National Wetlands Inventory
Region 5

WETLANDS INVENTORY REPORT FOR RADFORD ARMY AMMUNITION PLANT, MONTGOMERY AND PULASKI COUNTIES, VIRGINIA

U. S. FISH AND WILDLIFE SERVICE
JANUARY 2002

Wetlands Inventory Report for Radford Army Ammunition Plant
Montgomery and Pulaski Counties, Virginia

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A National Wetlands Inventory Special Report

January 2002

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INTRODUCTION

The U.S. Fish and Wildlife Service (Service) is the nation's leading agency for fish and wildlife management and conservation. Since the late 1970s, the Service's National Wetlands Inventory Program (NWI) has been producing large-scale wetlands maps and digital data for the country and preparing reports on wetland status and trends. The U.S. Army has numerous wetlands on their facilities and is interested in knowing more about the location, distribution, and types of these wetlands for resource management and other operations purposes. In August 1996, the U.S. Army and the Service entered into an agreement which provided funds to the Service to perform wetland inventories on selected military installations. To date, twenty two facilities have been inventoried. The inventories were to map wetlands based on standard NWI techniques, produce a digital wetland map database for the facility, provide four paper copies of final quad-sized maps and one set of clear reproducibles, and prepare a report describing the procedures used and a summary of the wetland acres by classification type for the installation. This report summarizes the results of the wetland inventory for the Radford Army Ammunition Plant.

Study Area

The subject report presents the findings of the wetlands inventory for the Radford Army Ammunition Plant. The Radford AAP includes two separate units, the New River Unit (2,840 acres) and the Radford Unit (6,901 acres). The Radford facilities are located in the heart of Southwest Virginia's New River Valley, in the Blue Ridge Mountain foothills. The New River drainage is a gently rolling land dissected by relatively shallow to moderate drainage ways.

Figure 1. Classification of hierarchy of wetlands and deepwater habitats. (Source: Cowardin, et al. 1979)

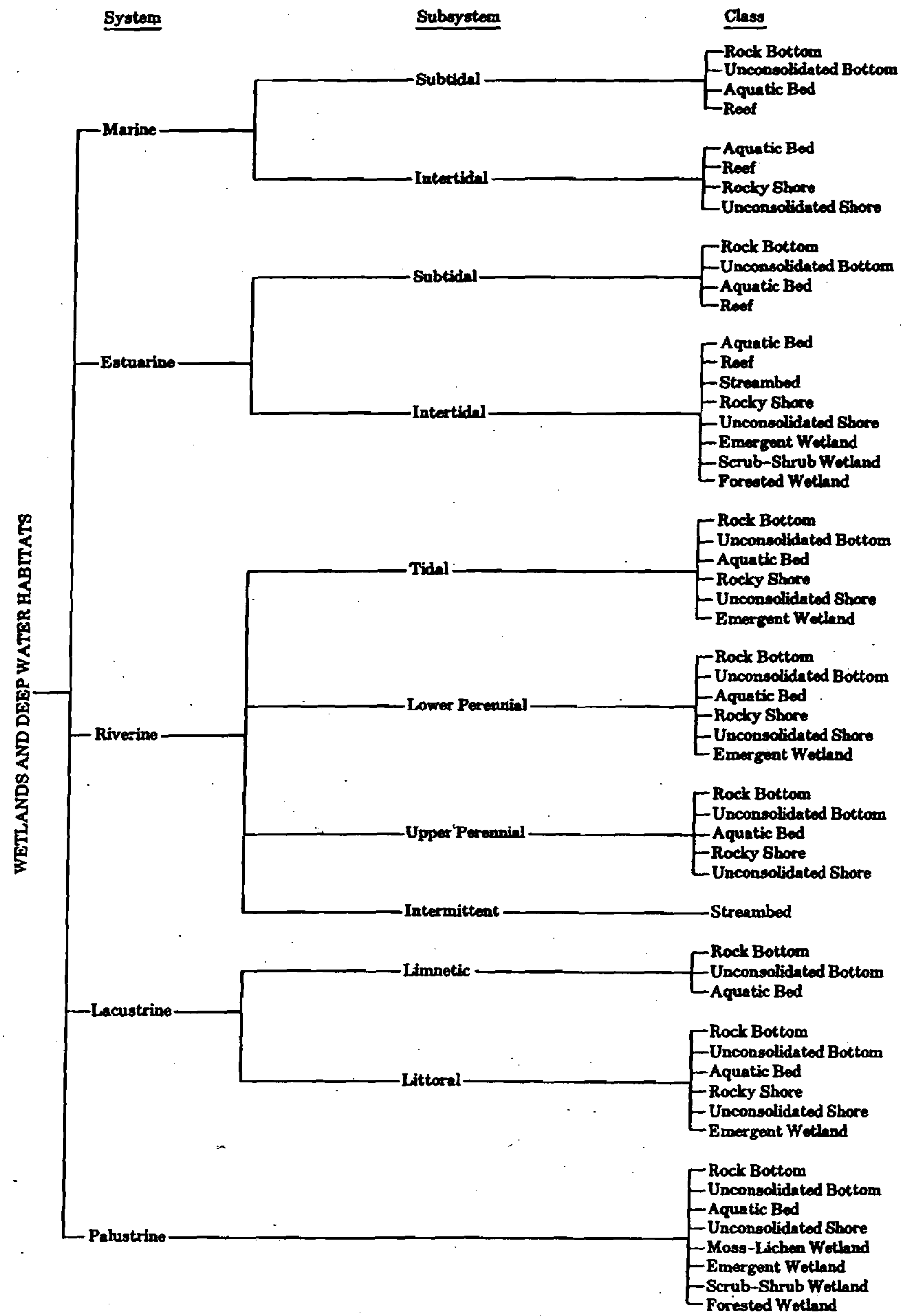

Figure 2. Typical Wetlands at Radford AAP

Cattail Marsh

Pond

Emergent Wetland Vegetation

Saturated Emergent Wetland

Wetland Vegetation along Stream

METHODS

The wetlands inventory was based on conventional photointerpretation techniques using mid-altitude aerial photography. Photointerpretation involves a number of steps: 1) initial review of aerial photos for likely wetlands identifying potential photo-signatures of wetland types and planning a field reconnaissance trip to the study area, 2) conduct field inspection to correlate photo-signatures with specific wetland types and to answer questions such as whether a particular signature indicates wetland or not and to collect data on wetland plant communities and soil types, 3) perform stereoscopic photointerpretation (including consultation of collateral data especially U.S. Department of Agriculture soil surveys), 4) prepare draft wetland maps, 5) conduct draft map review field work to verify accuracy of mapping, 6) make necessary edits to draft maps, and 7) compile final NWI maps. Prior to final publication, the maps are digitized to create a digital wetland map database for geographic information system (GIS) applications. This allows production of color-coded maps that show wetlands and deepwater habitats for the facility.

Wetlands and deepwater habitats were classified according to the Service's official wetland classification system (Cowardin, et al. 1979; Appendix A). Wetlands were typed to ecological system, subsystem, class, subclass, water regime, and special modifiers (Figure 1; Appendix A). Wetlands were also classified by hydrogeomorphic-type descriptors to indicate a wetland's landscape position, landform, and water flow path (Tiner 1997; Appendix B).

The aerial photography for this project was 1:40,000 color infrared acquired on April 11,1996. With this imagery, wetlands 1 acre and larger were consistently mapped. Every effort was made to identify wetlands on the facility within the inherent limitations of photointerpretation technology. Photointerpretation followed standard NWI conventions (U.S. Fish and Wildlife Service 1995).

The initial field reconnaissance trip took place on November 28, 2000. John Swords (project coordinator for the Service) and Charles Chase (Radford AAP) participated in this trip to ground-truth aerial photography for photointerpretation. The draft map review field trip occurred on Oct 11, 2001. National quality assurance of the photointerpretation was performed by NWI Center (NWIC) staff at St. Petersburg, Florida.

Map production and construction of the wetlands digital database, data analysis, GIS processing, custom map preparation, and report preparation were prepared by the Service's NWI regional staff in Hadley, Massachusetts

RESULTS

Wetland , Deepwater Habitat, HGM Maps and Digital Database

Maps showing wetlands and deepwater habitats for the Radford AAP (both facilities) were prepared and were provided to the facility's personnel along with the NWI paper and mylar maps for the facility. Map data were digitally prepared to create a digital database of wetlands, deepwater habitat and HGM classifications for the Radford AAP.

Wetland Types

Table 1 presents examples of wetland plant communities with dominant and common species given. Thirteen species of plants were observed at Radford AAP's wetlands: 3 tree species, 9 herbs and 1 aquatic species. (Table 2). Appendix C contains copies of field data sheets completed during ground-truthing exercises.

Palustrine unconsolidated bottom wetlands were most common on the facility (See Table 1). From the Hydrogeomorphic approach, most of the facility's ponds were most common.

TABLE 1. Examples of palustrine wetland plant communities at Radford AAP

Wetland Type (Map Code)	**Dominant Species**	**Common Associates**
Forested, Deciduous, Emergent , Persistent, Wetland, Temporarily, Flooded (PFO1A)	Red Maple	Sycamore, Black Gum
Emergent Wetland Persistent, Seasonally, Flooded, Saturated (PEM1E)	Cattail	Bluejoint, Sedge
Emergent Wetland, Phragmites, Seasonally Flooded, Excavated (PEM5Cx)	Phragmites	Cattail

TABLE 2. List of plants observed in Radford AAP's wetlands.

Trees
Black Gum *(Nyssa sylvaticum)*
Red Maple *(Acer rubrum)*
Sycamore *(Platanus occidentalis)*

Herb
Beak Rush (*Rhynchospora capitellata)*
Bluegrass (*Poa* sp.)
Broad-leaved Cattail *(Typha latifolia)*
Bluejoint (*Calamagrostis canadensis)*
Broom Sedge(*Carex scoparia)*
Canada Rush (*Juncus canadensis)*
Common Reed (*Phragmites australis)*
Sedge (*Carex* sp.)
Soft Rush (*Juncus effusus)*

Aquatic Bed
Duckweed (*Lemna minor)*

Wetland, Deepwater Habitat and HGM Acreage Summaries

Radford AAP Radford Unit contains 13 acres of wetland habitat and 225 acres of deepwater habitat. The New River Unit contains 3.5 acres of wetland habitat. This combined acreage amounts to 2 percent of the facility's total land area. Appendix D contains printouts of the statistical data for individual wetland and deepwater types as they were classified on the NWI map.

Palustrine unconsolidated bottom wetlands were the predominant type, representing fifty percent of the facility's wetlands. Riverine, lower perennial, unconsolidated bottom habitat was the only deepwater type. Linear wetlands totaled 13.2 miles including rivers and streams.

Hydrogeomorphic type (HGM) wetlands at Radford AAP were principally

NWI Wetland Type	**Acreage**
Palustrine Unconsolidated Bottom	8.34
Riverine Unconsolidated Shore	3.59
Palustrine Forested	2.69
Palustrine Emergent	1.64
Palustrine Unconsolidated Shore	0.30
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Total	**16.65**

Deepwater Habitat	
Riverine Unconsolidated Bottom	221.9
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Total	**225.5**

HGM Type	**Acreage**
Lotic Stream, Flat	0.48
Lotic River Floodplain	2.69
Terrene Flat, Isolated	0.18
Lotic Stream, Floodplain	0.48
Terrene Basin, Isolated	0.99
Ponds	8.64
Total	**13.46**

Deepwater Habitats

River Throughflow	225.55
Total	**225.55**

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DISCUSSION

Use of the Wetlands Inventory Maps

The NWI maps contain various alpha-numeric codes that describe a number of wetland and deepwater habitat characteristics including vegetation type (life-form), hydrology, water chemistry, and special modifiers (beaver and human impacts). A publication entitled "NWI Maps Made Easy" is provided in Appendix E to aid in interpreting map codes. This document plus the summary of wetland types in the results section should help users begin to translate the codes into familiar wetland types observed on the facility.

The maps show wetlands and deepwater habitats defined ecologically. Regulatory wetlands are often a subset of the ecologic wetlands and generally must meet certain requirements in order to be considered jurisdictional. The U.S. Army Corps of Engineers (Corps) is responsible for regulating vegetated wetlands under the Clean Water Act and the Rivers and Harbors Act. The Corps had developed a manual to identify wetlands (Environmental Laboratory 1987) and subsequent guidance memoranda re: clarification of the manual. According to the Corps manual, an area qualifies as a regulated wetland when it possesses positive indicators of three parameters: 1) hydrophytic vegetation, 2) hydric soil, and 3) wetland hydrology. While the so-called "three-parameter test" works well for identifying the wetter wetlands (i.e., permanently flooded, semipermanently flooded, and seasonally flooded types) as regulated wetlands, the drier-end wetlands (i.e., seasonally saturated and temporarily flooded types) may not satisfy the regulatory criteria (Tiner 1999 for detailed review of wetland delineation and related topics). Consequently, numerous flatwood wetlands may not have the necessary indicators to be regulated under current guidelines. While field delineations following manual protocols are required to determine the presence and extent of regulated wetlands, the wetland maps will help separate the following areas: 1) wetlands that will most likely qualify as potentially regulated wetlands, 2) wetlands that may or may not qualify as such, and 3) typical uplands (Table 3). The latter areas may possess wetland inclusions, particularly wetlands that were not mapped due to their small size (less than 1 acre) or that were not photointerpretable. See Appendix F. for an overview of NWI mapping strengths and weaknesses.

Wetland Publications

A list of wetland publications that maybe of interest is included as Appendix G. Also see Reference section for other publications.

TABLE 3. NWI wetlands and their likelihood for regulation under current federal guidelines. Examples of common map codes are used to designate wetland types for ease of interpreting the maps. F = Semipermanently Flooded; C = Seasonally Flooded; A = Temporarily Flooded; B = Saturated (seasonal).

Wetland Type or Upland (Map Codes)	**Likelihood for Regulation**
Semipermanently Flooded Wetlands (e.g., PEM1F, PSS1F, and PFO2F)	High
Seasonally Flooded Wetlands (e.g., PEM1C, PSS1C, PFO1C, and PFO4C)	Moderate to High
Temporarily Flooded Wetlands (e.g., PFO1A, PFO4A, PFO1/4A, PFO4/1A, and PSS1A)	Possible
Saturated Wetlands (e.g., PEM1B, PSS1B, PFO1B, PFO4B, and PFO4/1B)	Questionable
Uplands (U)	Not Regulated (may be wetland inclusions within these units)

NOTE: *The above decisions are based on considerations of water regimes and the likelihood that the wetland would have necessary indicators to satisfy regulatory requirements. Field studies are actually required to make site-specific determinations.*

General Wetland Functions and Values

The location of wetlands along rivers, streams, lakes, and estuaries facilitates the performance of certain functions. These functions are physical, chemical, and biological processes that exert a significant influence on plants, animals, and hydrology of these sites. Major wetland functions include water storage, maintenance of high water tables, nutrient cycling, sediment retention, accumulation of organic matter, and maintenance of plant and animal communities (Table 4: Tiner 1998). These functions may be performed throughout year or only at particular times. They also generate certain services that people now recognize as valuable whereas, in the past, wetlands were largely viewed as wastelands whose best use could only be attained through conversion to farmland or filled for development of various kinds.

Wetlands have been traditionally used for hunting, trapping, fishing, timber and hay production, and livestock grazing. These uses tend to preserve the wetland integrity, although the qualitative nature of wetlands may be modified, especially for salt hay and timber harvest. Wetlands in their natural state provide a wealth of values to society (Table 4). These benefits can be divided into three basic categories: 1) fish and wildlife values, 2) environmental quality values, and 3) socioeconomic values. The following discussion emphasizes the more important values of America's wetlands. For more information on wetland values, the reader is referred to "In Search of Swampland: A Wetland Sourcebook and Field Guide" (Tiner 1998), and "Wetlands" (Mitsch and Gosselink 1993). See Appendix F for list of other wetland publications.

TABLE 4. Major wetland functions and some of their values. (Source: Tiner 1998).

Function	Value
Water storage	Flood- and storm-damage protection, water source during dry seasons, groundwater recharge, fish and shellfish habitat, water source for fish and wildlife, recreational boating, fishing, shellfishing, waterfowl hunting, livestock watering, ice skating, nature photography, aesthetic appreciation
Slow water release	Flood-damage protection, maintenance of stream flows, maintenance of fresh and saltwater balance in estuaries, linkages within watersheds for wildlife and water-based processes, nutrient transport, recreational boating
Nutrient retention and cycling	Water-quality renovation, peat deposits, increases in plant productivity, decreases in eutrophication, pollutant abatement, global cycling of nitrogen, sulfur, methane, and carbon dioxide, reduction of harmful sulfates, production of methane to maintain Earth's protective ozone layer, mining (peat)
Sediment retention	Water-quality renovation, reduction of sedimentation of waterways, pollution abatement (contaminant retention)
Provision of substrate for plant colonization	Shoreline stabilization, reduction of flood crests and water's erosive potential, plant-biomass productivity, peat deposits, organic export, fish and wildlife habitat (specialized animals, including rare and endangered species), aquatic productivity, trapping, hunting, fishing, nature observation, production of timber and other natural commodities, livestock grazing, scientific study, environmental education, nature photography, aesthetic appreciation

Fish and Wildlife Values

Fish and wildlife utilize wetlands in a variety of ways. Some spend their entire lives in wetlands, while others use wetlands primarily for reproduction and nursery grounds. Many fish and wildlife frequent marshes and swamps for feeding or feed on organisms produced in wetlands. Wetlands are also essential for survival of numerous endangered animals and plants with more than half of the nation's federally listed species dependent on wetlands to meet the requirements for at least one life history stage.

Most freshwater fishes find wetlands essential for survival. In fact, nearly all freshwater fishes can be considered wetland-dependent because: 1) many species feed in wetlands or upon wetland-produced food, 2) many fishes use wetlands as nursery grounds, and 3) almost all important recreational fishes spawn in the aquatic portions of wetlands (Peters, et al. 1979). Chain and grass pickerels, basses, crappies, bluegills, bullheads, and carp are common species.

Waterfowl and Other Bird Habitat

In addition to providing year-round habitats for resident birds, wetlands are particularly important as breeding grounds, overwintering areas and feeding grounds for migratory waterfowl and numerous other birds.

Inland wetlands serve as important nesting, feeding, and resting areas for other resident and migrating birds. Some species using wetlands includes great crested flycatchers, pine warblers, towhees, chickadees, titmouses, prothonotary warblers, scarlet tanagers, vireos, acadian flycatchers, ovenbirds, black and white warblers, catbirds, common yellowthroats, brown creepers, hooded warblers, black throated green warblers, eastern wood pewees, wood thrushes, parula warblers, yellow warblers, redstarts, and song sparrows. American bitterns, various waterfowl, long-billed marsh wrens, red-winged blackbirds, and swamp sparrows nest in freshwater marshes, while veeries and yellowthroats utilize forested wetlands and wet thickets, respectively.

Wetlands are, therefore, crucial for the existence of many birds, ranging from waterfowl and shorebirds to migratory songbirds. Some spend their entire lives in wetland environments, while others primarily use wetlands for breeding, feeding, or resting.

Muskrat and beavers are the most important furbearers in the United States and they depend on wetlands. Muskrats are more abundant and wide ranging, inhabiting both coastal and inland marshes. Other wetland-utilizing furbearers include river otter, mink, raccoons, skunks, foxes, and weasels. Smaller mammals also frequent wetlands such as marsh and swamp rabbits, rice rats, numerous mice, meadow voles, bog lemmings and shrews, while large mammals, including white-tailed deer, may also be observed.

Other wildlife make their homes in wetlands. Reptiles (i.e., turtles and snakes) and amphibians (i.e., frogs and salamanders) are important residents. Turtles are most common in freshwater marshes and ponds. The more important ones nationally are the painted, spotted, Blanding's map, pond, musk and snapping turtles (Clark 1979). Many snakes also inhabit wetlands, with water snakes being most abundant throughout the U.S. (Clark 1979).

Nearly all of the approximately 190 species of amphibians in North America are wetland-dependent, at least for breeding (Clark 1979). Frogs occur in many freshwater wetlands and common frogs include the bull, green, leopard, mink, pickerel, wood, and chorus frogs and spring peepers. Many salamanders use temporary ponds or wetlands for breeding, although they may spend most of the year in uplands. Numbers of amphibians, even in small wetlands, can be astonishing. For example, 1,600 salamanders and 3,800 frogs and toads were found in a small gum pond (less than 100 feet wide) in Georgia (Wharton 1978).

Environmental Quality Values

Besides providing habitat for fish and wildlife, wetlands play a less conspicuous but essential role in maintaining high environmental quality, especially for aquatic habitats. They do this in a number of ways, including purifying natural waters by removing nutrients, chemical and organic pollutants, and sediment, and producing food which supports aquatic life.

Water Quality Improvement

Wetlands help maintain good water quality or improve degraded waters in several ways: 1) nutrient removal and retention, 2) processing chemical and organic wastes, and 3) reducing sediment load of water. Wetlands are particularly good water filters because of their locations between land and open water. Thus, they can both intercept runoff from land before it reaches the water and help filter nutrients, wastes, and sediment from flooding waters. Clean waters are important to humans as well as to aquatic life.

First, wetlands remove nutrients, especially nitrogen and phosphorus, from flooding waters for plant growth and help prevent eutrophication or over-enrichment of natural waters. It is, however, possible to overload a wetland and thereby reduce its ability to perform this function. Every wetland has a limited capacity to absorb nutrients and individual wetlands differ in their ability to do so.

Wetlands have been shown to be excellent removers of waste products from water. Sloey and others (1978) summarize the value of freshwater wetlands at removing nitrogen and phosphorus from the water and address management issues. They note that certain wetland plants are so efficient at this task that some artificial waste treatment systems are using these plants. For example, the Max Planck Institute of Germany has a patent to create such systems, where a bulrush (Scirpus lacustris) is the primary waste removal agent. Numerous scientists have proposed that certain types of wetlands be used to process domestic wastes and some wetlands are already used for this purpose (Sloey, et al. 1978; Carter, et al. 1979; Kadlec 1979). It must, however, be recognized that individual wetlands have a finite capacity for natural assimilation of excess nutrients and research is needed to determine this threshold (Good 1982).

Perhaps the best known example of the importance of wetlands for water quality improvement is Tinicum Marsh (Grant and Patrick 1970). Tinicum Marsh is a 512-acre freshwater tidal marsh lying just south of Philadelphia, Pennsylvania. Three sewage treatments plants discharge treated sewage into marsh waters. On a daily basis, it was shown that this marsh removes from flooding waters: 7.7 tons of biological oxygen demand, 4.9 tons of phosphorus, 4.3 tons of ammonia, and 138 pounds of nitrate. In addition, Tinicum Marsh adds 20 tons of oxygen to the water each day.

Swamps also have the capacity for removing water pollutants. Bottomland forested wetlands along the Alcovy River in Georgia filter impurities from flooding waters. Human and chicken wastes grossly pollute the river upstream, but after passing through less than 3 miles of swamp, the river's water quality was significantly improved. The value of the 2,300-acre Alcovy River Swamp for water pollution control was estimated at $1 million per year (Wharton 1970).

Wetlands also play a valuable role in reducing turbidity of flooding waters. This is especially important for aquatic life and for reducing siltation of ports, harbors, rivers, and reservoirs. Removal of sediment load is also valuable because sediments often transport absorbed nutrients, pesticides, heavy metals, and other toxins which pollute our nation's waters (Boto and Patrick 1979). Depressional wetlands should retain all of the sediment entering them (Novitzki 1978). In Wisconsin, watersheds with 40% coverage by lakes and wetlands had 90% less sediment in water than watersheds with no lakes or wetlands (Hindall 1975). Creek banks of salt marshes typically support more productive vegetation than the marsh interior. Deposition of silt is accentuated at the water-marsh interface, where vegetation slows the velocity of water causing sediment to drop out of solution. In addition to improving water quality, this process adds nutrients to the creekside marsh which leads to higher density and plant productivity (DeLaune, et al. 1978).

The ability of wetlands to retain heavy metals has been reported (Banus, et al. 1974; Mudroch and Capovianca 1978; Simpson, et al. 1983c). Wetland soils have been regarded as primary sinks for heavy metals, while wetland plants may play a more limited role. Waters flowing through urban areas often have concentrations of heavy metals (e.g., cadmium, chromium, copper, nickel, lead, and zinc). The ability of freshwater tidal wetlands along the Delaware River in New Jersey to sequester and hold heavy metals has been documented (Whigham and Simpson1976; Simpson, et al. 1983a,b). Additional study is needed to better understand retention mechanisms and capacities in these and other type of wetlands.

Aquatic Productivity

Wetlands are among the most productive ecosystems in the world and some types of wetlands may be the highest, rivaling our best cornfield. Wetlands plants are particularly efficient converters of solar energy. Through photosynthesis, plants convert sunlight into plant material or biomass and produce oxygen as a by-product. Other materials, such as organic matter, nutrients, heavy metals, and sediment, are also captured by wetlands and either stored in the sediment or converted to biomass. This biomass serves as food for a multitude of animals, both aquatic and terrestrial. For example, many waterfowl depend heavily on seeds of marsh plants, especially winter, while muskrat eat cattail tubers and young shoots.

Although direct grazing of wetland plants may be considerable in freshwater marshes, their major food value to most aquatic organisms is reached upon death when plants fragment to form "detritus." This detritus forms the base of an aquatic food web that supports higher consumers, e.g., commercial fishes. Thus, wetlands can be regarded as the farmlands of the aquatic environment where great volumes of food are produced annually. The majority of non-marine aquatic animals also depend, either directly or indirectly, on this food source.

Socio-economic Values

The more tangible benefits of wetlands to society may be considered socio-economic values and they include flood and storm damage protection, erosion control, water supply and groundwater recharge, harvest of natural products, livestock grazing, and recreation. Since these values provide either dollar savings or financial profit, they are more easily understood by most people.

Flood and Storm Damage Protection

In their natural condition, wetlands serve to temporarily store flood waters, thereby protecting downstream property owners from flood damage. After all, such flooding has been the driving force in creating these wetlands to begin with. This flood storage function also helps to slow the velocity of water and lower wave heights, reducing the water's erosive potential. Rather than having all flood waters flowing rapidly downstream and destroying private property and crops, wetlands slow the flow of water, store it for a period of time, and slowly release stored waters downstream. This becomes increasingly important in urban areas, where development has increased the rate and volume of surface water runoff and the potential for flood damage.

