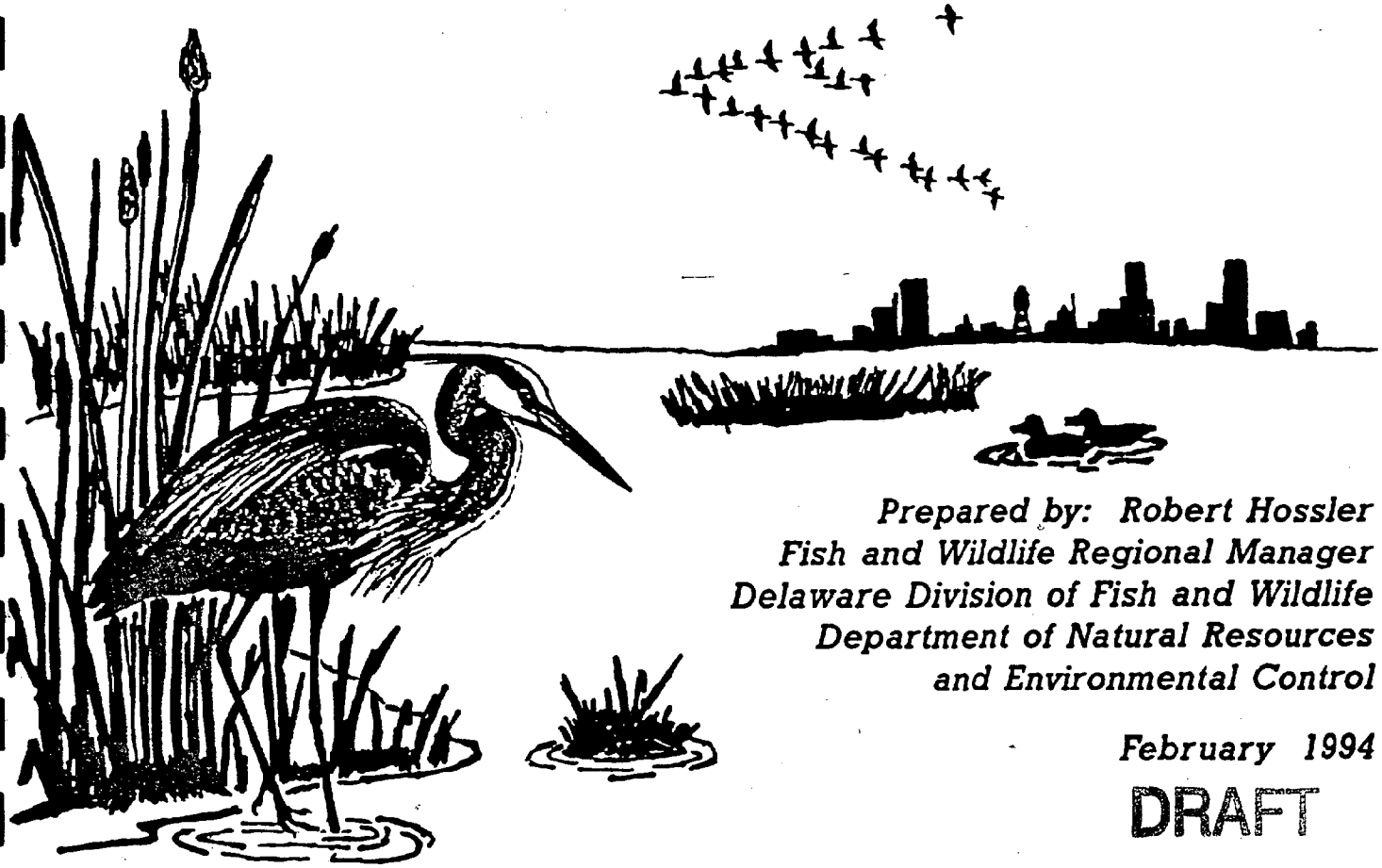
THE NORTHERN DELAWARE WETLANDS REHABILITATION PLAN
The Christina & Delaware Rivers Urban Wetland Corridor Rehabilitation



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PREFACE

Coastal northern Delaware had several thousand acres of high quality tidal wetlands that have gradually been degraded since European colonization. Although these wetlands are now protected under federal and state statutes, little has been done to restore and reintegrate them as a viable part of the Delaware Estuary. The lack of concern for these urban wetlands has been arguably due to the long-term commitment and tremendous resources necessary to restore wetlands that have been degraded for over three centuries. This document details the long-term, regional rehabilitation strategy that the Delaware Department of Natural Resources and Environmental Control is undertaking to restore a significant portion of these tidal wetlands along the urban corridor of the Christina and Delaware Rivers. These details are based on the findings and recommendations of a multi-agency rehabilitation team, constituting the Northern Delaware Wetlands Rehabilitation Program (NDWRP).

This planning document defines the regional objectives of this strategy, and specifies guidelines for the development and implementation of both site-specific wetland rehabilitation plans and a long-term restoration approach for the region. This document identifies the organizational framework of the NDWRP, and the programmatic involvement and responsibilities of various participating agencies and organizations. It also identifies rehabilitation sites within the corridor and their site-specific environmental needs.

The document will be used to provide long-term guidance of wetland restoration efforts within the urban corridor of the Christina and Delaware Rivers. It will act as a planning document, an implementation strategy, and a reference text; and will be periodically updated with new site-specific rehabilitation plans and post-implementation evaluations. Additional updates and minor modifications of ongoing projects will be necessary as rehabilitation efforts progress. These ongoing changes will be incorporated following review and approval by the multi-agency NDWRP team. Finally, besides serving as the plan for the long-term rehabilitation needs of the tidal wetlands and related aquatic habitats of Northern Delaware, this document is expected to serve as a model from which future coastal and wetland restoration programs can be developed.

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EXECUTIVE SUMMARY

The Delaware Department of Natural Resources and Environmental Control (DNREC), in cooperation with numerous other public and private organizations, has initiated an ambitious program to rehabilitate more than 10,000 acres of highly degraded tidal freshwater and brackish wetlands along the urban corridors of the Christina and Delaware Rivers in New Castle County. This portion of the State has a long history of wetland loss and abuse. Wetland degradation in northern Delaware began as early as the 17th century, when settlers extensively diked and drained tidal freshwater marshes along these rivers to accommodate agriculture and development of adjacent upland areas. Maintenance of this dike system promoted the filling and additional draining of many wetlands until the passage of state and federal wetland acts and executive orders in the 1970's. Although these and subsequent regulations prevented most tidal wetlands from continued degradation, little if any emphasis has been placed on rehabilitating those wetlands degraded prior to the passage of these laws. Unfortunately, these same severely degraded or lost wetlands were historically among the state's most important areas in terms of wetland wildlife and vegetation diversity.

The Northern Delaware Wetlands Rehabilitation Program (NDWRP) is a regional, non-regulatory restoration program for wetland areas degraded prior to the enactment of wetland protection acts. Currently, 31 potential wetland sites have been identified as needing rehabilitation and are proposed to be restored on a site-by-site basis. The NDWRP emphasizes three approaches to wetland restoration: 1) developing and implementing management practices designed to achieve regional multiple use objectives; 2) developing a multi-agency rehabilitation team; and 3) rehabilitating an urban corridor through a watershed-based approach whereby numerous individual wetland sites are ecologically improved, eventually forming a chain of restored wetlands. The NDWRP has developed a plan that provides DNREC with a systematic process to rehabilitate degraded wetlands and incorporate these strategies into local land-use plans. This plan is expected to serve as a model for future coastal rehabilitation programs, and will establish resource management/protection agreements among various government agencies, private organizations and industries, landowners, and environmental groups, thus replacing the traditional individual agency approach to similar programs.

Success of this regional wetland rehabilitation process depends on the cooperation and involvement of federal, state, and local agencies; private industries; landowners, and environmental groups. This multi-agency approach increases the available resources and funding opportunities, while including private industries, landowners, and environmental groups to provide

corporate sponsorships, property access, and broad-based public support, respectively. In order to promote this cooperation and involvement without burdening agency personnel that were only periodically involved in the program, a two-tiered organizational approach was established. This approach consisted of a NDWRP Steering Committee comprised of DNREC and New Castle Conservation District staff, and a adjunct committee comprised of various outside agencies and organizations. The Steering Committee convenes on a monthly basis and addresses a wide range of program-related topics, whereas the adjunct committee members were periodically included in the planning and evaluation process during permit review, funding requests, or rehabilitation plan review.

The NDWRP has developed a systematic procedure to facilitate the development and implementation of site-specific wetland rehabilitation plans. This process promotes frequent input by various participants and encourages utilizing the technical expertise of the rehabilitation team and allocating task responsibilities to various members. An important element in this systematic procedure is the development of a detailed restoration plan. This plan provides a foundation from which all rehabilitation efforts are based. Wetland rehabilitation plans should be constructed around scientifically-based biological inventories and ecological evaluations of the site and its surrounding landscape. The plan should also clearly define the site-specific objectives. A requisite to the long-term needs of this regional wetland rehabilitation strategy is development of site-specific operation, maintenance, and management plans. This component of the rehabilitation plan provides assurances that rehabilitation efforts will be implemented and maintained. The final component of the rehabilitation plan is a provision to actively involve the landowners and local environmental groups in the rehabilitation effort. Active involvement by the public not only promotes a increased awareness and understanding of wetland functions and values, but it also provides additional assurance of the long-term success of the project.

ACKNOWLEDGEMENTS

The Delaware Department of Natural Resources and Environmental Control (DNREC) provided State funding, staff support, equipment, and facilities necessary for the completion of this planning and implementation document. Additionally, the Delaware Coastal Management Program (DCMP) provided Federal funding during the past two years from the National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, to assist with plan development, in particular helping to support biotic inventories and site-specific assessments of potential wetland rehabilitation projects. These federal and state funds were used to help undertake the DNREC's Northern Delaware Wetlands Rehabilitation Program (NDWRP), co-administered by C.J. Stachecki and S.W. Cooksey.

I would like to acknowledge the former Secretary of the DNREC, E.H. Clark II, and former Director of the Division of Fish and Wildlife, W.C. Wagner, under whom the NDWRP was initiated and developed. Today, this wetland rehabilitation effort has been continued and expanded by C.A.G. Tulou, Secretary of the DNREC, and A.T. Manus, Director of the Division of Fish and Wildlife. Both individuals have shown enthusiasm and commitment to wetlands restoration, and the future success of the NDWRP depends heavily upon their guidance and support.

I would like to thank all the NDWRP Steering Committee members who made valuable contributions to the restoration program and the development of this planning and implementation document. These individuals, although occasionally polarized, all contributed to developing a quality end product. I am especially grateful to C.J. Stachecki, co-administrator of the program, and W.H. Meredith for their advice, guidance, and encouragement throughout the development of this program and document. Their humor and assistance kept me sane during trying times in a turbulent bureaucracy. S.W. Cooksey provided the prodding occasionally necessary to complete quarterly reports or meet deadlines of other DCMP deliverables. L.R. Irelan and J.E. Tarburton of the New Castle Conservation District made valuable contributions in terms of grant and budget initiatives, and local land-use issues. I would like to acknowledge D.B. Carter for his collation of a preliminary inventory of potential wetland rehabilitation sites, and his lead participation in the preparation of the DCMP grant. Finally, I would like to thank my staff (S.J. Link, A.A. Loveless III, J.G. Masten II, T.J. Moran) and others in (or formerly in) the Division of Fish and Wildlife (R.V. Cole, T.F. Cole, S.H. Innvaer, R.J. Wolfe) for their assistance throughout the development of this project.

INTRODUCTION AND HISTORICAL BACKGROUND

Northern Delaware, like many other urbanized areas on the East Coast, has a long history of wetland loss and abuse. Similarly, Delaware's wetlands degradation can be traced back to a predominately negative view of these areas. Wetlands were deemed as waste places, vermin haunts, and of little socioeconomic value. These negative views promoted the draining, diking, and filling of wetlands for a variety of purposes including agricultural practices, landfills, and industrial and residential developments in the Wilmington and New Castle areas (Fig. 1).

In Northern Delaware this degradation began as early as the mid-1600's, when Dutch and Swedish settlers extensively diked and drained tidal freshwater marshes along the Christina and Delaware Rivers to accommodate agriculture and development of adjacent upland areas (Weslager 1947). This extensive system of dikes and tide gates has, for the most part, been maintained since its initial construction, a practice that essentially prohibited several thousand acres of tidal wetlands from receiving normal tidal exchange with the Delaware Estuary for up to 340 years (Carter 1991). Maintenance of this dike system promoted the filling and additional draining of many wetlands for industrial, maritime, and residential development during the Industrial Revolution of the late 1800's and early 1900's. The construction of various transportation systems, particularly Interstate 95 in the mid-1960's, led to the draining and filling of over 1,000 acres of additional tidal freshwater marshes and the rerouting of a 1-mile stretch of the Christina River.

This continuous neglect along the Christina and Delaware Rivers over a 300-year period caused the permanent loss of approximately 6,000 acres of tidal wetlands (Tiner 1985), and the degradation of approximately 10,000 more (Carter 1992). Present estimates are that 1,000 acres are extremely degraded, another 2,500 acres are in poor condition, 5,300 acres are in moderate condition, and 1,200 had only limited degradation or recovered sufficiently to warrant very good condition (Fig. 2).

Unfortunately, these same severely degraded or lost wetlands were historically among the state's most important areas in terms of waterfowl abundance, wading bird and aquatic furbearer production, and vegetation diversity (Chamberlain 1951). Several of these marshes contained excellent stands of cattail (*Typha* spp.) and wild rice (*Zizania aquatica*). These marshes were important habitat for black ducks (*Anas rubripes*), pintails (*Anas acuta*), green-winged teal (*Anas crecca*), and Canada geese (*Branta canadensis*) during spring and fall migrations. The larger marshes in this region supported the best muskrat (*Ondatra zibethicus*) populations in the state and several of the best waterfowl production areas. Also two heronries, one the largest on the Atlantic Coast north of Florida, are currently located within and supported by the wetlands of this region. Because these

Fig. 1. New Castle, Delaware depicting the Wilmington and New Castle areas and the Christina and Delaware Rivers.

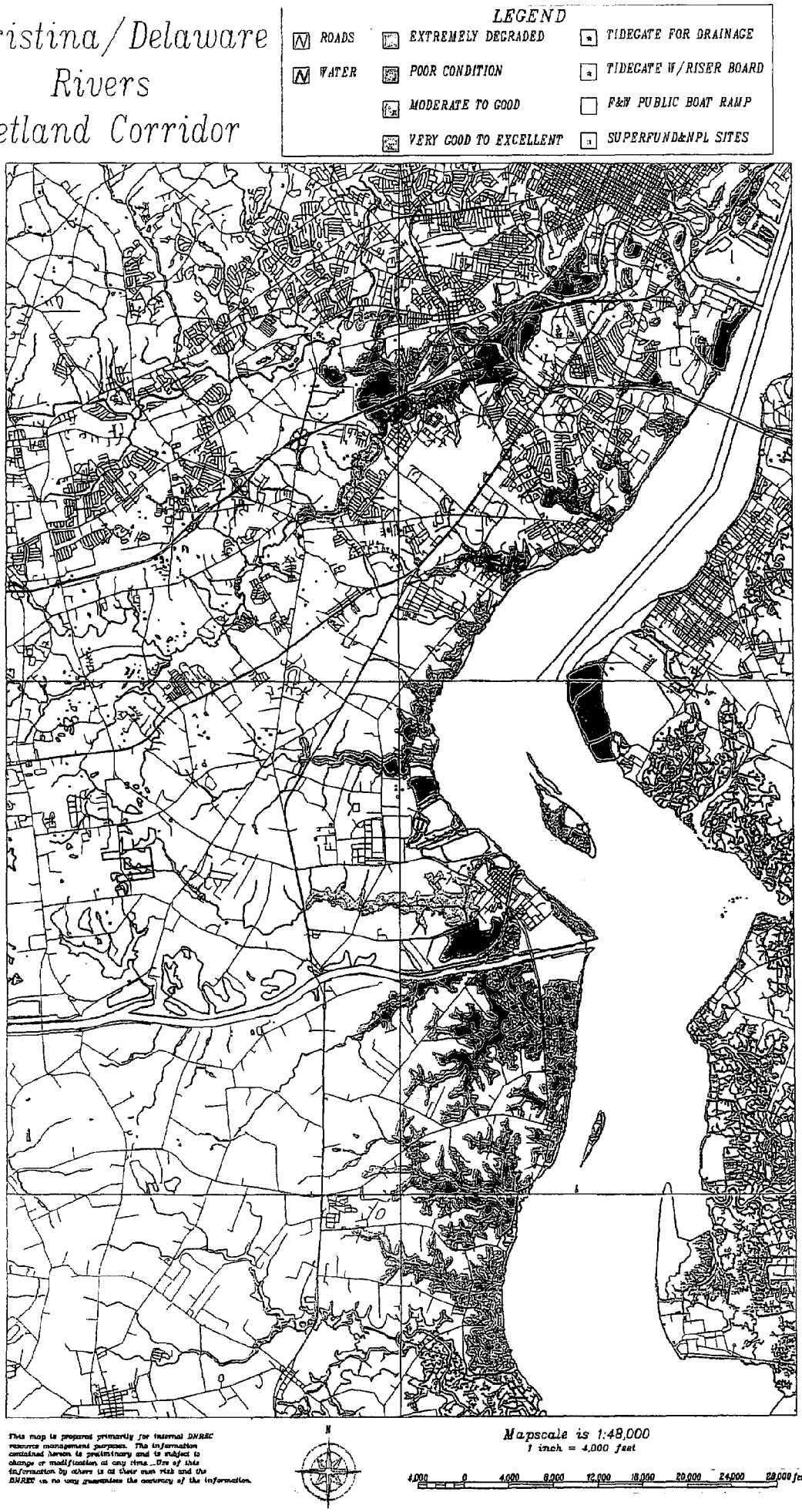


Fig. 2 Wetlands sites along the Christina/Delaware Rivers wetland corridor proposed for rehabilitation under the Northern Delaware Wetlands Rehabilitation Program (NDWRP)

historically rich wetlands of the Christina/Delaware Rivers are capable of being restored, they have been identified as a focus area under the Atlantic Coast Joint Venture of the North American Waterfowl Management Plan. This international plan seeks to protect and improve six million acres of wetlands (85,000 acres of which are along the Atlantic Coast) to increase migrating and breeding waterfowl populations to levels of the 1970's.

Degradation of Delaware's coastal wetlands was curtailed with the passage of state and federal wetland acts and executive orders in the 1970's. In fact, since the passage of the Delaware Wetlands Act of 1973, annual loss of tidal wetlands in Delaware has been reduced by approximately 22-fold (444 to 20 acres/year, Hardisky and Klemas 1983). Although current and proposed state and federal regulations should protect most coastal wetlands from continued degradation, little if any emphasis has been placed on rehabilitating those wetlands degraded prior to the passage of Delaware's tidal wetland regulations.

Annually, an increasingly larger percentage of our population resides in urban and suburban areas. Unfortunately, these urbanized communities are usually the least educated about the functions and values of wetlands. One possible explanation for this deficiency of wetland education among metropolitan residents is that urban wetlands are historically the most degraded and have received the least management and protection. The rehabilitation of these degraded wetlands can provide outdoor classrooms and effectively educate the public about wetland functions and values. A Delaware Division of Fish and Wildlife survey of needs in aquatic resources education (Kreamer 1993) presented to 306 elementary and high school teachers, community groups, nature centers, and state personnel indicated that wetland education was a priority topic.

PROJECT DESCRIPTION

The Delaware Department of Natural Resources and Environmental Control (DNREC), in cooperation with numerous other public and private organizations, has initiated an ambitious program to rehabilitate more than 10,000 acres of highly degraded tidal freshwater and brackish wetlands along the urban corridors of the Christina and Delaware Rivers in New Castle County (Fig. 2). The Northern Delaware Wetlands Rehabilitation Program (NDWRP) is a regional, non-regulatory restoration program for wetland areas degraded prior to the enactment of wetland protection acts. Currently, 31 potential wetland sites have been identified as needing rehabilitation and are proposed to be restored on a site-by-site basis. On a larger scale, the rehabilitation plans and

management practices of these sites address regional objectives and are integrated to restore an urban wetland corridor. The NDWRP is a long-term commitment by DNREC to wetland restoration. Many of the proposed wetland rehabilitation sites have been degraded for over three centuries, and it is anticipated that it might take several decades to restore many of their functions and values. However, it should be noted that land-use practices, manmade infrastructure, and other forms of economic development presently limit and will continue to limit full ecological restoration of many sites.

The NDWRP was officially unveiled at an October 1992 press conference held by former Governor M.N. Castle and former Secretary of the DNREC, E.H. Clark II. This outdoor press event held at one of the NDWRP sites, Gambacorta Marsh), was attended by civic and business leaders, resource managers, environmental scientists, and property owners. The conference outlined the program's goals, importance, rehabilitation strategy, and participants. At that time the NDWRP was in existence for approximately 6 months and attendees received an extensive press package describing the program.

The DNREC has recently completed a Comprehensive Conservation and Management Plan for Delaware's Tidal Wetlands (DNREC 1994), in part as a response to the National Wetlands Policy Forum's request for state-based comprehensive wetlands planning. The comprehensive tidal wetlands plan was developed by state, federal, and regional agencies; scientific academicians; private conservation organizations; user groups, and landowners. The plan is intended to provide guidance for the widest range of tidal wetlands issues, problems, and protection and stewardship needs. This comprehensive plan identified as one of its 10 "priority action projects" to recognize, support, and expedite implementation of the NDWRP.

The NDWRP emphasizes three approaches to wetland restoration: 1) developing and implementing management practices designed to achieve regional multiple use objectives; 2) developing a multi-agency rehabilitation team; and 3) rehabilitating an urban corridor through a watershed-based approach whereby numerous individual wetland sites are ecologically improved, eventually forming a chain of restored wetlands.

Besides the rehabilitation of several thousand acres of tidal wetlands along two major rivers and their reintegration into the Delaware Estuary, this program has developed a plan that provides DNREC with a systematic process to rehabilitate degraded wetlands and incorporate these strategies into local land-use plans. This plan is expected to serve as a model for future coastal rehabilitation programs, and will establish resource management/protection agreements among various government agencies, private organizations and industries, landowners, and

environmental groups, thus replacing the traditional individual agency approach to similar programs. Several of these resource management/protection agreements might involve enforceable actions. Finally, this program establishes a wetland rehabilitation policy upon which federal consistency determinations and environmental reviews can be based.

REGIONAL MULTIPLE-USE OBJECTIVES

An emphasis of the NDWRP is to rehabilitate an extremely degraded wetland corridor by addressing regional multiple-use objectives. The development and implementation of management practices that address multiple objectives provide a mechanism whereby the benefits of individual restoration projects can be maximized over an entire corridor. Although many rehabilitation projects will be unable to adequately address all these objectives because of site-specific limitations and landowner demands, efforts will be made to address as many regional objectives at each specific restoration site as possible. The development of measurable, evaluative criteria for each specific objective is also essential to provide temporal measurements of success. The following specific regional objectives were developed and approved by the DNREC/NDWRP Steering Committee and have been favorably received by several other governmental agencies and environmental groups.

- Improve water quality in both wetlands and rivers through tidal exchange and wetland filtering.
- Restore and improve spawning, nursery, and feeding sites for anadromous, estuarine, and riverine fishes.
- Increase biological diversity and improve wetland, riparian, and adjacent upland habitats for waterbirds and other wetland wildlife.
- Protect and enhance existing populations and critical habitats of threatened and endangered species and other species of concern.
- Increase diversity of shallow-water habitats and emergent vegetation.
- Control nuisance and exotic plant species (phragmites and purple loosestrife).

- Control pestiferous mosquito populations by water management where practical, thereby reducing the amount of chemical insecticides required.

- Reduce stormwater flooding through increased storage capacity and timely releases.

- Reduce shoreline erosion where needed for ecological or economic purposes, using environmentally acceptable methods.

- Improve a wide variety of recreational opportunities in wetland, riverine, and adjacent upland habitats and improve the aesthetic value of these areas.

- Increase environmental education opportunities for both general public and school groups.

MULTI-AGENCY REHABILITATION TEAM

The DNREC's Division of Fish and Wildlife initially administered this Departmental program; however, because of the complexity of rehabilitation issues, the scope of this effort, and the interests of staff, the Division of Soil and Water Conservation was designated as co-administrator of the program. This shared responsibility takes advantage of both Divisions' administrative, technical, and personnel resources. The formal inclusion of the Division of Soil and Water as co-administrator will add expertise in other technical fields beneficial to developing wetland rehabilitation plans, particularly for issues concerned with control of nonpoint source pollution.

To expand upon the strategy of maximizing Departmental resources and technical expertise while avoiding the traditional individual agency approach, representatives from all five DNREC Divisions and the Office of the Secretary were solicited as members of the DNREC/NDWRP Steering Committee (Table 1). Additionally, because of the close working relationship that the New Castle Conservation District (NCCD) has had with the Department in the development of this program, representatives from this agency were also included in the Steering Committee (Table 1).

Initially, additional representatives from other governmental agencies (federal, state, and county), academic institutions, environmental groups, private industry, and local communities were to be included in the Steering Committee. However, many of these "outside" committee members indicated that they would be best able

Table 1. Current members of the Northern Delaware Wetlands Rehabilitation Program (NDWRP) Steering and adjunct committees.

Steering Committee Members and Affiliation

Tulou, Christophe - Office of the Secretary, DNREC
Allen, Robert - Division of Air & Waste Management, DNREC
Baker, John - Divisions of Fish and Wildlife/Parks and Recreation, DNREC
Carter, David - Division of Soil & Water Conservation, DNREC
Chura, Mark - Division of Parks & Recreation, DNREC
Cooksey, Sarah - Division of Soil & Water Conservation, DNREC
Esposito, Gerald - Division of Water Resources, DNREC
Hossler, Robert - Division of Fish & Wildlife, DNREC
Hughes, John - Division of Soil & Water Conservation, DNREC
Irelan, Larry - New Castle Conservation District
Mahaffie, Michael - Office of the Secretary, DNREC
Manus, Andrew - Division of Fish & Wildlife, DNREC
Meredith, William - Division of Fish & Wildlife, DNREC
Stachecki, Chester - Division of Fish & Wildlife, DNREC
Tarburton, John - New Castle Conservation District
Vickers, Charles - Division of Parks & Recreation, DNREC
Vacant position - Tidal Wetlands Regulatory Program, Division of Water Resources, DNREC

Adjunct Committee Members and Affiliation

Appleby, Richard - Trustees of New Castle Common
Daiber, Franklin - University of Delaware, College of Marine Studies (emeritus)
Gallagher, John - University of Delaware, College of Marine Studies
Goodger, Timothy - National Marine Fisheries Service
Hassel, Richard - Army Corps of Engineers
Husband, Jonathan - New Castle County
Lapp, Jeffery - U.S. Environmental Protection Agency
Mitchell, Laura - U.S. Fish and Wildlife Service
Patrick, Ruth - Philadelphia Academy of Natural Sciences
Shevock, Daniel - Delaware Ducks Unlimited
Stocum, Faye - Delaware Historic Preservation Office
Verrico, Donald - Wildlife Habitat Enhancement Counsel
Wutka, Joseph - Delaware Department of Transportation

to serve the program by providing input periodically on a site-specific basis, e.g., during permit review, funding requests, or rehabilitation plan review. The logistical problems associated with scheduling and convening a Steering Committee of 30+ members, and the relative inefficiency revealed during such large meetings, were additional reasons for not including all rehabilitation team members in the Steering Committee. Instead, a two-tiered rehabilitation team was developed in which members from agencies other than DNREC or NCCD were designated adjunct committee status, and were not requested to convene at monthly Steering Committee meetings (Table 1). This two-tiered representation functions adequately, because many of the adjunct committee members are on the Delaware Wetland Joint Permit Processing Committee and review all wetland associated projects prior to implementation or advanced development. Additionally, other adjunct committee members are closely associated to the program in other capacities, e.g., Superfund Natural Resource Damage Trustees, funding source representatives, landowners, researchers of pertinent management practices, and project collaborators.

The organizational purposes of the DNREC/NDWRP Steering Committee are: 1) to assist with restoration plan development and to facilitate a high level of cooperation among DNREC Divisions; 2) to define the regional wetland rehabilitation goals, objectives, guidelines, and criteria for project evaluation; 3) to coordinate site-specific wetland rehabilitation activities; and 4) to identify the existing and future agency infrastructure needed to establish long-term maintenance and management of restored areas based on localized needs. The purposes of the adjunct committee members are: 1) to assist DNREC in restoration plan development and implementation; 2) to ensure a high level of cooperation among governmental agencies, private industries, environmental groups, and the public; 3) to assist DNREC in providing a mechanism to provide public input and increase public awareness, support, participation, and communication between resource managers and the public.

The personnel organization of the NDWRP includes DNREC program administrators, a DNREC/NDWRP program manager, and several DNREC/NDWRP project managers. The program administrators from the Divisions of Fish and Wildlife and Soil and Water Conservation are responsible for administration of the NDWRP, including coordinating efforts to acquire funding and technical assistance, and to foster inter- and intra-agency participation and cooperation.

Responsibilities of the NDWRP program manager include coordinating activities of NDWRP project managers, with emphasis on overall program goals and interactions among agencies. Additional responsibilities include: 1) reporting to granting and funding agencies and meeting established benchmarks; 2) allocating and setting priorities for resources among projects; 3)

maintaining a centralized tracking system for all individual projects; and 4) coordinating the work plan for permit application submission and responses to permit review. The NDWRP program manager is also a fish and wildlife regional manager with the Division of Fish and Wildlife, stationed in northern Delaware.

NDWRP project managers are other DNREC employees responsible for coordinating the activities associated with a specific wetland rehabilitation project. These duties include: 1) coordinating activities and interactions among individuals from other DNREC Divisions, federal, state, county, or municipal agencies; 2) coordinating landowner contacts for purposes of project orientation, explanation of project goals, landowner education, obtaining landowner input and support, and building a consensus for project cooperation; 3) coordinating collection of site-specific environmental information; 4) coordinating development of site-specific restoration and management plans; 5) preparing and reviewing environmental assessments and applications for federal 404 and state wetland permits; 6) implementing restoration and management activities; 7) developing broad-based public support and participation in the project; and 8) coordinating long-term monitoring and evaluation activities.

Although the personnel assigned to these positions are crucial to the development and implementation of the program, overall success of this regional wetland rehabilitation process depends on the cooperation and involvement of federal, state, and local agencies; private industries; landowners, and environmental groups. This multi-agency approach increases the available resources and funding opportunities, while including private industries, landowners, and environmental groups to provide corporate sponsorships, property access, and broad-based public support, respectively. Additionally, early involvement of parties interested or affected by rehabilitation efforts increases the probability of mediating any potential conflicting interests. Listed below are several agencies, divisions, and organizations that have contributed to the initial success of this program, or are slated to do so in the immediate future.

Division of Fish and Wildlife (DNREC) - Co-administrator of the program and responsible for developing water and vegetation management, wildlife enhancement, fisheries restoration, and mosquito abatement plans associated with restoration projects. This Division has, with the assistance of other agencies, conducted biological inventories and ecological evaluations of restoration sites, and developed and implemented water management and vegetation management plans at selected wetland sites. Fish and Wildlife has also lead or assisted in the design of proposed water control structures, and will assist in the supervision and installation of these structures. The submission of environmental assessments and state and federal permits for many of the projects will be undertaken by this Division. The Division has designated

70% of one of its general fund positions to function as the NDWRP program manger. Additional Division personnel involved with this program function in program administration, scientific assessment, technical assistance, project management, and committee participation.

Division of Soil and Water Conservation (DNREC) - Co-administrator of the program and responsible for developing and implementing nonpoint source pollution prevention, erosion and sedimentation control, and upstream stormwater management plans. With the assistance of other agencies these plans will address both site-specific and watershed/basin-wide issues. The Division's future development and use of stormwater management utilities might also help advance the nonpoint source pollution prevention goals of the NDWRP. This Division is currently pursuing the formation of site-specific, self-taxation, landowner associations that would utilize existing state code to develop marsh management organizations. Soil and Water has helped coordinate Conservation District input and action. As administrator of the Delaware Coastal Management Program (DCMP), sponsored by the National Oceanic and Atmospheric Administration, Division personnel are responsible for administering DCMP grants received by the NDWRP, developing coastal nonpoint source pollution control programs in upland areas adjacent to project sites, and reviewing wetland rehabilitation plans for consistency with the DCMP. Division personnel involved with this program function in program administration, project management, technical assistance, and steering committee participation.

Division of Air and Waste Management (DNREC) - Administrator and coordinator of wetlands remediation projects associated with Superfund sites, and of use of potential wetland rehabilitation monies received through enforcement of natural resource damage assessments. The Division has provided extensive information and guidance concerning contaminant issues associated with NDWRP restoration sites, and has assisted in contaminant sampling. Wetland rehabilitation efforts are being integrated with this Division's Christina River Basin Hazardous Waste Sites Restoration Project, which is developing a uniform approach for the investigation and remediation of hazardous waste sites within the Christina River watershed.

Division of Water Resources (DNREC) - Representatives have provided extensive guidance associated with wetlands permitting needs and procedures, and are currently supporting a site-specific wetland mitigation banking effort to promote wetland rehabilitation projects. NDWRP wetland rehabilitation activities will be integrated with several other programs being undertaken by this Division, including: the Whole Basin Planning approach to water resource protection; the National Pollutant Discharge Elimination System (NPDES), and efforts to address combined sewer overflow problems. The Division has assisted in ecological

evaluations of proposed restoration sites, especially through geographical information systems and water supply analysis, and has provided technical support in toxicological testing of sediment and water samples. Water Resources will also assist other agencies in addressing nonpoint and point source pollution issues and reviewing water and vegetation management plans.

Division of Parks and Recreation (DNREC) - Representatives have assisted in the development of recreation and environmental education plans; have provided guidance on developing conservation easement programs among landowners; and coordinated wetland recreation plans with the Delaware Coastal Heritage Greenway Program. The Division's Natural Heritage Inventory has conducted biotic composition and rare plant surveys in proposed restoration sites. The Natural Heritage Inventory is also funding a 3-year study of the heron colonies within the rehabilitation corridor.

Office of Information and Education (DNREC) - Representatives have organized press events, and published pamphlets, brochures, and articles promoting the NDWRP. Public involvement in several wetland rehabilitation sites has been initiated by the Office's Adopt-A-Wetland Program and their annual Christina River and Delaware Coastal Cleanups.

New Castle Conservation District (NCCD) - The District is assisting in all phases of various construction projects including design, hydrological modeling, developing bid packages and work plans, and the supervision of the construction and installation of water control structures. NCCD has assisted in the submission of wetland permits and grant applications, and in the development of promotional brochures. The District is also providing geographical information system support, assistance in local land-use issues, and in the development and implementation of stormwater management and nonpoint source pollution prevention plans. NCCD is undoubtedly one of the biggest contributors to the NDWRP in technical and promotional support, and site-specific implementation.

Delaware Department of Transportation (DelDOT) - This agency owns several water control structures associated with wetland rehabilitation projects and, as such, has provided assistance in their maintenance, repair, and redesign in order to promote project success. This agency is currently modifying minor road construction plans and maintenance practices to promote wetland restoration, and will assist in supervising the construction and installation of new water control structures. DelDOT is also a potential funding source through wetland mitigation associated with transportation projects.

U.S. Fish and Wildlife Service (FWS) - This agency has provided guidance in restoration efforts as a regulatory agency in the wetlands permit process and as a Superfund Natural Resources

Damages Trustee. The agency has provided promotion and technical support through assistance with grant submission (via the Delaware Estuary Project) and wildlife contaminant issues, respectively. FWS has provided funding for restoration-related ecological studies and has indicated potentially additional funding through its Partners for Wildlife Program.

National Marine Fisheries Service (NMFS) - This agency has provided guidance in restoration efforts as a regulatory agency in the wetlands permit process and as a Superfund Natural Resources Damages Trustee.

U.S. Environmental Protection Agency (EPA) - This agency has provided guidance in restoration efforts as a regulatory agency in the wetlands permit process and through its remediation of Superfund sites. It is also a potential funding source through various grant programs, e.g., Section 319 for nonpoint source pollution reduction.

Army Corps of Engineers (COE) - This agency has provided guidance in restoration efforts as a regulatory agency in the wetlands permit process. COE might also provide technical and funding support for experimental dredging operations associated with wetland restoration projects.

U.S. Soil Conservation Service (SCS) - This agency is assisting in developing a watershed-based approach to addressing nonpoint source pollution within the corridor. SCS is identifying areas where new or improved stormwater retention, conservation, and best management practices can reduce pollutant loading into the wetland restoration sites. This agency is also assisting in modeling surface water recharge and storm runoff for the rehabilitation sites.

New Castle County Government - The County will provide input on wetland rehabilitation projects as they relate to county stormwater management practices and recreational facilities. The County is also a landowner of several proposed wetland restoration projects and their water control structures, and might provide financial assistance to help implement restoration activities.

Trustees of New Castle Common - The Trustees are landowners of several proposed wetland restoration projects within the New Castle city limits. They are very supportive of the program and have annually provided funding, operational support, and property access ever since preliminary rehabilitation efforts were initiated in 1987 on Broad Dyke and Gambacorta Marshes.

Delmarva Power - This public service utility is a landowner of several proposed wetland restoration projects. Delmarva Power is very supportive of the program and has provided funding, operational support, and property access on several projects. A

significant amount of their support has been through the Delmarva Power Sportsmen Club, which has assisted in controlled burns, experimental water level manipulations, and beneficial wildlife plantings.

Brandywine & Christina Rivers Task Force - This broadly represented and diverse group of citizens, government leaders, business interests, and environmental proponents was formed by gubernatorial executive order in 1992. Its purpose was to develop recommendations on what actions state and local governments could take to protect and enhance these waterways. A Wetlands and Wildlands Committee was established by the Task Force, separate from the NDWRP, to identify and protect high quality wetlands; restore damaged and destroyed wetlands; and to reduce nonpoint source pollution in these rivers by improving watershed planning and hydrology management. Currently, the Task Force is pursuing the development of a wildlife refuge and recreation area at Old Wilmington Marsh, a NDWRP-listed project. Because the objectives of the NDWRP and the Wetlands and Wildlands Committee of this task force are nearly identical, it is hoped that these efforts are able to be collaborative rather than duplicative. The Steering Committee suggests that the NDWRP be the vehicle through which the Brandywine & Christina Rivers Task Force accomplishes its wetlands rehabilitation goals.

Delaware Ducks Unlimited - The Delaware Chapter has provided promotional support to the program and is interested in providing funding support for specific wetland rehabilitation projects.

Wildlife Habitat Enhancement Council - This international council of private industries has promoted corporate support for the NDWRP.

Various Private Landowners - Although not members of the steering committee, these private landowners are essential partners in many of the wetland rehabilitation projects. As property owners, their support of the program and input into the rehabilitation plans are required to access, develop, implement, and maintain the restoration projects. In instances where there are multiple landowners of a wetland rehabilitation project, a landowner association can be formed to enable the proprietors to determine management decisions based on a majority vote. The formation of a landowner association can also provide a legal mechanism in which taxation within the association provides a source of funds for marsh management.

Although involvement and cooperation by these agencies are important to the program, several interagency agreements or developing policies are particularly noteworthy. A policy being developed in concert with the NDWRP is the Delaware Divisions of Water Resources and Fish and Wildlife attempt to establish a Department position that allows for future wetland mitigation

credit (mitigation banking) for compensating for unavoidable wetlands loss in advance of development actions. Several basic elements of this policy have been proposed in the Delaware tidal wetlands comprehensive plan (DNREC 1994), and have been identified as a priority action project. This policy would differ from the Department's regular process of not pre-disposing wetland mitigation decisions on projects not completed or permitted, but would be consistent with views currently being supported by the Clinton Administration and being administered among natural resource agencies in other Mid-Atlantic states.

The benefits of this policy to the NDWRP are that it provides a mechanism and funding for the rehabilitation of the corridor by allowing developers and corporations to receive wetland mitigation credit for rehabilitation efforts conducted under the guidance of the program. An example of a proposed project that would benefit from this policy is the Artesian Marsh Rehabilitation. Artesian Marsh is a 136-acre tidal freshwater wetland whose property owner, the Artesian Water Company, is interested in assisting in its rehabilitation, but desires mitigation credit. Additionally, the Delaware Department of Transportation (DelDOT) has expressed interest in wetlands mitigation at this site, because during its permitting process the Army Corps of Engineers identified this marsh as the preferred mitigation site for the wetlands lost by the proposed widening of Interstate 95. Establishing a wetland banking policy would allow these two parties to consolidate resources and funding, historically slated from fragmented wetland mitigation projects, into one large contiguous mitigation project that can more effectively replace lost wetland functions and values within the watershed. An additional benefit of advanced compensation for wetland loss is that it provides for greater certainty of successful mitigation, because mitigation is established before permits are issued.

Several Superfund remediation settlements are currently ongoing, and most involve remediation of wetlands or compensation for natural resource injuries that are wetland related. Because of the complexity of assessing resource injuries and developing remediation plans, a task force comprised of state and federal resource agencies was formed to assist in the remediation negotiations for one of the NDWRP sites, Army Creek Marsh. This task force, the Army Creek Superfund Natural Resources Damages Trustees, is comprised of the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Delaware Divisions of Air and Waste Management and Fish and Wildlife. The task force has embraced the NDWRP, and is currently considering the program's regional rehabilitation strategy when assisting in the development of Superfund remediation plans and natural resource damages compensation. The next use of this task force approach to natural resources injury assessment and damages determination, which might not involve formation of an official trustee group, is in association with the DuPont Newport Superfund site. This

Superfund site might affect several NDWRP sites. This working relationship being forged among the various agencies will provide significant funding and technical resources to the NDWRP, while providing an appropriate avenue for compensation of Superfund-related natural resources injuries.

The Division of Soil and Water Conservation is currently pursuing the formation of a landowner association at a proposed wetland rehabilitation site by creatively utilizing the 200 year-old Delaware Drainage Code. Chapter 41 of the Delaware Drainage Code has historically been used to manage water and correct drainage problems via tax ditch associations. However, at Thousand Acre Marsh, an attempt is being made to help landowners help themselves by utilizing a "tax ditch" organization to biologically and hydrologically improve the marsh and its management practices.

Historically, landowner disputes over water management practices have significantly degraded and hindered the improvement of Thousand Acre Marsh. Therefore, to resolve these disputes and rehabilitate the marsh, the formation of the Thousand Acre Tax Ditch Association was proposed to determine marsh management decisions and implement actions based on a landowner majority vote. The formation of a tax ditch association not only provides a forum for decision making, but it also provides a legal mechanism for taxation within the association by establishing a dedicated source of funding for marsh management activities. Additionally, as a legally binding organization, a tax ditch association is eligible to apply for wetland restoration funding from appropriate state and federal agencies. If this unique use of the Delaware Drainage Code is successful at Thousand Acre Marsh, DNREC anticipates using the same approach for similar marsh management associations at other proposed wetland rehabilitation sites with multiple landowners.

