Delaware Center for the Inland Bays

PROMOTING THE WISE USE, PROTECTION, & ENHANCEMENT OF THE INLAND BAYS

BEGINNINGS . . . .

A comprehensive plan to protect, restore, and enhance living resources by improving water quality and protecting and enhancing habitat in the Inland Bays watershed

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DELAWARE

Limulus polyphemus

CENTER FOR THE INLAND BAYS

Rehoboth Indian River Little Assawoman

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ACKNOWLEDGEMENTS

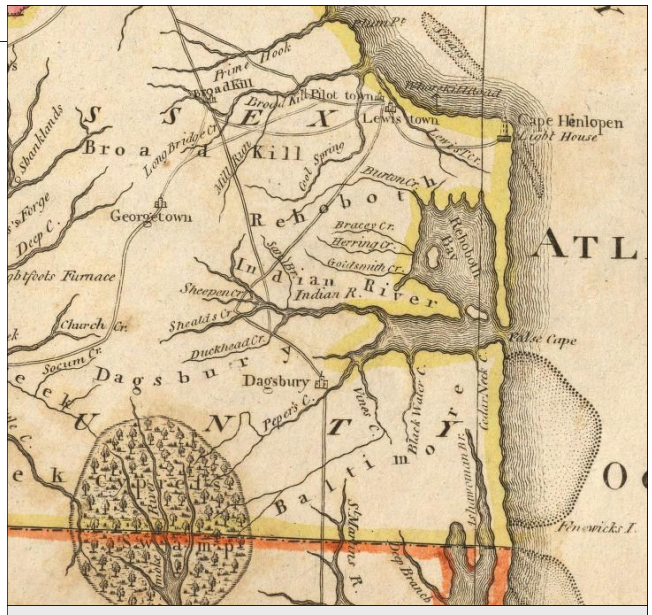
The development of this plan would not have been possible without the tireless dedication and commitment of the following individuals and organizations. Their ideas, knowledge, and desire to restore, enhance, and protect the Inland Bays Watershed is to be commended.

ORGANIZATIONS

U.S. Environmental Protection Agency
U.S. Army Corps of Engineers
U.S. Fish & Wildlife Service
NOAA-National Marine Fisheries Service
University of DE-College of Marine & Earth Studies
DE Department of Natural Resources and Environmental Control
- -Division of Water Resources
- -Division of Fish & Wildlife
- -Division of Parks & Recreation
- -Office of the Secretary

DE Department of Agriculture
- -Forest Service

The Nature Conservancy
Sussex Conservation District
Inland Bays Tributary Action Team



The Inland Bays as shown in an 1814 Map of Eastern Sussex County, Delaware

David Rumsey Collection

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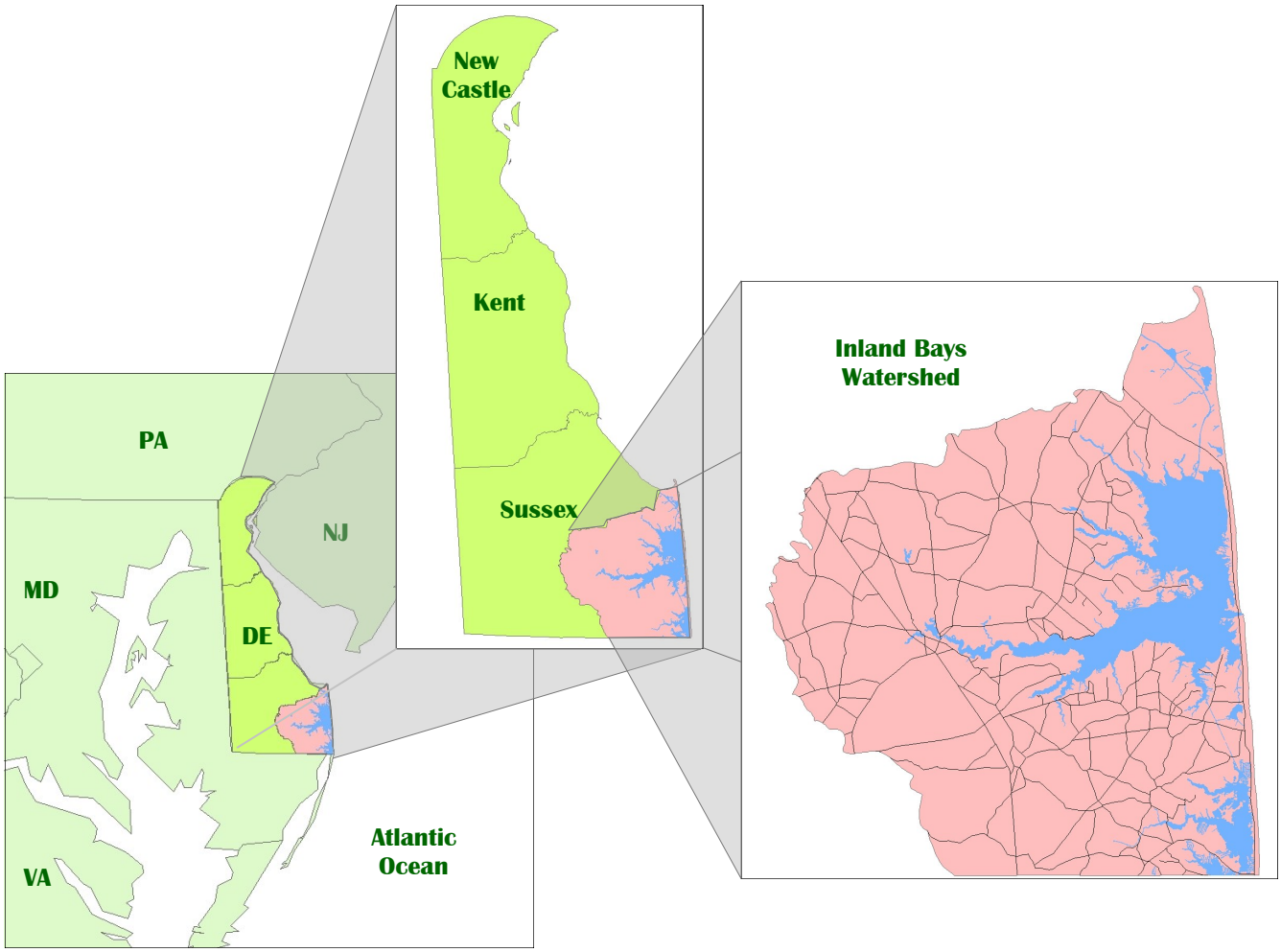
Released Fall 2012
Compiled and edited by Eric Buehl, Habitat Coordinator



About the Bays

Delaware's Inland Bays consist of three interconnected bodies of water - Indian River Bay, Little Assawoman Bay, and Rehoboth Bay - located in the southeastern part of Delaware, in Sussex County. Rehoboth and Little Assawoman Bays are estuaries built on sand bars; Indian River Bay is a drowned river valley. The Bays and their tributaries cover about 32 square miles and drain a 300-square-mile watershed.

They have a marsh area of 9 square miles, a mean low-water volume of 4 billion cubic feet, and a freshwater discharge of 300 cubic feet per second. Almost 30 square miles of the Inland Bays are classified as shellfish waters, of which 19 square miles presently are approved for shellfishing. There are about 126 people per square mile of the Inland Bays watershed. Fresh water enters the Bays through ground water discharges, by runoff from land, and from tributaries. Salt water from the Atlantic Ocean enters the Bays through the Indian River Inlet, Lewes and Rehoboth Canal, Roosevelt Inlet, and the Assawoman Canal, which connects Little Assawoman Bay to Indian River Bay.

The Indian River Inlet, the main link, has deepened and shoaled, temporarily closed, and migrated along the barrier island. Between 1935 and 1939, there was no free connection at all between the Bays and the sea; this led to the destruction of marine and estuarine organisms and habitats and to their replacement by freshwater organisms. In 1940, a new channel to the ocean was created - Indian River Inlet - providing the first stable connection between the upland and the sea and creating a more permanent estuary.

DE Inland Bays CCMP

"The disappearance of plants and animal species without visible cause, despite efforts to protect them, and the irruption of others as pests despite efforts to control them, must, in the absence of simpler explanations, be regarded as symptoms of sickness in the land organism."

Aldo Leopold

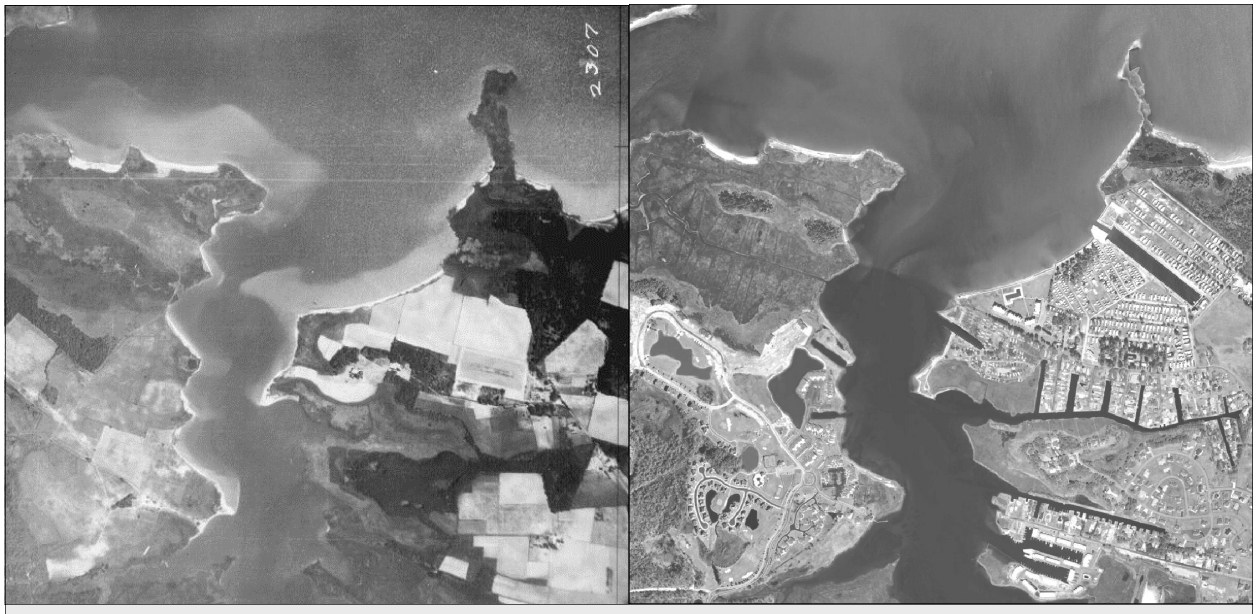
PURPOSE

Since its creation in 1995, the Delaware Center for the Inland Bays has represented the culmination of years of research to understand the impacts and processes that affect the Inland Bays Watershed and a steadfast commitment to restore them to a healthy state. Concern over the health of the estuary goes back to the 1960's but languished due to a lack of action. New momentum was gained in the 1970s and 1980s with a renewed focus not only on the causes of decline in water quality and certain plant and animal species in the watershed, but on correcting many of the problems that plagued the watershed.

> *"Since the Inland Bays' natural resources have been adversely affected historically and currently exist at below-optimal levels, there is great potential for improved habitat and greater numbers of desirable organisms. This improvement will require proper management, stewardship, and responsible use and harvest by the public."*
>
> *DE Inland Bays CCMP*

Like many of the other programs in the National Estuary Program system, the Delaware Center for the Inland Bays developed a Comprehensive Conservation and Management Plan (CCMP) that describes key impacts leading to the decline of the estuary and outlines solutions to correct them or minimize their impact. The CCMP was developed over the course of several years and represents the collaborative efforts of citizens, agencies, and academia, and specifically addresses a broad range of impacts ranging from industrial discharges, runoff from lawns and farms, septic systems, land development, to the loss of habitat. It is the latter that is the focus of Chapter 3 of the CCMP, the development of a Habitat Protection Action Plan. The CCMP, which serves as the guiding document for the restoration, enhancement, and protection of the Inland Bays Watershed, states:

"The goal of the habitat protection action plan is to protect, restore, and enhance living resources by improving water quality, controlling land use, and reducing habitat loss. Preserving habitat requires comprehensive planning to maintain the integrity of the Inland Bays by protecting freshwater wetlands; protecting shallow water, subaqueous land, and upland habitats; identifying, protecting, and enhancing living resources; and prohibiting damaging activities. At the same time, responsible public access and use of the Bays is highly desirable."



Aerial photographs of the mouth of White's Creek in 1927 (lt.) and in 2002 (rt.) highlight changes in land use. Pasture Point at the James Farm Ecological Preserve is located in the upper right-hand corner of each photograph.

PURPOSE (cont.)

The rare plant Swamp-pink (Helonias bullata) is a federally-listed endangered species. Growing to nearly 3' tall, it spreads by rhizomes and requires the saturated soils found in a floodplain. It has very specific criteria for where the groundwater level is in relation to its roots. Too much sediment or too many nutrients in surface and groundwater may affect its survivability.

Photo credit: Bill McAvoy (DNREC)

An example of a generalist would be a Gray Squirrel (*Sciurus carolinensis*) which will nest in trees cavities, attics of buildings, or other similar natural or man-made structures. They will also feed at a variety of locations including bird feeders.

A specialist on the other hand, such as the Pileated Woodpecker (*Dryocopus pileatus*), nests only in cavities in large trees in mature forested tracts, usually found in and around the floodplain of rivers and streams in our area. Their diet consists primarily of insects living in dead or dying trees found in forested areas.

Almost every species of plant and animal requires certain living (biotic) and non-living (abiotic) resources to be able to survive and reproduce. For animals, it is a place to safely raise its young and a location with adequate food and water. For plants, it is a certain amount of sunlight, a source of nutrients, and a source of water whether it is from precipitation, groundwater, or tidal exchange.

Animals that are considered "generalists" can usually handle a broader range of habitat types when it comes to finding food and reproducing and are more likely to be able to adapt to changes in conditions. On the other hand, those that are considered "specialists" may find it more difficult to breed or find food except only under very narrowly prescribed conditions.

As an amphibian, the Eastern Tiger Salamander (Ambystoma tigrinum tigrinum) can be found in coastal plain seasonal ponds (Delmarva Bays). They require shallow water areas to lay their eggs and for the young to mature in, and a moist forest bottom in which to feed; all of which are found in Delmarva Bays.

Photo credit: University of Georgia

The Delmarva Fox Squirrel (Sciurus niger cinereus) is the largest tree-dwellling squirrel in the western hemisphere, nearly twice the size of its local relative the Gray Squirrel. It requires food producing trees such as oaks and hickories and prefers mature mixed forests with an open understory.

Photo credit: DNREC

PURPOSE (cont.)

Due to its moderate climate and coastal location, the Inland Bays watershed has a broad variety of plants and animals. Some are generalists and are seen on a regular basis and some are specialists and may rarely be seen, if ever.

The few examples of rare plants and animals found in the Inland Bays and previewed here, and the types of habitat they need to survive, often serve as bellwethers to the overall health of the Inland Bays.

The priority areas, goals, and objectives outlined in this plan are intended to help protect and to restore the unique and important habitat areas that these and many other species need.

ENDANGERED SPECIES OF DELAWARE *(Effective June 12, 2000)*

Birds

Brown Creeper (*Certhia americana*)
Bald Eagle (*Haliaeetus leucocephalus*)
Pied-billed Grebe (*Podilymbus podiceps*)
Northern Harrier (*Circus cyaneus*)
Cooper's Hawk (*Accipiter cooperii*)
Black-Crowned Night Heron (*Nycticorax nycticorax*)
Yellow-Crowned Night Heron (*Nyctanassa violacea*)
Northern Parula (*Parula americana*)
Piping Plover (*Charadrius melodus*)
Short-eared Owl (*Asio flammeus*)
American Oystercatcher (*Haematopus palliatus*)
Black Rail (*Laterallus jamaicensis*)
Upland Sandpiper (*Bartramia longicauda*)
Loggerhead Shrike (*Lanius ludovicianus*)
Black Skimmer (*Rynchops niger*)
Henslow's Sparrow (*Ammodramus henslowii*)
Common Tern (*Sterna hirundo*)
Forster's Tern (*Sterna forsteri*)
Least Tern (*Sterna antillarum*)
Cerulean Warbler (*Dendroica cerulea*)
Hooded Warbler (*Wilsonia citrina*)
Swainson's Warbler (*Limnothlypis swainsonii*)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)
Sedge Wren (*Cistothorus platensis*)

Fish

Atlantic Sturgeon (*Acipenser oxyrhynchus*)

Amphibians

Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*)
Barking Treefrog (*Hyla gratiosa*)

Reptiles

Leatherback Sea Turtle (*Dermochelys coriacea*)
Atlantic Ridley Sea Turtle (*Lepidochelys kempii)*
Green Sea Turtle (*Chelonia mydas*)
Loggerhead Sea Turtle (*Caretta caretta*)
Bog Turtle (*Clemmys muhlenbergii*)
Corn Snake (*Elaphe guttata guttata*)

Mammals

Delmarva Fox Squirrel (*Sciurus niger cinereus*)

Mollusks

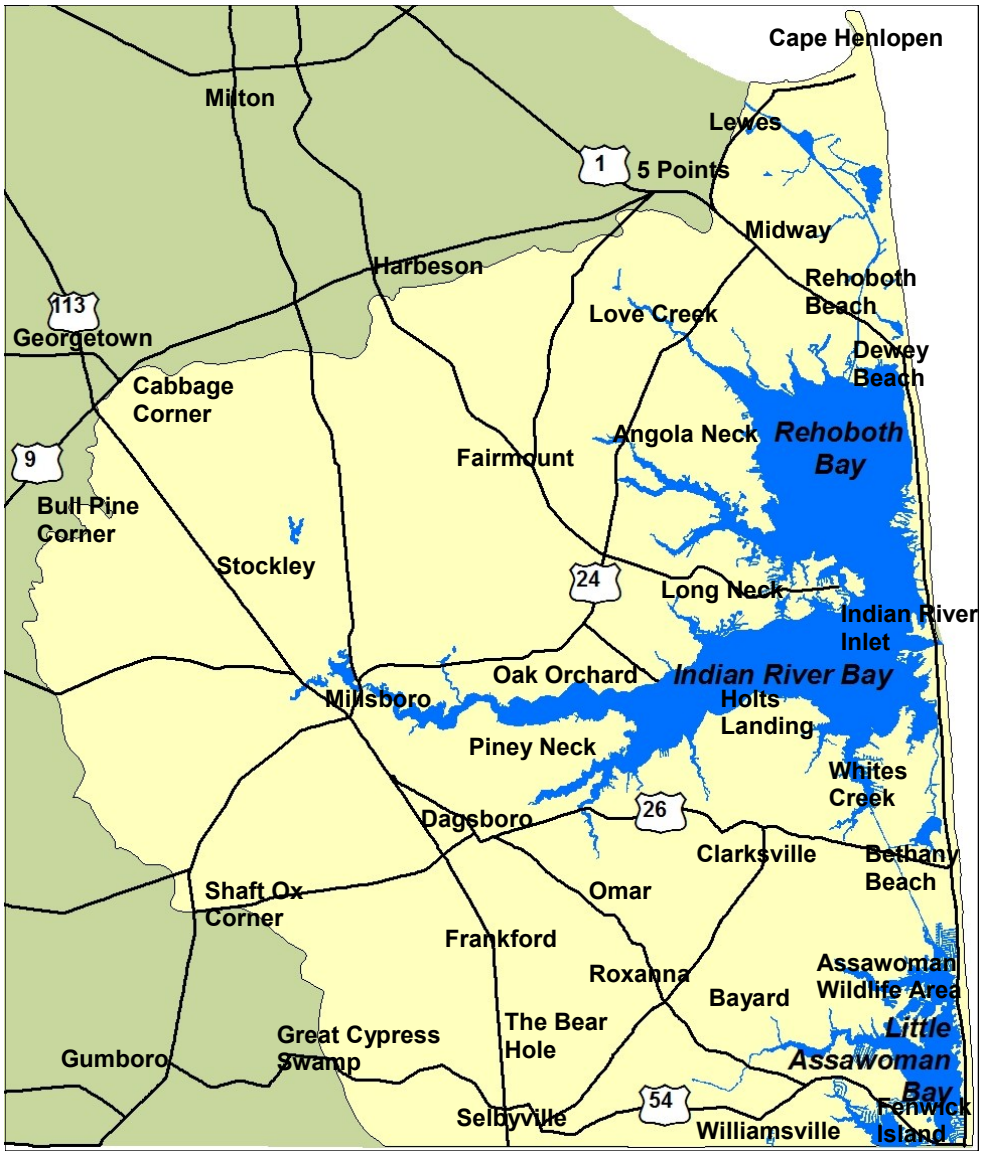
Yellow Lampmussel *(Lampsilis cariosa*)
Eastern Lampmussel (*Lampsilis radiata*)
Dwarf Wedgemussel (*Alasmidonta heterodon*)
Eastern Pondmussel (*Ligumia nasuta*)
Brook Floater (*Alasmidonta varicosa*)
Tidewater Mucket (*Leptodea ochracea*)

Insects

Little White Tiger Beetle (*Cicindela lepida*)
White Tiger Beetle (*Cicindela dorsalis)*
Seth Forest Scavenger Beetle (*Hydrochus* sp.)
Frosted Elfin (*Incisalia irus*)
Bethany Firefly (*Photuris bethaniensis*)
Hessel's Hairstreak (*Mitoura hesseli*)
King's Hairstreak (*Satyrium kingi*)
Rare Skipper (*Problema bulenta)*
Mulberry Wing (*Poanes massasoit chermocki*)

Known as a Neotropical migrant (page 13), the Hooded Warbler (Wilsonia citrina) needs fairly large areas (80-250 acres) of mixed or deciduous forests as their nesting area that has a shrub layer in the understory. They are insect eaters and their habitat is usually near water. They typically migrate to southeastern Mexico and parts of the Caribbean for the winter.
Photo Credit: Cornell Lab of Ornithology

PURPOSE (cont.)