In 1975, 107 people were killed by flood waters in the U.S. and potential property damage for the year was estimated to be $3.4 billion (U.S. Water Resources Council 1978). Almost half of all flood damage was suffered by farmers as crops and livestock were destroyed and productive land was covered by water or lost to erosion. Approximately 134 million acres of the conterminous U.S. have severe flooding problems. Of this, 2.8 million acres are urban land and 92.8 million acres are agricultural land (U.S. Water Resources Council 1977). Many of these flooded farmlands are wetlands. Although regulations and ordinances required by the Federal Insurance Administration reduce flood losses from urban land, agricultural losses are expected to remain at present levels or increase as more wetland is put into crop production. Protection of wetlands is, therefore, an important means to minimizing flood damages in the future.

The U.S. Army Corps of Engineers has recognized the value of wetlands for flood storage in Massachusetts. In the early 1970s, they considered various alternatives to providing flood protection in the lower Charles River watershed near Boston, including: 1) a 55,000 acre-foot reservoir, 2) extensive walls and dikes, and 3) perpetual protection of 8,500 acres of wetland (U.S. Army Corps of Engineers 1976). If 40% of the Charles River wetlands were destroyed, flood damages would increase by at least $3 million annually. Loss of all basin wetlands would cause an average flood damage cost of $17 million (Thibodeau and Ostro 1981). The Corps concluded that wetlands protection--"Natural Valley Storage"--was the least-cost solution to future flooding problems. In 1983, they completed acquisition of approximately 8,500 acres of Charles River wetlands for flood protection. Undeveloped floodplain wetlands everywhere protect against flood damages. A Wisconsin study projected that floods may be lowered as much as 80% in watersheds with many wetlands compared with similar basins with little or no wetlands (Novitzki 1978). Pothole wetlands in the Devils Lake basin of North Dakota store nearly 75% of the total runoff (Ludden, et al. 1983). Destruction of wetlands through floodplain development and wetland drainage have been partly responsible for recent major flood disasters throughout the country.

Besides reducing flood levels and potential damage, wetlands may buffer the land from storm wave damage. Salt marshes of smooth cordgrass are considered important shoreline stabilizers because of their wave dampening effect (Knudson, et al. 1982). Forested wetlands along lakes and large rivers function similarly.

Erosion Control

Located between watercourses and uplands, wetlands help protect uplands from erosion. Wetland vegetation can reduce shoreline erosion in several ways, including: 1) increasing durability of the sediment through binding with its roots, 2) dampening waves through friction, and 3) reducing current velocity through friction (Dean 1979). This process also helps reduce turbidity and thereby improves water quality.

Obviously, trees are good stabilizers of river banks. Their roots bind the soil, making it more resistant to erosion, while their trunks and branches slow the flow of flooding waters and dampen wave heights. The banks of some rivers have not been eroded for 100 to 200 years due to the presence of trees (Leopold and Wolman 1957; Wolman and Leopold 1957; Sigafoos 1964). Among the grass and grass-like plants, common reed and bulrushes have been regarded as the best at withstanding wave and current action (Kadlec and Wentz 1974; Seibert 1968). While most wetland plants need calm or sheltered water for establishment, they will effectively control erosion once established (Kadlec and Wentz 1974; Garbisch 1977). Wetland vegetation has been successfully planted to reduce erosion along U.S. waters. Willows, alders, ashes, cottonwoods, poplars, maples, and elms are particularly good stabilizers (Allen 1979). Successful emergent plants include reed canary grass, common reed, cattail, and bulrushes in freshwater areas (Hoffman 1977) and smooth cordgrass along the coast (Woodhouse, et al. 1976).

Water Supply

Most wetlands are areas of groundwater discharge and some may provide sufficient quantities of water for public use. In Massachusetts, 40% to 50% of wetlands may be valuable potential sources of drinking water, since at least 60 municipalities have public wells in or very near wetlands (Motts and Heeley 1973). Prairie pothole wetlands in the Dakotas store water which is important for wildlife and may be used for irrigation and livestock watering by farmers during droughts (Leitch 1981).

Groundwater Recharge

There is considerable debate over the role of wetlands in groundwater recharge, i.e., their ability to add water to the underlying aquifer or water table. Recharge potential of wetlands varies according to numerous factors, including wetland type, geographic location, season, soil type, water table location and precipitation. In general, most researchers believe that wetlands do not serve as groundwater recharge sites (Carter, et al. 1979). Yet, few studies have shown that certain wetland types may help recharge groundwater supplies. Shrub wetlands in the Pine Barrens may contribute to groundwater recharge (Ballard 1979). Depressional wetlands like cypress domes in Florida and prairie potholes in the Dakotas may also contribute to groundwater recharge (Odum, et al. 1975; Stewart and Kantrud 1972). Floodplain wetlands also may do this through overbank water-storage (Mundorff 1950; Klopatek 1978). In urban areas where municipal wells pump water from streams and adjacent wetlands, "induced infiltration" may draw in surface water from wetlands into public wells. This type of human-induced recharge has been observed in Burlington, Massachusetts (Mulica 1977). Additional research is needed to better assess the role of wetlands in groundwater recharge.

Harvest of Natural Products

A variety of natural products are produced by wetlands, including timber, fish and shellfish, wildlife, peat moss, cranberries, blueberries, and wild rice. Wetland grasses are hayed in many places for winter livestock feed. During other seasons, livestock graze directly in many wetlands. These and other products are harvested for human use and provide a livelihood for many people.

In the 49 continental states, an estimated 82 million acres of commercial forested wetlands exist (Johnson 1979). These forests provide timber for such uses as homes, furniture, newspapers, and firewood. Most of these forests lie east of the Rockies, where trees like oak, gum, cypress, elm, ash, and cottonwood are most important. The standing value of southern wetland forests was $8 billion in the late 1970s. These southern forests have been harvested for over 200 years without noticeable degradation, thus they can be expected to product timber for many years to come, unless converted to other uses.

Many wetland-dependent fishes and wildlife are also utilized by society. Commercial fishermen and trappers make a living from these resources. From 1956 to 1975, about 60 % of the U.S. commercial landings were fishes and shellfishes that depend on wetlands (Peters, et al. 1979). Nationally, major commercial species associated with wetlands are menhaden, salmon, shrimp, blue crab, and alewife from coastal waters and catfish, carp, and buffalo from inland areas. Recreational fishing, commercial fishing and shellfishing are valuable industries. Nationally, furs from beaver, muskrat, mink, nutria, and otter yielded roughly $35.5 million in 1976 (Demms and Pursley 1978). Louisiana is the largest fur-producing state and nearly all furs come from wetland animals.

Recreation and Aesthetics

Many recreational activities take place in and around wetlands. Hunting and fishing are popular sports. Waterfowl hunting is a major activity in wetlands, but big game hunting is also important locally. In 1980, 5.3 million people spent $638 million on hunting waterfowl and other migratory birds (U.S. Department of the Interior and Department of Commerce 1982). Saltwater recreational fishing has increased dramatically over the past 20 years, with half of the catch represented by wetland-associated species. Estuarine-dependent fishes, i.e., fluke, bluefish, winter flounder, and weakfish, were the most important species caught. Moreover, nearly all freshwater fishing is dependent on wetlands. In 1975 alone, sport fishermen spend $13.1 billion to catch wetland-dependent fishes in the U.S. (Peters, et al. 1979).

Other recreation in wetlands is largely nonconsumptive and involves activities like hiking, nature observation and photography, and canoeing and other boating. Many people simply enjoy the beauty and sounds of nature and spend their leisure time walking or boating in or near wetlands and observing plant and animal life. This aesthetic value is extremely difficult to evaluate or place a dollar value upon. Nonetheless, it is a very important one because, in 1980, 28.8 million people (17% of the U.S. population) took special trips to observe, photograph, or feed wildlife. Moreover, about 47% of all Americans showed an active interest in wildlife around their homes (U.S. Department of the Interior and Department of Commerce 1982).

Summary

Marshes, swamps, and other wetlands are assets to society in their natural state, providing numerous products for human use and consumption, protecting private property, and providing recreational and aesthetic appreciation opportunities. Wetlands may also have other values yet unknown to society. For example, a microorganism from Pine Barrens swamps has been recently discovered to have great value to the drug industry. In searching for a new source of antibiotics, the Squibb Institute examined soils from around the world and found that only one contained microbes suitable for producing a new family of antibiotics. From a Pine Barrens swamp micro-organism, scientists at the Squibb Institute have developed a new line of antibiotics which will be used to cure diseases not affected by present antibiotics (Moore 1981). This represents a significant medical discovery. If these wetlands were destroyed or grossly polluted, this discovery may not have been possible. Destruction or alteration of wetlands eliminates or minimizes their values. Drainage of wetlands, for example, eliminates all the beneficial effects of the marsh on water quality and directly contributes to flooding problems (Lee, et al. 1975). While the wetland landowner can derive financial profit from some of the values mentioned, the general public receives the vast majority of wetland benefits through flood and storm damage control, erosion control, water quality improvement, and fish and wildlife resources. It is, therefore, in the public's best interest to protect wetlands to preserve these values for themselves and future generations. Consequently, various laws have been passed to regulate wetland uses. At the national level, the Clean Water Act is the major law conserving wetlands. Individual states may have passed laws to protect, conserve, and restore coastal and/or inland wetlands.

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Acknowledgments

This project was funded by the Army Material Command based in Rock Island, Illinois. Rich Clewell is the coordinator for this and other Army wetland inventories throughout the country. Additionally, coordination and funding is supplied by the Army Environmental Center where John Bardwell serves as the liaison between the Army and the U.S. Fish and Wildlife Service.

During my visits to the Radford AAP Charles Chase assisted in the field and whose knowledge of the facility was helpful in preparing this report.

Other individuals contributing in the production of this report were the following: Herb Bergquist , Gabe DeAlessio and Bobbi Jo McClain (U.S. Fish and Wildlife Service, Region 5) were responsible for GIS processing, and custom map preparation. Iris Parzych (U.S. Fish and Wildlife Service, Region 5) was responsible in preparing the final report.

APPENDICES

Appendix A. Overview of U. S. Fish and Wildlife Service's Wetland Classification System
(Source: Tiner 1989. Wetlands of Rhode Island)

CHAPTER 2.

U.S. Fish and Wildlife Service's Wetland Definition and Classification System

Introduction

To begin inventorying the Nation's wetlands, the Service needed a definition of wetland and a classification system to identify various wetlands types. The Service, therefore, examined recent wetland inventories throughout the country to learn how others defined and classified wetlands. The results of this examination were published as *Existing State and Local Wetlands Surveys (1965–1975)* (U.S. Fish and Wildlife Service 1976). More than 50 wetland classification schemes were identified. Of those, only one classification—the Martin, *et al.* system (1953)—was nationally based, while all others were regionally focused. In January 1975, the Service brought together 14 authors of regional wetland classifications and other prominent wetland scientists to help decide if any existing classification could be used or modified for the national inventory or if a new system was needed. They recommended that the Service attempt to develop a new national wetland classification. In July 1975, the Service sponsored the National Wetland Classification and Inventory Workshop, where more than 150 wetland scientists and mapping experts met to review a preliminary draft of the new wetland classification system. The consensus was that the system should be hierarchical in nature and built around the concept of ecosystems (Sather 1976).

Four key objectives for the new system were established: (1) to develop ecologically similar habitat units, (2) to arrange these units in a system that would facilitate resource management decisions, (3) to furnish units for inventory and mapping, and (4) to provide uniformity in concept and terminology throughout the country (Cowardin, *et al.* 1979).

The Service's wetland classification system was developed by a four-member team, i.e., Dr. Lewis M. Cowardin (U.S. Fish and Wildlife Service), Virginia Carter (U.S. Geological Survey), Dr. Francis C. Golet (University of Rhode Island) and Dr. Edward T. LaRoe (National Oceanic and Atmospheric Administration), with assistance from numerous Federal and state agencies, university scientists, and other interested individuals. The classification system went through three major drafts and extensive field testing prior to its publication as *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin, *et al.* 1979). Since its publication, the Service's classification system has been widely used by Federal, state, and local agencies, university scientists, and private industry and non-profit organizations for identifying and classifying wetlands. At the First International Wetlands Conference in New Delhi, India, scientists from around the world adopted the Service's wetland definition as an international standard and recommended testing the applicability of the classification system in other areas, especially in the tropics and subtropics (Gopal, *et al.* 1982). Thus, the system appears to be moving quickly towards its goal of providing uniformity in wetland concept and terminology.

Wetland Definition

Conceptually, wetlands usually lie between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments (Figure 2). Wetlands generally include the variety of marshes, bogs, swamps, shallow ponds, and bottomland forests that occur throughout the country. They usually lie in depressions surrounded by upland or along rivers, lakes and coastal waters where they are subject to periodic flooding. Some wetlands, however, occur on slopes where they are associated with ground-water seepage areas. To accurately inventory this resource, the Service had to determine where along this natural wetness continuum wetland ends and upland begins. While many wetlands lie in distinct depressions or basins that are readily observable, the wetland-upland boundary is not always easy to identify. This is especially true along many floodplains, on glacial till deposits, in gently sloping terrain, and in areas of major hydrologic modification. In these areas, only a skilled wetland ecologist or other specialist can accurately identify the wetland boundary. To help ensure accurate and consistent wetland determination, an ecologically based definition was constructed by the Service.

Historically, wetlands were defined by scientists working in specialized fields, such as botany or hydrology. A botanical definition would focus on the plants adapted to flooding or saturated soil conditions, while a hydrologist's defintion would emphasize fluctuations in the position of the water table relative to the ground surface over time. Lefor and Kennard (1977) reviewed numerous definitions for inland wetlands used in the Northeast. Single

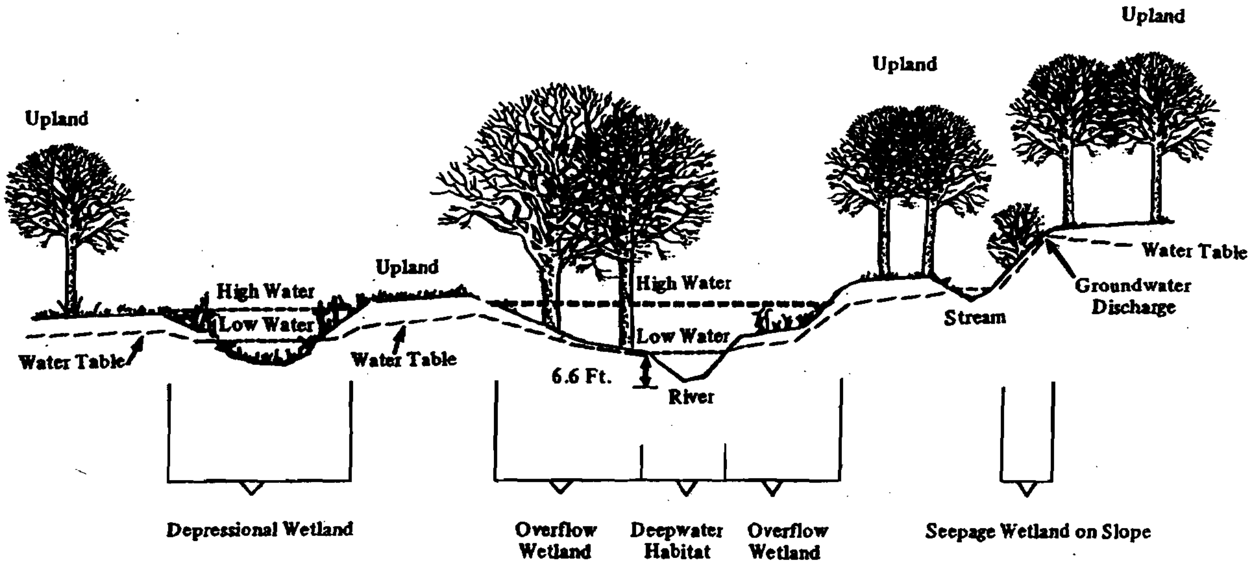

Figure 2. Schematic diagram showing wetlands, deepwater habitats, and uplands on the landscape. Note differences in wetlands due to hydrology and topographic position.

parameter definitions in general are not very useful for identifying wetlands. A more complete definition of wetland involves a multi-disciplinary approach. The Service has taken this approach in developing its wetland definition and classification system.

The Service has not attempted to legally define wetland, since each state or Federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes (Table 1). Therefore, according to existing wetland laws, a wetland is whatever the law says it is. The Service needed a definition that would allow accurate identification and delineation of the Nation's wetlands for resource management purposes.

The Service defines wetlands as follows:

"*Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*" (Cowardin, *et al.* 1979)

In defining wetlands from an ecological standpoint, the Service emphasizes three key attributes of wetlands: (1) hydrology—the degree of flooding or soil saturation, (2) wetland vegetation (hydrophytes), and (3) hydric soils. All areas considered wetland must have enough water at some time during the growing season to stress plants and animals not adapted for life in water or saturated soils. Most wetlands have hydrophytes and hydric soils present, yet many are nonvegetated (e.g., tidal mud flats). The Service has prepared a list of plants occurring in the Nation's wetlands (Reed 1988) and the Soil Conservation Service has developed a national list of hydric soils (U.S.D.A. Soil Conservation Service 1987) to help identify wetlands.

Particular attention should be paid to the reference to flooding or soil saturation during the growing season in the Service's wetland definition. When soils are covered by water or saturated to the surface, free oxygen is generally not available to plant roots. During the growing season, most plant roots must have access to free oxygen for respiration and growth; flooding at this time would have serious implications for the growth and survival of most plants. In a wetland situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on them.

Wetlands typically fall within one of the following four categories: (1) areas with both hydrophytes and hydric soils (e.g., marshes, swamps and bogs), (2) areas without hydrophytes, but with hydric soils (e.g., farmed wetlands), (3) areas without soils but with hydrophytes (e.g., seaweed-covered rocky shores), and (4) periodically flooded areas without soil and without hydrophytes (e.g., gravel beaches). All wetlands must be periodcially saturated or covered by shallow water during the growing season, whether or not hydrophytes or hydric soils are present. Completely drained hydric soils that are no

Table 1. Definitions of "wetland" according to selected Federal agencies and state statutes.

Organization (Reference)	Wetland Definition	Comments
U.S. Fish and Wildlife Service (Cowardin, *et al.* 1979)	"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."	This is the official Fish and Wildlife Service definition and is being used for conducting an inventory of the Nation's wetlands. It emphasizes flooding and/or soil saturation, hydric soils and vegetation. Shallow lakes and ponds are included as wetland. Comprehensive lists of wetland plants and soils are available to further clarify this definition.
U.S. Army Corps of Engineers (Federal Register, July 19, 1977) and U.S. Environmental Protection Agency (Federal Register, December 24, 1980)	Wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."	Regulatory definition in response to Section 404 of the Clean Water Act of 1977. Excludes similar areas lacking vegetation, such as tidal flats, and does not define lakes, ponds and rivers as wetlands. Aquatic beds are considered "vegetated shallows" and included as other "waters of the United States" for regulatory purposes.
U.S.D.A. Soil Conservation Service (National Food Security Act Manual, 1988)	"Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils."	This is the Soil Conservation Service's definition for implementing the "Swampbuster" provision of the Food Security Act of 1985. Any area that meets hydric soil criteria is considered to have a predominance of hydric soils. Note the geographical exclusion for certain lands in Alaska.
State of Rhode Island Coastal Resources Mgmt. Council (RI Coastal Resources Mgmt. Program as amended June 28, 1983)	"Coastal wetlands include salt marshes and freshwater or brackish wetlands contiguous to salt marshes. Areas of open water within coastal wetlands are considered a part of the wetland. Salt marshes are areas regularly inundated by salt water through either natural or artificial water courses and where one or more of the following species predominate: [8 indicator plants listed]. Contiguous and associated freshwater or brackish marshes are those where one or more of the following species predominate: [9 indicator plants listed]."	State's public policy on coastal wetlands. Definition based on hydrologic connection to tidal waters and presence of indicator plants. *Note:* Original definition made reference to the occurrence and extent of salt marsh peat; it was probably deleted since many salt marsh soils are not peats, but sands.
State of Rhode Island Dept. of Environmental Mgmt. (RI General Law, Sections 2-1-18 et seq.)	Fresh water wetlands are defined to include, "but not be limited to marshes; swamps; bogs; ponds; river and stream flood plains and banks; areas subject to flooding or storm flowage; emergent and submergent plant communities in any body of fresh water including rivers and streams and that area of land within fifty feet (50′) of the edge of any bog, marsh, swamp, or pond." Various wetland types are further defined on the basis of hydrology and indicator plants, including bog (15 types of indicator plants), marsh (21 types of plants), and swamp (24 types of indicator plants plus marsh plants).	Fresh Water Wetlands Act definition. Several wetland types are further defined. The definition includes deepwater areas and the 100-year flood plain as wetland. Minimum size limits are placed on ponds (one quarter acre), marsh (one acre), and swamp (three acres). Under the definition of "river bank," all land within 100 feet of any flowing body of water less than 10 feet wide during normal flow and within 200 feet of any flowing body of water 10 feet or wider is protected as wetland.

longer capable of supporting hydrophytes due to a change in water regime are not considered wetland. Areas with completely drained hydric soils are, however, good indicators of historic wetlands, which may be suitable for restoration through mitigation projects.

It is important to mention that the Service does not generally include permanently flooded deep water areas as wetland, although shallow waters are classified as wetland. Instead, these deeper water bodies are defined as deepwater habitats, since water and not air is the principal medium in which dominant organisms live. Along the coast in tidal areas, the deepwater habitat begins at the extreme spring low tide level. In nontidal freshwater areas, this habitat starts at a depth of 6.6 feet (2 m) because the shallow water areas are often vegetated with emergent wetland plants.

Wetland Classification

The following section represents a simplified overview of the Service's wetland classification system. Consequently, some of the more technical points have been omitted from this discussion. When actually classifying a wetland, the reader is advised to refer to the official classification document (Cowardin, *et al.* 1979) and should not rely solely on this overview.

The Service's wetland classification system is hierarchial or vertical in nature proceeding from general to specific, as noted in Figure 3. In this approach, wetlands are first defined at a rather broad level—the *SYSTEM*. The term *SYSTEM* represents "a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors." Five systems are defined: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The Marine System generally consists of the open ocean and its associated high-energy coastline, while the Estuarine System encompasses salt and brackish marshes, nonvegetated tidal shores, and brackish waters of coastal rivers and embayments. Freshwater wetlands and deepwater habitats fall into one of the other three systems: Riverine (rivers and streams), Lacustrine (lakes, reservoirs and large ponds), or Palustrine (e.g., marshes, bogs, swamps and small shallow ponds). Thus, at the most general level, wetlands can be defined as either Marine, Estuarine, Riverine, Lacustrine or Palustrine (Figure 4).

Each system, with the exception of the Palustrine, is further subdivided into *SUBSYSTEMS*. The Marine and Estuarine Systems both have the same two subsystems, which are defined by tidal water levels: (1) Subtidal—continuously submerged areas and (2) Intertidal—areas alternately flooded by tides and exposed to air. Similarly, the Lacustrine System is separated into two systems based on water depth: (1) Littoral—wetlands extending from the lake shore to a depth of 6.6 feet (2 m) below low water or to the extent of nonpersistent emergents (e.g., arrowheads, pickerelweed or spatterdock) if they grow beyond that depth, and (2) Limnetic—deepwater habitats lying beyond the 6.6 feet (2 m) at low water. By contrast, the Riverine System is further defined by four subsystems that represent different reaches of a flowing freshwater or lotic system: (1) Tidal—water levels subject to tidal fluctuations, (2) Lower Perennial—permanent, flowing waters with a well-developed floodplain, (3) Upper Perennial—permanent, flowing water with very little or no floodplain development, and (4) Intermittent—channel containing nontidal flowing water for only part of the year.

The next level—*CLASS*—describes the general appearance of the wetland or deepwater habitat in terms of the dominant vegetative life form or the nature and composition of the substrate, where vegetative cover is less than 30% (Table 2). Of the 11 classes, five refer to areas where vegetation covers 30% or more of the surface: Aquatic Bed, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland and Forested Wetland. The remaining six classes represent areas generally lacking vegetation, where the composition of the substrate and degree of flooding distinguish classes: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded nonvegetated areas are classified as either Rock Bottom or Unconsolidated Bottom, while exposed areas are typed as Streambed, Rocky Shore or Unconsolidated Shore. Invertebrate reefs are found in both permanently flooded and exposed areas.

Each class is further divided into *SUBCLASSES* to better define the type of substrate in nonvegetated areas (e.g., bedrock, rubble, cobble-gravel, mud, sand, and organic) or the type of dominant vegetation (e.g., persistent or nonpersistent emergents, moss, lichen, or broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen and dead woody plants). Below the subclass level, *DOMINANCE TYPE* can be applied to specify the predominant plant or animal in the wetland community.

To allow better description of a given wetland or deepwater habitat in regard to hydrologic, chemical and soil characteristics and to human impacts, the classification system contains four types of specific modifiers: (1) Water Regime, (2) Water Chemistry, (3) Soil, and (4) Special. These modifiers may be applied to class and lower levels of the classification hierarchy.