COMPONENTS OF THE REHABILITATION PLAN

An important element in any restoration effort is an appropriately detailed restoration plan, followed by the more difficult and essential task of actually implementing the planned actions. This plan provides a foundation from which all rehabilitation efforts are based. Without such a plan, rehabilitation efforts may take tangential courses that might not arrive at their targeted objectives. Although the plan should be a definitive outline focused on achieving specific rehabilitation objectives, it should also continue to evolve as new information is obtained. This plan should be of sufficient detail so that ambiguity during project implementation is minimized. Of course,

the reality of implementing planned but untried or unproven procedures might lead to alterations of the site-specific project goals.

Wetland rehabilitation plans should be constructed around scientifically-based biological inventories and ecological evaluations of the site and its surrounding landscape. These ecological studies should be designed to obtain information on the degree and causes of wetlands dysfunctions, and provide baseline data on all resources that might be affected by rehabilitation efforts. This baseline information should provide historic and current perspectives of the site, and insight on its potential. Pertinent baseline information includes in part:

1) Hydrologic characteristics - detailed information on tidal and groundwater influences, runoff characteristics, and basin dynamics.
2) Water quality - parameters related to aquatic organisms and state water quality standards.
3) Contaminants - point source and nonpoint source pollutants, and hazardous waste sites potentially impacting the site or its proposed restoration plan.
4) Fish communities - detailed analysis of present and potential species composition and abundances with emphasis on habitat requisites.
5) Wildlife use - emphasis placed on waterbirds and aquatic mammals including species composition, abundances, and seasonal habitat requirements.
6) Threatened and endangered species, and species of special concern - identify listed fauna and floral populations and their critical habitats for protection of biological diversity values.
7) Vegetation communities - determine species composition, areal cover, productivity, biomass, and indices of relative dominance and diversity.
8) Mosquito production - species composition, abundance indices, and previous control efforts.
9) Land use - previous and present uses of the wetland site and surrounding landscape.
10) Recreation and education opportunities and uses - existing and potential opportunities and uses.
11) Geology and soil resources - physiographic provinces and soil types.
12) Socioeconomic and cultural resources - potential impacts of proposed rehabilitation plans to residents and archeological sites.

Whenever possible, these studies should be designed to collect quantitative data rather than anecdotal information. Properly collected quantitative data are more likely to address issues raised during regulatory reviews of restoration proposals. Additionally, the comparison of properly collected quantitative

baseline data with post-implementation data provides better objective criteria for evaluating the success of site-specific goals. However, because quantitative data are often expensive and labor-intensive to collect, often at the expense of alternate funding uses of perhaps more importance, it is occasionally necessary to settle for scientifically-based qualitative information.

The rehabilitation plan should clearly define the site-specific objectives. The nature of these objectives should be such that they not only rehabilitate a specific wetland, but they also benefit the entire corridor by addressing one or more of the regional objectives. Each site-specific objective should include action steps required to accomplish the goal. These action steps should be in enough detail to provide both implementing and regulatory personnel with a clear understanding of what is proposed to be conducted. These steps should also include approximate initiation and completion dates. All site-specific objectives should have measurable evaluative criteria to provide temporal measures of success. If resources permit, these criteria should be quantitative and comparable with measurements of baseline data.

A requisite to the long-term needs of this regional wetland rehabilitation strategy is development of site-specific operation, maintenance, and management plans (OMM plans). These plans might have participation arrangements ranging from voluntary agreements to enforceable policies. This component of the rehabilitation plan provides assurances that rehabilitation efforts will be implemented, maintained, managed, and modified as needed to accommodate site-specific and regional objectives, and to prevent the extenuation or reversal of restoration achievements. The OMM plan identifies the agencies or parties responsible for site-specific long-term rehabilitation needs. These responsibilities include performing and funding the maintenance, repair, replacement and inspection of various structures, e.g, water control, wildlife enhancement, recreation, and erosion and sedimentation control structures. Other responsibilities could include implementing and funding various operating and management practices, such as water and vegetation management plans; phragmites, mosquito, and nonpoint source pollution control programs; and emergency response to structure failures. The responsibilities of a particular agency or party will be documented through operation, maintenance, and management agreements. This documentation might occur in the form of voluntary or mandatory memorandums of agreement (MOA's) among governmental agencies, voluntary or legally-binding documents signed by landowners or associations (e.g., conservation or water management easements), or enforceable programs or policies. These signed agreements provide the mechanisms needed to ensure long-term rehabilitation success, with enforceable arrangements having more certainty than voluntary measures.

The final component of the rehabilitation plan is a provision to actively involve the landowners and local environmental groups in the rehabilitation effort. Active involvement by the public not only promotes a increased awareness and understanding of wetland functions and values, but it also provides additional assurance of the long-term success of the project. Mechanisms to involve landowners include: providing opportunities for input into the rehabilitation process; developing water management and conservation easements; forming watershed associations; inclusion of landowner responsibility in the OMM plan; and developing biological monitoring projects. Environmental groups can also become advocates of a rehabilitation project through involvement in community service and biological monitoring projects, and the promotion of Departmental projects, e.g., Adopt-a-Wetland and Christina River Cleanup.

SYSTEMATIC REHABILITATION PROCEDURE

The NDWRP has developed a systematic procedure to facilitate the development and implementation of site-specific wetland rehabilitation plans. This process not only provides a framework for restoration planning and implementation, but it also promotes frequent input by landowners, Steering Committee members, adjunct committee members, and regulatory agencies. This framework also encourages utilizing the technical expertise of the rehabilitation team members and allocating task responsibilities to various members. It is important to the cohesion, credibility, and performance of the NDWRP effort that any proposed or new activities affecting the program be brought to the attention and review of the Steering Committee at the earliest possible time. NDWRP participants should keep other members of the Steering Committee fully informed about their activities on rehabilitation sites, and not undertake substantive activities without Steering Committee review and concurrence. Assignments of task responsibilities in the NDWRP effort should be guided by assessment of an agency's or individuals's official or traditional responsibilities, which usually represent the best and most appropriate source of knowledge, expertise, or experience about the topics or problems at hand.

The systematic rehabilitation procedure for site-specific projects is:

1) Present proposed rehabilitation site and preliminary project objectives to the Steering Committee. The Steering Committee reviews the rehabilitation candidate, and if approved, designates a site-specific project manager.

2) Designate or initiate acquisition of funding for the development and implementation of the rehabilitation plan.
3) Conduct tax map searches to identify landowners.
4) Contact landowners to solicit involvement in the rehabilitation project and acquire permission to conduct biological inventories and ecological evaluations.
5) Conduct biological inventories and ecological evaluations of site.
6) Formulate a draft rehabilitation plan and present to Steering Committee for review and approval. Rehabilitation plan should be outlined on a tracking form, which identifies site-specific multi-use objectives, action steps required, and evaluative criteria. This form provides a mechanism whereby project development, implementation, and success can be updated and assessed.
7) Conduct additional biological inventories, ecological evaluations, topographic surveys, hydrological studies, and engineering designs as needed.
8) Obtain input on the rehabilitation plan from adjunct committee members and regulatory agencies via presentations and site visits.
9) Hold a public meeting with the landowners to identify potential conflicts with the draft rehabilitation plan.
10) Finalize the rehabilitation plan and present to Steering Committee for review and approval.
11) Prepare project specific environmental assessments and permit applications.
12) Establish community or environmental groups as advocates of the rehabilitation project.
13) Present final rehabilitation plan to landowners for comment. This step is frequently required in the permit process.
14) Upon permit approval and acquisition of funding, implement the rehabilitation plan and develop a final work schedule.
15) Monitor evaluative criteria to determine the success of accomplishing site-specific multiple-use objectives. Make adjustments/additions to rehabilitation plan to better achieve these goals or accommodate additional objectives.

The chronology of achieving such benchmarks will undoubtedly deviate slightly among rehabilitation projects, as site-specific opportunities or problems arise. Several of these benchmarks can and should be initiated earlier in the process as opportunities present themselves, e.g., funding acquisition, landowner contacts, and obtaining biological inventories, hydrological studies, and ecological evaluations. Although minor changes in the chronology are acceptable, it is imperative to the overall success of the rehabilitation strategy that all the outline benchmarks are

achieved prior to plan implementation. This requirement of assuring that all pertinent benchmarks are addressed prevents projects from being implemented in a haphazard "shotgun approach". Such an approach is less likely to achieve regional objectives and more likely to promote negative feedback concerning the program. At the same time, the planning process must not take on a life of its own and become an excessively lengthy or costly procedure, which would also generate negative feedback.

SITE-SPECIFIC REHABILITATION PROJECTS UPDATES

Currently, 31 wetland rehabilitation sites are identified within the highly degraded urban corridor along the Christina and the Delaware Rivers (Table 2). Rehabilitation efforts on 11 of these sites have significantly advanced beyond this preliminary identification phase (Fig. 3). Progress varies among these 11 sites, ranging from the development of site-specific ecological evaluations, to landowner negotiations, to acquisition of funding, and implementation of the rehabilitation plan. Site-specific descriptions and tracking forms outlining the project goals, action steps needed, and evaluative criteria of several of these projects are presented in the appendices. Provided in the subsequent sections are updated progress reports for these 11 ongoing projects.

Broad Dyke Marsh

The administrative lead for this project is the Division of Fish and Wildlife with substantial technical and administrative support being provided by the New Castle Conservation District, particularly in the design and construction of the proposed water control structure. The Division of Air and Waste Management has provided extensive information concerning potential contaminant sources within the watershed and their likelihood of impacting the project. The Division of Parks and Recreation is coordinating the inclusion of portions of this marsh into the Delaware Coastal Heritage Greenway Program. Other Divisions and agencies have also provided support.

Studies initiated in 1987 have determined that the successful, long-term restoration of the Broad Dyke Marsh is dependent upon replacing the existing or installing an additional water control structure (Delaware Mosquito Control Section 1988). This new structure must be a larger, more specialized structure that allows carefully controlled tidal exchanges while having the capacity to release significant stormwater input. It should also

Table 2. Wetland sites proposed for rehabilitation under the Northern Delaware Wetland Rehabilitation Program (NDWRP).

Site (n=31)	Acreage
Airport Marsh Wetland Complex	139
Army Creek Marsh	235
Artesian Marsh	136
Augustine Creek Wetland Complex	1130
Banning Park Marsh	84
Broad Dyke Marsh	210
Buttonwood Marsh	100
Cherry Island	325+
Christina Creek Marshes	225
Churchman's Marsh	250
The Delmarva Power and Light Impoundment	81
Dragon Run Marsh	615
Everglades Marsh	289
Gambacorta Marsh	41
Glenville Marsh	45
Hamburg Cove Marsh	202
Holloway Terrace Marsh	46
ICI Marsh	30
Luken's Marsh	215
National Guard Marsh	170
NeCastro Marsh	29
Newport Marsh	44
Nonesuch Creek Basin	588
Old Canal Marshes/Scott Run	542
Old Wilmington Marsh	325+
Pea Patch Island Marsh	90
Red Lion Marsh	465
Shellpot Creek Marsh	150+
Silver Run/Augustine Wildlife Complex	2115
South Wilmington Wetland Fragments	200
Thousand Acre Marsh	1288
Total	10,404+

Fig. 3. Wetlands restoration sites currently being developed or implemented by the Northern Delaware Wetlands Rehabilitation Program (NDWRP).

operate in an automated fashion to eliminate the need for labor-intensive management and maintenance. Because most of the rehabilitation plans and management decisions regarding this proposed project are dependent on the hydrology of Broad Dyke Marsh being restored, rehabilitation efforts have focused on obtaining designs, funding, and permits for this new water control structure. Once this structure is in place, additional rehabilitation efforts will continue.

Complementing the extensive studies and management practices conducted in 1987-1989 (Delaware Mosquito Control Section 1988; 1990), a biological inventory and ecological evaluation of the marsh was completed in November 1992 (Cole and Fabean 1992). Information obtained in these studies has assisted in the hydrologic and hydraulic modeling of the system. This modeling (Williams and Broome 1992) has led to the design and final selection of a $500,000 automated water control structure, containing a vertical lift gate and automatic water-level sensors, that allows daily tidal exchange and regulates marsh water levels. This structure will be installed adjacent to the existing structure, which will be maintained to increase outflow during heavy storm events. Rehabilitation and water management plans have also been developed (Appendix A), and are awaiting approval by the Steering Committee. The permit submission process will be initiated when these plans are approved.

Current ongoing management practices include an annual maintenance program to control phragmites through aerial applications of herbicide. An initial herbicide treatment of 112 acres was conducted in the late 1980's. In 1993, 38 acres of persistent and regenerating stands were treated. Efforts are underway to conduct controlled burns on several of these persistent stands during the late winter of 1994. Additional ongoing management practices include daily monitoring of marsh water levels, annual surveys of wood duck production, seasonal inspections of mosquito breeding, and monitoring of floral and faunal communities. Permanent vegetation transects and water quality sampling stations will be established in the marsh during the summer of 1994 to provide a baseline for evaluative criteria.

Both landowner and community support for this project have been outstanding, with 90% of city of New Castle residents supporting it (Barnekov and Appel 1993). The largest landowner, the Trustees of New Castle Common, has provided significant funding for the project. Obtaining non-financial support has also been successful. Two environmental groups from local high schools have adopted the marsh through DNREC's Adopt-A-Wetland Program. During the 1993 Delaware Coastal Cleanup, these environmental groups initiated a trash cleanup in the marsh. These groups are currently developing additional environmental education, ecological monitoring, and cleanup programs through the assistance of DNREC.

Approval of the project by the appropriate regulatory agencies is anticipated in June 1994. A final version of the draft environmental assessment will be submitted in March 1994, with the appropriate permits. Several site visits and presentations have been attended by various regulatory agency personnel, and all feedback has been positive with several agencies providing helpful input regarding the development of the rehabilitation plan and the environmental assessment. Partial clearance for the project has been received by the State Historic Preservation Office. Currently, a draft operation and maintenance plan for the proposed water control structure has been developed. Participants in this plan include the Delaware Division of Fish and Wildlife, the New Castle County Public Works, the City of New Castle, the Trustees of New Castle Common, and the New Castle Immanuel Episcopal Church.

Funding support for the project has advanced slowly; however, sufficient funding is anticipated to initiate construction of the water control structure in the summer of 1994. Secured and pending funding sources for the structure include:

Secured	
EPA Section 319 Nonpoint Source Pollution Grant	$ 180,000
Trustees of New Castle Common	105,000
State of Delaware, FY-93 Appropriation	50,000
	$ 335,000
Pending	
New Castle County Public Works Department	$ 100,000
State of Delaware, FY-94 Appropriation	50,000
Ducks Unlimited, Inc. (Delaware Chapter)	40,000
	$ 190,000

Gambacorta Marsh

The administrative lead for this project is the Division of Fish and Wildlife. The New Castle Conservation District is assisting in the design of the proposed water control structure. The District has also taken the lead in addressing a sedimentation problem occurring in an adjacent lumber yard. Recent vegetation control and construction practices within this lumber yard have caused increased sedimentation of a portion of the marsh. The District is pursuing the installation of a water conveyance system with diversion berms, and subsequent revegetation of the area to prevent additional sedimentation from occurring. Once the sedimentation is controlled, the silted-in area of the marsh will be excavated. Other divisions and agencies have also provided support. The Division of Soil and Water Conservation has compiled a comprehensive nonpoint source pollution control plan for the marsh. The Division of Air and Waste Management has provided

extensive information concerning potential contaminant sources in the watershed, particularly the marsh sediment, and their likelihood of impacting the project. The Division of Parks and Recreation is coordinating the inclusion of portions of this marsh into the Delaware Coastal Heritage Greenway Program.

The rehabilitation status of Gambacorta Marsh is that it is awaiting funding and permit review. A biological inventory and ecological evaluation of the marsh was completed in November 1992 (Cole and Fabean 1992), and the rehabilitation and water management plans (Appendix B) were approved by the Steering Committee in April 1993.

The water management plan was implemented in August 1993 after the existing water control structure was temporarily modified to allow daily tidal exchange. Since the plan's implementation, water levels and salinity have been monitored on a weekly basis. Additional water quality parameters will be monitored in the near future. Other ongoing management practices include an annual maintenance program to control phragmites through aerial application of herbicide. In 1993, 10 acres of persistent and regenerating stands were treated. This control plan, initiated in the late 1980's, has reduced the areal coverage of phragmites within the marsh by approximately 82%. Efforts are underway to conduct controlled burns on several of these persistent stands during the late-winter of 1994. Annual surveys of wood duck production and weekly surveys of waterbird use are being conducted to determine the success of the wood duck nest boxes and the water management plan, respectively. Seasonal inspections of mosquito breeding, and monitoring of floral and faunal communities, are also being conducted. Five permanent vegetation transects were established in the marsh during August 1993. These transects provide baseline data to evaluate and modify the water management plan and future wetland rehabilitation efforts.

Community support for this project has been outstanding as determined by the mostly positive responses from visitors utilizing the adjacent New Castle Scenic Walkway. Several walkway users were concerned about the seasonal draw downs; however, an interpretive sign will address these concerns and provide an understanding of the management goals of the marsh. Although participants of the 1993 Delaware Coastal Cleanup assisted in removing a significant amount of trash from the marsh, DNREC is still soliciting for a local environmental group to formally adopt the marsh through the Adopt-A-Wetland Program.

The primary reason for the delay in implementing the Gambacorta Marsh rehabilitation plan is that the landowner, Trustees of New Castle Common, is currently funding another project, Broad Dyke Marsh. The Trustees are understandably hesitant to fund or approve extensive rehabilitation efforts on

Gambacorta Marsh until the other wetland rehabilitation project is partially completed. However in September 1993, the Trustees approved portions of an interim rehabilitation proposal for the marsh. Within the framework of this proposal, the Trustees have provided funding for additional phragmites control work, the creation of scenic vistas along the Scenic Walkway, and the construction of interpretive signs along the Scenic Walkway. The phragmites control and clearing of vistas along the walkway were preformed by the Trustees and the Division of Fish and Wildlife. Additional assistance in the clearing of brush was obtained through prison labor from the Delaware State Department of Corrections. Construction of the interpretive signs is proposed in the spring of 1994 after the Trustees and the Division of Parks and Recreation finalize the inclusion of the scenic walkway into the Delaware Coastal Heritage Greenway Program. These signs will be designed cooperatively among the Trustees and the Divisions of Fish and Wildlife and Parks and Recreation. The DuPont Company donated $5,000 to the Trustees to develop and construct these signs.

The only item of the interim proposal that was not approved by the Trustees was the construction of a 6-foot-high observation platform overlooking the marsh. This item was placed on hold because it was feared that the additional use of this structure might exacerbate a parking problem at the entrance of the Scenic Walkway. The Divisions of Fish and Wildlife and Air and Waste Management are currently assisting in developing a resolution to this parking problem through acquisition of property as part of the Army Creek Superfund Natural Resources Damages settlement.

An environmental assessment and permit applications will be submitted once funding for the new water control structure and final approval by the Trustees is received. Several site visits and presentations have been attended by various regulatory agency personnel, and all feedback has been positive with several agencies providing helpful input regarding the development of the rehabilitation plan. Existing and potential funding sources for this project include the Trustees of New Castle Common, Delaware Department of Transportation, Brosius-Eliason Lumber Company, and the DuPont Company.

Thousand Acre Marsh

The administrative lead for this project is the Division of Soil and Water Conservation. The New Castle Conservation District has administered a contract to develop a 2-foot contour map of the marsh's 3,067-acre watershed. The Division of Parks and Recreation's Natural Heritage Inventory is currently conducting a biotic composition and natural community description of the marsh. Other Divisions and agencies have also provided support.

This project was initiated by the Division of Fish and Wildlife in 1991 through a grant provided by the U.S. Fish and Wildlife Service. This grant provided the funding for completing a draft report on the general background, description, and management recommendations for Thousand Acre Marsh (Carter 1992a). Information obtained in this and subsequent studies have assisted in the development of rehabilitation and water management plans (Appendix C). These plans will be submitted to the appropriate regulatory agencies for permitting after review and approval by the Steering Committee.

Several site-specific marsh and watershed rehabilitation efforts are proposed for this marsh including: conducting an extensive phragmites control program; installing a new water control structure; utilizing innovative dredging technology to restore "wet island" habitats; restoring channels to improve marsh access and water circulation, and identifying areas within the watershed where conservation practices would improve surface water runoff quality. However, the implementation and funding of these rehabilitation efforts are conditioned on the formation of a landowner tax ditch association. This association would enable the 22 private landowners to determine management Actions based on a majority vote, and provides for a legal mechanism in which taxation within the association provides a source of funds for marsh management. Several landowner meetings have been held (the most recent in July 1993) to provide detailed overviews of the marsh rehabilitation and tax ditch formation plans. These public meetings were preceded and followed by meetings with individual landowners to address specific concerns, questions, and needs. A petition to investigate the feasibility of the formation of the Thousand Acre Tax Ditch Association was signed by a majority of landowners (55%) in July 1992. The Superior Court of Delaware approved the formation of this association in March 1993. A final vote by the landowners whether to form the Thousand Acre Tax Ditch Association is expected in February 1994.

There appears to be a concern by some landowners regarding the prospect of allowing limited estuarine exchange with Thousand Acre Marsh. These concerns are in regard to potential changes in marsh salinity and vegetation composition, and fluctuating water levels. This sensitivity over tidal exchange was sufficient to prevent the Division of Fish and Wildlife from undertaking an U.S. Fish and Wildlife supported estuarine fisheries habitat assessment of the marsh. Not reintegrating this large wetland area with the estuary would severely limit the number of regional multiple-use objectives achieved by the restoration plan. Limited tidal exchange would benefit water quality, fisheries use, control of pestiferous mosquito populations, and two large wading bird colonies within the corridor. Initiatives are now being made to convince landowners of the necessity and benefits of restoring limited estuarine exchange to the marsh.

Initiation of an environmental assessment and permit applications are pending formation of the Tax Ditch Association and its decision with regard to wetland rehabilitation activities. However, state and federal wetland permits have been received to construct 560 yards of rip-rap stabilization along an individual landowner's property, and to address an erosion problem along the intercoastal dike (Route 9). The rip-rap stabilization was completed in the summer of 1993 and the erosion problem along Route 9 will be addressed in January-February 1994. Additional ongoing management practices include the February 1992 implementation of an interim water management plan, weekly monitoring of water levels and water quality (salinity, temperature, dissolved oxygen, nitrogen, phosphorus), and seasonal inspections of mosquito breeding.

Several site visits and presentations were attended by various regulatory agency personnel, and feedback was mostly positive. Some concern was been raised regarding the funding and involvement by public agencies for the benefit of a private association; however, a position paper identifying the public benefit of this rehabilitation project is being developed. Additionally, the recent approval for the acquisition of 100 acres of this marsh by the Division of Fish and Wildlife should also enhance the public benefit of the proposed rehabilitation efforts.

Funding for this project has been received from the U.S. EPA Delaware Estuary Program Grant ($41,500), environmental reimbursement funds associated with the Presidente Rivera oil spill ($13,000), and other unspecified penalty monies ($17,000). The FY-94 DCMP Section 309 Enhancement Strategy for the NDWRP was redirected to provide funding for the establishment of a detailed nonpoint source pollution reduction plan and other wetland and watershed enhancement and rehabilitation projects at Thousand Acre Marsh. The Potential funding sources include the state bond bill, the Army Corps of Engineers, and funds derived from self-taxation by the Tax Ditch Association. The proposed Tax Ditch Association, as a legally binding organization, is also eligible to apply for wetland restoration funds from outside sources.

Delmarva Power and Light Impoundment (DPL Impoundment)

The administrative lead for this project is the Division of Fish and Wildlife. The New Castle Conservation District has assisted in developing watershed maps and addressing water supply issues. The Division of Soil and Water Conservation has compiled a comprehensive nonpoint source pollution control plan for the marsh. The Division of Air and Waste Management has provided extensive information concerning potential contaminant sources in the watershed and their likelihood of impacting the project, in particular a solid waste landfill within the proposed

rehabilitation area. Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the marsh was completed in November 1992 (Cole and Fabean 1992), and a rehabilitation plan (Appendix D) was developed. Current ongoing management practices include a phragmites control program that was initiated in 1992. This program involves annual aerial applications of herbicide on phragmites stands followed by controlled burns the subsequent winter. A partially successful burn was conducted in March 1993, and 58 acres of persistent and regenerating stands were retreated with herbicide in October 1993. Additional management practices include an extensive topographic survey of the marsh and surrounding upland areas, seasonal inspections of mosquito breeding, hydrological manipulations of the existing water control structure, and monitoring of floral and faunal communities.

The two landowners of this wetland have differed in their response to the rehabilitation project. Delmarva Power has fully supported this project through both their Real Estate Department and Sportsmen Club. The Real Estate Department provided funding for phragmites spraying, and the Sportsmen Club provided assistance with the controlled burns, hydrological manipulations, and trash removal during the 1993 Delaware Coastal Cleanup. Star Enterprises is supportive of the wetland rehabilitation initiative, but they are not interested in consenting to a long-term management agreement or providing any funding for the rehabilitation of the DPL Impoundment unless they can receive "environmental consideration" to be used as mitigation in an unrelated project. However, recent information indicates that Star Enterprises might reconsider consenting to a long-term management agreement in the near future.

The current rehabilitation status of the DPL Impoundment is that concerns regarding the feasibility of the rehabilitation effort need to be addressed before the Steering Committee approves the plan. One concern is that the proposed expansion of a sand and gravel extraction operation in the watershed might divert a significant amount of storm runoff away from the marsh and into another watershed, critically lessening the water supply of the marsh. This concern has recently been addressed by obtaining the contour maps and sedimentation control plans for the proposed extraction operation. These plans and maps indicate that the extraction operation will not significantly impact the water quality or supply for the proposed marsh. The other concern pertains to whether the integrity of the existing dike will support the proposed water levels. Efforts are currently underway to have a registered engineer examine the dike and rehabilitation proposal. An environmental assessment and permit applications will be submitted when the rehabilitation plan is approved by the Steering Committee; when funding for the new water control

structure is obtained; and when Star Enterprises supports a long-term management agreement for their portion of the wetland. Existing or potential funding sources for this project are Delmarva Power and Star Enterprises.

Newport Marsh

The administrative lead for this project is the Division of Fish and Wildlife; however, because this marsh has been potentially impacted by the E.I. DuPont Newport Superfund Site, the Division is coordinating this work with the Division of Air and Waste Management and the other DuPont Newport Superfund Natural Resources Trustees (U.S Fish and Wildlife Service, National Marine Fisheries Service). Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the marsh was completed in November 1992 (Cole and Fabean 1992), and a draft rehabilitation plan was developed and will require approval by the Steering Committee prior to submission for permits. Management practices and further rehabilitation efforts on this marsh have been curtailed until decisions regarding the potential impacts and natural resource injuries associated with the Superfund site are resolved. A primary concern is that by rehabilitating the marsh prior to addressing the Superfund contaminant issues, we might be increasing the potential risk of contamination to wildlife and humans. Management practices have been limited to topographic surveys of the marsh and surrounding upland areas, seasonal inspections of mosquito breeding, and monitoring of floral and faunal communities. The phragmites control program initiated in 1992 was discontinued.

There has been considerable community support to rehabilitate this state-owned property. The City of Newport has expressed a desire to maximize the marsh's educational and recreational potential, and a local high school has requested adopting it through the DNREC Adopt-A-Wetland Program. This community support will be utilized once the rehabilitation plan is finalized and the permit process initiated, which are dependent on the Superfund issues being addressed. If it is determined that the Superfund site significantly impacted the wetland, then potential funding for this project might be obtained through the DuPont Newport Superfund Remediation Plan. If the wetland has not been significantly impacted by the Superfund site, then restoration funding might be obtained through the compensation for the Superfund natural resource injuries.

Artesian Marsh

The administrative lead for this project is the Division of Fish and Wildlife, with substantial technical and administrative support being received from other Divisions and agencies. The Division of Air and Waste Management has provided extensive information concerning potential contaminant sources in the watershed, technical assistance in sediment sampling for toxins, and administrative assistance in coordinating potential rehabilitation plans with the DuPont Newport Superfund Site. The Division of Water Resources is currently assisting in the development of a site-specific wetlands mitigation banking effort to promote this wetland rehabilitation project. This Division has also provided technical assistance in testing sediment samples. The New Castle Conservation District has provided technical assistance in conducting topographic surveys of the marsh and has provided information regarding floodplain ordinances in the watershed. Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the marsh was completed in September 1993 (Cole and Cole 1993), and a draft rehabilitation plan (Appendix E) is being developed for review and approval by the Steering Committee. Rehabilitation efforts for this wetland have been delayed, because the marsh might have been impacted by the DuPont Newport Superfund Site or several other potential contaminant sources in the watershed. This site has also been identified as a potential mitigation site for natural resource damages associated with the superfund site. Therefore, the Division is coordinating this restoration with the DuPont Newport Superfund Natural Resources Trustees (Division of Air and Waste Management, U.S Fish and Wildlife Service, National Marine Fisheries Service). Because of the concern for potential contaminants, sediment sampling of the marsh was conducted in June 1993. This preliminary sampling identified high levels of zinc in the sediment; however, additional sampling is required for conclusive results. Rehabilitation plans will not proceed until this issue is addressed, because by rehabilitating the marsh prior to having contaminant issues addressed, we might be increasing the risk of exposing wildlife and humans to toxins. Current rehabilitation practices include conducting an extensive topographic survey of the marsh, surrounding upland areas, and adjacent flood plains; mapping and assessment of breaches in the existing dike; daily monitoring of water levels in the adjacent Christina River; seasonal inspections of mosquito breeding; and monitoring of floral and faunal communities.

The property owner of the marsh, Artesian Water Company, is interested in assisting in this rehabilitation, but desires mitigation credit for possible use on a proposed reservoir project. The DelDOT has also expressed interest in wetlands

mitigation at this site. During DelDOT's permitting process, the Army Corps of Engineers has identified this marsh as the preferred mitigation site for the wetlands lost by the proposed widening of Interstate 95. The Divisions of Fish and Wildlife and Water Resources are seeking a Departmental position that allows Artesian Water, and possibly DelDOT, to receive future mitigation credit for their support in this rehabilitation project. This policy would differ from the Department's regular process of not predisposing wetland mitigation decisions for projects not completed or permitted.

When the various contaminant, Superfund, and landowner issues are resolved, the rehabilitation plan, environmental assessment, and permit applications will be submitted to the Steering Committee and the appropriate regulatory agencies. Potential funding sources for this project are those previously mentioned, i.e., Artesian Water Company, DelDOT, and natural resource damages associated with the DuPont Newport Superfund Site. Another party interested in assisting DNREC in this project is the U.S. Fish & Wildlife Service, which has indicated that they would like to become involved through their private lands initiative, the Partners For Wildlife Program.

Augustine Creek Wetland Complex

The administrative lead for this project is the Division of Fish and Wildlife. The Division of Parks and Recreation's Natural Heritage Program has recently completed floristic composition studies and rare plant surveys of the marsh (Appendix F), and the New Castle Conservation District has assisted in developing watershed maps and sedimentation control plans. Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the marsh was completed in September 1993 (Cole and Cole 1993). Complementing these studies, the U.S. Fish and Wildlife Service funded a estuarine fish habitat suitability evaluation for the marsh, designed and coordinated by the Division of Fish and Wildlife and preformed by a contractual environmental consulting firm (Environmental Consulting Services, Inc. 1993). A rehabilitation plan is being developed for approval by the Steering Committee. Current management practices include hydrological manipulations of the water control structure to fine tune and implement an interim water management plan. Hydrological manipulations and weekly water level and salinity monitoring were initiated in December 1992 in response to landowner requests. Design specifications and installation procedures have been developed to install an automated water level recorder in the marsh during the summer of 1994. A solution to a sedimentation and highway stabilization problem along the intercoastal dike

(Route 9) is currently being developed with the assistance of DelDOT and the New Castle Conservation District. Additional ongoing practices include conducting an extensive topographic survey of the marsh and surrounding upland areas, seasonal inspections of mosquito breeding, and monitoring of floral and faunal communities.

The Augustine Creek Wetland Complex is owned by 46 different landowners, with most of the property in private ownership (90%). Currently, the Division of Fish and Wildlife is working with these landowners to establish long-term conservation and water management easements for the complex. The formation of a watershed association similar to that proposed at Thousand Acre Marsh is another long-term management option being investigated for possible consideration. The three largest landowners, representing 42% (471 acres) of the wetland complex, have indicated a desire for a long-term management agreement. The largest landowner, Delaware Wildlands (236 acres, 21%), has provided funding for the short-term maintenance of the existing water control structure and the installation of wildlife enhancement structures. This conservation organization also allows environmental groups to conduct educational tours through its Armstrong heronry, and has expressed a desire to contribute additional funding to rehabilitate the marsh.

A grant application for $240,894 has been submitted to the U.S. Fish and Wildlife Service for its 1994 National Coastal Wetlands Conservation Grant. This grant would fund the construction and installation of an additional water control structure that would allow limited tidal exchanges, plus the treatment of approximately 300 acres of monotypic phragmites stands. Last year a similar proposal for this project was ranked #1 in the Northeast Region and #11 nationally. Unfortunately, only the top 10 proposals were funded. Preliminary feedback from the granting agency does not look favorable again this year, but a final funding decision has not yet been conveyed. If funding is obtained for this project, emphasis will be placed on finalizing long-term management agreements and rehabilitation plans among the many landowners, and completing the environmental assessment and permit applications for the appropriate regulatory agencies. Other potential funding sources for this project include Delaware Wildlands, DelDOT, Public Service Electric Gas, and the Federal Emergency Management Agency.

Old Wilmington Marsh

The rehabilitation of this wetland is being co-administered by DNREC's Office of the Secretary and the Division of Soil and Water Conservation; however, they are coordinating all efforts with the Brandywine & Christina Rivers Task Force, the proponent

of this project. DNREC has agreed to assume the role of "facilitator" for this project, but it cannot assume management responsibilities. The NDWRP has had little direct involvement to date with this project. The Division of Air and Waste Management is assisting in addressing potential hazardous waste issues at the site by developing an environmental investigation strategy through its Christina River Basin Hazardous Waste Sites Restoration Project. The Division of Parks and Recreation is investigating recreational opportunities at the site, and the New Castle Conservation District is assisting in addressing stormwater flooding and nonpoint source pollution problems. Other Divisions and agencies have also provided support.

Before rehabilitation efforts can be further pursued, the potential of hazardous wastes at this site must be addressed. A primary concern is that by restoring the marsh to the proposed wildlife refuge and public recreation area prior to addressing these contaminant issues, we might be increasing the risk of contamination to wildlife and humans. A Departmental strategy to conduct sediment analysis throughout the project area is currently being developed. As proposed, all DNREC Divisions would contribute to the funding for this sediment testing. Once the contaminant issues are addressed and if it is determined that the wetland rehabilitation effort should go forward, emphasis will be placed on developing a biological inventory and ecological evaluation of the marsh. Information obtained from these studies will be used in the development of rehabilitation plans, which will be submitted to the appropriate regulatory agencies for permits once approved by the Steering Committee.

The City of Wilmington and the Brandywine & Christina Rivers Task Force have been very supportive of the project. Landowner support has also been positive; however, once sediment testing occurs this may change. Two landowners, Conrail and New Castle County, have indicated a desire to donate or lease the land to DNREC. However, DNREC will not accept any property suspected of containing hazardous wastes. The DCMP Section 309 Enhancement Strategy has redirected funding for the establishment of a detailed nonpoint source pollution reduction plan, plus other wetland and watershed enhancement and rehabilitation projects at Old Wilmington Marsh. Other potential funding sources for this project include the landowners of the marsh.

Army Creek Marsh

The wetlands of this project being rehabilitated under the direct guidance of the Army Creek Superfund Project; therefore, the rehabilitation procedure for this project will differ from those outlined in this planning document. The administrative

lead in preparing the wetland restoration plan is the Army Creek Superfund Natural Resources Damages Trustees comprised of the following agencies: Division of Fish and Wildlife, Division of Air and Waste Management, U.S Fish and Wildlife Service, and National Marine Fisheries Service. The Environmental Protection Agency (EPA) and the Steering Committee will review the final rehabilitation plan, but approval is only required among the Trustees. The permitting process might differ in that it is built into the Superfund guidelines; however, the appropriate regulatory agencies will be provided an opportunity to comment. The Division of Parks and Recreation is assisting the Trustees in the acquisition of upland areas as compensation for natural resource injuries, and in gaining marsh landowner cooperation to undertake wetlands restoration. The New Castle Conservation District will assist in the preliminary assessment and design of the proposed water control structure, and the development of an operation, maintenance, and management plan for the structure. The Department of Transportation is coordinating its proposed construction plans of Route 9 with this wetland rehabilitation project. Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the wetland complex was completed in November 1992 (Cole and Fabean 1992). Based on these and other studies associated with the Superfund site remediation, a final wetlands rehabilitation plan and its environmental assessment will be prepared and presented to the Steering Committee and the EPA in December 1994. Once the rehabilitation plan is completed, the Army Creek Superfund Natural Resources Damages Trustees will implement the plan. Formal contacts obtaining landowner support for the marsh restoration are currently being initiated. It is anticipated that community support for this project will develop following the proposed August 1994 public presentation of the rehabilitation plan. Funding for this project has been obtained through a mitigation settlement for natural resource damages associated with the Army Creek Superfund Site.

Airport Marsh Wetland Complex

The administrative lead for this project is the Division of Fish and Wildlife. The Division of Air and Waste Management has provided extensive information concerning potential contaminant sources in the watershed, and administrative assistance in coordinating rehabilitation plans with the DuPont Newport Superfund Site. Other Divisions and agencies have also provided support.

A biological inventory and ecological evaluation of the wetland complex was completed in September 1993 (Cole and Cole 1993), and a draft rehabilitation plan is being developed for

approval by the Steering Committee prior to submission for permits. Rehabilitation efforts for this wetland complex have been delayed, because the complex might have been impacted by the DuPont Newport Superfund Site or several other potential contaminant sources in the watershed. This site has also been identified as a potential compensation site for natural resource injuries associated with the Superfund site. Therefore, the Division is coordinating this restoration with the DuPont Newport Superfund Natural Resources Trustees (Division of Air and Waste Management, U.S Fish and Wildlife Service, National Marine Fisheries Service). Rehabilitation practices have been limited to inspections of the existing water control structure, seasonal inspections of mosquito breeding, monitoring of floral and faunal communities, and the aerial application of herbicide on 16 acres of phragmites in 1993.

The development of community and landowner support for this project were only recently initiated; however, the three largest landowners (Delaware Department of Transportation, New Castle County, Delmarva Power) are supportive of the project. Several private landowners of small sections of the wetland complex have also indicated their support. The Delaware Trappers Association has unofficially adopted this wetland area. This Association has conducted annual trash cleanups of the wetland complex and has posted "No Dumping" signs in an attempt to curb this continuing problem. A potential funding source for this project is the pending mitigation settlement for natural resource injuries associated with the DuPont Newport Superfund Site.

ICI Marsh

The administrative lead for this project is the Division of Fish and Wildlife. Although an enhancement report of the area was completed in 1991 by the Division and the Wildlife Habitat Enhancement Council, the formal rehabilitation process of this marsh has only been recently initiated. The landowner, ICI Specialty Chemicals, wants to restore this degraded marsh to encourage wildlife use, provide an aesthetic recreational area for its employees, and promote good public relations by being responsible land stewards. The Delaware Nature Society has also expressed support for this project and has attended site visits. Ecological evaluations have been limited to site visits and historical review of past practices within the marsh. Based on this information, the Division has recommended that water and sediment samples of the two lagoons at the site be tested for contaminants prior to any restoration efforts being undertaken. Funding for this project and the contaminant testing might be obtained from ICI Specialty Chemicals.

PROJECT SUMMARY AND ASSESSMENT OF FUTURE NEEDS

The Northern Delaware Wetlands Rehabilitation Program like many other large multi-agency initiatives was characteristically "slow out of the starting blocks" in terms of achieving benchmarks. This initial torpor was compounded by a change of personnel both within the program and the Department overseeing it. However, once this weaning period was completed, which involved the program being stretched in many different directions (some opposing), the program could better focus on addressing the tasks and objectives it was intended to tackle. After 1.3 years of implementation, the program has accomplished almost all of the objectives it proposed during the first 2 years of DCMP funding, namely to develop a planning and implementation document for a regional, multi-objective strategy to rehabilitate degraded tidal wetlands along the two urban river corridors.

The initial step required in developing this "regional" strategy was to define the focus area of the program, i.e., identify the sites proposed for rehabilitation and establish the initial boundaries of the corridors. Much of this work was completed prior to the DCMP granting period (Carter 1991a); however, this list of potential wetland rehabilitation sites (Table 2) has been and will continue to be updated, refined, and expanded as the program advances. A map (Fig. 3) identifying the proposed wetland rehabilitation sites will be periodically updated, identifying both primary target sites and successfully restored projects.

Enormous effort was expended in developing a Steering Committee and an administrative organization for the program that maximized multi-agency resources and technical expertise, while striving to minimize "turf battles", outside agendas, and biased viewpoints. Although initially an arduous task, a framework was developed that promoted a tiered organizational approach. After several attempts to organize and convene a steering committee comprised of all Department and outside agency representatives, two items became apparent: 1) the technical expertise and resources that each agency's representatives provided were essential to the program; and 2) convening a large steering committee on a monthly basis was logistically impractical, extremely inefficient, and a burden on agency personnel whom were only periodically involved in the program. Therefore, a two-tiered approach was established whereby agency representatives other than DNREC and NCCD staff were designated adjunct committee status and were not requested to convene at monthly Steering Committee meetings (Table 1). However, these adjunct committee members were frequently included in the planning and evaluation process, specifically during permit review, funding requests, or rehabilitation plan review. This tiered approach was also adopted to maximize Departmental resources and technical expertise within

the program's personnel organization. The tier approach is one in which two Division co-administrators coordinate inter- and intra-agency participation through the NDWRP program manager, who coordinates the overall program goals through site-specific project managers who are responsible for coordinating activities associated with a specific wetland rehabilitation project.

Once the Steering Committee was organized, its initial task was in developing program objectives. These objectives were selected based on a regional perspective, whereby benefits of individual rehabilitation projects could be maximized across an entire corridor. These objectives also had to be multiple-use in nature, so that in most cases objectives complemented each other or at the very least did not compromise one another. And finally, all objectives had to be capable of developing measurable evaluative criteria in order to provide temporal measures of success.

