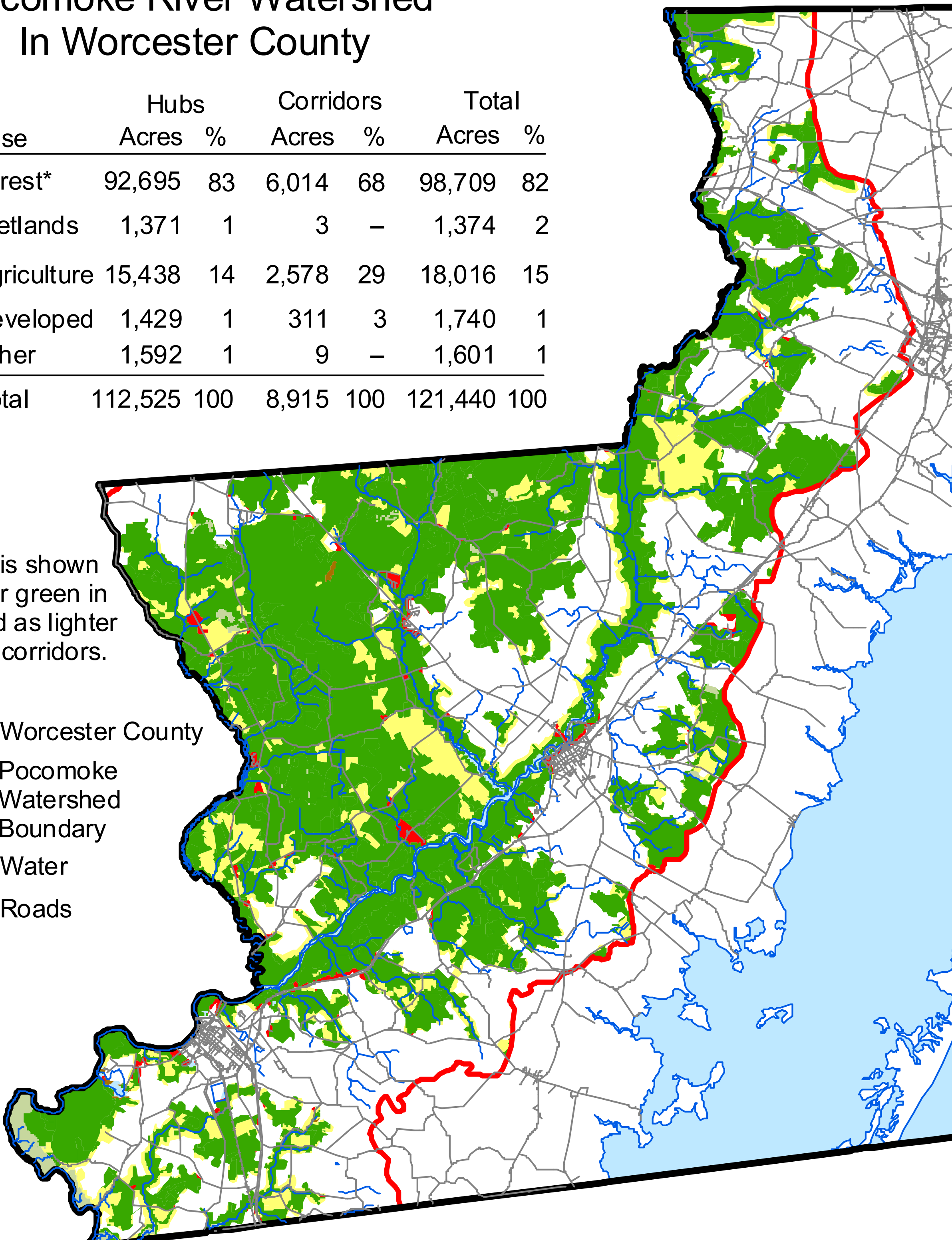
0 2.5 5 Miles
1:250,000

Maryland Dept. of Natural Resources
GIS: Watershed Services EAC Aug. 2005
Land Use Data: MDP 2002

Green Infrastructure - 2002
Pocomoke River Watershed
In Worcester County

Land Use	Hubs Acres	Hubs %	Corridors Acres	Corridors %	Total Acres	Total %
Forest*	92,695	83	6,014	68	98,709	82
Wetlands	1,371	1	3	–	1,374	2
Agriculture	15,438	14	2,578	29	18,016	15
Developed	1,429	1	311	3	1,740	1
Other	1,592	1	9	–	1,601	1
Total	112,525	100	8,915	100	121,440	100

"Forest" is shown as darker green in hubs and as lighter green in corridors.



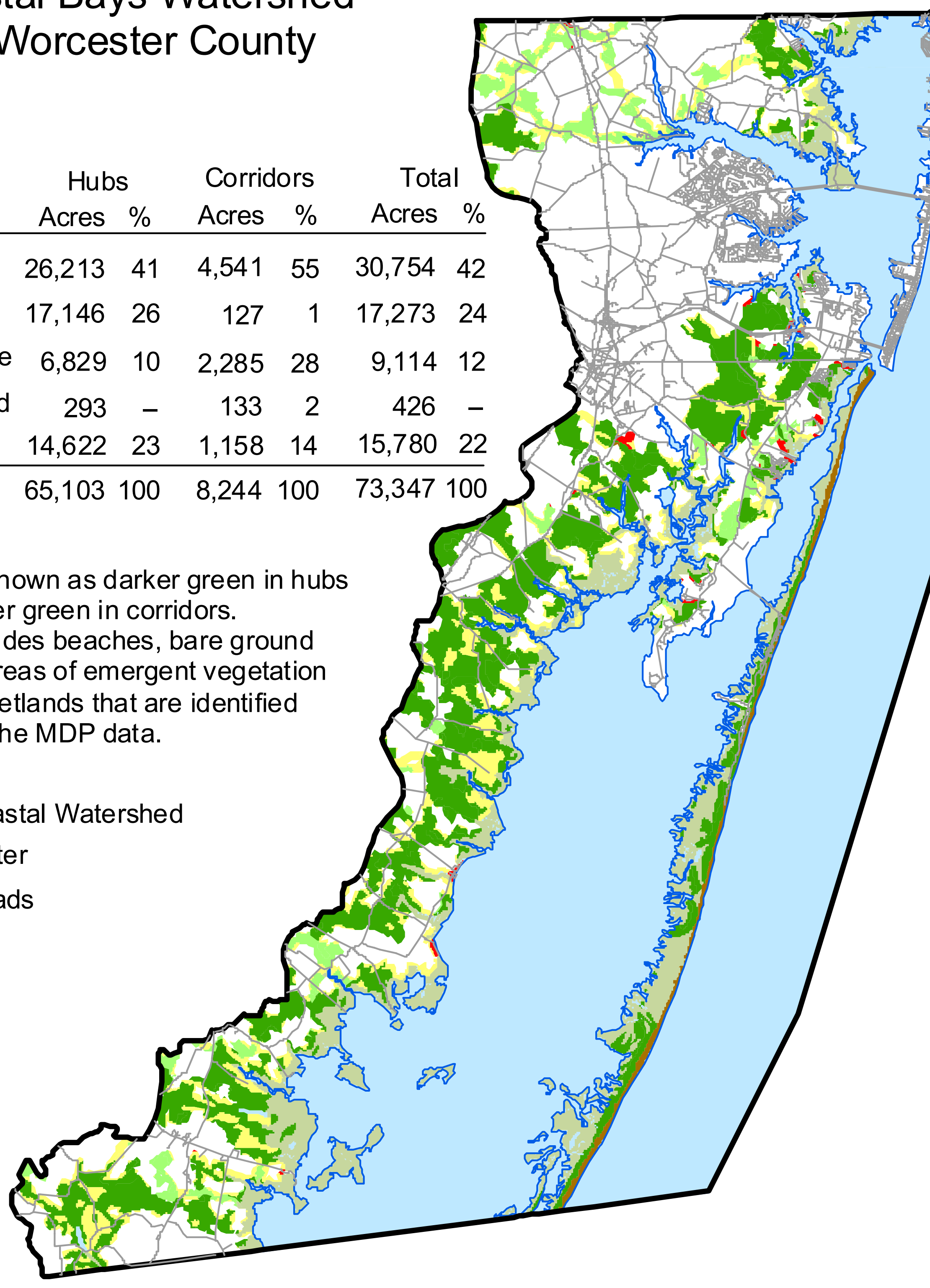
Maryland Dept. of Natural Resources
GIS: Watershed Services EAC Aug. 2005
Land Use Data: MDP 2002

Green Infrastructure - 1973
Coastal Bays Watershed
In Worcester County

Land Use	Hubs Acres	Hubs %	Corridors Acres	Corridors %	Total Acres	Total %
Forest*	26,213	41	4,541	55	30,754	42
Wetlands	17,146	26	127	1	17,273	24
Agriculture	6,829	10	2,285	28	9,114	12
Developed	293	–	133	2	426	–
Other	14,622	23	1,158	14	15,780	22
Total	65,103	100	8,244	100	73,347	100

"Forest" is shown as darker green in hubs and as lighter green in corridors. "Other" includes beaches, bare ground as well as areas of emergent vegetation and some wetlands that are identified as water in the MDP data.