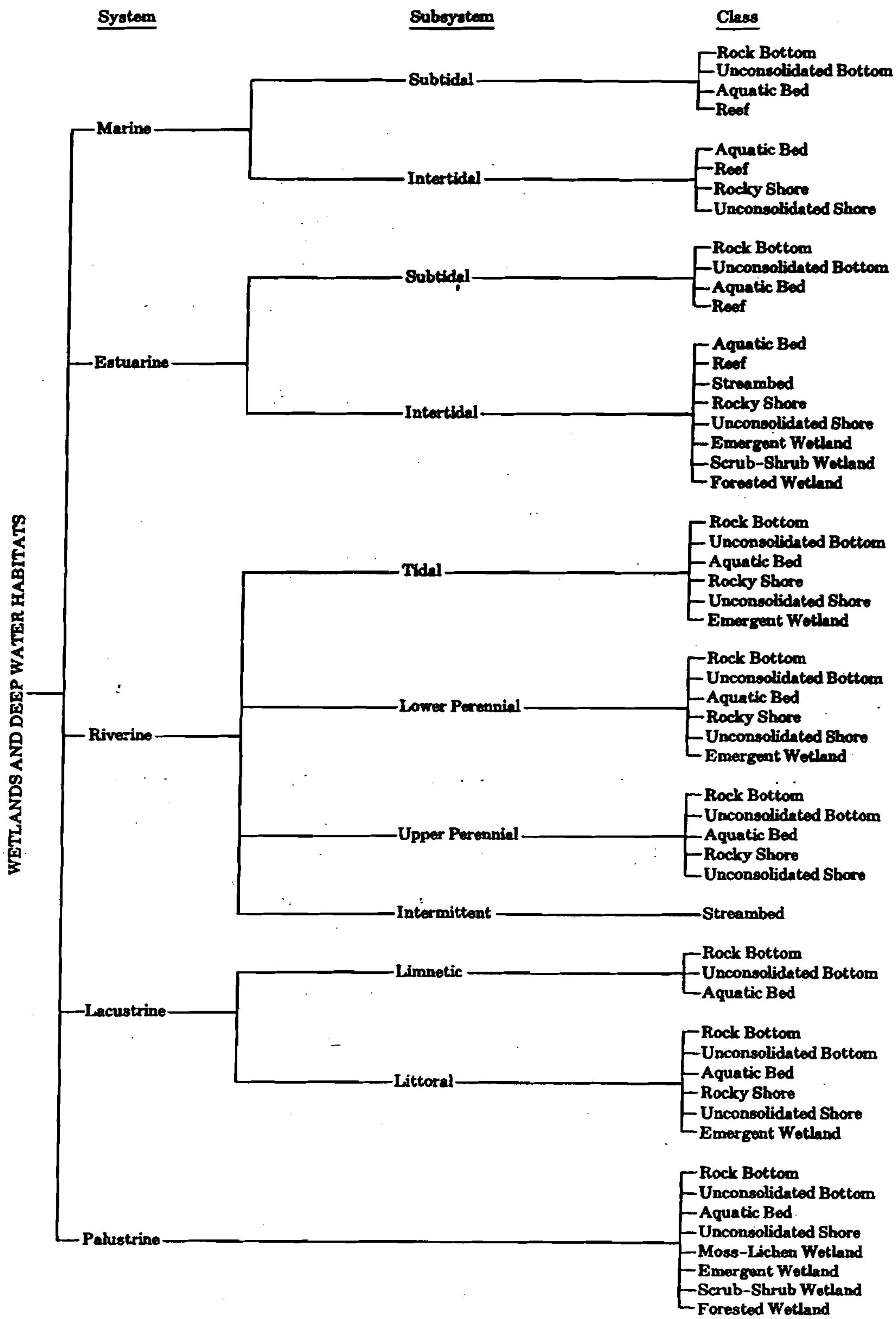

Figure 3. Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes. The Palustrine System does not include deepwater habitats (Cowardin, *et al.* 1979).

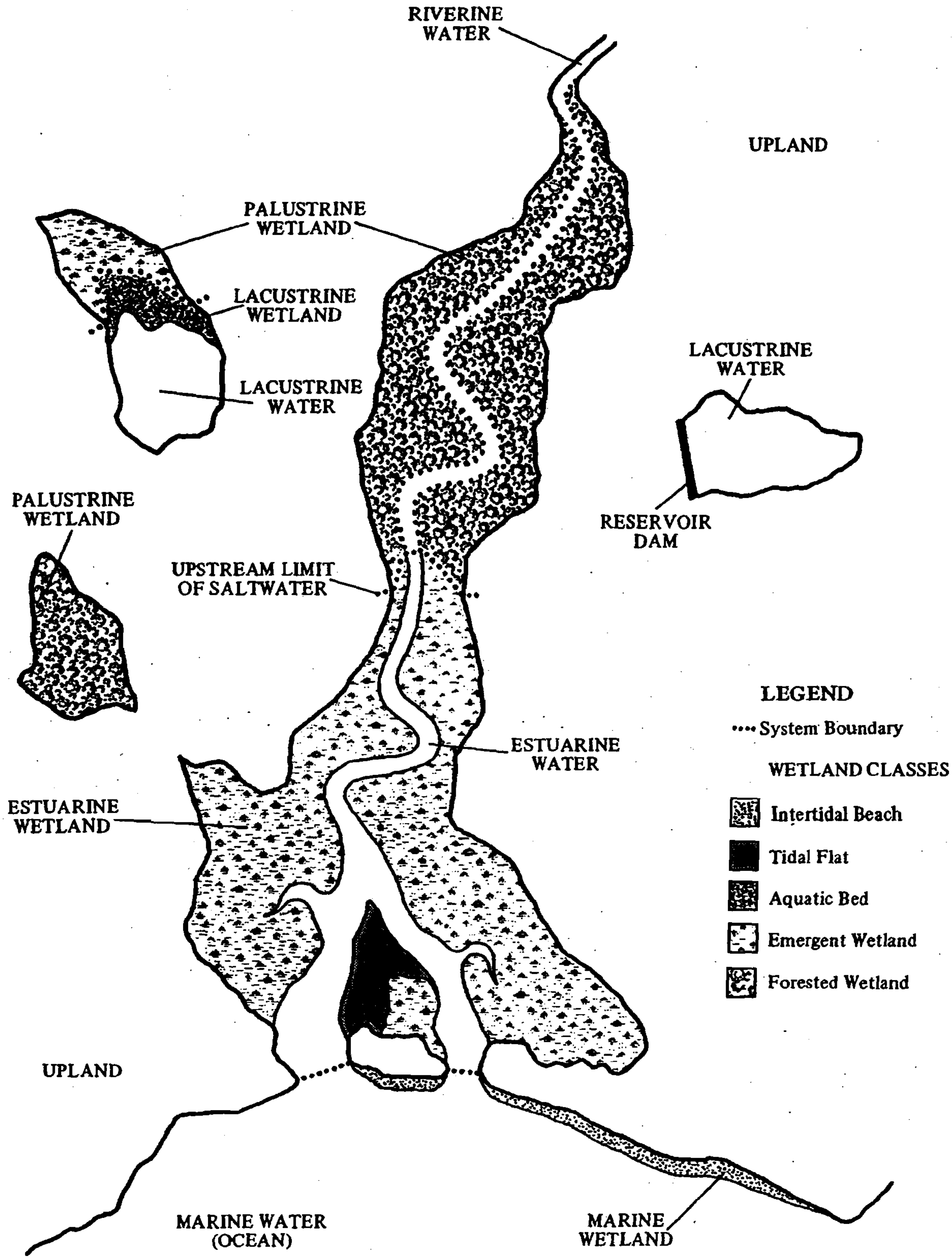

Figure 4. Diagram showing major wetland and deepwater habitat systems. Predominant wetland classes for each system are also designated. (*Note:* Tidal flat and beach classes are now considered unconsolidated shore.)

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Table 2. Classes and subclasses of wetlands and deepwater habitats (Cowardin, *et al.* 1979).

Class	**Brief Description**	**Subclasses**
Rock Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 75% stones and boulders and less than 30% vegetative cover.	Bedrock; Rubble.
Unconsolidated Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 25% particles smaller than stones and less than 30% vegetative cover.	Cobble-gravel; Sand; Mud; Organic
Aquatic Bed	Generally permanently flooded areas vegetated by plants growing principally on or below the water surface line.	Algal; Aquatic Moss; Rooted Vascular; Floating Vascular
Reef	Ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.	Coral; Mollusk; Worm
Streambed	Channel whose bottom is completed dewatered at low water periods.	Bedrock; Rubble; Cobble-gravel; Sand; Mud; Organic; Vegetated
Rocky Shore	Wetlands characterized by bedrock, stones or boulders with areal coverage of 75% or more and with less than 30% coverage by vegetation.	Bedrock; Rubble
Unconsolidated Shore*	Wetlands having unconsolidated substrates with less than 75% coverage by stone, boulders and bedrock and less than 30% vegetative cover, except by pioneer plants.	Cobble-gravel; Sand; Mud; Organic; Vegetated
	(*NOTE: This class combines two classes of the 1977 operational draft system—Beach/Bar and Flat)	
Moss-Lichen Wetland	Wetlands dominated by mosses or lichens where other plants have less than 30% coverage.	Moss; Lichen
Emergent Wetland	Wetlands dominated by erect, rooted, herbaceous hydrophytes.	Persistent; Nonpersistent
Scrub-Shrub Wetland	Wetlands dominated by woody vegetation less than 20 feet (6 m) tall.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead
Forested Wetland	Wetlands dominated by wood vegetation 20 feet (6 m) or taller.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead

Water regime modifiers describe flooding or soil saturation conditions and are divided into two main groups: (1) tidal and (2) nontidal. Tidal water regimes are used where water level fluctuations are largely driven by oceanic tides. Tidal regimes can be subdivided into two general categories, one for salt and brackish water tidal areas and another for freshwater tidal areas. This distinction is needed because of the special importance of seasonal river overflow and ground-water inflows in freshwater tidal areas. By contrast, nontidal modifiers define conditions where surface water runoff, ground-water discharge, and/or wind effects (i.e., lake seiches) cause water level changes. Both tidal and nontidal water regime modifiers are presented and briefly defined in Table 3.

Water chemistry modifiers are divided into two categories which describe the water's salinity or hydrogen ion concentration (pH): (1) salinity modifiers and (2) pH modifiers. Like water regimes, salinity modifiers have been further subdivided into two groups: halinity modifiers for tidal areas and salinity modifiers for nontidal areas. Estuarine and marine waters are dominated by sodium chloride, which is gradually diluted by fresh water as one moves upstream in coastal rivers. On the other hand, the salinity of inland waters is dominated by four major cations (i.e., calcium, magnesium, sodium and potassium) and three major anions (i.e., carbonate, sulfate, and chloride). Interactions between precipitation, surface runoff, ground-water flow, evaporation, and sometimes plant evapotranspiration form inland salts which are most common in arid and semiarid regions of the country. Table 4 shows ranges of halinity and salinity modifiers which are a modification of the Venice System (Remane and Schlieper 1971). The other set of water chemistry modifiers are pH modifiers for identifying acid (pH$<$5.5), circumneutral (5.5–7.4) and alkaline (pH$>$7.4) waters. Some studies have shown a good correlation between plant distribution and pH levels (Sjors 1950; Jeglum 1971). Moreover, pH can be used to distinguish between mineral-rich (e.g., fens) and mineral-poor wetlands (e.g., bogs).

The third group of modifiers—soil modifiers—are presented because the nature of the soil exerts strong influ-

Table 3. Water regime modifiers, both tidal and nontidal groups (Cowardin, *et al.* 1979).

Group	Type of Water	Water Regime	Definition
Tidal	Saltwater and brackish areas	Subtidal	Permanently flooded tidal waters
		Irregularly exposed	Exposed less often than daily by tides
		Regularly flooded	Daily tidal flooding and exposure to air
		Irregularly flooded	Flooded less often than daily and typically exposed to air
	Freshwater	Permanently flooded-tidal	Permanently flooded by tides and river or exposed irregularly by tides
		Semipermanently flooded-tidal	Flooded for most of the growing season by river overflow but with tidal fluctuation in water levels
		Regularly flooded	Daily tidal flooding and exposure to air
		Seasonally flooded-tidal	Flooded irregularly by tides and seasonally by river overflow
		Temporarily flooded-tidal	Flooded irregularly by tides and for brief periods during growing season by river overflow
Nontidal	Inland freshwater and saline areas	Permanently flooded	Flooded throughout the year in all years
		Intermittently exposed	Flooded year-round except during extreme droughts
		Semipermanently flooded	Flooded throughout the growing season in most years
		Seasonally flooded	Flooded for extended periods in growing season, but surface water is usually absent by end of growing season
		Saturated	Surface water is seldom present, but substrate is saturated to the surface for most of the season
		Temporarily flooded	Flooded for only brief periods during growing season, with water table usually well below the soil surface for most of the season
		Intermittently flooded	Substrate is usually exposed and only flooded for variable periods without detectable seasonal periodicity (Not always wetland: may be upland in some situations)
		Artificially flooded	Duration and amount of flooding is controlled by means of pumps or siphons in combination with dikes or dams

Table 4. Salinity modifiers for coastal and inland areas (Cowardin *et al.*, 1979).

Coastal Modifiers[1]	Inland Modifiers[2]	Salinity (‰)	Approximate Specific Conductance (Mhos at 25° C)
Hyperhaline	Hypersaline	>40	>60,000
Euhaline	Eusaline	30–40	45,000–60,000
Mixohaline (Brackish)	Mixosaline[3]	0.5–30	800–45,000
Polyhaline	Polysaline	18–30	30,000–45,000
Mesohaline	Mesosaline	5–18	8,000–30,000
Oligohaline	Oligosaline	0.5–5	800–8,000
Fresh	Fresh	<0.5	<800

[1]Coastal modifiers are employed in the Marine and Estuarine Systems.
[2]Inland modifiers are employed in the Riverine, Lacustrine and Palustrine Systems.
[3]The term "brackish" should not be used for inland wetlands or deepwater habitats.

ences on plant growth and reproduction as well as on the animals living in it. Two soil modifiers are given: (1) mineral and (2) organic. In general, if a soil has 20 percent or more organic matter by weight in the upper 16 inches, it is considered an organic soil, whereas if it has less than this amount, it is a mineral soil. For specific definitions, please refer to Appendix D of the Service's classification system (Cowardin, *et al.* 1979) or to *Soil Taxonomy* (Soil Survey Staff 1975).

The final set of modifiers—special modifiers—were established to describe the activities of people or beaver affecting wetlands and deepwater habitats. These modifiers include: excavated, impounded (i.e., to obstruct outflow of water), diked (i.e., to obstruct inflow of water), partly drained, farmed, and artificial (i.e., materials deposited to create or modify a wetland or deepwater habitat).

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Appendix B. Field Data Sheets

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44

NWI FIELD DATA SHEET

SITE NO. 1 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS: C. Chase

LOCATION(1:100,000 Map): Blue Field SE U.S.G.S. QUAD: Dublin

TOWN: Dublin COUNTY: Pulaski STATE: VA

Brief description of site relative to identifiable points on topographic map: ____

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PUBHh
LANDSCAPE POSITION: ____ LANDFORM: ____
WATER FLOW PATH: ____ OTHER: ____

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: —

Common Plants: ____

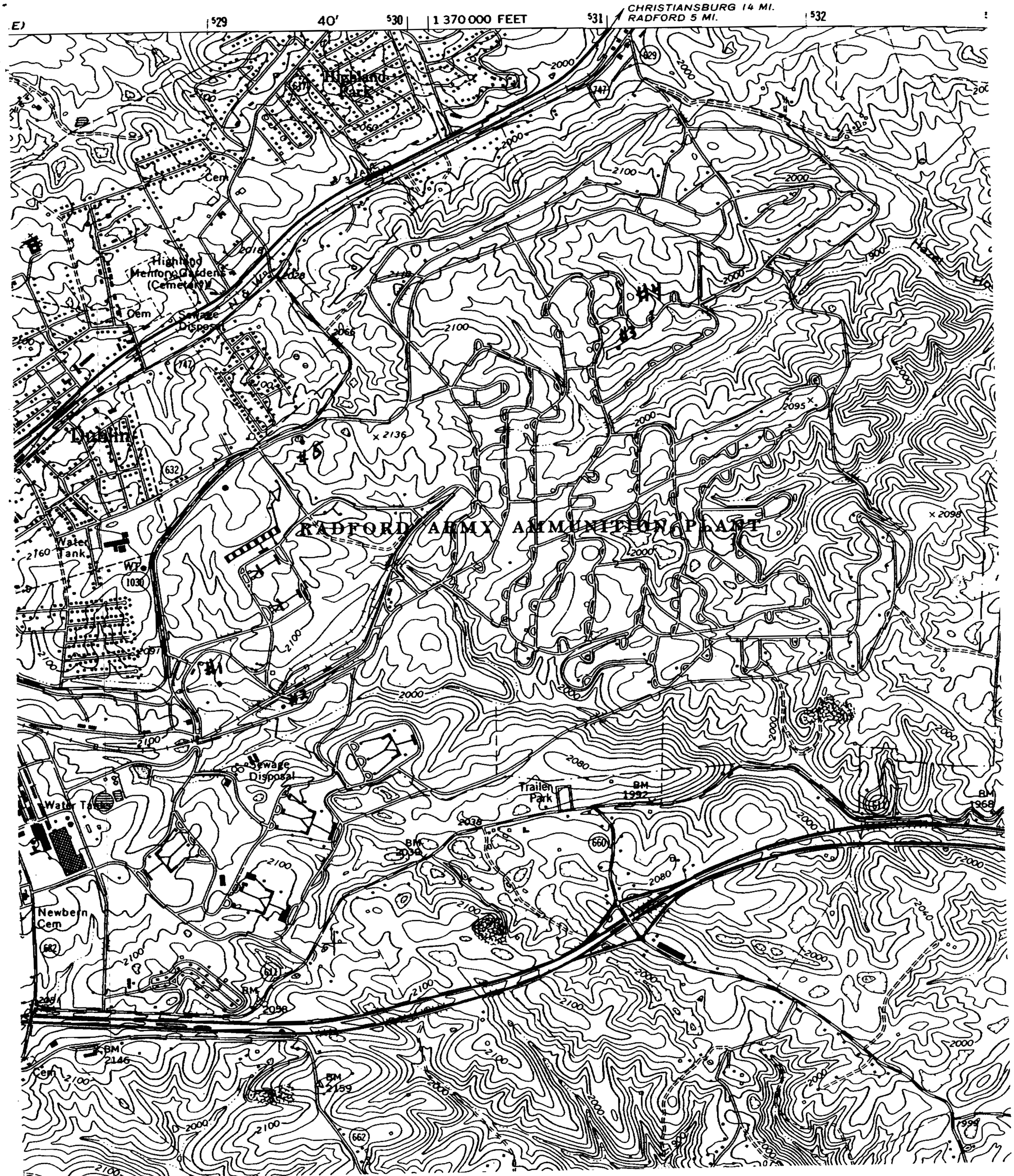
Less Common Plants: ____

LIST OF HYDROLOGY INDICATORS

- ____Standing Water Present____Depth
- ____Water Marks Present (explain)____
- ____Buttressed Trunks (Species)____
- ____Peat Moss
- ____Water-stained Leaves
- ____Water-carried Debris
- ____Other Hydrology Signs (specify)____
- ____Saturated Soils Present Within____
- ____Shallow Roots (Species)____
- ____Bare (scoured) Areas
- ____Oxidized Rhizospheres

DUBLIN QUADRANG
VIRGINIA–PULASKI C
7.5 MINUTE SERIES (TOPOG
SW/4 RADFORD 15' QUADRANGL

VIRGINIA
RESOURCES



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NWI FIELD DATA SHEET

SITE NO. 2 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS:

LOCATION(1:100,000 Map): BLUEFIELD SE U.S.G.S. QUAD: DUBLIN

TOWN: DUBLIN COUNTY: PuLaski STATE: VA

Brief description of site relative to identifiable points on topographic map:

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PEM1B
LANDSCAPE POSITION: TE LANDFORM: BA
WATER FLOW PATH: IS OTHER:

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Typha latifolia

Common Plants: Carex (spp), Juncus canadensis
Poa (sp), Rhynchospora capitellata

Less Common Plants:

LIST OF HYDROLOGY INDICATORS

____ Standing Water Present ____ Depth
____ Water Marks Present (explain) ____
____ Buttressed Trunks (Species) ____
____ Peat Moss
____ Water-stained Leaves
____ Water-carried Debris
____ Other Hydrology Signs (specify) ____

____ Saturated Soils Present Within ____
____ Shallow Roots (Species) ____
____ Bare (scoured) Areas
____ Oxidized Rhizospheres

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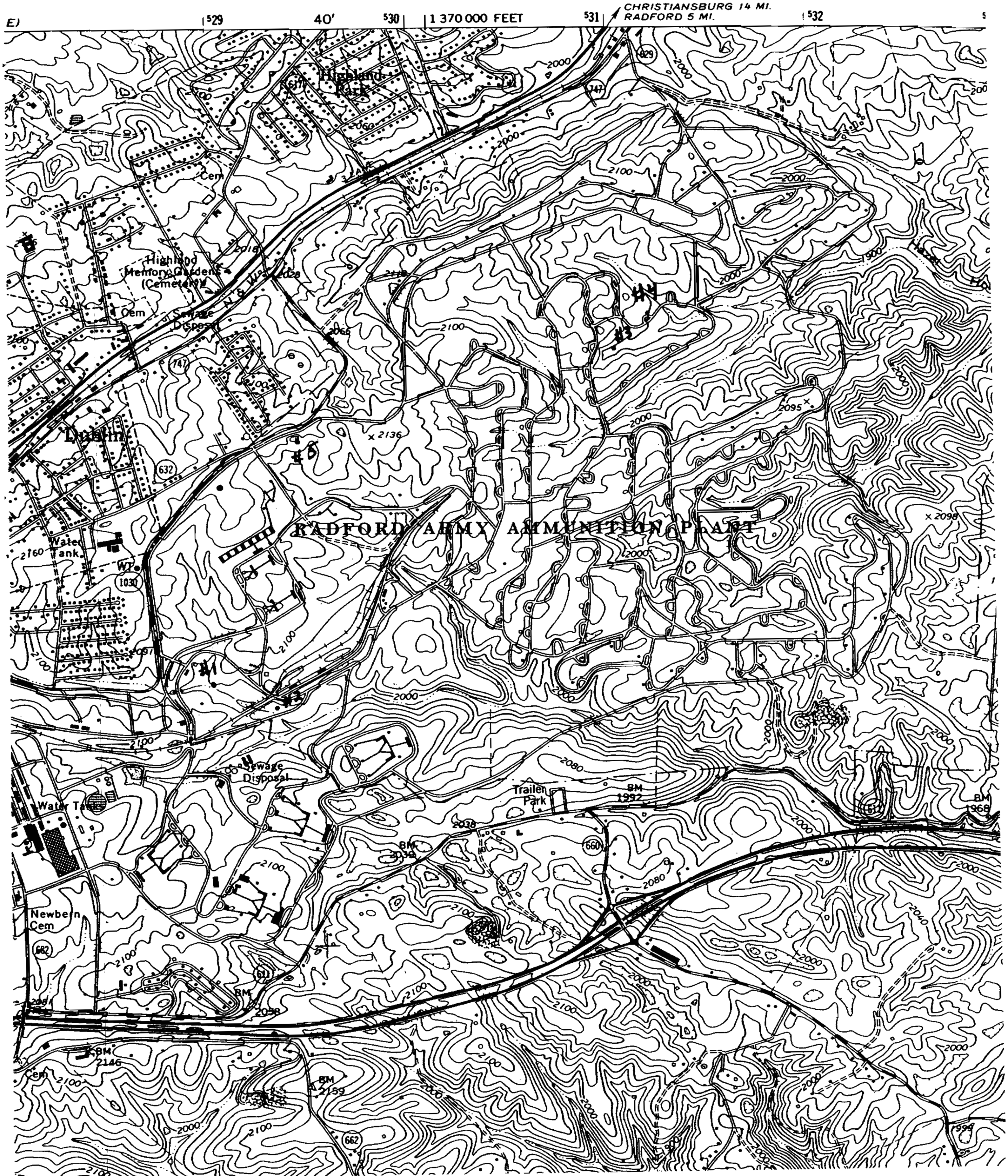

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NWI FIELD DATA SHEET

SITE NO. 3 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS: C. Chase

LOCATION(1:100,000 Map): Bluefield SE U.S.G.S. QUAD: Dublin

TOWN: Dublin COUNTY: Pulaski STATE: VA

Brief description of site relative to identifiable points on topographic map: ______

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PEM1C
LANDSCAPE POSITION: ______ LANDFORM: ______
WATER FLOW PATH: ______ OTHER: ______

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Rhynchospora capitellata

Common Plants: Juncus (spp), Typha latifolia

Less Common Plants: Calamagrostis canadensis

LIST OF HYDROLOGY INDICATORS

✓ Standing Water Present 3 in Depth
_____ Water Marks Present (explain) ______
_____ Buttressed Trunks (Species) ______
_____ Peat Moss
_____ Water-stained Leaves
_____ Water-carried Debris
_____ Other Hydrology Signs (specify) ______

_____ Saturated Soils Present Within ______
_____ Shallow Roots (Species) ______
_____ Bare (scoured) Areas
_____ Oxidized Rhizospheres

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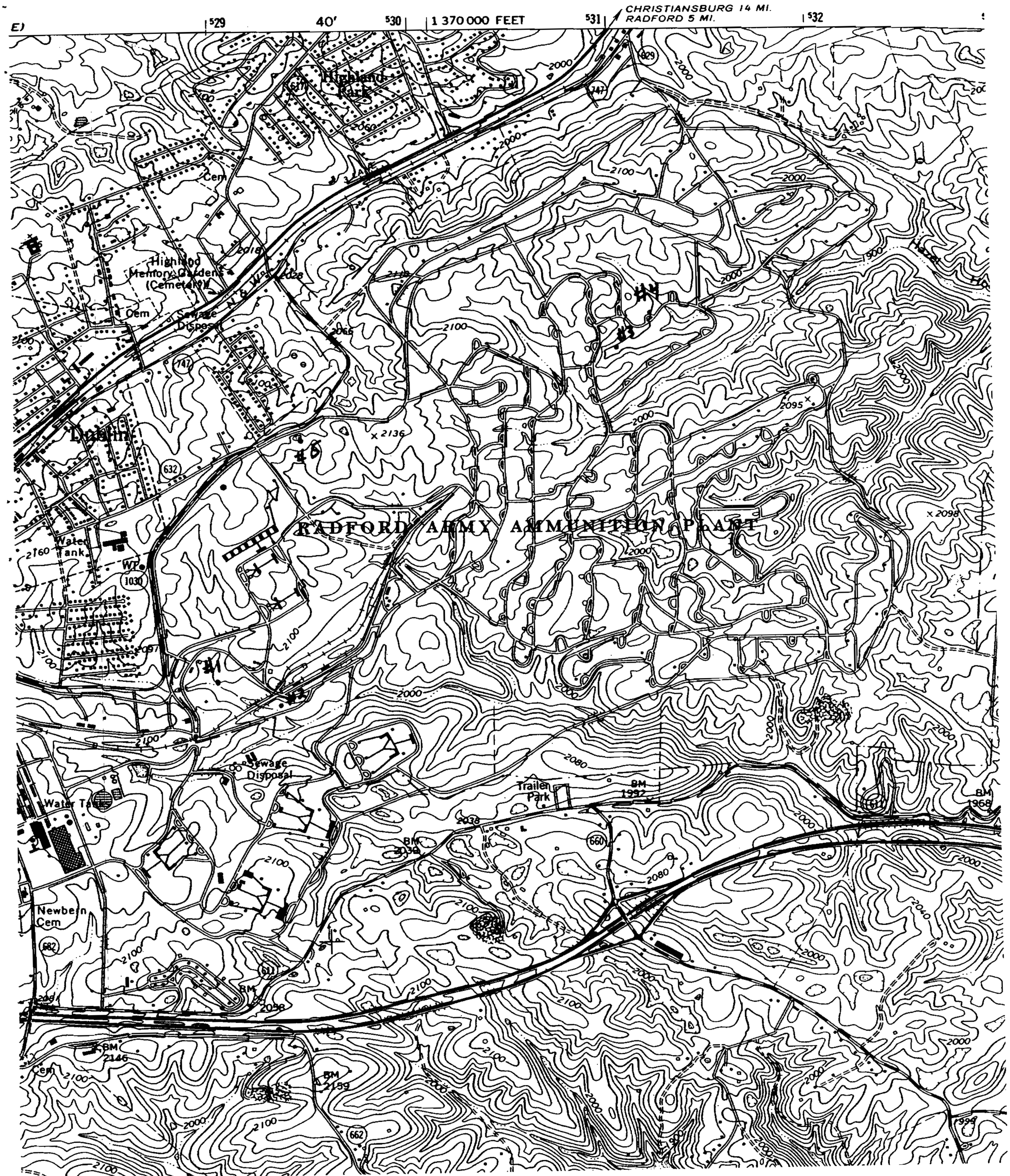