Biotic inventories and ecological evaluations of 9 proposed wetland rehabilitation sites were completed during FY-91 (Cole and Fabean 1992) and FY-92 (Cole and Cole 1993). These evaluations and subsequent studies provided background information and qualitative and quantitative data required to develop detailed rehabilitation plans. These rehabilitation plans, although site-specific, are developed under a corridor perspective, with emphasis placed on achieving as many of the 11 regional multi-use objectives as possible. Once the rehabilitation strategy is developed, measurable evaluative criteria will be established for each specific objective in order to provide temporal measurements of success. A prerequisite to the long-term success of the rehabilitation effort is the inclusion of operation, maintenance, and management agreements in the rehabilitation plan. These voluntary or enforceable agreements identify the responsibilities of various agencies or parties in the rehabilitation process. Without these operation, maintenance, and management agreements, rehabilitation efforts might not be implemented, and those objectives that are achieved could simply revert to their previously degraded conditions.

Rehabilitation plans are maintained and updated on a centralized tracking system. Each site-specific rehabilitation plan provides information on all aspects of the project, ranging from permit and funding status to project needs and completion dates. The rehabilitation plan is outlined to emphasize regional objectives, and is easily updated throughout the project's development and implementation. Committee members and regulatory agencies have found these trackable rehabilitation plans extremely beneficial in providing a quick, detailed perspective of the project prior to completion of environmental assessments and permit applications. Addendums to the trackable rehabilitation plans include maps, site descriptions, water management plans, and structure designs.

Essential to the overall success of this rehabilitation process is the cooperation and involvement of federal, state, and local agencies; private industries; landowners, and private environmental groups. Cooperation by governmental agencies has included technical assistance, access to Departmental resources, and funding support (Table 3). Many of these governmental agencies were previously active or familiar with this wetlands rehabilitation initiative, through their assistance with the program's development for the preliminary rehabilitation efforts initiated at Broad Dyke Marsh in 1987.

The NDWRP has also received substantial support from the private sector. Private funding support has been received from several industries and organizations including the Trustees of New Castle Common, Delmarva Power, Ciba-Geigy, Brand Mid-Atlantic, and DuPont (Table 3). Additional private support has been received in the form of program promotional activities, landowner access, and environmental fines and settlements. Private landowner participation in this program has been outstanding, with over 86% of those solicited allowing property access and supporting both the program and site-specific project objectives.

Public support for the program has been received from several environmental groups who became involved in the project through several of DNREC's outreach programs, e.g., Adopt-A-Wetland, Christina River Cleanup, Delaware Coastal Cleanup. The Adopt-A-Wetland Program has been the most successful method of getting environmental groups involved, with several groups adopting rehabilitation sites and others currently in the process. The Adopt-A-Wetland Program provides environmental groups an opportunity to become actively involved in the rehabilitation and protection of wetland areas by assisting in various activities, such as trash removal, wood duck box installation and maintenance, establishing and maintaining interpretative trails, and conducting biological inventories. Although most of the public support for this program has been from local groups, several state-wide and national organizations, such as The Delaware Nature Society and Delaware Ducks Unlimited, have indicated their support.

Additional support from both the private and public sectors is anticipated once the NDWRP brochure (Appendix G), published in February 1994, is widely distributed. This color, tri-folded brochure, designed to be utilized for public outreach and program fund-raising, provides an overview of the program in an easy to read format. The brochure identifies program goals, proposed and current rehabilitation sites, restoration methods, and benefits of wetland restoration. Periodic updates of the brochure will be accomplished with inserts identifying, new project sites, funding sources, and details on project successes.

Although the NDWRP planning and implementation document, with its site reports, and an outreach brochure have been completed,

Table 3. Secured and pending funding sources for the Northern Delaware Wetland Rehabilitation Program (NDWRP).

Funding source	Amount
Secured	
Army Creek Superfund Natural Resources Damages	$ 600,000
Ciba-Geigy	310,000
EPA Section 319 Non-Point Source Pollution Grant	180,000
DCMP Section 309 Grant (FY-92 and FY-93)	128,000
Trustees of New Castle Commons	113,700
Brand Mid-Atlantic	100,000
State Bond Bill, FY-93 Appropriation	50,000
EPA Delaware Estuary Program Grant	41,500
Unspecified Fine Monies	17,000
Presidente Rivera Oil Spill Fine Monies	13,000
Division of Fish & Wildlife	8,160
DuPont	5,000
Delmarva Power	4,926
U.S. Fish and Wildlife Service Mini-Grants (2)	9,000
Total	**$ 1,580,286**
Pending[a]	
National Coastal Wetlands Conservation Grant	$ 240,894
New Castle County Public Works Department	100,000
State Bond Bill, FY-94 Appropriation	50,000
Ducks Unlimited	40,000
Total	**$ 430,894**

[a]This list is comprised on only those pending sources for which funding amounts have been specified. Other potential funding sources of unspecified amounts are not included.

several important tasks need to be completed. In the next year emphasis will be placed on addressing nonpoint source pollution issues within the corridor, in conjunction with efforts to implement Section 6217 of the Coastal Zone Management Act. Detailed maps depicting nonpoint source pollution sources within the watersheds of all wetland restoration sites need to be generated. These maps supplemented with aerial photos, soil maps, and additional information will identify areas where stormwater detention/retention, conservation, and best management practices can reduce pollutant loading. The development and implementation of site-specific nonpoint source pollution reduction plans supported by the DCMP, for both an urban and a rural wetland rehabilitation site are also anticipated next year, to demonstrate the utility of this watershed-based approach.

Essential to maintaining the NDWRP's initial success is the continued emphasis on actually implementing the regional wetland rehabilitation strategy within the corridor, adhering to the planning document whenever possible. In the next and subsequent years, rehabilitation plans for additional sites need to be developed; funding, rehabilitation plan implementation, and public outreach efforts must continue; and completed projects must be evaluated in regards to their successes and failures. Only then can the rehabilitative success of the Christina/Delaware Rivers Urban Wetland Corridor be determined. Until then, this document serves as the plan for the long-term rehabilitation needs of the tidal wetlands and related aquatic habitats in Northern Delaware, from which future coastal and wetland rehabilitation programs can be developed.

LITERATURE CITED

BARNEKOV, T.K., and E. APPEL. 1993. Survey of Households: city of New Castle. Del. Public Adm. Inst., Coll. Urban Affairs Public Policy, Univ. Delaware, Newark. 102pp.

CARTER, D. 1991. The Christina and Delaware Rivers corridor: an opportunity for the restoration of important wetland habitat. Del. Ducks Unlimited Newsletter. Spring:33-34.

_____. 1991a. Christina and Delaware Rivers Wetland Corridor. Unpublished. Del. Dep. Nat. Resour. Environ. Control, Dover.

_____. 1992. The Christina/Delaware Rivers Wetland Corridor Rehabilitation Project. Unpublished. Del. Dep. Nat. Resour. Environ. Control, Dover. 6pp.

_____. 1992a. Thousand Acres Marsh: general background, area description, and management recommendations and alternatives. Del. Dep. Nat. Resour. Environ. Control, Dover. 119pp.

CHAMBERLAIN, E.B. 1951. A survey of the marshes of Delaware. Final Rep. Pittman-Robertson Proj., Del. Board Game and Fish Comm., Dover, 76pp.

COLE, R.V., and T. COLE. 1993. The Northern Delaware Wetlands Rehabilitation Program: a biotic inventory and environmental evaluation of four candidate wetland restoration sites. Del. Dep. Nat. Resour. Environ. Control, Dover. 75pp.

_____, and T. FABEAN. 1992. The northern Delaware wetlands rehabilitation program: a biotic inventory and environmental evaluation of five candidate wetland restoration sites. Del. Dep. Nat. Resour. Environ. Control, Dover. 154pp.

DNREC (Delaware Department of Natural Resources and Environmental Control). 1994. Comprehensive conservation and management plan for Delaware's tidal wetlands. Del. Dep. Nat. Resour. Environ. Control, Dover. 288pp.

DELAWARE MOSQUITO CONTROL SECTION. 1988. Broad Dyke Restoration Project: first year annual report. Unpublished. Del. Dep. Nat. Resour. Environ. Control, Dover. 52pp.

_____. 1990. Broad Dyke Restoration Project: second year annual report. Unpublished. Del. Dep. Nat. Resour. Environ. Control, Dover. 13pp and appendices.

ENVIRONMENTAL CONSULTING SERVICES, INC. 1993. Fish habitat suitability evaluation of Augustine Creek Marsh for fishes of the lower Delaware River. Prepared for Del. Dep. Nat. Resour. Environ. Control by Environmental Consulting Services, Inc., Middletown, Delaware. 11pp. and appendices.

HARDISKY, M.A. and V. KLEMAS. 1983. Tidal wetlands natural and human-made changes from 1973 to 1979 in Delaware: mapping techniques and results. Environ Manage. 7:1-6.

KREAMER, G. 1993. Needs assessment for Delaware aquatic resources education. Unpublished. Del. Div. Fish Wildl., Dover. 7pp.

TINER, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildl. Serv., Natl. Wetlands Inventory, Newton Corner, MA and Del. Dep. Nat. Resour. Environ. Control, Wetlands Sect., Dover, Coop. Publ. 77pp.

WILLIAMS and BROOME, INC. 1992. Preliminary design report for Broad Dyke Marsh control works project. Prepared for New Castle Conserv. Dist. by Williams and Broome, Inc., Newark, Delaware. 32pp. and appendices.

WESLAGER, C.A. 1947. Delaware's forgotten river: the story of the Christina. Hambleton Co., Inc., Wilmington, Del. 266pp.

APPENDIX A

BROAD DYKE MARSH REHABILITATION PLAN

Northern Delaware Wetlands
Rehabilitation Program

BROAD DYKE MARSH

A 210-acre freshwater tidal wetland located north of the city of New Castle along the Delaware River. The marsh is surrounded on 3 sides by residential and commercial developments and on the east side is separated from the Delaware River by a dike containing a water control structure. This wetland is comprised of 160 acres of estuarine marsh (76%), 50 acres of palustrine deciduous forest (24%), and has an 1811-acre watershed primarily consisting of residential and urban areas. Property owners are the Trustees of New Castle Common and the New Castle Immanuel Episcopal Church.

This marsh was once a lush mosaic of rushes, sedges, cattails, and smartweeds; and contained a high diversity of waterbirds and other wildlife. In the mid-1600's the marsh was diked and drained to accommodate agriculture and settlement of adjacent upland areas. These practices have continued to the present resulting in 53% of the marsh being dominated by the nuisance plant phragmites; a dramatic decrease in the diversity of fish, wildlife, and plant species; reduced wetland and water quality, and an increase in the potential for pestiferous mosquito breeding.

Over the past two decades the water management plan for Broad Dyke Marsh has essentially had a single purpose: prevent flooding of the basins peripheral properties, from Delaware River water entering on high tides or from upland storm runoff accumulating in the marsh. This plan involved the installation of a concrete sluice comprised of two 48-inch flap gates on the river side and riser board channels on the marsh side. This water control structure is designed to allow

one-way flow out of the marsh, thereby allowing storm runoff to exit the marsh while preventing river water from inundating the marsh during tidal events. However because of the increase in upland runoff, caused by increased development in the watershed, and the elevation of the marsh surface relative to the Delaware River, the existing structure is inadequate to handle storm runoff from severe rain events. This flooding problem is periodically compounded when individuals tamper with the flap gates by chocking them open and allowing river tides to flood the marsh.

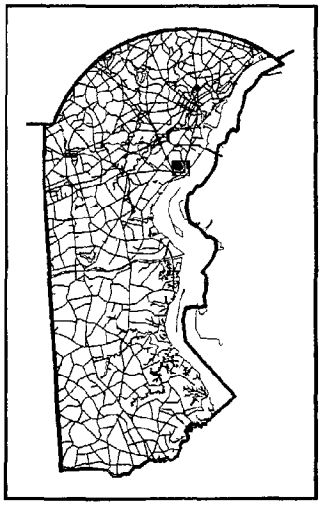
Extensive baseline studies and ecological assessments have been conducted on Broad Dyke Marsh since 1987, and have led to the development of preliminary water management and marsh rehabilitation plans. Management practices initiated in 1987 have fine tuned these plans and have partially restored the marsh. These practices include experimental water level manipulations, phragmites control programs, installation of wood duck boxes, and experimental planting of beneficial plant species. Although these efforts have indicated that a positive restoration of Broad Dyke can be achieved, the successful, long-term restoration of the marsh is dependent upon replacing the existing water control structure. This new structure must be a larger, more specialized structure that allows tidal exchange while having the capacity to handle significant stormwater input, yet operates in an automated fashion to eliminate the need for labor-intensive management and maintenance.

Besides the obvious ecological value of this marsh, its proximity within a mile of seven schools makes it an ideal site for environmental eduction opportunities.

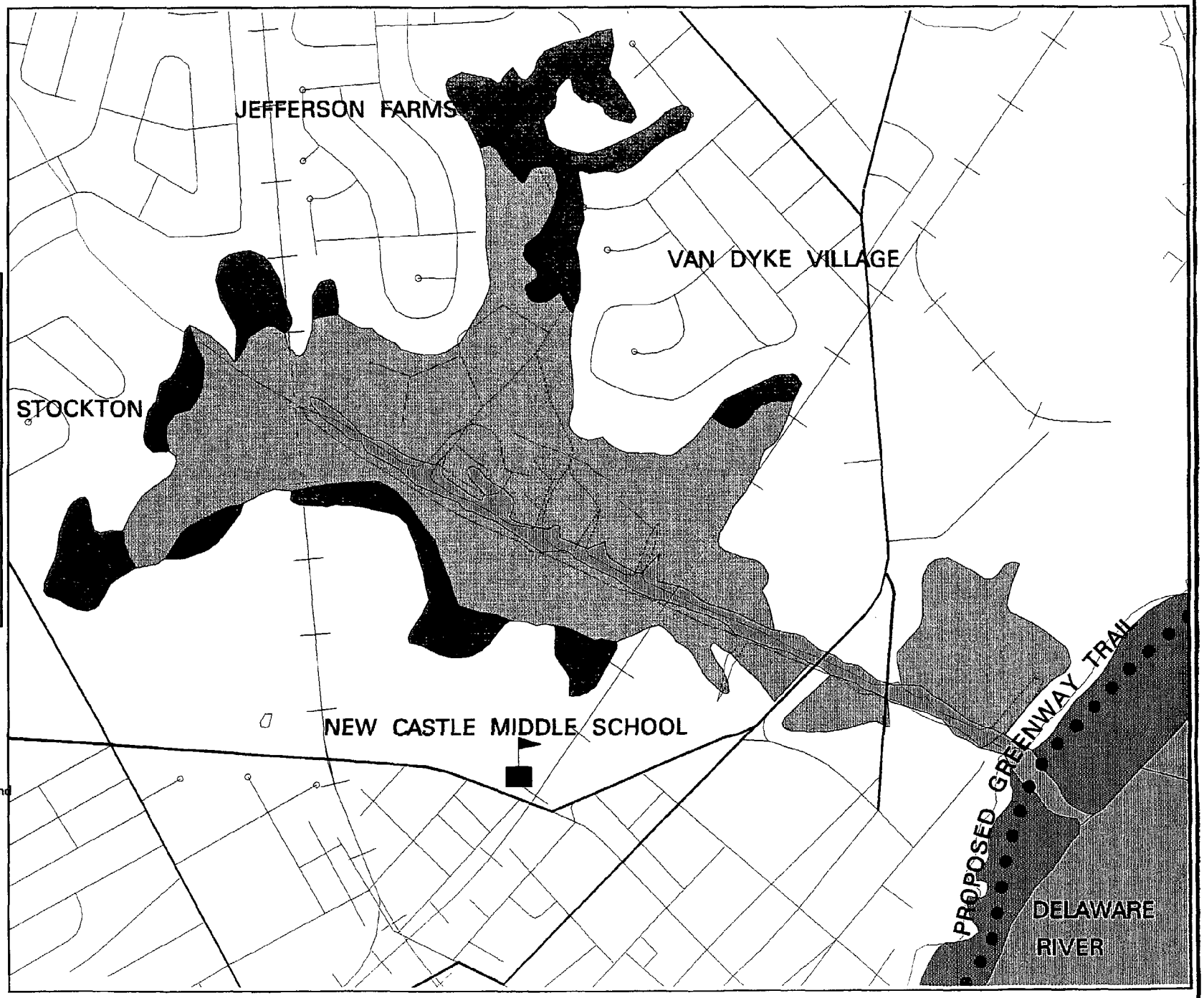
Broad Dyke Marsh

New Castle County, Delaware

LOCATOR MAP



- Open Water
- Beaches, Bars and Mudflats
- Estuarine Emergent and Estuarine Emergent/Beach/Mudflat
- Palustrine Forested, Palustrine Forested/Scrub Shrub and Palustrine Forested/Emergent



New Castle Conservation District

NORTHERN DELAWARE WETLANDS REHABILITATION PROGRAM

REHABILITATION TRACKING FORM

WETLAND PROJECT: **BROAD DYKE MARSH** **UPDATED:** 5 JANUARY 93

PROJECT MANAGER: Rob Hossler, Fish & Wildlife

PROJECT COMPLETION DATE: June 1998

REPORT STATUS:
1) Environmental Evaluation - Completed February 1993.
2) Water Management Plan - Completed 21 April 1993.
3) Operation, Maintenance, and Management Plan - Draft completed 15 November 1993.

PERMIT STATUS:
1) COE 404 Permit - not initiated.
2) State Type II Permit - not initiated.
3) Subaqueous Lands Permit - not required.
4) Environmental Assessment - Draft completed 15 November 1993.
5) Pre-proposal presented to Joint Permit Processing Committee on 18 February 1993. A site visit was conducted on 12 May 1993.

FUNDING STATUS: 1) Secured -

a. National Fish and Wildlife Foundation Grant - $80,000 for a new water control structure. Requires a $300,000 match in non-federal nor non-DNREC funds and must be encumbered by 15 January 1994.

b. State of Delaware - $50,000 FY-93 bond bill.

c. Trustees of New Castle Common - $100,000 firm commitment in 1992 for water control structure. Provided $5,000 for hydrologic and hydraulic modeling of proposed water control structures and, $6,600 over last 3 years for phragmites control.

2) Pending -

a. EPA-Section 319 Non-Point Source Pollution Guidelines - $180,000 grant application for water control structure. Decision expected 7 January 1994.

b. Ducks Unlimited - $40,000 considered for water control structure.

c. New Castle County - Interested in providing funding for the water control structure if their operation and maintenance responsibilities are reduced.

LANDOWNERS: Trustees of New Castle Common (Trustees) - own 162 acres (77%) of the marsh and have consented to a long-term management agreement for the marsh. The water control structure was installed in

1975 by New Castle County Public Works; however, the responsibility for the maintenance and operation of this structure is unclear. The Trustees might provide assistance in the operation and maintenance of the water control structures; additional phragmites control and wildlife plantings; and installation of the boardwalks, elevated observation platform, asphalt trail, or wildlife enhancement structures.

New Castle Immanuel Episcopal Church - owns 48 acres (23%) of the marsh and have consented to a long-term management agreement for the marsh.

PARTICIPATING PARTNERS: Trustees of New Castle Common, New Castle Immanuel Episcopal Church, DNREC, New Castle Conservation District, National Fish and Wildlife Foundation, Ducks Unlimited, New Castle Public Works.

PUBLIC RELATIONS 1) Needs - Involvement of nearby communities in certain aspects of the rehabilitation project.

2) Actions -

a) Environmental Groups - The McKean High School and New Castle Middle School have adopted, through DNREC's Adopt-A-Wetland program, the western and a portion of the middle basin, respectively. Additional groups are being solicited for the remaining portions of the marsh. These groups initiated a trash cleanup in this marsh during the 2 October 1993 Delaware Coastal Cleanup. A New Castle resident installed and is maintaining 8 wood duck boxes as part of a community service project.

b) Adjacent Landowners - A public presentation, on 13 October 1992, provided information on the tentative management plans for the proposed rehabilitations of Broad Dyke Marsh. Once the rehabilitation plan is approved and funding acquired, adjacent landowners will be notified and asked to comment on the plan at a public meeting. These comments will be incorporated into the environmental assessment prior to its submission to permitting agencies.

REGIONAL OBJECTIVE: IMPROVE WATER QUALITY

SITE SPECIFIC OBJECTIVE: Improve water quality of both the marsh and river through daily tidal exchange. Tidal exchange will provide nutrient and organismic exchange between the water bodies, and increase the volume of water exposed to wetland filtering and nutrient uptake benefits.

STATUS PRIOR TO PROJECT: The existing water control structure has essentially a single purpose - prevent the flooding of peripheral

properties - by allowing one way flow of storm runoff out of the marsh, while preventing tidal inundation. These practices essentially drain this former tidal marsh, causing water quality to degrade to levels that are detrimental to most aquatic life during the dry season, while increasing the potential for pestiferous mosquito breeding.

Experimental water level manipulations conducted in 1988, determined that daily tidal exchange with the existing structure could only occur on a limited basis without drastically increasing the potential of flooding peripheral properties. In order to reduce this flooding potential, constant monitoring along with labor intensive and time consuming adjustments of the structure were required prior to and following every heavy rain event or unusually high tide. Additionally, these manipulations required that one flap gate be chained open, which has been shown to create undue stress on the gate, occasionally damaging it.

Hazardous Wastes and Toxins - Four potential hazardous waste sites were identified in the vicinity of Broad Dyke Marsh. In 1988 a federal Superfund remedial investigation of the Witco site, located approximately 400 feet from the wetland, detected Tris(2-chloropropyl)phosphate in marsh sediments and surface water. Although caused by a large spill in 1977, the concentrations of trisphosphate were considered too low to have significant biological impact.

During this investigation, Trichloroethylene (TCE) was detected in groundwater at the site and in one sediment sample. The presence of TCE, which was not associated with operations at Witco, has resulted in a remedial investigation of the Castle Ford facilities. Waste solvent and paint disposal from the body shop, located approximately 500 feet from the wetland, have contaminated soils and groundwater. The impact on the marsh has not been determined; however, results from initial sampling might be available in the near future. Although the direction of flow of the aquifer in this area is towards the marsh, significant impact is not expected because there was never a large, permanent contaminant source, i.e., underground tank, and continued disposal has ceased. Therefore, impacts to the marsh should be diminishing as the remaining TCE degrades. Another potential source of TCE is the Knotts bus facility, located just south of Castle Ford and approximately 600 feet from the marsh. The investigation of Castle Ford should also provide information on this site.

The fourth potential hazardous waste site is Chicago Bridge & Iron, located approximately 1100 feet from the wetland and will be investigated in 1994 This facility used pickle liquor, lowering the pH of ground water. However because of the direction of flow of the aquifer in this area, potential contaminants from this site are not expected to impact Broad Dyke Marsh.

The DNREC Technical Services Section conducted tissue assays for heavy metals and pesticides of brown bullheads (n = 5) captured in Broad Dyke Marsh in September 1989. Results indicated that the toxins tested for were either found below state and federal action levels or were undetectable.

Non-point Source Pollution - Non-point source pollution enters the marsh from adjacent road runoff, storm sewer outflow from the surrounding residential and commercial developments, and a drainage ditch from an industrial park located approximately 0.9-mile north of the marsh. The specific types and severity of these pollutants has yet to be quantified. Because of the multiple sources of non-point source pollution, education and mass media programs directed to residents and facility managers that address best management practices appear to be a solution.

CURRENT STATUS: Water quality sampling and elevation surveys of the basin have been completed. The New Castle Conservation District has determined the watershed of the marsh and its corresponding land uses. Based on detailed hydrologic and hydraulic modeling of the basin and the proposed new water control structure, respectively, limited tidal exchange as proposed with the water management plan will allow an exchange equivalent to approximately 10.4% (8.8 acre-feet) of the marsh basin during each tidal cycle.

ACTION STEPS NEEDED: 1) Installation of the proposed water control structure.

COMPLETION DATE: February 1995

SITE SPECIFIC OBJECTIVE EVALUATION: Obtain comparable measurements of water quality and assessments of volume exchange.

REGIONAL OBJECTIVE: IMPROVE WETLAND HABITATS FOR WILDLIFE

SITE SPECIFIC OBJECTIVE: Improve wetland habitats by adhering to a water management plan involving daily tidal exchange and periodic water level manipulations; installing wildlife enhancement structures, and conducting beneficial plantings for wildlife. Adherence to a water management plan should improve habitats for wetland wildlife, especially aquatic mammals, waterfowl, and other waterbirds, by both adjusting the water level to accommodate the seasonal needs of these species and allowing this level to fluctuate on a daily basis through limited tidal exchange. These management practices should increase the number, species, and reproductive success of wildlife using the marsh.

STATUS PRIOR TO PROJECT: Experimental water level manipulations conducted by the Division of Fish and Wildlife (Division) in 1988 combined with a extensive phragmites control program conducted between 1986-1992 have increased the vegetation diversity of the marsh by 2.3% (Simpson's Index) and improved it for wildlife. Since the water manipulations were curtailed in 1991, one flap gate has been damaged allowing a minimal amount of tidal exchange to occur. However, this

minimal tidal exchange has protracted the marsh from degrading back to its pre-manipulation state.

The installation of 30 wood duck nesting boxes between 1989-1991 and the planting of beneficial plant species have also attempted to increase the diversity of the marsh and improve it for wildlife. Nesting success in the duck boxes was excellent in 1992, with 84% of the boxes indicating evidence of successful wood duck nesting. During avian surveys conducted in the spring and fall of 1988, 19 species of waterbirds or raptors were recorded for a combined total of 479 birds and an average of 53.2 birds/survey. A total of 12 species of fish are known to utilize the marsh. The planting of beneficial plant species; however, had limited success. The 500 lbs. of barnyard grass aerially dispersed in 1988 successfully germinated, but no natural reseeding occurred in subsequent years. The 25 lbs. of wild rice sown by hand in 1989 never germinated.

CURRENT STATUS: Biological and elevational surveys have been completed and a detailed water management plan has been developed.

ACTION STEPS NEEDED: 1) Implementation of a water management plan after installation of the proposed water control structure. Daily tidal exchange will promote tidal flushing and organismic exchange, especially fish populations. This plan is subject to adjustment and change based on the availability of additional information, climatic conditions, and in order to better achieve all anticipated benefits and regional objectives. Water levels are currently monitored via a float-operated recorder, and would continue to be after implementation of the proposed plan. Daily tidal exchange will only occur as long as it is consistent with water level goals and the proposed reduction in peripheral property flooding.

COMPLETION DATE: Implemented following installation of water control structure (January 1995).

2) Evaluation of the reproductive success of wood ducks in the existing nest boxes, with emphasis placed on the occurrence of dump nesting. This evaluation will help determine where additional boxes, if any, should be installed to improve reproductive success of this species.

COMPLETION DATE: March 1995

3) Install wood duck, goose, mallard, and osprey nesting structures. The number and location of these enhancement structures will be determined based on success of existing structures, and available of suitable microhabitats. Support in installation of wildlife enhancement structures might be available from the Trustees and/or private groups.

COMPLETION DATE: March 1996

4) Seeding of wild rice, and planting of river bulrush and sweet flag rootstocks during periodic draw-downs. The quantity planted will depend on the amount of suitable habitat available following implementation of the water management plan.

Financial support to purchase the seed might be available from the Trustees and/or private groups.

COMPLETION DATE: November 1995

SITE SPECIFIC OBJECTIVE EVALUATION: The success of the water management plan will be based on comparable surveys of waterbirds and fish utilizing the marsh, and of permanent vegetation transects established in the marsh during the summer of 1994. Success of wildlife enhancement structures will be based on the reproductive success of wildlife utilizing them. Success of beneficial wildlife plantings will be based on successful regeneration of the species, and their use by wildlife.

REGIONAL OBJECTIVE: UNDESIRABLE PLANT SPECIES CONTROL

SITE SPECIFIC OBJECTIVE: Reduce the area covered by monotypic stands of phragmites and increase the area covered by desirable emergent vegetation. The percent cover of phragmites will be reduced to less than 5% (11 acres). Phragmites cover will be confined to upland areas and the wetland/upland fringe.

STATUS PRIOR TO PROJECT: Previously, approximately 53% (112 acres) of the marsh was dominated by large monotypic stands of phragmites; however, treatments of aerially-applied herbicide during the late 1980's and early 1990's have reduced the percentage of phragmites cover to 18% (38 acres). A controlled burn was conducted in February 1990; however, due to wet conditions it had limited success.

CURRENT STATUS: A follow-up application of herbicide was applied on 38 acres of phragmites on 30 September 1993. Funding provided by Trustees of New Castle Common ($1,900).

ACTION STEPS NEEDED: **1)** Apply herbicide (glyphosate) periodically on monotypic stands of phragmites.

COMPLETION DATE: Annually as needed in early Fall.

2) Controlled burning of phragmites (where feasible) or other removal method of the standing dead canes will be conducted following application of herbicide. Controlled burning provides several additional benefits in controlling phragmites including: exposing regenerating canes to the second year treatment of herbicide, reducing gas exchange to surviving root stalks, stimulating the release of nutrients for other plant species, exposing the soil to sunlight, and stimulate the germination of desirable species in the existing seed bank.

COMPLETION DATE: In late winter, following the application of herbicide.

SITE SPECIFIC OBJECTIVE EVALUATION: Success determined by the reduction of monotypic stands of phragmites.

REGIONAL OBJECTIVE: INCREASE SHALLOW WATER HABITAT DIVERSITY

SITE SPECIFIC OBJECTIVE: Increase the percentage and diversity of open water and desirable emergent vegetation habitats. The percent cover of open water and desirable emergent vegetation habitats will range from 19-38% (40-80 acres) and 38-57% (40-120 acres), respectively. Shallow water habitats will include numerous shallow ponds, ditches, and flats.

STATUS PRIOR TO PROJECT: Currently only 9% (19 acres) of the marsh consistently retains open water habitat interspersed with desirable emergent vegetation; however, following the implementation of the water management plan this percentage might change.

CURRENT STATUS: Except for elevational and environmental surveys no work has been conducted in the marsh.

ACTION STEPS NEEDED: **1)** Reevaluate the diversity of shallow water habitats and the percentage of open water habitats following implementation of the water management plan. In the event an increase in this diversity or percentage is desired, a proposal to increase shallow water habitat diversity will be submitted either under the Division's existing Open Marsh Water Management permit or through a separate permit.

COMPLETION DATE: October 1995 and annually thereafter.

2) Excavation of sediment laden ditches and ponds, and potentially the formation of a few new ditches, ponds, and island habitats. New ponds will have tapered sides and most ponds and all ditches will be shallow $\leq$18 inches in depth. Several ponds will have sections excavated >18 inches in depth to provide habitat for fish during droughts and draw-downs. Islands for waterfowl nesting will be created by accumulation of construction spoil. Excavations will be conducted using Division of Fish and Wildlife personnel and equipment.

COMPLETION DATE: Dependent on annual evaluations of existing of shallow water habitat diversity and percentage of open water habitats.

SITE SPECIFIC OBJECTIVE EVALUATION: Success based on the diversity of shallow habitats and the percentage of open water habitat.

REGIONAL OBJECTIVE: INCREASE ENVIRONMENTAL EDUCATION OPPORTUNITIES

SITE SPECIFIC OBJECTIVE: Improve environmental education opportunities for both general public and school groups by constructing two boardwalks with interpretive signs, an observation platform, and 700 feet of asphalt trail.

An approximately 1000-foot boardwalk would be constructed between the marsh/upland interface along the southwest side of the marsh, behind the New Castle Junior High School. At the southeast terminus of the boardwalk, a 12x12-gazebo with an open roof and 3 benches is proposed. Access to the boardwalk would be via a ramp located adjacent to the abandoned railroad bed/tressel, and proposed nature and greenway trails behind the New Castle Junior High School.

An additional 800-foot boardwalk is proposed at the east end of the marsh adjacent to the intercoastal dike along the Delaware River. This proposed boardwalk would descend from the dike via switching ramps. The boardwalk would extend northwest into the marsh approximately 300 feet, and then curve back towards the dike forming a half circle. At mid-length of the boardwalk, the deck would be widened to provide a scenic viewing area with two benches. To provide access to this boardwalk, approximately 1100 feet of the dike would have to be resurfaced with an asphalt walkway. This trail and boardwalk would provide a looped extension to the New Castle-Dobbinsville Scenic Walkway.

The boardwalks would be wooden, approximately 5-foot wide, built on pilings at an elevation 4 feet above the maximum managed water level (4.0 feet NGVD), and have handicap access incorporated where feasible. Interpretive signs would be located along the boardwalks, and paved walkway.

STATUS PRIOR TO PROJECT: There is no known organized or formal environmental education being conducted at the marsh; even though, there are seven schools located within 1 mile of the marsh.

CURRENT STATUS: A presentation and field trip explaining the Broad Dyke Marsh Rehabilitation Project was presented to the New Castle Middle School's Science Department on 22 November 1993 and 7 December 1993, respectively. Preliminary designs for the boardwalks, observation platform, and access trails were completed 15 November 1993.

ACTION STEPS NEEDED: **1)** Develop final designs and construct the boardwalks, observation platform, interpretive signs, and access trails

COMPLETION DATE: September 1997

2) Promote the use of the marsh and its interpretive trail through organized events, press releases, and by

direct contact with school districts.
COMPLETION DATE: April 1998

SITE SPECIFIC OBJECTIVE EVALUATION: Improvements in environmental education would be determined by surveys of public and school groups utilizing the facilities.

REGIONAL OBJECTIVE: IMPROVE RECREATION AND AESTHETIC VALUES

SITE SPECIFIC OBJECTIVE: Improve recreational opportunities and the aesthetic value of the marsh by creating vistas (clearing phragmites and dense shrub cover) along the dike between the river and the marsh, and constructing a public canoe launch. These improvements would be in addition to constructing two boardwalks with interpretive signs, an observation platform, and 700 feet of asphalt trail.

STATUS PRIOR TO PROJECT: Recreational activities in Broad Dyke Marsh include limited amounts of nature watching, crabbing, trapping, and fishing. The location of the marsh behind the New Castle Middle School and among several developments makes it an attractive area for children and adolescents, as indicated by the presence of numerous bike paths, play forts, and socializing areas. An existing access road provides limited boat access to the center of the marsh.

CURRENT STATUS: A 1993 University of Delaware survey of New Castle households found that 90% of the respondents indicated that the marsh should be restored as a normal freshwater marsh - completed 26 April 1993. Preliminary designs for the canoe launch have been completed 15 November 1993.

ACTION STEPS NEEDED: 1) Create vistas of the marsh along the proposed extension of the Scenic Walkway by clearing brush and phragmites along the dike between the river and the marsh. The Trustees or the City of New Castle might provide assistance in maintaining these clearings.
COMPLETION DATE: February 1995 - with annual maintenance as needed.

2) Refurbish the existing access road into a public canoe launch. Financial assistance might be provided by Wallop-Breaux funds, the Trustees, or the City of New Castle.
COMPLETION DATE: 4 April 1995

3) Determine the overall opinion of visitors utilizing the recreation facilities in regards to recreational and aesthetic value of the marsh.
COMPLETION DATE: June 1998

SITE SPECIFIC OBJECTIVE EVALUATION: Improvements in the recreational opportunities and aesthetic value of the marsh will be determined through surveys of the use of recreational facilities, and visitor responses to questionnaires regarding the marsh's aesthetic and recreational value.

REGIONAL OBJECTIVE: REDUCE STORMWATER FLOODING

SITE SPECIFIC OBJECTIVE: Reduce the stormwater flooding of peripheral properties by increasing the outflow potential and having it occur through timely releases. The scouring action associated with daily tidal exchange will also potentially reduce flooding by maintaining a channel on both the marsh and the riverside of the structure. This daily channel maintenance will eliminate the problem of sediment accumulating in front of the flap gates during periods of drought, which previously prevented them from opening sufficiently to allow storm runoff to leave the marsh.

STATUS PRIOR TO PROJECT: Due to the relative elevations of the marsh surface verses the mean river level, which has risen 0.5 ft over the last 60 years, discharge of water out of the marsh can only occur for about 4 hours out of every 12.5-hour tide cycle. Because of this limited interval of discharge from the marsh, heavy rain events with associated upstream runoff, which has increased with increased development of upland area, elevates marsh water levels above desirable levels occasionally causing flooding of peripheral properties. This potential for flooding is compounded by both the short concentration time of runoff into the basin (10 hours) and the restriction in flow caused by the conduits under the abandoned railroad embankment and the active railroad bridge. An additional factor contributing to elevating water levels to undesirable levels, is when individuals tamper with the flap gates by chocking them open and allowing river tides to flood the marsh.

CURRENT STATUS: Detailed hydrologic and hydraulic modeling of the marsh and evaluations of six potential water control structures, including the existing structure, were completed 20 November 1992. Based on this and supplemental information the District, Division, and Trustees selected the scheme that involved the construction of a 8x3-foot box culvert adjacent to the existing water control structure. This new structure would have an automatically controlled vertical lift gate activated by sensors recording both the river and the marsh water levels. These sensors would relay water levels back to a programmable logic controller, which would then make the decision to either open or close the sluice gate based on selected target settings and logic scenarios. In the event of a system malfunction or power failure, the structure would be equipped with a system that would send

an alarm signal to the New Castle Police Station via telephone service, and automatically cause the vertical lift gate to close. Additionally by maintaining the two existing flap gates, if a malfunction were to occur, outflow from the marsh would still occur as with the existing system.

The additional water control structure should increase the outflow potential by approximately 95%, and theoretically reduce the overall probability and duration of flooding of most peripheral properties by approximately 60%. However because of the limited interval of discharge from the marsh, due to its elevation relative to the river, flooding of peripheral properties may still occur, especially to the commercial car-repair garage. Although under a worst case scenario, in which the marsh is at full pool (0.0 ft NGVD) and the maximum 6.25 hours of greatest stormwater concentration into the marsh coincides with a 6.25-hour flood tide, the duration of flooding of a 100-year storm would be reduced from 5.3 to 2.3 days. This worst case scenario would be similar to that occurring during a northeaster, in which significant precipitation occurs and an easterly wind keeps the tide high for a prolonged period of time, thus preventing outflow from the marsh. Additionally, under this worst case scenario flooding of peripheral properties other than the commercial car-repair garage, would require a 134-year storm event, an increase of 5% over the existing structure. This storm event would bring water levels to 3.0 ft NGVD, the maximum tolerable water level by all landowners other than the owner of the commercial car-repair garage. This water level would inundate halfway across the backyard of the lowest-lying house within the basin.

Implementation of the proposed water management plan would increase the average water level in the marsh by 0.5 feet (0.6 to 1.1 feet NGVD); however, it would not significantly increase the probability of flooding peripheral properties. This lack of increase in flooding is because the maximum water management level (0.0 ft NGVD) would only occupy 12.7% of the volume of the marsh, as determined at the maximum tolerable water level (3.0 ft NGVD).

ACTION STEPS NEEDED: **1)** Monitor the impact of the proposed new water control structure and water level manipulations, on the flooding of peripheral properties, and make appropriate adjustments to the water management plan.

COMPLETION DATE: Continuous, following the installation of the new water control structure.

SITE SPECIFIC OBJECTIVE EVALUATION: Evaluations based on comparable measurements of flooding severity, periodicity, and duration.

SECONDARY OBJECTIVES: **1)** Restore and improve spawning, nursery, and feeding sites for anadromous, estuarine, and riverine fishes.

2) Protect and enhance existing populations and critical habitats of threatened and endangered species and other species of concern. The Natural Heritage Inventory has documented the presence of several State Species of Special Concern (S1) in Broad Dyke Marsh: purple-stemmed swamp beggar's-tick (*Bidens connata*), Engelmann umbrella-sedge (*Cyperus engelmannii*), redroot galingale (*Cyperus erythrorhizos*), and an arrowhead (*Sagittaria calycina*).

3) Control pestiferous mosquito populations by water management where practical, thereby enhancing biological control via predacious fish and reducing the amount of chemical insecticides required.

BROAD DYKE MARSH - WATER MANAGEMENT PLAN[a]

DATE	MANIPULATION (Pool level at low tide)	ELEVATION (NGVD)	RATIONALE
1 March - 30 April	Reduce pool level to 0%, but allow maximum tidal exchange[b,c].	**-1.3 ft** - All flats are exposed and approximately 16 inches are maintained in the ditches.	Promotes maximum flushing of accumulated overwinter detritus and sediment, while permitting anadromous fish exchange and regrowth of emergent plant species.
1-30 May	Increase pool level to 50% allowing limited tidal exchange.	**-0.8 ft** - Inundates 52% of the flats at an average depth of 2.6 inches with tidal fluctuations of ± 0.4 ft.	Increases pool level for waterfowl without inundating nesting areas, while permitting anadromous fish use and regrowth of emergents.
1 June- 31 July	Increase pool level to 75% allowing limited tidal exchange.	**-0.5 ft** - Inundates 65% of the flats at an average depth of 4.3 inches with tidal fluctuations of ± 0.4 ft.	Provides habitat for waterfowl brood rearing; increases invertebrate populations; encourages SAV growth; and provides shallow mud flats for waterbirds.
1 Aug. - 15 Oct.	Decrease pool level to 50% allowing limited tidal exchange.	**-0.8 ft** - Inundates 52% of the flats at an average depth of 2.6 inches with tidal fluctuations of ± 0.4 ft.	Exposes mud flats for migrating shorebirds; promotes regrowth of late season annual plant species; and increases exchange of estuarine fish species, particularly for egress following the nursery season.
15 Oct. - 28 Feb.	Increase pool level to 100% allowing limited tidal exchange.	**-0.2 ft** - Inundates 96% of the flats at an average depth of 7.3 inches with tidal fluctuations of ± 0.2 ft[d].	Provides habitat for waterbirds, waterfowl, muskrats, and overwintering fish species.

[a]Water management plan is subject to adjustments and change based on the availability of additional information, climatic conditions, and in order to better achieve all regional objectives.