Coastal Watershed
Water
Roads



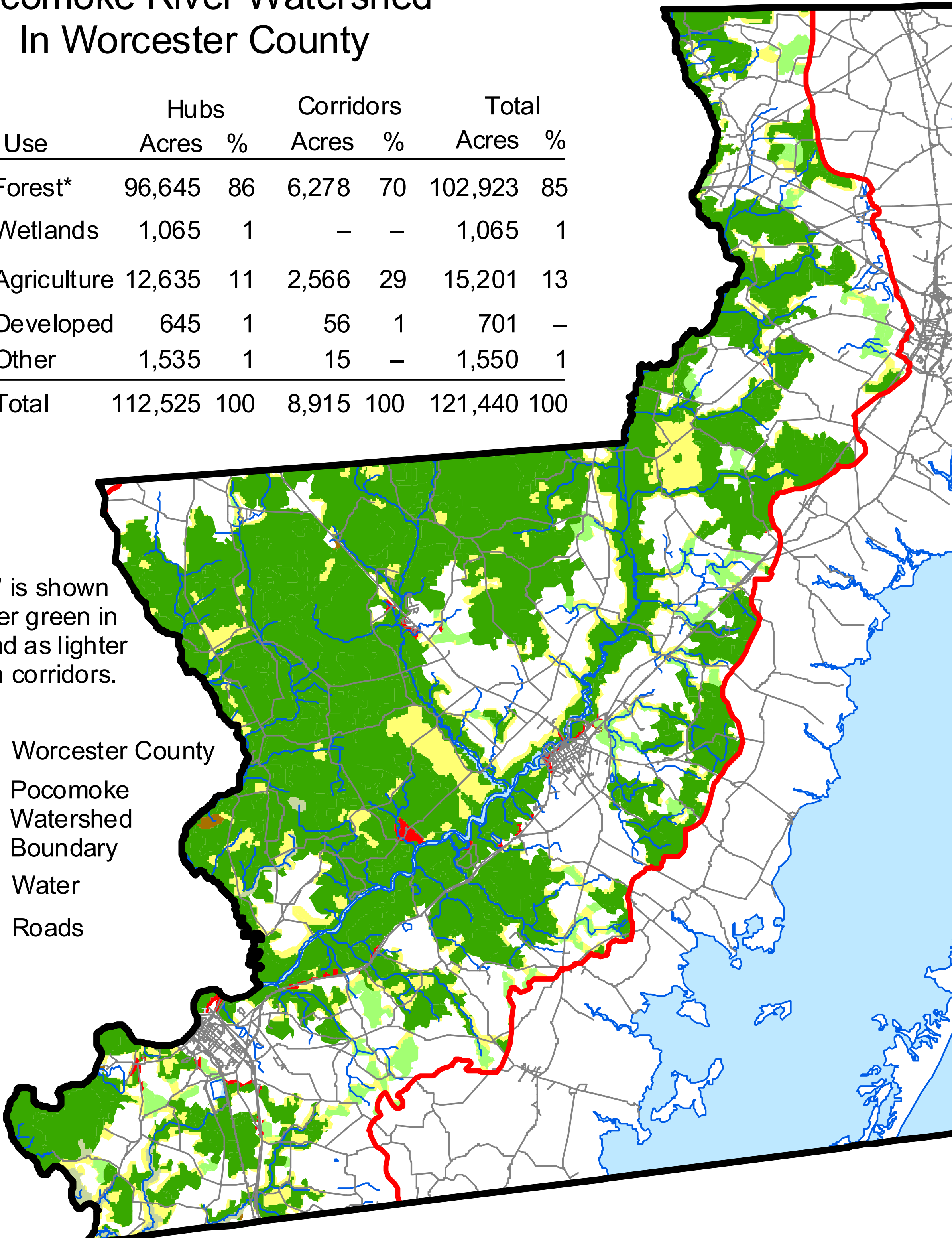
0 2 4 Miles
1:250,000

Maryland Dept. of Natural Resources
GIS: Watershed Services EAC Aug. 2005
Land Use Data: MDP 1973

Green Infrastructure - 1973
Pocomoke River Watershed
In Worcester County

Land Use	Hubs Acres	Hubs %	Corridors Acres	Corridors %	Total Acres	Total %
Forest*	96,645	86	6,278	70	102,923	85
Wetlands	1,065	1	–	–	1,065	1
Agriculture	12,635	11	2,566	29	15,201	13
Developed	645	1	56	1	701	–
Other	1,535	1	15	–	1,550	1
Total	112,525	100	8,915	100	121,440	100

"Forest" is shown as darker green in hubs and as lighter green in corridors.