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NWI FIELD DATA SHEET

SITE NO. 4 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS:

LOCATION(1:100,000 Map): Blue Field SE U.S.G.S. QUAD: Dublin

TOWN: Dublin COUNTY: Pulaski STATE: VA

Brief description of site relative to identifiable points on topographic map:

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PEM1A
LANDSCAPE POSITION: LANDFORM:
WATER FLOW PATH: OTHER:

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Calamagrostis canadensis

Common Plants:

Less Common Plants: Rhynchospora capitellata

LIST OF HYDROLOGY INDICATORS

____ Standing Water Present ____ Depth
____ Water Marks Present (explain)
____ Buttressed Trunks (Species)
____ Peat Moss
____ Water-stained Leaves
____ Water-carried Debris
✓ Other Hydrology Signs (specify) cracked mud

____ Saturated Soils Present Within
____ Shallow Roots (Species)
____ Bare (scoured) Areas
____ Oxidized Rhizospheres

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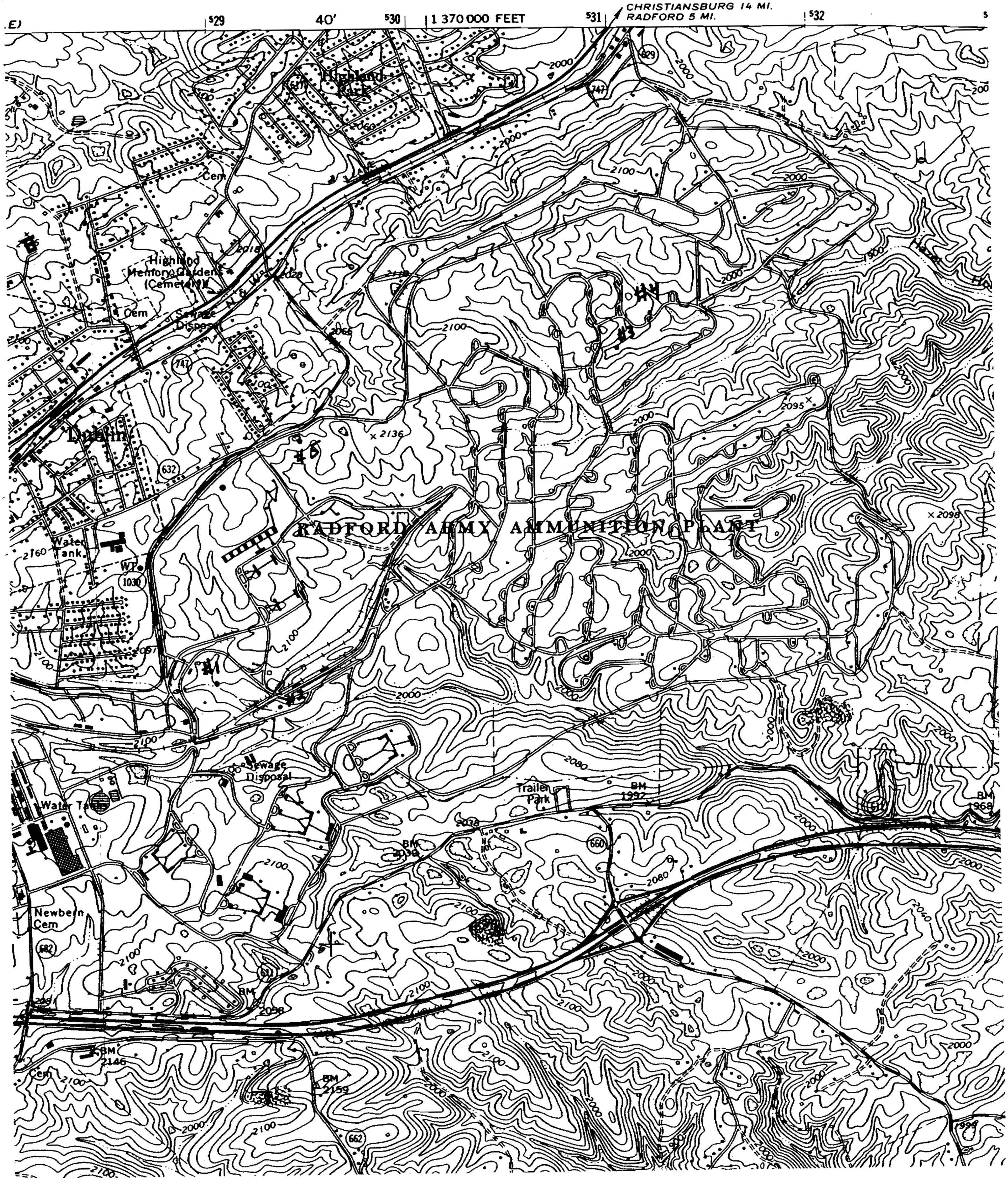

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NWI FIELD DATA SHEET

SITE NO. 5 **REPORTED BY:** J. Swords **DATE:** 11-28-00
OTHER PARTICIPANTS:

LOCATION(1:100,000 Map): Bluefield SE **U.S.G.S. QUAD:** Dublin

TOWN: Dublin **COUNTY:** Pulaski **STATE:** VA

Brief description of site relative to identifiable points on topographic map:

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — **IN-FIELD CLASSIFICATION:** PEM1A
LANDSCAPE POSITION: **LANDFORM:**
WATER FLOW PATH: **OTHER:**

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Juncus effusus

Common Plants: unknown grass, Carex (sp)

Less Common Plants: Scirpus (sp), Carex scoparia

LIST OF HYDROLOGY INDICATORS

_____Standing Water Present_____Depth
_____Water Marks Present (explain)_____
_____Buttressed Trunks (Species)_____
_____Peat Moss
_____Water-stained Leaves
_____Water-carried Debris
_____Other Hydrology Signs (specify)_____

_____Saturated Soils Present Within_____
_____Shallow Roots (Species)_____
_____Bare (scoured) Areas
_____Oxidized Rhizospheres

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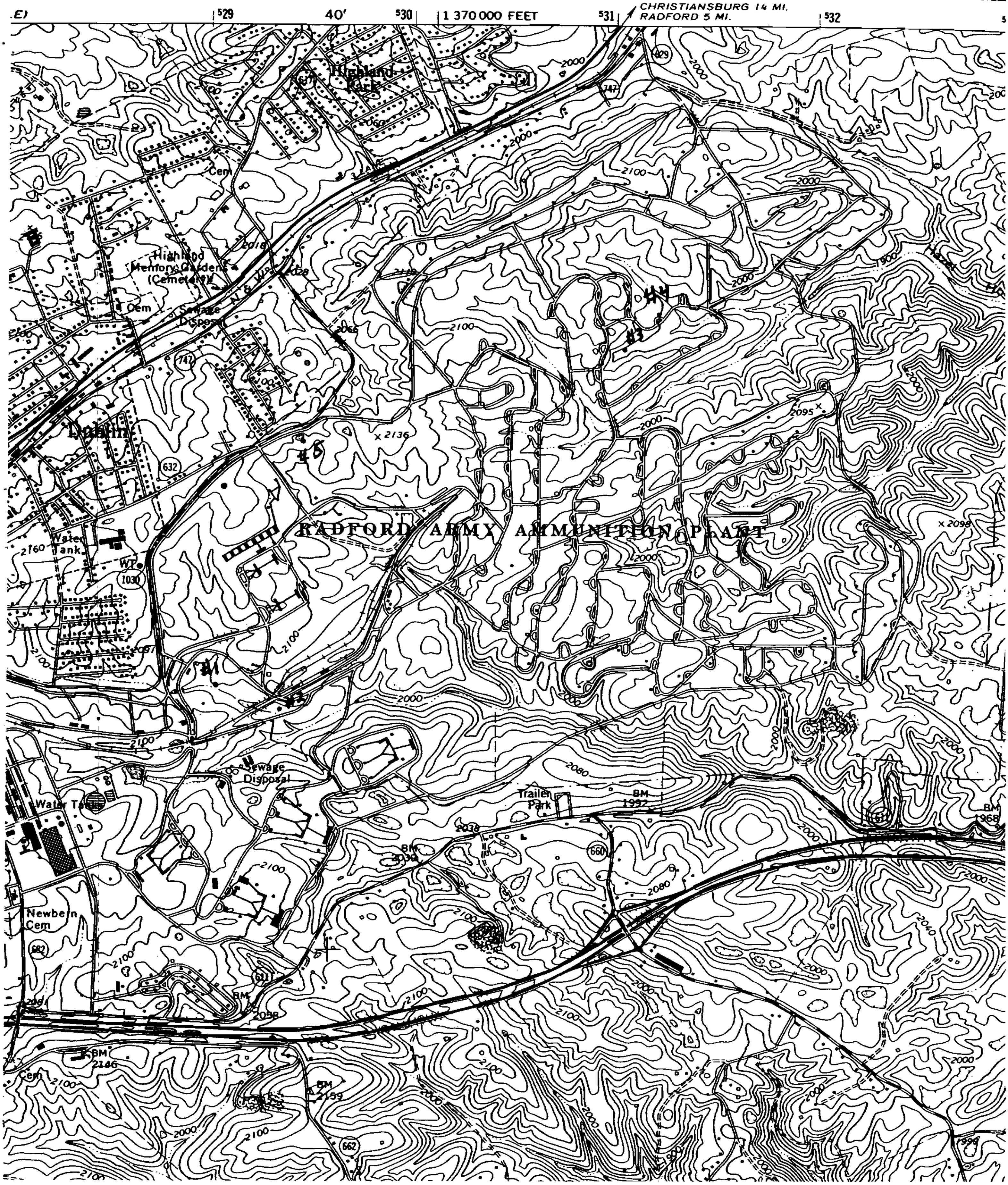

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NWI FIELD DATA SHEET

SITE NO. 6 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS: C Chase

LOCATION(1:100,000 Map): Bluefield SE U.S.G.S. QUAD: Radford N
TOWN: COUNTY: Montgomery STATE: VA
Brief description of site relative to identifiable points on topographic map:
(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PEM5Cx
LANDSCAPE POSITION: LANDFORM:
WATER FLOW PATH: OTHER:

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Phragmites australis
Common Plants:

Less Common Plants: Typha latifolia

LIST OF HYDROLOGY INDICATORS

✓ Standing Water Present 5 in Depth
___ Water Marks Present (explain)
___ Buttressed Trunks (Species)
___ Peat Moss
___ Water-stained Leaves
___ Water-carried Debris
___ Other Hydrology Signs (specify)
___ Saturated Soils Present Within
___ Shallow Roots (Species)
___ Bare (scoured) Areas
___ Oxidized Rhizospheres

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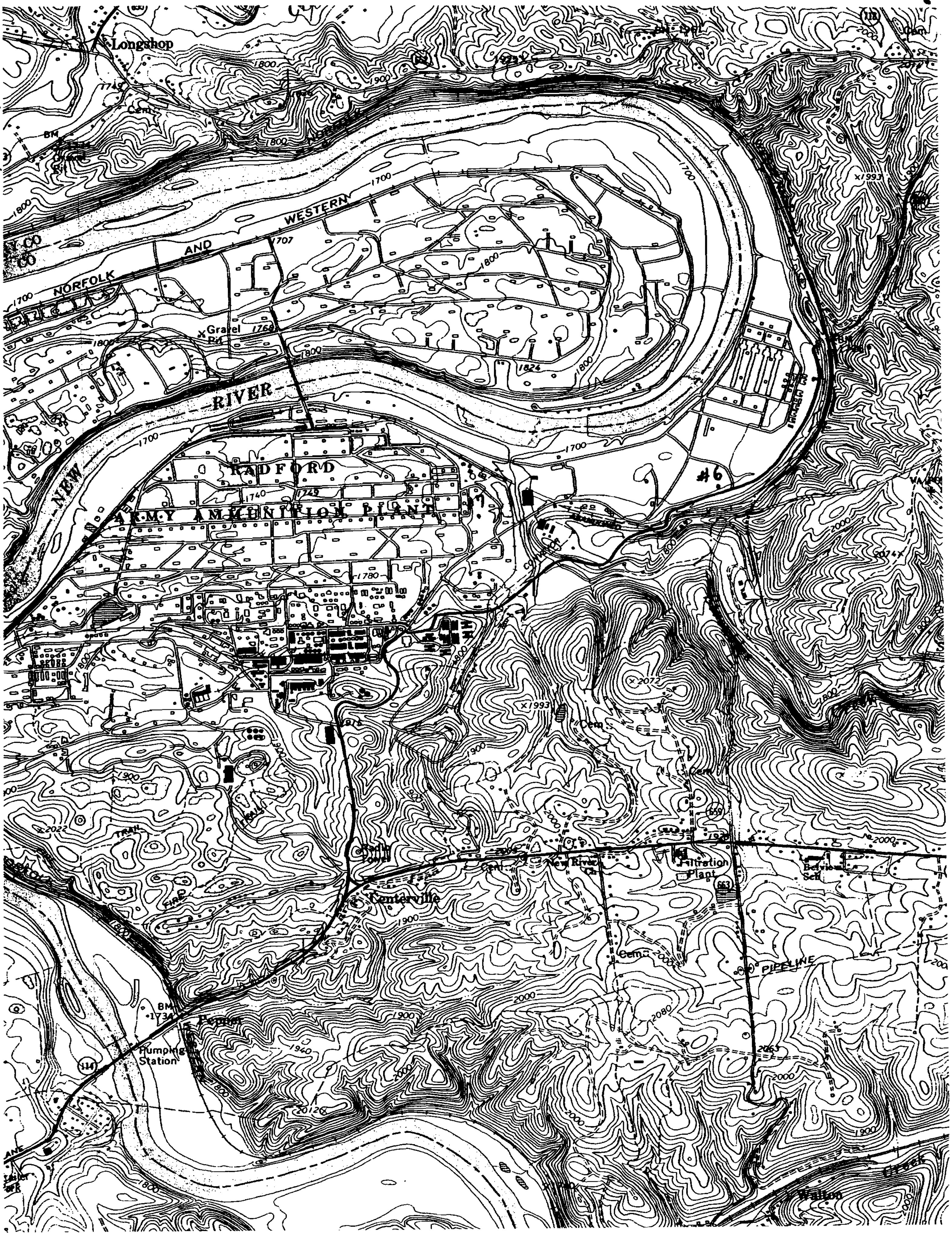

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Gravel Pit
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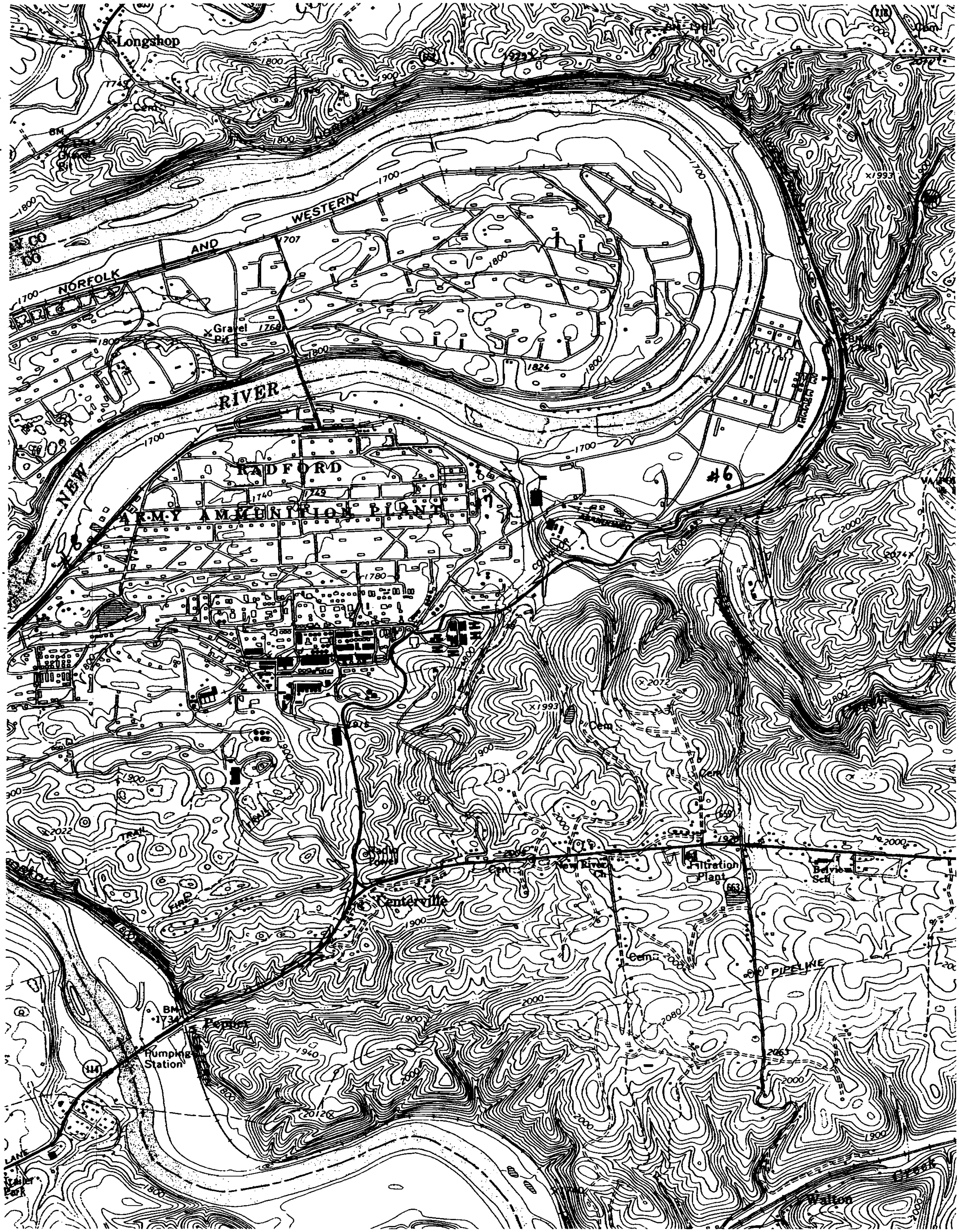
New River Ch
Filtration Plant
Belview Sch
PIPELINE
Pepper
Pumping Station
Walton
Creek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#8
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2000
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1824
1740
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X1993
2072
2074
Cem
BM
Radio Tower
Centerville
New River Ch
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FIRE
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Creek
Park
LANE

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8

NWI FIELD DATA SHEET

SITE NO. 7 REPORTED BY: J. Swords DATE: 11-28-00
OTHER PARTICIPANTS: C. Chase

LOCATION(1:100,000 Map): Bluefield SE U.S.G.S. QUAD: Radford N

TOWN: ______ COUNTY: Montgomery STATE: VA

Brief description of site relative to identifiable points on topographic map: ______

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: — IN-FIELD CLASSIFICATION: PEM1E
LANDSCAPE POSITION: TE LANDFORM: BA
WATER FLOW PATH: IS OTHER: ______

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Typha latifolia

Common Plants: Lemna minor, Calamagrostis canadensis

Less Common Plants: Carex (spp)

LIST OF HYDROLOGY INDICATORS

✓ Standing Water Present 6 in Depth
____ Water Marks Present (explain) ______
____ Buttressed Trunks (Species) ______
____ Peat Moss
____ Water-stained Leaves
____ Water-carried Debris
____ Other Hydrology Signs (specify) ______

____ Saturated Soils Present Within ______
____ Shallow Roots (Species) ______
____ Bare (scoured) Areas
____ Oxidized Rhizospheres

58

NWI FIELD DATA SHEET

SITE NO. 8 REPORTED BY: J. Swiels DATE: 11-28-66
OTHER PARTICIPANTS:

LOCATION(1:100,000 Map): Bluefield SE U.S.G.S. QUAD: Radford N

TOWN: COUNTY: Montgomery STATE: VA

Brief description of site relative to identifiable points on topographic map:

(Attach copy of topographic map)

NWI MAP CLASSIFICATION: ——
LANDSCAPE POSITION:
WATER FLOW PATH:
IN-FIELD CLASSIFICATION: PFO1A
LANDFORM:
OTHER:

DESCRIPTION OF PLANT COMMUNITY

Dominance Type: Acer rubrum

Common Plants: Platanus occidentalis, Nyssa sylvatica

Less Common Plants:

LIST OF HYDROLOGY INDICATORS

_____Standing Water Present_____Depth
_____Water Marks Present (explain)_____
_____Buttressed Trunks (Species)_____
_____Peat Moss
_____Water-stained Leaves
_____Water-carried Debris
_____Other Hydrology Signs (specify)_____

_____Saturated Soils Present Within_____
_____Shallow Roots (Species)_____
_____Bare (scoured) Areas
_____Oxidized Rhizospheres

Appendix C. Acreage and linear mileage totals of wetlands and HGM Acreage at Radford AAP

6a

Radford Army Ammunition Plant
Radford Unit
Linear Wetlands

Palustrine Emergent Wetlands

Attribute	Frequency	miles
PEM1Cx	13	3.23
PEM5Cx	1	0.02
total	14	3.25

Palustrine Forested Wetlands

Attribute	Frequency	miles
PFO1A	1	0.1
total	1	0.1

Riverine Unconsolidated Bottom Wetlands

Attribute	Frequency	miles
R2UBH	1	0.06
R3UBH	1	1.09
total	2	1.15

Riverine Streambed Wetlands

Attribute	Frequency	miles
R4SBC	17	4.60
total	17	4.60

Overall Total	**19**	**5.75**

Radford Army Ammunition Plant
Radford Unit
Polygonal Wetlands and Deepwater Habitats

Palustrine Emergent Wetlands

Attribute	Frequency	Acres
PEM1E	1	0.16
total	1	0.16

Palustrine Forested Wetlands

Attribute	Frequency	Acres
PFO1A	1	2.69
total	1	2.69

Palustrine Unconsolidated Bottom Wetlands

Attribute	Frequency	Acres
PUBHh	1	0.96
PUBHx	2	0.18
PUBKx	6	5.39
total	9	6.53

Palustrine Unconsolidated Shore Wetlands

Attribute	Frequency	Acres
PUSC	1	0.04
total	1	0.04

Riverine Unconsolidated Bottom Wetlands

Attribute	Frequency	Acres
R2UBH	11	221.95
total	11	221.95

Riverine Unconsolidated Shore Wetlands

Attribute	Frequency	Acres
R2USA	4	2.82
R2USC	1	0.77
total	5	3.59

Overall Total **17** **234.96**

8

Radford Army Ammunition Plant
Radford Unit
HGM Data

Lotic River Floodplain Wetlands

HGM code	Frequency	Acres
LR1FPflTH	1	2.69
	1	2.69

Isolated Ponds

HGM code	Frequency	Acres
PD1IS	1	0.04
PD3IS	8	5.56
	9	5.61

Throughflow Ponds

HGM code	Frequency	Acres
PD2THhw	1	0.96
	1	0.96

Rivers

HGM code	Frequency	Acres
RV1TH	16	225.55
	16	225.55

Terrene Basin Isolated Wetlands

HGM code	Frequency	Acres
TEBAIS	1	0.16
	1	0.16

Total Wetlands	**28**	**234.95**

61

Radford Army Ammunition Plant
New River Unit
Linear Wetlands

Palustrine Emergent Wetlands

Attribute	Frequency	miles
PEM1Cx	9	3.15
total	9	3.15

Riverine Unconsolidated Bottom Wetlands

Attribute	Frequency	miles
R2UBHx	2	0.83
R3UBH	1	0.77
total	3	1.6

Riverine Streambed Wetlands

Attribute	Frequency	miles
R4SBC	5	2.61
R4SBCx	1	0.13
total	6	2.74

Overall Total	**18**	**7.49**

Vk

Radford Army Ammunition Plant
New River Unit
Polygonal Wetlands

Palustrine Emergent Wetlands

Attribute	Frequency	Acres
PEM1A	1	0.48
PEM1B	1	0.18
PEM1C	1	0.29
PEM1E	2	0.54
Total	5	1.48

Palustrine Unconsolidated Bottom Wetlands

Attribute	Frequency	Acres
PUBHh	3	1.61
PUBHx	1	0.21
Total	4	1.82

Palustrine Unconsolidated Shore Wetlands

Attribute	Frequency	Acres
PUSCh	1	0.08
PUSCx	1	0.18
Total	2	0.26

Total Wetlands **3.56**

65

Radford Army Ammunition Plant
New River Unit
HGM Data

Lotic Wetlands

HGM Code	Frequency	Acres
LS4FLTHhw	1	0.48
Total	1	0.48

Isolated Ponds

HGM Code	Frequency	Acres
PD2IS	3	0.57
PD3IS	2	0.38
Total	5	0.94

Throughflow Ponds

HGM Code	Frequency	Acres
PD2THhw	1	1.13
Total	1	1.13

Terrene Basin Isolated Wetlands

HGM Code	Frequency	Acres
TEBAIS	3	0.83
Total	3	0.83

Terrene Flat Isolated Wetlands

HGM Code	Frequency	Acres
TEFLIS	1	0.18
Total	1	0.18

Total Wetlands	**11**	**3.56**

Appendix D. "NWI Maps Made Easy" by G .S. Smith (1991)

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NWI MAPS MADE EASY

A User's Guide to National Wetlands Inventory Maps of the Northeast Region

by

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November 1991

Additional copies may be ordered from:

U.S. Fish & Wildlife Service
Ecological Services - NWI
300 Westgate Center Drive
Hadley, MA 01035-9589

Introduction

The purpose of this document is to explain how to read and interpret information from a National Wetlands Inventory map. By following the "decoding" procedure examples, the user will learn to quickly decipher the wetland classification code. The user will be given definitions of specific terms, and examples of wetland types are presented in the accompanying tables. This User's Guide also clarifies some of the seemingly complex wetland terminology and provides a quick reference table to general wetland types.