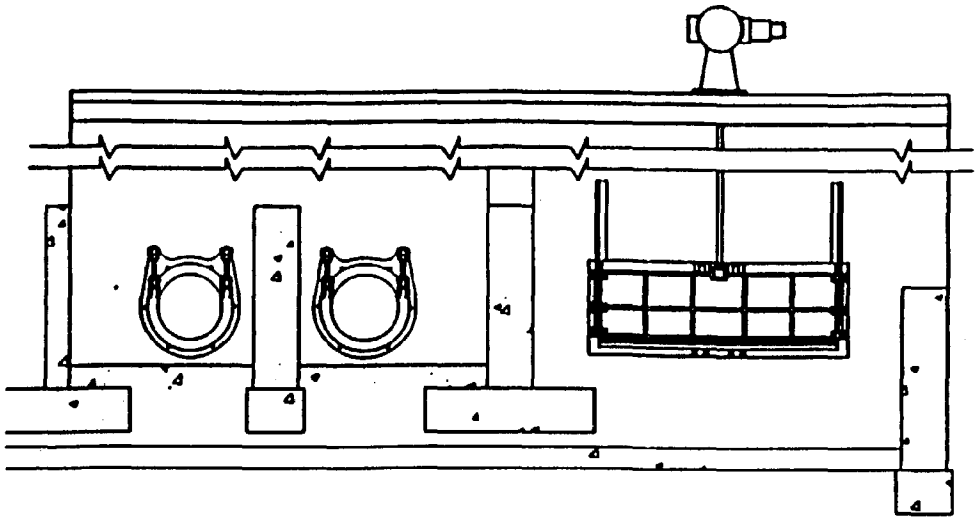
[b]Maximum tidal exchange is equivalent to the maximum volume (not to exceed 0.0 ft. NGVD) that allows the water level to recede to the 0% pool level during an average tidal cycle.

[c]Tentatively a drawdown to the 0% pool level, with limited tidal exchange during each tidal cycle, will occur every 3 years to solidify the flats and promote the revegetation of emergent plant species.

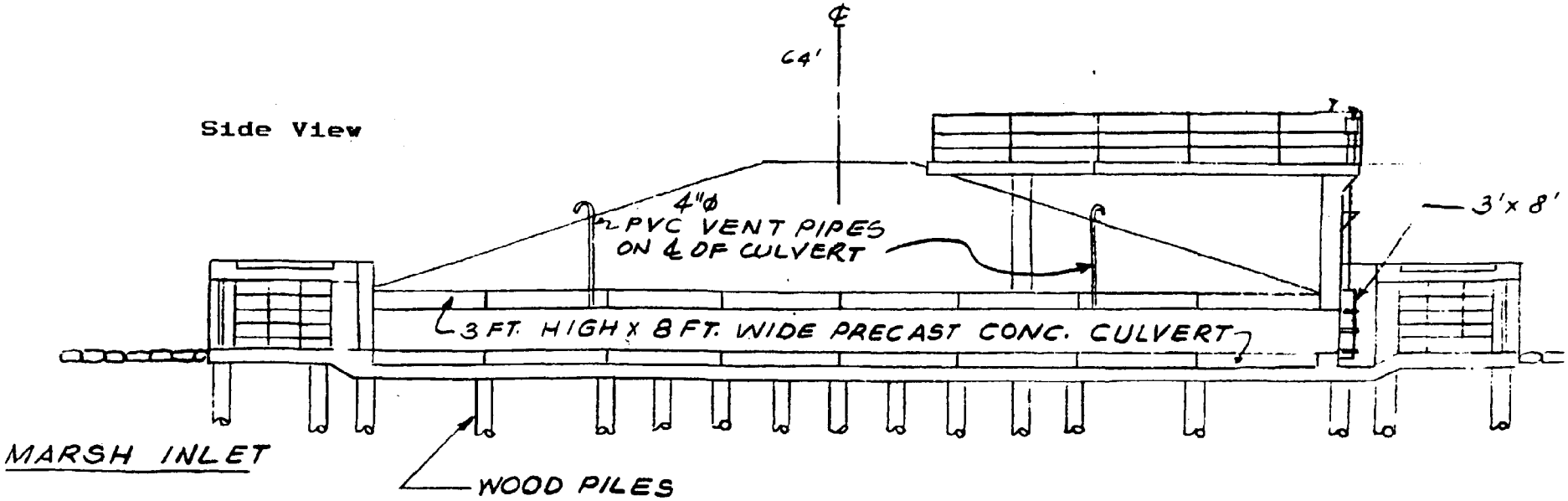
[d]This maximum water management level (0.0 ft. NGVD) will occupy approximately 12.7% of the capacity of the marsh if capacity is the maximum tolerable water level (3.0 ft NGVD).

Proposed Vertical Lift Gate

River View



Side View



PROPOSED BROAD DYKE MARSH WATER CONTROL STRUCTURE

APPENDIX B

GAMBACORTA MARSH REHABILITATION PLAN

Northern Delaware Wetlands
Rehabilitation Program

GAMBACORTA MARSH

A 41-acre tidal freshwater wetland located within the New Castle city limits and currently owned by the Trustees of New Castle Common. The marsh is bordered on the south by the New Castle-Dobbinsville Scenic Walkway paralleling the Delaware River, and surrounded by urban and commercial development on the other sides. The marsh's watershed encompasses 257.7 acres comprised of 143.7 (56%) and 114 (44%) acres of urban and non-urban land uses, respectively. This former tidal wetland was a hazardous waste disposal site having been drained and then filled with industrial waste from Deemer Steel, the Abex Corp., and Wilmington Fibre Co. In the mid 1980's, the waste was removed, the landfill capped, and a system of monitoring wells installed. Investigations of the landfill and monitoring wells have indicated that the landfill was successfully capped and no impacts to groundwater are occurring.

The existing water control structure traverses under the scenic walkway and consists of a tide gate with a single 42-inch flap gate that allows one-way flow of water out of the marsh. A sluice gate structure containing riser boards maintains water levels. The structure was constructed by the Delaware Department of Transportation (DelDot) in 1953, and records indicate it is located on public lands and maintained by DelDot. However, the City of New Castle conducts regular inspections of the structure and preforms minor maintenance. In 1989, the New Castle Conservation District repaired the sluice gate structure and attached protective grates to prevent tampering of the riser boards. The structure has been

temporarily modified to allow daily tidal exchange; however, the volume of exchange is limited.

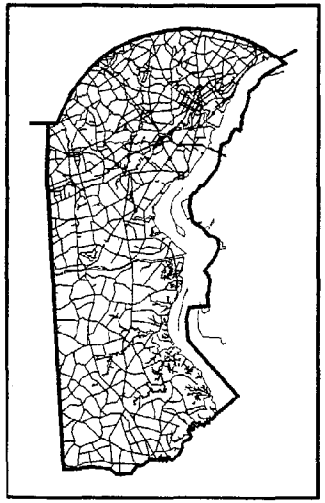
The marsh was dominated (90%) by large monotypic stands of phragmites; however, Open Marsh Water Management practices (OMWM) conducted by the Division of Fish and Wildlife in the early 1980's, followed by installation of wood duck nesting boxes and phragmites control in the late 1980's and early 1990's, have increased the habitat and vegetative diversity of the marsh and improved it for wildlife. The improvements to the marsh combined with its proximity to the heavily used scenic walkway make it an ideal location to facilitate the exposure of wetlands values and their associated wildlife to the public.

Vegetation control and construction practices at a lumber yard, located on the east side of the marsh, have recently caused increased sedimentation of the adjacent marsh area. Additional non-point source pollutants might be conveyed into the marsh through a series of six ditches that drain into the marsh. These ditches receive storm runoff from adjacent upland areas and Route 9.

Gambacorta Marsh

New Castle County, Delaware

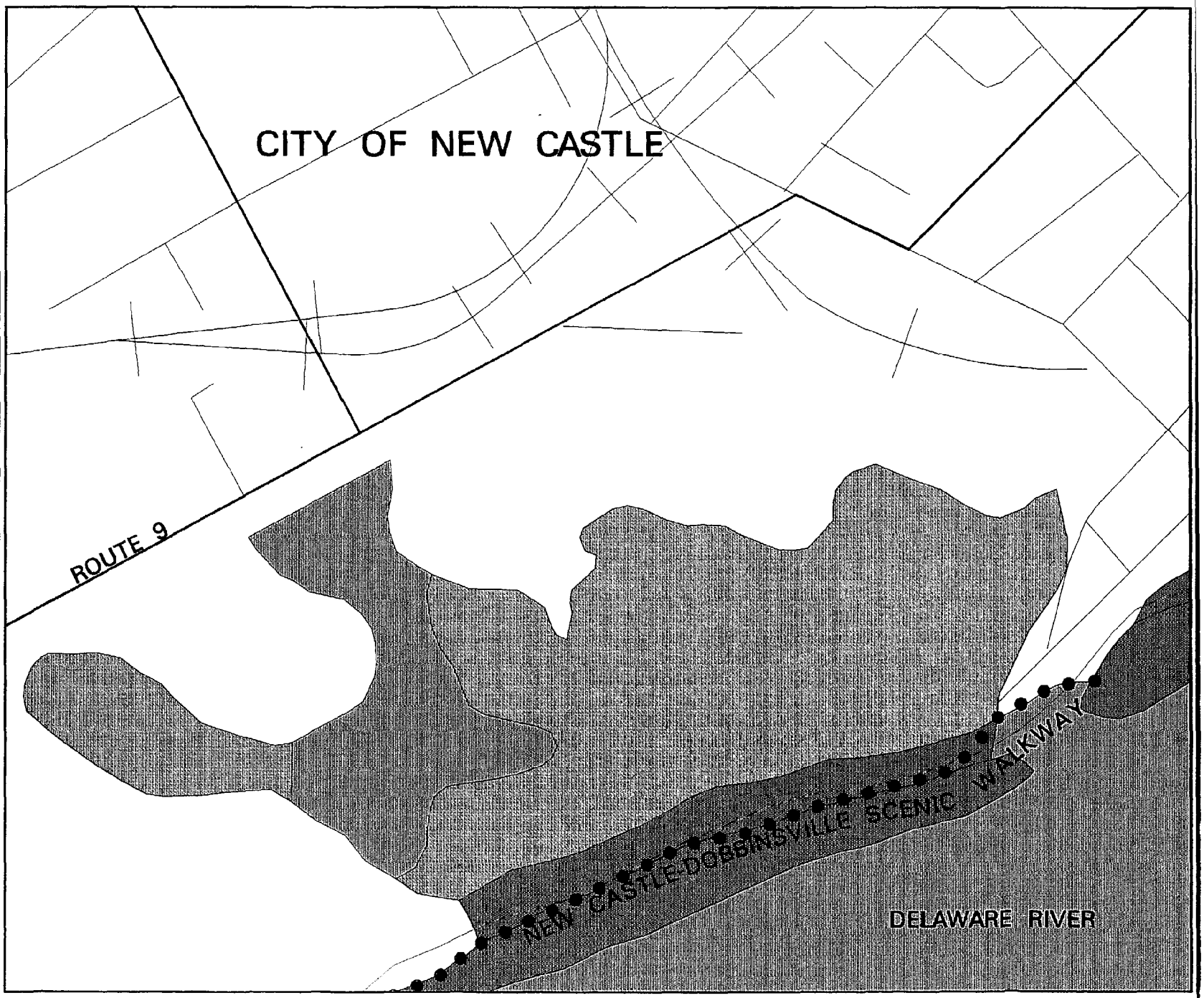
LOCATOR MAP



Open Water

Beaches, Bars and Mudflats

Estuarine Emergent and Estuarine Emergent/Beach/Mudflat



New Castle Conservation District

NORTHERN DELAWARE WETLANDS REHABILITATION PROGRAM

REHABILITATION TRACKING FORM

WETLAND PROJECT: **GAMBACORTA MARSH** **UPDATED:** 6 JANUARY 94

PROJECT MANAGER: Rob Hossler, Fish & Wildlife

PROJECT COMPLETION DATE: July 1997

REPORT STATUS:
1) Environmental Evaluation - Completed 13 November 1992.
2) Water Management Plan - Completed 26 March 1992 and implemented 9 August 1993.
3) Operational Management Plan - not initiated.

PERMIT STATUS:
1) COE 404 Permit - not initiated.
2) State Type II Permit - not initiated.
3) Subaqueous Lands Permit - not required.
4) Environmental Assessment - not initiated.

FUNDING STATUS: 1) Secured -

a. Trustees of New Castle Common - $1,700 provided over last 3 years for phragmites control.

b. DuPont Co. - $5,000 donated to the Trustees of New Castle Common for installation of interpretive signs along scenic walkway.

2) Pending -

a. Trustees of New Castle Common - Interested in providing additional funding to this project; however, this funding is most likely encumbered until rehabilitation efforts at Broad Dyke Marsh are implemented.

b. Brosius-Eliason Co. - interested in partially funding the excavation of the silted in area behind their lumber yard.

c. Delaware Department of Transportation (DelDOT) - constructed the structure and might provide partial funding for the new structure.

LANDOWNERS: Trustees of New Castle Common (Trustees) - own the marsh and have consented to a long-term management agreement for the marsh. The water control structure was constructed by DelDOT and is listed as being on public land. Operation and maintenance of this structure has been a joint effort between the City of New Castle, the Trustees, the New Castle Conservation District (NCCD), and the Division of Fish and Wildlife. Prior to implementation of this project, the marsh's water level was being managed by a local muskrat trapper under verbal agreement with the City of New Castle. The Trustees and the City of New Castle might provide assistance in the operation and maintenance

of the water control structure; additional phragmites control and scenic vista clearing; and installation of the elevated observation platform, wildlife enhancement structures, and wildlife plantings.

PARTICIPATING PARTNERS: Trustees of New Castle Common, City of New Castle. Brosius-Eliason Co.,DNREC, New Castle Conservation District, DelDOT.

PUBLIC RELATIONS: 1) Needs - Involvement of nearby communities in certain aspects of the rehabilitation project.

2) Actions -

a) Environmental Groups - Currently an environmental group is considering being a sponsor for this marsh through DNREC's Adopt-A-Wetland Program. A trash cleanup in this marsh was initiated by several participants of the 2 October 1993 Delaware Coastal Cleanup. A New Castle resident installed and is maintaining 12 wood duck boxes as part of a community service project.

b) Public Presentations - Gambacorta marsh was the site of Governor Castle's 28 October 1992 announcement of the Northern Delaware Wetlands Rehabilitation Project. A public presentation, on 13 October 1992, provided information on the tentative management plans for the proposed rehabilitation of Gambacorta Marsh.

REGIONAL OBJECTIVE: IMPROVE WATER QUALITY

SITE SPECIFIC OBJECTIVE: Improve water quality of both the marsh and river through daily tidal exchange, and by reducing the transportation of potential upland pollutants conveyed into the wetland by stormwater runoff. Tidal exchange will provide nutrient and organismic exchange between the water bodies, and increase the volume of water exposed to wetland filtering benefits and nutrient uptake.

STATUS PRIOR TO PROJECT: The existing water control structure has essentially a single purpose - prevent the flooding of peripheral properties - by allowing one way flow of storm runoff out of the marsh, while preventing tidal inundation. These practices essentially drained this former tidal marsh, causing water quality to degrade while increasing the potential for pestiferous mosquito breeding. The structure has been temporarily modified to allow daily tidal exchange; however, the volume of exchange is limited. Additionally, the portion of the existing outlet pipe that extends into the river is degraded and in need of repair or replacement.

Hazardous Wastes and Toxins - Four potential hazardous waste sites were identified in the vicinity of Gambacorta Marsh. The marsh itself was a hazardous waste disposal site having been drained and then filled with industrial waste from Deemer Steel, the Abex Corp., and

Wilmington Fibre Co. In the mid-1980's, the waste was removed from the marsh, the landfill capped, and a system of monitoring wells installed. Investigations of the landfill and monitoring wells have indicated that the landfill was successfully capped and no impacts to groundwater are occurring. Tidal exchange is not expected to impact the landfill due to the extensive layer of 6-inch rip-rap, overlaying stone choked with sand and gravel, along the marsh border. However, continued monitoring of this site should continue once tidal exchange is increased.

In 1987, an investigation of the Deemer Steel facility, located approximately 1000 feet north of the wetland, identified elevated levels of lead in the drainage channel that bisects this facility and drains into the marsh. Elevated levels of lead were also found in marsh sediments; however, the levels at both sites were not considered a significant threat to human health or the environment. Additionally, these contaminants could have been transported by stormwater from areas further upstream of the Deemer facility.

A portion of the New Castle Gas Co. coal gassification plant was located in the north end of the marsh, evident by the brick silo located in the center of the marsh (Boo-Boo Island). This plant operated from the 1850's to about 1914, and during this time frame waste coal tar could have been disposed in the marsh. Because this compound does not move rapidly through groundwater, it is possible that some of this material remains in the marsh. However, 80 years of sediment deposition (potentially 30 inches) probably limits the availability of this material to vegetation and benthic organisms. Nevertheless, sampling for the presence of coal tar compounds should be conducted prior to disturbing the sediment within the marsh.

Recent vegetation control and construction practices within a section of the Brosius-Eliason Co. lumber yard have caused increased sedimentation of a portion of the marsh. This section of the lumber yard has historically and continues to be a primary storage area of treated lumber. Treated lumber is frequently preserved with heavy metals, which when exposed to elements might be released into the substrate and then washed into the marsh by the increased erosion and sedimentation occurring in the area. This potential is evident by the large quantity of lumber treatment tags found along the marsh/upland edge. Prior to excavating sediment from this area, some sampling should be conducted in order to assess whether any sediment-bound contaminants will be introduced into the marsh.

Non-point Source Pollution - Non-point source pollution enters the marsh via six drainage ditches, of which only two drain upland areas of significant acreage. Of the other four, three receive road runoff from Route 9, and the other drains a small commercial area near the adjacent lumber yard. The specific types and severity of these pollutants has yet to be quantified.

CURRENT STATUS: Water quality sampling and elevation surveys have been completed and the New Castle Conservation District has determined the watershed of the marsh and its corresponding land uses. Drainage ditches have been identified and mapped, but no practices or systems

for reducing potential non-point source pollution have been implemented.

ACTION STEPS NEEDED: 1) Conduct a preliminary hydrological study of the marsh and the two large ditches draining into it.
COMPLETION DATE: March 1995

2) Modeling and engineering design to evaluate the following water control structures: a) a self-regulating tide gate controlled by floats that automatically opens and closes the gate depending on river water levels; b) an automated electro-mechanical vertical lift gate with sensors; and c) any other appropriate structure. The selection of a structure will be based on several factors including: ability of achieving regional objectives, volume of tidal exchange, cost, ability to be retrofitted to existing structure, versatility in manipulating water levels, storm release potential, and operation and maintenance requirements.
COMPLETION DATE: June 1995

3) Installation of the selected water control structure and replacement of the outlet pipe.
COMPLETION DATE: June 1996

4) Establish check dams or wetland vegetation (preferably cattail) in the two existing drainage ditches to increase water retention and pollutant filtering, if applicable.
COMPLETION DATE: August 1995

5) Sample silted in area of marsh behind lumber yard for heavy metals associated with treated lumber.
COMPLETION DATE: June 1994

6) Excavate the silted in area of the marsh behind the lumber yard, and prevent additional sedimentation from occurring by establishing a water conveyance system and a diversion berm in the cleared portion of the lumber yard. Revegetate cleared areas with birds-foot trefoil or lathco flat pea. The lumber yard has indicted that it is interested in assisting in this effort.
COMPLETION DATE: August 1994

SITE SPECIFIC OBJECTIVE EVALUATION: Obtain comparable measurements of water quality within the marsh and downstream of the ditches, and assessments of volume exchange.

REGIONAL OBJECTIVE: IMPROVE WETLAND HABITATS FOR WILDLIFE

SITE SPECIFIC OBJECTIVE: Improve wetland habitats by adhering to a water management plan involving daily tidal exchange and periodic water level manipulations, installing wildlife enhancement structures, and conducting beneficial plantings for wildlife. Adherence to a water management plan should improve habitats for wetland wildlife, especially aquatic mammals, waterfowl and other waterbirds, by both adjusting the water level to accommodate the seasonal needs of these species and allowing this level to fluctuate on a daily basis through limited tidal exchange. These management practices should increase the number, species, and reproductive success of wildlife using the marsh.

STATUS PRIOR TO PROJECT: Open Marsh Water Management (OMWM) practices conducted by the Division of Fish and Wildlife in the mid 1980's, followed by phragmites control in the late 1980's and early 1990's, and installation of 12 wood duck nesting boxes in 1991 have increased the habitat diversity of the marsh and improved it for wildlife. Nesting success in the duck boxes was good in 1992, with 64% of the boxes indicating evidence of successful wood duck nesting. Wetland habitats were also improved by the 1989 repair of the sluice structure, which raised water levels within the marsh. During avian surveys conducted in 1991-1992, 14 species of waterbirds were recorded for a combined total of 178 birds and an average of 35.6 birds/survey. Reproductive success of Canada geese and common gallinules have also been documented in the marsh. A total of 12 species of fish are known to utilize the marsh.

CURRENT STATUS: A detailed water management plan was implemented 9 August 1993. The implementation of this plan was possible by temporarily modifying the water control structure to allow limited daily tidal exchange, and installing new riser boards to provide greater flexibility in manipulating water levels. Daily tidal exchange will promote tidal flushing and organismic exchange, especially fish populations. This plan is subject to adjustment and change based on the availability of additional information, climatic conditions, and in order to better achieve all anticipated benefits and regional objectives. Biological and elevational surveys have been completed. Supplemental studies include weekly avian abundance and diversity surveys, and weekly monitoring of water and salinity levels. In August 1993, 5 permanent vegetation transects were established in the marsh. The vegetation on these transects will be periodically reassessed to evaluate the success of the water management plan and other rehabilitation efforts.

ACTION STEPS NEEDED: 1) Evaluation of the reproductive success of wood ducks in the existing nest boxes, with emphasis placed on the

occurrence of dump nesting. This evaluation will help determine where additional boxes, if any, should be installed to improve reproductive success of this species.

COMPLETION DATE: March 1995

2) Install wood duck, goose, mallard, passerine, and squirrel nesting structures. The number and location of these enhancement structures will be determined based on success of existing structures, and the availability of suitable microhabitats. Support in installation of wildlife enhancement structures might be available from the Trustees and/or private groups.

COMPLETION DATE: March 1996

3) Seeding of wild rice, and planting of big-leaved arrowhead tubers and river bulrush rootstocks during periodic draw-downs. The quantity planted will depend on the amount of suitable habitat available. Financial support to purchase the seed might be available from the Trustees and/or private groups.

COMPLETION DATE: November 1995

SITE SPECIFIC OBJECTIVE EVALUATION: The success of the water management plan will be based on comparable surveys of waterbirds and fish utilizing the marsh, and the permanent vegetation transects established in the marsh during the summer of 1993. Success of wildlife enhancement structures will be based on the reproductive success of wildlife utilizing them. Success of beneficial wildlife plantings will be based on successful regeneration of the species, and their use by wildlife.

REGIONAL OBJECTIVE: UNDESIRABLE PLANT SPECIES CONTROL

SITE SPECIFIC OBJECTIVE: Reduce the area covered by monotypic stands of phragmites and increase the area covered by desirable emergent vegetation. The percent cover of phragmites will be reduced to less than 5% (2 acres). Phragmites cover will be confined to upland areas and the wetland/upland fringe.

STATUS PRIOR TO PROJECT: Previously, approximately 90% (37 acres) of the marsh was dominated by large monotypic stands of phragmites; however, treatments of aerially-applied herbicide during the late 1980's and early 1990's have reduced the percentage of phragmites cover to 17% (7 acres).

CURRENT STATUS: A follow-up application of herbicide was applied on 7 acres of phragmites on 30 September 1993. Funding provided by Trustees of New Castle Common ($500).

ACTION STEPS NEEDED: 1) Apply herbicide (glyphosate) periodically on monotypic stands of phragmites.

COMPLETION DATE: Annually as needed in early Fall.

2) Controlled burning of phragmites (where feasible) or other removal method of the standing dead canes will be conducted following application of herbicide. Controlled burning suppresses phragmites through several methods including: exposing regenerating canes to the second year treatment of herbicide, reducing gas exchange to surviving root stalks, stimulating the release of nutrients for other competing plant species, exposing the soil to sunlight, and stimulating germination of desirable species in the existing seed bank.

COMPLETION DATE: In late winter, following the application of herbicide.

SITE SPECIFIC OBJECTIVE EVALUATION: Success determined by the reduction of monotypic stands of phragmites.

REGIONAL OBJECTIVE: INCREASE SHALLOW WATER HABITAT DIVERSITY

SITE SPECIFIC OBJECTIVE: Increase the percentage and diversity of open water and desirable emergent vegetation habitats. The percent cover of open water and desirable emergent vegetation habitats will range from 22-44% (9-18 acres) and 44-66% (18-27 acres), respectively. Shallow water habitats will include numerous shallow ponds, ditches, and flats.

STATUS PRIOR TO PROJECT: Open Marsh Water Management practices conducted in the early 1980's increased the percentage and diversity of open water habitats; however, several of the ponds and smaller ditches have silted in. Currently only 15.4% (6.3 acres) of the marsh consistently retains open water habitat interspersed with desirable emergent vegetation; however, following the implementation of the water management plan this percentage might change.

CURRENT STATUS: Except for contour and environmental surveys no work has been conducted in the marsh.

ACTION STEPS NEEDED: 1) Reevaluate the diversity of shallow water habitats and the percentage of open water habitats following implementation of the water management plan. In the event an increase in this diversity or percentage is desired, a proposal to increase shallow water habitat diversity will be submitted either under the Division's existing Open Marsh Water Management permit or through a separate permit.

COMPLETION DATE: June 1997 and annually thereafter.

2) Sample the proposed excavation sites for the presence of coal tar compounds.
COMPLETION DATE: July 1997

3) Excavation of sediment laden ditches and ponds, and potentially the formation of a few new ditches, ponds, and island habitats. New ponds will have tapered sides and most ponds and all ditches will be shallow, ≤18 inches in depth. Several ponds will have sections excavated >18 inches in depth to provide habitat for fish during droughts and draw-downs. Islands for waterfowl nesting will be created by accumulation of construction spoil. Excavations will be conducted using Division of Fish and Wildlife personnel and equipment.
COMPLETION DATE: Dependent on annual evaluations of existing shallow water habitat diversity and percentage of open water habitats.

SITE SPECIFIC OBJECTIVE EVALUATION: Success based on the diversity of shallow habitats and the percentage of open water habitat.

REGIONAL OBJECTIVE: IMPROVE RECREATION AND AESTHETIC VALUES

SITE SPECIFIC OBJECTIVE: Improve recreational opportunities and the aesthetic value of the marsh by creating vistas (clearing phragmites and dense shrub cover), constructing a 6-foot-high observation platform, and constructing interpretative signs along the New Castle-Dobbinsville Scenic Walkway.

STATUS PRIOR TO PROJECT: The Scenic Walkway receives a considerable amount of visitor use; however, scenic vistas of the adjacent marsh and its wildlife are limited to a few small openings through the phragmites and dense brush between the walkway and the marsh.

CURRENT STATUS: Implementation of the water management plan and other rehabilitation efforts in the marsh have recently generated interest in the marsh and its management plan. In response to this interest the Division of Fish and Wildlife proposed the previously mentioned rehabilitation plans to the Trustees. Vistas of the marsh along the Scenic Walkway were created in 1993 by the Trustees with assistance from the Division of Fish and Wildlife and the State Department of Corrections. In mid-September, Division employees sprayed upland vegetation with herbicide using a vehicle-mounted power sprayer. In October, prison labor removed the dead vegetation.

ACTION STEPS NEEDED: 1) Determine the overall opinion of visitors utilizing the walkway, in regards to the aesthetic and recreational values of the marsh both prior to and after the implementation of the marsh rehabilitation plan.

COMPLETION DATE: September 1994

2) Maintain vistas of the marsh along the Scenic Walkway by clearing brush and phragmites. The Trustees and the State Department of Corrections has provided assistance in this effort.

COMPLETION DATE: Annual maintenance as needed.

3) Construct interpretive signs along the Scenic Walkway providing a mechanism to environmentally educate users about the marsh and the river. The Trustees are funding this project through a donation from the DuPont Co.

COMPLETION DATE: April 1994.

4) Construct an observation platform along the Scenic Walkway, overlooking the marsh. Assistance in the construction of the platform might be provided by the Trustees; however prior to its construction, a parking problem along the Scenic Walkway needs to be addressed.

COMPLETION DATE: April 1995

SITE SPECIFIC OBJECTIVE EVALUATION: Improvements in the recreational opportunities and aesthetic value of the marsh will be determined through surveys of the observation tower's use, and visitor responses to questionnaires regarding the marsh's aesthetic and recreational value.

REGIONAL OBJECTIVE: REDUCE STORMWATER FLOODING

SITE SPECIFIC OBJECTIVE: Reduce stormwater flooding of Route 9 by maintaining the drainage ditches entering into the marsh and monitoring the impact of the water management plan on them. Stormwater flooding of Route 9 should be eliminated, except following unusually heavy rain events.

STATUS PRIOR TO PROJECT: A drainage ditch near the intersection of Route 9 and Washington Street becomes choked with vegetation, trash, and sediment; thereby, impeding stormwater runoff and causing flooding of Route 9 following heavy rain events.

CURRENT STATUS: The drainage ditch was cleared in March 1992 and inspected in November 1992.

ACTION STEPS NEEDED: 1) Periodic inspections and clearing of drainage ditches entering the marsh. Clearing will be conducted by Division of Fish and Wildlife personnel and equipment.
COMPLETION DATE: Inspections will be seasonal, while clearing will be on an as needed basis.

2) Monitor the impact of tide gate manipulations, tidal exchange, and installation of check dams on stormwater surge, making appropriate adjustments as necessary.
COMPLETION DATE: Ongoing and coinciding with water manipulations.

SITE SPECIFIC OBJECTIVE EVALUATION: Evaluations based on comparable measurements of flooding severity, periodicity, and duration.

SECONDARY OBJECTIVES: 1) Restore and improve spawning, nursery, and feeding sites for anadromous, estuarine, and riverine fishes.

2) Protect and enhance existing populations and critical habitats of threatened and endangered species and other species of concern. The Natural Heritage Inventory has documented the presence of the Engelmann umbrella-sedge (*Cyperus engelmannii*), a S1 State Species of Special Concern, in Gambacorta Marsh.

3) Control pestiferous mosquito populations by water management where practical, thereby enhancing biological control via predacious fish and reducing the amount of chemical insecticides required.

4) Increase environmental education opportunities for both general public and school groups.

GAMBACORTA MARSH - WATER MANAGEMENT PLAN[a]

DATE	MANIPULATION (Pool level at low tide)	ELEVATION (NGVD)	RATIONALE
1 March - 15 April	Reduce pool level to 0%, but allow maximum tidal exchange[b,c].	**0.75 ft** - All flats are exposed and approximately 2 and 11 inches are maintained in the ponds and ditches, respectively.	Promotes maximum flushing of accumulated overwinter detritus and sediment, while permitting anadromous fish exchange and regrowth of emergent plants species.
16-30 April	Increase pool level to 25% allowing limited tidal exchange.	**1.15 ft** - Inundates 27% of the flats at an average depth of 2.5 inches.	Concentrates invertebrates and exposes mud flats for waterfowl and shorebirds, respectively, while permitting anadromous fish use and regrowth of emergents plants.
1-30 May	Increase pool level to 50% allowing limited tidal exchange.	**1.41 ft** - Inundates 45% of the flats at an average depth of 4.5 inches.	Increases pool level for waterfowl without inundating nesting areas, while permitting anadromous fish use and regrowth of emergents.
1 June- 31 July	Increase pool level to 75% allowing limited tidal exchange.	**1.83 ft** - Inundates 72% of the flats at an average depth of 7.7 inches.	Provides habitat for waterfowl brood rearing; increases invertebrate populations; encourages SAV growth; and provides shallow mud flats for waterbirds.

1 Aug. - 15 Oct.	Decrease pool level to 50% allowing limited tidal exchange.	**1.41 ft** - Inundates 45% of the flats at an average depth of 4.5 inches.	Exposes mud flats for migrating shorebirds; promotes regrowth of late season annual plant species; and increases exchange of estuarine fish species, particularly for egress following the nursery season.
15 Oct. - 28 Feb.	Increase pool level to 100% allowing limited tidal exchange.	**2.33 ft** - Inundates 100% of the existing flats at an average depth of 11 inches	Provides habitat for waterbirds, waterfowl, muskrats and overwintering fish species.

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[a]Water management plan is subject to adjustments and change based on the availability of additional information, climatic conditions, and in order to better achieve all regional objectives.

[b]Maximum tidal exchange is equivalent to the maximum volume (not to exceed the level that causes peripheral flooding of adjacent properties) that allows the water level to recede to the 0% pool level during an average tidal cycle.

[c]Tentatively a drawdown to the 0% pool level, with limited tidal exchange during each tidal cycle, will occur every 3 years to solidify the flats and promote the revegetation of emergent plant species.

APPENDIX C

THOUSAND ACRE MARSH REHABILITATION PLAN

Northern Delaware Wetlands
Rehabilitation Program

Northern Delaware Wetlands Rehabilitation Project

Thousand Acre Marsh Watershed Protection and Wetland Rehabilitation Project

Preliminary Tracking Form

Contacts:

David Carter and Elaine A. Logothetis

Delaware Coastal Management Program
Division of Soil & Water Conservation
Delaware Department of Natural Resources
& Environmental Control

Watershed Project: Thousand Acre Marsh

Project Coordinators: David B. Carter, DSWC/DCMP
Elaine A. Logothetis, DSWC/DCMP

Form Updated: January 12, 1994

Project Background

A. *Project Description*

The proposed management scheme for the Thousand Acre Marsh is a comprehensive watershed approach to the management of wetlands. This project the first of its kind in Delaware and its success may serve as a prototype for future marsh management. By novelly incorporating Delaware's Tax Ditch Program as the essence of management, long term funds, managers and maintenance is secured. In the absence of the Tax Ditch Organization, the future of the marsh, adjacent and regional resources are in jeopardy.

The Thousand Acre Marsh Project is an ecosystem based, comprehensive watershed restoration, protection, and management project that shall involve numerous governmental agencies and 22 private landowners. The project intends to coordinate numerous proven water quality improvement technologies, land protection approaches, wildlife management techniques, wetland management techniques, and habitat restoration techniques to improve and protect the 3,067 acre watershed (see project organization and flow chart). More importantly, the project will creatively use Delaware's Drainage Code (7 Delaware Code, Chapter 41) to ensure a coordinated long term commitment from landowners through a legally binding watershed plan and a dedicated funding source to ensure long term success.

The project plans to utilize upgraded technologies for dredging and dredge material placement for the purposes of marsh restoration and creation. This procedure will utilize as much as 160,000 cubic yards of dredge material removed during the restoration of in-basin tidal creeks. This material will be used in a beneficial manner for the restoration of wetlands via the creation of "wet islands" in open water areas and for the enhancement of several areas of deteriorated emergent marsh.

These areas were locations of historic emergent wetlands which have been lost due to sediment deprivation from tidal exclusion (impounding), land subsidence due to approximately 150 years of drainage, and inadequate water management.

This project is expected to improve water quality, restore approximately 25,000 linear feet of tidal streams, create 34 acres of "wet island", emergent wetland area in the former location of the wetlands, and re-invigorate 25 acres of threatened emergent wetland by the replenishment of low level marsh with thin layered dredged material. The construction phase of this project is expected to last approximately one year.

Methods and technologies to be tested and upgraded include: 1) comprehensive watershed management approaches which will require extensive interagency and private sector coordination; 2) wetland restoration technology; 3) dredge operations for the restoration and enhancement of wetlands; 4) thin layer application of dredged material; and 5) innovative approaches for coordination of private lands management.

B. *Project Benchmark Dates*

1.)	Meet with Tax Ditch Commissioners	4/30/93 (completed)
2.)	Survey water level benchmarks	5/5/93 (completed)
3.)	Site visit with Natural Heritage Staff	6/4/93 (completed)
4.)	MOA with Natural Heritage Staff	6/8/93 (executed)
5.)	Begin weekly water quality monitoring for temperature, salinity, DO, nitrogen, & phosphorus)	6/4/93 (executed)
6.)	Watershed Topography mapping	6/14/93 (completed)
7.)	Joint Permitting Committee Meeting	6/17/93 (completed)
8.)	U.S. Army Corps of Engineers (Presentation to Design and Planning Branches)	6/29/93 (completed)
9.)	Site visit by DSWC administrative staff regarding project planning and management	7/1/93 (completed)
10.)	Tax Ditch Organization Meeting with all Landowners	7/29/93 (completed)
11.)	JPPC meeting regarding Rte. (Shoreline Stabilization Project	11/18/93 (completed)

12.) Site visit with JPPC to assess proposed permit required projects — 12/3/93 (completed)

13.) Open Space Council approved of approximately 100A of Warren tract for purchase of public lands — 12/7/93 (completed)

14.) Tax Ditch Referendum — February 94

15.) Initiate permit process for Aquatic Rehabilitation activities — December 93 (continuous)

C. ***Report Status***

1.) Draft Report - Thousand Acre Marsh: General Background, Description, and Management Recommendations and Alternatives (pgs. 119)
- Completed February 1992.

2.) Final Tax Ditch Commissioners Report
- Final Report - expected January 31, 1994

3.) Natural Heritage Inventory Biotic Composition and Natural Community Description
- January 15, 1994

4.) Non-Point Source Pollution Assessment and Recommendation Report
- expected September 30, 1994

D. ***Permit Status***

1.) State of Delaware Subaqueous Lands Permit for the construction of 560 cubic yards of rip-rap stabilization and 50 cubic yards associated fill on Selby tract.

Permit No. SP-0302/92
Issued April 22, 1993

2.) U.S. Army Corps of Engineers Section 404 Permit for the construction of 560 cubic yards of rip-rap stabilization and 50 cubic yards associated fill on Selby tract.

Permit No. CENAP-OP-R-199200588-36 (NP13)
Issued March 26, 1993

3.) Permit type under review of DNREC Wetland Branch and U.S. ACE for Delaware Rte. 9 Shoreline Stabilization Project via DelDOT.

4.) No other permit needs have been definitively identified

at this time. Initiation of permit activities is pending landowner decisions with regards to the extent of wetland dependent activities to be undertaken as part of the project. Permits effort will be initiated as needed.

- Completion time for permits and Environmental Assessments between 3-5 months.

5.) Joint Permit Processing Committee received project scope (June 17, 1993). Suggested to apply for one permit that included all project activities.

E. *Funding*

1.) Secured

a. Environmental Fines	
· Presidente Rivera	$ 13,000 (expended)
· Other Penalties	
Unspecified Source	$ 17,000 (expended)
NPS Encumbered Account	$100,000[1]
b. DCMP Section 309 Grant (Oct. 1993 - Sept. 1994)	$ 64,000[1]
c. U.S. EPA Delaware Estuary Program Grant	$ 41,500
d. DelDOT Shoreline Stabilization Project	$ 50,000
e. Land Protection (Warren Tract)	$390,000

2.) Non-Secured
   a. State General Funds for Dredging
   b. Additional Fines Monies
   c. Additional Federal & State Grants
   d. Tax Ditch Fees

3.) Cost-Share Programs
   a. Phragmites control
   b. BMPs for aglands (NCCD, ASCS, SCS)

[1] Only a portion of this amount is available for Thousand Acre Marsh

F. *Landowners*

Property ownership is distributed amongst 22 owners of 19 separate parcels of land. Historic landowner disputes over marsh management have significantly hindered wetland management. In order to resolve long standing conflicts, a Tax Ditch Association has been proposed to ensure one voice in management decisions and to provide a dedicated source of funds for long term marsh management and maintenance. If this organization is approved via

landowner votes and superior court concurrence, decisions of this association will be legally binding and enforceable. Note that in Deceember 1993, the Open Space Council approved the purchase of approximately 100 acres on the Warren tract for public land.

G. *Project Participants*

- Landowners (Proposed Tax Ditch Association)
- New Castle Conservation District
- USDA Soil Conservation Service
- Delaware Department of Natural Resources and Environmental Control
  - Division of Soil & Water Conservation
  - Division of Parks & Recreation
  - Division of Fish & Wildlife
  - Division of Water Resources
- National Oceanic and Atmospheric Administration
  - Ocean and Coastal Resource Management
- Delaware Department of Transportation (Del DOT)
- U.S. Army Corps of Engineers, Design and Planning Branches
- U.S. Fish and Wildlife Service

H. *Other Potential Participants*

- U.S. Environmental Protection Agency
- NOAA, National Marine Fisheries Service
- Delaware Department of Agriculture
- University of Delaware, Department of Agriculture - Cooperative Extension Service
- New Castle County

Preliminary Project Schedule and Activities Organized by Goals, Objectives, and Tasks

Goal I: Improve Water Quality

A. *Condition Prior to Project*

There is limited quantitative data of water quality, however, qualitative information has identified algae and phytoplankton blooms, and fish kills which are indicative of excess nutrients and other water quality problems.

Although some past efforts have been made to develop Agricultural Conservation and Management Plans for aglands within

the watershed, a coordinated and concentrated watershed approach was not apparent. Many agland areas are still in need of conservation plans or plan updates. This will require significant technical assistance to local farmers as well as a source of funds for plan implementation.

In addition, potential conversion of watershed uplands from aglands to residential land use exists. This land-use change may potentially increase toxic inputs from urban sources as well as nutrient loadings from a high concentration of on-site septic systems. It may also affect watershed hydrology.

B. *Site Specific Objective I.1*

Reduce pollutant loadings from watershed area surface water runoff.

1.) Tasks Required to Meet Objective I.1:

a. Develop and inventory all agricultural lands in the watershed, a listing of any lands covered by SCS, Conservation District, or ASCS Agricultural Conservation and Management Plans. Conduct an assessment of all plans identified. This will determine the level of compliance with plans and develop a list of those areas in which efforts should be directed to develop additional plans.

b. Identify specific locations where implementation of conservation practices would improve surface water runoff quality. This may include potential locations for grassed waterways, manure management sheds, buffer strips, integrated crop management areas, nutrient management areas, etc. An estimate of implementation costs will also be included for each site specific conservation measure or best management practice (BMP) identified.

c. Conduct an assessment of the NPS impacts of the planned residential development on the former Port Penn Hunting Club property. Identify any additional management measures which could reduce these impacts (eg. vegetated roadside ditches instead of curbs, wet stormwater retention basin, etc.).

d. Develop a detailed map of the watershed's drainage system.

e. Generate an estimate of the surface water recharge potential for Thousand Acre Marsh in an average year, wet year, and drought year. (SCS TR55 or AGNPS continuous simulation/unit hydrograph approach).

f. Identify land-use and land-cover types.

g. Conduct detailed mathematical model of runoff quality with an emphasis on nutrients and sediments to simulate the impact of various conservation practice scenarios on water quality. The model will utilize Agricultural Nonpoint Source Pollution Model (AGNPS) for priority agricultural watershed areas.

h. Develop a two foot contour map of watershed area to improve accuracy of watershed modelling for NPS.

2.) <u>Current Status of Objective I.1</u>

a. A 2 foot contour map of the watershed has been conducted under a contract administered by the New Castle Conservation District. The map is available in both hard copy and digital (DWG Format) form.

   Status: Completed
   Cost: $ 21,000

b. Nonpoint Source Pollution Assessment Project encompassing all other tasks under Objective I.1 will be initiated.