Worcester County

Pocomoke Watershed Boundary

Water

Roads

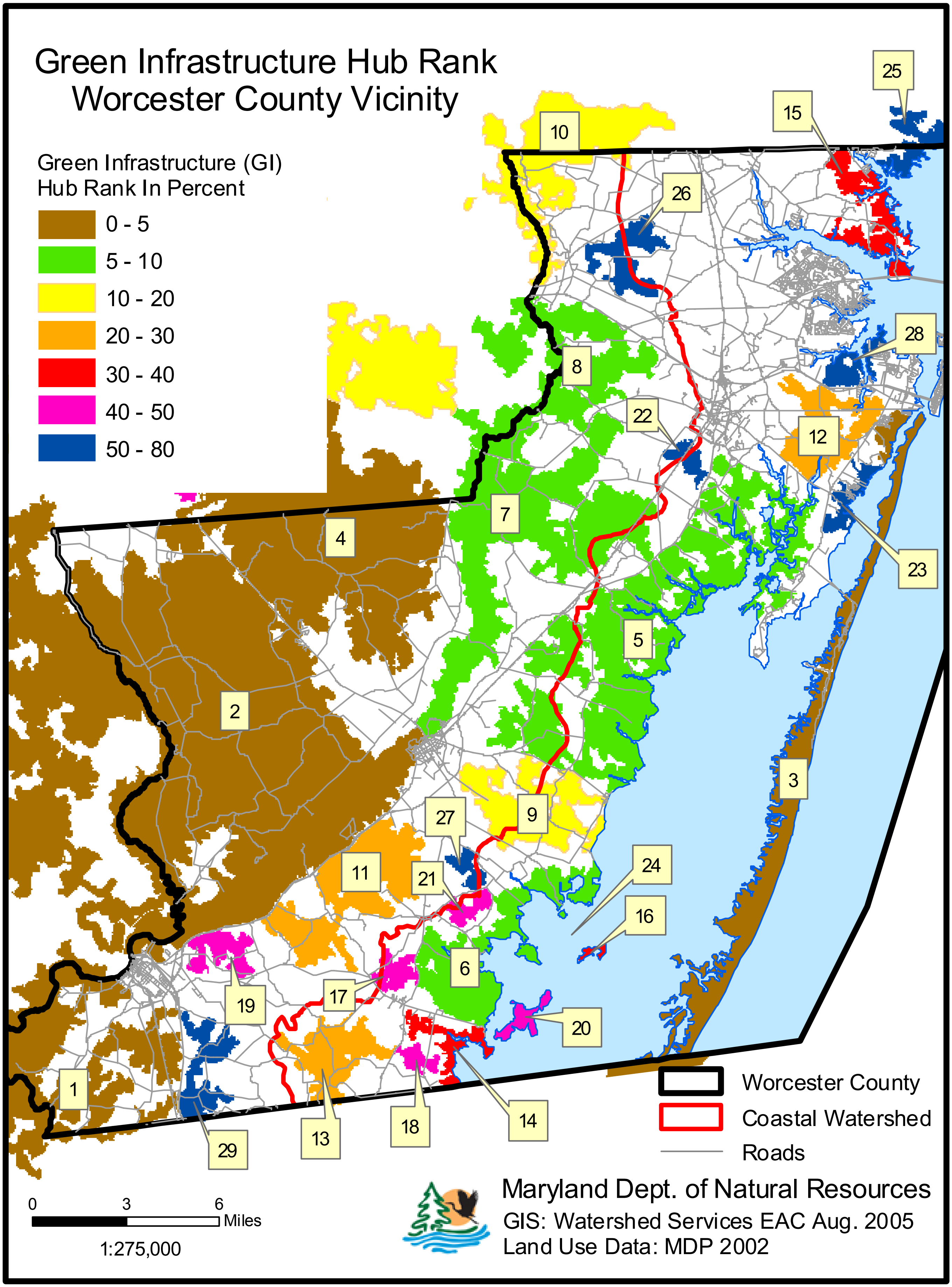
0 2.5 5 Miles

1:250,000

Maryland Dept. of Natural Resources

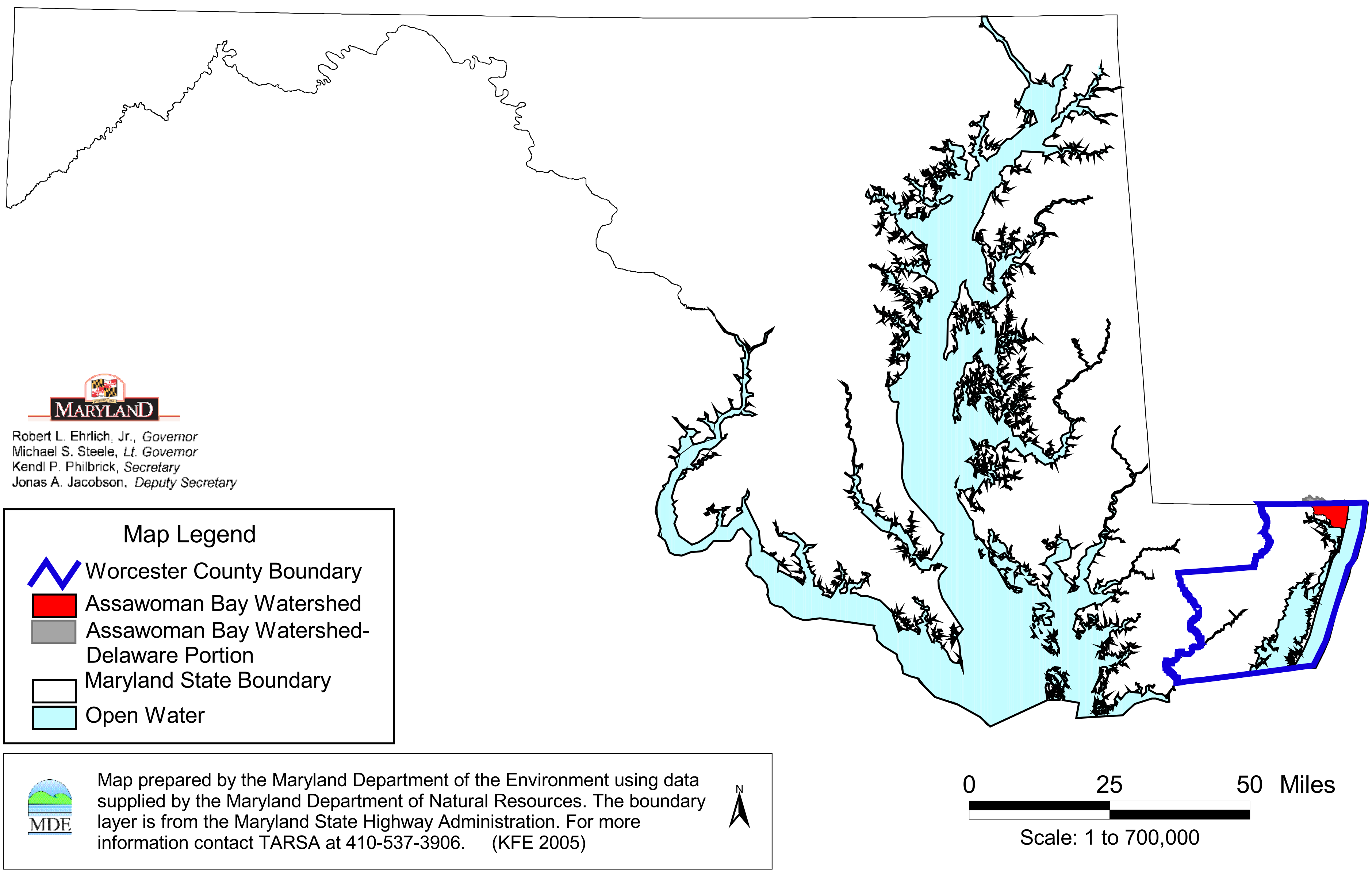
GIS: Watershed Services EAC Aug. 2005

Land Use Data: MDP 2002


Green Infrastructure Hub Rank
Worcester County Vicinity
Green Infrastructure (GI)
Hub Rank In Percent
0 - 5
5 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 80
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
Worcester County
Coastal Watershed
Roads
0
3
6
Miles
1:275,000
Maryland Dept. of Natural Resources
GIS: Watershed Services EAC Aug. 2005
Land Use Data: MDP 2002

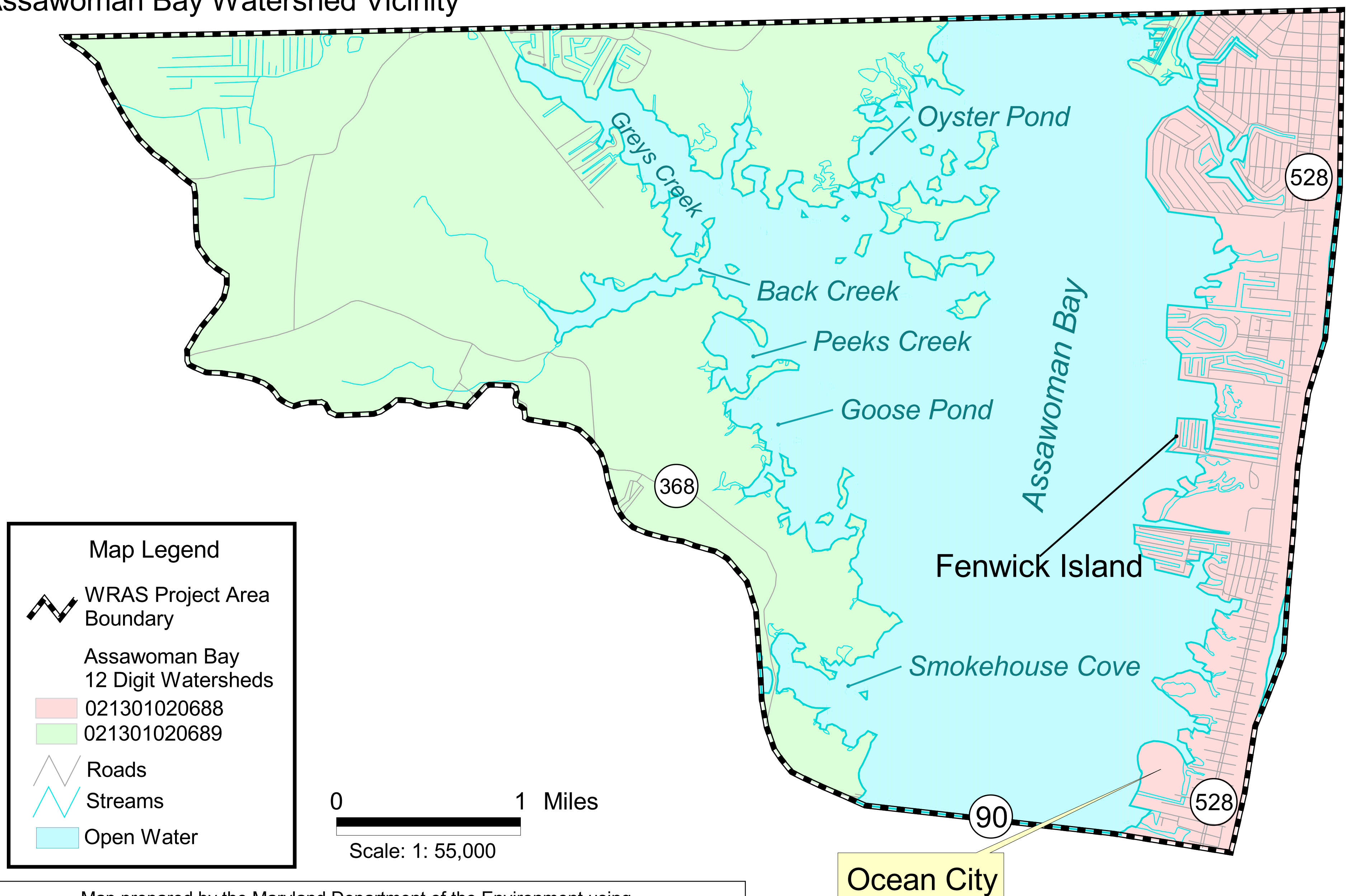
Assawoman Bay Watershed
Characterization Maps