National Wetlands Inventory

The U.S. Fish & Wildlife Service's National Wetlands Inventory Project (NWI) was established in 1974 to produce information on the characteristics, locations and extent of wetlands and deepwater habitats on a nationwide basis. The two main types of information produced are wetland maps and status and trends reports. The maps are used for local and regional site-specific planning and management purposes, while the status and trends reports provide information on the type, amount, location and causes of wetland changes on a regional and national scale.

Classification System

In order to provide national consistency of wetland concepts, terminology and classification for its National Wetlands Inventory Project, the U.S. Fish and Wildlife Service developed a new classification system, Classification of Wetlands and Deepwater Habitats of the United States. The classification system was developed in 1979, and takes a hierarchical approach to classifying different wetland types. It first describes wetlands broadly by five *systems*: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. The term *system* is defined as "...a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors" (Table 1). Each system (with the exception of the Palustrine System) is divided into *subsystems* based on major hydrologic characteristics (Table 2). Subsystems are subdivided into *classes*, describing the general vegetative types or substrate types (Table 3). The classes are then divided into *subclasses* which describe specific vegetative and substrate types. Additional "modifiers" describing hydrologic and soil properties, water chemistry, or physical modifications of the wetland, are commonly used following the class or subclass level designation (Tables 4, 5 ,6 and 7).

The National Wetlands Inventory (NWI) Map

The main product of the National Wetlands Inventory is the large-scale NWI map. These maps show approximate boundaries and wetland classifications on a 1:24,000 scale* U.S. Geological Survey topographic base map (Figure 1). Actual wetland classifications are abbreviated on the map as alpha-numeric codes. These map codes can be translated using the map legend located in this guide and at the bottom of each NWI map.

The classification system, its terminology, and alpha-numeric map codes may seem overwhelming at first, but the user does <u>not</u> need a thorough understanding of the classification system to use the maps. The following section shows how quick and easy it is to translate any map code into a meaningful description of a particular wetland type.

****Most maps are produced at the 1:24,000 scale, however, some maps are only available at the 1:25,000 or 1:62,500 scale.***

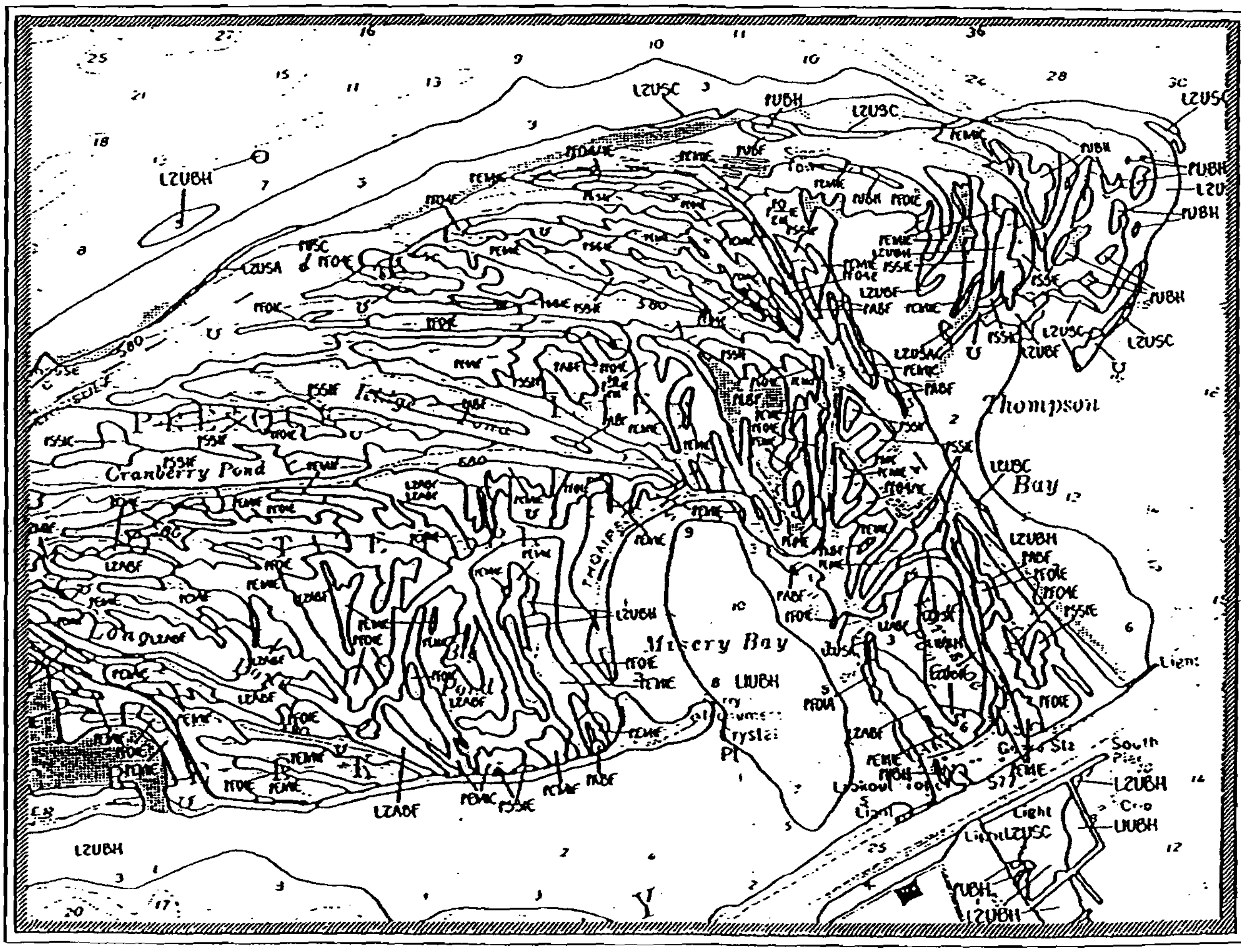


Figure 1. Section of NWI map - Presque Isle Peninsula - Erie North Quadrangle, Pennslyvania

How To Interpret the Map Codes

Each map code consists of an ordered series of letters and numbers (alpha-numeric) that reflect certain characteristics of wetlands and deepwater habitats. While the number of characters in each map code may vary from three to ten symbols depending on the date of the map production, most codes will have from five to seven characters. All maps will have at least three characters for the system, subsystem and class. All map codes are identified under the appropriate system in the map legend at the bottom of each map. The most commonly used codes will be described in the tables of this guide.

Since Palustrine (inland freshwater) and Estuarine (coastal salt and brackish) wetlands are the most common types of wetlands on the maps, they will be used as examples.

Example #1: E2EM1P6

Step 1. *The first character is an upper case letter representing which SYSTEM the wetland belongs to.*

[E] = the ESTUARINE SYSTEM (salt and brackish tidal wetland)

(Refer to Table 1 for descriptions of SYSTEMS.)

Step 2. *The second character is a number, (except in the Palustrine System - no Subsystems) which represents the SUBSYSTEM.*

[2] = the INTERTIDAL SUBSYSTEM (periodically flooded by tides).

(Refer to Table 2 for descriptions of SUBSYSTEMS.)

Step 3. *The third character is a set of two upper case letters representing the CLASS.*

[EM] = the EMERGENT CLASS (non-woody vegetation)

(Refer to Table 3 for descriptions of CLASSES.)

Step 4. *The next character is a* *number* *representing the SUBCLASS.*

1	= the PERSISTENT EMERGENT SUBCLASS (vegetation remains throughout the year)

(Note: To determine SUBCLASS, you *must* refer to the legend under the appropriate CLASS to find the proper subclass, i.e., SUBCLASS codes are *not* interchangeable between CLASSES.)

(The SUBCLASSES are generally self explanatory; refer to map legend.)

Step 5. *The next character is an* *upper case letter* *representing the WATER REGIME MODIFIER.*

P	= the IRREGULARLY FLOODED, TIDAL WATER REGIME (flooded less than once daily)

(Refer to Tables 4, 5 and 6 for descriptions of WATER REGIMES.)

Step 6. *Following the WATER REGIME MODIFIER, there may be additional numbers or lower case letters identifying WATER CHEMISTRY or SPECIAL MODIFIERS.*

6	= the OLIGOHALINE WATER CHEMISTRY MODIFIER (salinity between 0.5 and 5.0 ppt)

(Refer to Table 7 for descriptions of commonly used additional MODIFIERS.)

There is no limit to how many additional modifiers may be used to describe a wetland. Generally, however, there will be only one modifier following the WATER REGIME MODIFIER.

Solution: E2EM1P6 means ESTUARINE, INTERTIDAL, PERSISTENT EMERGENT WETLAND, IRREGULARLY FLOODED, OLIGOHALINE
(common name = slightly brackish marsh).

Example #2: PFO1Cb

Step 1. *The first character is an <u>upper case letter</u> representing which SYSTEM the wetland belongs to.*

P	= the PALUSTRINE SYSTEM (freshwater wetland)

(Refer to Table 1 for descriptions of SYSTEMS.)

Remember, there are no SUBSYSTEMS in the Palustrine System. Proceed to Step 2 to determine the CLASS.

Step 2. *The second character in a Palustrine wetland classification, is a <u>set of two upper case letters</u> representing the CLASS.*

FO	= the FORESTED CLASS (tree-dominated)

(Refer to Table 3 for description of CLASS.)

Step 3. *The next character is a <u>number</u> representing the SUBCLASS.*

1	= the BROADLEAF DECIDUOUS SUBCLASS (hardwoods that drop their leaves annually)

<u>(Note: To determine subclass, you *must* refer to the legend under the appropriate CLASS to find the proper subclass, i.e., subclass codes are *not* interchangeable between classes.</u>)

(The SUBCLASSES are generally self explanatory; refer to map legend.)

Step 4. *The next character is an <u>upper case letter</u> which represents the WATER REGIME MODIFIER.*

C	= the NONTIDAL SEASONALLY FLOODED WATER REGIME (flooded for two weeks or more during the growing season)

(Refer to Tables 4, 5 and 6 for descriptions of WATER REGIMES.)

Step 5. *Following the WATER REGIME MODIFIER, there may be additional numbers or lower case letters identifying WATER CHEMISTRY or SPECIAL MODIFIERS.*

b	= the BEAVER SPECIAL MODIFIER (created by or modified by beaver activity)

(Refer to Table 7 for descriptions of commonly used additional modifiers.)

Solution: PFO1Cb means: **PALUSTRINE, FORESTED WETLAND, BROADLEAF DECIDUOUS, SEASONALLY FLOODED, BEAVER MODIFIED** (common name - wooded swamp).

Review of Examples #1 and # 2:

MAP CODE	SYSTEM	SUB-SYSTEM	CLASS	SUBCLASS	WATER REGIME	SPECIAL MODIFIER	COMMON NAME
E2EM1P6	E	2	EM	1	P	6	brackish marsh
PFO1Cb	P	--	FO	1	C	b	wooded swamp

NWI Map Uses and Limitations

The brief statement below, found in the map legend, outlines how the map was produced and some limitations of map use.

SPECIAL NOTE

This document was prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States, (FWS/OBS-79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in a revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on this document.

Federal, State and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, State or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, State or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

The information on the NWI map is an excellent source of general wetland locations, boundaries and characteristics, however, as stated in the SPECIAL NOTEit is *not* a substitute for intensive on-ground, site-specific investigations when detailed information is required. Due to the limitations of the photointerpretation process, all wetlands are not shown on the NWI map. Certain wetland types such as evergreen forests can be difficult to identify on aerial photographs and are sometimes missed. Aquatic bed wetlands are often not visible on early spring photography, making identification nearly impossible without the use of collateral information. Also, the drier wetland types are difficult to detect, especially on aerial photography taken during drier seasons, dry years or during drought conditions. NWI maps are utilized by a wide variety of users such as engineers, environmental consultants, local conservation commissions, foresters, hunters and fisherman, planning commissions as well as local, county, state and federal conservation and regulatory agencies. Some of the common uses of the maps include project review, analysis of wildlife habitat, comprehensive management plans, land acquisition, oil spill contingency plans, baseline data, environmental impact assessment, identification and education, permit review, wetland evaluation, and utility corridor and facility siting.

TABLE 1. GENERAL CHARACTERISTICS OF SYSTEMS

SYSTEM (MAP CODE)	DESCRIPTION
Marine (M)	Open ocean and its high energy shoreline; salinity > 30 ppt*
Estuarine (E)	Tidal ecosystems, usually semi-enclosed by land, with varying salinities
Riverine (R)	Freshwater flowing water contained within a channel; salinity < 0.5 ppt
Lacustrine (L)	Fresh waterbodies, generally > 20 acres, > 2 meters deep at low water
Palustrine (P)**	Mostly freshwater wetlands; and waterbodies < 20 acres and < 2 meters deep at low water.

**ppt = parts per thousand*

***Examples of this system are ponds, freshwater swamps, marshes and bogs.*

TABLE 2. GENERAL CHARACTERISTICS OF SUBSYSTEMS*

SUBSYSTEM (MAP CODE)	DESCRIPTION	RELEVANT SYSTEMS
Subtidal (1)	Permanently flooded (below mean low tide level)	Marine, Estuarine
Intertidal (2)	Periodically flooded and exposed by tides	Marine, Estuarine
Tidal (1)	Fresh water, tidally influenced river	Riverine
Lower Perennial (2)	Slow-moving river, with low gradient, and well developed floodplain	Riverine
Upper Perennial (3)	Fast moving river with high gradient and little floodplain development	Riverine
Intermittent (4)	Seasonally flowing river	Riverine
Unknown (5)	River sharing characteristics of other subsystems	Riverine
Limnetic (1)	Lake water greater than 2 meters deep	Lacustrine
Littoral (2)	Shallow lake water and adjacent shoreline, less than 2 meters deep	Lacustrine

**NOTE: There are no Subsystems in Palustrine system..*

TABLE 3. GENERAL CHARACTERISTICS OF THE CLASSES

CLASS (MAP CODE)	DESCRIPTION
Rock Bottom (RB)	Permanently flooded bedrock or large chunks of bedrock
Unconsolidated Bottom (UB)*	Permanently flooded sand, gravel, mud or cobble substrate
Unconsolidated Shore (US)	Periodically exposed sand, mud or gravel substrate
Aquatic Bed (AB)	Floating or floating-leaved submerged aquatic vegetation (e.g., duckweed, pondweed, algae)
Reef (RF)	Substrate composed of living organisms (e.g. mussels, oysters)
Rocky Shore (RS)	Periodically exposed bedrock or large chunks of bedrock
Open Water (OW)*	Open water, no visible vegetation
Streambed (SB)	Periodically flooded channel composed of gravel, sand or bedrock
Emergent Wetland (EM)	Herbaceous (non-woody) vegetation (e.g., grasses, sedges, rushes and flowering herbs)
Scrub/Shrub Wetland (SS)	Woody vegetation <20 feet tall (includes dwarf trees in bogs, shrubs and saplings)
Forested Wetland (FO)	Woody vegetation 20 feet or taller (trees)
Moss/Lichen Wetland (ML)	Dominant vegetative cover of mosses, lichens or both

**Earlier NWI maps used the Open Water (OW) class, while present mapping conventions use the Unconsolidated Bottom (UB) class.*

TABLE 4. TIDAL WATER REGIMES (used for Marine and Estuarine systems where salinities > 0.5 ppt)

WATER REGIME (MAP CODE)	DESCRIPTION OF WATER REGIME
Subtidal (L)	Permanently flooded by tides all year long
Irregularly Exposed (M)	Flooded most times except extreme low tides
Regularly Flooded (N)	Flooded and exposed by tides at least once daily
Irregularly Flooded (P)	Flooded less often than once daily by tides

TABLE 5. NONTIDAL WATER REGIMES (used for Riverine, Lacustrine, Palustrine Systems)

WATER REGIME (MAP CODE)	DESCRIPTION OF WATER REGIME
Temporarily Flooded (A)	Floods most years for less than two weeks during growing season; usually dry by mid-growing season
Saturated (B)	Substrate is saturated for most of growing season (commonly year round) and rarely floods
Seasonally Flooded (C)	Floods most years for two weeks or more during growing season; usually dry by end of growing season
Seasonally Flooded/Saturated (E)*	Floods most years for two weeks or more during growing season and remains saturated near the surface for most of the growing season
Semipermanently Flooded (F)	Remains flooded throughout the growing season in most years
Intermittently Exposed (G)	Nearly permanently flooded, exposed only during drought conditions
Permanently Flooded (H)	Remains flooded throughout the year in all years
Intermittently Flooded (J)	Exposed most years, but flooded (usually briefly) during growing season on an irregular basis
Artificial (K)	Flooding controlled by pumps, siphons, etc.

**Not used on all maps*

TABLE 6. FRESHWATER - TIDAL. These areas have freshwater (having salinities of < 0.5 ppt) that fluctuates with tidal movements.

WATER REGIME (MAP CODE)	DESCRIPTION OF WATER REGIME
Temporarily Flooded-Tidal (S)	Floods most years less than two weeks during growing season, but also periodically inundated by freshwater tides*
Seasonally Flooded-Tidal (R)	Floods for two weeks or more during growing season, but also periodically inundated by freshwater tides*
Semipermanently Flooded-Tidal (T)	Remains flooded through most of growing season in most years and is affected by freshwater tides
Permanently Flooded-Tidal (V)	Remains flooded throughout the year in all years and is influenced by freshwater tides
Regularly Flooded-Tidal (N)**	Flooded and exposed at least once daily by freshwater tides

**Periodically inundated means flooded <u>less than once</u> daily by freshwater tides*

***This tidal (salt water) modifier is also used in the Lacustrine, Palustrine, and Riverine systems to describe the water regime of freshwater areas that are flooded (regularly) at least once daily by freshwater tides.*

TABLE 7. COMMONLY USED MODIFIERS

MODIFIER (MAP CODE)	GENERAL DESCRIPTION
Oligohaline (6)	Used to distinguish transitional zone (slightly brackish) between freshwater tidal systems and brackish tidal systems; salinity = 0.5-5.0 ppt
Acid (a)	Used to distinguish floating mat, kettlehole type acidic bogs from other non-acidic wetland types
Beaver (b)	Used to indicate an area that has been either created by, or hydrologically affected by beaver dams
Partially ditched/drained (d)	Used to show an area that has been visibly ditched or partially drained, but maintains wetland hydrology and functions
Farmed (f)	Used in this region (Northeast) to identify commercial cranberry bogs
Artificial (r)	Used to identify manmade impoundments with artificial bottoms (i.e., concrete fish ponds, sewage treatment ponds); also used to identify wetlands created by bench mining of coal
Diked/Impounded (h)	Used to identify areas that have been hydrologically altered or created by construction of a dike or dam which obstructs or stops water flow
Excavated (x)	Created or modified by excavation and removal of existing substrate (i.e., quarries, gravel pits, farm ponds, channelized rivers, drainage ditches)

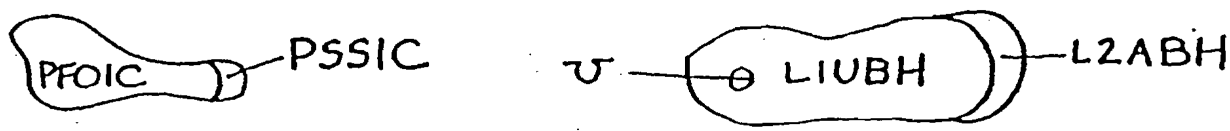
TABLE 8. QUICK CROSS REFERENCE OF MAP CODES TO COMMON WETLAND TYPES (Using System, Subsystem and Class)

MAP CODE	COMMON NAME or WETLAND TYPE
PFO	FORESTED OR WOODED SWAMP OR BOG
PSS	SHRUB SWAMP OR BOG
PEM	EMERGENT MARSH, FEN, OR WET MEADOW
PUB	POND
PUS	POND SHORELINE
PAB	POND WITH FLOATING OR SUBMERGED AQUATIC VEGETATION (DUCKWEEDS, POND LILIES)
R1UB	FRESHWATER TIDAL RIVER
R2UB	SLOW MOVING RIVER WITH FLOODPLAIN
R2AB	RIVER WITH AQUATIC VEGETATION(PICKERELWEED)
R3US	BANK OR SHORELINE OF FAST FLOWING RIVER
R4SB	INTERMITTENT STREAM CHANNEL
R5UB	RIVER SHOWING CHARACTERISTICS OF BOTH UPPER AND LOWER PERENNIAL RIVERS
M1UB	OPEN OCEAN WITH UNCONSOLIDATED BOTTOM
M2AB	INTERTIDAL SEAWEED BED IN OCEAN
M2RF	INTERTIDAL OYSTER AND MUSSEL REEFS IN OCEAN
E2EM	SALT OR BRACKISH TIDAL MARSH
E2SS	ESTUARINE SHRUB SWAMP
E2US	ESTUARINE FLATS, BEACH, OR SAND BARS
E1UB	OPEN WATER ESTUARY
L1UB	DEEPWATER ZONE OF LAKE
L2US	LAKE SHORE OR SHALLOW WATER ZONE OF LAKE
L2AB	AQUATIC VEGETATION IN LAKE
L2UB	SHALLOW WATER ZONE OF LAKE

ADDITIONAL TIPS FOR INTERPRETING THE NWI MAP

*The inverted omega symbol ℧ represents non-wetlands or uplands.

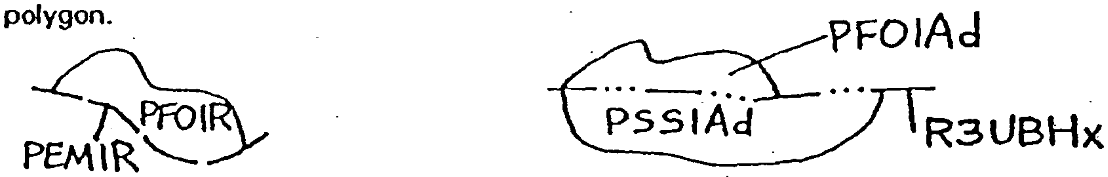
*All wetland polygons are labelled with a map code; the label is located either inside the polygon or a leader line runs from the map code into the appropriate polygon.



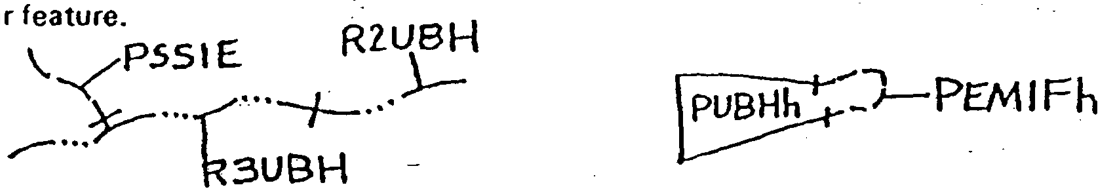
*Wetlands that are too narrow to be delineated with polygons are identified by linear symbols consisting of a dashed line, or a series of dots and dashes.

*Each linear wetland is labelled with a leader line running from the map code.

*A linear wetland may form the boundary of a wetland polygon, or run through a wetland polygon.



*The ends of a linear segment which form the boundary of a wetland polygon, or a classification change along a linear segment, are shown by a short dash, perpendicular to the linear feature.



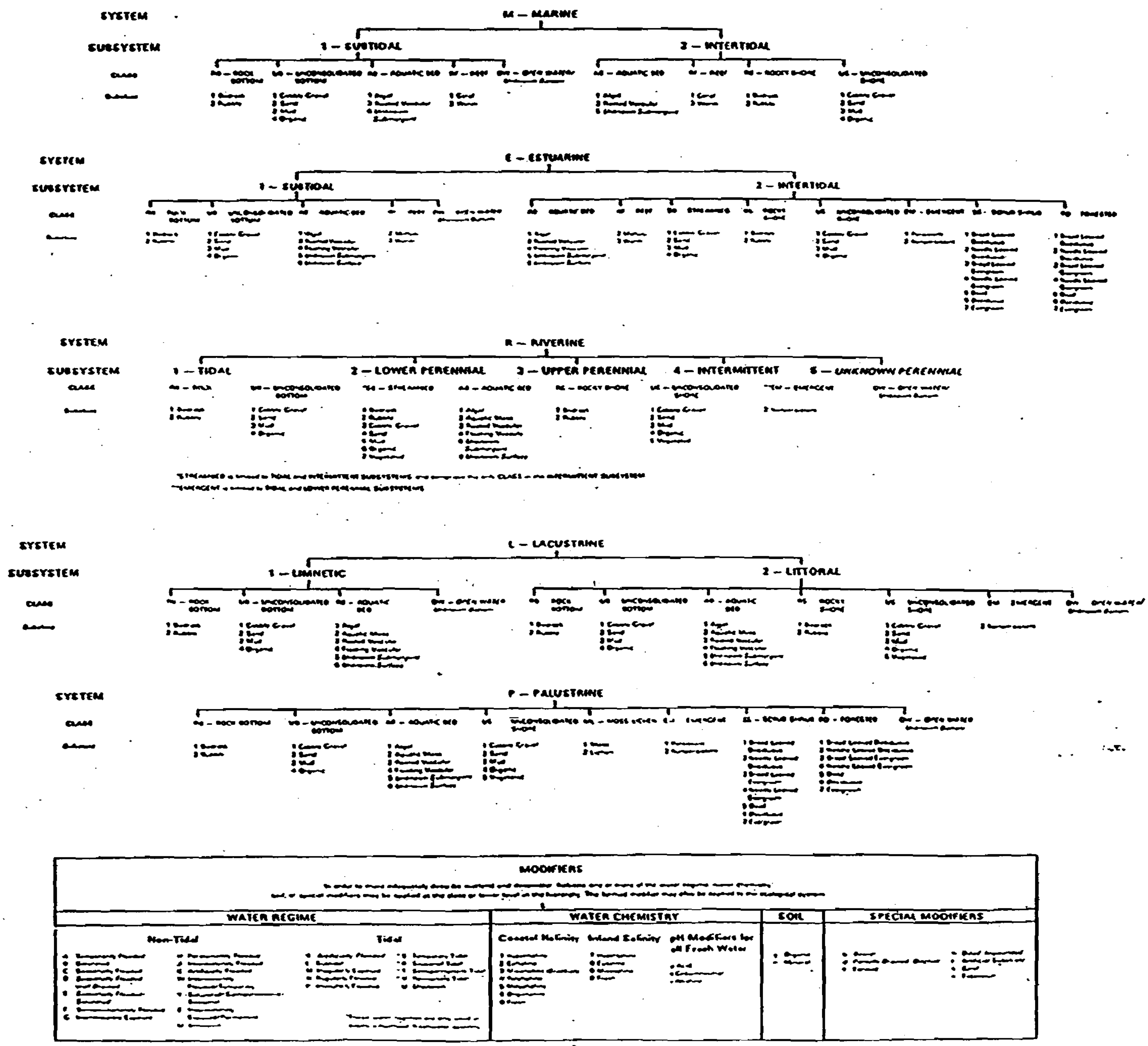
*Some map codes indicate a mixture of either *classes* or *subclasses* within a single polygon. The *class* or *subclass* listed first in the mixed map code is dominant in terms of the amount of surface area covered by that classification type.

mixed class PFO1/SS1E or $P\frac{FO}{SS}1E$

mixed subclass PSS1/3Ba or $PSS\frac{1}{3}Ba$

NWI MAP LEGEND

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



(FOUND AT THE BOTTOM OF EACH NWI MAP)

LIST OF NATIONAL WETLANDS INVENTORY
MAP DISTRIBUTION OUTLETS FOR THE NORTHEASTERN U.S.