   Status: October 1, 1993
   Completion Date: September 30, 1994
   Cost: Approximately $ 30,000 (secured)

c. Perform weekly gross water quality analysis by DSWC staff.

   Status: continuous
   Cost: DSWC In-Kind Staff Time

d. Conduct hydrologic analysis of marsh and tidegates. Initial analysis completed by DSWC Engineer

   Cost: Engineering Staff Time
   DSWC In-Kind Services

e. Initiate study to assess the phosphorus loadings from agriculutral lands. DSWC responsible for sample collection and UofDE and SCS conduct analysis.

   Status: Started 12/20/93, thwarted by weather conditions will continue once ground thaws
   Cost: DSWC Staff Time
   $7.00/sample

C. *Site Specific Objective I.2*

Improvements of waterbody water quality through the implementation of any applicable measure at receiving water end of watershed.

1.) Tasks Required to Meet Objective I.2

a. Evaluate various options for structural improvement to enable desired water management.

b. Install new or retrofit existing tide gate with alternative structure that will enable increase water management flexibility and limited tidal flushing.
   - Possible renovation of the historic flow direction and tidal prism via installation of a tide gate structure between the marsh and C-D canal.
   - Increase water management flexibility via retrofit of existing structure.

c. Permit tidal exchange of impoundment with estuarine waters during low salinity seasons of year (Spring).

   1. Provide for dilution of nutrients in marsh basin with tidal waters in a reach of Delaware River that is not significantly impaired by nutrient concentrations (1992 305(b) Water Quality Inventory Reports).
   2. Improve dissolved oxygen concentrations through the increase in water mixing and circulation, and addition of more oxygenated estuarine waters.

2.) Current Status of Objective I.2

Status: Pending formation of Tax Ditch Association
Cost: Unknown - Pending Engineering and Design (Estimate $ 15,000 - $ 125,000 dependent upon structure)

D. *Site Specific Objective II.1*

Implement a consistent approach to water management at the Thousand Acre Marsh.

1.) Tasks Required to Meet Objective II.1

a. Include water management schedule in Final Tax Ditch Commissioners Report to provide the mechanism for mandatory compliance.

b. Establish a Tax Ditch Association by landowner majority vote to ensure one voice in management decisions and to provide a legal mechanism for taxation. The dedicated

source of funds will cover a part of initial project costs

and long term maintenance of the water control structure, channel maintenance, and Phragmites control.

c. Assist landowners in the coordination and implementation of an interim water management plan.

2.) Current Status of Object II.1

a. Tax Ditch Association
- Petition filed in Superior Court - July 14, 1992
- Superior Court order that the Tax Ditch Commissioners Review Plan in accordance with Chapter 41, Title 7, Delaware Code 1953, as amended.
  - Issued March 12, 1993
- Tax Ditch Commissioners Review
  - Initiated May 3, 1993
- Interim Landowner Meeting - July 29, 1993
- Landowner Vote on Tax Ditch - Early Fall 1993

Cost: DCMP Grant Staff and State Drainage Program Staff Time

b. Assist Landowners with Interim Water Management Regime
- Currently carried out by landowners in accordance with March 1993 to February 1994 water management schedule. Technical assistance provided by David Carter and Elaine Logothetis.

Cost: DSWC Staff Time

Goal III: Aquatic Habitat Rehabilitation

A. *Condition Prior to Project*

Thousand Acre Marsh is a low level impoundment with water levels regulated via tide restricting flapper gates and an inland riser board weir. This type of structure provides very limited flexibility for wetlands water management and has been the subject of long standing contention amongst the numerous marsh property owners.

Due to the combined effects of natural processes and inconsistent management efforts, the wetland area has experienced a general decline in habitat quality for approximately two decades. Evolution of the marsh area has been toward a shallow, sediment laden, open water area; devoid of vegetation important for waterfowl, waterbirds, muskrats, and most other wetland wildlife species.

B. *Site Specific Objective III.1*

Improve Vegetative Diversity

1.) Tasks Required to Meet objective III.1:

a. Eradicate Phragmites with basin wide spray program followed by out-year maintenance spray program. For long term control, implement a low level (acreage) annual treatment program for spot treatment of areas of Phragmites re-invasion.

b. Implement a consistent water management plan to encourage recovery of emergent vegetation in open water areas.

c. Vegetation planting should not be necessary due to natural seed bed, however some supplemental plantings may be initiated in designated areas, such as; erodible soils, island creation sites, exposed sediments, buffer strips, and reclamation sites.

Cost: Unknown (will be included with dredge operation budget)

2.) Current Status of Objective III.1

a. Phragmites control - Pending approval of Tax Ditch for basin wide treatment.

Cost: Year I 400 acres @ $ 60.^{00} = $24,000.^{00}
Year II 400 acres @ $ 38.^{00} = $15,200.^{00}

Total = $39,200.^{00}
Annual out-year maintenance
35 acres @ $102.^{90} = $ 3,600.^{00}

b. Water Management

1. Pending approval of Tax Ditch Association - cost analysis for implementation.

Cost: $500.^{00} - $1000.^{00} /year (Proposed Tax Ditch Association annual fees)

2. Following schedule of interim water management regime for 1993 - 1994 seasons with landowner and interagency coordination.

C. *Site Specific Objective III.2*

Shoreline stabilization and wetland in-basin erosion control

1.) Tasks to Meet Site Specific Objective III.2

a. Vegetative losses have been a result of exposure to the open water marsh. This direct exposure has subjected the shorelines to harsh winds and wave action. Utilize innovative dredging technologies to restore "wet island" emergent wetland that will reduce wind fetch and dissipate wave energy.

b. Coordinate with Del DOT for a shoreline stabilization using fabric and rip rap to prevent over flow erosion of Route 9 embankment during coastal storms.

c. Environmentally sensitive bioengineering techniques have been proposed; such as the natural fibre logs (Bio-Logs^{R}) and vegetative plantings in areas of severe shoreline erosion.

2.) Current Status of Objective III.2

All tasks pending approval of Tax Ditch Association.

D. *Site Specific Objective III.2*

Conduct In-Basin channelization with Cookie Cutter for improved water circulation and marsh access.

1.) Tasks to Meet Objective III.3

a. Limited channel restoration may be accomplished with the U.S. Fish and Wildlife Service, and/or Pennsylvania Department of Fish and Game Cookie Cutter. The equipment has been designed for shallow depths and a channel width of eight feet.

b. For channel maintenance, Cookie Cutter channelization may be periodically required. Regular maintenance funds may be procured from the Tax Ditch program.

Cost: Maximum of $15,000.^{00}

2.) Current Status of Objective III.3

- Pending approval of Tax Ditch Association

E. *Site Specific Objective III.4*

Restore emergent vegetation and tidal stream size and depths to pre-1940s characteristics.

1.) Tasks to Meet Site Objective III.4

a. Dredging feasibility analysis, Environmental Assessment and cost analysis.

b. Conduct sediment analysis, for physical characteristics and for any potential pollutants of concern.

c. Restore tidal creeks via relatively new, innovative and beneficial dredging techniques. At a minimum, create 34 acres of "wet island" and emergent low marsh, and reinvigorate 25 acres of threatened marsh via thin layer of dredged material.

d. Monitor during and after dredging operations.

e. Implement limited tidal flushing as part of water management plan.

2.) Current Status of Objective III.4

a. Pending approval of Tax Ditch Organization
- Met with DSWC Staff, Joint Permit Processing Committee, and U.S. Army Corps of Engineers with regards to feasibility, permits and procurement of funds.
- Cost analysis

Cost: Pending Design

Goal IV: Improve Wildlife Resources

A. *Site Specific Objective IV.1*

Improve species diversity and protection of organisms utilizing watershed

1.) Tasks to meet site specific objective IV.1

a. Implement previously outlined Wetland Management and Aquatic Habitat Rehabilitation activities.

b. Encourage landowner participation on this level. Basic wildlife management practices allow for the landowner to become actively involved in the watershed

management plan. Tools such as those listed below, stimulate the landowners to reap the rewards of their own management in consumptive and non-consumptive uses and may foster stewardship and land protection for future generations.

List of potential conservation practices:

1. install nest structures (i.e. wood duck and bluebird boxes)
2. permit only ethical hunting practices
3. leave snags
4. create or widen buffer and/or riparian zones
5. harvest 90% crop and leave 10% as wildlife food
6. encourage designation of sites as refuge or natural areas on and/or amongst property boundaries.

2.) Current Status of Objective IV.1

a. SCS and NCCD have worked in the past with some property owners on agricultural conservation planning.

Goal V: Land Protection

A. ***Site Specific Objective V.1***

Preserve and protect as much undeveloped land in the watershed as possible.

1.) Tasks to meet Site Specific Objective V.1

a. Coordinate with Open Space Council for easements, development rights, deed restrictions, land trusts, natural area protection and acquisition.

b. Coordinate with DP&R for natural areas protection.

c. Inquire with DE Department of Agriculture for applicability and/or availability of participation with the federal Farmland Preservation Program.

2.) Current Status of Objective V.1

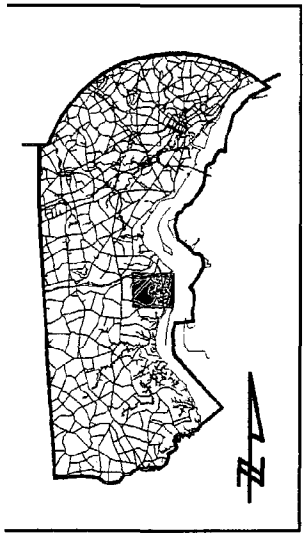
Open Space Council approved the purchase of approximately 100 acres of palustrine forest on the Warren tract for public lands.

Other land protection efforts at this time are confidential.

Thousand Acre Marsh

New Castle County, Delaware

LOCATOR MAP



NATIONAL WETLANDS INVENTORY:

- Open Water
- Beaches, Bars and Mudflats
- Estuarine Emergent and Estuarine Emergent/Beach/Mudflat
- Estuarine Scrub Shrub and Estuarine Scrub Shrub/Emergent
- Palustrine Emergent and Palustrine Emergent/Open Water
- Palustrine Forested, Palustrine Forested/Scrub Shrub and Palustrine Forested/Emergent
- Palustrine Scrub Shrub and Palustrine Scrub/Shrub/Emergent

New Castle Conservation District

APPENDIX D

DELMARVA POWER & LIGHT IMPOUNDMENT REHABILITATION PLAN

Northern Delaware Wetlands
Rehabilitation Program

DELMARVA POWER AND LIGHT IMPOUNDMENT

An 81-acre impoundment located at Hamburg Cove on the Delaware River, 2 miles northwest of Pea Patch Island. The site was a former tidal wetland that was diked and filled with dredge spoil in the 1950's. The spoil increased the elevation of the marsh above sea level by approximately 14 ft, eliminating tidal influence. In the 1970's this area was used as a mitigation site for compensation of another dredge disposal site by the Getty Oil Refinery. Mitigation involved creating several shallow ponds and installing a water control structure. In 1973, a 500 kv power line was constructed across the marsh, and an 1100-foot culvert pipe was installed to divert storm runoff from the marsh and into an adjacent watershed. Current landowners are Delmarva Power and Star Enterprises. A portion of the marsh is currently used by the Delmarva Power Sportsmen's Club for recreational hunting.

The existing water control structure is over 40 years-old and nonfunctional in terms of maintaining, increasing, or manipulating water levels. This inability of the structure to retain water combined with the fact that the marsh's only hydrologic input is rainfall, have contributed to the marsh becoming dominated by a monotypic stand of phragmites. Currently, 3 small shallow depressions (totaling 3.5 acres) consistently retain water, 2 only seasonally. Two degraded ponds (7.8 acres combined) adjacent to the marsh receive a significant amount of the storm runoff from the marsh's watershed. These ponds provide limited hydrologic input to the marsh, but they and can be utilized to create a stair-step

reservoir system between the ponds and the marsh, thereby benefiting all three waterbodies. A sand and gravel extraction operation within the marsh's watershed has been identified as potentially impacting the marsh's water quality and supply. Over the last 4 years, pestiferous mosquito breeding in this marsh has been sufficient to warrant an average of 1.25 aerial applications of insecticide per year.

The marsh is a potentially important area for wildlife. It is in close proximity to the Pea Patch Heronry, the largest wading bird colony on the Atlantic Coast north of Florida, and Hamburg Cove, an important area for migrating black ducks. The juxtaposition of the marsh among primarily agriculture lands the adjacent to 2 ponds inhabited by a beaver colony increases this value. Delaware's only consistently successful osprey nest in the upper Delaware River is located on one of the 500 kv power line towers within 1 mile of the marsh.

The Delmarva Power
and Light Impoundment
New Castle County, Delaware

LOCATOR MAP

DP&L Impoundment

NATIONAL WETLANDS INVENTORY:

Open Water

Palustrine Emergent and Palustrine Emergent/Open Water

Palustrine Scrub Shrub and Palustrine Scrub/Shrub/Emergent

New Castle Conservation District

NORTHERN DELAWARE WETLANDS REHABILITATION PROGRAM

REHABILITATION TRACKING FORM

WETLAND PROJECT: **D.P. & L. IMPOUNDMENT** **UPDATED:** 26 JANUARY 94

PROJECT MANAGER: Rob Hossler, Fish & Wildlife

PROJECT COMPLETION DATE: 31 MAY 1995

REPORT STATUS:
1) Environmental Evaluation - Completed 18 November 1992.
2) Water Management Plan - not initiated, dependent on water control structure design.
3) Operation, Maintenance and Management Plan - not initiated.

PERMIT STATUS:
1) COE 404 Permit - not initiated.
2) State Type II Permit - not initiated.
3) Subaqueous Lands Permit - not required.
4) Environmental Assessment - not initiated.

FUNDING STATUS: 1) Secured -

a. Delmarva Power - $4,926 provided over last 2 years for phragmites control.

b. Delmarva Power Sportsmen's Club - Donated an unknown amount to the Delaware City Fire Department for their assistance with the 1993 controlled burn.

c. Division of Fish and Wildlife - $1,260 provided over last 2 years for phragmites control.

2) Pending -

a. Delmarva Power - Potentially interested in providing additional funding to this project.

b. Delmarva Power Sportsmen's Club - interested in providing additional funding to this project.

c. Star Enterprise - A potential funding source.

LANDOWNERS: Delmarva Power (Delmarva)- owns 57 acres (70%) of the marsh including the water control structure. The property is currently used by the Delmarva Power Sportsmen's Club (Sportsmen's Club) for recreational hunting. Both Delmarva and the Sportsmen's Club have consented to a long-term management agreement and Delmarva has issued an access permit to conduct biological surveys. Delmarva might provide assistance in the installation of the proposed water control structure, and additional phragmites control efforts. The Sportsmen's Club is interested in assisting with the installation of the proposed water control and wildlife enhancement structures; the operation and maintenance of these structures; and additional phragmites control and wildlife plantings.

Delmarva Power has identified a 2.1-acre solid waste landfill within the proposed rehabilitation area. This fly ash and sludge landfill was capped in 1982, and in accordance with state regulations has been maintained with vegetative cover and monitored with wells for 5 years. Well abandonment was conducted in the winter of 1993. Delmarva Power has requested that the landfill not be inundated with water or physically disturbed by construction, i.e., ditch or pond construction. This request should not significantly affect rehabilitation efforts because the landfill cap is approximately 4 feet above existing water levels. The landfill is currently vegetated with a mix of phragmites and old field species; however, phragmites control practices and reseeding of upland plant species can rehabilitate this area into a more desirable habitat type. The proposed rehabilitation plan does not pose a threat to releasing any potential contaminants from this landfill.

Star Enterprises (Star) - owns 24 acres (30%) of the marsh, including the two ponds proposed as water supply reservoirs. The property's trapping rights are currently leased to a local resident. Although Star considers the project worthwhile, they are not interested in consenting to a long-term management agreement or providing any funding for rehabilitation unless they can receive "environmental consideration" to be used against their proposed future dredge disposal sites. However, recent information indicates that Star might reconsider consenting to a long-term management agreement in the near future.

PARTICIPATING PARTNERS: Delmarva Power, Delmarva Power Sportsmen's Club, DNREC, and New Castle Conservation District.

PUBLIC RELATIONS 1) Needs - Inclusion of Star Enterprises as a participating partner in the project.

2) Actions -

a) Environmental Groups - The Sportsmen's Club has assisted in controlled burns and temporary modification of the existing water control structure. The Sportsmen's Club is also enhancing adjacent upland areas by conducting wildlife habitat improvements, i.e., border cuttings, beneficial plantings, and the creation of clearings. The Sportsmen's Group participated in the 2 October 1993 Delaware Coastal Cleanup.

b) Landowners - Consultations with Star are ongoing.

REGIONAL OBJECTIVE: IMPROVE WETLAND HABITATS FOR WILDLIFE

SITE SPECIFIC OBJECTIVE: Improve wetland habitats by increasing habitat diversity, installing wildlife enhancement structures, and

adhering to a water management plan involving periodic water level manipulations. The increase in habitat diversity will be accomplished by increasing the percentage of open water and desirable emergent vegetation habitats to 21-42% (17-34 acres) and 42-63% (34-51 acres), respectively. Adherence to a water management plan should improve habitats for wetland wildlife, especially aquatic mammals, waterfowl and other waterbirds, by adjusting the water level to accommodate their seasonal needs when possible. These management practices should increase the number, species, and reproductive success of wildlife using the marsh.

STATUS PRIOR TO PROJECT: Habitat types of the marsh are comprised of the following approximate percentages: 81% (65 acres) monotypic stands of phragmites, 4% (3.5 acres) open water habitat interspersed with desirable emergent vegetation, 15% (12.5 acres) upland habitats. During avian surveys conducted in 1991-1992, 17 species of waterbirds and raptors were recorded for a combined total of 67 birds and an average of 13.4 birds/survey. The only known waterbirds or raptors nesting in the marsh or the adjacent area were a pair of osprey and a pair of Canada geese.

The existing water control structure, consisting of 5, 30-inch-diameter outlet pipes, is nonfunctional in terms of maintaining, increasing, or manipulating water levels. Additionally, a 1100-foot culvert pipe diverts a significant amount of storm runoff from the marsh and into an adjacent watershed. These two structures essentially limit the amount of water in the marsh, thereby decreasing habitat diversity by promoting dominant monotypic stands of phragmites.

CURRENT STATUS: Biological and initial contour surveys have been completed. Additional elevation surveys are currently being conducted of surrounding upland and agricultural lands to determine the maximum allowable water level. Temporary modifications have been made to the existing water control structure to slightly increase the water level in the marsh. These modifications have included sealing several of the outlet pipes with expandable foam epoxy donated by Delmarva Power. Contour maps and sedimentation control plans for the sand and gravel extraction operation within the marsh's watershed have been obtained. These plans and maps indicate that the extraction operation will not significantly impact the water quality or supply for the proposed marsh. Land use mapping of the watershed has been completed.

ACTION STEPS NEEDED: 1) Completion of elevation surveys to determine the maximum and minimum allowable water levels and water supply requirements.

COMPLETION DATE: March 1994.

2) Evaluate the structural integrity of the existing dikes for use as an impoundment through consultation with a registered civil engineer.

COMPLETION DATE: April 1994.

3) Monitor the sedimentation and erosion control practices, and the reestablishment of contours conducted by the extraction operation. Promote best management practices where current techniques are inadequate.

COMPLETION DATE: April 1994.

4) Obstruct the culvert that is diverting storm runoff from the marsh.

COMPLETION DATE: May 1994.

5) Remove existing nonfunctional water control structure by removing all above ground structures, and then sealing the remaining pipes with expandable foam epoxy.

COMPLETION DATE: October 1994

6) Install a 48-inch stop-log structure connected to a 2-foot-diameter, aluminum outflow pipe that traverses through the dike. Install a riprap spillway at the outflow (river side). Set riser boards from the minimum to the maximum allowable water levels. Riser boards will be initially set at the maximum allowable level in order to assist in the control of phragmites and to determine an approximate 100% pool level, based on "average" hydrologic inputs and outputs. Periodic manipulations of the water level to improve regional objectives will be made as needed after estimates of the approximate 100% pool level are determined. Delmarva might provide assistance in the installation of the structure.

COMPLETION DATE: October 1994

7) Install two water control structures and an emergency spillway in the dikes of the two adjacent ponds creating a stair-step reservoir system between the ponds and the marsh. This stair-step system would allow greater flexibility in manipulating water levels in both the marsh and the ponds, and would allow beneficial draw downs of the ponds, thus promoting submerged and emergent aquatic vegetation growth. The water control structures would be 48-inch, stop-log structures connected to a 2-foot-diameter aluminum outflow pipe. A 20-foot-wide grassed emergency spillway would be constructed in the dike between the two ponds.

COMPLETION DATE: April 1995

8) Install wood duck and passerine nesting boxes, and goose and osprey nesting platforms. The number and location of these enhancement structures will be determined based on the approximate 100% pool level. Support in installation of wildlife enhancement structures is anticipated from the employee sportsmen club.

COMPLETION DATE: March 1995

SITE SPECIFIC OBJECTIVE EVALUATION: The success of the proposed habitat improvements will be based on comparable surveys of waterbirds utilizing the marsh, and of permanent vegetation transects established in the marsh during the summer of 1994. Success of wildlife

enhancement structures will be based on the reproductive success of wildlife utilizing them.

REGIONAL OBJECTIVE: UNDESIRABLE PLANT SPECIES CONTROL

SITE SPECIFIC OBJECTIVE: Reduce the area covered by monotypic stands of phragmites and increase emergent vegetation diversity. The percent cover of phragmites will be reduced to less than 5% (4 acres). Phragmites cover will be confined to upland areas and the upland/wetland fringe.

STATUS PRIOR TO PROJECT: The marsh is a large monoculture of phragmites, characteristic of sites that were disturbed by the disposal of dredge spoil. Approximately 81% (65 acres) of the marsh is covered by this single species.

CURRENT STATUS: An initial application of herbicide was applied on 52 acres (80%) of phragmites on 30 September 1992. This application was followed by a controlled burn in March 1993. A second application of herbicide was applied on 13 acres of untreated phragmites, and 50 acres of regenerating phragmites on 30 September 1993. Funding was provided by Delmarva Power ($4,926) and the Division of Fish and Wildlife ($1,260).

ACTION STEPS NEEDED: 1) Apply herbicide (glyphosate) periodically on monotypic stands of phragmites.

COMPLETION DATE: Annually as needed in early Fall.

2) Controlled burning of phragmites (where feasible) or other removal method of the standing dead canes will be conducted following application of herbicide. Controlled burning suppresses phragmites through several methods including: exposing regenerating canes to the second year treatment of herbicide, reducing gas exchange to surviving root stalks, stimulating the release of nutrients for other competing plant species, exposing the soil to sunlight, and stimulating germination of desirable species in the existing seed bank.

COMPLETION DATE: In late winter, following the application of herbicide.

SITE SPECIFIC OBJECTIVE EVALUATION: Success determined by the reduction of monotypic stands of phragmites.

REGIONAL OBJECTIVE: INCREASE SHALLOW WATER HABITAT DIVERSITY

SITE SPECIFIC OBJECTIVE: Increase the percentage and diversity of open water and desirable emergent vegetation habitats. The percent cover of open water and desirable emergent vegetation habitats will range from 21-42% (17-34 acres) and 42-63% (34-51 acres), respectively. Shallow water habitats will include numerous shallow ponds, ditches, and flats.

STATUS PRIOR TO PROJECT: Only 4% (3.5 acres) of the marsh consistently retains open water habitat interspersed with desirable emergent vegetation. This shallow water habitat is comprised of 3 small ponds. Approximately 81% (65 acres) of the marsh is covered by a monoculture of phragmites.

CURRENT STATUS: Except for contour and environmental surveys, no habitat diversity-related work has been conducted in the marsh.

ACTION STEPS NEEDED: **1)** Evaluate the necessity of testing sediments for potential contaminants prior to excavating ditches and ponds.
COMPLETION DATE: July 1994.

2) Design a system of interconnecting ditches and ponds with interspersed island habitats. Ponds will have tapered sides and most ponds and all ditches will be shallow ≤18 inches in depth. Several ponds will have sections excavated >18 inches in depth to provide habitat for fish during droughts and draw-downs. Islands for waterfowl nesting will be created by accumulation of construction spoil. The proposal to increase the shallow water habitat diversity will be submitted either under the Division's existing Open Marsh Water Management permit or through a separate permit.
COMPLETION DATE: November 1994.

3) If necessary, sample the proposed excavation sites for the presence of contaminants.
COMPLETION DATE: Might not be required.

4) Excavate ditches and ponds, and construct island habitat using Division of Fish and Wildlife personnel and equipment.
COMPLETION DATE: March 1995, depending on sediment sampling requirement.

SITE SPECIFIC OBJECTIVE EVALUATION: Success based on the diversity of shallow habitats and the percentage of open water habitat.

REGIONAL OBJECTIVE: MOSQUITO CONTROL

SITE SPECIFIC OBJECTIVE: Reduce pestiferous mosquito populations by establishing predacious fish populations. Mosquito populations are anticipated to be reduced to <1 larvae/dipping unit, based on periodic inspections for breeding activity.

STATUS PRIOR TO PROJECT: Rain events cause the flooding of previously exposed oviposition sites and promote mosquito breeding. However, the marsh currently has a limited amount of area inundated with sufficient depths or durations of water to support predacious fish. During the previous 4 years, pestiferous mosquito breeding averaged 3.4 larvae/dipping unit and was sufficient to warrant an average of 1.25 aerial applications of insecticide per year, totaling 47 lbs of pesticide product.

CURRENT STATUS: Except for the collection of environmental data and conducting routine mosquito control pratices, no work has been conducted in this marsh.

ACTION STEPS NEEDED: 1) Stocking of ponds and ditches with predacious mosquito fish (*Gambusia holbrooki*) at a rate of 500 fish/acre. Fish will be obtained from Division of Fish and Wildlife ponds and previously stocked areas.

COMPLETION DATE: May 1995

SITE SPECIFIC OBJECTIVE EVALUATION: Success of biological mosquito control programs will be based on comparable indices of mosquito breeding.

SECONDARY OBJECTIVES: 1) Improve water quality by wetland filtering, especially non-point source pollution from adjacent agricultural fields, and gravel extraction areas.

2) Protect and enhance existing populations and critical habitats of threatened and endangered species and other species of concern. Emphasis will be placed on enhancing the site for foraging use by the Pea Patch Island wader colony.

APPENDIX E

ARTESIAN MARSH REHABILITATION PLAN

Northern Delaware Wetlands
Rehabilitation Program

ARTESIAN MARSH

An 134-acre tidal freshwater marsh located south of Churchman's Marsh, along Interstate 95 in Stanton. The marsh is bordered by the interstate to the north, by the Christina River on the south and east, and by an office complex to the west. In the southwest corner of the marsh, the Division of Fish and Wildlife maintains the Churchman's Boat Ramp facility. The marsh is currently owned by the Artesian Water Company and is leased for cattle grazing.

This formerly productive marsh was contiguous with Churchman's Marsh, and was considered an important area for migrating waterfowl. However in the 1960's, Artesian marsh was diked and used as a dredge disposal site during the construction of I-95. This accumulation of dredge spoil raised the elevation of the marsh by approximately 3.5 feet, above the average high tide of the Christina River. Characteristic of sites that were diked and filled with dredge spoil, the marsh became a large monoculture of phragmites. This percentage of phragmites was reduced by the grazing of cattle and the restoration of limited tidal exchange through several breaches in the dike. Currently the marsh is comprised of: 39% monotypic stands of phragmites, 32% cattle grazed rushes, 17% forested willows, 5% cattail stands, 4% upland areas, and 3% other wetland emergent plants.

The marsh still retains its floodplain values by accepting floodwater during storm surges and unusually high tides. However, this periodic flooding promotes pestiferous mosquito breeding by inundating previously exposed oviposition sites. This mosquito breeding problem is compounded by the grazing of cattle in the area.

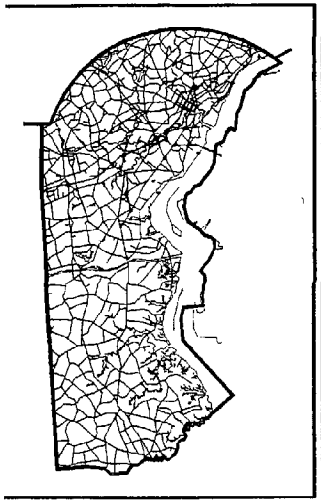
The cattle create small depressions (hoof prints) throughout the marsh, which retain a high nutrient content (manure) and act as breeding pockets for mosquitos. In 1992, pestiferous mosquito breeding in this marsh was sufficient to warrant 7 aerial applications of insecticide, totaling 3,875 lbs of pesticide product. Another potential problem with this marsh is its proximity to several Superfund or other state-listed hazardous wastes sites.

The juxtaposition of this marsh to I-95, the boat ramp facility, and among several residential neighborhoods presents a ideal situation to increase the recreational and educational benefits of a wetland. Additionally, the tremendous wildlife value that the adjacent Churchman's marsh currently and historically has had, indicates the wildlife potential for a rehabilitated Artesian Marsh

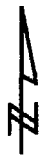
Artesian Marsh

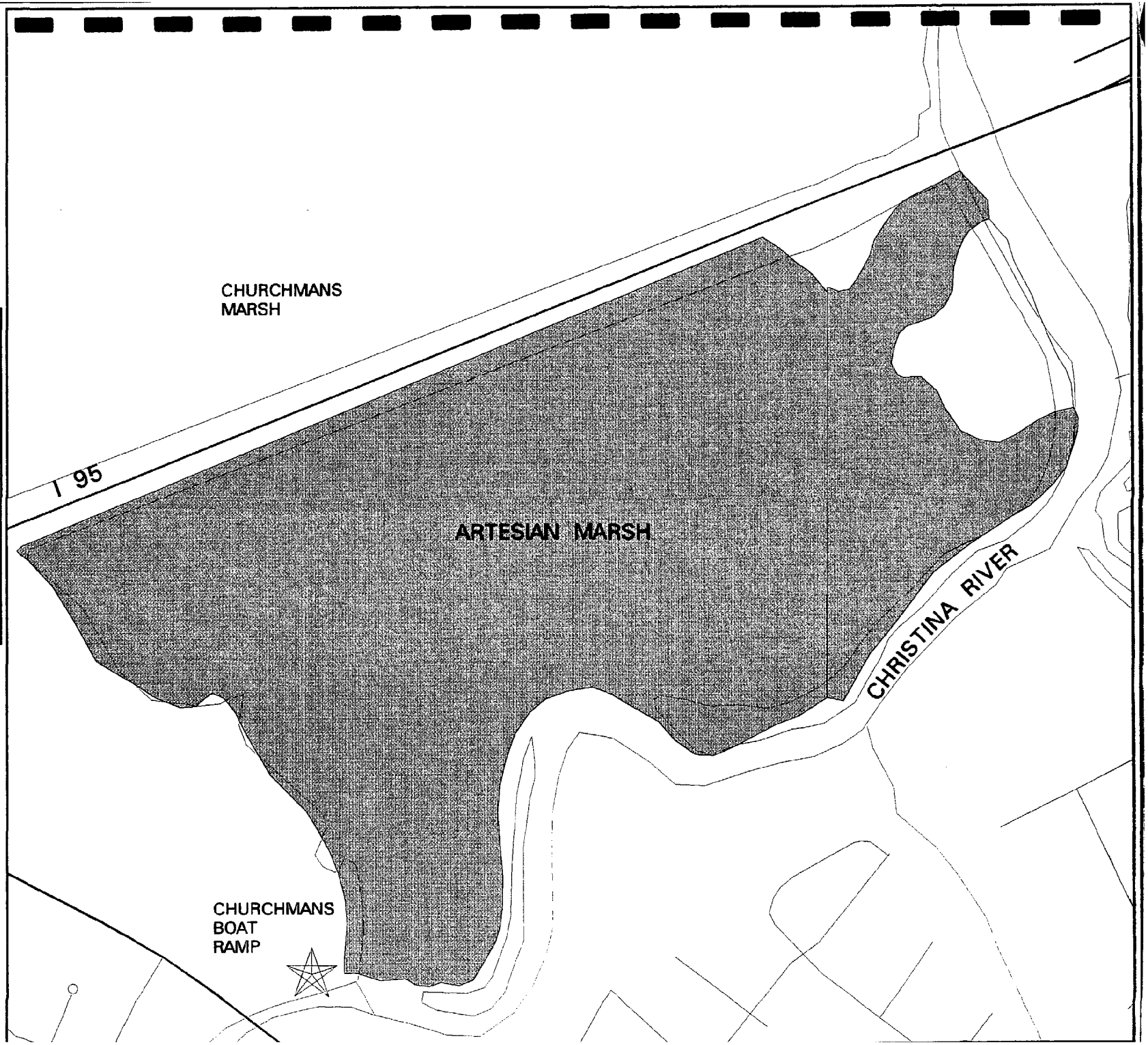
New Castle County, Delaware

LOCATOR MAP



Estuarine Emergent and
Estuarine Emergent/Beach/Mudflat





New Castle Conservation District

NORTHERN DELAWARE WETLANDS REHABILITATION PROGRAM

REHABILITATION TRACKING FORM

WETLAND PROJECT: **ARTESIAN MARSH** **UPDATED:** 26 JANUARY 94

PROJECT MANAGER: Rob Hossler, Fish & Wildlife

PROJECT COMPLETION DATE: March 1998

REPORT STATUS:
1) Environmental Description - Completed September 1993.
2) Water Management Plan - not initiated.
3) Operation, Maintenance, and Management Plan - not initiated.

PERMIT STATUS:
1) COE 404 Permit - not initiated.
2) State Type II Permit - not initiated.
3) Subaqueous Lands Permit - not required.
4) Environmental Assessment - not initiated.

FUNDING STATUS: 1) Secured - Ciba-Geigy - contributed $310,000 towards tidal wetlands rehabilitation in Christina River basin, a portion of which will be used on Artesian Marsh.

2) Pending -

a. Artesian Water Company - Interested in providing funding to this project.

b. Delaware Department of Transportation (DelDOT) - Potentially interested in funding this project as mitigation for the proposed expansion of Interstate 95.

c. U.S. Fish and Wildlife Service - Interested in funding this project through their Partners for Wildlife Program.

d. DuPont Company - Potential funding source through mitigation of natural resource damages associated with the DuPont Newport Superfund Site.

LANDOWNERS: Artesian Water Company (Artesian) - owns the marsh and is interested in assisting in its rehabilitation and long-term management, but desires mitigation credit for possible use on the proposed Churchman's Reservoir Project or other appropriate projects. The property is currently leased for cattle grazing; however, Artesian has indicated that this practice might not be continued in 1994. The Division of Fish and Wildlife maintains the Churchman's Boat Ramp, located adjacent to this marsh on the Christina River.

PARTICIPATING PARTNERS: Artesian Water Company, DNREC, New Castle Conservation District, and New Castle County.

PUBLIC RELATIONS: 1) Needs -

a) Landowners - Development of a mitigation policy that provides for the establishment of future wetland mitigation credit (mitigation banking).

b) Environmental Groups - Involvement of nearby communities in certain aspects of the rehabilitation project.

2) Actions -

a) Landowners - A departmental policy is being developed that allows for the establishment of future wetland mitigation credit (mitigation banking). Artesian Marsh is being proposed as the experimental prototype for this policy.

b) Environmental Groups - The Churchman's Boat Ramp has been a staging area for the annual Christina River Cleanup, co-sponsored by Artesian Water Company.

REGIONAL OBJECTIVE: IMPROVE WETLAND HABITATS FOR WILDLIFE

SITE SPECIFIC OBJECTIVE: Improve wetland habitats by increasing habitat diversity, installing wildlife enhancement structures, and adhering to a water management plan involving daily tidal exchange and periodic water level manipulations. The increase in habitat diversity will be accomplished by increasing the percentage of open water and desirable emergent vegetation habitats to 19-37% (25-50 acres) and 37-55% (25-74 acres), respectively. Adherence to a water management plan should improve habitats for wetland wildlife, especially aquatic mammals, waterfowl and other waterbirds, by adjusting the water level to accommodate their seasonal needs when possible. These management practices should increase the number, species, and reproductive success of wildlife using the marsh.

STATUS PRIOR TO PROJECT: Habitat types of the marsh are comprised of the following approximate percentages: 39% (52 acres) monotypic stands of phragmites, 32% (43 acres) of rushes, 17% (23 acres) of willow, 5% (7 acres) cattails, 4% (5 acres) upland , and 3% (4 acres) of other emergent plants. During avian surveys conducted in 1993, 2 species of waterbirds were recorded for a combined total of 4 birds and an average of 2.0 birds/survey. Aerial waterfowl surveys of the adjacent Churchman's Marsh have recorded 81.7 birds/survey indicating the rehabilitation potential for Artesian Marsh.

The area was a former freshwater tidal marsh which was diked and used as a dredge disposal site during the construction of I-95 in the 1960's. Tidal exchange occurs in this marsh through 10 breaches in the dike along the Christina River, but this exchange is limited as the accumulation of spoil has raised the marsh elevation approximately 0.1 feet (4.4 feet NGVD) above average high tide (4.3 feet NGVD). Approximately 7% (9 acres) of the marsh is exposed to daily tidal flushing. Although the marsh is above average high tide, it still

retains its floodplain values by accepting floodwater during storm surges and unusually high tides.

Hazardous Wastes and Toxins - This marsh and the spoil deposited in it during the 1960's might have been impacted by the E.I. DuPont Newport Superfund Site, located approximately 1.3 miles downstream, or several other potential contaminant sources in the watershed. Because of this concern, 2 sediment samples of the marsh was collected in June 1993 and analyzed for potential contaminants. This preliminary sampling identified levels of zinc in the sediment 2.0 to 4.6 times higher than concentrations at which adverse biological effects are frequently or always observed among most species (Long and Morgan 1991). However, in order to obtain conclusive results, additional sampling is required.

Non-point Source Pollution - Non-point source pollution entering the marsh is limited to storm runoff from an office complex. Road runoff from the adjacent interstate is diverted away from the marsh via a borrow ditch.

CURRENT STATUS: Ecological evaluations, including extensive contour and vegetation surveys have been conducted. A water level recording device has been established at the adjacent Churchman's Boat Ramp to chart hydrological data. Sediment sampling has revealed questionable zinc levels, requiring additional sampling prior to entertaining any sediment disturbing activities.

ACTION STEPS NEEDED: 1) Additional contaminant sampling is required, including water samples and acid volatile sulfide sediment testing to determine dissolved zinc concentrations and zinc bioavailability, respectively.

COMPLETION DATE: August 1994.

2) Conduct modeling (HEC II) to determine the impact of moving spoil and impounding the marsh on the floodplain. Assistance might be obtained from the New Castle County Planning Department.

COMPLETION DATE: September 1994.

3) Conduct modeling and engineering designs to predict the hydrology and hydraulics of the proposed impoundment and water control structures, respectively.

COMPLETION DATE: August 1995.

4) Plug the 10 breaches in the dike, two with 48-inch-diameter Delaware rice trunk water control structures, and two with sheet metal weirs and 20-foot-wide riprap emergency spillways. These weirs and spillways will be designed to accept and release storm surges and unusually high tides.

COMPLETION DATE: June 1996.

5) Scrape approximately 93,702 yds^3 of sediment from 88 acres of the marsh, to an average elevation of 3.8 feet NGVD (0.5 feet below average high tide). The Delaware Department of Transportation (DelDOT) might be interested in assisting with this excavating.

COMPLETION DATE: October 1996.

6) Install wood duck, goose, mallard, osprey, squirrel, bat, and passerine nesting structures. The number and location of these enhancement structures will be determined based on the availability of suitable microhabitats. Support in installation of wildlife enhancement structures might be available from local school groups and the private sector.

COMPLETION DATE: March 1997

7) Conduct plantings of beneficial species for wildlife during periodic draw-downs. The quantity planted will depend on the amount of suitable habitat available. Support in installation of wildlife enhancement structures might be available from local school groups and the private sector.

COMPLETION DATE: October 1997

SITE SPECIFIC OBJECTIVE EVALUATION: The success of the proposed habitat improvements will be based on comparable surveys of waterbirds utilizing the marsh, and of permanent vegetation transects established in the marsh. Success of wildlife enhancement structures will be based on the reproductive success of wildlife utilizing them.

REGIONAL OBJECTIVE: UNDESIRABLE PLANT SPECIES CONTROL

SITE SPECIFIC OBJECTIVE: Reduce the area covered by monotypic stands of phragmites and increase emergent vegetation diversity. The percent cover of phragmites will be reduced to less than 5% (6 acres). Phragmites cover will be confined to upland areas and the upland/wetland fringe.

STATUS PRIOR TO PROJECT: The marsh contains a large monoculture of phragmites, characteristic of sites that were disturbed by the disposal of dredge spoil. Approximately 39% (52 acres) of the marsh is covered by this single species. Cattle grazing during 7 months of each year has prevented this species from dominating a larger portion of the marsh.

CURRENT STATUS: No phragmites control efforts have occurred at this site.

ACTION STEPS NEEDED: 1) Apply herbicide (glyphosate) periodically on

monotypic stands of phragmites.

COMPLETION DATE: Annually as needed in early Fall with the first anticipated application occurring September 1997.

2) Controlled burning of phragmites (where feasible) or other removal method of the standing dead canes will be conducted following application of herbicide. Controlled burning suppresses phragmites through several methods including: exposing regenerating canes to the second year treatment of herbicide, reducing gas exchange to surviving root stalks, stimulating the release of nutrients for other competing plant species, exposing the soil to sunlight, and stimulating germination of desirable species in the existing seed bank.

COMPLETION DATE: In late winter, following the application of herbicide.

SITE SPECIFIC OBJECTIVE EVALUATION: Success determined by the reduction of monotypic stands of phragmites.

REGIONAL OBJECTIVE: INCREASE SHALLOW WATER HABITAT DIVERSITY

SITE SPECIFIC OBJECTIVE: Increase the percentage and diversity of open water and desirable emergent vegetation habitats. The percent cover of open water and desirable emergent vegetation habitats will range from 19-37% (25-50 acres) and 37-55% (25-74 acres), respectively. Shallow water habitats will include numerous shallow ponds, ditches, and flats.

STATUS PRIOR TO PROJECT: No portion of the marsh consistently maintains open water habitat and only 7% (9 acres) is dominated by desirable emergent vegetation. Approximately 39% (52 acres) of the marsh is covered by a monoculture of phragmites.

CURRENT STATUS: Except for extensive contour and environmental surveys, no habitat diversity-related work has been conducted in the marsh.