Map 1: Assawoman Bay Watershed WRAS Project Area
Worcester County, Maryland



Map prepared by the Maryland Department of the Environment using data supplied by the Maryland Department of Natural Resources. The boundary layer is from the Maryland State Highway Administration. For more information contact TARSA at 410-537-3906. (KFE 2005)

Map 2: WRAS Project Area
Assawoman Bay Watershed Vicinity



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Map prepared by the Maryland Department of the Environment using data supplied by the Maryland Department of Natural Resources. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

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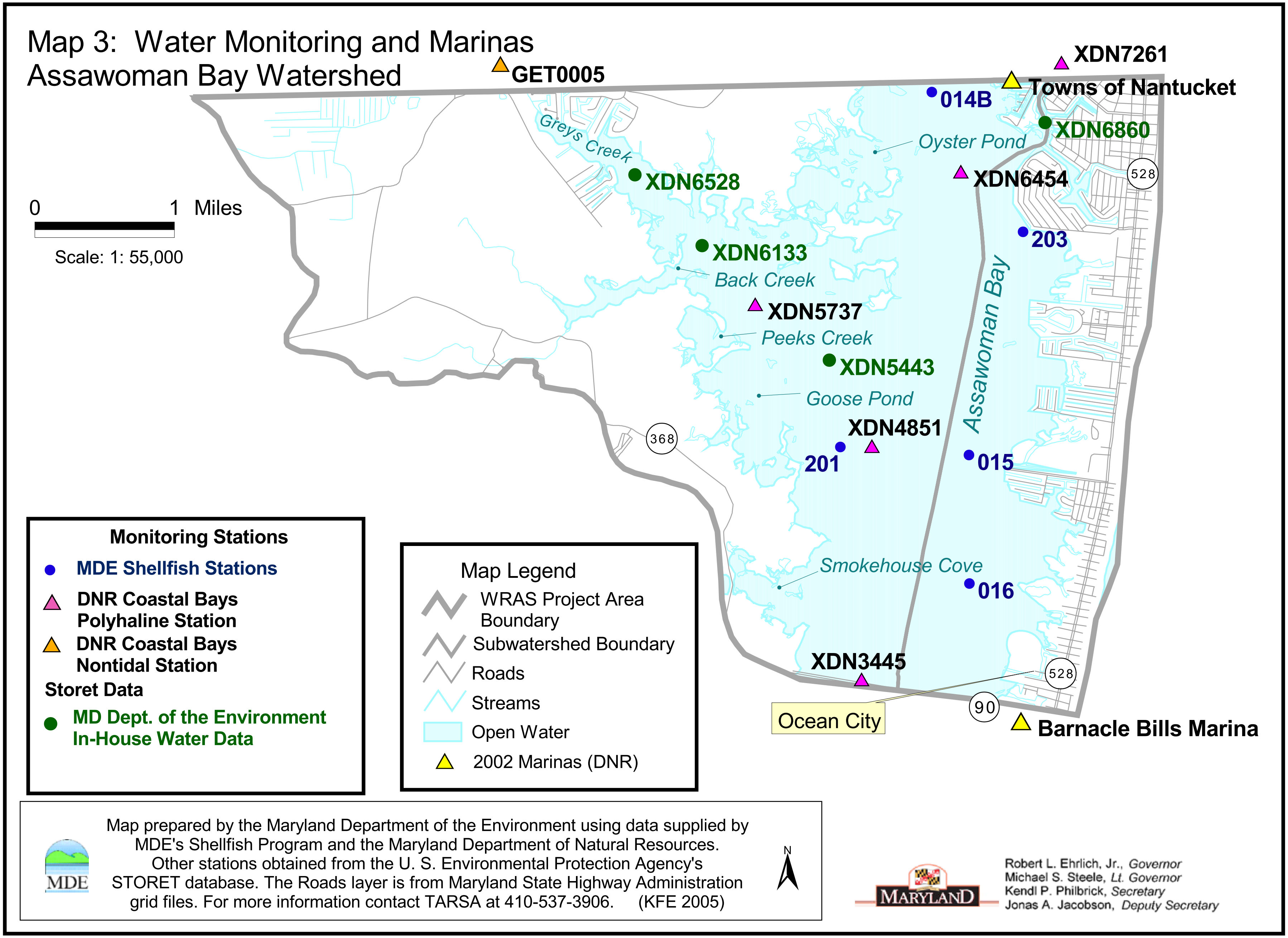

Map 3: Water Monitoring and Marinas
Assawoman Bay Watershed
GET0005
XDN7261
Towns of Nantucket
014B
XDN6860
Oyster Pond
Greys Creek
XDN6528
XDN6454
528
203
XDN6133
Back Creek
XDN5737
Peeks Creek
XDN5443
Goose Pond
Assawoman Bay
XDN4851
368
201
015
Smokehouse Cove
016
XDN3445
528
90
Ocean City
Barnacle Bills Marina
0
1 Miles
Scale: 1: 55,000
Monitoring Stations
MDE Shellfish Stations
DNR Coastal Bays Polyhaline Station
DNR Coastal Bays Nontidal Station
Storet Data
MD Dept. of the Environment In-House Water Data
Map Legend
WRAS Project Area Boundary
Subwatershed Boundary
Roads
Streams
Open Water
2002 Marinas (DNR)
Map prepared by the Maryland Department of the Environment using data supplied by MDE's Shellfish Program and the Maryland Department of Natural Resources. Other stations obtained from the U. S. Environmental Protection Agency's STORET database. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)
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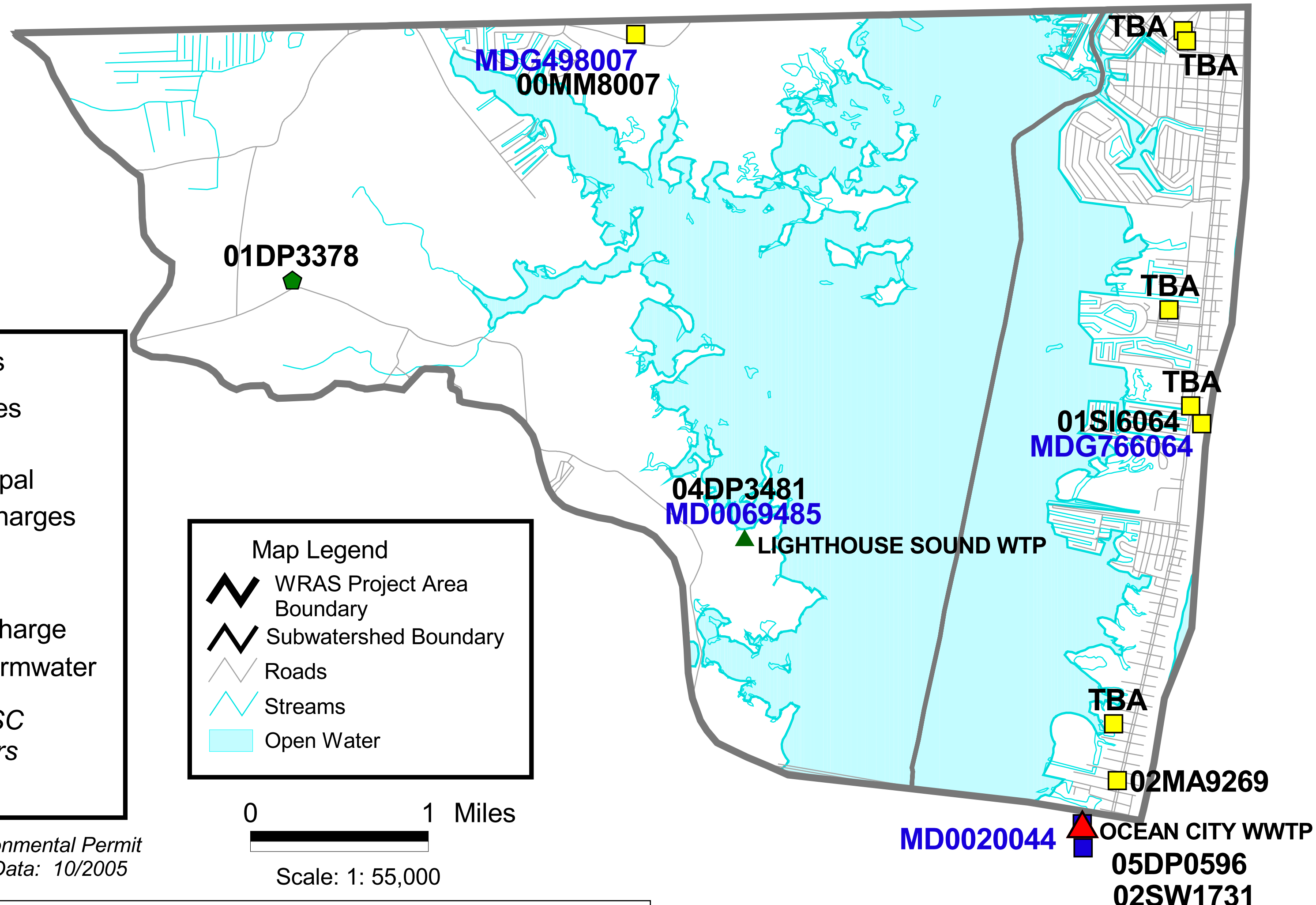
Map 4: MDE Permits
Assawoman Bay Watershed