U.S. Fish and Wildlife Service - Region 5

State Outlets (verified 4/97)

CT Al Levere
CT Dept. Env'l. Protection
Natural Resources Center
Maps and Publication Sales
79 Elm Street
Hartford, CT 06106
860-424-3643

DE *For Quantities of 1-5 Only*:
Delaware Dept. of Natural Resources
Wetlands Section
89 Kings Highway
P.O. Box 1401
Dover, DE 19903
302-739-4691

For Any Size Order:
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Dover, DE 19904
302-674-2903

ME Bob Tucker
Maine Geological Survey
22 State House Station
Augusta, ME 04333-0022
207-287-2801

MD Maryland Geological Survey
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2300 St. Paul Street
Baltimore, MD 21218
410-554-5505

* MA, PA, VA Dennis Swartwout
Earth Science Information Office
Blaisdell House
Univ. of Massachusetts
Amherst, MA 01003
413-545-0359
413-545-2304 FAX

NH Bea Jillette
Office of State Planning
State of New Hampshire
2 1/2 Beacon Street
Concord, NH 03301
603-271-2155

NJ NJ Dept. Env'l. Protection
Office of Support Services
Maps and Publications - CN-420
Trenton, NJ 08625-0420
609-777-1038

NY Institute for Resource Information Systems (IRIS)
Resource Information Lab
Cornell University
462 Hollister Hall
Ithaca, NY 14853
607-255-4864

RI Dept. of Environmental Mgmt.
Div. of Freshwater Wetlands
235 Promenade Street
Providence, RI 02908
401-277-6820

VT Patty Usle
Dept. of Env'l. Conservation
Water Quality Division
103 South Main St., Bldg. 10-N
Waterbury, VT 05671-0408
802-241-3770

WV Barbara Sargent
Natural Heritage Program
WV Div. of Natural Resources
P.O. Box 67 - Ward Road
Elkins, WV 26241
304-637-0245

National Outlet
Eastern Mapping Center - NCIC
Earth Science Info. Center
U.S. Geological Survey
Reston, VA 22092
703-648-6045
OR
1-800-USA-MAPS (outside of Area Code 703)

*Also distributes NWI maps for AZ, AR, IA, ID, MS, MO, and NM.

Appendix E. Article on NWI Maps. (Tiner, R.W. 1997. NWI Maps: What They Tell Us. National Wetlands Newsletter 19(2): 7-12.)

NWI Maps: What They Tell Us

National Wetlands Inventory maps continue to be the most frequently requested source of wetland data in the country. Yet the maps are frequently misinterpreted, prompting this review of what exactly NWI maps measure — and what they don't

By R.W. Tiner

Since the U.S. Fish and Wildlife Service began producing National Wetlands Inventory (NWI) maps in the mid-1970s, many advances in wetland science, technology, and protection have been made. The definition of wetland has been better articulated, largely out of the need to identify specific boundaries on the ground for regulatory purposes. Significant changes in the NWI mapping procedures and technology have improved the quality of the maps.

However, NWI maps have major advantages and disadvantages, and expectations about using a NWI map to identify wetlands must be realistic. Recent studies evaluating NWI maps have demonstrated that the maps are being improperly interpreted. These studies either were unaware of or did not consider NWI's target mapping unit (see below). Rather than evaluate the accuracy of what NWI was intending to map versus what it actually did map, studies have simply compared NWI maps to field delineations without regard to wetland size or wetland photointerpretability. In addition, some researchers believed that the smallest wetland designated on a NWI map is the minimum mapping unit, rather than being simply the tiniest wetland shown. While most of the assessments involved field work, one study compared NWI maps to soil survey data and made claims about the inaccuracy of NWI maps without any field data. These researchers also assumed that all hydric soil map units were regulated wetlands and even declared that somewhat poorly drained soils are often such wetlands.

In this article, I will describe the major strengths and weaknesses of NWI maps. I also will discuss the differences between NWI wetlands and regulated wetlands and between hydric soil map units and NWI wetlands. Finally, I offer some suggestions on what could be done with future wetland maps.

R.W. Tiner is Regional Wetland Coordinator for the Northeast Region of the U.S. Fish and Wildlife Service. He has been mapping wetlands since 1970.

The definition of wetland

Regulatory and nonregulatory wetland definitions have been developed for different purposes. The federal regulatory wetland definition for administering Section 404 of the Clean Water Act was published in the *Federal Register* on July 19, 1977. The Service's nonregulatory definition for conducting an inventory of the nation's wetlands was first published in 1977, then revised and finalized in 1979 in *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1977, 1979). The regulatory definition deals strictly with vegetated wetlands while the latter includes both vegetated and nonvegetated areas. Yet both definitions are essentially the same for vegetated wetlands.

The Service's definition mentions a list of "hydrophytes and other plants occurring in wetlands" and a preliminary list of hydric soils being prepared to help recognize the nation's wetlands. Over the past 20 years, both lists have undergone critical review and refinement because of increased knowledge of plant-soil-hydrology relationships and widespread use of the lists for wetland delineation. When the NWI began, "hydric soil" was a new term coined by the authors of the Service's wetland classification system. The NWI Project brought the concept of hydric soils to the forefront of wetland identification. Today hydric soil is a criterion for identifying regulated wetlands, and an illustrated national list of hydric soil field indicators has been published. The concept of a hydrophyte is also better understood, and today there is much better information on what vegetation and soil characteristics are reliable wetland indicators.

We must also recognize that it wasn't until 1989 that the federal government standardized its practices for making wetland determinations. The *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*, an interagency document, was adopted by four agencies (the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the Fish and Wildlife Service, and the Soil Conservation Service) as "the technical basis for identifying and delineating jurisdictional wetlands in the United States." The 1989 manual combined existing methods used by these agencies into a consistent set of procedures for identifying and delineating vegetated wetlands. It was the first national technical standard for identifying vegetated wetlands in a consistent, repeatable, and scientifically defensible manner and remains the technical benchmark for identifying vegetated wetlands from a *scientific standpoint*.

These developments plus experience gained from mapping wetlands in numerous states have influenced NWI's application of the Service's definition of wetland. Many areas that might have been overlooked, principally because their plant communities were not dominated by typical wetland species, today are recognized as wetlands when undrained hydric soils are present. Consequently when using a NWI map, it is important to know when the map was produced.

NWI map strengths

In many areas of the country, NWI maps are the only wetland maps available. They are more comprehensive and current than the U.S. Geological Survey topographic map information (which uses swamp and marsh symbols).

NWI maps have been used for a variety of purposes. The most frequent usage is by wetland regulators, the regulated public, and environmental consultants for *preliminary* site assessments, as recommended by federal wetland delineation manuals. Other map uses include: refuge planning and acquisition, park and military base management, watershed planning, environmental impact assessment reports, preliminary site evaluation for development and transportation/utility corridors, oil spill contingency planning, potential wetland restoration site identification, natural resource inventories, wildlife surveys, preliminary assessment of damaged resources at Superfund sites, and land appraisals.

The state of Vermont uses NWI maps to identify "class two wetlands" (wetlands so significant that they merit protection under the state's wetland rules). They recognize NWI wetlands and any unmapped wetlands contiguous with them as this class. Indiana and Illinois use NWI maps to help assess property taxes (those owning wetland acreage receive reduced tax bills). Researchers have used NWI maps to identify training sites for satellite mapping studies. Sportsmen use the maps to locate areas for hunting and fishing. NWI maps and published reports have provided the public with better information on the distribution of nation's wetlands than previously available.

The NWI maps were "generally found to be very accurate" in a multi-agency Maryland field evaluation of NWI maps and satellite mapping produced by the National Oceanic and Atmospheric Administration. Studies have reported high accuracies of NWI maps in Massachusetts, Vermont, New Jersey, and Maine. The National Research Council's 1995 report *Wetlands Characteristics and Boundaries* noted that "wetland delineation on NWI maps is generally accurate [in] areas where there is an abrupt change in hydrology, soil, or vegetation at the wetland boundary." In evaluating various remote sensors for wetland mapping, the Wetland Subcommittee of the Federal Geographic Data Committee concluded that "the best technique for *initial* wetland habitat mapping and inventory is the technique currently used by the FWS's NWI project. . . ." (emphasis added).

By current design, NWI maps tend to err more by omission (Type I error) than by commission (Type II error). This means that if a NWI map indicates the presence of wetland in a given area, it is highly likely that a wetland is there. This is supported by several studies. Conversely, if a NWI map does not indicate a wetland, one is usually not there, but users should not be surprised to find unmapped wetlands, especially drier-end wetlands and wetlands that are difficult to photointerpret (such as certain evergreen forested wetlands, farmed wetlands, mowed and grazed wetlands, and significantly drained wetlands).

The fact that NWI maps do not show all wetlands should not negate their use or value to the public. Users should realize that remote sensing technology (photointerpretation or satellite image analysis) cannot detect all wetlands. In most cases, the larger and wetter wetlands plus most open waterbodies are depicted on the NWI maps. NWI maps can form the base for more detailed local inventories, such as was done in Puget Sound, Washington.

Another strength of NWI maps is that they attempt to show all types of wetland, regardless of whether they are regulated or not. In some areas, such as the Gulf-Atlantic Coastal Plain, many mapped wetlands are not regulated by the Corps because they fail the Corps manual's three-parameter test. While these requirements may change due to politics, the NWI maps attempt to show scientifically accepted wetlands. Moreover, the Service's wetland trends studies show how the nation's wetland resource (at least that which is photointerpretable) is faring and, therefore, provide a consistent means of assessing to what level these wetlands are being protected.

NWI maps continue to be the most frequently requested source of wetland data in the country. Resource managers, regulators, industry representatives, scientists, and others request more than 250,000 NWI map products (hard-copy and digital) annually. Many of these users are repeat customers who have used the information for many years. The usefulness of the NWI maps also is reflected in the fact that more than 100 state and federal agencies and local governments have provided nearly $26 million to the NWI to produce wetland maps and digital data for their area of interest.

Map limitations

The earliest NWI maps (pre-1980) used the operational draft

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Table 1
Examples of major NWI map limitations

1. Target Mapping Unit (tmu). A tmu is an *estimate* of the minimum sized wetland that the NWI is attempting to consistently map. It is *not* the smallest wetland shown on the maps. The tmu for wetlands generally varies with the scale of the aerial photography used, wetland type, project design, and funding. See Table 2.
2. Spring photography. Where spring photography is used, aquatic beds and nonpersistent emergent wetlands are usually undermapped. These areas are classified as open water, unless vegetation was observed during field investigations. In a few cases, scrub-shrub wetlands are submerged, avoiding photo-detection; they too are included within mapped open waterbodies.
3. Summer (leaf-on) photography. This photography makes it difficult to identify many forested wetlands as well as seasonal wetlands. For example, the presence of a leafy canopy makes it extremely difficult to separate all but the wettest forested wetlands from upland forests. The wetness of the forest floor is obscured, except where canopy openings exist. In some areas, such as the Pacific Northwest, spring photography is difficult to acquire due to cloud cover so leaf-on photography was used for wetland mapping. In Alaska, most of the aerial photography is acquired in mid-summer. In both these examples, the NWI Project is conservative in mapping forested wetlands. Also, summer photography makes it more difficult to recognize seasonal wetlands that are flooded in winter and spring, but dry out before the aerial photos are acquired.
4. Forested wetlands. These are among the more difficult types to photointerpret. Consequently, these types are conservatively mapped. Forested wetlands on glacial till are often difficult to photointerpret, so many of these wetlands do not appear on NWI maps. The location of temporarily flooded or seasonally saturated forested wetlands are among the most difficult to identify on the ground as well as through photointerpretation, so many of these wetlands do not appear on the NWI maps. This limitation is common along the Coastal Plain and perhaps in glaciolacustrine plains such as the Ontario Plain (New York). In areas where 1:80,000 black and white photography was used, many forested wetlands were not photointerpretable.
5. Upland inclusions. Small upland areas may occur within delineated wetlands below the target mapping size. Field inspections and/or use of larger-scale photography may be used to refine wetland boundaries where necessary.
6. Estuarine and tidal waters. Delineation of estuarine and riverine (tidal) systems and the oligohaline (slightly brackish) segment of estuaries should be considered approximate based on available reports and limited field checking.
7. Intertidal flats. Since the aerial photos are not always captured at low tide, all intertidal flats are not visible; boundaries of these nonvegetated wetlands are approximated from coastal and geodetic survey maps and topographic maps.
8. Coastal wetlands. Identification of high marsh versus low marsh in estuarine wetlands is often approximated, since the photo-signature of these zones is not distinctive in many instances.
9. Water regimes. Water regimes are identified based on photosignatures coupled with limited field verification; they should be considered approximate. Long-term hydrologic studies are required to accurately describe the hydrology of any particular wetland.
10. Linear wetlands. Long, narrow wetlands that follow drainageways and stream corridors may or may not be mapped, depending on project objectives. Most NWI maps identify at least some of these features using a dashed pattern. In most cases, no attempt was made to map all linear wetlands. Users can infer the possible occurrence of these wetlands by looking for pertinent topographic features on the NWI maps.
11. Farmed wetlands. In general, only five types of farmed wetlands are shown on NWI maps: cranberry bogs, prairie potholes, pothole-like depressions, playa lakes, and seasonally flooded diked former tidelands in California. This is based on technical considerations and an interagency agreement between the U.S. Fish and Wildlife Service and the U.S.D.A. Natural Resources Conservation Service, developed in the 1970s.
12. Partly drained wetlands are mapped based on recognizable photo-signatures. Many of these wetlands may have been missed.
13. Tundra. Moist tundra (usually wetland) is often difficult to separate from dry upland tundra due to photo-signatures. This is especially true where wide transition zones exist between the two types.
14. Map date. NWI map data are dependent on the date of the photography. Maps do not show losses or gains in wetlands since that date.

Cowardin classification system and were prepared during NWI's operational testing of the system. This also marked the Service's first large-scale application of remote sensing technology for mapping wetlands. These earlier maps generally tend to be far more conservative and omit more wetlands than later maps (where 1:40K photos were used). While some of this difference is due to a better technical understanding of the concept of wetland, other differences relate to changes in mapping technology (such as the use of color infrared photos versus black and white photos, and use of larger scale photography) and procedures (such as an increased level of quality control and field review).

A strength of NWI maps is that they attempt to show all types of wetland, regardless of whether they are regulated or not

Relying on photointerpretation to map wetlands imposes numerous constraints. First and foremost, it must be recognized that wetland identification is not always clearcut. Wetlands have been described as ecotones between water and terrestrial habitats, although this notion is a gross oversimplification. Ecotonal wetlands along the wetland-upland interface are expected to possess a somewhat confusing mix of plants and soils. Wetland identification requires analyzing often subtle changes in vegetation patterns, soil properties, and signs of hydrology, so it is easy to understand why photointerpretation fails to accurately identify subtle wetland-upland boundaries and many of the drier-end wetlands.

Studies have reported significant omissions of wetlands from NWI maps when compared to field delineations in North Carolina, New York, Virginia, and Washington. The latter study erroneously reported significant omissions on NWI maps that were later found to be the result of a digitizing error by the researchers. Forested wetlands, small wetlands, and narrow (linear) wetlands tend to be the major sources of omissions. Also, the fact that NWI maps, by design, do not show many farmed wetlands in most of the country also leads to a significant underestimate of the amount of wetland in agricultural regions, with the Pothole Region being a major exception.

The accuracy of wetland photointerpretation is, in large part, dependent on the landscape setting and wetland type. The National Research Council reported that "mapping wetlands in level landscapes, such as coastal or glaciolacustrine plains, is less precise because boundaries are not as evident." Wetland mapping in more varied terrain is more accurate because boundaries are better defined by abrupt changes in slope. Problems associated with photointerpreting forested wetlands have been reported; Table 1 lists some major limitations of NWI mapping due to reliance on photointerpretation.

NWI maps have a target mapping unit (tmu). A tmu is an *estimate* of the minimum sized wetland that should be consistently mapped. It is *not* the smallest wetland that appears on the map, but it is the size class of the smallest group of wetlands that NWI attempts to map *consistently*. The NWI Project could edit the maps to guarantee that no smaller wetlands are designated, but this would not benefit users, so smaller wetlands are permitted. The tmu is conveyed to photointerpreters working on individual projects, but not to map users, which probably has invited some justified criticism.

Accurately determining an appropriate tmu is somewhat problematic. Some wetland types are more conspicuous and smaller wetlands of these types may be mapped, while other types are more difficult to photointerpret and larger ones will be missed. This is inherent in the use of remote sensing to map wetlands. Despite these difficulties, specifying a tmu can serve as a benchmark or another caution to users. However, at this time, such a note is not anticipated to be added to NWI maps. Users should contact the appropriate Service Regional Wetland Coordinator for specifics. Table 2 presents some examples of tmus across the country.

Maps produced by photointerpretation will never be as accurate as a detailed on-the-ground delineation. This is not to say that photointerpretation cannot produce accurate boundaries at a fraction of the cost of field delineation. For some types in certain landscapes (such as marshes, fens, bogs, wetter swamps surrounded by upland, and seasonally flooded bottomland swamps), photointerpretation works well for locating the boundary of these types. For other types in different situations (such as certain evergreen forested wetlands, drier-end wetlands in relatively flat landscapes, and significantly drained wetlands), it does not work well and the boundaries are more generalized.

NWI wetlands versus regulated wetlands

The NWI maps were never intended to show the limits of regulated wetlands. A "Special Note" that appears on the map clearly points this out: "Federal, state and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any federal, state or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities." After reading this statement, it should be evident to a map user that he or she should contact the regulatory agencies regarding the extent of regulated areas and not rely on a NWI map for this information.

Within the limitations of NWI photointerpretation techniques, the Service attempts to map all types of wetlands without regard to their jurisdictional status. As a result, NWI maps also depict nonregulated wetlands. Besides policy guidelines (such as wetland size, location, and artificial hydrology), the extent of nonregulated wetlands is a product of the amount of proof required to identify a regulated wetland. In 1991, the burden of proof was increased when the federal government shifted from using the 1989 interagency manual to the 1987 Corps manual. The former manual assumes the presence of wetland hydrology when positive indicators of hydrophytic vegetation and hydric soils were found *in the absence of any signs or knowledge of significant drainage*, which is consistent with the National Research Council's findings. In contrast, the Corps manual requires more proof of wetland hydrology and has a more restrictive vegetation requirement. Corps districts also were given discretion for using the facultative neutral rule and interpreting the length of the growing season, which can significantly affect wetland determinations. (The facultative neutral rule compares better wetland indicator plants against species that are better indicators of upland, giving no weight to species that occur nearly equally in both wetlands and uplands.) Now, many drier-end wetlands do not meet the requirements for federal regulation because they either: 1) have plant communities dominated by FAC- or FACU species (species with a frequency of occurrence in wetlands of less than 50 percent), 2) possess wet soils that do not display typical hydric soil field indicators, 3) lack currently accepted wetland hydrology indicators, or 4) are not wet enough during the Corps-defined growing season to qualify as a regulated wetland, despite significant wetness during the rest of the year.

NWI maps versus soil survey maps

Using GIS technology, some researchers have reported on digital data comparisons between NWI maps and soil survey maps. These types of studies cannot assess the accuracy of either source in wetland identification unless field verification is performed. Researchers also must ensure accurate digitizing of data sources since this can be a significant source of error.

Significant discrepancies between wetlands identified on NWI maps and "hydric soil map units" of soil surveys usually exist. The soil survey focuses on management, while NWI is concerned strictly with wetland identification. Soil map units often contain both hydric and nonhydric soils if the management of those soils is similar. This approach leads to more Type II errors (commissions) for wetland determinations while NWI maps tend to make more Type I errors (omissions). This difference in design can lead to enormous differences in estimating the extent of wetlands.

Several other reasons also cause notable contradictions between NWI maps and hydric soil map units. Soil maps have a minimum map unit tied to the final map scale, which reflects the level of effort given. When a 1:24,000 scale map is desired, a minimum map unit of 5.7 acres is the typical target according to the *Soil Survey Manual.* Yet most map units are much larger than this, especially in forested areas. For example, the *Soil Survey of Umatilla County Area, Oregon* identifies a five-acre minimum for strongly contrasting soils, a 40-acre minimum for small grain-fallow and annual cropping areas, and a 100-acre minimum for rangeland and woodland. This can result in large units of mixed soil types, since soil map units often contain more than one type of soil.

For some hydric soil map units, hydric soils comprise 60 percent of the unit and nonhydric soils as much as 40 percent, although inclusions of other soils may usually represent less than 20 percent. Thus, only 60-80 percent of any hydric soil map unit may actually contain hydric soils and have a *potential* for being a wetland or regulated wetland. Also some map units are associations of two or more series. Hydric and nonhydric soils can comprise a single association. If the acreage of potential wetlands is estimated by the sum total of hydric soil map units and any association including a hydric soil component, the projected figure could be vastly inflated. It would be prudent to use an appropriate percentage of these units to estimate historic wetland acreage.

Soil maps generally do not distinguish between undrained or

[illegible]

[illegible]	[illegible] map all wetlands
Northwest	[illegible] Northeast
Southwest	1-3 acres
Alaska	2-5 acres

In all cases, user must recognize basic limitations of NWI mapping.

partly drained hydric soils (wetlands) and effectively drained or filled hydric soils (nonwetlands), so both types are designated as "hydric soil map units." Translating hydric soil acreage to wetland usually leads to a significant overestimate of current wetland acreage. Again, since former wetlands are not designated on the NWI maps, this too accounts for significant "wetland" acreage discrepancies.

Finally, the series level of soil classification was never intended to separate hydric soils from nonhydric soils. Some series are so broadly characterized that they include both hydric and nonhydric members. This situation applies to most, if not all, of the soils with an aquic suborder (saturated soils with reducing conditions due to a lack of free oxygen) and an "aeric" subgroup (soils that are drier in the upper part of the soil). When these soils occur lower in the landscape, they often have hydric soil properties, whereas when they are upslope, they do not. These types of series need to be subdivided into two series, one that has hydric soil morphology (poorly drained) and another that does not (somewhat poorly drained). In the meantime, considering map units with such series as wetlands also adds to exaggerating wetland acreage.

Future options

The NWI Project could design a product that could attempt to map more wetlands by changing the basic inventory design to favor Type II errors over Type I. This would require mapping certain landscapes that favor wetland formation. These areas could be labelled with a unique code to separate them from the photointerpretable wetlands to maintain data integrity. These additions could be called "areas potentially supporting some wetlands," for example. A map like this may be more valuable than the current NWI maps, especially to regulatory agencies and the regulated community, since it may better inform landowners and developers on where regulated wetlands *may* exist.

Another option involves assembling information from field delineations to update and enhance NWI maps. If regulatory agencies required applicants to approximate verified wetland boundaries on a USGS topographic map or on a NWI map and provided such information to the Service, future updates of NWI maps could incorporate this valuable site-specific information. This would make more use of the work of professional wetland delineators and help enhance the existing national wetland map database. Environmental consultants and regulators alike are encouraged to provide the NWI Project with this information.

In the meantime, people with an interest in knowing whether regulated wetlands are on their property should be advised to do the following:

1. Consult both NWI maps and soil surveys to get an idea of where wetlands may be located on their properties. Also learn to interpret maps to identify landscapes where wetlands tend to form (such as floodplains, drainageways, toes of slopes, flats, depressions, and saddles between mountains). Considering these sites as potential wetland areas is also good practice. These landscapes can be seen on the NWI maps by interpreting topographic contours.

2. Learn how to identify wetland plants and hydric soils. Numerous easy-to-use wetland plant field guides and at least one hydric soil guidebook are available for the nonscientist.

3. Contact the appropriate regulatory agency.

While regulations and the criteria employed by regulators may change and how they are interpreted on the ground may vary, the average person, using a variety of sources of information including NWI maps and once familiar with wetland plants and soils, should be able to recognize wetlands or questionable areas that might be regulated wetlands on their property. ■

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Nichols, C. 1994. *Map Accuracy of National Wetlands Inventory Maps for Areas Subject to Land Use Regulation Commission Jurisdiction.* U.S. Fish and Wildlife Service, Hadley, MA.

Stolt, M.H. and J.C. Baker. 1995. *Evaluation of National Wetland Inventory maps to inventory wetlands in the southern Blue Ridge of Virginia.* Wetlands 15(4): 346-353.

Swartwout, D.J., W.P. MacConnell, and J.T. Finn. 1982. *An evaluation of the National Wetlands Inventory in Massachusetts.* Proc. of In-Place Resource Inventories Workshop (University of Maine, Orono, August 9-14, 1981). pp. 685-691.

Thurston Regional Planning Council. 1991. Thurston Regional Wetland Pilot Project. Olympia, WA.

U.S. Fish and Wildlife Service. 1996. *Some Uses of National Wetlands Inventory Maps and Digital Map Data in the Northeast.* Ecological Services, Region 5, Hadley, MA.

U.S. Fish and Wildlife Service. 1992. *An Investigation and Verification of Draft NWI Maps for Cape May County,* New Jersey. New Jersey Field Office, Pleasantville, NJ.

*A complete list of references can be obtained from the author by written request: U.S. Fish and Wildlife Service, Ecological Services (NWI), Region 5, 300 Westgate Center Drive, Hadley, MA 01035.

Appendix F. List of Wetland Publications

Updated July 2001

LIST OF SELECTED WETLAND PUBLICATIONS

The following is a list of selected reports, articles, and books dealing with a variety of wetland topics. Most of these publications are produced by and available from the U.S. Fish and Wildlife Service, Northeast Region and the Service's National Wetlands Inventory Project. Publications are arranged by general topics. Information on where to order each is provided. For other Federal publications, visit your local Federal Depository Library. For a list by state contact: Federal Depository Libraries, U.S. Govt. Printing Office, Mail Stop SL, H and North Capital Streets, Northwest,Washington, D.C. 20401; email address: www.access.gpo.gov.