ACTION STEPS NEEDED: **1)** Design a system of interconnecting ditches and ponds with interspersed island habitats. Ponds will have tapered sides and most ponds and all ditches will be shallow, $\leq$18 inches in depth. Several ponds will have sections excavated >18 inches in depth to provide habitat for fish during droughts and draw-downs. Islands for waterfowl nesting will be created by accumulation of construction spoil. The proposal to increase the shallow water habitat diversity will be submitted either under the Division's existing Open Marsh

Water Management permit or through a separate permit.
COMPLETION DATE: November 1996.

2) Excavate ditches and ponds, and construct island habitat using Division of Fish and Wildlife personnel and equipment.
COMPLETION DATE: March 1997.

SITE SPECIFIC OBJECTIVE EVALUATION: Success based on the diversity of shallow habitats and the percentage of open water habitat.

REGIONAL OBJECTIVE: IMPROVE RECREATION AND AESTHETIC VALUES

SITE SPECIFIC OBJECTIVE: Improve recreational opportunities and the aesthetic value of the marsh by constructing a greenway trail from the Division of Fish and Wildlife boat ramp, along the dike and then looping back along a raised walkway paralleling I-95. Additionally, along this trail a blind will be constructed to be used for photography and as a dog retrieving training area.

STATUS PRIOR TO PROJECT: Recreational use of Artesian Marsh are limited to a few fisherman who fish the Christina River from the dike and from boats launched from the adjacent ramp, and a local trapper who pursues muskrats in the marsh's tidal guts.

CURRENT STATUS: No recreation-related work has been conducted for this project.

ACTION STEPS NEEDED: **1)** Construct a circular greenway around the perimeter of the marsh. This construction would include clearing and grading a trail from the Division of Fish and Wildlife boat ramp along the existing dike. The spoil scraped off the marsh to form the impoundment would be used to create a 10-foot-high, 62-foot-wide, elevated walkway paralleling I-95 and connecting to the existing dike. A trail would also need to be cleared and graded along the upland area on the west side of the marsh to connect the Division of Fish and Wildlife boat ramp with the raised walkway.
COMPLETION DATE: May 1997.

2) Construct a blind along the trail to be used for photography and as a dog retrieving training area.
COMPLETION DATE: July 1997.

3) Determine the overall opinion of visitors utilizing the recreation facilities, in regards to the aesthetic and recreational values of the marsh both prior to and after the implementation of the rehabilitation plan.

COMPLETION DATE: September 1997.

4) In order to accommodate the anticipated increase in visitor use, establish portable toilet facilities and enlarge the parking facilities at the Division of Fish and Wildlife Churchman's Boat Ramp.

COMPLETION DATE: March 1998.

SITE SPECIFIC OBJECTIVE EVALUATION: Improvements in the recreational opportunities and aesthetic value of the marsh will be determined through surveys of the use of recreational facilities, and visitor responses to questionnaires regarding the marsh's aesthetic and recreational value.

REGIONAL OBJECTIVE: INCREASE ENVIRONMENTAL EDUCATION OPPORTUNITIES

SITE SPECIFIC OBJECTIVE: Improve environmental education opportunities for both general public and school groups by constructing an environmental interpretative trail along the marsh's proposed greenway.

STATUS PRIOR TO PROJECT: There is no known organized or formal environmental education being conducted at the marsh; even though, there are seven schools located within 2 miles of the marsh.

CURRENT STATUS: No education-related work has been conducted for this project.

ACTION STEPS NEEDED: **1)** Develop final designs and construct the interpretive signs.

COMPLETION DATE: July 1997

2) Promote the use of the marsh and its interpretive trail through organized events, press releases, and by direct contact with school districts.

COMPLETION DATE: August 1997

SITE SPECIFIC OBJECTIVE EVALUATION: Improvements in environmental education would be determined by surveys of public and school groups utilizing the facilities.

REGIONAL OBJECTIVE: REDUCE MOSQUITO BREEDING

SITE SPECIFIC OBJECTIVE: Reduce pestiferous mosquito populations by reducing potential breeding sites, and by establishing predacious fish populations. Mosquito populations are anticipated to be reduced to <1 larvae/dipping unit, based on periodic inspections for breeding activity.

STATUS PRIOR TO PROJECT: Rain events and unusually high tides cause the flooding of previously exposed oviposition sites, and promote mosquito breeding. However, the marsh currently has a limited amount of area inundated to sufficient depths or durations to support predacious fish. This mosquito breeding problem is compounded by the grazing of cattle in the area. The cattle create small depressions (hoof prints) throughout the marsh, which retain a high nutrient content (manure) and act as breeding pockets for mosquitos. In 1992, pestiferous mosquito breeding averaged 1.74 larvae/dipping unit and was sufficient to warrant 7 aerial applications of insecticide, totaling 3,875 lbs of pesticide product.

CURRENT STATUS: Except for collecting of environmental data and conducting routine mosquito control practices, no work has been conducted in this marsh.

ACTION STEPS NEEDED: 1) Discontinue the grazing of cattle in the marsh.

COMPLETION DATE: April 1994.

2) Stock ponds and ditches with predacious mosquito fish (*Gambusia holbrooki*) at a rate of 500 fish/acre. Fish will be obtained from Division of Fish and Wildlife ponds and previously stocked areas.

COMPLETION DATE: May 1997.

SITE SPECIFIC OBJECTIVE EVALUATION: Success of biological mosquito control programs will be based on comparable indices of mosquito breeding.

SECONDARY OBJECTIVES: 1) Restore and improve spawning, nursery, and feeding sites for anadromous, estuarine, and riverine fishes.

2) Protect and enhance existing populations and critical habitats of threatened and endangered species and other species of concern.

3) Improve water quality of both the marsh and the river through increased wetland filtering and nutrient uptake.

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AUGUSTINE CREEK MARSH
BIOTIC INVENTORY AND NATURAL COMMUNITY EVALUATION

Delaware Natural Heritage Inventory
Division of Parks and Recreation
Department of Natural Resources and Environmental Control
Dover, Delaware

February 1994

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INTRODUCTION

A biological inventory of Augustine Creek Marsh, New Castle County, Delaware was conducted in 1993 by the Delaware Natural Heritage Inventory. This survey was requested and funded by the Division of Fish and Wildlife, Department of Natural Resources and Environmental Control, to assess the biological components of the marsh so that data collected can be considered in future management plans.

Augustine Creek Marsh is used extensively for public and private recreation, especially hunting and fishing. A portion of the area is owned and managed by Delaware Wildlands that includes some of the more diverse sections of the Augustine Creek Marsh, as well as an active great blue heron colony.

The Augustine Creek Marsh is located south of the town of Port Penn and is bounded on the north by the St. George's-Port Penn Road, and on the east by the Delaware River. The southern boundary is Route 423 (McDonough Road) and the western boundary is Route 420 (Port Penn-Boyd's Corner Road).

Objectives:

(1) To determine and map the gross biotic composition of the marsh based on dominant vegetation present.

(2) To undertake an inventory for rare plant species (species of special concern).

(3) To undertake a cursory inventory of the marsh for rare animals.

METHODS

During the months of August, September and October 1993, several random field surveys were made of the Augustine Creek Marsh. It was expected that much of the survey work would be done by boat, however water levels in August were generally too low for this survey method to be practical. At this time, several surveys were conducted on foot, and access to the marsh was from the adjacent uplands. In October, water levels were higher and surveys were accomplished almost entirely by boat.

Individual survey sites are assigned a letter, from A to F (see Appendix III, page 13). Natural communities were characterized at observation points within individual survey sites (each observation point is assigned a number, see Appendix III, page 13). At each observation point, data were taken on plant species composition and relative abundance. Dominant species were also noted. Plants that could not be identified in the field to the species level, were collected and identified in the lab. Uncertain species identification are indicated on the data sheets (and on the species list) by an sp. after the genus name.

After data were compiled, the dominant vegetation types were determined and mapped (see Appendix III, page 13), using survey data and through a review of 1988 color infrared aerial photography. In addition, location maps for plant species of special concern are included (see Appendix III, page 13). Surveys for rare species were incomplete, as staff time was limited. Future inventory work may reveal the presence of additional rare species.

RESULTS

The vegetation in the eastern section of the marsh is dominated by dense, monospecific stands of *Phragmites australis*. From the start of the survey in August, until approximately early October, water levels were relatively low, water temperatures were high, and algal blooms were common. In some portions of the eastern section there is a narrow fringe of emergent vegetation, which includes: *Peltandra virginica, Pontederia cordata, Echinochloa walteri*, and other common brackish-to-fresh water emergent species.

As one moves west (upstream), emergent plant species become more abundant. Dominant emergent vegetation includes: *Echinochloa walteri, Polygonum lapathifolium, Peltandra virginica,* and *Hibiscus moscheutos. Nuphar lutea* and *Ludwigia palustris* are also found in abundance within this area.

Overall species diversity appears to be low in the Augustine Creek Marsh (see Appendix I, page 10 for a list of plant species associated with the Augustine Creek Marsh). Sixty eight species of vascular plants were identified, which is rather low for a fresh to brackish, emergent wetland. Eight alien species of plants were also identified, indicating an environment that is somewhat stressed.

The establishment of the invasive plant species *Phragmites australis* is a serious problem throughout the marsh. The alien *Lythrum salicaria* (purple loosestrife) is also quiet abundant. Phragmites and purple loosestrife are displacing many of the emergent plant species of the wetland, and control methods should be undertaken to help restore biodiversity to the marsh.

Only two State rare plant species were found during this survey (see Appendix III, page 13): *Polygonum densiflorum* (dense flower knotweed **S1**, extremely rare, 5 or fewer occurrences in the state) and *Spartina pectinata* (slough cordgrass **S1**). A more intensive search of the marsh, particularly along the upper reaches of the tributaries, over an entire growing season, may prove to be more productive.

Overall habitat quality of the Augustine Creek Marsh was subjectively assessed as ranging from poor to good.

Augustine Creek Marsh was found to be heavily used by wading birds, shore birds, raptors, waterfowl, etc. over the entire season (see Appendix II, page 12 for bird species observed at Augustine Creek Marsh).

SURVEY SITE DESCRIPTIONS

The following information contains brief descriptions and locations of survey sites (A through F, see Appendix III, page 13). Natural communities are described, and community scientific and common names are given.

AREA A

This rather small survey site is along the shoreline of the Delaware River. To reach this site, proceed south on Route 9 from the village of Port Penn. Just past Augustine Beach, where Route 9 curves to the right, there is a pull-off between the road and the river. The Observation Point is at the shore where the path from the parking area ends. This site appears to be a popular fishing spot.

The shoreline consists of a sandy substrate with some rip-rap material throughout.

Observation 1: *Spartina alterniflora* shoreline (cord grass shoreline). This point is a narrow fringe of vegetation ranging from several emergent species at the rivers edge, to shrubs and trees at the road. The dominant woody species is *Baccharis halimifolia*, while the dominant herbaceous species are *Spartina alterniflora* and *Phragmites australis*. This community is subjected to tidal fluctuations and erosion along the exposed shoreline. Negative impacts from recreational use includes trash disposal and trampling.

Species of Special Concern:

Spartina pectinata **(S1)** - A clump of plants, approximately 5 meters by 3 meters, with ca 50 culms. To date, this is the only known site for this species in the state of Delaware.

AREA B

This area includes the shoreline of the eastern end of the Augustine Creek, west of Route 9. This area was surveyed by canoe, but since water levels were very low, only a portion could be explored from the water. The shoreline generally consists of a narrow fringe of emergent plants, which includes: *Peltandra virginica, Leersia oryzoides, Echinochloa walteri,* and *Polygonum* species. Just above the emergent zone the communities vary, with the dominant plants being either *Phragmites australis* or *Hibiscus moscheutos*. Woody vegetation varies in dominance, between *Diospyros virginiana, Viburnum dentatum., Cornus sp.*, and *Rhus copallina.*

Observation 1: *Phragmites australis* brackish shoreline. At this point there is a narrow fringe of emergent vegetation and a monospecific stand of *Phragmites australis*.

Observation 2: *Hibiscus moscheutos - Echinochloa walteri* brackish marsh (marsh mallow-Walter's millet brackish marsh). This community is along a smaller stream leading into the main Augustine Creek. Within this larger community is a small pond/cove dominated by *Typha*

latifolia and *Scirpus tabernaemontanii*. *Phragmites australis* was less common here, and there generally appears to be greater species diversity.

Species of Special Concern:

Polygonum densiflorum **(S1)** - This species is relatively frequent along the shoreline of Augustine Creek, growing in shallow water mixed with other *Polygonum* species.

AREA C

This area is on Delaware Wildlands property; to reach this site, proceed south on Route 9 from Port Penn, when Route 9 turns sharply south, continue on Route 423 (McDonough Road). Turn onto the first road on the right. Although this area contains dense stands of *Phragmites australis*, it does not dominate, as it does in the eastern sections of the marsh. The vegetation is relatively diverse and the area seems to support many bird species.

Observation 1: ***Hibiscus moscheutos - Leersia oryzoides - Peltandra virginica*** **fresh to brackish marsh (marsh mallow - rice cutgrass - arrow arum marsh).** A heterogeneous marsh with a variety of species assemblages. A zone of woody vegetation between the marsh and the agricultural fields is dominated by *Viburnum dentatum* and also includes *Rhus copallina* and *Diospyros virginiana*.

Observation 2: ***Hibiscus moscheutos - Echinochloa walteri*** **fresh to brackish marsh (marsh mallow - Walter's millet marsh).** This emergent wetland has a berm across its outlet. It appears to be impounded, but low water levels and thick vegetation make that determination difficult. The wetland outside the "impoundment" is a scrub-shrub wetland. Observation point 2 includes only the emergent wetland. The vegetation is relatively diverse; *Phragmites australis* dominates in a small portion of the area, mainly along the northeast woody edge.

Species of Special Concern: No State species of special concern were found in this area.

AREA D

This area is on Delaware Wildlands property; to reach the site, proceed south on Route 9 from Port Penn; when Route 9 turns sharply south, continue on Route 423 (McDonough Road). Turn onto the first road on the right. Continue on the dirt farm road and turn into the lane just beyond the house trailer on the left. All the observation points in Area D are on this peninsula. An active great blue heron nesting colony is visible across the marsh in Cumples Woods. The marsh is used extensively by herons, as well as by many other waders, ducks, ospreys, and other birds. This is a relatively diverse, high quality marsh.

Observation 1: ***Hibiscus moscheutos - Leersia oryzoides*** **fresh to brackish marsh (marsh mallow - rice cutgrass marsh).** This is a diverse wetland, closely bordering a small creek entering the larger marsh. Common emergents include *Echinochloa walteri, Rumex verticillatus,*

Peltandra virginica, and *Typha latifolia*. *Polygonum densiflorum* is frequent at this observation point. There is woody vegetation throughout the area, with an abundance of trees and shrubs along the wetland-upland interface, species include: *Salix nigra* and *Viburnum dentatum*.

Observation 2: *Typha angustifolia* fresh to brackish marsh (narrowleaf cattail marsh). This is a broad marsh, which gently grades to agricultural fields. Although dominated by *Typha*, the marsh is relatively diverse, with frequent occurrences of *Sambucus canadensis*, *Solidago rugosa*, *Polygonum densiflorum*, and other species.

Observation 3: *Cephalanthus occidentalis* - *Hibiscus moscheutos* fresh to brackish marsh (button bush - marsh mallow marsh). This wetland is dominated by woody vegetation, including *C. occidentalis*, *Rosa palustris*, and *Cornus* sp.

Observation 4: *Bidens sp.* - *Echinochloa walteri* fresh to brackish marsh (tickseed - Walter's millet marsh). This is a broad, relatively diverse marsh. Some sections of the marsh are dominated by *Typha latifolia* and *Phragmites australis*. The *Bidens* species that is dominant in the marsh, was not blooming at the time of the survey and could not be identified. Other common species found were: *Polygonum spp.*, *Scirpus cyperinus*, *Solidago rugosa*, and several grasses.

Species of Special Concern:

Polygonum densiflorum (S1) - Is frequent at observation point 1, common at point 2.

AREA E

The objective of the Area E survey was to cover all the major channels of Augustine Creek by boat for a general study of cover types. This survey was limited by low water depths in the smaller channels and detailed investigations of each observation point could not be done. The survey was conducted beginning at the boat launch where Route 9 crosses Augustine Creek. It progressed going west (upstream), generally following the main channel to the bridge where Route 420 (Port Penn-Boyd's Corner Road) crosses the creek. There is an active beaver dam below the bridge (between observation points 12 and 13). Going back downstream, observations were made in several of the guts, minor channels, and feeder streams up to points where access was limited by low water depths.

Observation 1: *Phragmites australis* brackish shoreline (common reed shoreline). This is the boat launch site at Route 9. There is a sandy landing with *Acer negundo*. The banks of the creek here are dominated by *Phragmites australis*.

Observation 2: *Polygonum pennsylvanicum* brackish shoreline (smartweed shoreline). There is a narrow emergent zone here, which includes *Rumex verticillatus*, *Panicum dichotomiflorum*, and *Peltandra virginica*. The slightly higher woody zone is dominated by *Diospyros virginiana* and *Rhus copallina*.

Observation 3: *Phragmites australis* brackish shoreline (common reed shoreline). Although *Phragmites australis* dominates this area, there were many emergent species along a narrow inundated zone. These include *Peltandra virginica, Ludwigia palustris,* and *Pontederia cordata.*

Observation 4: *Echinochloa walteri - Ludwigia palustris* brackish marsh (Walter's millet - water purslane marsh). This point is a shallow pond/cove off the main creek. *Phragmites australis* is common in this area and *Typha latifolia* is frequent.

Observation 5: *Typha latifolia* brackish marsh (broadleaf cattail marsh). Another shallow cove near Observation Point 4, with somewhat different vegetation. In addition to the dominant *T. latifolia, Scirpus tabernaemontanii* is frequent.

Observation 6: *Phragmites australis* brackish shoreline (common reed shoreline). The shoreline emergent includes: *Leersia oryzoides, Peltandra virginica,* and *Scirpus tabernaemontanii.*

Observation 7: *Polygonum pennsylvanicum - Leersia oryzoides* fresh to brackish shoreline (smartweed - rice cutgrass shoreline). The narrow emergent zone is bordered by a broader zone of woody vegetation, dominated by *Diospyros virginiana* and *Rhus copallina.*

Observation 8: *Hibiscus moscheutos* fresh to brackish marsh (marsh mallow marsh). This point is dominated by *H. moscheutos.* The emergent zone includes *Nuphar lutea, Peltandra virginica,* and *Rumex verticillatus. N. lutea* increases in abundance going upstream, beginning in this area.

Observation 9: *Phragmites australis - Peltandra virginica* brackish shoreline (common reed shoreline). This narrow emergent zone includes *Rumex verticillatus, Hibiscus moscheutos,* and *Ludwigia palustris.*

Observation 10: *Typha latifolia - Polygonum lapathifolium* fresh to brackish marsh/shoreline (broadleaf cattail - nodding smartweed marsh/shoreline). The creek banks here are thickly lined with *P. lapathifolium* and *Ludwigia palustris. T. latifolia* dominates the marsh beyond. *Viburnum dentatum* and *Lythrum salicaria* are scattered throughout this area of the marsh in thick, dense stands.

Observation 11: *Hibiscus moscheutos - Nuphar lutea* fresh to brackish shoreline (marsh mallow - spatterdock shoreline). At this point, there are patches of *Viburnum dentatum* scattered among the *H. moscheutos. N. lutea* is abundant in the channel.

Observation 12: *Nuphar lutea - Ludwigia palustris* fresh to brackish shoreline (spatterdock - water purslane shoreline). *Phragmites australis* and *Lythrum salicaria* are common here and there is a zone of woody vegetation dominated by *Viburnum dentatum* and *Diospyros virginiana.*

Observation 13: ***Nuphar lutea - Ludwigia palustris*** **fresh water shoreline (spatterdock-water purslane shoreline).** This observation point is found just above the beaver dam; *Rosa palustris* dominates the woody zone here.

Observation 14: ***Acer rubrum - Viburnum dentatum*** **wooded wetland/shoreline (red maple-arrowwood wetland/shoreline).** This is a forested flood plain wetland dominated by *Acer rubrum*. There is little herbaceous vegetation, which includes *Onoclea sensibilis* and *Boehmeria cylindrica.*

Observation 15: ***Nuphar lutea - Ludwigia palustris*** **fresh water shoreline (spatterdock-water purslane shoreline).** This observation point is very similar to #13. *Rosa palustris* dominates the woody zone here.

Observation 16: ***Hibiscus moscheutos - Ludwigia palustris*** **fresh water marsh (marsh mallow - water purslane marsh).** This marsh is located near the bridge crossing on Augustine Creek (Pole Bridge Road/Port Penn-Boyd's Corner Road). The vegetation is a mixture of woody and herbaceous species, including *Cephalanthus occidentalis, Salix nigra, Acer rubrum, Leersia oryzoides, Scirpus cyperinus,* and *Peltandra virginica.*

Observation 17: ***Nuphar lutea - Peltandra virginica*** **fresh water gut/shoreline (spatterdock-arrow arum gut/shoreline).** This point is a shallow gut off the main creek, below the beaver dam. Common emergent plants include: *Acorus calamus* and *Rumex verticillatus.* Beyond the emergent zone, *Hibiscus moscheutos* and *Viburnum dentatum* are abundant.

Observation 18: ***Polygonum pennsylvanicum - Peltandra virginica*** **fresh water gut/shoreline (nodding smartweed - arrow arum gut/shoreline).** This gut branches off Augustine Creek further downstream than #17. The water levels are relatively shallow here and plants species found were: *Nuphar lutea, Leersia oryzoides,* and *Rumex verticillatus. Viburnum dentatum* occurs at slightly higher elevations along the stream banks.

Observation 19: ***Hibiscus moscheutos - Peltandra virginica*** **fresh to brackish shoreline (marsh mallow - arrow arum shoreline).** This point is near the mouth of a stream entering Augustine Creek from the southwest. There is some invasion of *Phragmites australis,* but it is not dominant. Other emergent plants include: *Juncus effusus, Polygonum lapathifolium,* and *Typha latifolia.*

Observation 20A: ***Phragmites australis*** **fresh to brackish marsh/shoreline (common reed marsh/shoreline).** Although *P. australis* is the dominant species in this area, there are many emergents on the shoreline, including: *Echinochloa walteri, Leersia oryzoides, Peltandra virginica,* and *Hibiscus moscheutos.*

Observation 20B: *Echinochloa walteri - Ludwigia palustris* **fresh to brackish cove/pond (Walter's millet - water purslane cove/pond).** A shallow pond adjacent to the main creek. Common species include *Scirpus tabernaemontanii, Hibiscus moscheutos, Ludwigia palustris,*

and *Peltandra virginica.*

Observation 21: *Typha latifolia - Hibiscus moscheutos - Rumex verticillatus* fresh to brackish shoreline (broadleaf cattail - marsh mallow - swamp dock shoreline). Common species include: *Echinochloa walteri, Leersia oryzoides, Typha latifolia,* and *Ludwigia palustris. Viburnum dentatum* is abundant in the woody zone.

Observation 22: *Echinochloa walteri - Polygonum arifolium* fresh to brackish marsh/wet meadow (Walter's millet - halberd-leaved tearthumb marsh/wet meadow). This point (north side of Augustine Creek) is accessed by a boardwalk leading into the marsh from the adjacent upland. The area is dominated by *Panicum dichotomiflorum* and *P. virgatum.*

Observation 23: *Echinochloa walteri - Leersia oryzoides* fresh to brackish shoreline (Walter's millet - rice cutgrass shoreline). This point (as well as #24 and #25) is upstream in one of the larger streams flowing from the north into the eastern portion of Augustine Creek. Many emergent plants are found growing along the shoreline, and there is a dense woody zone dominated by *Viburnum dentatum* and *Diospyros virginiana.*

Observation 24: *Viburnum dentatum - Leersia oryzoides* fresh to brackish shoreline (arrowwood - rice cutgrass shoreline). The woody zone is close to the shoreline here, dominated by *V. dentatum, Diospyros virginiana,* and *Rhus copallina. Echinochloa walteri, Ludwigia palustris, Leersia oryzoides* and *Rumex verticillatus* make up the relatively sparse emergent community.

Observation 25: *Viburnum dentatum- Echinochloa walteri* fresh to brackish shoreline (arrowwood - Walter' millet shoreline). Emergent plants are abundant at this observation point, and include *Leersia oryzoides, Ludwigia palustris, and Hibiscus moscheutos.*

Species of Special Concern: No State species of special concern were found in this area.

AREA F

This area includes wetlands associated with a headwater wetland/stream that leads to Augustine Creek Marsh, as well as a marsh reached by a boardwalk. Access to both areas was through the Fortner property bordering the north edge of the creek. The boardwalk is reached by driving through the Fortner property agricultural fields to the edge of the marsh.

Observation 1: *Hibiscus moscheutos - Sagittaria latifolia* fresh to brackish marsh (marsh mallow - arrowhead marsh). This area was observed from the more western of two boardwalks constructed into the marsh from the north side of Augustine Creek Marsh. As the elevation increases, species such as *Polygonum arifolium* and *Echinochloa walterii* become more common, with slightly more elevation, woody species such as *Viburnum dentatum* become dominant.

Observation 2: *Zizania aquatica* fresh water marsh (wild rice marsh). This nearly monotypic stand of *Z. aquatica* is located in the upper portions of a headwater stream that leads to a tributary of Augustine Creek. The swale/depression in which it is located is surrounded by wooded wetlands dominated by *Acer rubrum*. A large stand of *Phragmites australis* is located nearby.

Observation 3: *Hibiscus moscheutos - Typha latifolia - Phragmites australis* fresh to brackish marsh (mixed marsh). This observation point followed the stream toward Augustine Creek. Species found, generally form large, rather monotypic stands throughout the marsh. Species diversity is relatively low here, and the area appears to be disturbed (earth-moving, ditching, etc.).

Species of Special Concern: No State species of special concern were found in this area.

ZOOLOGICAL INVENTORY RESULTS

Although not specified in the scope of this project, a limited zoological inventory was done. Bird species were recorded when seen, but other animals were not specifically searched for. It is difficult to speculate to what extent this system provides feeding or breeding habitat for many of the animal species present. Future zoological inventories should be done to determine the significance of Augustine Creek Marsh to breeding birds, migratory birds, invertebrates (dragonflies, *Lepidopteran* species, etc.) and fish. A bird species list with state ranks can be found in Appendix II.

Pea Patch Island, which lies approximately 8 miles northeast of Augustine Creek Marsh is the largest multi-species heronry on the Atlantic coast north of Florida. Preliminary results from a study undertaken on Pea Patch Island in 1993 (Manomet Bird Observatory), to determine critical foraging areas for these species, indicates that Augustine Creek Marsh is providing important feeding habitat for this colony. Great egrets (*Casmerodius albus*), snowy egrets (*Egretta thula*), little blue heron (*Egretta caerulea*), cattle egret (*Bulbulcus ibis*), glossy ibis (*Plegadis falcinellas*), and great blue herons (*Ardea herodeas*) all use this system regularly.

Ospreys were observed during each visit (one to three per visit). This indicates that Augustine Creek Marsh may provide important foraging habitat for this species. Osprey populations have declined in northern Delaware, so these observations may be significant in terms of habitat management for this species.

APPENDIX I

PLANT SPECIES ASSOCIATED WITH AUGUSTINE CREEK MARSH
1993
(incomplete)

Acer rubrum	*red maple*
Acer negundo	*box elder*
Acorus calamus	*sweetflag*
Amaranthus cannabinus	*water hemp*
Baccharis halimifolia	*groundsel bush*
Bidens sp.	*beggarticks*
Boehmeria cylindrica	*false nettle*
Cephalanthus occidentalis	*buttonbush*
Cyperus erythrorhizos	*red-root nut-sedge*
Cyperus odorata	*fragrant nut-sedge*
Cyperus sp.	*an umbrella sedge*
Diospyros virginiana	*persimmon*
Echinochloa walteri	*Walter's millet*
Eclipta prostrata	*Yerba-de-tajo* **(alien)**
Erechtites hieracifolia	*fire-weed*
Eragrostis sp.	*love grass*
Eupatorium dubium	*joe-pye-weed*
Eupatorium pilosum	*hairy thoroughwort*
Euthamia graminifolia	*slender fragrant goldenrod*
Hibiscus moscheutos	*marsh mallow*
Ilex verticillata	*winterberry*
Impatiens capensis	*jewel weed*
Iris pseudacorus	*yellow iris* **(alien)**
Juncus effusus	*smooth rush*
Leersia oryzoides	*rice-cut grass*
Lemna minor	*duckweed*
Lobelia cardinalis	*cardinal flower*
Lonicera japonica	*Japanese honeysuckle* **(alien)**
Ludwigia palustris	*water purslane*
Lycopus americanus	*water horehound*
Lythrum salicaria	*purple loosestrife* **(alien)**
Microstegium vimineum	*alien grass* **(alien)**
Nuphar lutea	*spatterdock*
Onoclea sensibilis	*sensitive fern*
Panicum dichotomiflorum	*fall panic grass*
Panicum virgatum	*switch grass*

Peltandra virginica	*arrow arum*
Phragmites australis	*common reed*
Pluchea odorata	*marsh fleabane*
Polygonum arifolium	*tearthumb*
Polygonum densiflorum (S1)	*smartweed*
Polygonum hydropiperoides	*mild water pepper*
Polygonum lapathifoium	*pale smartweed (alien)*
Polygonum pennsylvanicum	*Pennsylvania smartweed*
Polygonum punctatum	*water smartweed*
Polygonum sagittatum	*arrowleaf tearthumb*
Polygonum sp.	*smartweed*
Prunus serotina	*black cherry*
Rhus copallina	*winged sumac*
Rosa palustris	*swamp rose*
Rumex verticillatus	*swamp dock*
Sagittaria latifolia	*broad-leaf arrowhead*
Salix nigra	*black willow*
Sambuccus canadensis	*elderberry*
Scirpus cyperinus	*woolgrass sedge*
Scirpus tabernaemontanii	*bullrush (alien)*
Scutellaria lateriflora	*mad-dog skullcap*
Setaria magna	*giant fox-tail*
Solidago rugosa	*rugose goldenrod*
Spirodela polyrhiza	*duckweed*
Typha angustifolia	*narrow-leaf cattail (alien)*
Typha latifolia	*broad-leaf cattail*
Verbena hastata	*wild vervain*
Viburnum dentatum	*southern arrowood*
Zizania aquatica	*wild rice*

APPENDIX II

BIRD SPECIES OBSERVED AT AUGUSTINE CREEK MARSH
1993

Great blue heron (*Ardea herodeas*)	**S2B**
Great egret (*Casmerodius albus*)	**S2B**
Green heron (*Butorides striatus*	S5B
Snowy egret (*Egretta thula*)	**S1B**
Little blue heron (*Egretta caerulea*)	**S2B**
Cattle egret (*Bulbulcus ibis*)	**S2B**
Glossy ibis (*Plegadis falcinellas*)	**S2B**
Canada goose (*Branta canadensis*)	**S3B,** S5N
Wood duck (*Aix sponsa*)	S4B
Green-winged teal (*Anas crecca*)	S4B
American black duck (*Anas rubripes*)	S4B
Mallard (*Anas platyrhynchos*)	S5B
American coot (*Fulica americana*)	**S2B, S3N**
Greater yellowlegs (*Tringa melanoleuca*)	**S3N**
Common tern (*Sterna hirundo*)	**S1B, S3N**
Osprey (*Pandion haleatus*)	S4B
Red-tailed hawk (*Buteo Jamaiccensis*)	S5B
Turkey vulture (*Cathartes aura*)	S5B
Tree swallow (*Tachycineta bicolor*)	S4B
Eastern kingbird (*Tyrannus tyrannus*)	S5B
Gray catbird (*Dumetella carolinensis*)	S5B
Eastern phoebe (*Sayornis phoebe*)	S5B
Common yellowthroat (*Geothlypis trichas*)	S5B
Yellow-breasted chat (*Icteria virens*)	S5B
Northern cardinal (*Cardinalis cardinalis*)	S5
Indigo bunting (*Passerina cyanea*)	S5B
American goldfinch (*Carduelis tristis*)	S5

APPENDIX III

MAPS AND FIGURES

Figure 1: Survey Areas, A through F
Figure 2: Observation Points for Survey Areas A, B, C, D, F
Figure 3: Observation Points for Survey Area E
Figure 4: Species of Special Concern
Figure 5: Vegetative Cover Types

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL
DIVISION OF PARKS AND RECREATION
89 KINGS HIGHWAY, P.O. BOX 1401
DOVER, DELAWARE 19903

OFFICIAL BUSINESS, PENALTY FOR PRIVATE USE $300

40-06-00

STATE RANK

S1 Extremely rare within the state (typically 5 or fewer occurrences) or because some factor immediately threatens the future existence of this species within the state.

S2 Very rare within the state (typically 6 to 20 known occurrences). Species is succeptable to becoming extirpated.

S3 Rare to uncommon; typically 21 to 100 known occurrences. S3 species are not immediately threatened with extirpation, but may be if additional populations are destroyed.

S4 Species apparently secure within the state under present conditions.

S5 Species very common throughout the state; demonstrably secure under present conditions.

SU Species status uncertain within the state. Usually an uncommon species which is believed to be of conservation concern but there is inadequate data to determine degree of rarity.

SH Species historically known from the state but populations or reproductive evidence not verified for an extended period of time (usually 15+ years). There are expectations that this species may be rediscovered.

SX Species presumed to be entirely extirpated from the state. All historical locations and/or potential habitat has been inventoried unsuccessfully. There are no expectations that this species will be rediscovered within the state.

SE Exotic (introduced through human influence) within the state; not a part of the native fauna.

SR Reported from the state, but no evidence exists for accepting or rejecting the report.

SRF Reported falsely from the state but this report persists in the literature.

SA A species which occasionally accidentally enters the state.

SC A species which casually enters the state on a periodic basis but there is no evidence of reproduction or of potential reproductive habitat existing within the state.

For long distance migrant animals, a particular species' breeding status may be very different than its nonbreeding status, i.e. a species which winters commonly in Delaware may be a rare breeder within the state. **B** and **N** qualifiers are used to denote breeding and nonbreeding status respectively. For example, the Northern Harrier (*Circus cyaneus*) is an uncommon winter resident but a very rare breeder and is therefore ranked **S1B, S3N**. A **Z** qualifier is used to denote species which regularly migrate through the state but do not breed or winter in Delaware. For lepidoptera species, however, a **SZB** rank can be given for those individuals which regularly migrate through the state, breed, but no individuals survive to maturity.

DOMINANT VEGETATION TYPES:

RP: *Rosa palustris*

HM: *Hibiscus moscheutos*

S/S: *Scrub-Shrub (Viburnum dentatum, Diospyros virginiana, Rhus copallina)*

PFO/AR: *Palustrine Forested/Acer rubrum*

TL: *Typha latifolia*

ME: *Mixed emergents*

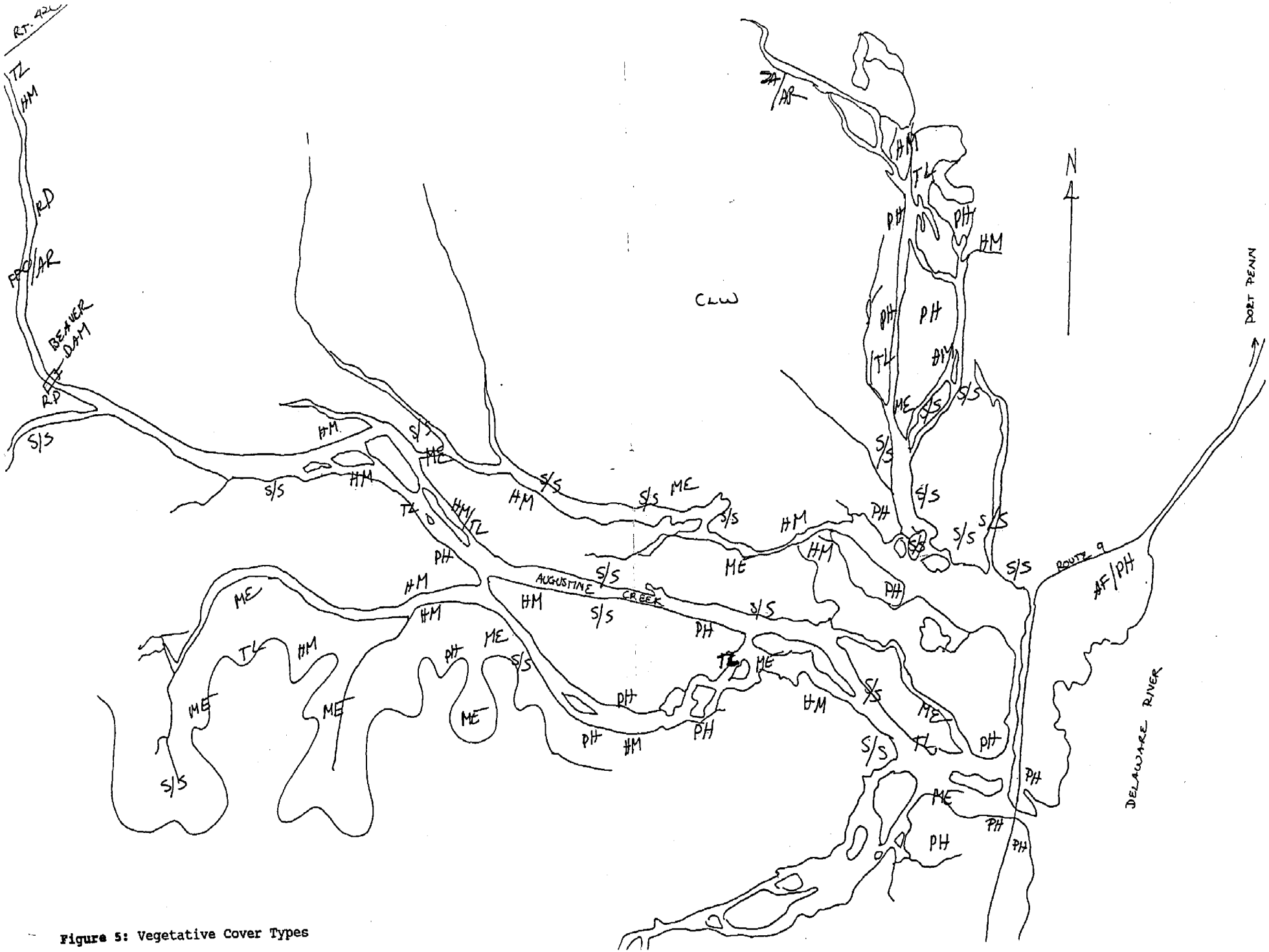
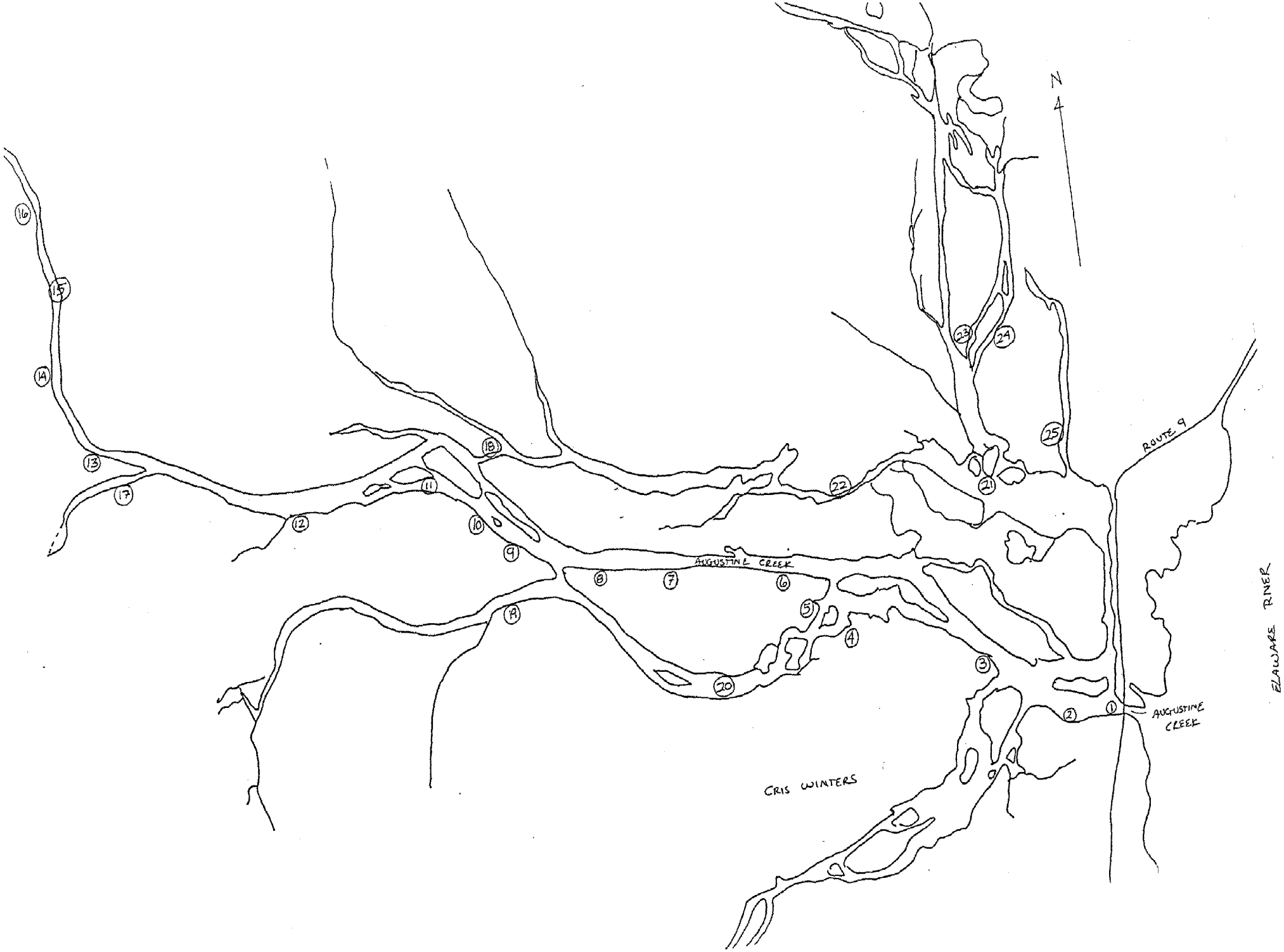


Figure 5: Vegetative Cover Types

N
POST TENN
ROUTE 9
Spartina pectinata
AUGUSTINE CREEK
Polygonum densiflorum
Polygonum densiflorum
DELAWARE RIVER