CCMP Tactics related to habitat protection, restoration, and enhancement

G2: Protect, restore, and enhance living resources by improving water quality and protecting and enhancing habitat.
G2A: Promote recurrence of submerged aquatic vegetation.
G2B: Restore finfish and shellfish populations.
G2C: Decrease potential for fish kills.
G2F: Enhance and restore impacted shallow and near-shore habitats.
G3B: Provide maximum protection of waterways, groundwater, natural areas, open space, and tidal and non-tidal wetlands.

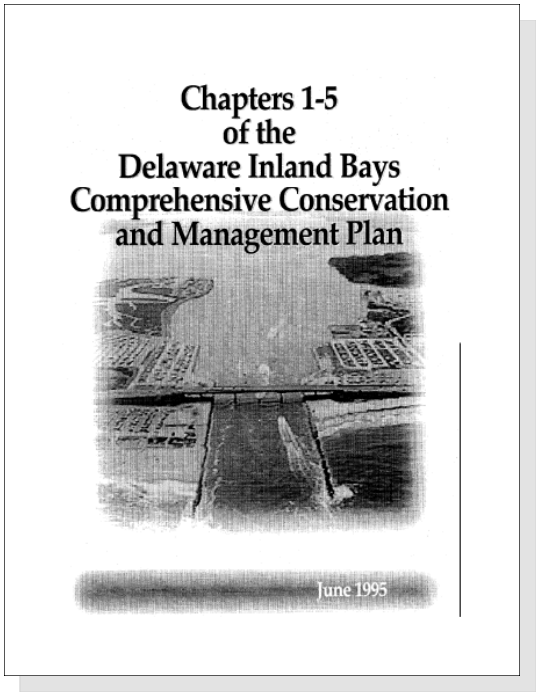
The purpose of this plan is to guide and support restoration and land protection efforts in the watershed for many years to come. The plan helps to identify areas in need of restoration, enhancement, or protection and can be used by governmental agencies, non-governmental organizations (NGOs), and individuals to accomplish the goals outlined within. This plan does not attempt to compete with other successful federal, state, or local programs, rather it serves to compliment their efforts and to focus attention on priority areas using water quality and biodiversity as the means to an end. In keeping with the CCMP, the plan is ever mindful of the fact that the Inland Bays is a resource to be used and treasured by all. Wherever possible, responsible public use and access should be a consideration.

"Let us a little permit Nature to take her own way: she better understands her own affairs than we."

Michel De Montaigne

Delaware Inland Bays CCMP Summary

The following information is summarized from the Delaware Inland Bays Comprehensive Conservation and Management Plan, which was approved in June of 1995. The overarching goal of this action plan involves the protection, restoration, and enhancement of living resources by improving water quality and protecting and enhancing habitat.



Chapter 3. Habitat Protection Action Plan
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CCMP Action Plan
The goal of the habitat protection action plan is to protect, restore, and enhance living resources by improving water quality, controlling land use, and reducing habitat loss. Preserving habitat requires comprehensive planning to maintain the integrity of the Inland Bays by protecting freshwater wetlands; protecting shallow water, subaqueous land, and upland habitats; identifying, protecting, and enhancing living resources; and prohibiting damaging activities. At the same time, responsible public access and use of the Bays is highly desirable.

Since the Inland Bays' natural resources have been adversely affected historically and currently exist at below-optimal levels, there is great potential for improved habitat and greater numbers of desirable organisms. This improvement will require proper management, stewardship, and responsible use and harvest by the public.

Summary of Tactics to a Cleaner Inland Bays Goals and Objectives
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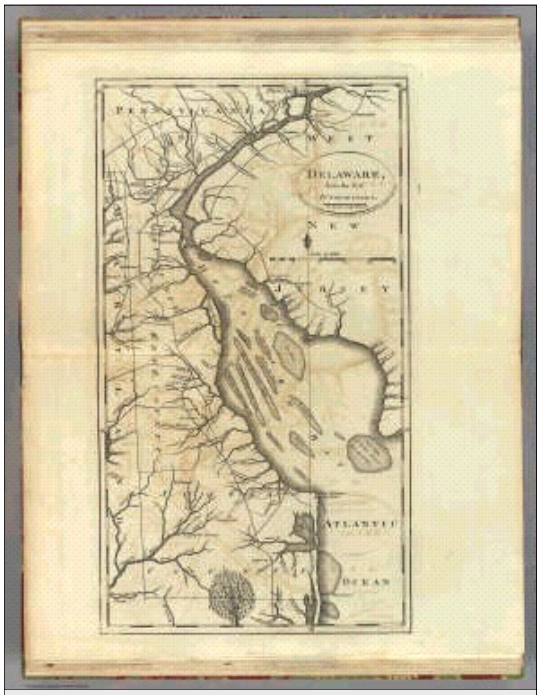
- G2: Protect, restore, and enhance living resources by improving water quality and protecting and enhancing habitat.
- G2A: Promote recurrence of submerged aquatic vegetation.
- G2B: Restore finfish and shellfish populations.
- G2C: Decrease potential for fish kills.
- G2F: Enhance and restore impacted shallow and nearshore habitats.
- G3B: Provide maximum protection of waterways, groundwater, natural areas, open space, and tidal and non-tidal wetlands.
- G7B Attain maximum wetlands preservation by providing adequate setbacks and buffer zones.
- G7C Develop regulations to protect non-tidal wetlands.
- G7D Strengthen enforcement of existing wetland protection regulations.
- G7F Develop criteria to implement policy for use of rip-rap and vegetation for shoreline protection.

BACKGROUND

Impacts and Trends in the Watershed

Once renowned for its farmland, wooded areas, and open space, the Inland Bays watershed is under tremendous pressure from development and recreational use. Being located in an area with a moderate climate, having 25 miles of Atlantic coastline, offering a relatively low cost of living, and being within a 4-hour drive of Baltimore, Maryland, Washington, D.C., and Philadelphia, Pennsylvania, eastern Sussex County is a desirable destination for vacationers, retirees, and the businesses that support them. The following trends in population growth and land use give an indication why these types of restoration projects are vital to the ecological health of the Inland Bays watershed.



1795 Map of Delaware *David Rumsey Collection*

Population Growth

Considerable growth in population and associated land development has impacted many living resources in and around the Inland Bays. A popular vacation spot since before the turn of the 20th century, coastal Sussex County has experienced unprecedented growth over the past 50 years. Table 1 lists actual and projected changes in population for Sussex County from 1950 through 2030. Note that in 1950, the population of the county was 61,336 and that by 2030, the Delaware Population Consortium estimates that it will exceed 253,000. Because of the area's popularity, the county's population has seen double-digit growth for the past half century, averaging an unprecedented 21.1% from 1960 to 2000. With an area of approximately 959 square miles of land, the density of people per square mile of land in Sussex County has increased from 64 in 1950 to 164 in 2000.

Based on the 2000 census, estimates placed the population of year-round residents within the Inland Bays watershed at 70,008 individuals (Table 2). Looking exclusively at the population growth trends in the Inland Bays watershed, note that when the entire county experienced a population growth rate of over 39%, the Inland Bays grew by almost 60%. With an area of approximately 300 square miles of land, the density of people per square mile of land in the Inland Bays increased from 148 in 1990 to 233 in 2000 during this time of unprecedented growth. Using the moderately conservative Sussex County growth rates developed by the Delaware Population Consortium, applied to the Inland Bays watershed, the area could have a population of 112,593 people with a density of 375 people per square mile by the year 2030.

Some estimates, although anecdotal, indicate that the population in the county may triple during summertime weekends with the number of visitors that come to visit the Inland Bays and adjoining coastal area.

Table 2

	1990	2000	Increase	% Increase
Delaware	666,168	783,600	117,432	17.6%
Sussex County	113,863	156,638	42,775	37.6%
Inland Bays	44,430	70,008	25,578	57.6%

Table 1

Year	1950	1960	1970	1980	1990	2000	2010	2020	2030
Sussex Population	61,336	73,195	80,356	98,004	113,229	157,459	194,430	226,766	253,240
Increase	-	11,859	7,161	17,648	15,225	44,230	36,971	32,336	26,474
% Increase	-	19.3%	9.8%	22.0%	15.5%	39.1%	23.5%	16.6%	11.7%
Persons per Sq. Mi.	64	76	84	102	118	164	203	236	264

BACKGROUND (cont.)

Economic Impact

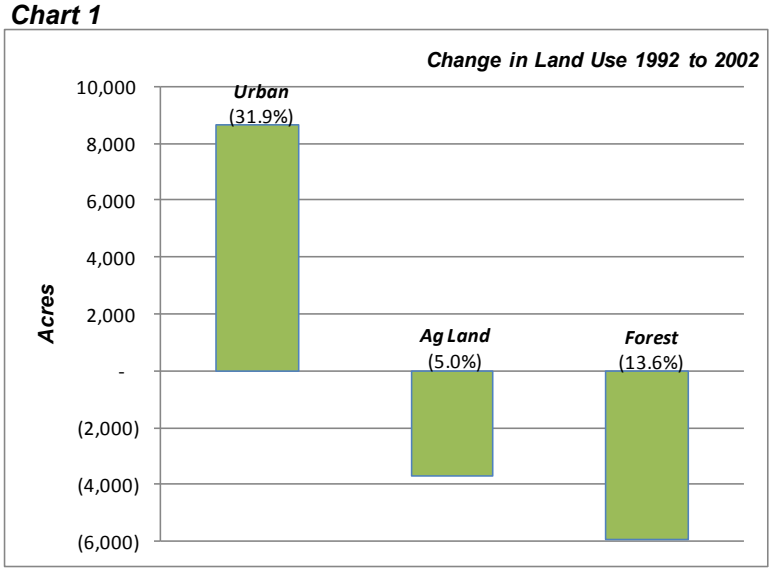
In 1996, $507,000,000 was spent state-wide in Delaware on wildlife-associated recreation. This involved 232,000 individuals over the age of 16 who hunted, fished, bird watched, or photographed wildlife. In 2006, although there was a decrease in amount of money spent since the 1996 study, there was a sizable increase in the number of individuals who participated in these various outdoor activities when 395,000 individuals spent $299,000,000. In their pursuit of recreation, these individuals supported local businesses through the purchase of fuel, equipment, supplies, rentals, lodging, food, bait and tackle, permit fees and licenses, leases, guide services, etc. Obviously, these activities are dependent upon a healthy environment with stable plant and animal populations. Because of this direct economic relationship between wildlife-associated recreation and plants, animals, and the habitat that supports them, it is all the more important to protect what remains and to restore what is impaired.

As for the economic impact of tourism, the company *Global Insight* estimated that in 2003, the core tourism industry in eastern Sussex County employed over 9,000 people and in 2004 it was estimated that tourism accounted for over $600,000,000 spent on the sales of merchandise, accommodations, meals, and entertainment. Certainly far fewer visitors than the number estimated in surveys actually visited the Inland Bays for recreational purposes, but even if a small percentage did, the economic impact would be sizable. Again, the need for clean water and healthy plant and animal populations are needed to support key recreational activities that bring tourists who come to fish, clam, crab, boat, and swim in the Bays' waters.

Increases in Developed Land

A comparison of a 1992 University of Delaware and a 2002 DNREC land-use analyses indicates that Residential/Urban and Commercial/Industrial land uses grew by nearly 32% during the study period (see Chart 1 and Table 3). Both studies evaluated land use/land cover specifically for the Inland Bays watershed. Primary impacts from increases in developed land that affect habitat areas are the loss of forested lands, scrub/shrub areas, and wetlands. These areas serve a feeding, resting, and nesting areas for many animals.

Chart 1



The loss of habitat can drive animals out of an area entirely or force them closer together, increasing chances for loss due to disease, predation, and starvation as food resources dwindle. Additional impacts can result from changes in hydrology (increased runoff and less infiltration), increases in nutrient concentrations in runoff, the introduction of non-native, invasive species (both plant and animal), and death or injury to animal species from automobile and pet encounters. Also, as larger forested blocks are separated into isolated "islands" of fragmented woods, there is a potential that inbreeding within animal populations can increase, affecting the health and long-term survivability of a species.

Table 3

1992 UD Analysis	*Acres*	*2002 DNREC-DWR*	*Acres*	*Change*	*% Change*
Urban	27,135	Urban	35,797	8,662	31.9%
Ag Land	74,722	Ag Land	70,997	(3,725)	-5.0%
Forest	43,587	Forest	37,667	(5,920)	-13.6%

BACKGROUND (cont.)

"Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetlands soils." U.S. EPA

Wetland Status and Trends

Over the years, the Inland Bays has lost a considerable amount of its wetland resources to both natural events and anthropogenic activities. Some estimates place the amount of wetland acreage lost as high as 60%. Information on page 32 lists a number of the ecosystem services that various types of wetlands provide.

As more and more land within the Inland Bays is converted toward urban/suburban land uses, what little wetland resources are left will be unable to perform many of the functions such as nutrient retention and removal and flood control; hence the need to protect, enhance, or restore wetlands wherever possible. Greater detail on wetland status and trends in the Inland Bays is provided starting on page 32.

Forests and wetlands of the Inland Bays.

Forested Land Classification

When used in this plan, references to forest type are based on the Anderson Classification system. Forested or wooded land use/land cover falls into three primary categories that includes any species of plant that produces an aerial stem that persists for more than one season and includes Evergreen, Deciduous, and Mixed Forest.

- *Evergreen Forest Classification* includes those areas in which 2/3rd of the trees remain green throughout the year. This includes both coniferous and broad-leaf evergreens such as Loblolly Pine (*Pinus taeda*) and the American Holly (*Ilex opaca*).
- *Deciduous Forest Classification* includes those areas having a predominance of trees that lose their leaves or needles at the end of the frost-free season. These areas are dominated by single-stemmed, woody vegetation unbranched two to three feet above the ground having a height of at least 20 feet. This includes trees such as Oaks (*Quercus spp*), Maples (*Acer spp*), Yellow Poplar (*Liriodendron tulipifera*), and Hickories (*Carya spp*).
- *Mixed Forest Classification* includes those areas where both evergreen and deciduous trees and shrubs grow and neither predominates.

Wildlife Habitat Buffer Size Justification

An important practice to help restore critical wildlife habitat will be the implementation of forested riparian buffers. A general recommendation or "rule-of-thumb" on buffer width from the stream edge is 300 feet. For the purposes of this plan, 250 feet was used, based on local considerations such as the lack of any appreciable slope in the flood plain or adjacent uplands, soils, potential for flooding, cost to implement, and a perceived willingness by landowners to implement larger buffers. Following is additional justification on the width of the wildlife habitat buffer recommended in this plan.

In a review of scientific literature, Richard Fisher et al found a variety of ranges for buffer widths depending upon the ultimate goal. For instance, the results of their review indicated that to provide adequate habitat for reptiles and amphibians the range was from 98 feet to 3,280 feet (30 m. to 1,000 m.), for bird habitat they found a range from 131 feet to 5,249 feet (40 m. to 1,600 m.), to maintain plant diversity they found a minimum recommendation of 98 feet (30 m.), and to maintain an unaltered microclimate gradient the minimum recommendation was for 147 feet (45 m.).

In 2004, the U.S. Army Corps of Engineers issued draft guidance on vegetated buffer widths related to compensatory mitigation and require wildlife habitat buffers in a range from 95 feet to more than 330 feet depending upon species. In the process of developing habitat protection ordinances for the City of Tampa, Florida, Gregory Howe found in a review of literature that R. Forman and M. Gordon recommended that to be

BACKGROUND (cont.)

effective, wildlife corridors required a width greater than 600 feet. Regionally, the Chesapeake Bay Program recommends riparian forest buffers of 300 feet in order to provide adequate wildlife habitat.

Neotropical Migratory Species of Birds

According to U.S. Fish and Wildlife Service, "There are 341 species of neotropical migratory birds that breed in the United States and Canada and winter in Latin America including species of plovers, terns, hawks, cranes, warblers and sparrows. Many of these birds are presently in decline, and several species are protected as threatened or endangered under the Endangered Species Act."

Neotropical migrant species can be defined as bird species in the Western Hemisphere of which a majority of individuals of that species breed north of the Tropic of Cancer and spend their winters south of that same line, 23 degrees North latitude. This can include winter grounds in South and Central America, the Caribbean Islands, and Mexico, and summer grounds in the U.S. and Canada.

According to local records (Table 4), there are 84 species of neotropical migratory birds that either migrate through or spend their summer season in Delaware. Of the 84 species, 63% remain in Delaware to breed and nest, 29% are considered rare in Delaware, and 19% have either a "high" or "moderately high" risk of extinction based on the total range size and percent of breeding range in the northeastern U.S. Approximately 7% of these species meet all three of the previously mentioned criteria.

Many of these species of birds require large blocks of forested land to breed, nest, raise their young, and search for food.