The NWI Project has a home page on the internet. Digitized NWI maps can be accessed through the internet. Come browse our home page (http://www.nwi.fws.gov) or (http://wetlands.fws.gov).

All publications with numbers in the margin can be obtained free of charge from: USFWS, Ecological Services, 300 Westgate Center Drive, Hadley, MA 01035-9589. An order form is provided at the end of this list for your convenience.

At the end of this list is a listing of Wetland Regulatory Agencies. This list is provided for readers interested in specific Federal regulations relative to potential building/construction projects.

WETLAND DEFINITION, CLASSIFICATION, AND BASIC CONCEPTS
(See also, "General Wetland References")

178 *Classification of Wetlands and Deepwater Habitats of the United States* by L.M. Cowardin, V. Carter, F.C. Golet, and E.T. LaRoe. 1979. FWS/OBS-79/31. 103 pp. (Limited copies available)

101 *"Wetlands are ecotones - reality or myth?"*

102 *"How wet is a wetland?"*

103 *"The concept of a hydrophyte for wetland identification"* (BioScience)

104 *"Classification of wetland ecosystems"*

195 *"A Clarification of the U.S. Fish and Wildlife Service's Wetland Definition "*

Wetlands and Ecotones: Studies on Land-Water Interactions edited by B. Gopal, A. Hillbrichtt-Ilkowska, and R.G. Wetzel. 1993. National Institute of Ecology and International Scientific Publications, New Delhi, India. Available from: International Scientific Publications, 50-B Pocket C, Siddhartha Extension, New Delhi 110014 India.

165 *"Keys to Waterbody Type and Hydrogeomorphic - type Descriptors for the U.S. Waters and Wetlands"* (operational Draft) by R. Tiner, May 2000

167 *"Technical Aspects of Wetlands: Wetland Definitions and Classifications in the United States"* by R. Tiner. 1997.

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping by R.W. Tiner. 1999. Lewis Publishers, CRC Press Inc., 2000 Corporate Boulevard NW, Boca Raton, FL 33431; (561) 994-0555.

WETLAND AND RIPARIAN MAPPING

105 *"The National Wetlands Inventory - The First Ten Years"*

106 *"Creating a national georeferenced wetland data base for managing wetlands in the United States"*

107 *"Use of high-altitude aerial photography for inventorying forested wetlands in the United States"*

108 *NWI Maps Made Easy: A User's Guide to National Wetlands Inventory Maps of the Northeast Region* by G.S. Smith. 1991.

109 *"Results of a Field Reconnaissance of Remotely Sensed Land Cover Data"* (Maryland Department of Natural Resources).

110 *"Application of Satellite Data for Mapping and Monitoring Wetlands"* (Federal Geographic Data Committee).

111 *Comparison of Four Scales of Color Infrared Photography for Wetland Mapping in Maryland* by R.W. Tiner and G.S. Smith. 1992. U.S. Fish and Wildlife Service, Region 5, Newton Corner, MA. National Wetlands Inventory Report. R5-92/03. 15 pp. plus tables.

An Investigation and Verification of Draft NWI Maps for Cape May County, New Jersey by U.S. Fish and Wildlife Service, New Jersey Field Office. 1992. Available from: New Jersey Field Office, U.S. Fish and Wildlife Service, 927 N. Main Street (Bldg. D-1), Pleasantville, NJ 08232.

157 "Strategic Interagency Approach to Developing a National Digital Wetlands Data Base" (Federal Geographic Data Committee).

158 *Map Accuracy of National Wetlands Inventory Maps for Areas Subject to Maine Land Use Regulation Commission Jurisdiction* by C. Nichols. 1994.

162 *Assessment of Remote Sensing/GIS Technologies to Improve National Wetlands Inventory Maps* by B. Wilen and G. Smith. 1996. Proceedings: Sixth Biennial Forest Service Remote Sensing Applications Conference, Denver, CO.

164 "Some Uses of National Wetlands Inventory Maps and Digital Map Data in the Northeast".

166 "NWI Maps: What They Tell Us".

169 "Wetlands", R.W. Tiner. *In*: Manual of Photographic Interpretation, second edition. 1996.

170 "Adapting the NWI for Preliminary Assessment of Wetland Functions", R.W. Tiner. 1997. *In*: The Future of Wetland Assessment: Applying Science through the Hydrogeomorphic Assessment Approach and Other Approaches. The Association of State Wetland Managers Institute for Wetland Science and Public Policy.

171 "NWI Maps--Basic Information on the Nation's Wetlands", Ralph Tiner. *In*: BioScience. May 1997.

172 "Piloting a More Descriptive NWI", Ralph Tiner. *In:* National Wetlands Newsletter, Vol. 19(5). September-October 1997.

176 "A System for Mapping Riparian Areas in the Western United States: An Operational Draft". December 1997. U.S. Fish and Wildlife Service.

AERIAL PHOTOGRAPHY AND PHOTO SEARCHES - may be ordered from the following sources:

U.S. Geological Survey
EROS (Earth Resources Observation Systems)
Customer Services
Sioux Falls, SD 57198
(605) 594-6151

U.S. Department of Agriculture
APFO
Customer Services
2222 West 2300 South
P.O. Box 30010
Salt Lake City, UT 84130-0010
(801) 975-3503

Earth Science Information Office
Blaisdell House
University of Massachusetts
Amherst, MA 01003
(413) 545-0359

WETLAND IDENTIFICATION - FIELD GUIDES

Field Guide to Nontidal Wetland Identification by R.W. Tiner, Jr. 1988. Maryland Department of Natural Resources and U.S. Fish and Wildlife Service. Cooperative publication. 283 pp. + 198 color plates. Full color reproductions are available from: Institute for Wetland and Environmental Education and Research, P.O. Box 288, Leverett, MA 01054;
(413) 548-8866.

A Field Guide to Coastal Wetland Plants of the Northeastern United States by R.W. Tiner, Jr. 1987. University of Massachusetts Press, P.O. Box 429, Amherst, MA 01004; (413) 545-2219. 286 pp.

Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast by D.W. Magee. 1981. University of Massachusetts Press, P.O. Box 429, Amherst, MA 01004; (413) 545-2219. 246 pp.

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Northeastern States Plant Lists are available from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; (703) 605-6000. *Add $4.00 handling charge for each order. (**Attention**: Individual State Plant Lists can often be obtained at a lower price through NWI Map Distribution Outlets, which are listed at the back of this Publications List.)

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WETLAND PROTECTION

Protecting America's Wetlands: An Action Agenda by The Conservation Foundation, Washington, DC. 69 pp. Available from: The World Wildlife Fund, 1250 Twenty-fourth Street NW, Washington, DC 20037; (202) 778-9521 (Mrs. Keller). Limited copies available.

Protecting Nontidal Wetlands by D.G. Burke, E.J. Meyers, R.W. Tiner, Jr., and H. Groman. American Planning Association, 1313 East 60th Street, Chicago, IL 60637. Planning Advisory Service Report 412/413. 76 pp. (Contains model local wetland protection ordinance.)

Statewide Wetlands Strategies: A Guide to Protecting and Managing The Resource by World Wildlife Fund. Available from: Island Press, Box 7, Covelo, CA 95428, (800) 828-1302 OR Island Press, 1718 Connecticut Avenue NW, Washington, DC; (202) 232-7933.

WETLAND MITIGATION

Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base by J.S. Larson and C. Neill (editors). 1987. The Environmental Institute, University of Massachusetts and the Fund for New England, 143 pp. Available from: The Environmental Institute, University of Massachusetts, Blaisdell House, Amherst, MA 01003.

Compensatory Wetland Mitigation in Massachusetts by S. Brown and P. Veneman, 1998, available from Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, Massachusetts 01003.

WETLAND WEB SITES

Some sites that may be of interest:

1) http://www.sws.org (Society of Wetland Scientists)
2) http://www.wes.army.mil/el/wetlands.html (U.S. Army Corps of Engineers Waterways Experiment Station
3) http://www.nwi.fws.gov (U.S. Fish and Wildlife Service National Wetlands Inventory)
4) http://www.statlab.iastat.edu/soils/hydric (Hydric Soils Information)
5) http://www.pwrc.usgs.gov/wli/ (USDA's Wetland Science Institute)
6) http://www.epa.gov/owow/wetlands/wetline.html (U.S. EPA)
7) http://www.lwv.org/webwalk/index.html (League of Women Voters - Wetland Education Projects)
8) http://www.eli.org/bookstore/nwnindex.htm (Environmental Law Institute's National Wetlands Newsletter Index)
9) http://www.beaversww.org (Beavers: Wetlands and Wildlife-information on beaver and structures to control beaver caused flooding at dams and culverts)
10) http://www.cas.psu.edu/docs/CASDEPT/FOREST/wetlands/cwchome.htm (Penn State Cooperative Wetland Center)
11) http://www.terrene.org (Terrene Institute; some wetland information, but links to many environmental organizations)
12) http://plants.usda.gov/plants (NRCS information on plants, including wetland search for "wetland indicator status")
13) http://www.vernalpool.org (Vernal Pool Information)
14) http://www.topozon.com (free access to USGS topographic maps)
15) http://plants.ifas.ufl.edu (University of Florida's Aquatic, Wetland, and Invasive Plant Information Retrieval System)
16) http://ramsar.org/strp_rest_index.htm (Ramsar information on wetland restoration)
17) http://www.epa.gov.watertrain/wetlands/ (wetland functions and value module)
18)http://www.dec.state.ny.us/website/dow/stream/index.htm(New York State pictorial key to wetland/stream macroinvertebrates)

PUBLIC INFORMATION REPORTS/BOOKLETS/POSTERS/COLORING BOOKS

U.S. Department of the Interior, *The Impact of Federal Programs on Wetlands, Vol. I*, A Report to Congress by the Secretary of the Interior, Washington, DC. October 1988. (Geographic Area includes: The Lower Mississippi Alluvial Plain and the Prairie Pothole Region.) Available from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; (703) 605-6000.

U.S. Department of the Interior, *The Impact of Federal Programs on Wetlands, Vol. II*, A Report to Congress by the Secretary of the Interior, Washington, DC. March 1994. (Geographic Area Includes: The Everglades, Coastal Louisiana, Galveston Bay, Puerto Rico, California's Central Valley, Western Riparian Areas, Southeastern and Western Alaska, The Delmarva Peninsula, North Carolina, Northeastern New Jersey, Michigan, and Nebraska.) Available from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; (703) 605-6000.

America's Wetlands: Our Vital Link Between Land and Water. 1988. U.S. Environmental Protection Agency, Office of Wetlands Protection, Washington, DC. 9 pp. Free single copies available from: Public Information Center (PM-211B), U.S. EPA, 401 M Street S.W., Washington, DC 20460.

My Wetland Coloring Book. 1991. Explains why wetlands are important. Available from: Superintendent of Documents, Gov't Printing Office, 710 North Capital Northwest, Washington, DC 20401, (202) 512-1800, email address: http://www.access.gpo.gov/su_docs

Young Scientist's Introduction to Wetlands..1994. Educational coloring book that defines wetlands, wetland plants/animals. Available from: Superintendent of Documents, Govt. Printing Office, 710 North Capital Northwest, Washington, D.C. 20401, (202) 512-1800, email address: http://www.access.gpo.gov/su_docs/

"Wetlands Fact Sheets" on topics related to wetland protection and regulation, as well as any other general wetland questions. **EPA Wetland Protection Hotline 1-800-832-7828.**

163 *Restoring Massachusetts Wetlands*. Coloring book for elementary school children produced by the Massachusetts Wetlands Restoration and Banking Program (WRBP), Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, MA 02202; phone (617) 727-9300, x213. (Copies also available from WRBP.)

Habitat Values of New England Wetlands by C. Pedevillano. Available from: U.S. Fish and Wildlife Service, New England Field Office, 22 Bridge St., Concord, NH 03301; (603) 225-1411.

WETLAND JOURNALS/NEWSLETTERS

Wetlands - The Journal of the Society of Wetland Scientists. Available from: The Society of Wetland Scientists, P.O. Box 296, Wilmington, NC 28402.

Wetland Journal. Available from: Environmental Concern, Inc., P.O. Box P, St. Michaels, MD 21663, (410) 745-9620.

National Wetlands Newsletter. Available from: Environmental Law Institute, 1616 P Street N.W., Suite 200, Washington, DC 20036.

Association of State Wetland Managers Newsletter. Available from: Association of State Wetland Managers, Box 2463, Berne, NY 12023.
Wetlands Ecology and Management. SPB Academic Publishing Inc., Amsterdam.

Swamp Things Mailing List (notes from U.S. EPA's Wetland Division)
To be added to the list, contact Stephanie Peters, Wetlands Division (4502F), USEPA, 401 M Street, SW, Washington, DC 20460; (202) 260-7946; FAX: (202) 260-2356; email address: peters.stephanie@epamail.epa.gov.

Wetland Breaking News (latest in up-to-date wetland issues and publications). Produced by the Association of State Wetland Managers. Electronic mailings. To get on the mailing list, email: news@aswm.org.

WETLAND NATURAL HISTORY

Days Afield - Exploring Wetlands in the Chesapeake Bay Region by W.S. Sipple. Available from: W.S. Sipple, 518 Red Bluff Court, Millersville, MD 21108; (410-987-4083; email: www.bsip333@aol.com)

See also *In Search of Swampland* listed under "Wetland Identification - Field Guides."

WETLAND PLANT NURSERIES

Inclusion of this list does not represent endorsement by the U.S. Fish and Wildlife Service. The list is simply presented as a guide for individuals looking for wetland plants to purchase. *CAUTION*: When considering native plantings, seek out nurseries as close to your property as possible, as they should have the best genetically adapted plants for your climate and soil conditions.

Pinelands Nursery, Inc.
323 Island Road
Columbus, NJ 08022
(609) 291-9486
(Also has nurseries in Gloversville, NY and Toano, VA

New England Wetland Plants, Inc.
800 Main Street
Amherst, MA 01002
(413) 256-1752

New England Environmental Services
Blackledge River Nursery
155 Jerry Daniels Road
Marlborough, CT 06447
(860) 295-1022

Bigelow Nurseries
P.O. Box 718
Northboro, MA 01532
(508) 845-2143

Ernest Crownvetch Farms
RD 5, Box 806
Meadville, PA 16335
(800) 873-3321

Sylva Native Nursery & Seed Co.
RD 2, Box 1033
New Freedom, PA 17349
(717) 227-0486

Environmental Concern, Inc.
P.O. Box P
St. Michaels, MD 21663
(410) 745-9620

Southern Tier Consulting Inc.
2701 A Route 305
P.O. Box 30
West Clarksville, NY 14786
(716) 968-3120

Wildlife Nurseries Inc.
P.O. Box 2724
Oshkosh, WI 54903-2724
(920)231-3780

Ecoscience Wetland Nursery
RR4, Box 4294
Moscow, PA 18444
(717) 842-7631

Octoraro Wetland/Native Nurseries
Box 24
Oxford, PA 19363
(610) 932-3762

WETLAND REGULATORY AGENCIES IN THE NORTHEAST

FEDERAL AGENCIES

Chief, Regulatory Branch
U.S. Army Corps of Engineers
Baltimore District
P.O. Box 1715
Baltimore, MD 21203
(410) 962-3670
Geographic Area: Susquahanna and Chesapeake Bay Watersheds; Maryland and Central Pennsylvania

Chief, Regulatory Branch
U.S. Army Corps of Engineers
Buffalo District
1776 Niagara Street
Buffalo, NY 14207
(716) 879-4104
Geographic Area: Western New York

Chief, Regulatory Branch
U.S. Army Corps of Engineers
Huntington District
502 Eighth Street
Huntington, WV 25701
(304) 529-5211
Geographic Area: Ohio River Drainage; West Virginia

Chief, Regulatory Branch
U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, VA 23510
(757) 441-7601
Geographic Area: Virginia

Chief, Regulatory Branch
U.S. Army Corps of Engineers
Philadelphia District
100 Penn Square East
Philadelphia, PA 19107
(215) 656-6734
Geographic Area: Delaware River Drainage; Eastern Pennsylvania, Southern New Jersey, and Delaware

Chief, Regulatory Branch
U.S. Army Corps of Engineers
New York District
Jacob K.Javits Federal Bldg.
New York, NY 10278
(212) 264-3996
Geographic Area: New York and Northern New Jersey

Chief, Regulatory Branch
U.S. Army Corps of Engineers
New England Division
696 Virginia Road
Concord, MA 01742
(978) 318-8220
Geographic Area: New England States

Chief, Regulatory Branch
U. S. Army Corps of Engineers
Pittsburgh District
1000 Liberty Avenue
Pittsburgh, PA 15222
(412) 644-4204
Geographic Area: Western Pennsylvania

For information on state wetland regulatory agencies, contact the appropriate U.S. Fish and Wildlife Service field office:

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401
(410) 573-4500

Eastern Pennsylvania Field Office
P.O. Box H
Tobyhanna, PA 18466
(570) 894-1275

Long Island Field Office
P.O. Box 608
Islip, NY 11751
(516) 581-2941

Maine Field Office
1033 South Main Street
Old Town, ME 04468
(207) 827-5938

New England Field Office
22 Bridge Street, Unit #1
Concord, NH 03301
(603) 225-1411

New Jersey Field Office
927 North Main St., Bldg. D
Pleasantville, NJ 08232
(609) 646-0620

New York Field Office
3817 Luker Road
Cortland, NY 13045
(607) 753-9334

Pennsylvania Field Office
315 S. Allen St., Ste. 322
State College, PA 16801
(814) 234-4090

Rhode Island Field Office
P.O. Box 307
Charlestown, RI 02813
(401) 364-9124

Southwestern Virginia Field Office
P.O. Box 2345
Abingdon, VA 24210
(540) 623-1233

Virginia Field Office
6669 Short Lane
Gloucester, VA 23061
(804) 693-6694

West Virginia Field Office
P.O. Box 1278
Elkins, WV 26241
(304) 636-6586

LIST OF NATIONAL WETLANDS INVENTORY MAP DISTRIBUTION OUTLETS FOR THE NORTHEASTERN U.S.

U.S. Fish and Wildlife Service - Region 5

State Outlets (verified 4/97)

CT
Diane DeTuccio
CT Dept. Env'l. Protection
Natural Resources Center
Maps and Publication Sales
79 Elm Street
Hartford, CT 06106
860-424-3581

DE
***For Quantities of 1-5 Only*:**
Delaware Dept. of Natural Resources
Wetlands Section
89 Kings Highway
Dover, DE 19903
302-739-4691

***For Any Size Order*:**
Gerald A. Donovan Associates, Inc.
429 South Governors Avenue
Dover, DE 19904
302-674-2903

ME
Bob Tucker
Maine Geological Survey
22 State House Station
Augusta, ME 04333-0022
207-287-2801

MD
Maryland Geological Survey
Dale Shelton, Publications
2300 St. Paul Street
Baltimore, MD 21218
410-554-5505

*** MA, PA, VA**
Dennis Swartwout
Earth Science Information Office
Blaisdell House
Univ. of Massachusetts
Amherst, MA 01003
413-545-0359
413-545-2304 FAX

NH
Bea Jillette
Office of State Planning
State of New Hampshire
2 1/2 Beacon Street
Concord, NH 03301
603-271-2155

NJ
NJ Dept. Env'l.Protection
Office of Support Services
Maps and Publications -CN-420
Trenton, NJ 08625-0420
609-777-1038

NY
Eugena Barnaba
Cornell Institute for Resource Information Systems (IRIS)
Resource Information Lab
Cornell University
302 Rice Hall
Ithaca, NY 14853
607-255-4864; 607-255-6520

RI
Chuck Herbert
Dept. of Environmental Mgmt.
Water Resource Program
235 Promenade Street
Providence, RI 02908
401-222-4700 (x7710, wetlands)

VT
Patty Usle
Dept. of Env'l. Conservation
Water Quality Division
103 South Main St., Bldg. 10-N
Waterbury, VT 05671-0408
802-241-3770

WV Barbara Sargent
Natural Heritage Program
WV Div. of Natural Resources
P.O. Box 67 - Ward Road
Elkins, WV 26241
304-637-0245

National Outlet
Eastern Mapping Center - NCIC
Earth Science Info. Center
U.S. Geological Survey
Reston, VA 22092
703-648-6045
OR
1-888-ASK-USGS
(1-888-275-8747)

*** Also distributes NWI Maps for AZ, AR, ID, MS, MO, and NM.**

NOTICE: NWI maps are available in digital form for many areas via the Internet (http://www.nwi.fws.gov).

PUBLICATION ORDER FORM

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115	130	144a	159	174	189
190	191	192	193	194	195
196					

Mail to: U.S. Fish and Wildlife Service
Ecological Services (NWI)
300 Westgate Center Drive
Hadley, MA 01035-9589

p:/drobinso/ralph/pubs/publists2.wpd

Appendix G. Wetlands: Best Management Practices (Source: Welsch, et al. 1995)

WETLANDS
BEST MANAGEMENT PRACTICES

The following is a list of wetland best management practices intended to supplement existing upland forestry best management practices and to reduce potential adverse impacts of forest management activities on wetlands. Note that some upland BMP's have been included as appropriate to facilitate understanding. While some of the practices may be required by law, they are listed here simply as a means of protecting the wetlands functions and values.

This list is intended as an example and to be effective should be supplemented or refined by individual State Foresters in consultation with representatives of other natural resource management agencies such as the U.S. Army Corps of Engineers, Environmental Protection Agency, Natural Resources Conservation Service, Fish and Wildlife Service, State Water Quality Agency, consultant foresters, forest industry representatives and others for use in their respective states. The list should not be considered a checklist of mandatory practices as there will seldom be a situation in which all of the practices will be needed on the same area at the same time.

THREE PRIMARY CONSIDERATIONS

1. Consider the relative importance of the wetland in relation to the total property to be managed. Perhaps the wetland should simply be left undisturbed.
2. Protect the environment. Do not alter the hydrology of the wetland by:
   - restricting the inflow or outflow of surface, sub-surface or groundwater,
   - reducing residence time of waters,
   - introducing toxic substances,
   - changing the temperature regime.
3. Protect wildlife habitat to the extent that knowledge permits and to a level consistent with its value to society.

All of the BMP's in this document can be traced back to these three primary considerations.

PLANNING

Identify and comply with federal, state, and local laws and regulations as discussed in the legal requirements section of this document.

Identify control points: those places within the area to be managed that should be accessed, those that should be avoided or those that need special consideration.

Some examples of control points are:

- Location of surface water, spring seeps and other wetlands. *Note that these are best located in the spring as many wetlands are difficult to identify during dry periods.*
- Location of environmentally preferable stream crossing points.
- Location of streamside management zones as described below.
- Location of areas requiring special equipment or timing of operations.

The timber sale contract or harvest agreement should contain language to require the use of the BMP's identified as necessary in the planning process.

Establish streamside management zones, strips of land bordering surface waters and in which management activities are adjusted to protect or enhance riparian and aquatic values. An example would be a strip managed for shade or larger trees to help maintain cooler water temperatures or provide large woody debris to streams respectively.

Establish filter strips, strips of land bordering surface waters, that are sufficient in width based on slope and roughness factors and on which machine access is controlled to prevent sedimentation of surface water.

Locate access system components such as roads, landings, skid trails, and maintenance areas outside of filter strips and streamside management zones.

To eliminate unnecessary soil disturbance, plan the most efficient access system to serve the entire property, then build only what is currently necessary.

Limit equipment entry into wetlands to the minimum necessary. Avoid equipment entry into wetlands whenever possible.

ACCESS SYSTEMS

Examples of BMP's presented in the Haul Roads section are based on BMP's being prepared by the Minnesota Department of Natural Resources, Division of Forestry and the Minnesota Wetland BMP Committee.

PERMANENT HAUL ROADS

Haul roads are travelways over which logs are moved while fully supported on the bed of a wheeled truck.

Timber haul costs include construction, hauling and maintenance of both roads and equipment. Use of poor practices to reduce construction costs only results in related increases in hauling and maintenance costs. A properly located and constructed road will be most cost efficient and will have limited adverse impact on water resources including wetlands and aquatic and riparian habitats.

Consider threatened and endangered species habitat, trout spawning seasons, and public water supplies when locating and building roads.

Avoid constructing roads through wetlands unless there are no reasonable alternatives.

Where roads must be constructed through wetlands, use the following and other BMP's to design and construct the road system so as neither to create permanent changes in wetland water levels nor alter the wetland drainage patterns.

Road drainage designs in wetlands must provide cross drainage of the wetland during both flooded and low water conditions.

Avoid road construction and use during spring thaw and other wet periods.

Use drainage techniques such as crowning, insloping, outsloping and 2 percent minimum grades as well as surface gravel and maintenance to ensure adequate drainage and discourage rutting and associated erosion and sedimentation.

Divert outflow from road drainage ditches prior to entering wetlands and riparian areas to minimize the introduction of sediment and other pollutants into these sensitive areas.

Minimize the width of the road running surface to the minimum necessary to safely meet owners objectives, typically 12 feet wide for straight sections and 16 feet wide for curves. Additional width may need to be cleared of large vegetation to accommodate plowed snow.

Cease road use if ruts exceed 6 inches in depth for more than 300 feet.

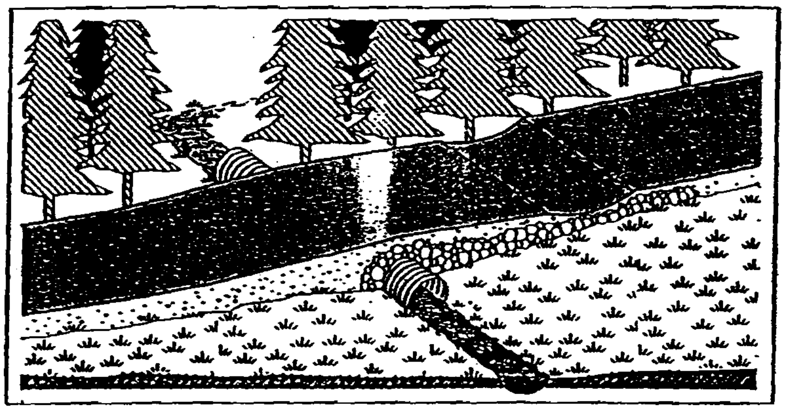
Consider use of geotextile fabric during construction to minimize disturbance, fill requirements, and maintenance costs.

All fills in wetlands should be constructed of free draining granular material.

Road construction on soils with organic layers in excess of 16 inches in thickness

Organic soils vary greatly in strength, and consultation with a registered engineer is advised when designing roads on these soils.