Survey Area E

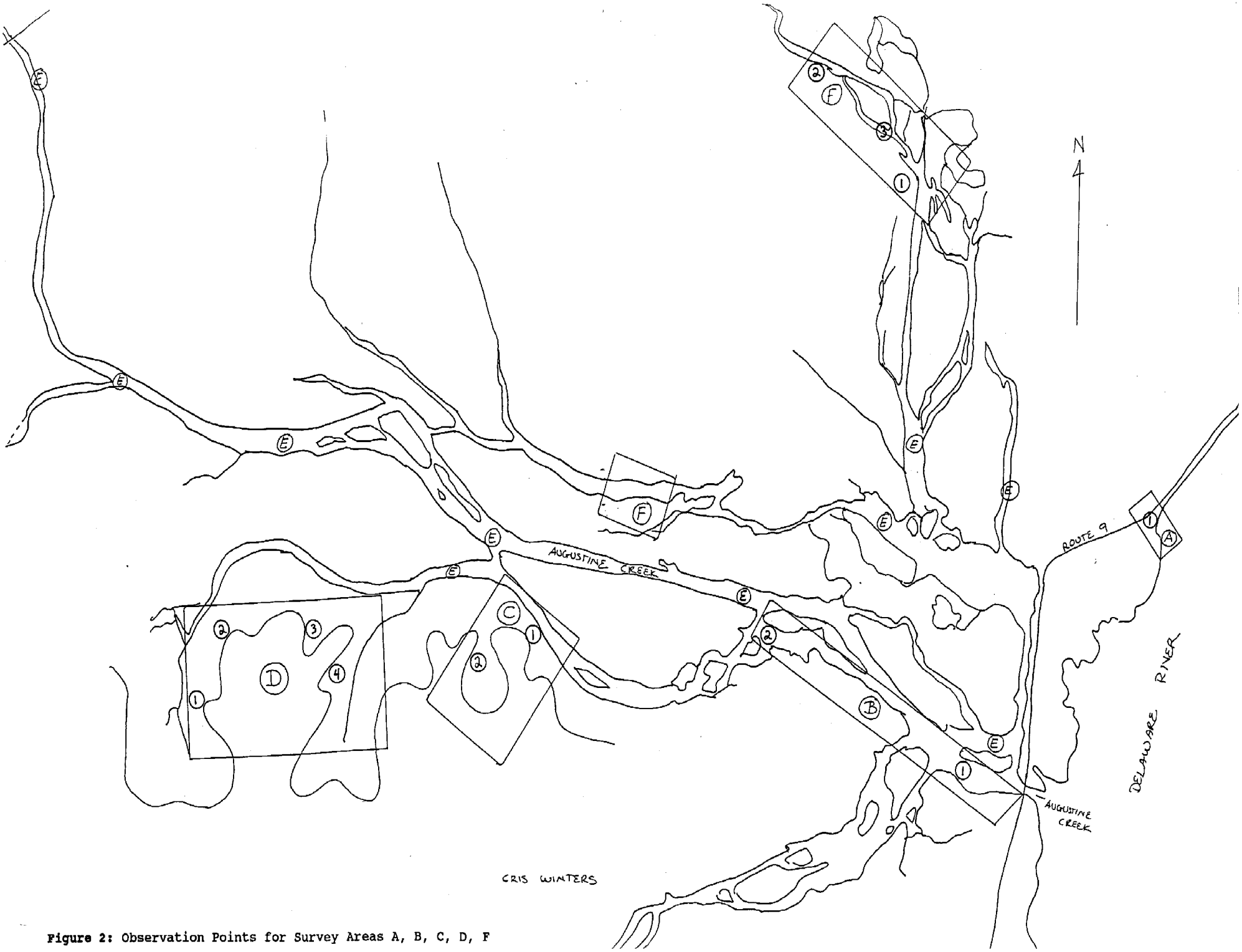


Figure 2: Observation Points for Survey Areas A, B, C, D, F

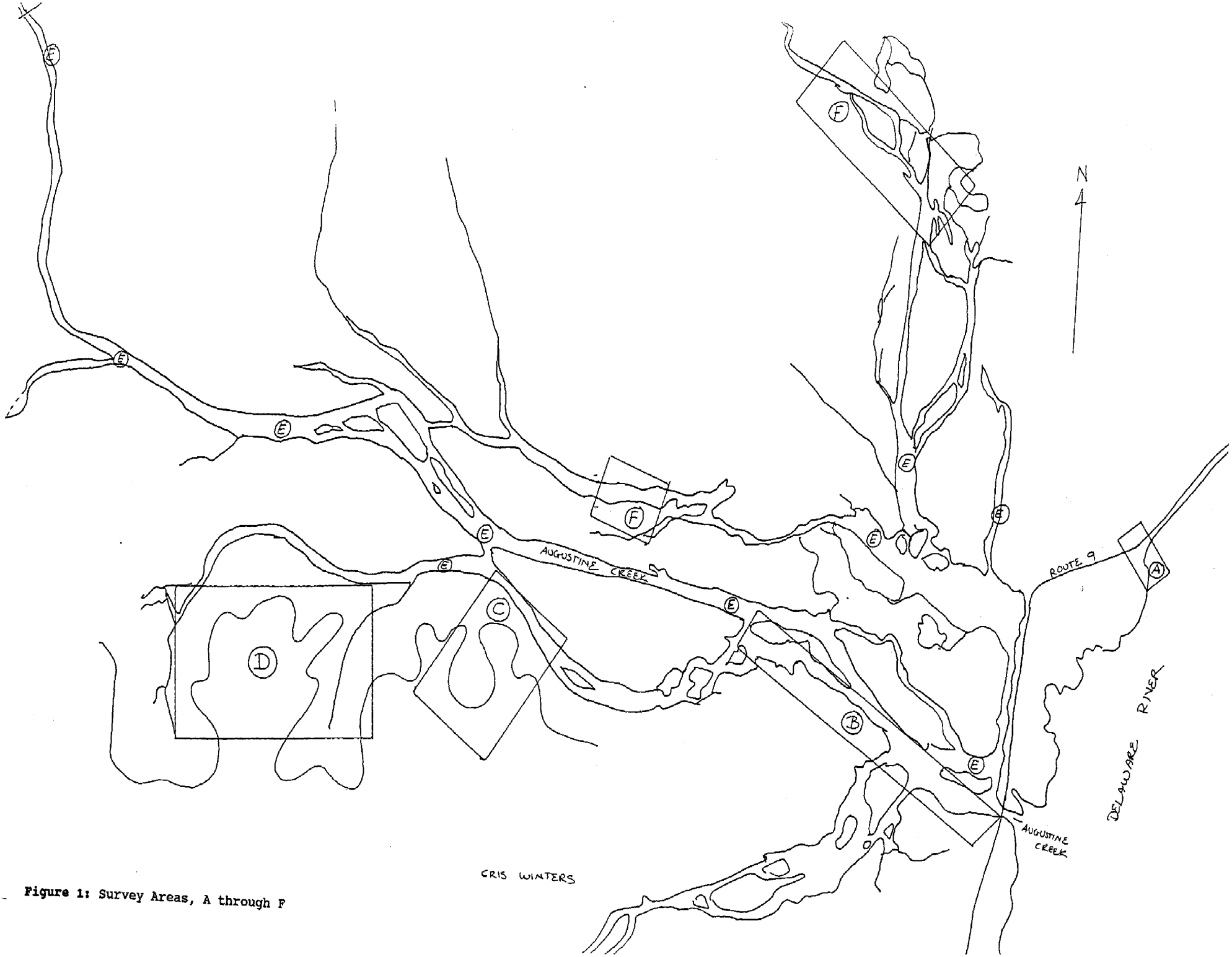


Figure 1: Survey Areas, A through F

APPENDIX IV

FIELD FORMS

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL
DIVISION OF PARKS AND RECREATION
89 KINGS HIGHWAY, P.O. BOX 1401
DOVER, DELAWARE 19903

OFFICIAL BUSINESS, PENALTY FOR PRIVATE USE $300

40-06-00

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

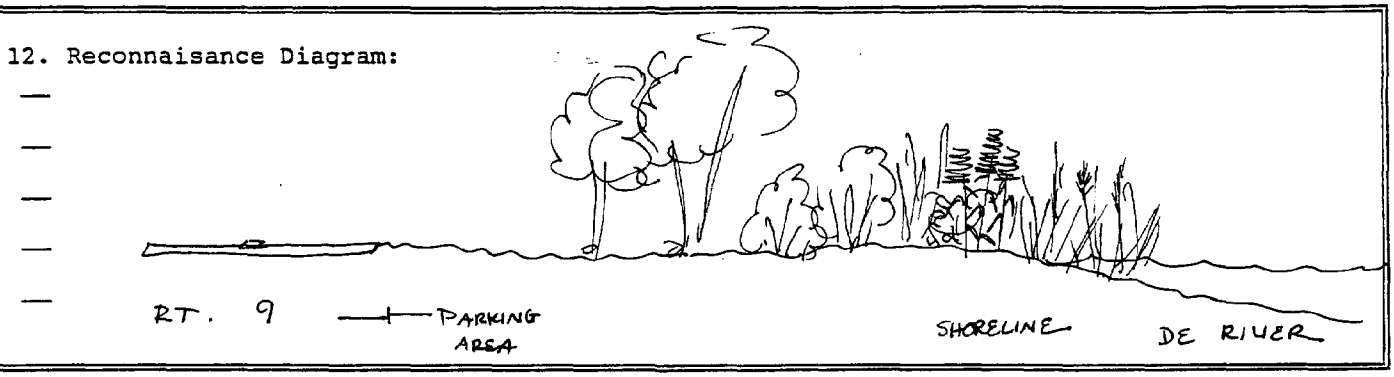
A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK
2. Site name: AREA (A)
3. Source Code: F93WIN05A
4. Surveyors: CRIS WINTERS
5. Date: 082393
6. USGS Quad: DELAWARE CITY
7. Quadcode: 3907555
8. State: DE
9. County: NEW CASTLE
10. Town: PORT PENN
11. Directions:

Going south on RT. 9, after passing through Port Penn, pull off on left just past the Augustine Inn as the road curves sharply to the right. Follow trail to water edge - popular fishing area.

B. TOPOGRAPHY

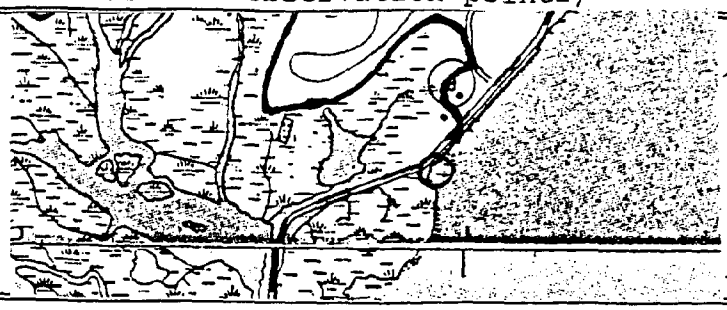
12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 1	Observation Point:	Observation Point:
Community name: Spartina alterniflora Low Marsh	Community name:	Community name:
Soil comments: Saturated → Inundated	Soil comments:	Soil comments:
Dominant species Tree/Shrub: Bacharris halimifolia	Dominant species: Tree/Shrub:	Dominant species: Tree/Shrub:
Herb: Spartina alterniflora/ Phragmites australis	Herb:	Herb:
Comments: This area is quite disturbed by nearby roadway, filled beach, and gravel/fill placed along shoreline.	Comments:	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)



E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	CV
Acorus calamus		
Alisma subcordatum		
Amaranthus cannabinus		
Ambrosia trifida		
Amorpha frutescens		
Apios americana		
Aslepias incarnata		
Aster puniceus		
Aster sp.		
Bidens bidentoides		
Bidens connata		
Bidens coronata		
Bidens frondosa		
Bidens laevis		
Bidens polylepis		
Carex stricta		
Carex sp.		
Cephalanthus occidentalis		
Ceratophyllum demersum		
Cicuta maculata		
Cinna arundinacea		
Clethra alnifolia		
Cornus amomum		
Cornus racemosa		
Cryptotaenia canadensis		
Cuscuta sp.		
Cyperus odoratus		
Cyperus engelmannii		
Cyperus erythrorhizos		
Cyperus esculentus		
Cyperus sp.		
Decodon verticillatus		
Echinochloa crusgalli		
Echinochloa walteri		
Eleocharis obtusa		
Eleocharis palustris		
Eleocharis parvula		
Eleocharis tenuis		
Erechtites hieracifolia		
Eupatorium sp.		
Euthamia sp.		
Fraxinus pensylvanica		
Glyceria sp.		
Heteranthera reniformis		
Hibiscus moscheutos		
Humulus japonicus		
Hydrocotyle americana		
Ilex opaca		
Ilex verticillata		

Species	Ob # 1	CV
Impatiens capensis		
Iris pseudacorus		
Iris versicolor		
Juncus acuminatus		
Juncus canadensis		
Juncus effusus		
Leersia oryzoides		
Leersia virginica		
Lemna minor		
Lilaeopsis chinensis		
Lilium superbum		
Lobelia cardinalis		
Ludwigia palustris		
Ludwigia peploides		
Lycopus sp.		
Lysimachia terrestris		
Lythrum salicaria		
Nuphar lutea		
Osmunda cinnamomea		
Oxypolis rigidior		
Panicum virgatum	X	FRE
Panicum sp.		
Peltandra virginica		
Phalaris arundinacea		
Phragmites australis	X	CON
Pluchea odorata		
Polygonum arifolium		
P. hydropiperoides		
P. punctatum		
P. sagittatum		
Pontederia cordata		
Ptilimnium capillac.		
Riccia fluitans		
Rosa palustris		
R. multiflora		
Rumex verticill.		
Sagittaria calycina		
S. latifolia		
Salix nigra		
Samolus parvulus		
Scirpus cyperinus		
S. fluviatilis		
S. pungens	X	FRE
S. robustus		
Sium suave		
Sparganium eurycarp.		
Spartina alterniflora	X	ABUN
S. cynosuroides		
Spirodela polyrhiza		

Species	Ob # 1	CV
Thalictrum pubescens		
Thelypteris palustris		
Toxicodendron rad.		
Triad. virginicum		
Typha angustifolia		
T. x glauca		
T. latifolia		
Vaccinium corymb.		
Viburnum recogn.		
Viola sp.		
Wolffia braziliensis		
Zizania aquatica		
OTHER		
Tripsacum dactyloides	X	INF
Calystegium sepium	X	FRE
Teucrium canadense	X	INF
Solidago sempirvirens	X	INF
*Sporbina pectinata	X	INF
Bachamus halmifolia	X	FRE

* Species of Special Concern

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 **MARSH SURVEYS**

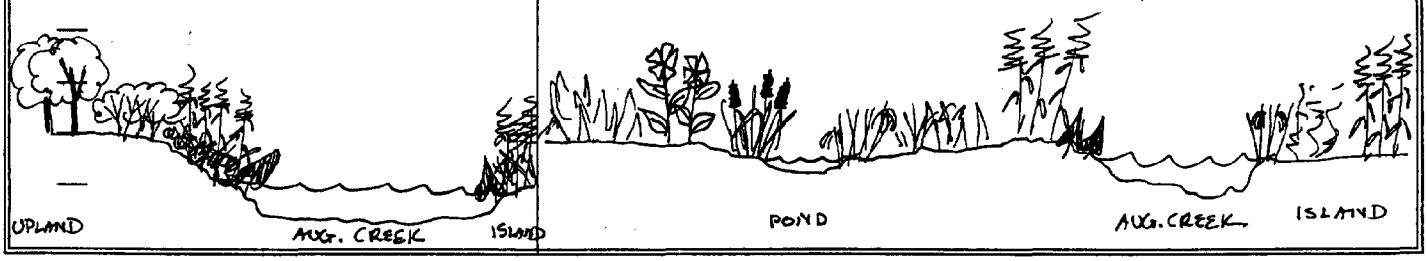
A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK
2. Site name: AREA (B)
3. Source Code: F93 WIN ØB
4. Surveyors: C. WINTERS, B. McAVOY
5. Date: 090393
6. USGS Quad: DELAWARE CITY / TAYLORSBRIDGE
7. Quadcode: 3907555 / 3907545
8. State: DE
9. County: NEWCASTLE
10. Town: PORT PENN
11. Directions:

To reach observation points (1) and (2), take RT. 9 south from Port Penn. Where road crosses Augustine Creek, there is a boat launch. Canoe west on Augustine Creek (see map).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 1	Observation Point: 2	Observation Point:
Community name: [HISTORICALLY] TIDAL BRACK MARSH/CREEK	Community name: [HISTORICALLY] TIDAL BRACKISH MARSH	Community name:
Soil comments: UPLAND EDGE → CREEK (INUNDATED)	Soil comments:	Soil comments:
Dominant species Tree/Shrub: Diospyros/Viburnum	Dominant species: Tree/Shrub: (rel. few)	Dominant species: Tree/Shrub:
Herb: Phragmites australis	Herb: Hibiscus/Echinochloa walterii	Herb:
Comments: Much of the creek bank is dominated by Phragmites; scattered between Phrag. are more diverse communities. The tree/shrub wetland edge is relatively close to creek in this area. Dry/low water.	Comments: Some of this area was a small pond/marsh of S. tabermontanii/T. latifolia dominance. Very dry at time of survey.	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	Ob# 2
Acorus calamus		
Alisma subcordatum		
Amaranthus cannabinus		FR
Ambrosia trifida		
Amorpha frutescens		
Apios americana		
Aslepias incarnata var. pulchra		INF
Aster puniceus		
Aster sp.		
Bidens bidentoides		
Bidens connata		
Bidens coronata		
Bidens frondosa		
Bidens laevis		
Bidens polylepis		
Carex stricta		
Carex sp.		
Cephalanthus occidentalis		INF
Ceratophyllum demersum		
Cicuta maculata		
Cinna arundinacea		
Clethra alnifolia		
Cornus amomum	FRE	
Cornus racemosa		
Cryptotaenia canadensis		
Cuscuta sp.		
Cyperus odoratus	FRE	FRE
Cyperus engelmannii		
Cyperus erythrorhizos		
Cyperus esculentus		
Cyperus sp.		
Decodon verticillatus		FRE
Echinochloa crusgalli		
Echinochloa walteri	INF	COM
Eleocharis obtusa		
Eleocharis palustris		
Eleocharis parvula		
Eleocharis tenuis		
Erechtites hieracifolia	INF	INF
Eupatorium rugosum	INF	
Euthamia sp.		
Fraxinus pensylvanica		
Glyceria sp.		
Heteranthera reniformis		
Hibiscus moscheutos	FRE	COM
Humulus japonicus		
Hydrocotyle americana		
Ilex opaca		
Ilex verticillata		

Species	Ob # 1	Ob.# 2
Impatiens capensis		
Iris pseudacorus		
Iris versicolor		
Juncus acuminatus		
Juncus canadensis		
Juncus effusus		
Leersia oryzoides	COM	FRE
Leersia virginica		
Lemna minor	FRE	
Lilaeopsis chinensis		
Lilium superbum		
Lobelia cardinalis		
Ludwigia palustris	FRE	
Ludwigia peploides		
Lycopus sp.		
Lysimachia terrestris		
Lythrum salicaria	INF	
Nuphar lutea		
Osmunda cinnamomea		
Oxypolis rigidior		
Panicum virgatum	FRE	
Panicum dichotomoflor.	INF	FRE
Peltandra virginica	FRE	FRE
Phalaris arundinacea		
Phragmites australis	COM	FRE
Pluchea odorata	FRE	
Polygonum arifolium	FRE	FRE
*P. densiflorum	FRE	
P. hydropiperoides	FRE	
P. punctatum	FRE	
Pontederia cordata		
Ptilimnium capillac.		
Riccia fluitans		
Rosa palustris		
R. multiflora		
Rumex verticill.	INF	INF
Sagittaria calycina		
S. latifolia	INF	
Salix nigra		
Samolus parvulus		
Scirpus cyperinus	FRE	
S. tabernae montanii	FRE	FRE
S. pungens		
S. robustus		
Sium suave		
Sparganium eurycarp.		
Spartina alterniflora		
S. cynosuroides		
Spirodela polyrhiza		FRE

Species	Ob # 1	Ob # 2
Thalictrum pubescens		
Thelypteris palustris		
Toxicodendron rad.		
Triad. virginicum		
Typha angustifolia	INF	FRE
T. x glauca		
T. latifolia	FRE	FRE
Vaccinium corymb.		
Viburnum recogn.	COM	
Viola sp.		
Wolffia braziliensis		
Zizania aquatica		
OTHER		
Prunus serotina	INF	
Rhus copalina	FRE	
Diospyros virginiana	COM	
Verbena hastata	INF	
Eclipta prostrata	INF	
Sambucus candensis		FRE
Baccharis halimifolia		INF

F. ADDITIONAL NOTES:

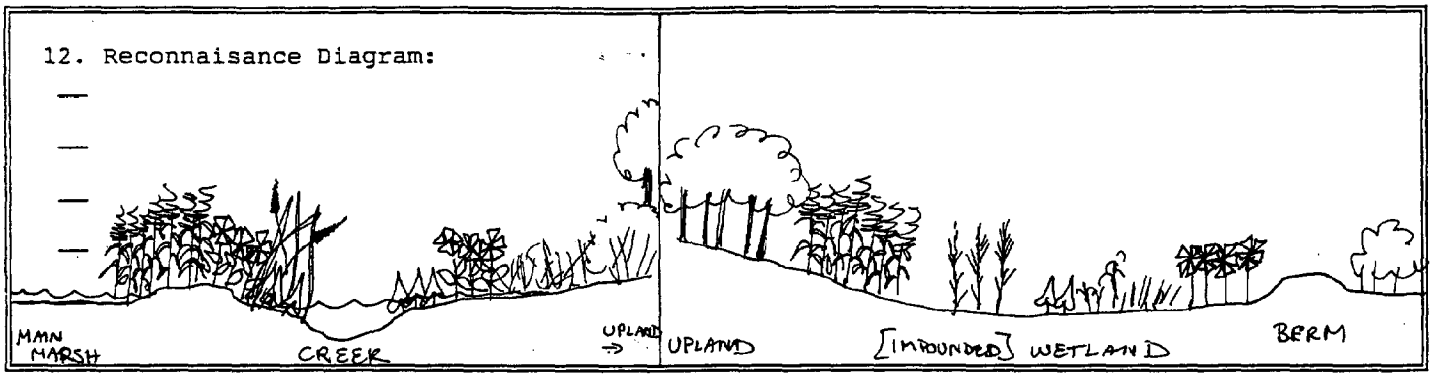
FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK
2. Site name: AREA (C)
3. Source Code: F93WIN 12
4. Surveyors: C. WINTERS
5. Date: 091193
6. USGS Quad: TAYLOR'S BRIDGE
7. Quadcode: 3907545
8. State: DE
9. County: NEWCASTLE
10. Town: PORT PENN
11. Directions:
Take Route 9 south from Port Penn. When RT. 9 turns south, continue on RT. 423 (McDonough Road). Turn onto the 1st road on the right. Continue on farm road to peninsulas indicated on map.

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 1	Observation Point:	Observation Point:
Community name: [HISTORICALLY] TIDAL FRESH → BRACKISH MARSH	Community name: →	Community name:
Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED	Soil comments:
Dominant species Tree/Shrub: VIBURNUM	Dominant species: Tree/Shrub: —	Dominant species: Tree/Shrub:
Herb: HIBISCUS/LEERSIA/PELTANDRA	Herb: HIBISCUS/ ECHINOCHLOA WALTERI	Herb:
Comments: This area appeared to support many birds spp. Relatively diverse; Phrag. not dominant.	Comments: Wetland has a berm across outlet. Could not determine whether impounded (low water, dry).	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	Ob # 2
Acorus calamus		
Alisma subcordatum		
Amaranthus cannabinus		
Ambrosia trifida		
Amorpha frutescens		
Apios americana		
Asclepias incarnata		
Aster puniceus		
Aster sp.		
Bidens triportita		COM
Bidens connata		
Bidens coronata		
Bidens frondosa		
Bidens laevis		
Bidens polylepis		
Carex stricta		
Carex		INF
Cephalanthus occidentalis		
Ceratophyllum demersum		
Cicuta maculata		
Cinna arundinacea		
Clethra alnifolia		
Cornus amomum		
Cornus racemosa		
Cryptotaenia canadensis		
Cuscuta sp.		
Cyperus odoratus	INF	
Cyperus engelmannii		
Cyperus erythrorhizos		
Cyperus esculentus		
Cyperus sp.		
Decodon verticillatus		INF
Echinochloa crusgalli		
Echinochloa walteri	INF	ABUN
Eleocharis obtusa		
Eleocharis palustris		
Eleocharis parvula		
Eleocharis tenuis		
Erechtites hieracifolia	INF	COM
Eupatorium dubium		INF
Euthamia sp.		
Fraxinus pensylvanica		
Glyceria sp.		
Heteranthera reniformis		
Hibiscus moscheutos	ABUN	ABUN
Humulus japonicus		
Hydrocotyle americana		
Ilex opaca		
Ilex verticillata		

Species	Ob # 1	Ob # 2
Impatiens capensis	FRE	
Iris pseudacorus		
Iris versicolor		
Juncus acuminatus		
Juncus canadensis		
Juncus effusus		
Leersia oryzoides	ABUN	ABUN
Leersia virginica		
Lemna minor	COM	FRE
Lilaeopsis chinensis		
Lilium superbum		
Lobelia cardinalis		
Ludwigia palustris	COM	COM
Ludwigia peploides		
Lycopus sp.		
Lysimachia terrestris		
Lythrum salicaria		INF
Nuphar lutea		FRE
Osmunda cinnamomea		
Oxypolis rigidior		
Panicum virgatum		
Panicum dichotomiflorum		FRE
Peltandra virginica	ABUN	FRE
Phalaris arundinacea		
Phragmites australis	FRE	COM
Pluchea odorata		
Polygonum arifolium		COM
P. scandens	COM	INF
P. hydropiperoides		ABUN
P. pennsylvanicum		ABUN
Pontederia cordata		COM
Ptilimnium capillac.		
Riccia fluitans		
Rosa palustris	INF	
R. multiflora		
Rumex verticill.	COM	
Sagittaria calycina		
S. latifolia		INF
Salix nigra		
Samolus parvulus		
Scirpus cyperinus		INF
S. fluviatilis		
S. pungens		
S. robustus		
Sium suave		
Sparganium eurycarp.		
Spartina alterniflora		
S. cynosuroides		
Spirodela polyrhiza	FRE	

Species	Ob # 1	Ob # 2
Thalictrum pubescens		
Thelypteris palustris		
Toxicodendron rad.		
Triad. virginicum		
Typha angustifolia		
T. x glauca		
T. latifolia	INF	ABUN
Vaccinium corymb.		
Viburnum recogn.	ABUN	COM
Viola sp.		
Wolffia braziliensis		
Zizania aquatica		
OTHER		
Rhus copalina	COM	
Diospyros virginiana	COM	
Lonicera japonica		COM
Boehmeria cylindrica		FRE
Eupatorium serotinum		INF
Microstegium Viminum		FRE

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (D) page 1

3. Source Code: F93WIN05B 4. Surveyors: CRIS WINTERS

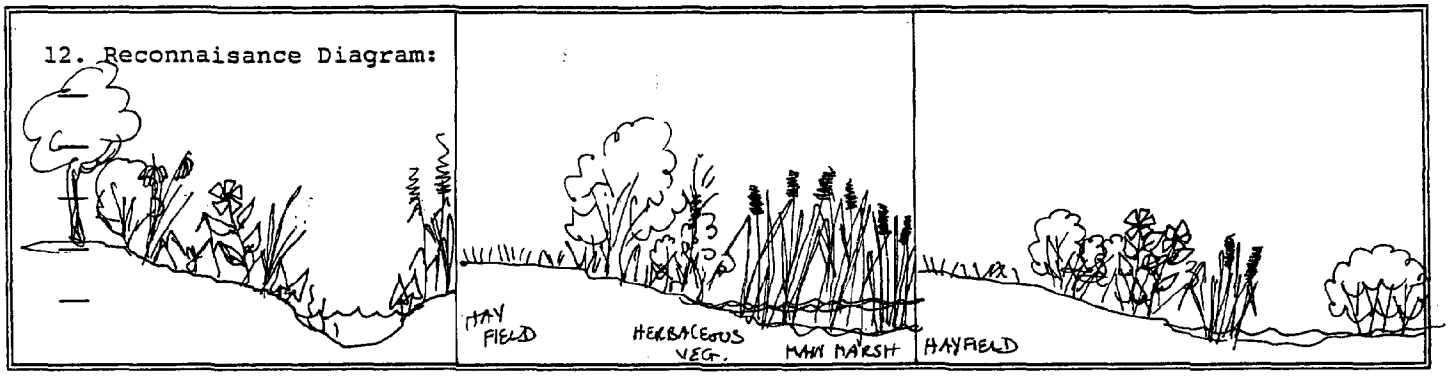
5. Date: 082393 6. USGS Quad: TAYLOR'S BRIDGE 7. Quadcode: 3907545

8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:
Take Route 9 south from Port Penn. When Rt. 9 turn south, continue on Rt. 423 (Mc Donough Rd). Turn onto the 1st road on the right. Turn onto farm road on left just past the house trailer. Follow road (stay to right) out to hayfield / marsh.

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 1	Observation Point: 2	Observation Point: 3
Community name: [HISTORICALLY] TIDAL FRESH TO BRACKISH MARSH →	Community name:	Community name: →
Soil comments: SATURATED → INUNDATED, MUCKY SUBSTRATE	Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED
Dominant species Tree/Shrub: SALIX / VIBURNUN	Dominant species: Tree/Shrub: SAMBUCUS CANADENSIS	Dominant species: Tree/Shrub: CEPHALANTHUS OCCIDENTALIS
Herb: HIBISCUS / LEERSIA	Herb: TYPHA ANGUSTIFOLIA	Herb: HIBISCUS MOSCHEUTOS
Comments: Diverse wetland-bordering creek. Similar vegetation across creek. Scattered woody vegetation, especially at wetland/upland boundaries	Comments: This community sloped more gradually to the main marsh.	Comments: Dominated by shrubs and Hibiscus.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	Ob # 2	Ob # 3
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			ABUN
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus sp.	FRE		FRE
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
*Cyperus erythrorhizos	INF		
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri	COM		
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia	FRE		
Eupatorium pilosum	INF		
Euthamia graminifolia		COM	
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	ABUN	FRE	ABUN
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 1	Ob # 2	Ob # 3
Impatiens capensis			
Iris pseudacorus	FRE		
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus	FRE		
Leersia oryzoides	ABUN		
Leersia virginica			
Lemna minor			
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			FRE
Ludwigia palustris			
Ludwigia peploides	COM		
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			FRE
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum	FRE		
Panicum sp.			
Peltandra virginica	COM		
Phalaris arundinacea			
Phragmites australis	COM	FRE	
Pluchea odorata			
Polygonum arifolium			
P. hydropiperoides			
* P. densiflorum	FRE	COM	
P. sagittatum			
Pontederia cordata	FRE		
Pilimnium capillac.			
Riccia fluitans			
Rosa palustris			FRE
R. multiflora			
Rumex verticill.	ABUN		
Sagittaria calycina			
S. latifolia	FRE		
Salix nigra	FRE		
Samolus parvulus			
Scirpus cyperinus			
S. tabernaemontani	FRE		
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 1	Ob # 2	Ob # 3
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia		ABUN	
T. x glauca			
T. latifolia	COM		COM
Vaccinium corymb.			
Viburnum recogn.	COM		
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Solidago sempervirens	INF		
Commelina sp.	INF		
Solidago rugosa		COM	
Verbena hastata		FRE	
Sambucus canadensis		FRE	
Eupatorium dubium			FRE

F. ADDITIONAL NOTES: * species of special concern

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

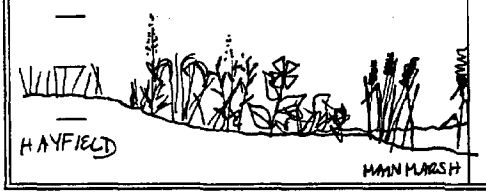
A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK
2. Site name: AREA (D) page. 2
3. Source Code: F93WIN05B
4. Surveyors: C. WINTERS
5. Date: 082393
6. USGS Quad: TAYLOR'S BRIDGE
7. Quadcode: 3907545
8. State: DE
9. County: NEW CASTLE
10. Town: PORT PENN
11. Directions:

(see page 1)

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 4	Observation Point:	Observation Point:
Community name: [HISTORICALLY] TIDAL FRESH TO BRACKISH MARSH	Community name:	Community name:
Soil comments: SATURATED → INUNDATED STABLE SUBSTRATE	Soil comments:	Soil comments:
Dominant species Tree/Shrub: [CEPHALANTHUS OCCIDENTALIS]	Dominant species: Tree/Shrub:	Dominant species: Tree/Shrub:
Herb: Bidens sp. (not in bloom)/ Echinochloa walterii	Herb:	Herb:
Comments: Relatively diverse, broad marsh. At edge of open water, dominated by Typha latifolia and Phragmites australis.	Comments:	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

(see page 1)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 4	
Acorus calamus		
Alisma subcordatum		
Amaranthus cannabinus		
Ambrosia trifida		
Amorpha frutescens		
Apios americana		
Aslepias incarnata		
Aster puniceus		
Aster sp.		
Bidens sp.	ABUN	
Bidens connata		
Bidens coronata		
Bidens frondosa		
Bidens laevis		
Bidens polylepis		
Carex stricta		
Carex sp.		
Cephalanthus occidentalis	FRE	
Ceratophyllum demersum		
Cicuta maculata		
Cinna arundinacea		
Clethra alnifolia		
Cornus amomum		
Cornus racemosa		
Cryptotaenia canadensis		
Cuscuta sp.		
Cyperus odoratus		
Cyperus engelmannii		
Cyperus erythrorhizos		
Cyperus esculentus		
Cyperus sp.		
Decodon verticillatus		
Echinochloa crusgalli		
Echinochloa walteri	ABUN	
Eleocharis obtusa		
Eleocharis palustris		
Eleocharis parvula		
Eleocharis tenuis		
Erechtites hieracifolia	FRE	
Eupatorium sp.		
Euthamia sp.		
Fraxinus pensylvanica		
Glyceria sp.		
Heteranthera reniformis		
Hibiscus moscheutos	FRE	
Humulus japonicus		
Hydrocotyle americana		
Ilex opaca		
Ilex verticillata		

Species	Ob # 4	
Impatiens capensis		
Iris pseudacorus		
Iris versicolor		
Juncus acuminatus		
Juncus canadensis		
Juncus effusus		
Leersia oryzoides		
Leersia virginica		
Lemna minor		
Lilaeopsis chinensis		
Lilium superbum		
Lobelia cardinalis		
Ludwigia palustris		
Ludwigia peploides		
Lycopus sp.		
Lysimachia terrestris		
Lythrum salicaria	FRE	
Nuphar lutea		
Osmunda cinnamomea		
Oxypolis rigidior		
Panicum virgatum		
Panicum sp.		
Peltandra virginica		
Phalaris arundinacea		
Phragmites australis	(ABUN)	
Pluchea odorata		
Polygonum arifolium		
P. hydropiperoides		
P. pennsylvanicum	COM	
P. sagittatum	COM	
Pontederia cordata		
Ptilimnium capillac.		
Riccia fluitans		
Rosa palustris		
R. multiflora		
Rumex verticill.		
Sagittaria calycina		
S. latifolia		
Salix nigra		
Samolus parvulus		
Scirpus cyperinus	COM	
S. fluviatilis		
S. pungens		
S. robustus		
Sium suave		
Sparganium eurycarp.		
Spartina alterniflora		
S. cynosuroides		
Spirodela polyrhiza		

Species	Ob # 4	
Thalictrum pubescens		
Thelypteris palustris		
Toxicodendron rad.		
Triad. virginicum		
Typha angustifolia		
T. x glauca		
T. latifolia	ABUN	
Vaccinium corymb.		
Viburnum recogn.		
Viola sp.		
Wolffia braziliensis		
Zizania aquatica		
OTHER		
Verbena hastata	FRE	
Solidago rugosa	COM	
Onoclea sensibilis	FRE	
Microsteglum vimineum	COM	
Gramineae sp.	COM	

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 1

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

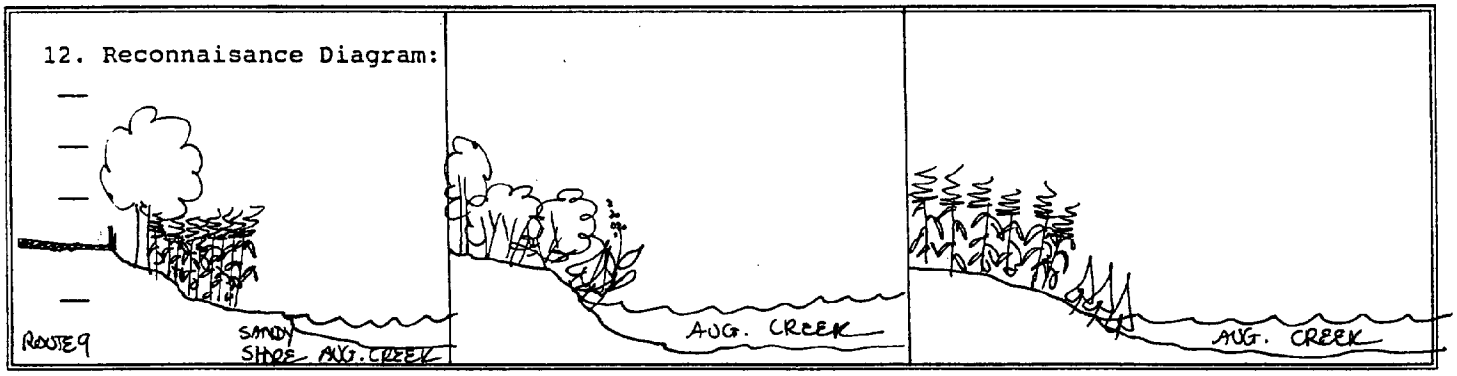
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 1	Observation Point: 2	Observation Point: 3
Community name: (Boat launch site)	Community name: BRACKISH SHORELINE	Community name: →
Soil comments: Gen. inundated	Soil comments: Sl. saturated → inundated	Soil comments: Sl. saturated → inundated
Dominant species Tree/Shrub: Acer negrundo	Dominant species: Tree/Shrub: Diospyros virginiana / Rhus copalina	Dominant species: Tree/Shrub: /
Herb: Phragmites australis	Herb: Polygonum pennsylvanicum	Herb: Phragmites australis
Comments: This area is a sandy landing next to RT. 9, some mature A. negrundo. Shoreline dominated by Phrag.	Comments: Scrub/shrub to narrow emergent zone. Water levels relatively high for this survey. Many smaller emergents not visible.	Comments: Phrag. dominated to upland; narrow emergent zone.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	Ob# 2	Ob# 3
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha fruteseens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri			
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia		COM	
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos		FRE	INF
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 1	Ob# 2	Ob# 3
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides			
Leersia virginica			
Lemna minor			
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris			COM
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum dichotomiflorum		FRE	
Peltandra virginica		INF	COM
Phalaris arundinacea			
Phragmites australis	DOM		DOM
Pluchea odorata		INF	
Polygonum arifolium			
P. hydropiperoides			
P. pensylvanicum		COM	
P. sagittatum			
Pontederia cordata			FRE
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.		FRE	
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 1	Ob# 2	Ob# 3
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia		INF	
Vaccinium corymb.			
Viburnum recogn.			
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Acer negundo	FRE		
Rhus copalina		COM	
Diospyros virginiana		COM	
Microstegium viminum		COM	

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 2

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

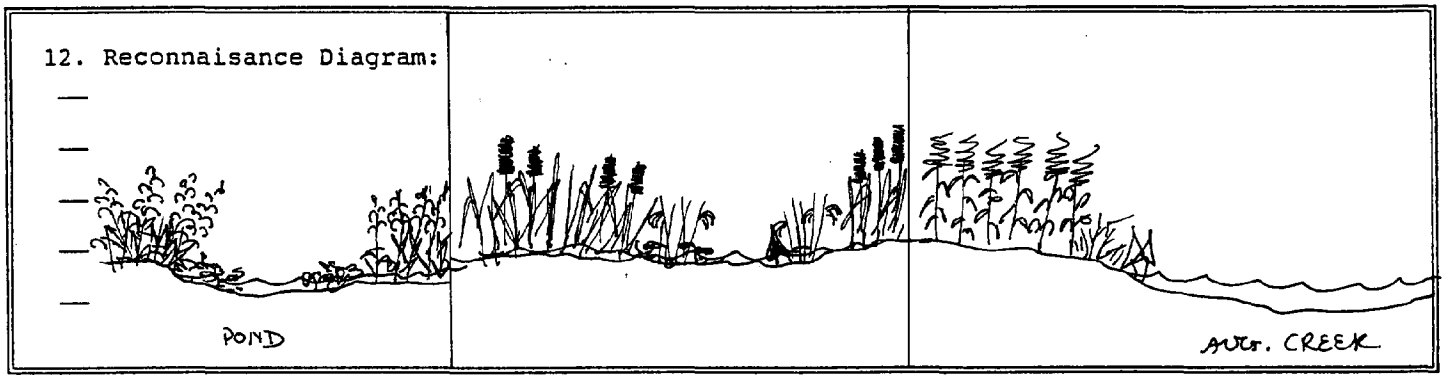
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 4	Observation Point: 5	Observation Point: 6
Community name: [HISTORICALLY] TIDAL BRACKISH MARSH →	Community name:	Community name: BRACKISH SHORELINE
Soil comments: Inundated	Soil comments: Inundated	Soil comments: Saturated → Inundated
Dominant species Tree/Shrub: —	Dominant species: Tree/Shrub: /	Dominant species: Tree/Shrub: /
Herb: Echinochloa walteri / Ludwigia palustris	Herb: Typha latifolia	Herb: Phragmites australis
Comments: This area is a pond/cove off the main creek. Completely inundated now.	Comments: This is another shallow cove near ob. pt. #4 - very different vegetatively.	Comments: Shoreline dominated by Phrag.; emergents along shoreline.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 4	Ob# 5	Ob# 6
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus	FRE		
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri	ABUN	FRE	
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos			COM
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 4	Ob# 5	Ob# 6
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides			
Leersia virginica			ABUN
Lemna minor	COM		
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	ABUN	ABUN	
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica		INF	COM
Phalaris arundinacea			
Phragmites australis	COM		DOM
Pluchea odorata			
Polygonum sp.			INF
P. hydropiperoides			
P. punctatum			
P. sagittatum			
Pontederia cordata		INF	
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.	INF		COM
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. tabernaemontani		FRE	FRE
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 4	Ob# 5	Ob# 6
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia	FRE	DOM	FRE
Vaccinium corymb.			
Viburnum recogn.			
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 3

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

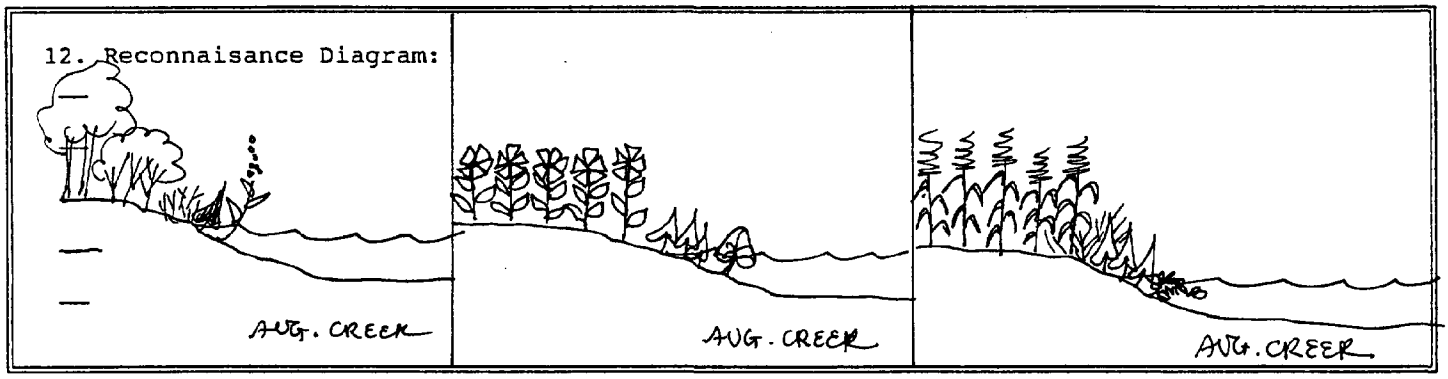
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 7	Observation Point: 8	Observation Point: 9
Community name: BRACKISH SHORELINE	Community name: →	Community name: →
Soil comments: Sl. saturated → inundated	Soil comments: Saturated → inundated	Soil comments: Saturated → inundated
Dominant species Tree/Shrub: Diospyros virginiana / Rhus copalina	Dominant species: Tree/Shrub: /	Dominant species: Tree/Shrub: /
Herb: Polygonum pennsylvanicum / Leersia oryzoides	Herb: Hibiscus moscheutos	Herb: Phragmites australis / Peltandra virginica
Comments: Scrub/shrub to narrow emergent zone.	Comments: Hibiscus dominated; narrow emergent zone, including Nuphar lutea. (This species increases in occurence going upstream)	Comments: Narrow emergent zone.