Table 4

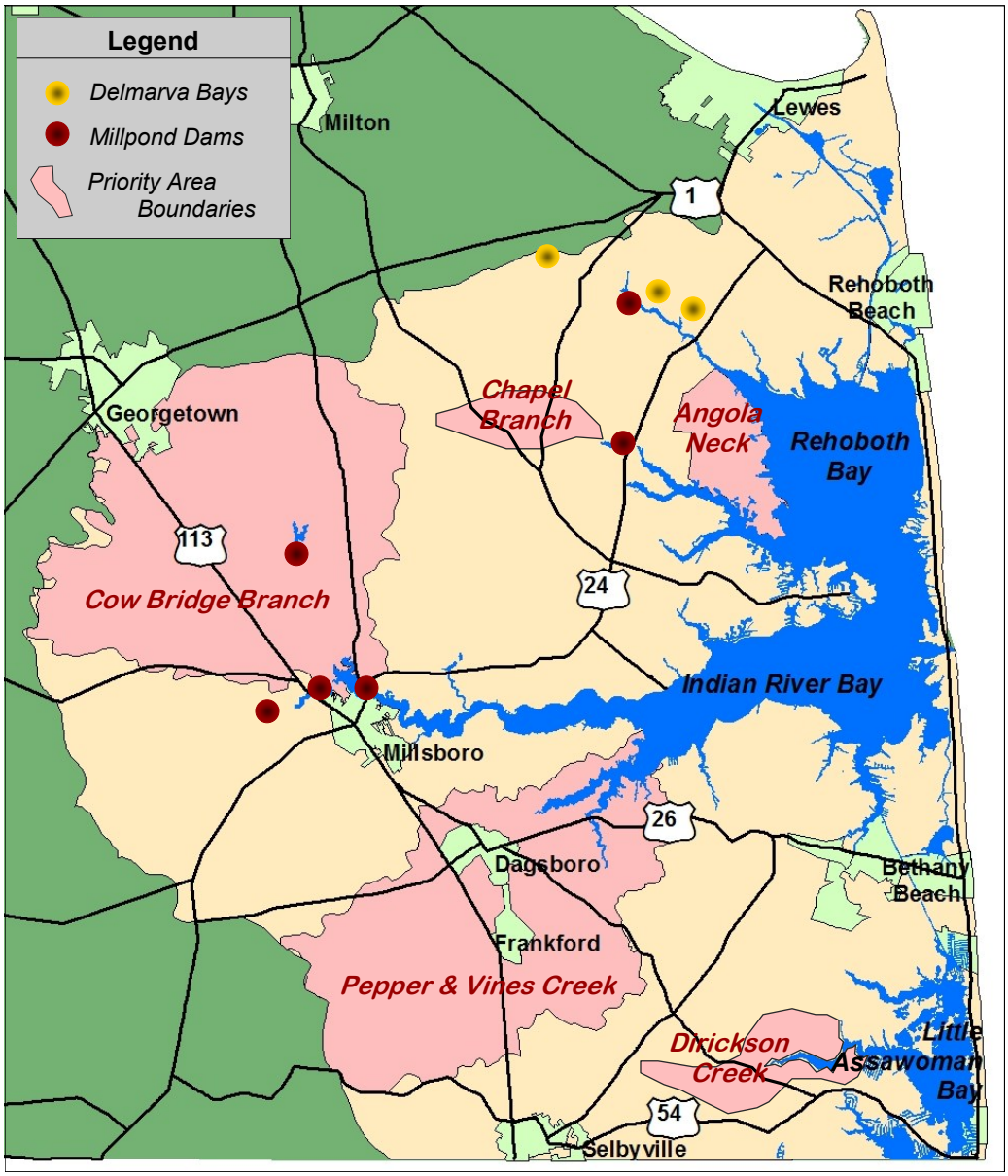
DELAWARE NEOTROPICAL MIGRANTS

1. **M** Migrates through DE
   B Breeds and nests in DE
   H Historically bred in Delaware
2. Abundance in DE (**C** = common, **R** = rare)
3. Extinction Risk Category, based on total range size and % of breeding range in the northeast U.S. (High Risk = ***, Mod. High Risk = **, Mod. Low Risk = *)

	1	2	3
Broad-winged Hawk	B	R	
Merlin	M	-	
Peregrine Falcon	B	R	
Upland Sandpiper	H	R	
Black-billed Cuckoo	B	R	*
Yellow-billed Cuckoo	B	C	*
Common Nighthawk	B	R	
Chuck-will's-widow	B	R	
Whip-poor-will	B	C	*
Chimney Swift	B	C	*
Ruby-throated Hummingbird	B	C	*
Olive-sided Flycatcher	M	-	
Eastern Wood Pewee	B	C	*
Yellow-bellied Flycatcher	M	-	
Acadian Flycatcher	B	C	**
Alder Flycatcher	M	-	
Willow Flycatcher	B	R	*
Least Flycatcher	M	-	
Eastern Phoebe	B	C	*
Great Crested Flycatcher	B	C	*
Eastern Kingbird	B	C	
Purple Martin	B	C	*
No. Rough-winged Swallow	B	C	
Bank Swallow	B	R	
Cliff Swallow	B	R	
Barn Swallow	B	C	
Blue-gray Gnatcatcher	B	C	*
Veery	B	R	*
Grey-cheeked Thrush	M	-	
Swainson's Thrush	M	-	
Wood Thrush	B	C	*
Gray Catbird	B	C	
White-eyed Vireo	B	C	**
Solitary Vireo	M	-	*
Yellow-throated Vireo	B	R	*
Warbling Vireo	B	R	
Philadelphia Vireo	M	-	
Red-eyed Vireo	B	C	
Blue-winged Warbler	B	R	**
Golden-winged Warbler	M	-	***
Tennessee Warbler	M	-	
Orange-crowned Warbler	M	-	
Nashville Warbler	M	-	**
Northern Parula Warbler	B	R	*
Yellow Warbler	B	C	
Chestnut-sided Warbler	B	R	***
Magnolia Warbler	M	-	
Cape May Warbler	M	-	
Black-throated Blue Warbler	M	-	***
Black-throated Green Warbler	M	-	*
Blackburnian Warbler	M	-	***
Yellow-throated Warbler	B	R	
Prairie Warbler	B	C	
Palm Warbler	M	-	
Bay-breasted Warbler	M	-	
Blackpoll Warbler	M	-	
Cerulean Warbler	B	R	**
Black-and-white Warbler	B	R	
American Redstart	B	R	
Prothonotary Warbler	B	C	
Worm-eating Warbler	B	R	***
Swainson's Warbler	H	-	
Ovenbird	B	C	*
Northern Waterthrush	M	-	
Louisiana Waterthrush	B	C	**
Kentucky Warbler	B	R	**
Connecticut Warbler	M	-	
Mourning Warbler	M	-	**
Common Yellowthroat	B	C	
Hooded Warbler	B	R	**
Wilson's Warbler	M	-	
Canada Warbler	M	-	**
Yellow-breasted Chat	B	R	
Summer Tanager	B	R	
Scarlet Tanager	B	C	***
Rose-breasted Grosbeak	M	-	*
Blue Grosbeak	B	C	
Indigo Bunting	B	C	*
Chipping Sparrow	B	C	
Grasshopper Sparrow	B	R	*
Lincoln's Sparrow	M	-	
Orchard Oriole	B	C	
Baltimore Oriole	B	C	
Bobolink	M	-	*

The birds on this list can be seen in Delaware. Many breed here; others are seen only in migration to their more northern nesting grounds. They all spend their non-breeding period primarily south of the U.S.

PRIORITY AREA OVERVIEW



This habitat restoration, enhancement, and protection plan is not so much a site-specific project plan, rather it identifies key areas, types of projects, and issues or concerns for consideration and inclusion with other activities or priorities under consideration by the Center for the Inland Bays; local, state, and federal governmental agencies; other NGOs; and private individuals.

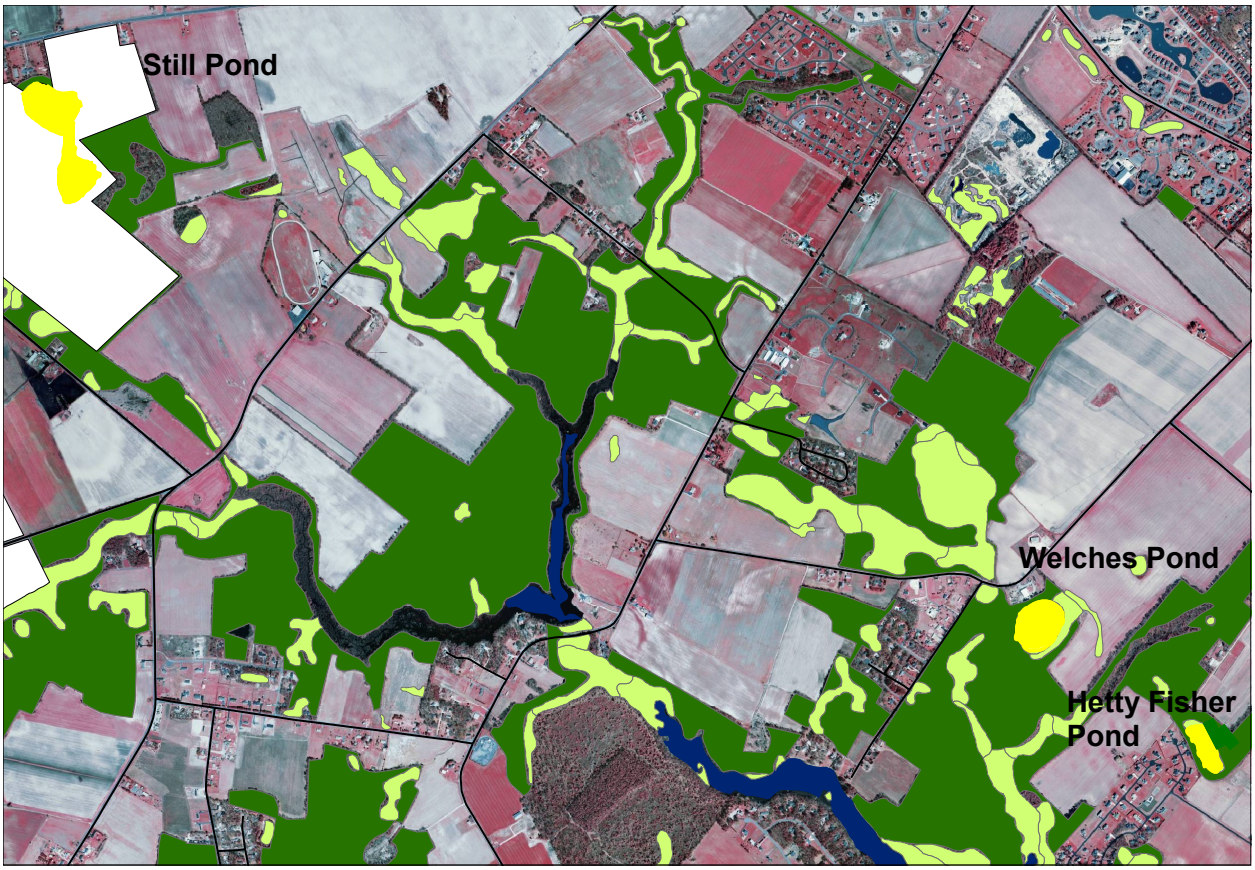
Smaller Priority Areas (Delmarva Bays, Angola Neck, etc.) have been well-studied and are small enough that the plan suggests specific targets for restoration. Larger Priority Areas (Cow Bridge Branch and Pepper & Vines Creek) are considerably larger areas with more opportunities and options on potential restoration, so in these cases the plan offers a range of potential restoration goals.

Within each priority area or project activity is the need for site-specific assessment and evaluation, planning, design, and project monitoring based on the goals and objectives of each particular site or project. Those plans will need to consider such factors as specific ecosystem benefits, soils, hydrology, construction feasibility, costs, funding availability, and operation and maintenance issues and requirements.

"When the heron takes flight, what a change in size and appearance! It is presto change! There go two great undulating wings pinned together, but the body and the neck must have been left behind somewhere."

Henry David Thoreau

Delmarva Bays (#1)



Description: Formed approximately 100,000 years ago, these shallow, nearly-circular depressions in the ground seasonally fill with freshwater creating non-tidal wetland embayments that are usually groundwater or precipitation-driven and normally do not receive surface water inflows. Delmarva Bays can range from less than an acre to tens of acres in size.

More common in the northern parts of the Delmarva Peninsula and relatively rare in the Inland Bays watershed, Delmarva Bays are also referred to as *whale wallows* and should not be confused with tidal or estuarine embayments such as lagoons, salt ponds, back bays, coastal bays. They are more technically known as Coastal Plain Seasonal Ponds.

During the winter and spring months, Delmarva Bays fill with water and provide critical habitat for amphibians, reptiles, plants, and insects. During drier times in the summer and fall, the Bays will usually dry out and fill with mosses, grasses, sedges, rushes, and shrubby plants. All three Delmarva Bays shown above are in private or community association ownership.

Goal: Work closely with private landowners, area businesses, and local, state, and federal agencies to determine what impacts are affecting the function of the Delmarva Bays, such as invasive species, changes in hydrology, and the loss of forested buffers, and to cooperate on their restoration.

The three Delmarva Bays shown above: Hetty Fisher Pond (lower right corner); Welches Pond (northwest of Hetty Fisher); and Still Pond (upper left corner) are highlighted in yellow and are shown over an infrared image of the northwestern Rehoboth Bay watershed.

Forested areas are shown in dark green and wetlands of various types, including tidal (estuarine) and non-tidal (palustrine) forested, shrub, and emergent, are shown in light green. This map shows how each pond has different stressors and needs.

- Hetty Fisher Pond has a multi-unit subdivision along its western edge that uses the pond for stormwater drainage and has very little wooded buffer to the north and south.

Delmarva Bays (cont.)

- Welches Pond has very little wooded buffer on two sides and a commercial operation that also drains into the pond.
- Still Pond and the wooded areas to the north, west, and south are protected through the agricultural easements (red cross-hatched area). Several homes are located immediately adjacent to Still Pond and there is a need to control non-native invasive plants. The area to the east is currently under development. Wetland areas are not shown adjacent to Still Pond in this image.

Table 5

Delmarva Bay	*Approx. Size in Acres*
Hetty Fisher Pond	3.24
Welches Pond	5.92
Still Pond	16.09

A shallow-water area in Hetty Fisher Pond. These areas are very sensitive to invasive plants, the addition of surface runoff, and loss of wooded buffers.

Objective 1: Protect Delmarva Bays -

1. Work directly with private landowners to educate them about the uniqueness of the Delmarva Bays located on or adjacent to their property.
2. Work closely with the landowners and key groups such as the DNREC Heritage Program and *The Nature Conservancy* to determine threats and opportunities that exist at all three Delmarva Bay sites, such as surface water inflows, loss of wooded buffers, excessive groundwater withdrawal, etc.
3. Assist in determining what actions, opportunities, or programs, if any, exist to assist the landowners in protecting the Delmarva Bays, such as conservation easements, tax incentives, fee simple sale to conservation groups (if that is the landowner's desire), building/ construction setbacks, etc.
4. Protect 25+ acres (Table 5) of Delmarva Bays in the watershed through easements, purchase, or enhancement.
5. Estimated cost to complete this objective of working with the 15 adjoining landowners would involve agency and NGO staff time and legal costs for document preparation.

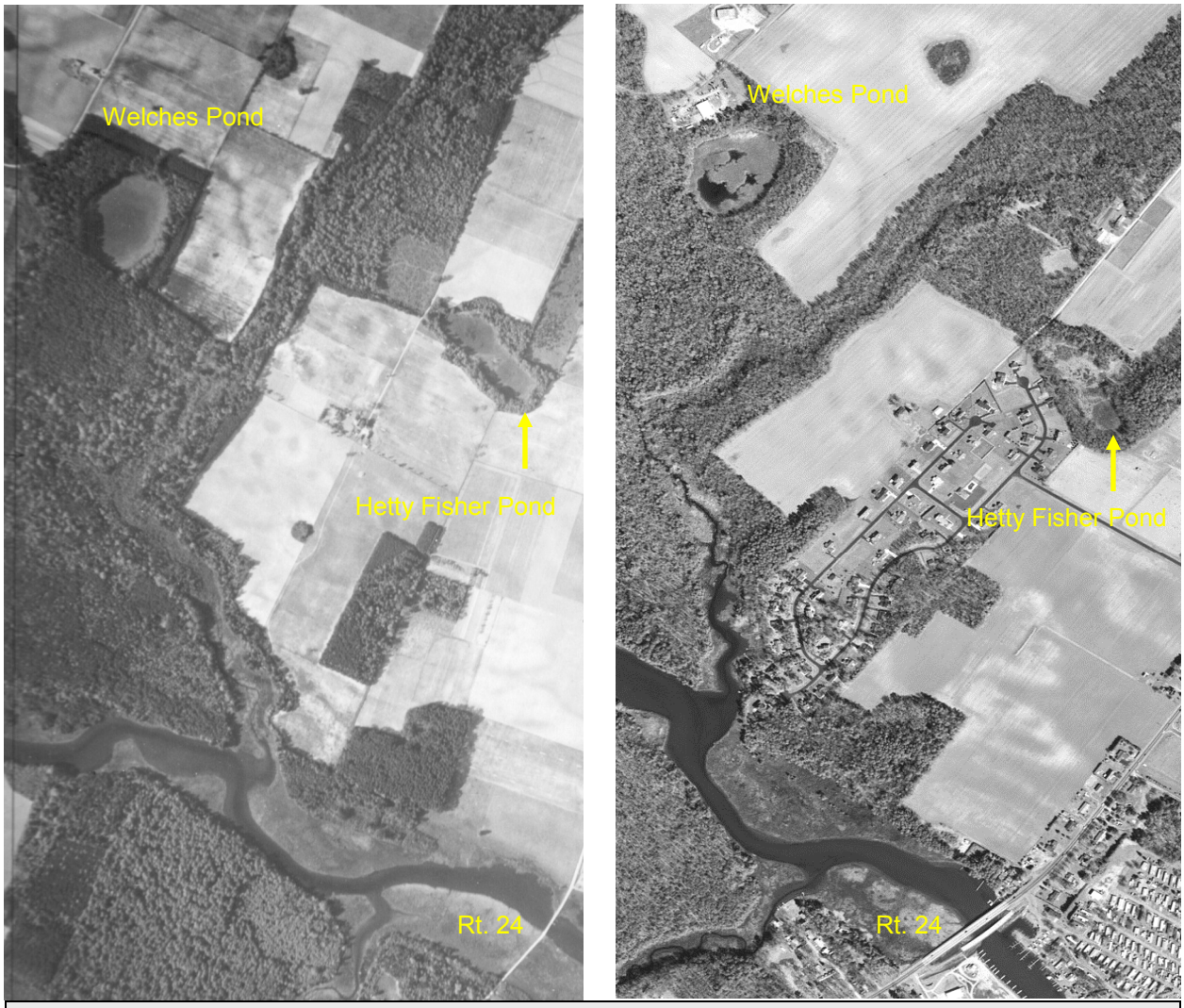
Objective 2: Assess Delmarva Bay Hydrology -

1. Work with hydrologists from the USDA-Natural Resources Conservation Service, the U.S. Geological Survey, Delaware Geological Survey, and Delaware Department of Natural Resources and Environmental Control to determine subsurface flow characteristics and its affects on the Delmarva Bays, along with the impacts of stormwater runoff from adjoining properties.
2. Based on the hydrologists' findings, assist in determining the causes and potential solutions to localized groundwater impacts.
3. Work with the U.S Department of Agriculture, Cooperative Extension System, Delaware Department of Natural Resources and Environmental Control, Delaware Department of Agriculture, local landowners, farmers, and businesses to address groundwater conservation and surface runoff.
4. The estimated cost of completing this objective (hydrologic analysis) and to address stormwater impacts at both Hetty Fisher and Welches Pond is $40,000.