Permit Types

Surface Discharges
- Municipal
- Major Municipal

Groundwater Discharges
- Municipal

General Permits
- General Discharge
- Industrial Stormwater

Labels are EPSC Permit Numbers

Map Legend
- WRAS Project Area Boundary
- Subwatershed Boundary
- Roads
- Streams
- Open Water

0 1 Miles

Scale: 1: 55,000

Publication Date of Environmental Permit Service Center (EPSC) Data: 10/2005

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Map prepared by the Maryland Department of the Environment using data from MDE's EPSC database. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 10-537-3906. (KFE 2005)

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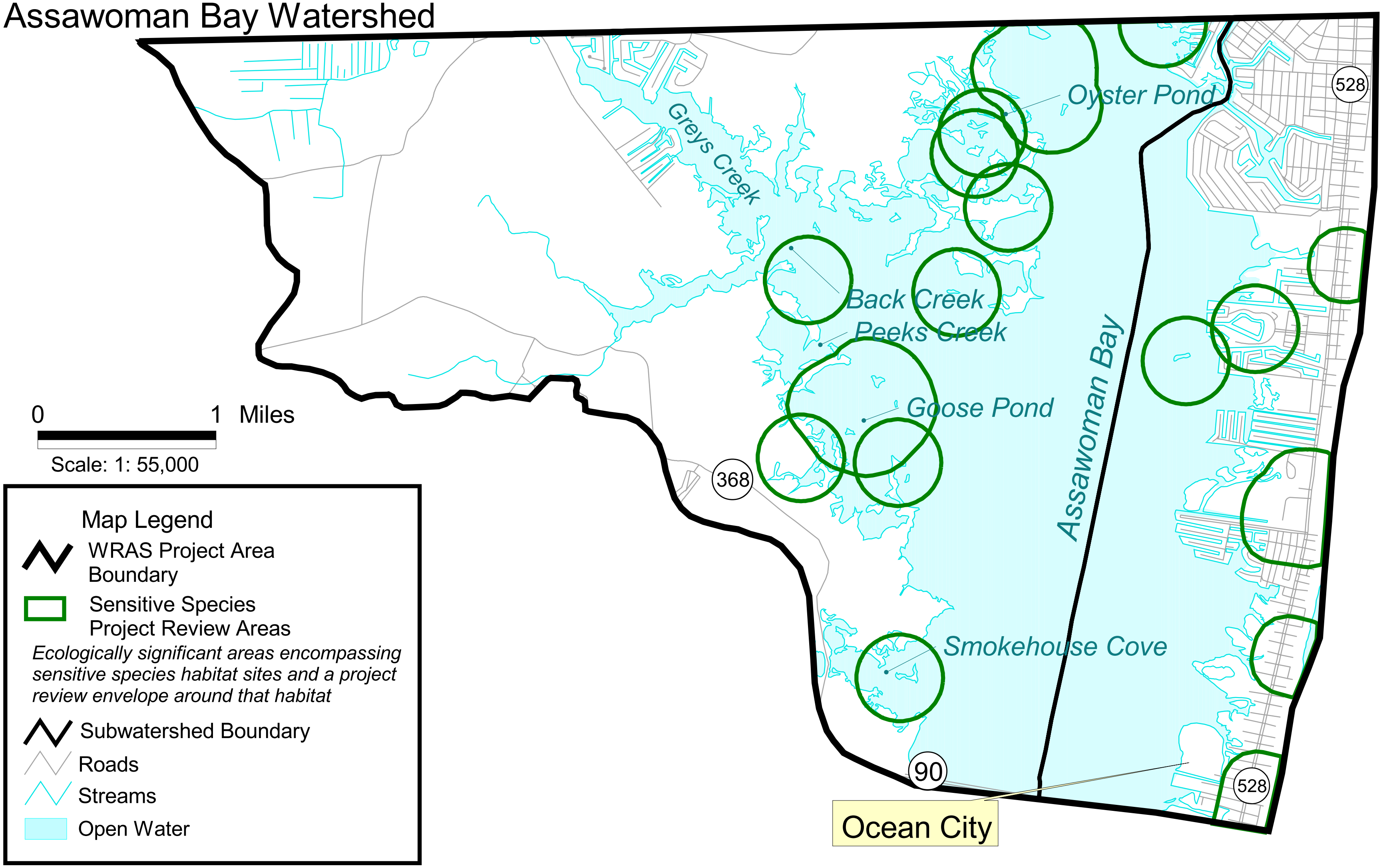
Map 5: Sensitive Species
Assawoman Bay Watershed



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Map prepared by the Maryland Department of the Environment using data supplied by the Maryland Department of Natural Resources. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

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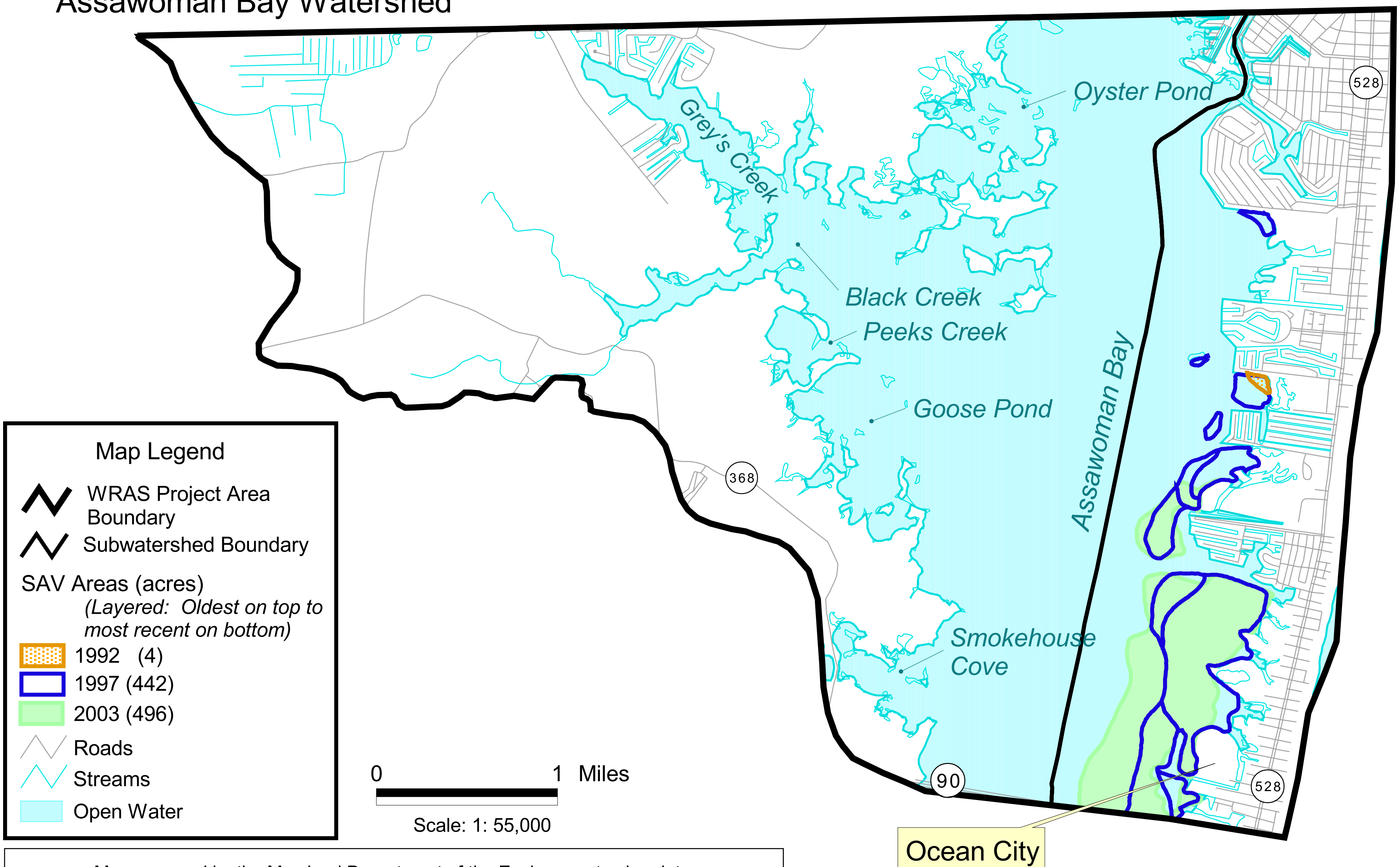
Map 6: Submerged Aquatic Vegetation
Assawoman Bay Watershed