ION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 7	Ob# 8	Ob# 9
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri			
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia	FRE		
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	FRE	DOM	COM
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 7	Ob# 8	Ob# 9
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides	COM		FRE
Leersia virginica			
Lemna minor			FRE
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris			COM
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea		FRE	
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum dichotomoflorum	FRE		
Peltandra virginica	INF	COM	ABUN
Phalaris arundinacea			
Phragmites australis		INF	DOM
Pluchea odorata	INF		
Polygonum arifolium			
P. hydropiperoides			
P. pennsylvanicum	COM	INF	
P. sagittatum			
Pontederia cordata			FRE
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.	FRE	COM	COM
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 7	Ob# 8	Ob# 9
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia			
Vaccinium corymb.			
Viburnum recogn.			
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Rhus copalina	COM		
Diospyros virginiana	COM		
Microstegium vimineum	COM		

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 4

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

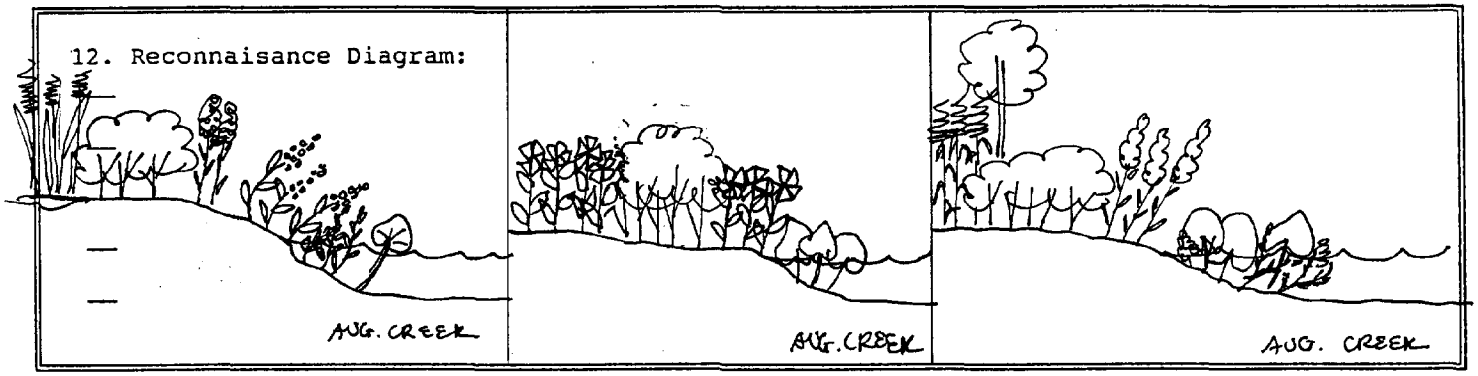
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 10	Observation Point: 11	Observation Point: 12
Community name: FRESH → BRACKISH SHORELINE	Community name: →	Community name: →
Soil comments: Saturated → Inundated	Soil comments: Saturated → Inundated	Soil comments: Saturated → Inundated
Dominant species Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub: Viburnum recognitum
Herb: Typha latifolia / Polygonum lapathifolium	Herb: Hibiscus moscheutos / Nuphar lutea	Herb: Nuphar lutea / Ludwigia palustris
Comments: Creek banks are lined thickly with P. lapathifolium and Ludwigia palustris. Viburnum scattered in dense stands. T. latifolia marsh beyond.	Comments: Patches of Hibiscus and Viburnum. Channel has much Nuphar.	Comments: Patches of Phrag., Viburnum/ Diospyros, Lythrum.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 10	Ob# 11	Ob# 12
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri			
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos		ABUN	
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 10	Ob# 11	Ob# 12
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides			
Leersia virginica			
Lemna minor			
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	ABUN		ABUN
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria	ABUN		COM
Nuphar lutea	INF	ABUN	ABUN
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica			
Phalaris arundinacea			
Phragmites australis			COM
Pluchea odorata			
Polygonum arifolium			
P. hydropiperoides			
P. lapathifolium	ABUN		
P. sagittatum			
Pontederia cordata			
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			INF
R. multiflora			
Rumex verticill.			
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 10	Ob# 11	Ob# 12
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia	DOM		
Vaccinium corymb.			
Viburnum recogn.	ABUN	ABUN	DOM
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Diospyros virginiana			COM

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey Site Name: AUGUSTINE CREEK 2. Site Name: AREA (E) page 5

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

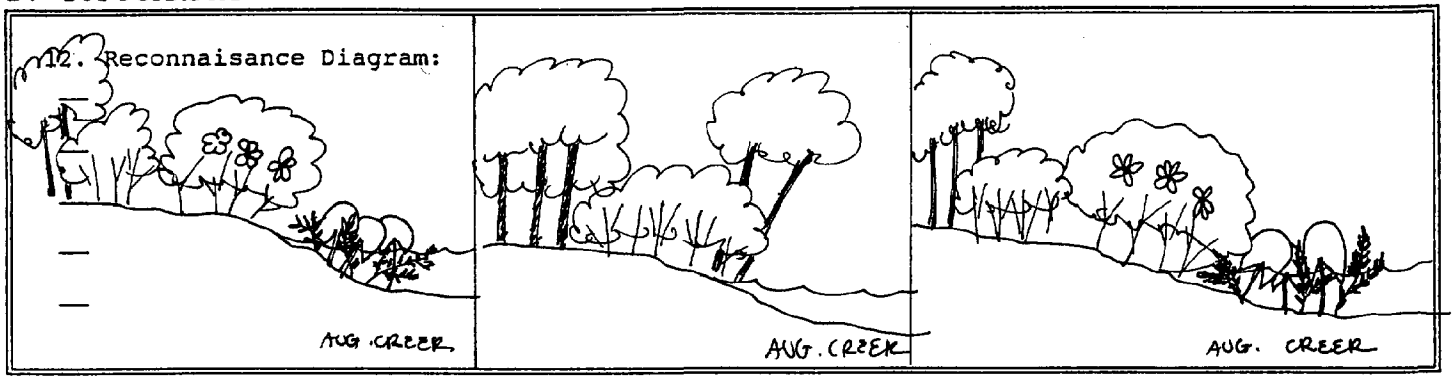
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 13	Observation Point: 14	Observation Point: 15
Community name: FRESH(?) SHORELINE →	Community name: →	Community name: →
Soil comments: saturated → Inundated	Soil comments: Saturated → Inundated	Soil comments: Saturated → Inundated
Dominant species Tree/Shrub: Rosa palustris	Dominant species: Tree/Shrub: Acer rubrum / Viburnum recognitum	Dominant species: Tree/Shrub: Rosa palustris
Herb: Nuphar lutea / Ludwigia palustris	Herb: —	Herb: Nuphar lutea / Ludwigia palustris
Comments: This area is just above a beaver dam. Probably quite fresh water.	Comments: Flood plain dominated by Acer rubrum. Both sides of creek wooded — Creek completed shaded.	Comments: Very similar to ob. pt. # 13.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 13	Ob# 14	Ob# 15
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Asclepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri			
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	FRE		FRE
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata	INF		INF

Species	Ob # 13	Ob# 14	Ob# 15
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides			
Leersia virginica			
Lemna minor			
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	ABUN		ABUN
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria	FRE		FRE
Nuphar lutea	ABUN		ABUN
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica			
Phalaris arundinacea			
Phragmites australis			
Pluchea odorata			
Polygonum arifolium			
P. hydropiperoides			
P. punctatum			
P. sagittatum			
Pontederia cordata			
Pilimnium capillac.			
Riccia fluitans			
Rosa palustris	DOM		DOM
R. multiflora			
Rumex verticill.			
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 13	Ob# 14	Ob# 15
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia			
Vaccinium corymb.			
Viburnum recogn.		COM	COM
Viola sp.			
Wolffia brazilicusis			
Zizania aquatica			
OTHER			
Diospyros virginiana	COM		COM
Acer rubrum		DOM	
Onoclea sensibilis		FRE	
Boehmeria cylindrica		FRE	

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 6

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

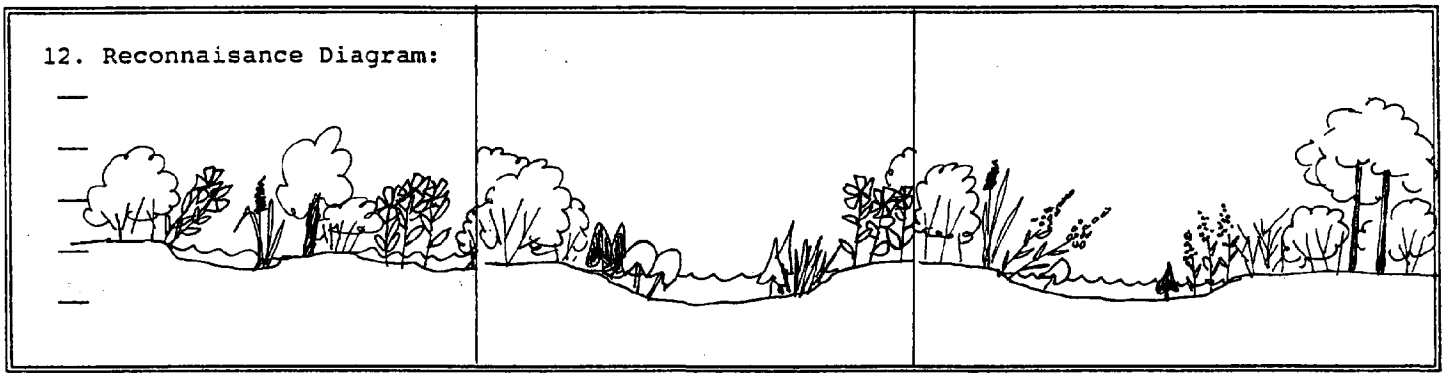
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 16	Observation Point: 17	Observation Point: 18
Community name: FRESH WATER MARSH	Community name: FRESHWATER GUT / SHORELINE	Community name: FRESH → BRACKISH GUT / SHORELINE
Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED
Dominant species Tree/Shrub: Salix sp. / Cephalanthus occidentalis	Dominant species: Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub: Viburnum recognitum
Herb: Hibiscus moscheutos / Ludwigia palustris	Herb: Nuphar lutea / Peltandra virginica	Herb: Polygonum lapathifolium / Peltandra virginica
Comments: This marsh was behind Ob. Point #15, near the Pole Bridge Road crossing of Augustine Creek. Mixture of deciduous woody and herbaceous species.	Comments: This area is a shallow gut off the main creek, below the beaver dam, Shoreline dominance of Hibiscus increases going upstream	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 16	Ob# 17	Ob# 18
Acorus calamus		ABUN	
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Asclepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis	FRE	FRE	
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus sp.	FRE		
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus		INF.	
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri			
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	DOM	ABUN	
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata		INF	

Species	Ob # 16	Ob# 17	Ob# 18
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides	ABUN		ABUN
Leersia virginica			
Lemna minor			COM
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	ABUN		
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			FRE
Nuphar lutea		ABUN	ABUN
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica	FRE	ABUN	ABUN
Phalaris arundinacea			
Phragmites australis			INF
Pluchea odorata			
Polygonum arifolium			
P. lapathifolium			ABUN
P. punctatum			
P. sagittatum			
Pontederia cordata			
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.		ABUN	COM
Sagittaria calycina			
S. latifolia			
Salix sp.	COM		
Samolus parvulus			
Scirpus cyperinus	COM		
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 16	Ob# 17	Ob# 18
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia	COM		COM
Vaccinium corymb.			
Viburnum recogn.		ABUN	ABUN
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Acer rubrum	COM		
Diospyros virginiana			COM

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 7

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

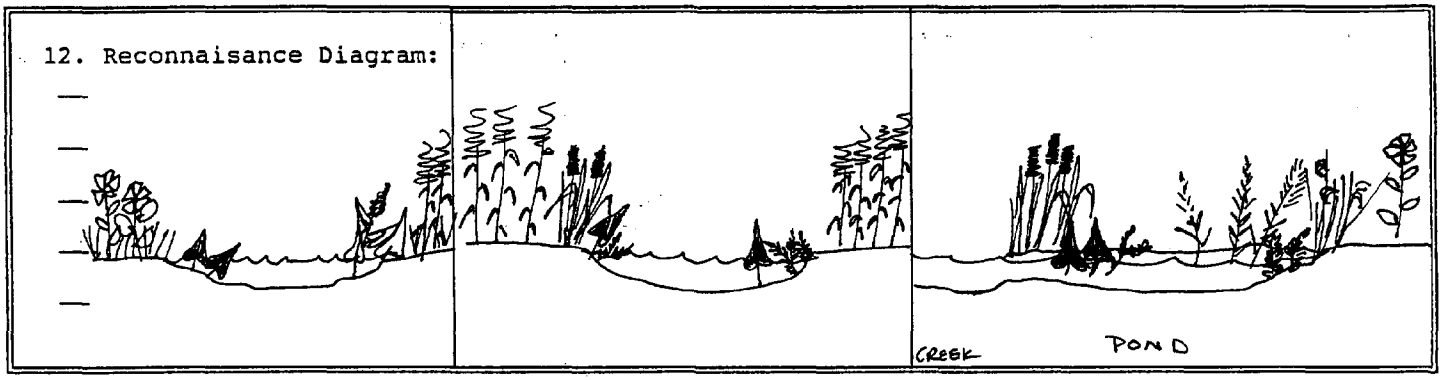
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 19	Observation Point: 20A	Observation Point: 20B
Community name: FRESH → BRACKISH SHORELINE →	Community name:	Community name: FRESH → BRACKISH COVE / POND
Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED	Soil comments: INUNDATED
Dominant species Tree/Shrub: —	Dominant species: Tree/Shrub: —	Dominant species: Tree/Shrub: —
Herb: Peltandra virginica / Hibiscus moscheutos	Herb: Phragmites australis	Herb: Echinochloa walteri / Ludwigia palustris
Comments: This point is near the mouth of a gut/stream entering Augustine Creek from the southwest. Some Phrag. invasion, but not dominant.	Comments:	Comments: This point is a small shallow pond/cove connected and adjacent to the main channel.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 19	Ob# 20A	Ob# 20B
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Asclepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			INF
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri		COM	ABUN
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	ABUN	COM	COM
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 19	Ob# 20A	Ob# 20B
Impatiens capensis			
Iris pseudacorus		INF	
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus	FRE		
Leersia oryzoides	ABUN	ABUN	COM
Leersia virginica			
Lemna minor		FRE	
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	COM	ABUN	ABUN
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea	COM	FRE	
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum		INF	
Panicum sp.			
Peltandra virginica	ABUN	COM	COM
Phalaris arundinacea			
Phragmites australis	COM	DOM	
Pluchea odorata			
Polygonum arifolium			
P. lapathifolium	FRE		
P. punctatum			
P. sagittatum			
Pontederia cordata		FRE	FRE
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris	INF		
R. multiflora			
Rumex verticill.	ABUN	ABUN	COM
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			FRE
S. tabernaemontani		FRE	COM
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 19	Ob# 20A	Ob# 20B
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia	FRE	FRE	FRE
Vaccinium corymb.			
Viburnum recogn.			
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) page 8

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

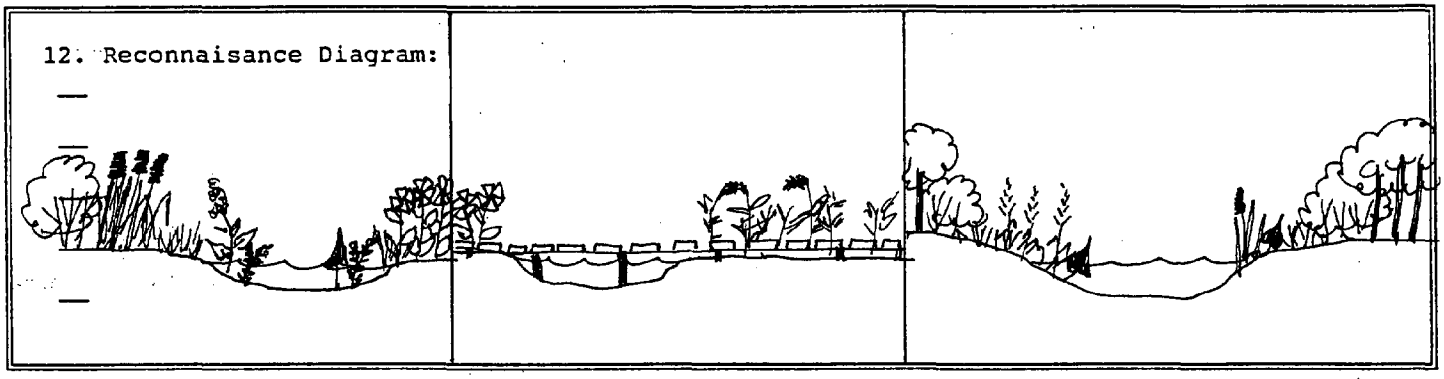
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 21	Observation Point: 22	Observation Point: 23
Community name: FRESH → BRACKISH SHORELINE	Community name: WET MEADOW	Community name: FRESH → BRACKISH SHORELINE
Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED	Soil comments: SATURATED → INUNDATED
Dominant species Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub: /	Dominant species: Tree/Shrub: Viburnum recognitum / Diospyros virginiana
Herb: Typha latifolia / Hibiscus moscheutos	Herb: Echinochloa walteri / Polygonum arifolium	Herb: Echinochloa walteri / Leersia oryzoides
Comments: DOM. EMERGENT: Rumex verticillatus	Comments: This obs. point was at the second of two boardwalks. The area was dominated by Graminoides.	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 21	Ob# 22	Ob# 23
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens sp.		INF	
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri	COM	ABUN	ABUN
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia		INF	
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	ABUN	FRE	FRE
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 21	Ob# 22	Ob# 23
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides	ABUN		ABUN
Leersia virginica			
Lemna minor			
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	ABUN		ABUN
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum		FRE	
Panicum dichotomiflorum		COM	
Peltandra virginica			COM
Phalaris arundinacea			
Phragmites australis	FRE	INF	
Pluchea odorata			
Polygonum arifolium		ABUN	
P. lapathifolium	FRE		
P. punctatum			
P. sagittatum			
Pontederia cordata			
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.	ABUN		
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. Tabernaemontanii	INF		
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 21	Ob# 22	Ob# 23
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia	ABUN	FRE	COM
Vaccinium corymb.			
Viburnum recogn.	ABUN		ABUN
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Rhus copallina	COM		
Setaria		INF	
Diospyros virginiana			ABUN
Baccharis halimifolia			INF

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 MARSH SURVEYS

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK 2. Site name: AREA (E) p.9

3. Source Code: F93WIN20 4. Surveyors: C. WINTERS, S. LINK

5. Date: 102293 6. USGS Quad: TAYLOR'S BRIDGE/DELAWARE CITY 7. Quadcode: 3907545, 3907555

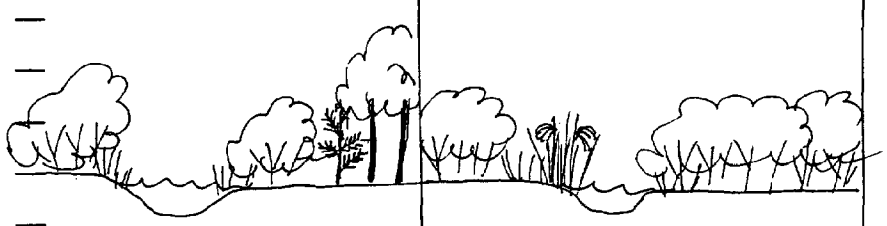
8. State: DE 9. County: NEW CASTLE 10. Town: PORT PENN

11. Directions:

Take ROUTE 9 south from Port Penn. Where road crosses Augustine Creek there is a boat launch. Canoe west on Augustine Creek to bridge crossing of RT. 420 (Port Penn - Boyd's Corner Road).

B. TOPOGRAPHY

12. Reconnaisance Diagram:



C. VEGETATION/HABITAT

Observation Point: 24	Observation Point: 25	Observation Point:
Community name: FRESH → BRACKISH SHORELINE	Community name: →	Community name:
Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED	Soil comments:
Dominant species Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub: Viburnum recognitum	Dominant species: Tree/Shrub:
Herb: Leersia oryzoides	Herb: Echinochloa walteri	Herb:
Comments:	Comments:	Comments:

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 24	Ob# 25	Ob#
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Asiepias incarnata			
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens connata			
Bidens coronata			
Bidens frondosa			
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus			
Echinochloa crusgalli			
Echinochloa walteri	COM	ABUN	
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	FRE	FRE	
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 24	Ob# 25	Ob#
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides	ABUN	COM	
Leersia virginica			
Lemna minor		COM	
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris	COM	COM	
Ludwigia peploides			
Lycopus sp.			
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica			
Phalaris arundinacea			
Phragmites australis			
Pluchea odorata			
Polygonum sp.	INF		
P. hydropiperoides			
P. punctatum			
P. sagittatum			
Pontederia cordata			
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.	COM	FRE	
Sagittaria calycina			
S. latifolia			
Salix nigra			
Samolus parvulus			
Scirpus cyperinus			
S. tabernaemontani		INF	
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 24	Ob# 25	Ob#
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia		INF	
Vaccinium corymb.			
Viburnum recogn.	COM	ABUN	
Viola sp.			
Wolffia braziliensis			
Zizania aquatica			
OTHER			
Baccharis halimifolia	FRE		
Diospyros virginiana	COM		
Rhus copalina	COM		

F. ADDITIONAL NOTES:

FORM 1: RECONNAISANCE / DELAWARE DRAFT 1993 **MARSH SURVEYS**

A. IDENTIFIERS/LOCATION

1. Survey site name: AUGUSTINE CREEK
2. Site name: AREA (P)
3. Source Code: F93WIN Ø8
4. Surveyors: C. WINTERS, B. McAVOY
5. Date: 090393
6. USGS Quad: DELAWARE CITY
7. Quadcode: 3907555
8. State: DE
9. County: NEW CASTLE
10. Town: PORT PENN
11. Directions:

Observation points 3, 4 and 5 are reached by taking the Port Penn - Boyd's Corner Road west from Port Penn (RT. 420). Close to the intersection (from the right/north) with the Thoumtown Road (RT. 418), take the farm road to the left. Follow to house of Ed Fortner - ask permission to enter property. Obs. #3 is from a boardwalk.

B. TOPOGRAPHY

12. Reconnaisance Diagram:

C. VEGETATION/HABITAT

Observation Point: 1	Observation Point: 2	Observation Point: 3
Community name: [HISTORICALLY] TIDAL BRACKISH MARSH	Community name: FRESHWATER MARSH	Community name: ? Tidal FRESH → BRACKISH MARSH
Soil comments: SATURATED → INUNDATED MUCKY SUBSTRATE	Soil comments: SATURATED → INUNDATED	Soil comments: SATURATED → INUNDATED
Dominant species Tree/Shrub: VIBURNUM	Dominant species: Tree/Shrub: Acer rubrum	Dominant species: Tree/Shrub: /
Herb: HIBISCUS / SAGITTARIA	Herb: ZIZANIA AQUATICA	Herb: HIBISCUS MOSCHEUTOS
Comments: Species composition similar to AREA (B). Area observed from boardwalk. Higher elevations have woody vegetation. Occurence of Phrag. increases to dominance at creek/open water. Low water.	Comments: This pure stand of Z. aquatica was found in the middle of a wooded swale - headwaters of stream leading to Augustine marsh. Nearby is monotypic stand of Phrag.	Comments: Following the creek toward Aug. Marsh from OB. #2, the marshes along the creek supported stands of Hibiscus, Typha, and Phrag. Generally low diversity. Appears to have been quite disturbed.

D. OBSERVATION POINTS LOCATIONS (in space below attach topo photocopy and indicate precise location of observation points)

N

USGS DELAWARE CITY QUAD

X 165%

E. LIST OF PLANT SPECIES [by strata and w/cover values: [estimate percent cover values]

Species	Ob # 1	ob # 2	Ob # 3
Acorus calamus			
Alisma subcordatum			
Amaranthus cannabinus			
Ambrosia trifida			
Amorpha frutescens			
Apios americana			
Aslepias incarnata var. pulchra	INF		
Aster puniceus			
Aster sp.			
Bidens bidentoides			
Bidens sp.			ABUN
Bidens coronata			
Bidens frondosa		FRE	
Bidens laevis			
Bidens polylepis			
Carex stricta			
Carex sp.			
Cephalanthus occidentalis			
Ceratophyllum demersum			
Cicuta maculata			
Cinna arundinacea			
Clethra alnifolia			
Cornus amomum			
Cornus racemosa			
Cryptotaenia canadensis			
Cuscuta sp.			
Cyperus odoratus			
Cyperus engelmannii			
Cyperus erythrorhizos			
Cyperus esculentus			
Cyperus sp.			
Decodon verticillatus	FRE		
Echinochloa crusgalli			
Echinochloa walteri	FRE		COM
Eleocharis obtusa			
Eleocharis palustris			
Eleocharis parvula			
Eleocharis tenuis			
Erechtites hieracifolia			
Eupatorium sp.			
Euthamia sp.			
Fraxinus pensylvanica			
Glyceria sp.			
Heteranthera reniformis			
Hibiscus moscheutos	ABUN		ABUN
Humulus japonicus			
Hydrocotyle americana			
Ilex opaca			
Ilex verticillata			

Species	Ob # 1	ob# 2	ob# 3
Impatiens capensis			
Iris pseudacorus			
Iris versicolor			FRE
Juncus acuminatus			
Juncus canadensis			
Juncus effusus			
Leersia oryzoides		COM	ABUN
Leersia virginica			
Lemna minor	COM		
Lilaeopsis chinensis			
Lilium superbum			
Lobelia cardinalis			
Ludwigia palustris			
Ludwigia peploides			
Lycopus americanus	FRE		
Lysimachia terrestris			
Lythrum salicaria			
Nuphar lutea			
Osmunda cinnamomea			
Oxypolis rigidior			
Panicum virgatum			
Panicum sp.			
Peltandra virginica	FRE		
Phalaris arundinacea			
Phragmites australis	FRE	COM	ABUN
Pluchea odorata			
Polygonum arifolium	COM		
P. hydropiperoides			
P. punctatum			
P. sagittatum			
Pontederia cordata			
Ptilimnium capillac.			
Riccia fluitans			
Rosa palustris			
R. multiflora			
Rumex verticill.	FRE		
Sagittaria calycina			
S. latifolia	COM		
Salix sp.		FRE	
Samolus parvulus			
Scirpus cyperinus			
S. fluviatilis			
S. pungens			
S. robustus			
Sium suave			
Sparganium eurycarp.			
Spartina alterniflora			
S. cynosuroides			
Spirodela polyrhiza			

Species	Ob # 1	ob # 2	Ob# 3
Thalictrum pubescens			
Thelypteris palustris			
Toxicodendron rad.			
Triad. virginicum			
Typha angustifolia			
T. x glauca			
T. latifolia			COM
Vaccinium corymb.			
Viburnum sp.	COM		
Viola sp.			
Wolffia braziliensis			
Zizania aquatica		ABUN	
OTHER			
Scutellaria lateriflora	INF		
Rhus copalina	FRE		
Diospyros virgiana	FRE		
Lonicera japonica	FRE		
Boehmeria cylindrica		FRE	
Onoclea sensibilis		FRE	
Acer rubrum		COM	
Erigrostis hyemale			FRE
Microstegium viminaum			COM

F. ADDITIONAL NOTES:

Dept. of Natural Resources & Environmental Control
Division of Fish & Wildlife
Richardson/Robbins Building
P.O. Box 1401
Dover, Delaware 19903

Official Business, Penalty For Private Use $300.

APPENDIX G

NORTHERN DELAWARE

WETLANDS REHABILITATION PROGRAM

The Northern Delaware Wetlands Rehabilitation Program was established by the Department of Natural Resources and Environmental Control to bring together civic and business leaders, scientists, resource managers, and property owners to develop strategies to restore nearly 10,000 acres of wetlands—31 distinct sites—along the Christina and Delaware rivers in New Castle County.

Nearly 10,000 acres of tidal freshwater marshes in New Castle County are targeted for restoration by the Northern Delaware Wetlands Rehabilitation Program.

These marshes once contained some of the state's richest waterfowl populations and served as important nursery grounds and breeding habitat for a wide variety of fish and other wildlife.

They also helped filter pollutants and sediments out of river water and provided a buffer zone during storms, protecting properties from flooding.

The marshes that are the focus of this recovery initiative have undergone a varied history of change over the years: some were drained by early Dutch and Swedish settlers, who wanted to turn marshland into farmland. Other areas were drained in hopes of decreasing mosquito populations. And still other wetlands were drained to support a growing population and its attendant industrial, residential, and highway expansion.

Despite nearly three centuries of environmental abuse, however, Delaware's northern marshes *can* be brought back to life.

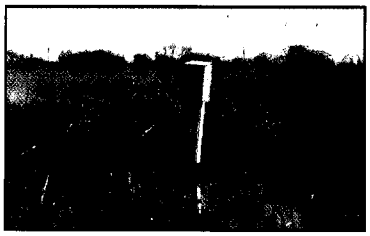
How Do You Restore a Marsh?

The Northern Delaware Wetlands Rehabilitation Program seeks to achieve the following goals.

Improve Water Quality. One key to restoring most degraded marshes is to re-establish their hydrology—that is, daily tidal exchange between marsh and river. Water control structures can be installed, permitting the tides to flush nutrients and aquatic organisms into and out of the marsh as well as increase the volume of water that can be cleansed by the wetland.

Another key is controlling the inputs of pollution to the marsh, conveyed during storms, through implementation of non-point source control plans.

Increase Wildlife Populations. Constructing duck and songbird boxes, establishing preferred food and cover plants, adjusting water levels to accommodate the needs of aquatic mammals, water birds, and endangered species, and increasing the diversity of shallow-water habitats—ponds, ditches,



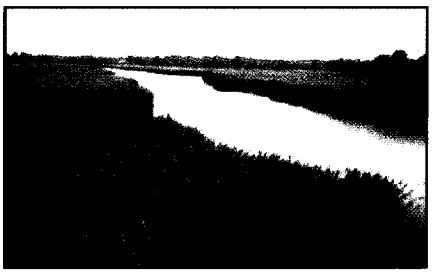
Installing wood duck boxes is just one way to help attract wildlife back to once-degraded marshes.

and islands—all can help attract wildlife to once-damaged marshes.

Control Nuisance Plants. *Phragmites* is a tall, tasseled plant that can overtake a wetland, forming dense stands of little value to wildlife. When interspersed among other plants and open water, however, *Phragmites* can provide good habitat. Thus, the goal is to control rather than eradicate this plant. The current practice is to spray *Phragmites* with herbicides in late summer, followed by the controlled burning of dead, standing canes during winter.

Control Mosquitoes. Historically, wetlands were drained as a mosquito control measure. However, removing the water from the wetland surface creates a prime egg-laying site for floodwater mosquito species. Heavy rains or malfunctioning tide gates can then flood the marsh, permitting mosquito eggs to hatch and the larvae to develop, essentially promoting mosquito breeding.

Several practices can help control mosquito populations in wetlands and decrease the



Phragmites *is a tall, tasseled reed that can quickly overtake a wetland, forming thick stands that are relatively useless as wildlife habitat. Controlling the spread of this plant is a major goal of marsh restoration.*

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use of insecticides: increase the abundance of mosquito-eating fish and insects, increase the access of these species to mosquito breeding areas, and eliminate mosquito egg-laying sites.

Control Flooding. Wetlands help soak up water during heavy rains. Rehabilitation efforts focus on installing new water control structures or improving the efficiency of existing ones to expedite floodwater removal without flooding adjacent properties.

Reduce Shoreline Erosion. As buffer strips between land and sea, wetlands absorb wave action and protect shoreline soils with an extensive root network. These features can be enhanced by revegetating exposed shoreline or installing other forms of erosion control, such as riprap.

Improve Recreational & Educational Opportunities. Rehabilitation plans for many wetlands include installing nature trails and greenways, observation towers, and canoe and boat ramps. Environmental curricula will give school groups and the public the opportunity to learn more about wetlands and their values.

What Wetlands Are Targeted for Rehabilitation?

Planning has begun for rehabilitating four northern marshes: Gambacorta and Broad Dyke marshes in New Castle, Augustine Marsh near Port Penn, and Old Wilmington Marsh.

Gambacorta Marsh. This 41-acre marsh, located within the New Castle city limits, is owned by the Trustees of New Castle Common. It is bordered on the east by a recreational trail that runs atop a dike, which isolates the marsh from the Delaware

WHY SHOULD WE RESTORE DELAWARE'S NORTHERN MARSHES?

What good is a marsh? To some folks, the word marsh is synonymous with "muck" and "mosquitoes." But a marsh is worth much more than that. . . .

- Like giant kidneys, marshes filter out nutrients, suspended sediments, toxic substances, and other pollutants from local waters thereby improving water quality.
- Coastal freshwater marshes support the largest and most diverse populations of birds and are vital habitats for ducks, geese, herons, egrets, and shorebirds. Many other wildlife depend on wetlands, from deer to turtles.
- The wetlands of the Delaware and Christina rivers provide spawning, nursery, and feeding sites for eels, shad, herring, catfish, crabs, and perch.
- Many endangered species depend on wetlands for survival. In Delaware, 38% of the state's endangered species rely on wetlands for breeding, nesting, foraging, or resting. These species range from barking tree frogs to bald eagles and bog turtles.
- A marsh is like a big sponge during heavy rains, soaking up floodwater and then slowly releasing it downriver after peak storm flows have subsided.
- Wetlands act as buffer strips between sea and mainland, absorbing wave action from storms, and thereby reducing shoreline erosion.
- Marshes provide a wealth of recreational activities including birdwatching, boating, fishing, wildlife photography, hunting, hiking, and crabbing.

Wetlands provide a host of benefits, from cleansing coastal waters of pollutants to providing vital wildlife habitat.

nt Phragmites *control es aerial spraying of ant with an herbicide g the late summer the plant is storing ter reserves. As the stores nutrients, it akes in the herbicide, weakens and kills ant.*

The winter after Phragmites *is sprayed with an herbicide, the dead, standing canes are burned, freeing areas for colonization by plants more beneficial to wildlife.*

River. However, the dike does contain a water control structure. On its other three sides, the marsh is surrounded by urban and commercial development.

Part of the marsh was drained and used as landfill for industrial waste. However, the waste has been removed, and the landfill site has been capped.

Gambacorta Marsh is already on the rebound. *Phragmites* control efforts have cleared part of the marsh, the addition of wildlife habitat enhancement structures has attracted more waterfowl, the water control structure has been temporarily modified to allow daily tidal exchange, and a water management plan has been implemented.

Preliminary plans call for permanently modifying the existing water control structure to allow for daily tidal exchange, clearing clogged waterways to increase open water habitat, continuing *Phragmites* control, and enhancing the recreational and educational opportunities presented by the walkway.

Broad Dyke Marsh. Located north of New Castle and owned by the Trustees of New Castle Common and New Castle Immanuel Episcopal Church, this 210-acre tidal freshwater marsh is bordered on three sides by housing developments and separated from the Delaware River by a dike containing a water control structure.

This structure is designed to allow a one-way flow of water—out of the marsh. Occasional malfunctions, however, have caused flooding of adjacent properties. In addition, the one-way exchange of water has degraded the marsh and made it a potential breeding ground for mosquitoes. Plant and animal diversity are down, and *Phragmites* has taken over parts of the marsh.

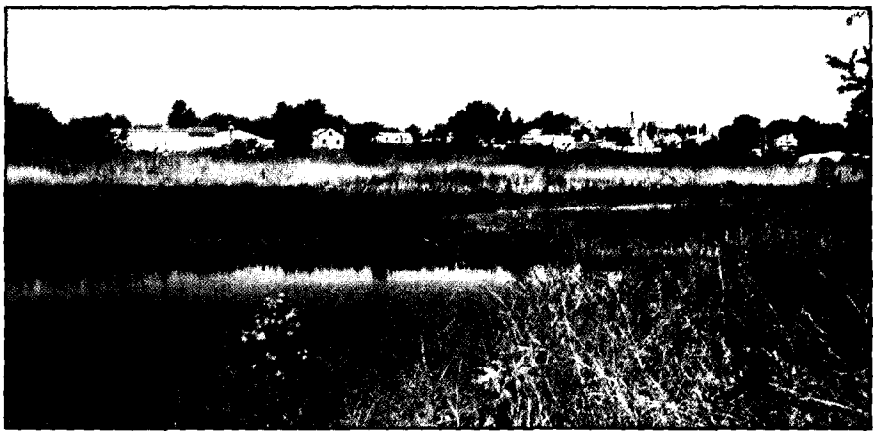
A recent temporary water management plan allowing tidal exchange, combined with a *Phragmites* control program and installation of wildlife enhancement structures, has restored much of the marsh's biodiversity. A design for a new water control structure also has been selected. It will allow managers to continue to improve tidal exchange between marsh and river, and release floodwaters rapidly during major storms.

Preliminary plans call for adding more wildlife enhancement structures and open water habitat for mosquito-eating fish, continuing *Phragmites* control, and building a trail, boardwalk, observation tower, and canoe launch.

Augustine Creek Marsh. This 1,130-acre wetland south of Port Penn is bordered to the east by Route 9 and surrounded by agricultural lands. The wetland is owned by many different landowners including the State and Delaware Wildlands Inc., a private nonprofit conservation organization.

Restoration efforts can bring back a diversity of plants to a formerly degraded marsh, providing attractive habitat for waterfowl, turtles, and other wildlife.

Migrating and wintering waterfowl make extensive use of the 912-acre tidal impoundment within this wetland as do migrating neotropical shorebirds. Surrounding the impoundment are forested areas that are critical habitat for many wildlife,



Gambacorta Marsh in New Castle already is beginning to rebound from years of environmental abuse.

This technician is checking a water sample for mosquito larvae. Years ago, many New Castle County marshes were drained as a mosquito control measure. But over time, these areas became less efficient in removing rainwater and essentially promoted mosquito breeding.

Marshes provide a host of environmental benefits, from filtering pollutants from the water to providing wildlife habitat, but they also offer us a wide range of recreational opportunities, from canoeing and fishing, to birdwatching and other activities.

BRINGING THE PAST TO LIFE IN DELAWARE'S MARSHES

Not long after their arrival in Delaware in the 1600s, Dutch and Swedish settlers began to build dikes to drain the extensive freshwater tidal marshes of the northern portion of the state. Today, some 300 years later, a nearly continuous series of dikes and tide gates extends from Wilmington south along the lower Delaware River to Port Penn, and west along the Christina River to Churchman's Marsh.

Urbanization, coupled with drainage activities, destroyed or seriously damaged many of Delaware's northern wetlands, which once boasted the largest waterfowl populations in the state. The top photo was taken of Broad Dyke Marsh, near New Castle, in the 1940s. The bottom photo shows the same marsh in 1973. With proper management techniques, once-degraded marshes can be restored.

Despite this rigorous drainage system, as recent as 40 years ago, many of northern Delaware's tidal marshes were still productive habitats, thick with stands of wild rice, cattails, sweet flag, rushes, smart weed, and other plants favored by birds, waterfowl, muskrats, and many other wildlife.

Indeed, these marshes were full of life. Aerial waterfowl censuses in 1950–51 registered from 705 to 1,516 waterfowl per square mile—dramatically eclipsing the statewide average of 155 waterfowl per square mile. An aerial count on November 1, 1950, recorded as many as 15,000 pintail ducks on the Newport marshes at one time. And in 1957, the marsh areas from the Christina River to the C&D Canal were estimated to produce about 20,000 muskrat hides each year. Eventually, however, increasing urbanization and constant drainage took their toll on these marshes, rendering many areas unsuitable for wildlife.

Can these marshes be saved? A major restoration project at the 615-acre Dragon Run Creek Impoundment, just northwest of Delaware City, is proving that through water management and water-quality improvement, the past *can* be brought to life again. This site is now a diverse wetland with more than 35 plant and 200 bird species, an abundance of game fishes including largemouth bass and chain pickerel, and a wide range of mammals such as beaver, otter, and mink. Presently, Dragon Run Creek Impoundment is one of the most important waterfowl areas in northern Delaware.

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