Objective 3: Control Non-native, Invasive Species -

1. Work with the Delaware Invasive Species Council, U.S. Departments of Agriculture and Fish and Wildlife Service, the Delaware Departments of Agriculture, Transportation, and Natural Resources and Environmental Control to identify which non-native, invasive species are threatening the areas in and around the Delmarva Bays.
2. Prioritize findings and establish a list of problem plant and animal species, the areas threatened, potential funding, and partners to control and/or eliminate these nuisances.
3. Estimated cost to complete this objective is $7,600 over three years.

Delmarva Bays (cont.)



Welches and Hetty Fisher Pond, typical Delmarva bays, shown in 1926 (lt) and 2002 (rt). Changes in surrounding land use and increases in groundwater withdrawal and surface runoff threaten the long-term survivability of these small, unique ecosystems. Aside from increasing groundwater withdrawal and the loss of wooded buffers, all three ponds (Still Pond not shown) have adjoining developed land that are contributing additional runoff.

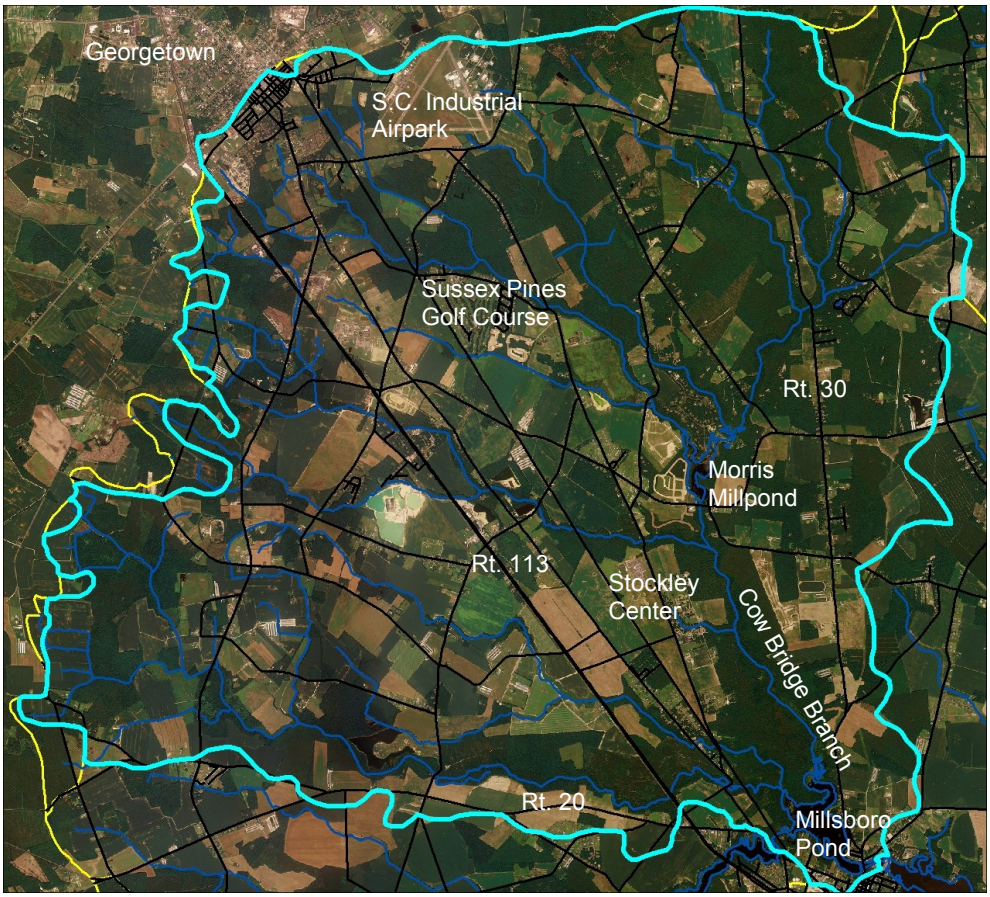
Objective 4: Delmarva Bay Restoration -

1. Based on the specific condition of each of the Delmarva Bays, work with local landowners and resource agencies and groups to identify areas for potential restoration. This may include; planting native trees, shrubs, and grasses to re-establish or increase the size of buffers around the Delmarva Bays; reducing or eliminating surface water sources discharging into the Delmarva Bays; removal or control of woody vegetation in open pond areas; and the elimination of non-native, invasive species.
2. The estimated cost to implement this objective of re-establishing a 250 foot riparian habitat buffer ranges from $2,500 to $6,500 depending upon site preparation needs. To control woody vegetation within the ponds and to replant desirable native vegetation is estimated to cost approximately $9,600 over a two year period. Site preparation costs for buffer planting can vary based on whether mowing, disking, or herbicide application is necessary before planting, as well as by the size and species of trees selected.

"We abuse land because we regard it as a commodity belonging to us. When we see the land as a community to which we belong, we may begin to use it with love and respect."

Aldo Leopold

Cow Bridge Branch (#2)



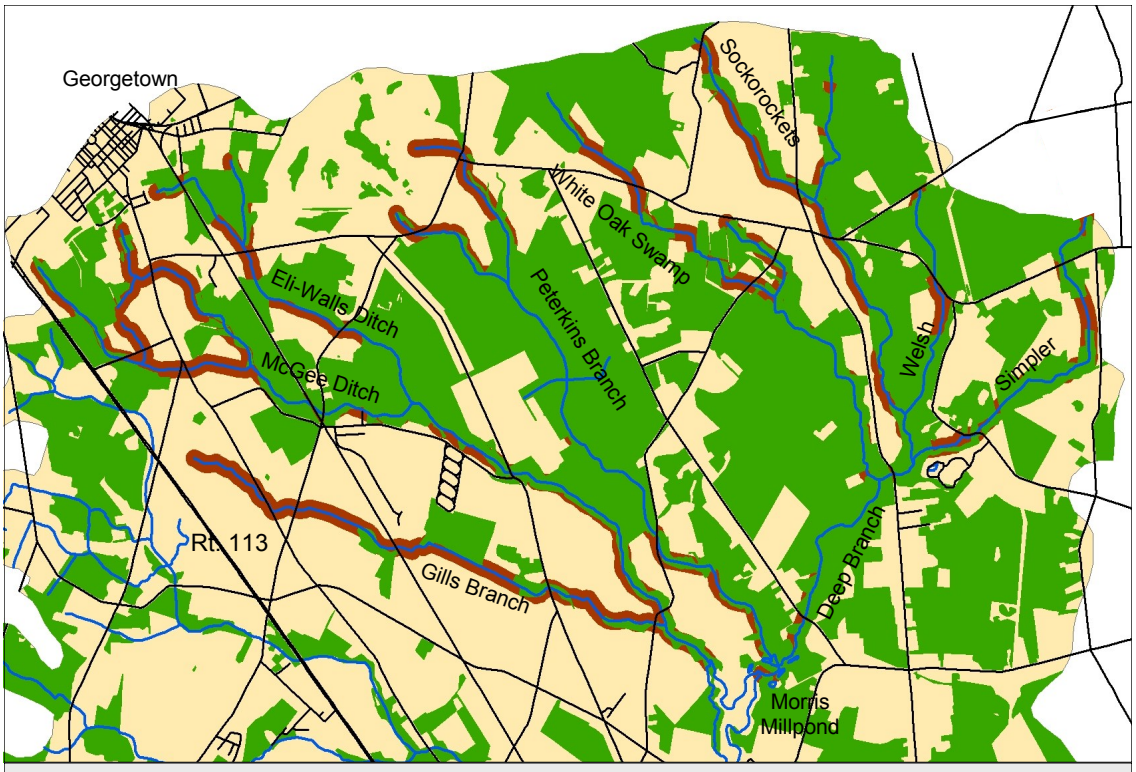
Description: Cow Bridge Branch physically starts below the dam and spillway of Morris Millpond and meanders south for approximately 2.5 miles until it empties into the upper end of Millsboro Pond. In the aerial photograph above (*USDA 2006*), the Cow Bridge/Millsboro Pond watershed is outlined in light blue (approximately 28,045 acres), primary streams and ditches in dark blue, with regional features labeled. The primary focus of this priority area is the main stem of Cow Bridge Branch and the headwater region above Morris Millpond, which is 11,100 acres.

Upstream from Morris Millpond, the tributaries that form Morris Millpond/Cow Bridge Branch include: Eli Walls and McGee Ditches and Gills Branch to the northwest; Peterkins Ditch to the north; and White Oak Swamp and Sockorockets Ditches and Welsh and Simpler Branches from the northeast. The confluence of White Oak Swamp, Sockorockets, Welsh, and Simpler form Deep Branch, which flows directly into Morris Millpond. Channel length of primary streams and ditches upstream of Morris Millpond total 30.7 miles or 161,870 linear feet. Forested lands within the Morris Millpond headwaters account for approximately 59.5% of the land cover, or 6,600 acres.

Because of this watershed's proximity to Georgetown, Millsboro, Sussex Correctional Institution, the Sussex County Industrial Airpark, and the Stockley Center, residential subdivision, single family home construction (road front strip lots), commercial development, and the clearing/conversion of farmland and wooded areas is occurring at a rapid pace. The impact of these activities have resulted in fragmented forested areas, a decrease in riparian areas, increases in stormwater runoff, increased nutrient loads, the spread of non-native, invasive plants and animals, thereby placing increased pressure on native plants and animals and the habitats they depend upon for survival.

Goal: Work closely with state and private landowners, area businesses, NGOs and land trusts, and local, state, and federal agencies to protect and enhance riparian area habitat, restore degraded headwater or channelized streams, protect unique habitat areas and open space, and reforestation.

Cow Bridge Branch (cont.)



The dark green areas above represent forested lands (2007). The red areas shown along certain streams and ditches represents a 250' forested buffer on both sides of the waterway where habitat areas could be re-established.

Objective 1: Reforestation-

1. Work closely with state and federal agencies to identify potential areas on state or privately-owned lands for native species reforestation/aforestation.
2. Assist state and federal agencies in contacting landowners and in determining site suitability.
3. Increase forested acres in the Cow Bridge Branch subwatershed. A 5% increase would involve 615 acres and 10% would involve 1,170 acres.
4. The estimated cost of a 5% increase in forested lands would range from $123,000 to $375,000 depending upon site preparation needs. The estimated cost of a 10% increase in forested lands would range from $234,000 to $713,000. Reforestation costs can vary widely based on the amount of site preparation (i.e. mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected.

Objective 2: Stream Channel Restoration-

1. Work closely with state and federal agencies to identify potential streams and ditches on state or privately-owned lands that would benefit from restoration activities including tree or native grass buffers, stream channel restoration, wetland enhancement or creation, and flood plain restoration.
2. Assist state and federal agencies in contacting landowners and in site feasibility evaluations.
3. The cost to restore degraded stream channel or ditches in the Morris Millpond/Cow Bridge Branch subwatershed can vary from $86 to $221 per linear foot. There is easily the potential to restore 10,000 feet of degraded stream/ditches on Gills Branch and McGee Ditch, as well as other tributaries and drainageways that flow into Cow Bridge Branch. To restore 10% or 1,000 feet of impaired or degraded channel would cost approximately $115,000 and to restore 20% or 2,000 feet would cost approximately $307,000.

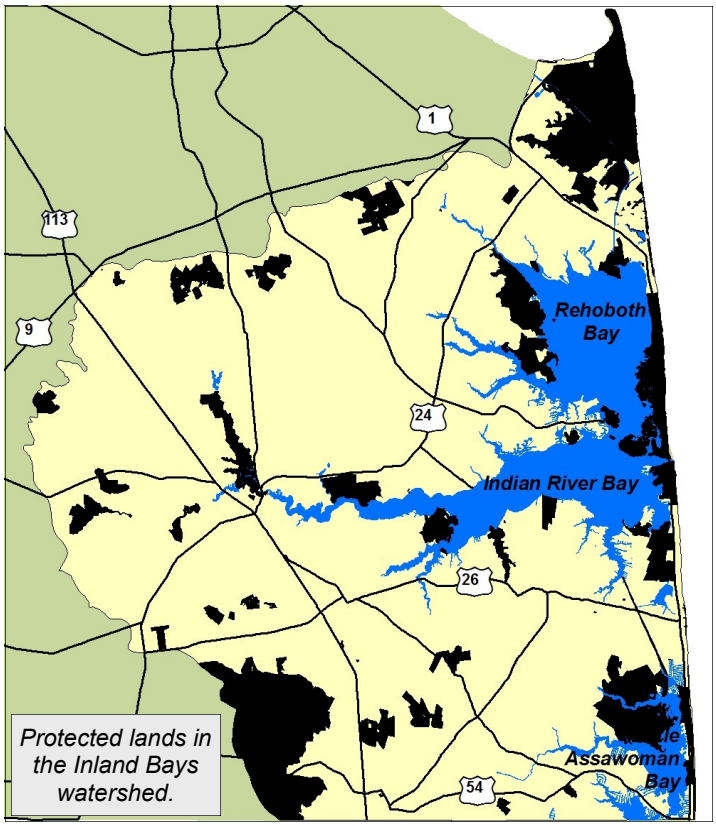
Cow Bridge Branch (cont.)

Objective 3: Riparian Area Habitat Protection and Enhancement-

1. Work closely with local, state, and federal agencies and NGOs to determine which riparian habitat areas are in need of enhancement or expansion and which stream segments are in need of riparian area habitat re-establishment.
2. Determine which techniques would be most effective in protecting existing, well-established riparian zones consistent with the landowner's wishes, such as conservation easements, donation, bargain sale, etc.
3. Work with all groups on site assessments and to complete riparian enhancement and re-establishment activities with native species where appropriate.
4. Based on a 250 foot habitat buffer on both sides of waterways, restore 800 acres of riparian habitat area.
5. The estimated cost to restore 800 acres of riparian area habitat would range from $160,000 to $488,000. Costs can vary based on the amount of site preparation (i.e. mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected.

Objective 4: Native Plant and Animal Habitat Protection-

1. Work with DNREC's Heritage Program, NGOs, and other state and federal agencies in identifying sensitive habitat areas on both state and private lands in need of protection through various techniques, such as conservation easements, donation, or bargain sale.
2. Assist in determining which technique would be most effective in protecting sensitive native plant and animal populations. The determination of the most appropriate method of protection would result from direct consultation with the landowners or managers in an effort to meet their long-term goals and needs as well as those of the plant and animal populations.
3. Work with approximately 140 landowners with parcels of land adjoining streams in wooded areas, not in urbanized portions of the subwatershed.
4. Estimated cost to complete this objective of working with the 140 landowners would involve agency and NGO staff time and legal costs for document preparation.



Protected lands in the Inland Bays watershed.

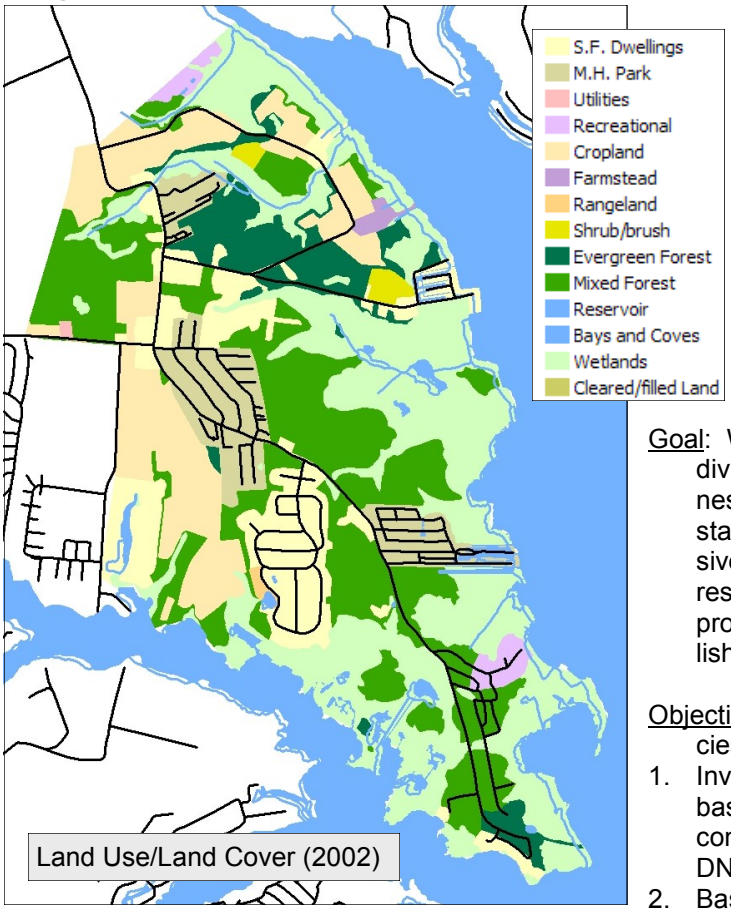
Nature is what we see,
The hill, the afternoon -
Squirrel, eclipse, the bumble-bee,
Nay—Nature is Heaven.

Nature is what we hear,
The Bobolink, the sea -
Thunder, the cricket -
Nay—Nature is Harmony.

Nature is what we know
But have no art to say,
So impotent our wisdom is
To Her simplicity.

Emily Dickinson

Angola Neck (# 3)



Land Use/Land Cover (2002)

Description: Ranging from the mouth of Love Creek in the north to Herring Creek in the south, Angola Neck has a unique diversity of plants, physical characteristics, and habitat types, ranging from salt marsh, hardwood forests, open water areas, sandy beaches, and freshwater wetlands. Because of its broad diversity, Angola Neck is rivaled by few other areas in the state.

Most notable are the sea-level fens located in Angola Neck. Fens are where groundwater with relatively low pH discharges onto the surface, giving rise to an unusual assembly of plants. What makes the fens in Angola Neck even more unusual is that they occur at or near sea-level. Angola Neck is also known for its mature hardwood forests, providing excellent habitat for mammals, reptiles, and various species of birds.

The area shaded above in the land use/land cover map encompasses 2,910 acres, of which, 44% is forested lands and 32% is wetlands (Table 6). The 390 acreage overlap in Table 6 can be attributed to the fact that property lines of subdivisions extend into wetland areas.

Unfortunately, Angola Neck is under pressure from current and proposed development. These activities have fragmented forest areas, filled or degraded wetlands, altered groundwater levels and quality, and have accelerated natural processes such as erosion and sedimentation. Another major concern in the area are non-native, invasive species such as the Common Reed (*Phragmites australis*).

Goal: Work closely with private landowners, subdivision associations, farmers, area businesses, conservation groups, and local, state, and federal agencies to control invasive species, address changes in hydrology, restore eroding shoreline and tidal wetlands, protect sensitive natural areas, and to establish or increase forested buffers.