Map prepared by the Maryland Department of the Environment using data provided by the Maryland Department of Natural Resources and the Virginia Institute of Marine Science. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

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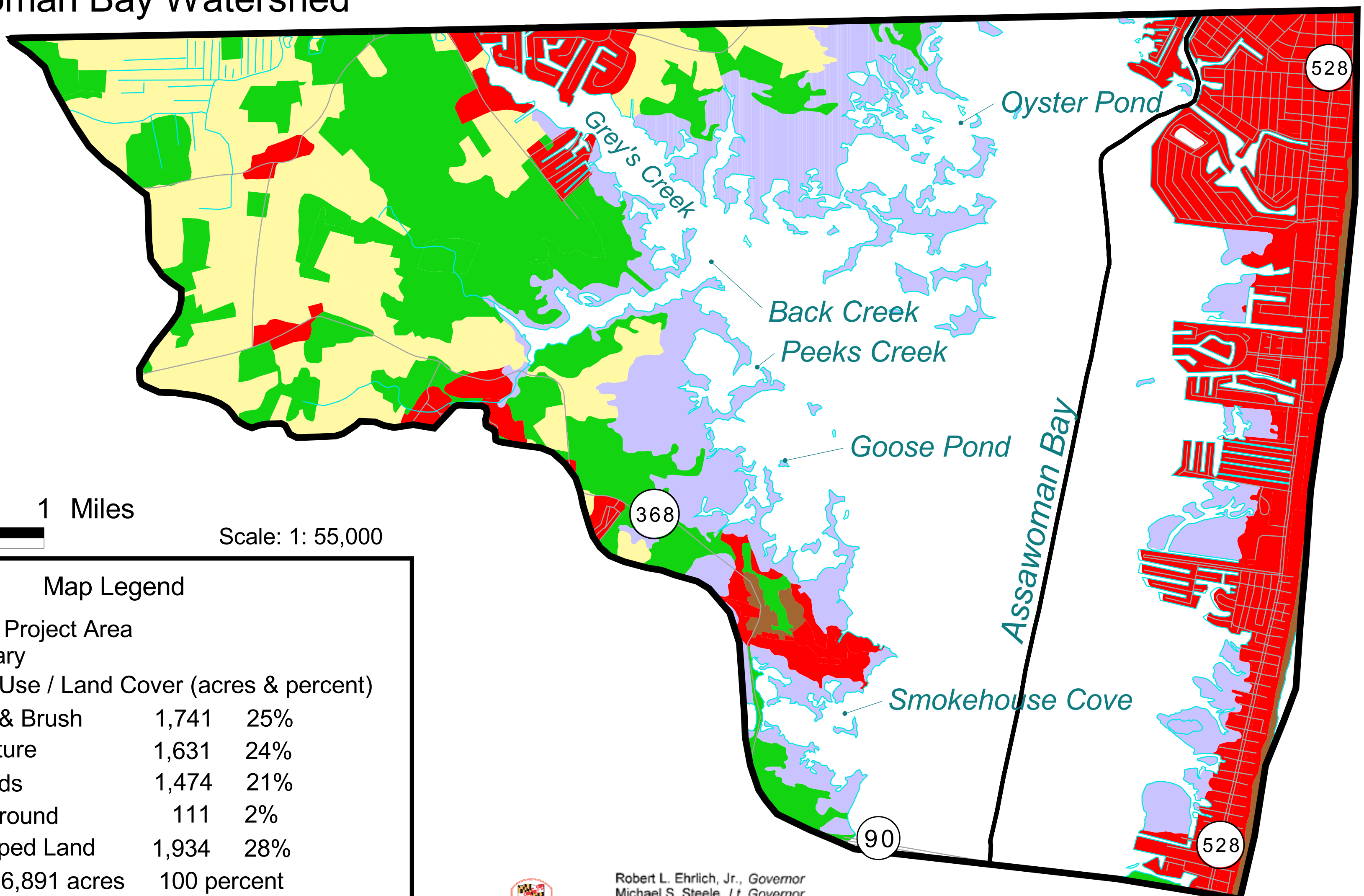
Map 7: Land Use / Land Cover
Assawoman Bay Watershed



0 1 Miles

Scale: 1: 55,000

Map Legend

WRAS Project Area Boundary

2002 Land Use / Land Cover (acres & percent)

Forest & Brush	1,741	25%
Agriculture	1,631	24%
Wetlands	1,474	21%
Bare Ground	111	2%
Developed Land	1,934	28%

Total Land: 6,891 acres 100 percent

Total Including Water: 12,802 acres

Subwatershed Boundary

Roads

Streams

Open Water

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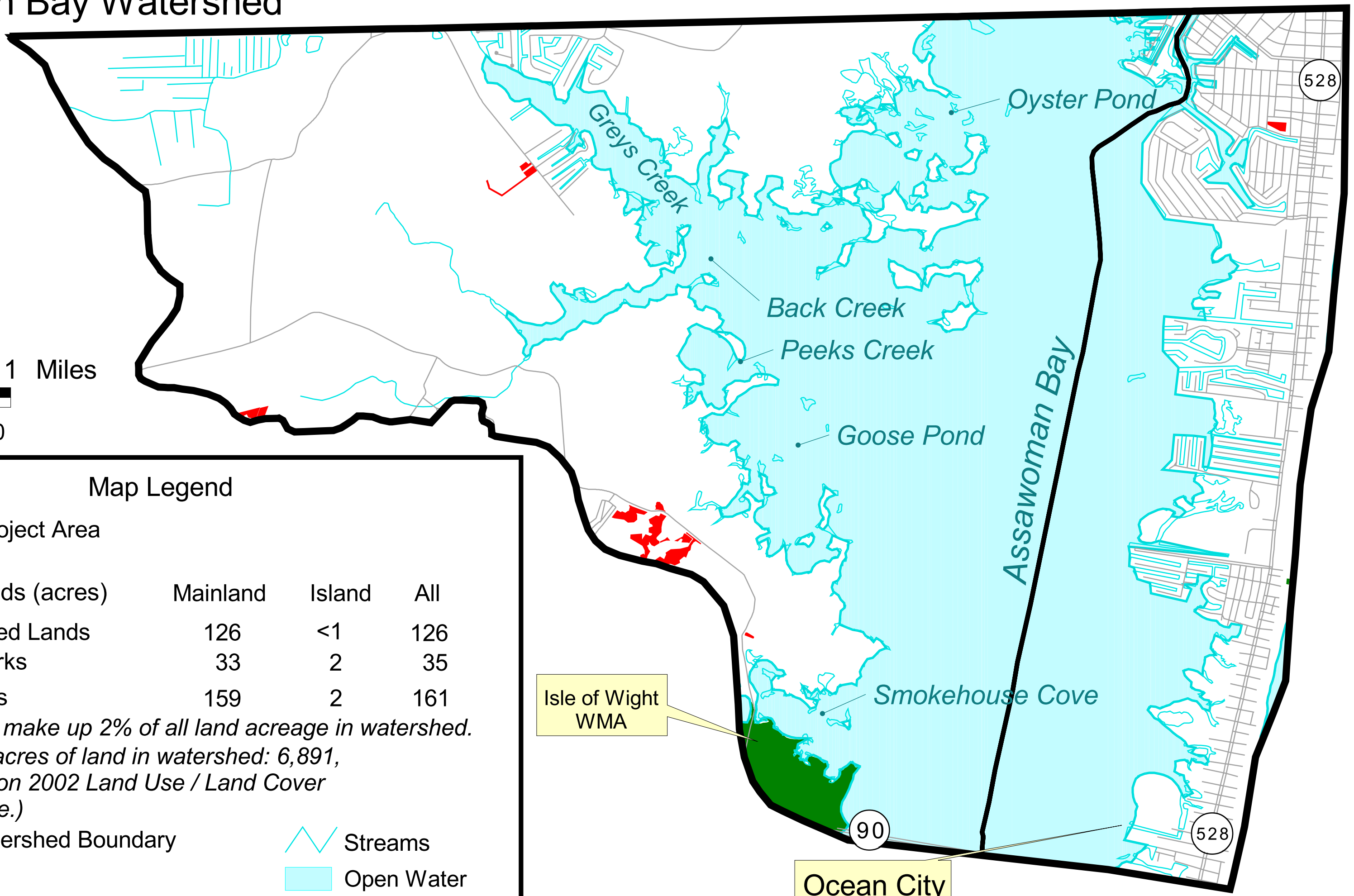
Map 8: Protected Land
Assawoman Bay Watershed



0 1 Miles

Scale: 1: 55,000

Map Legend

WRAS Project Area Boundary

Protected Lands (acres)	Mainland	Island	All
State-Owned Lands	126	<1	126
County Parks	33	2	35
Total Acres	159	2	161

Protected Lands make up 2% of all land acreage in watershed.
(Total acres of land in watershed: 6,891, based on 2002 Land Use / Land Cover acreage.)