Objective 1: Control Non-native Invasive Species (predominately plants)-

1. Inventory and identify invasive plant locations based on the State list of plant species of concern that has been developed for use by DNREC and other groups.
2. Based on the results of the inventory of the Angola Neck area, prioritize actions based on species, threat potential, extent, or location, especially for those in close proximity to sensitive natural areas.
3. In conjunction with eradication efforts, develop and implement a localized education program specific to the area that emphasizes the use of native plants as opposed to non-native invasive plants such as Giant Reed (*Arundo donax)* used in local landscaping.
4. Identify programs or sources of funding that can assist with the inventory, plant identification, action prioritization, eradication efforts, and restoration of any disturbed areas.
5. Resources that can assist with these efforts include the Delaware Invasive Species Council, DNREC-Division of Fish &Wildlife, USDA-Natural Resources Conservation Service, and Delaware Wild Lands.

Table 6

Angola Neck	***Acres***	***%***
Forests	1,286	44.2
Wetlands	935	32.1
Subdivisions	1,080	N/A

Angola Neck (cont.)

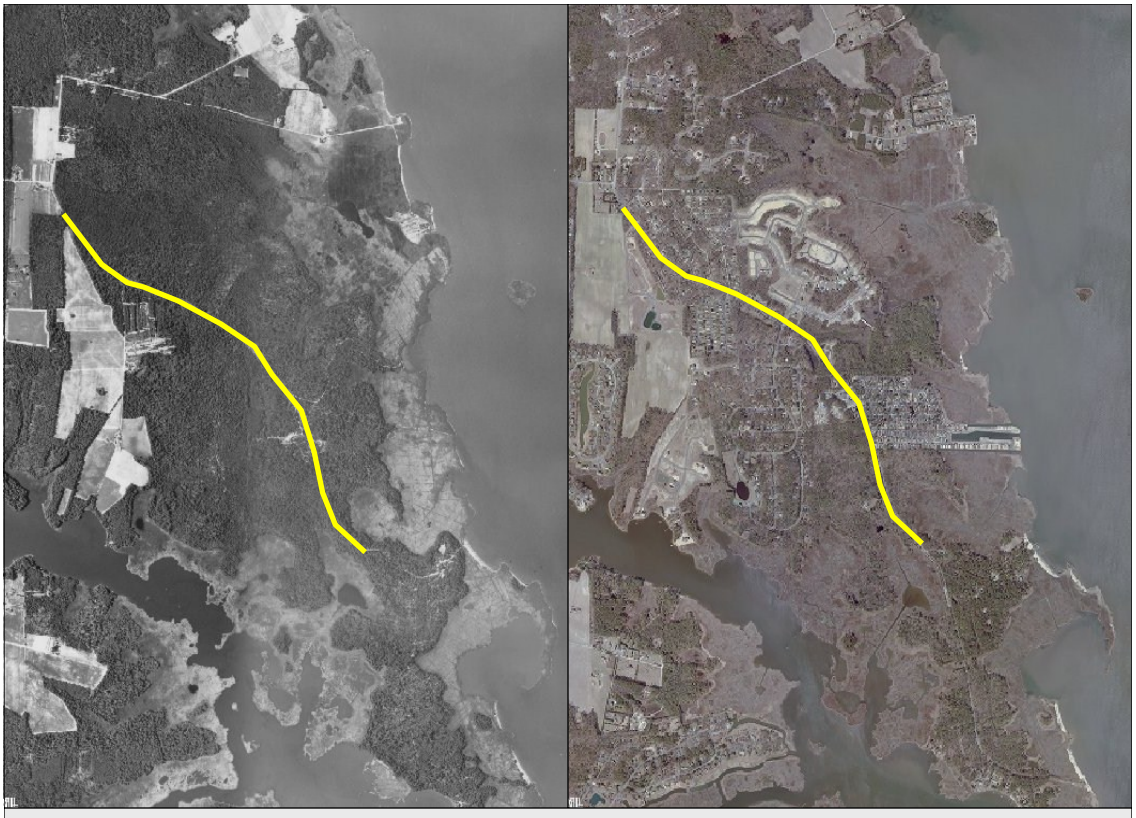
6. The estimated cost of completing this objective will depend upon the results of the inventory and the priority list developed by the resource agencies.

Objective 2: Assess Changes in Hydrology-
Over time, there have been numerous activities that have affected how water flows on and under the Angola Neck area. These activities can affect both surface runoff characteristics and subsurface flow, or the movement of groundwater.
Surface water:

1. Assess the quality (i.e. failing septic systems, urban NPS, sediment, nutrients, etc.) and the quantity (i.e. stream channel erosion, increase in the frequency of flooding, impoundment behind undersized culverts) of surface runoff in the area.
2. Dirt roads in the area have been built on steep slopes and may create problems with sediment transport. These should be evaluated and if problems exist, alternatives or solutions should be explored.
3. Determine if there have been any major changes in the hydroperiod or if there are nuisance flow issues that may have an impact on the sea-level fens and other wetlands in the area.

Groundwater:

1. Assess the quality of groundwater (i.e. failing septic systems, underground storage tanks, nutrients, etc.) in the area that may affect plant or animal life in the sea-level fens and other wetland areas.
2. Emphasis should be placed on identifying and protecting sea-level fen discharge and recharge areas. If these areas are not yet identified, efforts should commence to determine where they are, who owns them, and site specific strategies should be developed to see what can be done to protect them, such as installing buffers or voluntary easements.
3. Focus should be placed on groundwater quantity and determining if there are any large or excessive groundwater withdrawals occurring in the area. It is vital to determine where they are and what can be done. This may include specific water budgets or conservation based on regional uses and needs. It could also include the purchase of groundwater withdrawal/pumping rights. Agencies



Angola Neck in 1954 (lt.) and 2007 (rt.) part of Camp Arrowhead Road is highlighted for comparison.

Angola Neck (cont.)

and groups with expertise or resources that can assist in this objective include Delaware Wild Lands, USDA-NRCS, Delaware Geological Survey, U.S. Geological Survey, The Nature Conservancy, and DNREC's Groundwater Discharges and Water Supply Sections, NPS Program, Drainage Program, and Heritage Program.

4. The estimated cost to complete this objective would be in conjunction with Objective 3 of the Delmarva Bays hydrologic analysis and would involve primarily agency staff time.

Objective 3: Address Shoreline Erosion and Tidal Wetland Loss-

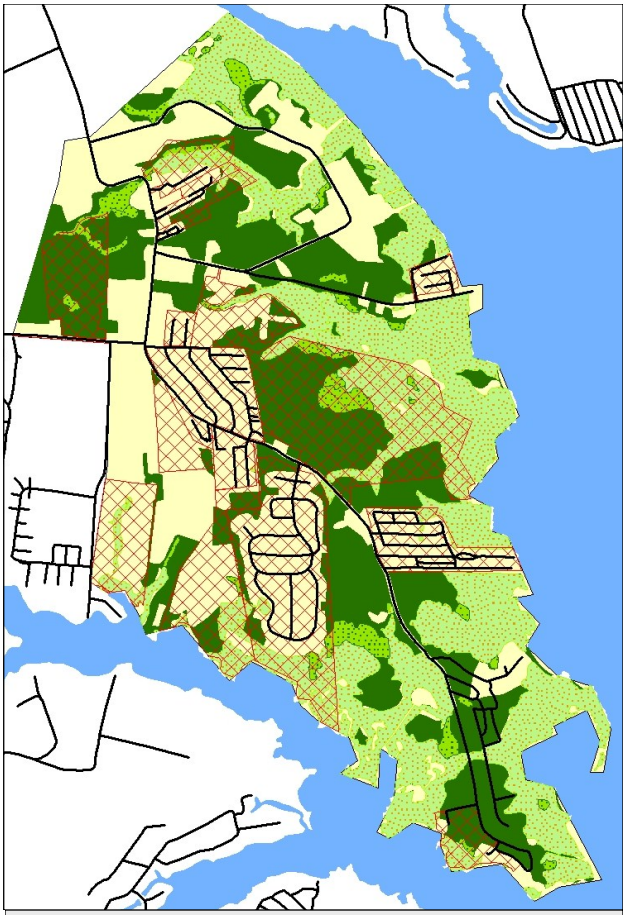
Sensitive tidal wetland areas along the shore of Angola Neck are being lost due to erosion from a myriad of sources. Although erosion is a natural process, it can be accelerated by a combination of wave action, sea-level rise, increases in tidal amplitude, subsidence, currents, and boat and personal watercraft wake. Areas such as Arrowhead Point provide protection for tidal marsh from wind and waves from the east and northeast. Unfortunately, Arrowhead Point itself is eroding, growing smaller over time and offering less protection of the marsh. Efforts should be made to stabilize areas of eroding marsh, where appropriate, or upland areas that protect marshes that are themselves suffering from erosion.

1. Identify areas where landforms such as Arrowhead Point help to protect tidal wetlands and other marsh areas experiencing significant erosion.
2. Determine cause(s) of erosion (i.e. boat wake, wind, current, other).
3. Determine most appropriate means to protect the resource, such as vegetative stabilization, low-profile sills, off-shore groins, etc.
4. Resources and groups that can assist with this objective include DNREC-Division of Water Resources Wetlands and Subaqueous Lands Program, US Fish & Wildlife Service, Delaware and US Geological Survey, and Delaware Wild Lands.
5. Restore/Protect between 3,000 and 6,000 linear feet of shoreline along the eastern side of Angola Neck, primarily north and south of Arrowhead Point and Joy Beach, and areas in between.
6. The estimated cost of completing this objective will vary based on the stabilization technique(s) used and the overall scope and complexity of the project. Prices per linear foot can range from as low as $20 per linear foot for low-energy sites using bio-stabilization practices and volunteer labor to well in excess of $600 per linear foot for higher-energy sites using rip-rap for low-profile sills and breakwaters, involving marine contractors and engineered designs.

Objective 4: Expand Forested Areas-

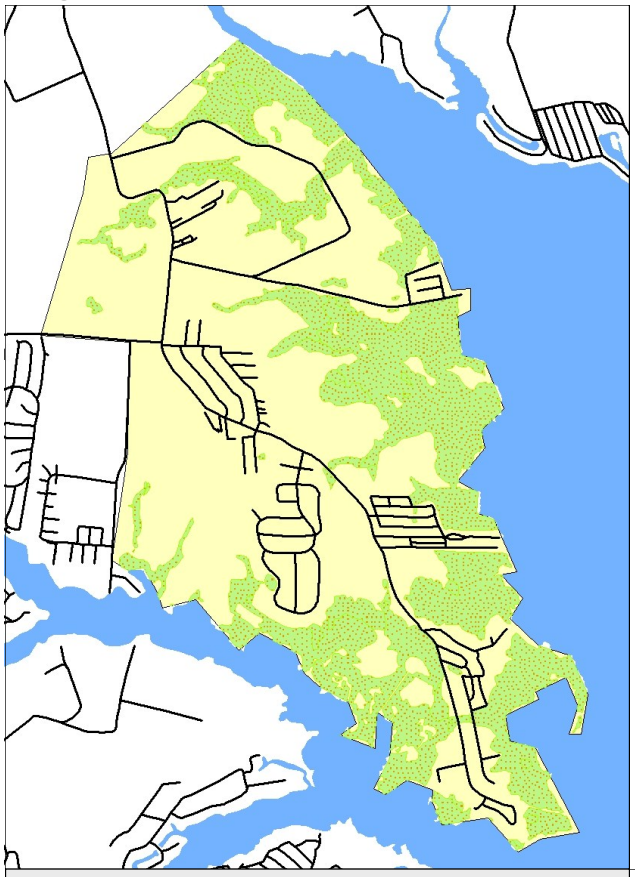
The mature evergreen and mixed hardwood forest in the Angola Neck area are being lost at a rapid pace, primarily to development. Although land costs often deter some landowners from making a long-term commitment to reforestation or expanding forested areas/buffers to connect isolated patches, both public and private groups need to develop incentives specific to the watershed that will increase landowner participation.

1. Work closely with local, state, and federal agencies and private groups to identify potential areas on state or privately-owned lands that would be candidates for native



Forested areas (2007) are shown in dark green, tidal and non-tidal wetlands, including forested wetlands, are the two lighter shades of green with stippling, and subdivided lands (2007) are shown with red cross-hatching.

Angola Neck (cont.)



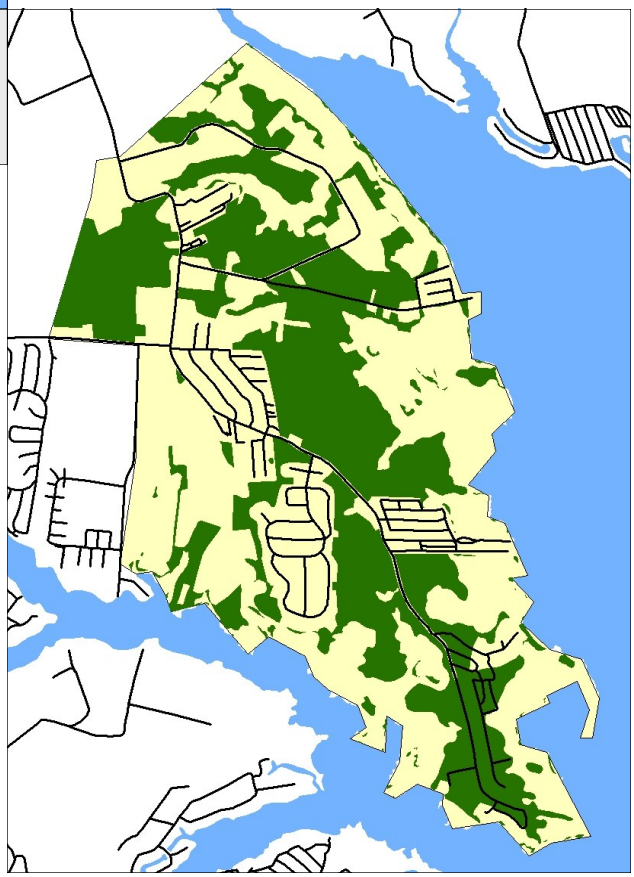
Wetland resources (top lt.) of Angola Neck, shown light green with stippling, includes tidal, non-tidal, and forested wetlands. Forested areas (bottom rt.) shown in dark green, includes deciduous, evergreen, mixed, and forested wetlands.

species reforestation / aforestation projects and to expand forested buffers and to connect isolated wooded areas (corridors).

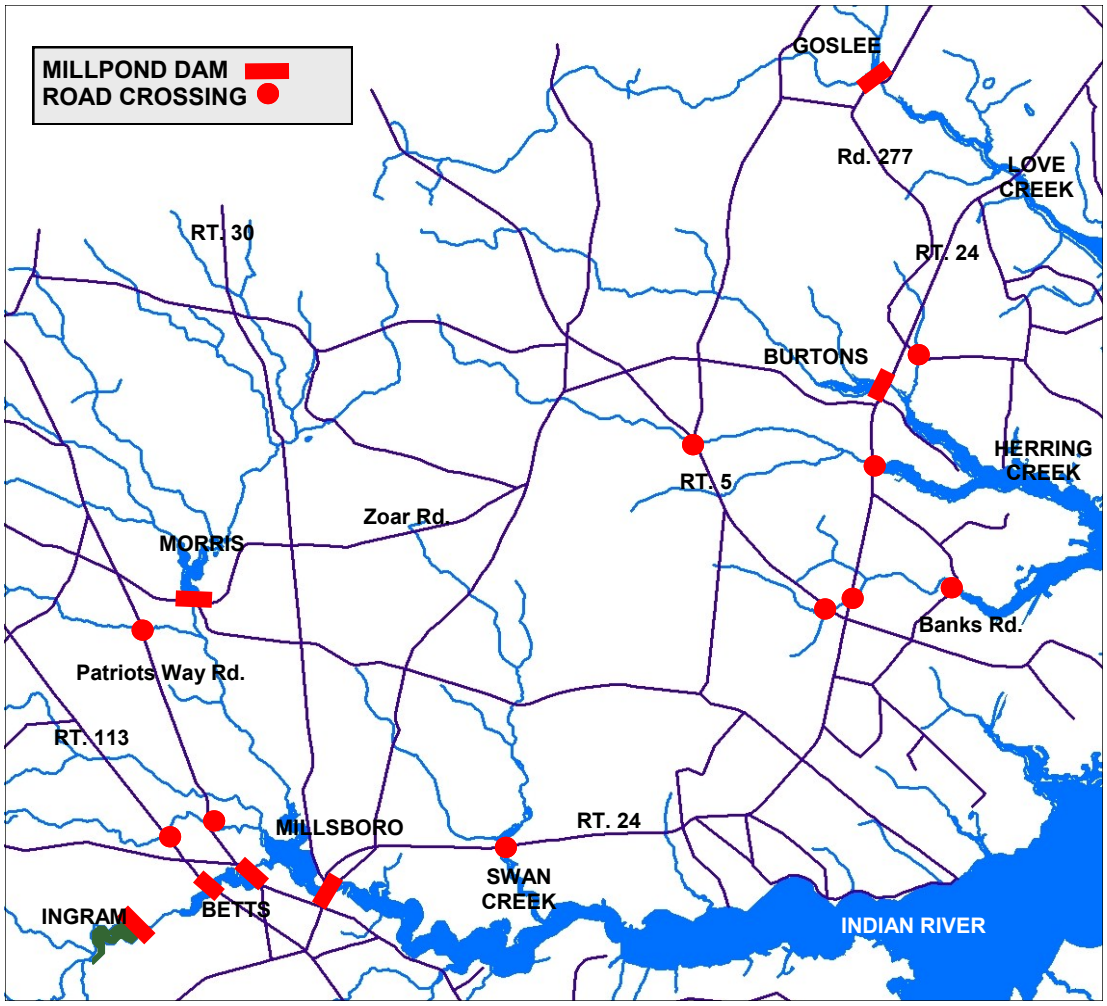
2. Determine if financial assistance programs are available to aid landowners and managers in all phases of reforestation activities. Search for additional funds to assist in overcoming the barriers to implementation.
3. Assist state and federal agencies in contacting landowners and in determining program eligibility and if sites are suitable.
4. Expand forested areas in the Angola Neck area by 128 acres (10%) to 257 acres (20%).
5. The estimated cost to increase forested areas by 10% would range from $25,600 to $78,000, and to increase forested areas by 20% would cost between $51,400 and $156,770. Reforestation costs can vary widely based on the amount of site preparation (i.e. mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected.

Objective 5: Protect Sea-level Fens-

1. Work directly with private landowners to educate them about the uniqueness of the sea-level fens located on or adjacent to their property.
2. Work closely with the landowners and key groups such as the DNREC Heritage Program and *The Nature Conservancy* to determine threats and opportunities that exist at these sites, such as surface water inflows, loss of wooded buffers, and excessive groundwater withdrawal.
3. Assist in determining what actions, opportunities, or programs exist to assist the landowners in protecting sea-level fens, such as conservation easements, tax incentives, fee simple sale to conservation groups and building/ construction setbacks, etc.
4. Estimated cost to complete this objective of working with landowners would involve agency and NGO staff time and legal costs for document preparation.



Mill Pond Dams (#4)



Description: Numerous streams throughout the Inland Bays watershed were dammed in the 1700s and 1800s to provide power for saw and grist mill operations. These dams were constructed from a variety of materials including compacted earth, concrete, wood, and steel that range from less than 2' in height (*Betts upper*) to nearly 10' in height (*Burtons*). The ponds formed behind these dams create shallow, non-tidal freshwater habitat for a variety of fish and serve as traps for sediments and nutrients that normally would be transported downstream.

In more recent times, these ponds provide opportunities for recreation such as boating, fishing, and swimming as well as a desirable location for waterfront homes and communities. Unfortunately, these dams may also form barriers to the migration of anadromous and catadromous fish species such as striped bass (*Morone saxatilis*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), Alewife (*Alosa pseudoharengus*), white perch (*Morone Americana*), and American eel (*Anguilla rostrata*). Only two of the seven ponds (Table 7) and their dams listed here are in public ownership while others are privately owned and maintained.

Another issue to be investigated as part of this priority relates to the potential problems caused by road and highway crossing pipes or culverts and their impact on fish migration. Pipes that are set too high, that may be in need of cleaning or replacement, or those that create flows that are

Table 7

Millpond Information	*Betts Upper*	*Betts Lower*	*Burtons*	*Goslee*	*Ingram*	*Millsboro*	*Morris*
Spillway Height (feet)	2'	8'	10'	6'	7'	3'	8'
Pond Surface Area (acres)	21	29	46	27	24	101	44
Pond Ownership	Private	Private	Private	Private	Public	Public	Private

Mill Pond Dams (cont.)

too strong for some species to pass through should be evaluated as to their impact on various fish species. There are approximately 10 road crossings of interest pending a more detailed survey.

Goal: Work closely with pond and dam owners and managers, local sportfishing clubs, along with state and federal agencies, to identify which dams, ponds, and road crossings should be considered candidates for fish and eel passages, or other types of restoration or retrofit projects.

Objective 1: Work with state and federal resource agencies to conduct an investigation on the suitability of upstream habitat areas for anadromous and catadromous fish to spawn and mature. Based on the findings, work closely with dam and pond owners/managers and state and federal fisheries agencies to determine the most appropriate course of action.

Objective 2: Determine what is in the best interest of the fisheries resource and develop a site specific strategy to address both the short and long-term goals needed to accomplish the objective. This might include cases where suitable upstream habitat exists but no existing runs of desirable species occurs. This will involve determining if it is appropriate to install a fish passage and then transplant key species to re-establish a spawning migration

Objective 3: Work with state and federal agencies to review each dam, pond, and road crossing determined to be a problem and decide if certain retrofits, modifications, or maintenance activities may help accommodate flushing, enhance aquatic habitat or water quality, or help with the control of non-native, invasive plants and animals.

The estimated cost to complete Objectives 1 through 3 involve primarily NGO and agency staff time to complete.

Objective 4: Solicit funding from a variety of sources to offset cost of evaluation, installation or restoration, fish acquisition and transport, design and assessment, and the development of both short and long-term strategies.

The estimated cost to complete Objective 4 varies based on the fish species of concern and scope of the potential solution. In cases of road crossings, it may simply be a matter of routine maintenance or it might involve an increase in size, which would dictate increased cost, planning, interagency coordination, and construction scheduling. Eel passages generally run less than $5,000 and fish passages can range from $35,000 to $44,000 per vertical foot.

"Like winds and sunsets, wild things were taken for granted until progress began to do away with them. Now we face the question whether a still higher 'standard of living' is worth its cost in things natural, wild, and free."

Aldo Leopold

Millsboro Pond Dam on Rt. 24 forms the head of the tidal portion of the Indian River.

Chapel Branch (#5)

Description: Comprised of a mix of agricultural land, forested areas, and single family residences and subdivisions, the Chapel Branch watershed offers a relatively rural setting yet is still close to the amenities of the beach area. The area has experienced steady growth with the conversion of farm fields and forested land to residences, which may be due to the fact that Chapel Branch is located equidistant from Georgetown, Millsboro, Lewes, and Rehoboth Beach. Chapel Branch is approximately 5.3 miles (27,800') in length and is one of the primary streams in the Herring Creek watershed. The entire Chapel Branch subwatershed encompasses approximately 3,350 acres, which flows through Burtons Pond and ultimately drains into Rehoboth Bay.

Above-looking west over Burtons Pond at the inflow of Chapel Branch.
Below-an example of how forested areas in the Chapel Branch watershed have been fragmented by conversion from forests to subdivisions and farmland.

Although the primary stream corridor has a relatively intact riparian area, issues that affect terrestrial and aquatic habitat in this sub-watershed include: the loss of farmland to residential development; the fragmentation of forested areas for conversion to strip lots, subdivisions, and for agricultural production; drainage/channelization in headwater areas to deal with localized flooding; and the need for wooded and/or native grass buffers along streams and ditches to protect and enhance habitat and water quality. State identified water quality concerns in the watershed include nutrients, bacteria, and metals, which can impact both plant and animal species.

Goal: Work with farmers, developers, land planners, and various resource agencies to implement and enhance the use of wooded and grassed wildlife habitat buffers along streams and ditches, and to create and/or protect wooded corridors between forested areas.

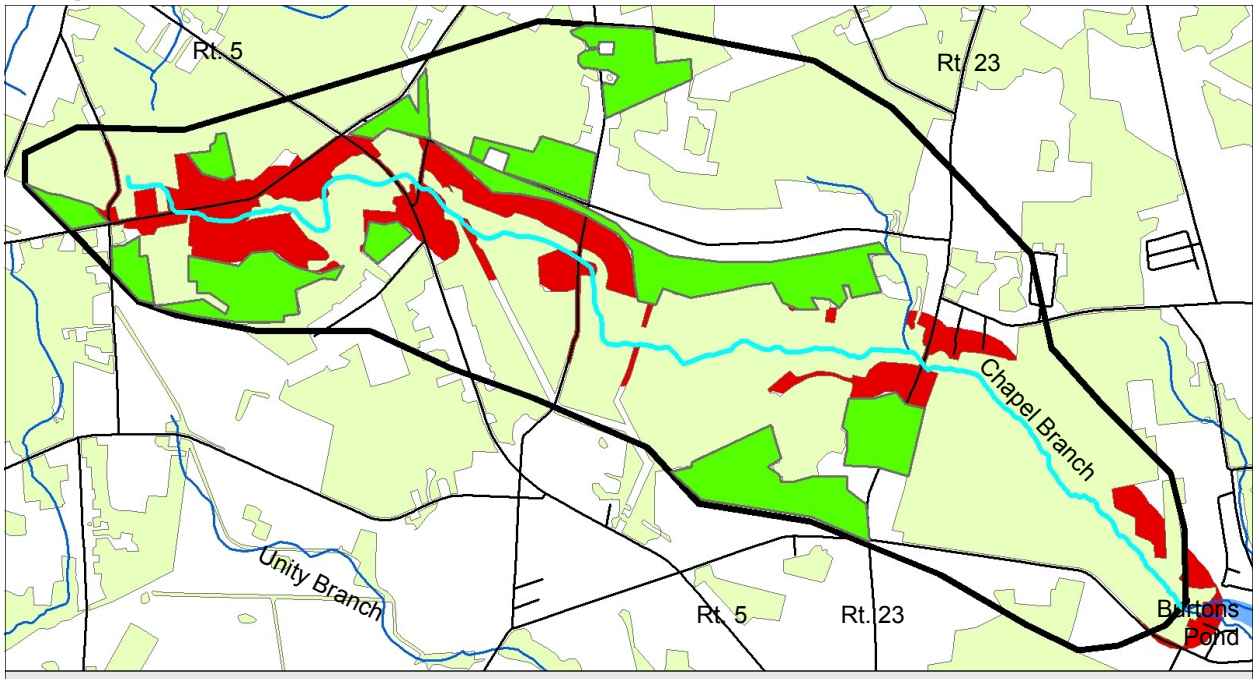
Objective 1: Riparian Area Habitat Protection and Enhancement-

1. Work closely with state and federal agencies and NGOs to determine which riparian areas are in need of enhancement or expansion and which stream segments are in need of riparian area re-establishment.
2. Determine which techniques would be most effective in protecting existing, well-established riparian zones consistent with the landowner's wishes, such as conservation easements, donation, and bargain sale.
3. Work with all groups on site assessments and to complete riparian enhancement and re-establishment activities with native species of trees and/or grasses where needed and appropriate.
4. Based on a 250 foot riparian area habitat buffer on both sides of Chapel Branch (see map on page 25), restore 335 acres of riparian area habitat.
5. The estimated cost to restore 335 acres of riparian area habitat would range from $67,000 to $204,000. Costs can vary based on the amount of site preparation (i.e. mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected.

Objective 2: Stream Channel Restoration-

1. Work closely with state and federal agencies to identify potential streams and ditches on privately-owned lands that would benefit from a variety of restoration activities including riparian or native grass buffers, stream channel restoration, wetland enhancement or creation, flood plain restoration, etc.

Chapel Branch (cont.)



The main stem of Chapel Branch is shown in light blue with the subwatershed boundary in black. Forested areas are shown in light green and the dark green areas are open lands that could potentially be reforested to expand the core riparian zone along Chapel Branch or to reconnect fragmented forested areas. Red areas represent a 250' forested buffer on both sides of the waterway where habitat areas could be re-established.

2. Determine if financial assistance is available to aid landowners and public drainage organizations that are interested in various stream channel restoration activities.
3. Assist state and federal agencies in contacting landowners and in site feasibility evaluations and solicit funding to assist in project completion.
4. The estimated cost to complete Objective 2 is dependent upon the outcome of a detailed evaluation of the drainage network within the Chapel Branch subwatershed.

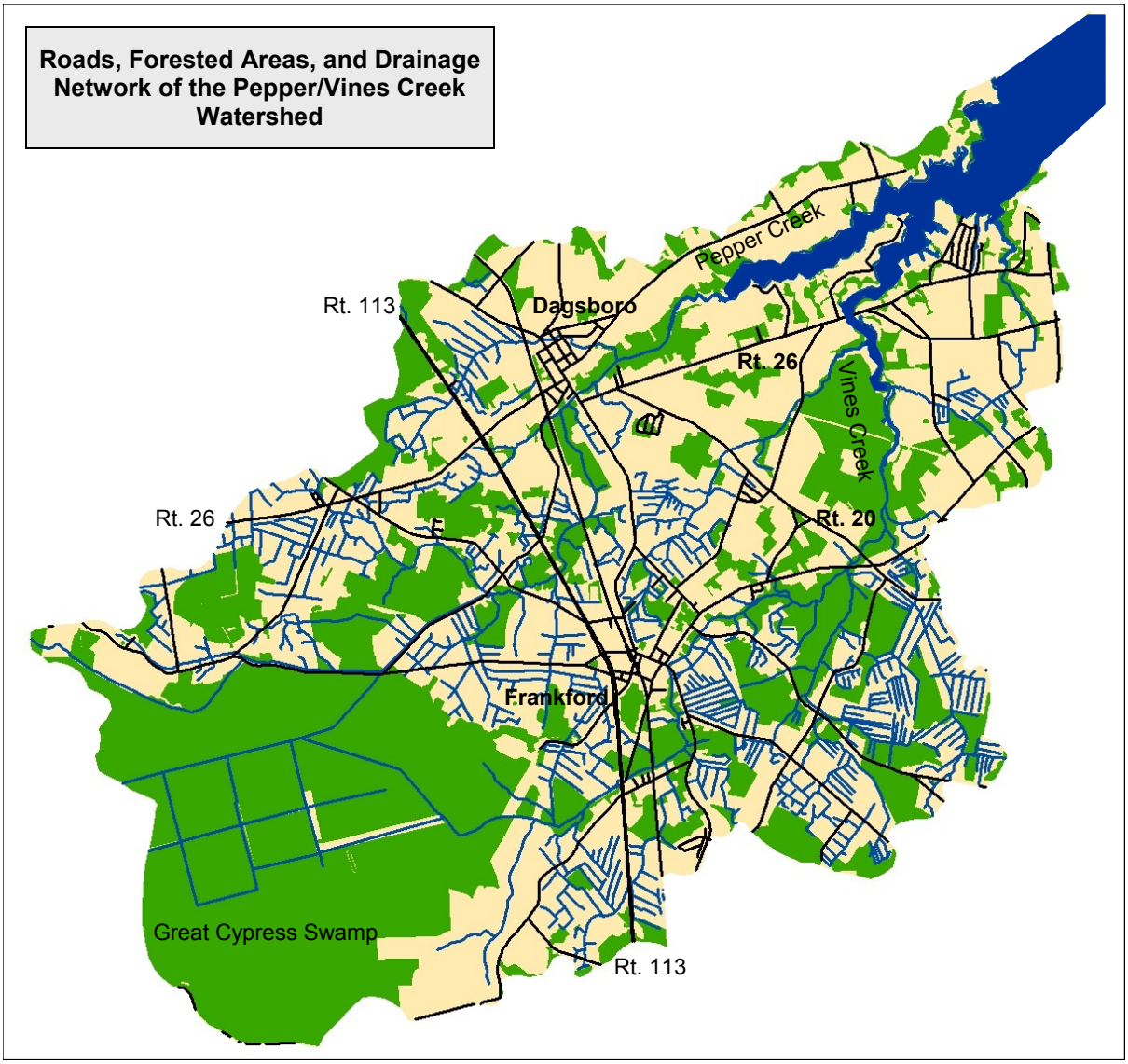
Objective 3: Reforestation/Aforestation-

1. Work closely with state and federal agencies to identify potential areas on privately-owned lands that would be candidates for native species reforestation/aforestation to increase the interior size of a forested area or to create wildlife corridors between fragmented areas.
2. Determine if financial assistance programs are available to aid landowners in all phases of reforestation/aforestation activities.
3. Assist state and federal agencies in contacting landowners and in determining program eligibility and if sites are suitable.
4. The estimated cost to increase forested lands in the Chapel Branch by 370 acres, which is approximately 11% of the subwatershed, would range from $74,000 to $225,000 depending upon site preparation needs. Potential sites for reforestation are shown in bright green on the map shown above. Reforestation costs can vary widely based on the amount of site preparation (i.e. mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected.

IT is not growing like a tree
In bulk, doth make Man better be;
Or standing long an oak, three hundred year,
To fall a log at last, dry, bald, and sere:
A lily of a day
Is fairer far in May,
Although it fall and die that night -
It was the plant and flower of Light.
In small proportions we just beauties see;
And in short measures life may perfect be.

Ben Jonson

Pepper & Vines Creeks (#6)



Description: The majority of growth and development in this area has occurred more to the east in the waterfront areas of both Pepper and Vines Creeks and on land fronting along Route 113, including in the towns of Dagsboro and Frankford. Other than these areas, a majority of the land in these two subwatersheds has retained much of their rural and agricultural character and land use. Both watersheds combined total approximately 22,260 acres, of which, only 39% (8,780 acres) remains as forested land.

The soils in the lower portion of the Inland Bays watershed can be characterized as having a moderately-high organic matter content, relatively shallow depth to groundwater, and very little relief, topographically-speaking. When properly managed, these soils can be very productive from an agriculture perspective. Originally installed to aid in crop production and in some cases for flood control and prevention, the subwatershed has a very extensive drainage network of public, private, tax ditches, and streams totaling over 170 miles.

Goal: Work with farmers, land owners and managers, and various resource agencies to implement and enhance the use of wooded and grassed wildlife habitat buffers along streams and ditches, to create wildlife habitat corridors between existing forested areas, and to restore degraded headwater or channelized streams.

"If a plant cannot live according to its nature, it dies; and so a man."

Henry David Thoreau

Pepper & Vines Creeks (cont.)

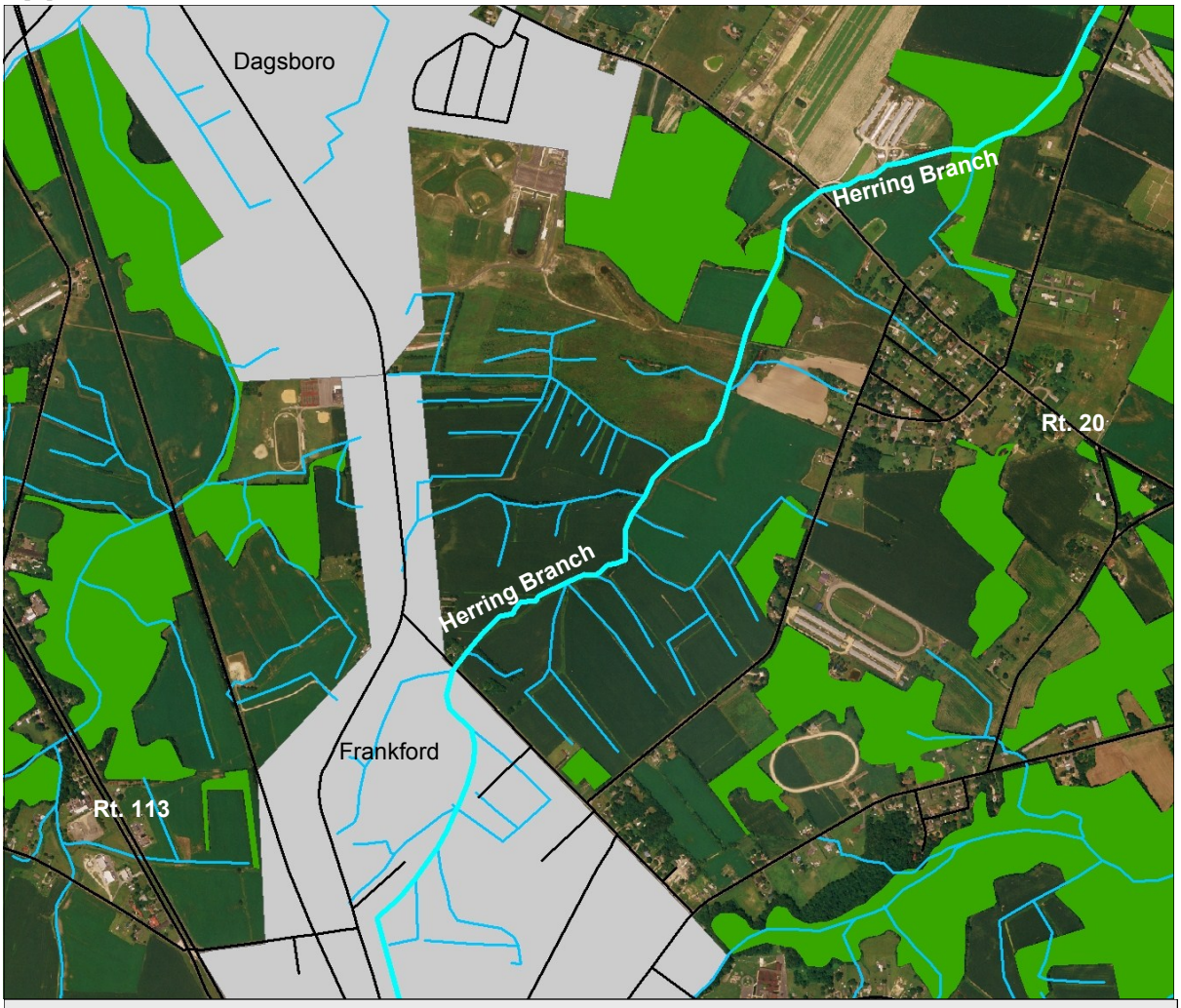
Objective 1: Riparian Area Habitat Protection and Enhancement-

The development of priority areas in Objective 1 were partly based on a review of data developed by resource agencies intended to aid in focusing efforts to expand or enhance critical forested habitat for neotropical migratory bird species. See page 13 for information on Delaware's neotropical migratory bird species.