Subwatershed Boundary
Roads
Streams
Open Water

Map prepared by the Maryland Department of the Environment using data supplied by the Maryland Department of Natural Resources and the Maryland Department of Planning. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

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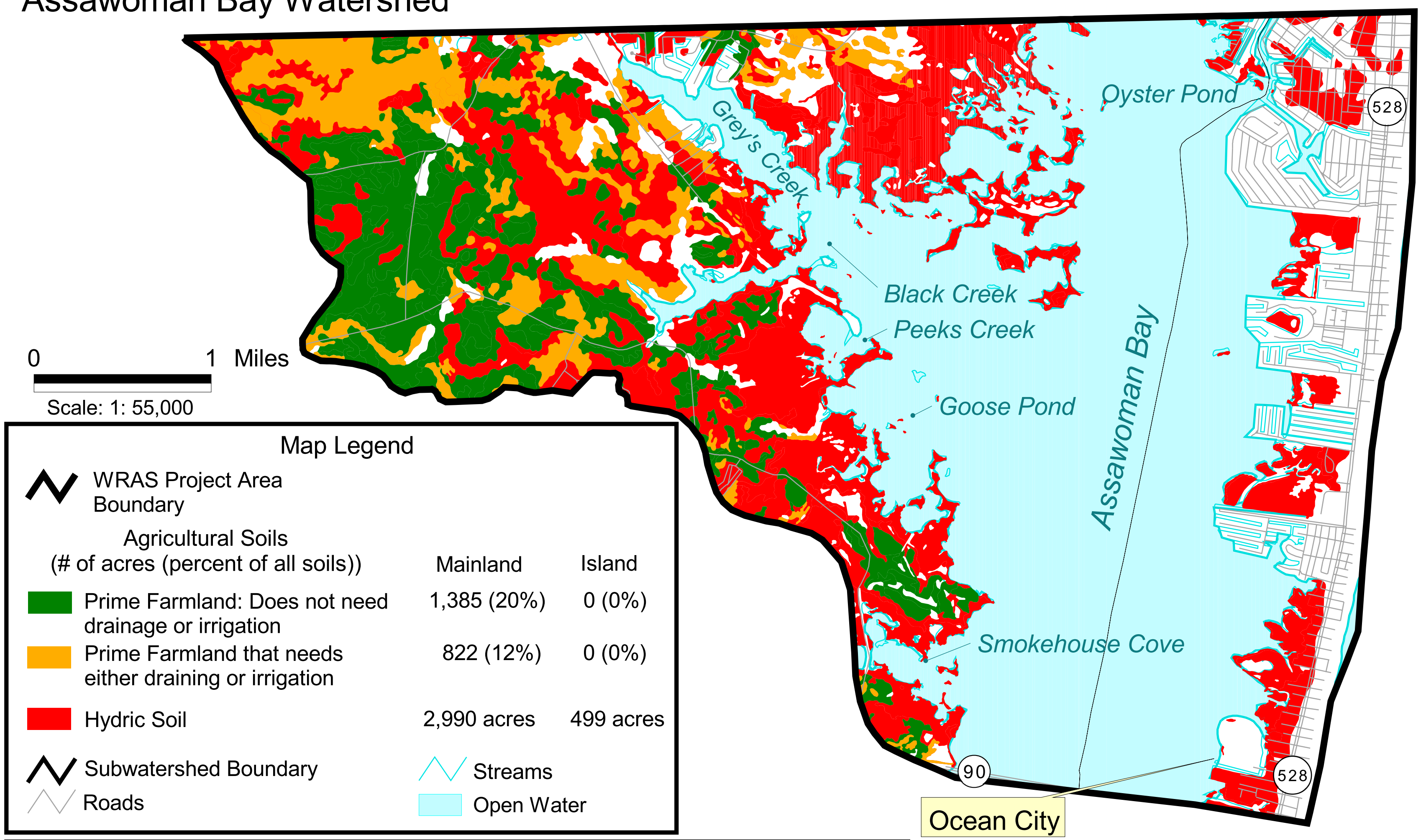
Map 9: Soils Important for Watershed Planning
Assawoman Bay Watershed



Map prepared by the Maryland Department of the Environment using data supplied by Worcester County, Maryland, the United States Department of Agriculture and the Maryland Department of Natural Resources. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

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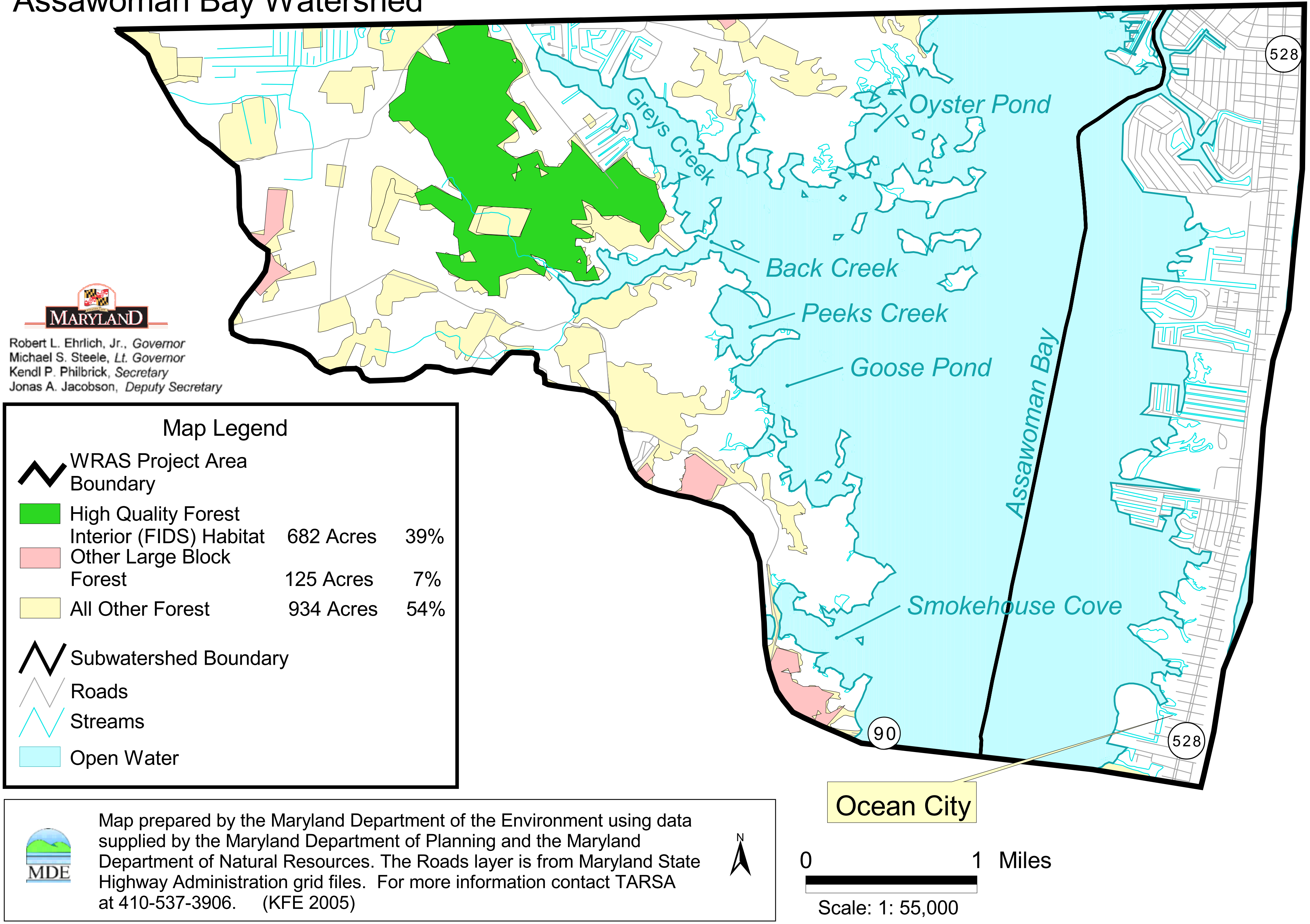
Map 10: Large Block Forest Habitat
Assawoman Bay Watershed