1. Work closely with state and federal agencies and NGOs to determine which riparian areas are in need of enhancement or expansion and which stream segments are best suited for riparian area habitat re-establishment.
2. Determine which techniques would be most effective in protecting existing, well-established riparian zones consistent with the landowner's wishes, such as conservation easements, donation, or bargain sale.
3. Work with all groups on site assessments and to complete riparian enhancement and re-establishment activities with native species of trees and/or grasses where needed and appropriate.
4. Increase forested areas by focusing on re-connecting isolated blocks of forests within the Pepper/Vines Creek watershed by 10% (878 acres) or by 20% (1,756 acres), or by utilizing a 250 foot riparian area habitat buffer on both sides of primary streams and ditches (see map below) involving approximately 2,056 acres, which would be an increase of 23.4% in forested area.
5. The estimated cost to increase forested land by 10% would range from $175,600 to 535,600 a 20% increase would be from $351,200 to $1.07 million. To implement the 250 foot riparian area habitat along primary streams and ditches would cost approximately $411,200 to $1.25 million. Re-establishing riparian area habitat costs can vary widely based on the amount of site preparation (i.e.

An example of how re-establishing habitat areas in the riparian zone along streams and ditches can increase the amount of forested land in a watershed, creating vital habitat for neotropical migratory species of birds and wildlife corridors. Areas in red indicates a potential 250' riparian area habitat along non-forested segments of primary waterways in the Pepper/Vines Creek subwatershed.

Pepper & Vines Creeks (cont.)



This 2006 aerial photograph of the Dagsboro/Frankford area indicates the riparian habitat potential along the main stem of Herring Branch within the Pepper/Vines Creek subwatershed. In the photograph, farm fields and lots are dark green, Herring Branch is shown in bright blue, other streams/ditches are a darker blue, forested areas are light green, and municipalities are shown in grey. Lands abutting these waterways offer the potential to reconnect larger forested areas and to provide corridors for wildlife movement.

mowing, disking, or herbicide application) that is necessary before planting, as well as by the size and species of trees selected and if native grasses are involved in the development of the habitat areas.

Objective 2: Stream Channel Restoration-

1. Work closely with state and federal agencies to identify potential streams and ditches on privately-owned lands that would benefit from a variety of restoration activities including riparian or native grass buffers, stream channel restoration, wetland enhancement or creation, and flood plain restoration.
2. Determine if financial assistance is available to aid landowners and tax ditch companies that are interested in various stream channel restoration activities and assist state and federal agencies in contacting landowners and in site feasibility evaluations.
3. There is the potential to restore more than 100,000 linear feet of degraded stream channel and ditches.
4. Using a range of average restoration costs of $86 to $221 per linear foot, the cost could easily exceed $8 million. To promote the value and benefits of stream channel restoration and riparian area habitat development, approximately 5,000 feet of Herring Branch (see map above) could be used as a demonstration project. Stream channel restoration costs for this would be approximately $768,000.

Tidal and Non-Tidal Wetland Restoration (#7)

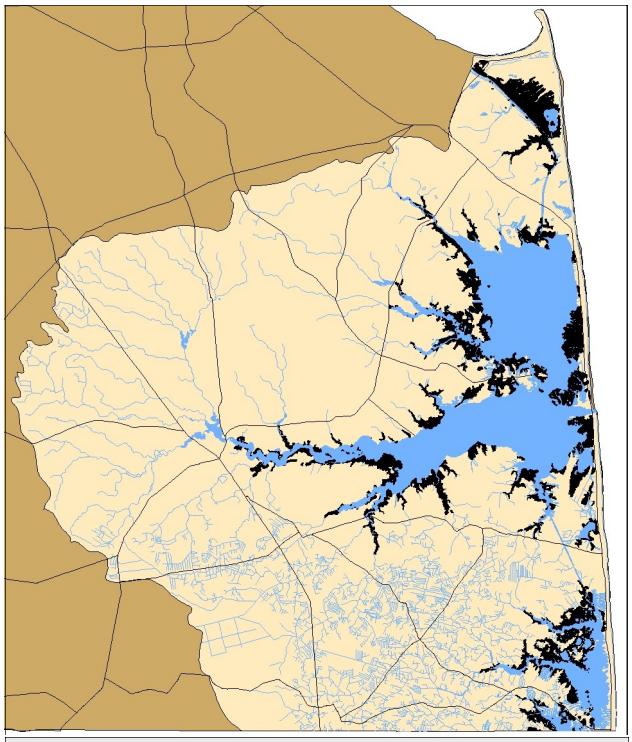
The desire to live near the water has caused considerable loss and impairment of wetlands in the Inland Bays over the past several decades. These impacts not only decrease functions such as nutrient cycling, flood control, and food production, it can permanently alter or destroy much needed habitat.

Description: Considered by some to be a wasteland serving little or no real purpose, wetlands have been cleared, drained, filled, and ditched in an effort to turn them into something that was perceived to have a greater value. Whether changed to grow crops, harvest timber, construct homes and roads, or build marinas, wetlands have been impacted by attempts to convert them to a variety of other uses. Wetlands offer numerous ecological and economical benefits worldwide that run contrary to the negative light that has been cast upon them. Ecologically, they serve as a source of food, shelter, and nesting areas for many micro and macro-invertebrates, birds, reptiles, mammals, and amphibians that inhabit them. It has been estimated that estuaries and their tidal wetlands serve as a habitat for up to 80% of the world's fish and shellfish species, and depending upon their type and size, wetlands also serve to trap sediments, utilize nutrients, reduce flooding, and aid in the improvement of water quality. Although non-tidal wetlands found in inland areas may not play host to a majority of the world's fish and shellfish species, they do provide similar benefits like their tidal counterparts as well as groundwater recharge and serve as important habitat.

Harvesting salt hay (Spartina spp.) from newly-ditched marshes in Little Assawoman Bay in the mid-1930s.

Since the earliest times, having cleared land and adequate drainage were very important to early settlers. It has been estimated that from colonization (mid-1600s) to present time, the Inland Bays watershed may have lost up to 45,000 acres of its wetlands. From 1938 to 1970, over 2,000 acres of wetlands were lost in the Inland Bays, due mostly to human activities. The U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control (DNREC) estimate that from 1982 to 1992, *Estuarine Emergent* wetland losses totaled approximately 20 acres, and was attributed to excavation, impoundment, and residential development. This type of wetland is most commonly associated with those that fringe the edge of the three Inland Bays, inundated by the daily tide cycle and dominated by several species of salt-tolerant marsh grasses.

Tidal and Non-Tidal Wetland Restoration (cont.)



Estuarine wetlands (tidal marshes) of the Inland Bays.

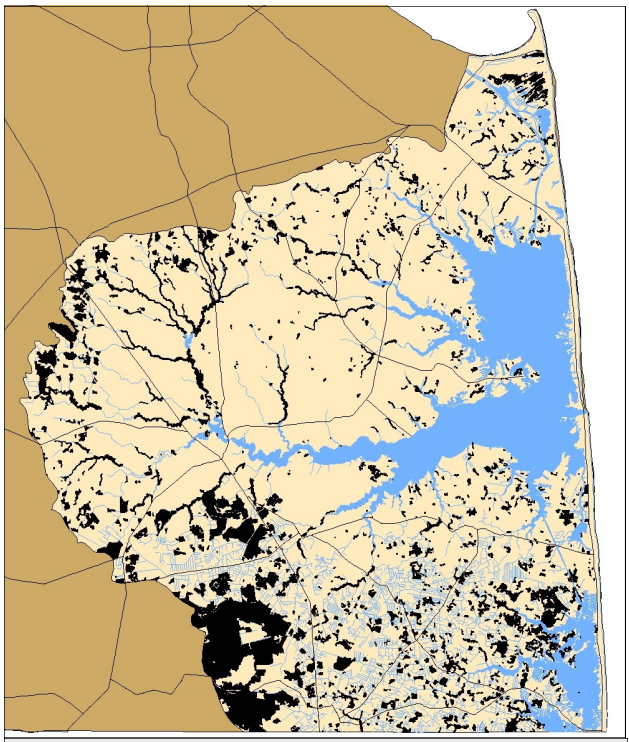
In 2000, the DNREC Wetlands and Subaqueous Lands Program reported that the net loss of State regulated tidal wetlands was less than one acre, due to permitted activities. This would not include natural gains or losses due to accretion and avulsion. With the adoption of State tidal wetland protection regulations in the early 1970s, losses appear have decreased dramatically, but are still occurring. Current estimates (Table 8 on the following page) place the number of *Estuarine Vegetated* wetlands in the Inland Bays watershed at approximately 9,419 acres.

From 1982 to 1992, it is estimated that 277 acres of *Palustrine Vegetated* wetlands were lost. Data from 2001 indicates that losses continued over the decade and that the acreage had decreased by an additional 154 acres. *Palustrine* wetlands are characterized as being "beyond the influence of tidal brackish waters and typically dominated by persistent vegetation (trees, shrubs, emergents) that remain standing into the next growing season."

Table 8 identifies various wetland types and acreages in the Inland Bays watershed based on data extracted from DNREC's GIS layer of wetland coverage *(SWMP 2001)*. Non-tidal wetlands (forested, scrub/shrub, emergent, and agricultural) total approximately 34,022 acres. This number is borne out by a separate land use analysis in 2002 by DNREC that identified 34,120 acres of non-tidal wetlands in the Inland Bays.

The quantification of more recent wetland losses is somewhat difficult due to variation in numbers. This may be attributed to the fact that land use classification systems for both wetlands and forests may overlap when it comes to forested wetlands. Another issue may have to do with the level of accuracy, which has increased with technological advances in aerial and satellite imagery and GIS, allowing further refinement of measurements and changes on the ground.

Over the years, the knowledge base of wetland functions and values has grown. In the case of tidal wetlands, the loss has decreased dramatically due to increased protection through regulation. Unfortunately, non-tidal wetlands have seen less protection and continue to be lost, degraded, or impacted at an alarming rate. The protection of certain categories of non-tidal wetlands is continually challenged in both state and federal courts, and continues to leave many important habitat areas unprotected.

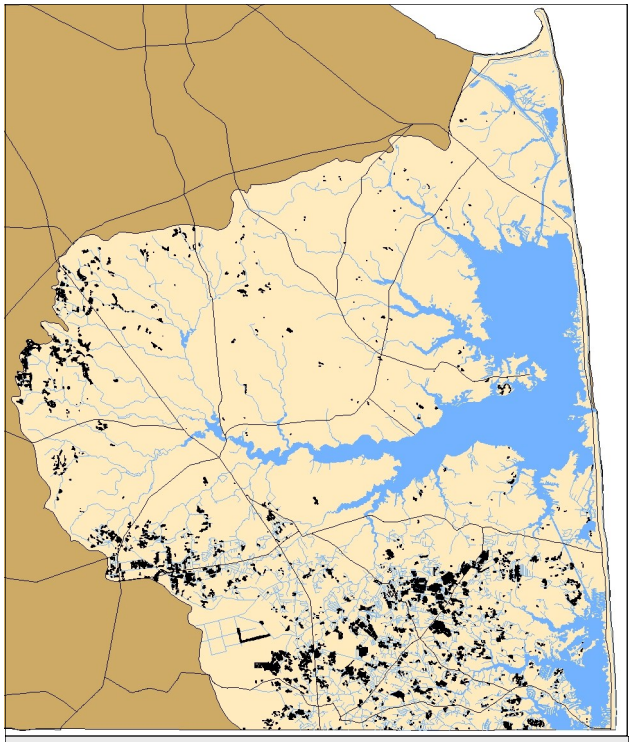


Palustrine Forested wetlands (wooded non-tidal) of the Inland Bays.

"Hope and the future for me are not in lawns and cultivated fields, not in towns and cities, but in the impervious and quaking swamps."

Henry David Thoreau

Tidal and Non-Tidal Wetland Restoration (cont.)



Farmed wetlands (agricultural) of the Inland Bays.

Goal: Work with local, state, and federal agencies, NGOs, and private landowners to enhance, restore, and increase protection of all wetland resources.

Objective 1: Since the early 1990s, Delaware has attempted to develop freshwater wetland regulations, to no avail. The CCMP supports protecting wetland resources in the Inland Bays watershed.

1. Support efforts at the county, state, and federal level and private efforts to increase the legal protection of freshwater, non-tidal wetlands.

Table 8

Inland Bays Wetland Category	*Acres*	*Classification*
Agriculture	5,261.79	Pf10,7
Estuarine Vegetated	9,419.14	E2EM1/SS3Pd
Palustrine Emergent	741.09	PEM1A
Palustrine Forested Deciduous	13,665.46	PFO1E
Palustrine Forested Evergreen	9,892.19	PFO4A
Palustrine Open Water/Flats	725.31	PUBHx
Palustrine Scrub-shrub Deciduous	1,372.20	PSS1/EM1A
Palustrine Tidal Emergent	88.84	PEM1R6
Palustrine Tidal Forested	317.61	PFO1/SS3R
Palustrine Tidal Scrub-shrub	151.42	PSS1R
Palustrine scrub-shrub evergreen	2,363.87	PSS3/4C7
River Tidal Non-Vegetated	1.81	R1UBVx

Objective 2: Many successful state, federal, and NGO-funded restoration programs struggle for adequate funding. Support Adequate funding for local, state, federal, and private programs intended to restore and enhance wetlands.

1. Support programs such as NRCS's *Wildlife Habitat Incentives Program* (WHIP) and *Wetland Reserve Program* (WRP), DNREC's *Landowner's Incentive Program* (DELIP), USFW's Partners *for Fish and Wildlife Program* (PFWP), Ducks Unlimited and The Nature Conservancy programs through direct and indirect financial support and legislative support, where appropriate and legal.

Objective 3: Work closely with state and federal agencies and NGOs to prioritize and perform wetland restoration and enhancement in the Inland Bays. Work is currently underway to assess the quantity and quality of wetlands in Delaware and the Inland Bays.

1. Support these efforts and ensure that the Inland Bays are included in the prioritization of potential restoration and enhancement sites.
2. Restore decadal wetland losses listed on pages 32-33 totaling 431 acres of non-tidal wetlands and 20 acres of tidal wetlands.

Objective 4: Support the Delaware Wetlands Conservation Strategy. The Wetlands Conservation Strategy includes the following goals:

- To update wetland inventory maps and improve access to wetland related data;
- To increase monitoring efficiency and effort to provide insight into wetland function and health;
- To integrate wetland restoration, creation, enhancement, and protection efforts to ensure efficient use of resources;
- To coordinate information and resource sharing among wetland protection programs, professionals, and agencies;
- To enhance education and outreach efforts to broaden wetland stewardship among all wetland stakeholders;
- And to work with partners to provide support and enhancement for existing regulatory programs and to provide protection of wetlands that are not covered by state and federal regulations.

Dirickson Creek (#8)

Description: Dirickson Creek is the largest tributary to Little Assawoman Bay. Like many other areas in the Inland Bays with waterfront property, this area has seen considerable growth and the subsequent land conversion that precedes construction. The area also has a considerable amount of agricultural land. Part of the headwaters of Dirickson Creek was the first project under the then Soil Conservation Service's PL-566 program, implemented in 1956.

The PL-566 Program provided drainage to areas affected by flooding which included land from just north of Selbyville down through Johnson's Corner. From this project, there resulted increased agricultural drainage throughout the Little Assawoman Bay watershed. On the north side of Dirickson Creek is the Assawoman Wildlife Area, which was originally purchased from the federal government in early 1940s. It is managed by DNREC and now totals approximately 3,100 acres.

Goal: Promote the use of vegetated/non-structural methods or techniques to stabilize eroding shoreline.
Objective 1: Identify areas in Dirickson Creek and western Little Assawoman Bay with deteriorating bulkheads and where poor shoreline stabilization practices were implemented, such as the use of construction debris.
Objective 2: Where possible, implement the use of alternative shoreline stabilization techniques such as bio-logs, vegetation, and low-profile sills. These practices should be encouraged in areas where appropriate. This will also involve working with various agencies that provide both technical and financial assistance to implement alternative shoreline stabilization.

Goal: Restore & Enhance Degraded Stream Channels.
Objective 1: Identify stream channel restoration and enhancement sites on the numerous small public and private drainage ditches that flow into Dirickson Creek on the north side, especially in the area of Old Mill Bridge.
Objective 2: Implement stream channel restoration and enhancement sites on small public and private drainage ditches that flow into Dirickson Creek. This may involve complete channel reconstruction and restoration or simply the implementation of riparian buffers in more urbanized/ suburbanized areas.

Goal: Support Land Preservation Efforts at the Assawoman Wildlife Area, managed by DNREC's Division of Fish and Wildlife. It is host to a variety of rare plants and animals and is a seasonal refuge for waterfowl and neotropical migratory bird species. It is also a recreational destination for residents and visitors alike who utilize the area to hike, bike, birdwatch, fish, crab, and hunt.
Objective 1: Support efforts to expand the protected lands in and around the wildlife area through the use of conservation easements and additional land purchases.

Aerial images of Dirickson Creek in 1938 on the left and in 2002 on the right. In the 2002 image, note the loss of forested land in the lower right, the increase in large scale drainage on the north side of the creek incising the woods and at the head of tide on the left, and the loss of agricultural land to development and to resource extraction (aka borrow pit) on both sides of the creek.

Aquatic Project List

At the final meetings of the CIB's Habitat Restoration Plan Development Committee, the group was asked to review, discuss, and prioritize a list of potential aquatic habitat restoration and enhancement projects. It was understood that CIB staff would most likely seek funding for the projects through grant applications after detailed study and assessment for the respective project had been completed. The following list of projects is a result of their prioritization and ranking. In several instances, similar types of projects have been combined.

Shoreline Stabilization

Goal: Promote the use of vegetated/non-structural methods or techniques to stabilize eroding shoreline.

Objective 1: Work with DNREC, USDA NRCS, and the Sussex Conservation District to secure adequate funding and where appropriate, to promote the use of vegetated/non-structural shoreline stabilization.

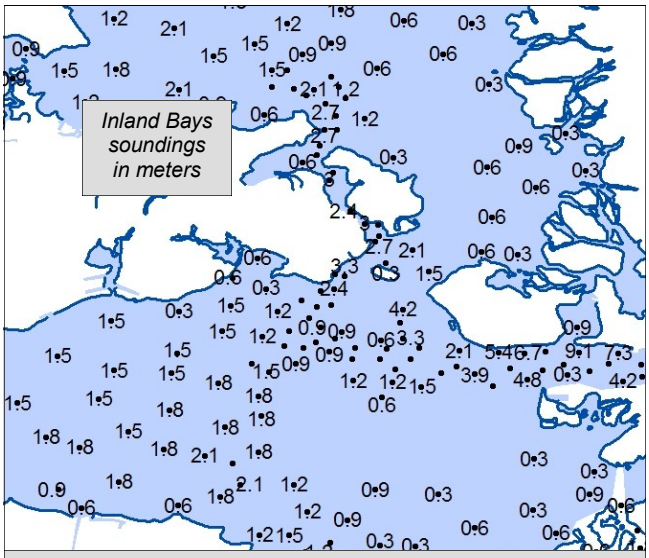
Objective 2: Identify candidate sites where failing or dilapidated bulkheads can be removed and replaced with appropriate vegetated/non-structural practices.

Submerged Aquatic Vegetation Restoration and Enhancement

Goal: Work to promote a healthy and expanding population of Eelgrass (*Zostera marina*) and Widgeongrass (*Ruppia maritima*) in the Inland Bays.