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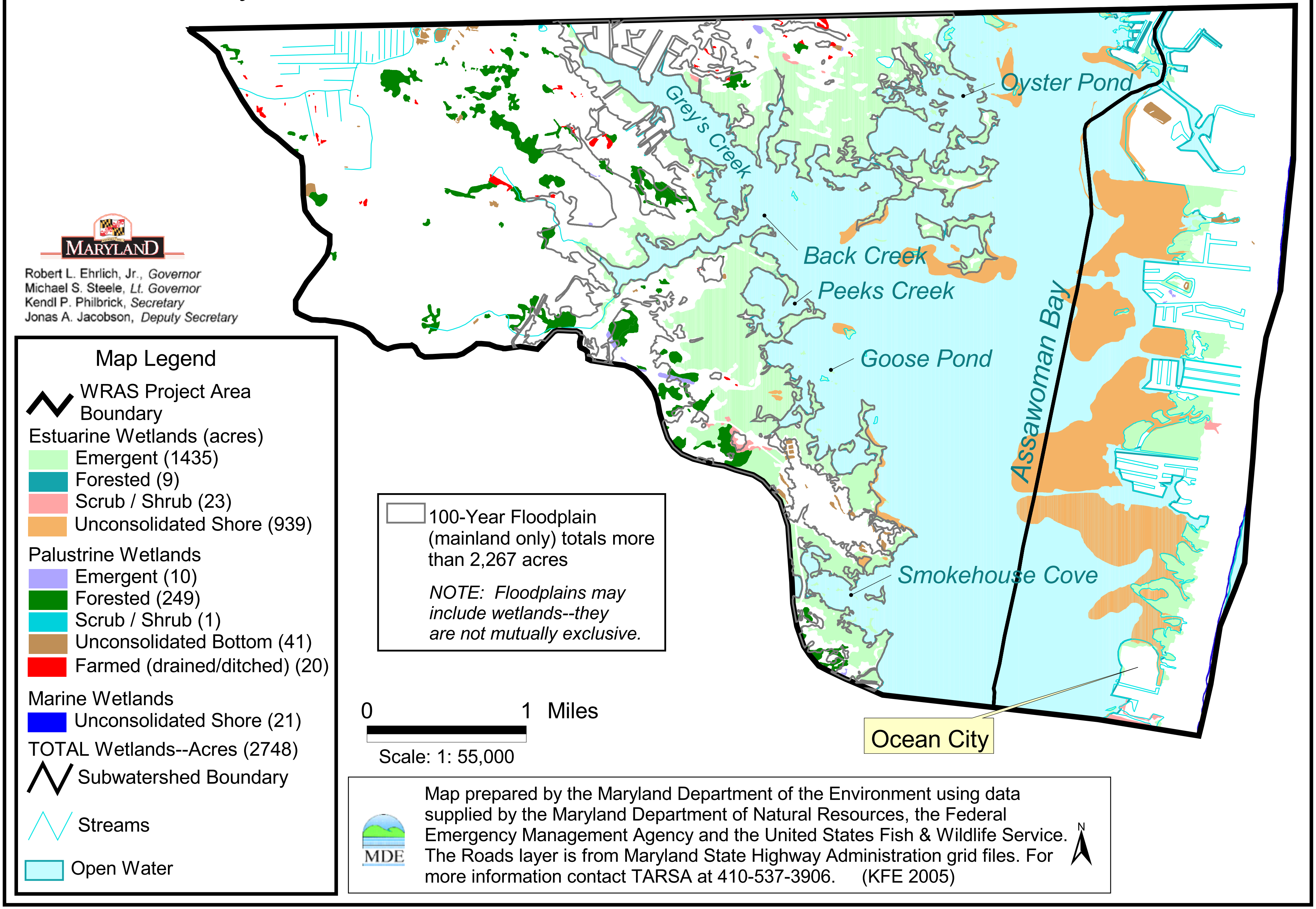
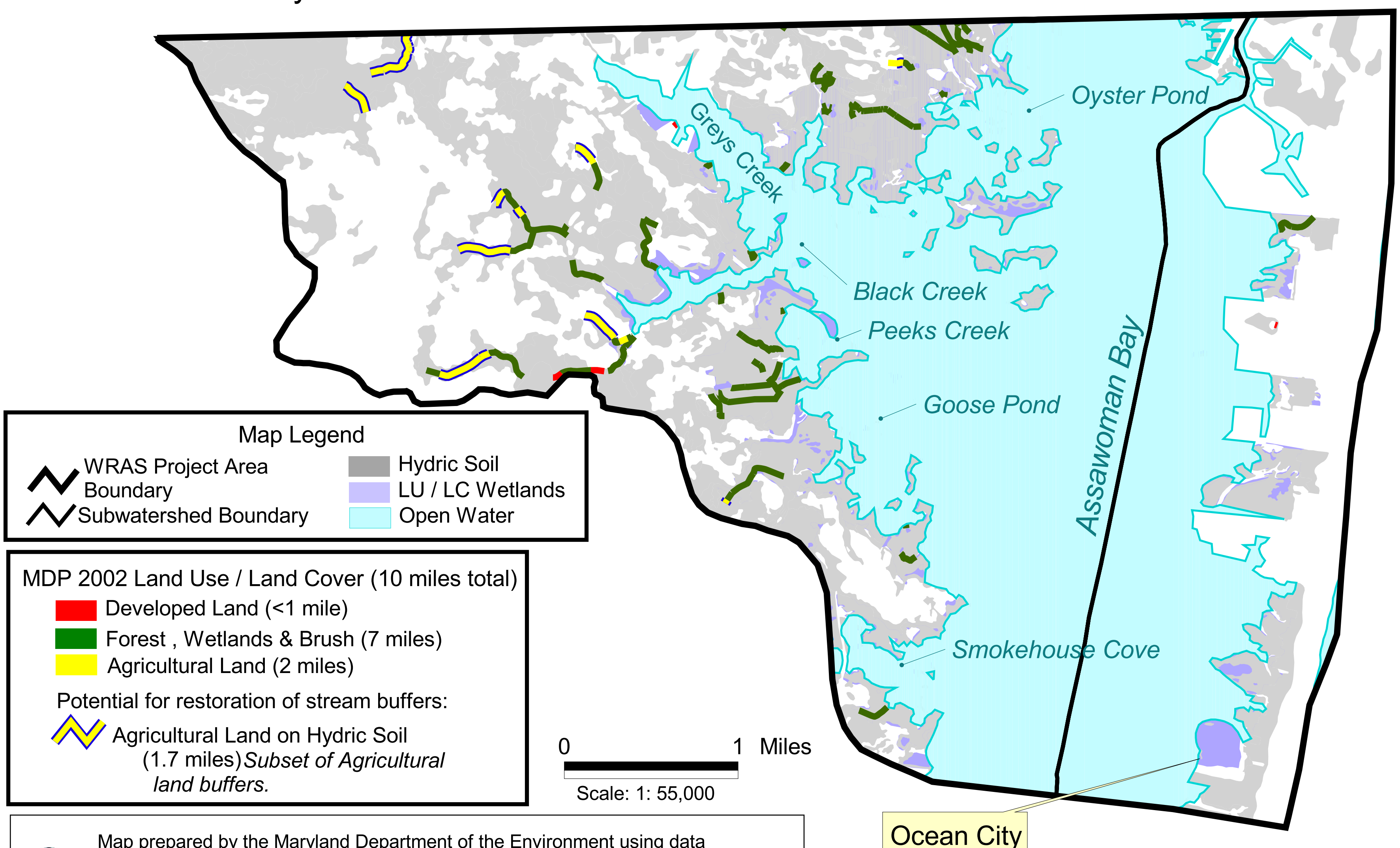
Map prepared by the Maryland Department of the Environment using data supplied by the Maryland Department of Planning and the Maryland Department of Natural Resources. The Roads layer is from Maryland State Highway Administration grid files. For more information contact TARSA at 410-537-3906. (KFE 2005)

Map 11: Wetlands and Mainland Floodplains
Assawoman Bay Watershed



Map 12: Land Use / Land Cover at Stream's Edge
Assawoman Bay Watershed



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