Objective 1: Work closely with DNREC resource experts, UD CMES, and WUPIC to identify potential sites for restoration or enhancement

Objective 2: Secure funding to accomplish the specific goals and needs identified.



It will be vital to work closely with resource experts and to gather much-needed information such as depth, substrate composition, current speed, and light penetration to determine the most suitable locations for SAV restoration.

Resource Protection Areas (RPA)

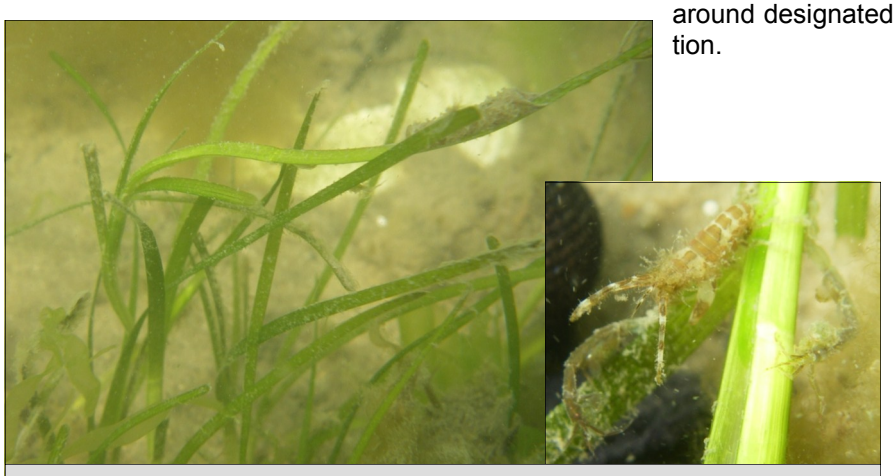
Goal: Protect critical aquatic habitat areas through the establishment of RPAs.

Objective 1: Work closely with DNREC resource experts, UD CMES, and the CIB's Water Use Plan Implementation Committee (WUPIC) to identify critical aquatic habitat areas in need of protection.

Objective 2: Work with the DNREC and the General Assembly to develop and codify necessary RPA protections.

Objective 3: Begin a multi-media public awareness campaign to garner support for the need for RPAs.

Objective 4: Secure funding to post signage around designated RPAs and for map preparation.



Photograph of Eelgrass at the James Farm and several of its residents (inset).
Courtesy of Kayti Tigani

Aquatic Project List

Great Blue Heron on Middle Island, located near Massey's Landing between Rehoboth and Indian River Bays.

Diamondback Terrapin, Horseshoe Crab, and Colonial Nesting Bird Habitat Restoration

Goal: Work with state and federal agencies and NGOs to restore or enhance critical habitat areas for Diamondback Terrapin (*Malaclemys terrapin terrapin*), Horseshoe Crab (*Limulus polyphemus*), and Colonial nesting bird species including: Great Blue Heron; several species of Egret; Oystercatchers; Black Skimmers; and several species of Tern.

Objective 1: Identify potential restoration or enhancement sites based on historic locations.

Objective 2: Determine the best technique(s) to accomplish the needs of each species.

Objective 3: Secure funding to accomplish specific goals and needs identified.

American Oystercatchers resting on Middle Island.

Potential restoration or enhancement sites might include:

- *Piney Island - Upper Rehoboth Bay*
- *Marsh Island - Upper Rehoboth Bay*
- *Gull Island - Lower Indian River Bay*
- *Sand Island - Lower Indian River Bay*
- *Middle Island - Lower Rehoboth Bay*
- *Unnamed island between Raccoon Point and Little Cedar Island - Lower Rehoboth Bay (northeast of Burton Island)*
- *Bush Island - Upper Little Assawoman Bay*
- *Cherrybush Island - Little Assawoman Bay*
- *Point of Cedars Island - Little Assawoman Bay*
- *Point of Ridge Point - Little Assawoman Bay*
- *Seal Island - Little Assawoman Bay*

Pasture Point Stabilization

Goal: Stabilize the shoreline at Pasture Point, located at the James Farm, to reduce its loss due to erosion.

Objective 1: Convene an ad hoc committee of state, federal, and private resource experts to oversee the evaluation and materials/methods selection for the project.

Objective 2: Evaluate the rate of marsh and shoreline loss and determine an acceptable baseline condition that adequately addresses the shoreline stabilization practice selected.

Objective 3: Evaluate a variety of materials and techniques that have the potential to be used on the project.

Objective 4: Select the most appropriate and acceptable method and material and acquire all necessary permits.

Objective 5: Secure funding to complete the project based on its specific design, goals, objectives, and permit conditions.

Shellfish Restoration and Enhancement

Goal: Ensure a healthy and robust shellfish population within the Inland Bays.

Objective 1: Secure funding to work with DNREC and the UD College of Marine and Earth Studies (UD CMES) to perform a suction dredge survey to determine the current state of the Hard Clam (*Mercenaria mercenaria*) population within the bays.

Objective 2: Work with both groups to evaluate the information and determine if current management is adequate and if stock enhancement is necessary.

Objective 3: Continue to work with CIB and UD CMES staff on the expansion of the existing American Oyster (*Crassostrea virginica*) reef, stock enhancement efforts, and to promote the CIB's Oyster Gardening Program.

Habitat Restoration, Enhancement, and Protection Programs

Delaware Department of Agriculture
Forest Service
2320 South DuPont Highway
Dover, DE 19901
(302) 698-4500
Forest Legacy Program
Forestland Preservation Program
Low-cost Seedling Program

Delaware Department of Natural Resources and Environmental Control
Division of Fish and Wildlife
6180 Hay Point Landing Road
Smyrna, DE 19977
(302) 735-3600
Delaware Landowner Incentive Program (DELIP)
Non-Point Source Program
89 Kings Highway
Dover, DE 19901
(302) 739-9922
Conservation Reserve Enhancement Program

Ducks Unlimited
Mid Atlantic Field Office
34 Defense Street, Suite 200
Annapolis, MD 21401
(410) 224-6620
Partners on certain habitat restoration projects

Sussex Conservation District
23818 Shortly Road
Georgetown, DE 19947
(302) 856-3990 ext. 103
Conservation Cost-Share Assistance

Sussex County Land Trust
P.O. Box 763
Rehoboth Beach, DE 19971
(302) 227-0287
Conservation Easements

The Nature Conservancy
Delaware Chapter Office
100 West 10th Street, Suite 1107
Wilmington, DE 19801
(302) 654-4707
Conservation Easements

U.S. Fish & Wildlife Service
177 Admiral Cochrane Dr.
Annapolis, MD 21401
(410) 573-4500
Partners for Fish and Wildlife Program

USDA Natural Resources Conservation Service
Sussex County Agricultural Center
21315 Berlin Road, Unit #3
Georgetown, DE 19947
(302) 856-3990
Wildlife Habitat Incentives Program
Wetland Reserve Program
Conservation Reserve Program

Photo Credit: U.S. Fish & Wildlife Service

Monitoring Requirements Under the Estuary Restoration Act

This information is added for reference purposes only.

The Estuary Restoration Act of 2000 directs the National Oceanographic and Atmospheric Administration (NOAA) to develop standard monitoring protocols for estuary habitat restoration projects. This document summarizes NOAA's guidelines for evaluating the success of restoration activities in meeting project goals, posted on the NOAA website *http://era.noaa.gov/htmls/era/era_monitoring.html*. Because restoration project monitoring is often the responsibility of local project partners, the costs of monitoring and likely access of these parties to specialized equipment and technical expertise were considered in developing a set of standards that are both fiscally responsible and biologically pertinent. The supporting document *Science-based Restoration Monitoring of Coastal Habitats* (Thayer et al., 2003) contains additional information useful for preparing restoration monitoring plans.

A restoration monitoring plan must include information to allow for successful implementation and evaluation of the project over the long term. Because restoration science is still in development, restoration projects may not meet intended goals. Monitoring can provide information to explain why goals are not met, and data from these projects can help evaluate relative efficacy of different methods and improve restoration techniques and project designs for future efforts. The following five critical elements must be included in monitoring plans for projects supported by Estuary Restoration Act funds:

1. Monitoring <u>parameters</u> must be directly linked to the goals established for the project and/or the restoration of the watershed as a whole. Monitoring parameters should be driven by success criteria, which should be driven by project goals. They should be determined early in the restoration process and in conjunction with project planning and design. Success criteria may represent conditions at a reference site, or they may represent target conditions considering surrounding land use or other factors. Selected monitoring parameters must:

   - include at least one *structural* parameter (in addition to project acreage) to be monitored from the initiation/implementation of the restoration project,
   - include the addition of at least one *functional* parameter (in addition to project acreage) no later than one year from the initiation/implementation of the restoration project, and
   - continue to be measured until results (see #2) indicate a trend in whether or not the project is successful at meeting its goals (see #5 for recommended timeline). If a trend indicates that the project is not successfully meeting its goals, steps should be taken to determine why goals are not being met and determine whether mid-course corrections should occur (see item 5 page 38).

2. Methods for <u>evaluating results</u> must be established (for example, statistical tests of hypotheses, trend analysis, or other quantitative or qualitative approaches) that directly relate to the goals for the project and/or watershed.

3. To establish initial conditions for each measure included in the monitoring plan, pre-construction or pre-design (baseline) monitoring must occur. Historical databases and other existing information about the study site and surrounding area can contribute to assessing baseline conditions. Depending on the project site and ecosystem specifics, this may involve a one-time evaluation or multi-seasonal sampling.

Monitoring Requirements Under the Estuary Restoration Act (cont.)

4. Project sites should be compared to a reference site or historical data representing a reference condition in order to evaluate progress toward reaching goals. Ideally, reference sites would be monitored according to the same plan as the project site, so that natural variability and other regional fluctuations can be detected. Even if success criteria are not based on conditions at a reference site, reference sites provide useful information to interpret project performance.

5. Monitoring must be conducted in a timely fashion with a frequency and length of time appropriate to each parameter in the context of project goals and the status of the project. Immediately following construction it is imperative to intensively monitor those parameters that will drive the success of the project in order to allow for corrective measures. As the restored habitat matures, these measurements may become less frequent, while functional parameters may be more closely monitored.

- Restoration projects must include provisions or contingency plans for adaptive management. Data must be provided in a timely fashion to project managers to allow for potential mid-course corrections.

- The length of time over which monitoring is to be conducted should be driven by the project goals, success criteria, and monitoring parameters. Some impacts of a restoration project may be observed rather rapidly after construction, while others may take decades to fully appear. Five years should be considered a minimum for monitoring for projects with physical goals such as the stabilization of a shoreline. Any project including goals for organisms or ecological function should consider a longer monitoring period. If mid-course corrections occur, monitoring should continue, but is not required to continue for an additional five years after corrections are in place.

- The monitoring schedule should be designed to measure each parameter at the most appropriate time of day, month and/or year; for example, according to wildlife activity levels, tidal cycles, migratory patterns, vegetation growing seasons, and other relatively predictable variations.

- Monitoring results, both positive and negative, must be made available to others designing or managing restoration projects. Restoration practitioners are strongly encouraged to use the on-line National Estuary Restoration Inventory (www.neri.noaa.gov) to share project information, so that techniques can be selected and refined based on the collective experience of the restoration community.

Monitoring Section Reference:

Thayer GW, TA McTigue, RJ Bellmer, FM Burrows, DH Merkey, AD Nickens, SJ Lozano, PF Gayaldo, PJ Polmateer, PT Pinit. 2003. Science-Based Restoration Monitoring of Coastal Habitats. Volume 1: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA, National Ocean Service, National Centers for Coastal Ocean Science. 91 pages.
http://coastalscience.noaa.gov/ecosystems/estuaries/restoration_monitoring.html

Indicators of Habitat Structure and Function

Indicators of Habitat Structure

Physical
Channel characteristics/Dimensions
Currents magnitude and timing/Water column current velocity
Fetch
Hydroperiod/tidal regime/Water level fluctuation over time
Inflow from upland sources/Sheet flow
Light penetration/Secchi/PAR
Pool/riffle ratio
Riverine water velocity and source
Temperature
Topography/Geomorphology/Basin elevations
Turbidity

Soil/Substrate
Bulk density
Moisture levels and drainage
Organic content
Redox potential
Sediment grain size/Percent sand, silt, clay, gravel, cobble
Sedimentation rate and quality

Vegetation
Algae species composition/percent cover
Basal area
Canopy areal extent and structure
Edge to area ratio
Epiphyte species composition/percent cover
Plant species composition/percent cover
Plant height
Ratio of vegetation to open water
Stem density
Woody debris

Fauna
Vertical relief of reef

Indicators of Habitat Function

Vegetation
Algae species composition/percent cover
Basal area
Biomass/Plant weight (above/below-ground parts)
Canopy areal extent and structure
Edge to area ratio
Epiphyte species composition/percent cover
Herbivory/Disease/Plant health
Invasives species composition/percent cover
Litter fall
Phytoplankton diversity/abundance
Plant species composition/percent cover
Plant height
Productivity rate
Rate of canopy closure
Seedling survival
Stem density
Woody debris

Physical
Channel characteristics/Dimensions
Currents magnitude and timing/Water column current velocity
Hydroperiod/tidal regime/Water level fluctuation over time
Inflow from upland sources/Sheet flow
Light penetration/Secchi/PAR
Pool/riffle ratio
Riverine water velocity and source
Temperature
Topography/Geomorphology/Basin elevations
Turbidity

Fauna
Amphibians: species composition/ abundance/life stage distribution/behavior
Animal health/disease
Birds: species composition/abundance/ life stage distribution/behavior
Coral growth rate
Coral recruitment/survivorship
Fish: species composition/abundance/ life stage distribution/behavior
Grazer density (for coral)
Invasives: species composition/abundance
Invertebrates: species composition/ abundance/life stage distribution/behavior
Mammals: species composition/ abundance/life stage distribution/behavior
Reptiles: species composition/ abundance/life stage distribution/behavior
Shellfish disease/predation

Chemical characteristics of water
Chlorophyll concentration
Dissolved oxygen
Nitrogen
Phosphorous
Salinity

Soil/Substrate
Bulk density
Moisture levels and drainage indicators
Nitrogen (pore water)
Phosphorous (pore water)
Organic content
Redox potential
Salinity (pore water)
Sediment grain size/Percent sand, silt, clay, gravel, cobble
Sedimentation rate and quality

Other
Trash
Fecal coliforms
Toxics

REFERENCES

The following is a list of printed materials and websites that contained information used in the development of this plan.

1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation-Delaware. March 1998. U.S. Fish and Wildlife Service. Document No. FHW/96-DE.

2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation-Delaware. January 2008. U.S. Fish and Wildlife Service. Document No. FHW/06-DE.

A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000. 2003. National Oceanographic and Atmospheric Administration. *http://coastalscience.noaa.gov/ecosystems/estuaries/restoration_monitoring.html*

Appendix A - Significant Wildlife Habitat Minimum Width/Size Criteria. 2006. Gregory Howe. *http://www.floridahabitat.org.*

Assessment of the Ecological Condition of the Delaware and Maryland Coastal Bays. September 1996. U.S. Environmental Protection Agency. Document No. EPA/620/R-96/004.

Between Ocean and Bay. A Natural History of Delmarva. 1991. Jane Scott.

Center for Applied Demography and Research. March 2008. University of Delaware. *http://www.cadsr.udel.edu;census2k;default.htm*

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers. 1997. U.S. Department of Agriculture Forest Service. Document No. NA-TP-02-97.

Delaware Inland Bays Estuary Program Comprehensive Conservation and Management Plan (Ch 1-5). June 1995. State of DE and U.S. Environmental Protection Agency. Document No. 40-08/95/06/02.

Delaware Inland Bays Watershed Nutrient Management Project - Draft. January 1999. John Mackenzie, John Martin, Lilian Pintea, Boonchauy Boonmee, Negede Gedamu and Theresa Thomas. University of Delaware, College of Agriculture and Natural Resources, Spatial Analysis Lab. *http://www.udel.edu/FREC/spatlab/spot/*

Delaware Nonpoint Source Management Plan. May 1, 1995. Delaware Department of Natural Resources and Environmental Control, Nonpoint Source Pollution Program.

Delaware's Freshwater and Brackish Water Fishes. 1991. Maynard Raasch and V. Altemus, Sr.

Delaware Wetlands Conservation Strategy. 2008. Delaware Department of Natural Resources and Environmental Control.

Delaware's Wetlands: Status and Recent Trends. June 2001. Delaware Department of Natural Resources and Environmental Control and U. S. Fish and Wildlife Service Cooperative Publication. Document No. 40-08/01/01/03.

Delmarva Coastal Bay Watershed: Not Yet Up the Creek (Proceedings). May 1996. U.S. Environmental Protection Agency. Document No. EPA/600/R-96/052.

Gross Land Use Changes in Delaware, 1992 to 1997. August 1999. Delaware Office of State Planning Coordination. *http://stateplanning.delaware.gov/information/dpc.shtml*

Guidance on the Use of Vegetated Buffers as Compensatory Mitigation Under Section 404 - Draft. August 2004. U.S. Army Corps of Engineers. *http://www.mitigationactionplan.gov/Buffer_8-27-04.htm.*

REFERENCES (cont.)

Improving Riparian Buffer Strips and Corridors for Water Quality and Wildlife. August 2000. Richard Fisher, C. O. Martin, and J.C. Fischenich.

Inland Bays/Atlantic Ocean Basin Assessment Report. June 2001. Delaware Department of Natural Resources and Environmental Control, Whole Basin Program. Document No. 40-01/01/01/02.

Inland Bays Wetland Status. January 2008. Amy Jacobs, Delaware Department of Natural Resources and Environmental Control. Personal Communication.

In Search of Swampland. A Wetland Sourcebook and Field Guide. 1998. Ralph Tiner.

Migratory Bird Center. June 2008. Smithsonian National Zoological Park. *http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Fact_Sheets/default.cfm?fxsht=9*

Migratory Bird Conservation. March 2008. U.S. Fish and Wildlife Service. *http://www.fws.gov/*

Population of Counties by Decennial Census: 1900 to 1990. March 1995. Richard Forstall. U.S. Census Bureau. *http://www.census.gov/population/cencounts/de190090.txt*

Population Projection Series. October 2007. Delaware Population Consortium. Delaware Office of State Planning Coordination. *http://stateplanning.delaware.gov/information/dpc.shtml*

Preserving Delaware's Natural History...The First Century. April 2006. Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife. *http://www.fw.delaware.gov/Pages/FWPortal.aspx*

Principles of Estuarine Habitat Restoration. September 1999. Restore America's Estuaries and the Estuarine Research Federation.

Research and Data Management Services (RDMS). March 2008. University of Delaware. *http://maps.rdms.udel.edu/*

Sussex County Comprehensive Plan Update. 2002. Sussex County Council.

Sussex County Long Range Transportation Plan. 2001. Sussex County Council.

Tourism Analysis. 2005. Global Insight, Inc. for Southern Delaware Tourism Office. *http://www.visitsoutherndelaware.com/tourism_research.htm*

United States Census Bureau. February 2008. *http://factfinder.census.gov/*

United States Census Bureau. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) *http://www.census.gov/prod/www/abs/fishing.html*

Wetlands Functions and Values. May 2006. Watershed Academy. U.S. Environmental Protection Agency. *http://www.epa.gov/watertrain/wetlands/*