Permanent haul roads built on organic wetlands must provide for cross drainage of water on the surface and in the top 12 inches of soil. This can be accomplished through the incorporation of culverts or porous layers at appropriate levels in the road fill to pass water at its normal level through the road corridor.

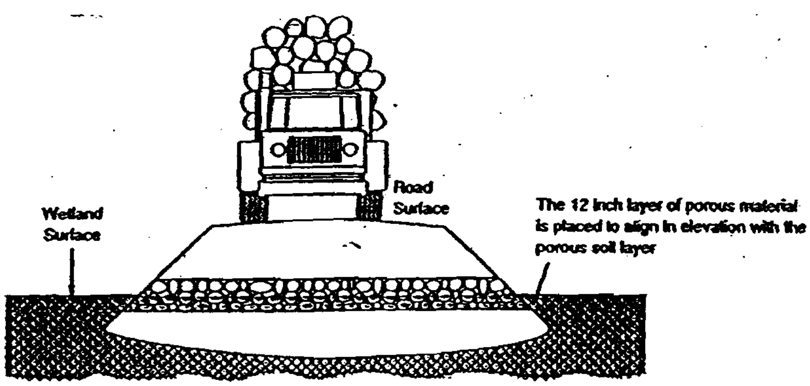


All culverts in organic soils should be 24 inch diameter and placed with their bottom half in the upper 12 inches of the soil to handle the subsurface flow and their top half above the surface to handle above ground flow. Failure to provide drainage in the top 12 inches of the soil can result in changes in the hydrology of the wetland and subsequent changes in water chemistry and plant and animal habitat.

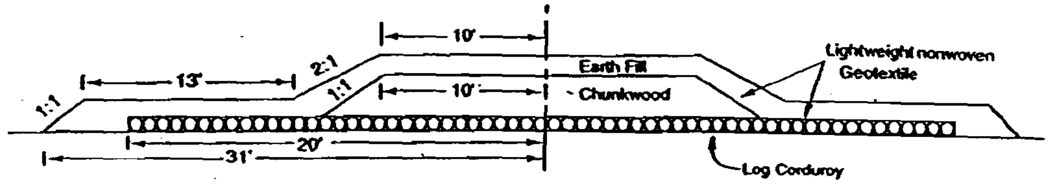
Road construction on soils with organic layers in excess of 4 feet in thickness

Where organic soils are greater than 4 feet deep, the road should be constructed across the top of the soil surface by placing fill material on top of geotextile fabric and/or log corduroy. The road will sink into the peat somewhat due to its weight and the low bearing strength of the soil and will require cross drainage to prevent interruption of the wetland flow.

POROUS ROAD DESIGN



ALTERNATIVE POROUS ROAD DESIGN
(shown in photo sequence below)



One method of drainage is to incorporate a 12 inch thick layer of porous material such as large stone or chunkwood into the roadbed. This material should be separated from the adjacent fill layers by geotextile fabric, and be incorporated into the road fill design so as to lie in the top 12 inches of the soil thus providing a continuous cross drainage.

Minnesota Department of Natural Resources

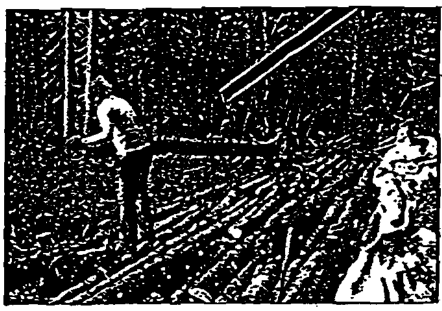
▲ A permeable section road being constructed by first laying geotextile fabric.

Climate permitting, construction on soils with deep organic layers is best undertaken when the organic soil is frozen in order to preserve the strength of the root mat.

Where continuous porous layers are not used, culverts should be placed at points where they will receive the greatest support from the soil below. These areas generally occur near the edge of the wetlands or as inclusions where the organic soil is shallow.

Ditches parallel to the roadbed on both sides should be used to collect surface and subsurface water, carry it through the culvert and redistribute it on the other side. These ditches should be located three times the depth of the organic layer from the edge of the road fill unless otherwise determined by an engineer.

Road construction on soils with organic layers between 1.3 and 4 feet in thickness



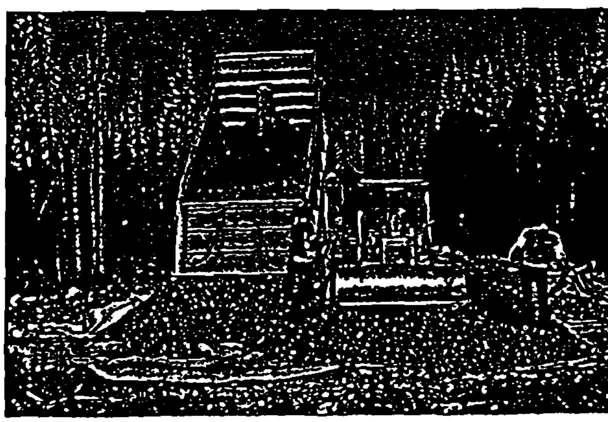
Minnesota Department of Natural Resources

▲ A corduroy of parallel laying logs is placed on top of the geotextile.

Where organic soils are less than 4 feet deep, fill can be placed directly on the peat surface and allowed to sink compressing or displacing the peat until equilibrium is reached. With this method, culverts are used instead of porous layers to move surface and subsurface flows through the road fill material.

Culverts should be placed at the lowest elevation on the road centerline with additional culverts as needed to provide adequate cross drainage.

Ditches parallel to the road centerline should be constructed along the toe of the fill to collect surface and subsurface water, carry it through the culvert and redistribute it on the other side.



Minnesota Department of Natural Resources

▲ Geotextile is then placed on top of the corduroy along with a layer of wood chunks to form the porous layer. Coarse gravel could be substituted.

Minnesota Department of Natural Resources

▲ Another layer of geotextile is placed on top of the chunkwood to prevent contamination and sealing of the porous layer. The gravel running surface is placed on top of the geotextile fabric.

Road Construction on Mineral Soils or Those with Surface Organic Layers Less than 1.3 Feet in Thickness

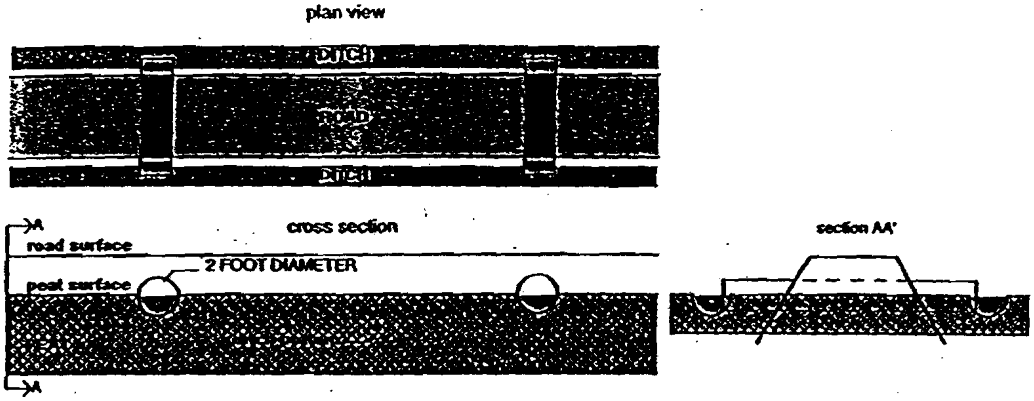
Roads through mineral soil wetlands can be constructed using normal road construction techniques. Use geotextiles to increase bearing strength of the road and to preserve the bearing strength of fill material by preventing contamination with fine soil particles.

In mineral soil wetlands, a culvert should be placed at the lowest elevation on the road centerline with additional culverts as needed to provide adequate cross drainage..

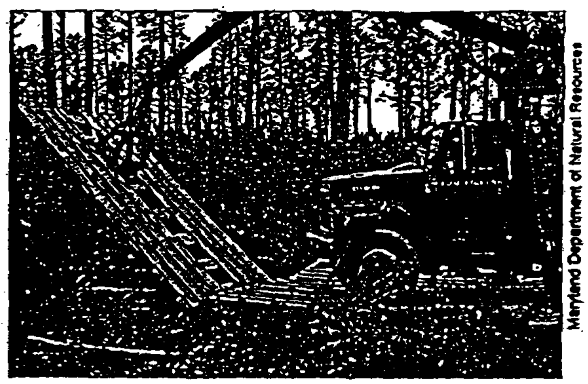
Ditches parallel to the road centerline should be constructed along the toe of the fill to collect surface and subsurface water, carry it through the culvert and redistribute it on the other side.

Fills should be constructed of free draining granular material.

CULVERT LOCATION FOR ROADS ON MINERAL SOIL AND SHALLOW ORGANIC SOIL WETLANDS

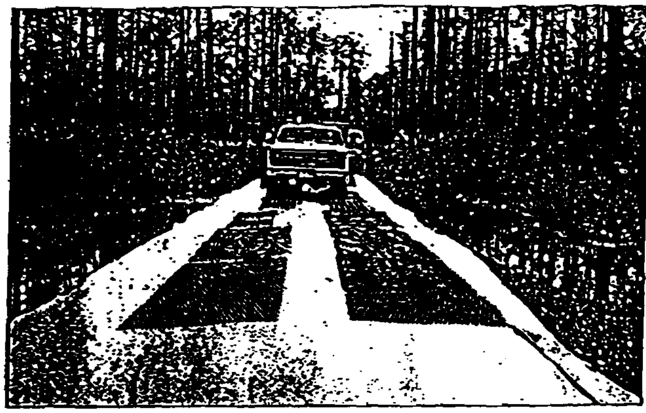


24 inch diameter culverts should be installed with the lower half in the porous upper 12 inch layer of organic soil to accommodate drainage during normal and inundated conditions.



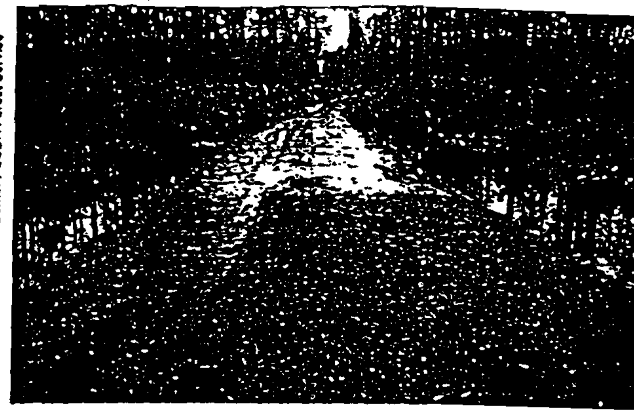
▲ Wooden mats are an efficient solution to temporary road access and can be carried and placed by a log truck.

▲ A mat road to a log landing in Maryland



San Dimas Equipment Development Center / USDA Forest Service

▲ Geotextile and expanded metal sheets are used to strengthen an existing road.



San Dimas Equipment Development Center / USDA Forest Service

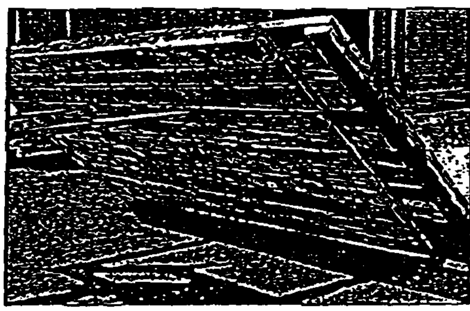
▲ Removal of the geotextile and expanded metal leave the road surface relatively undisturbed.

TEMPORARY ROAD CONSTRUCTION ON ALL SOILS

Examples of BMP's used in the Temporary Roads section are based on methods in use in Maryland and Delaware.

For temporary roads, consider the use of support systems such as geotextiles and various wood and metal platform devices

Consider subsoiling or chiseling to break up compacted road surface to reestablish soil porosity when hauling is completed.

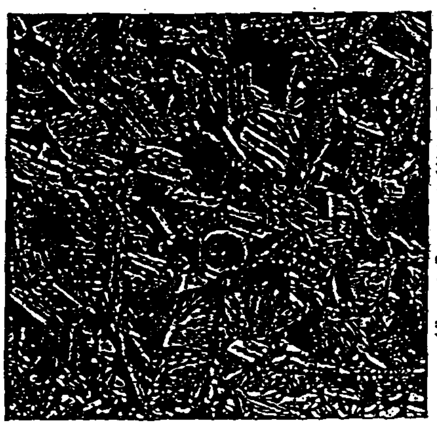


San Dimas Equipment Development Center / USDA Forest Service

▲ Wooden mats vary considerably in construction and handling characteristics.

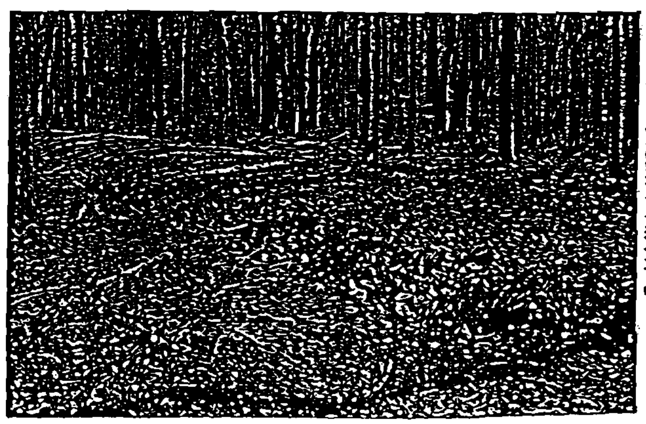
Maryland Department of Natural Resources

▲ Wooden mats can be used to provide mud-free highway approaches.



Minnesota Department of Natural Resources

▲ Typical size of chunkwood fill material



David J. Welsch / USDA Forest Service

▲ Gravel surface may be used directly over chunkwood fill for a lightweight road where a porous section is less important.

SKID TRAILS

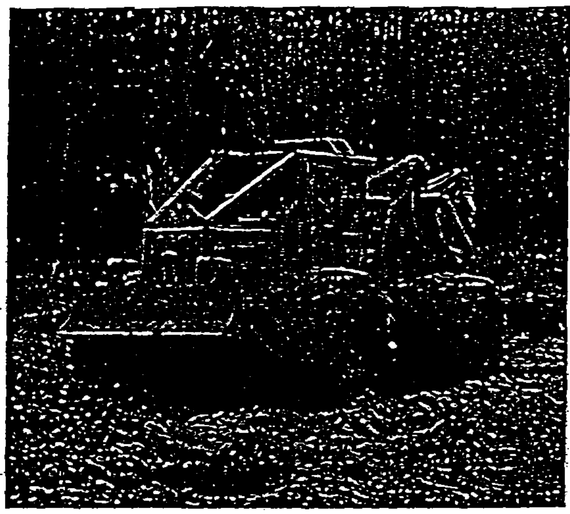
Skid trails are rough travelways for logging machinery. Logs are often dragged over the skid trail surface only partially supported by the machine pulling them and partially supported on the trail surface.

Avoid equipment entry into wetlands especially those that can be logged by cable from adjoining uplands.

Where equipment entry into wetlands is unavoidable, minimize the area disturbed as well as the number of repeated passes over the same trail.

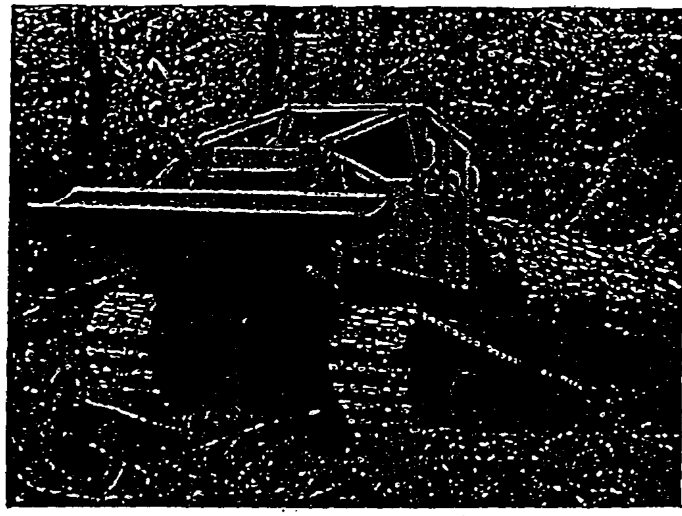
Ruts over 6 inches in depth can block normal subsurface drainage and create surface channels resulting in either a raised water table or shorter residence time and excessive drainage. Do not create a pattern of trails with 6 inch ruts that either blocks or facilitates drainage.

Use low ground pressure equipment when possible or tracked vehicles on both organic soil wetlands and mineral soil wetlands where soils have greater than 18 percent fines as defined by the Natural Resources Conservation Service. Use conventional tires on skidders only when the ground is dry or frozen.



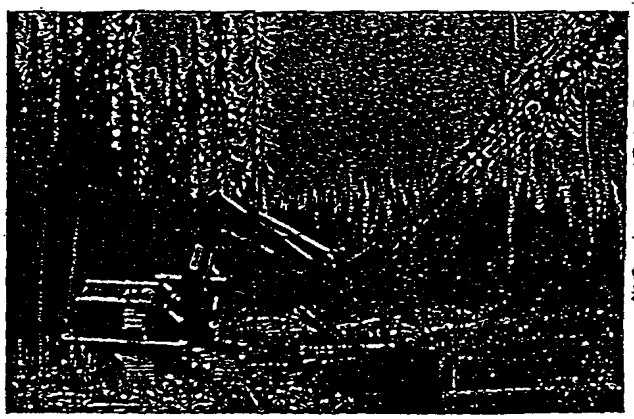
Blanchard Machinery Co., Columbia, SC

▲ High floatation equipment such as these extra wide tires helps to prevent rutting.



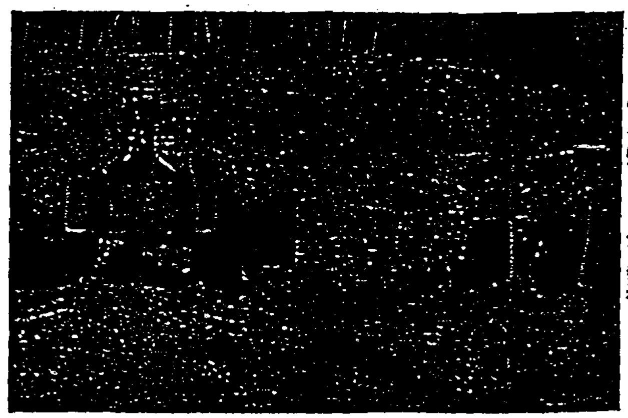
San Dimas Equipment Development Center / USDA Forest Service

▲ Track vehicles with elevated pans also limit rutting.



Northern Logger and Timber Processor

▲ This track vehicle fells and bunches trees, reducing the density of the skid trail pattern.



Northern Logger and Timber Processor

▲ Note the difference in rutting between wide tire (left) and conventional tires (right) in the same skidding situation.

Use of high flotation tires on areas that are marginally operable with conventional equipment results in minimal impact. Use of high flotation tires to extend operations into areas that could not be operated with conventional equipment can result in adverse impacts.

Schedule the harvest during the drier seasons of the year or during time when the ground is frozen. Consider ceasing operations in areas where rutting exceeds 6 inches in depth.

Prepare skid trails for anticipated traffic and weather conditions including spring thaws to facilitate drainage and avoid unnecessary rutting, relocation and washouts.

Minimize the crossing of perennial or intermittent streams and waterways. Use portable bridges, poled fords and corduroy approaches or other mitigating measures to prevent channel and bank disturbance and sedimentation.

Cross streams at right angles and use bumper trees to keep logs on the trail or bridge and off the stream banks.

Do not skid through vernal ponds, spring seeps, or stream channels.

Use brush or corduroy to minimize soil compaction and rutting when skidding in wet areas.

Reduce skid volumes when skidding through wetland areas.

Northern Logger and Timber Processor

▲ This smaller feller/buncher uses a track system over rubber tires for versatility.

David J. Welsch / USDA Forest Service

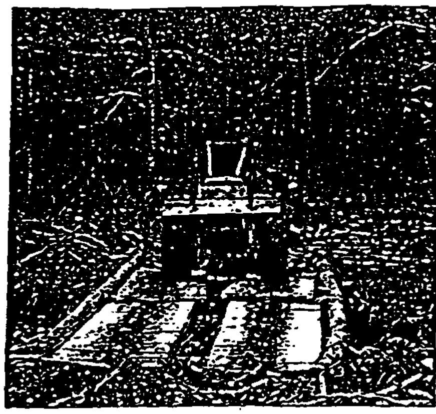
▲ The staggered-end design of this low-cost portable skidder bridge, built by John Conkey Logging Co., helps to keep it in position in use.

Carmine Angeloni / Massachusetts Division of Forests & Parks

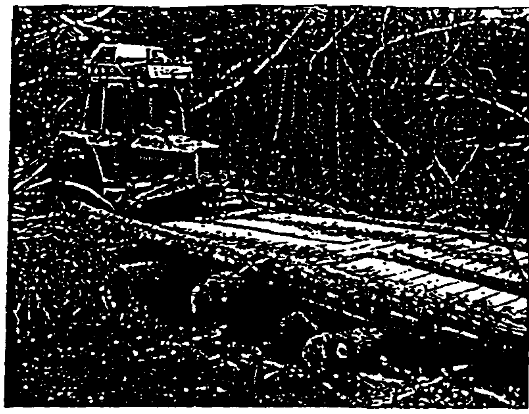
▲ The skidder bridge consists of two sections, permitting it to be carried and placed by the skidder that will use it.

David Kittredge / University of Massachusetts

The skidder bridge is strong enough to carry the skidder without intermediate support. ▶



▲ Corduroy approaches help to control erosion and keep mud off the logs and out of the stream.

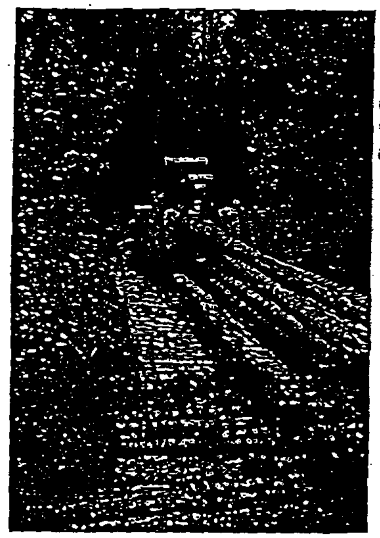


▲ These skidder ramps are lighter weight and will sometimes require logs for support.

LANDINGS

Keep the number and size of landings to the minimum necessary to accommodate the area, the products harvested and the equipment necessary to the activity prescribed.

Where possible, locate landings outside wetlands and far from streams on well drained areas with gentle grades where drainage into and away from the landing can be controlled. These practices will minimize soil compaction as well as soil erosion and sedimentation of surface waters that can result from concentrated heavy equipment use.



▲ Several ramps can be used together to extend the length of the crossing.

▲ This is an excellent landing located on a well-drained area immediately adjoining the wetland.

If no other locations are practical, place landings on the highest ground possible within the wetland and use them under dry or frozen conditions only.

Geotextile fabric use at landing sites is recommended in wetlands and on soils with low bearing strength to minimize soil erosion and compaction.

Geotextile fabric is difficult to impractical to remove when covered with gravel or fill. Where removal is required consider the use of wood or metal platforms or mats with or without geotextiles as necessary.

Consult with Federal, State and local authorities regarding permit requirements before using fill or pads for landings located in wetlands.

MAINTENANCE AREAS

Locate maintenance areas to avoid the spillage of oil, fuel and other hazardous materials into wetlands. Store operating supplies of such materials away from wetlands.

Designate a specific location for draining lubricants and other fluids during routine maintenance. Provide for collection, storage and proper disposal.

Provide containers to collect fluids when the inevitable breakdown occurs in the wetland and repairs must be made on the site.

LOGGING UNDER FROZEN CONDITIONS

Avoid crossing springs, seeps and areas of water which do not freeze well.

Where water crossings cannot be avoided or frozen conditions cannot be relied upon, use portable bridges or poled fords. Temporary structures are preferable to permanent ones unless the crossing is on a permanent road.

Design the crossing to save the structure and accommodate high flows in the event of an untimely thaw.

Plow or pack snow in the operating area to minimize the insulation value and facilitate ground freezing. Clear enough area to accommodate future snow plowing.

Monitor the operating conditions closely after three consecutive nights of above freezing temperatures or the occurrence of warm rain. Cease operations when ruts exceed 6 inches in depth. When daytime temperatures are above freezing, but nighttime temperatures remain below freezing, plan to operate only in the morning and cease operations when rutting begins.

Plan to move equipment and materials to upland areas prior to the occurrence of thawing conditions.

STREAMSIDES AND STREAM CROSSINGS

Streamside Management Zones (SMZ's) are strips of land which border surface waters and in which management activities are adjusted to protect or enhance riparian and aquatic values. The width of SMZ's varies with the intended purpose. An example would be a strip managed for shade or larger trees to help maintain cooler water temperatures or provide large woody debris to streams.

Filter Strips are strips of land bordering surface waters and sufficient in width, based on slope and roughness factors, to prevent soil erosion and sedimentation of surface water.

Establish a streamside management zone with a minimum width equivalent to one and one half tree heights between heavy harvest cuts such as clearcuts or seed tree cuts and permanent and intermittent streams to prevent nutrient leaching into streams.

Establish a streamside management zone on perennial and intermittent streams. Maintain 50 percent crown cover to limit water and ground surface temperature increases. Manage for older trees at the water's edge to provide a natural supply of large woody debris and to shade the water surface. The necessary width of the zone will vary with climate and stream direction. SMZ's should normally be one and one half tree heights in width, however, due to sun position, a 15 foot width may be all that is necessary on the north side of east-west running stream sections in northern latitudes.

Within the streamside management zone, maximize cable lengths and minimize the number and length of skid trails to reduce canopy and ground disturbance.

Establish filter strips on lands adjacent to lakes and streams using the following guide to control erosion and sedimentation of surface waters.

Percent slope	Recommended width of filter strip *(slope distance in feet)*
0 – 1	25
2 – 10	30 – 50
11 – 20	50 – 70
21 – 40	70 – 110
41 – 70	110 – 170

Roads and trails should be minimized in streamside management zones, but should be located outside of the filter strips except where stream crossing is necessary.

Naturally occurring woody debris should be allowed to remain in streams. However, avoid felling trees into streams and remove from the streams any tree tops and other slash resulting from the logging operation. In some cases, potential damage to the channel and bank will outweigh the need for removal.

FELLING PRACTICES

Precautions should be taken when logging near a wetland or stream. Felling trees into water bodies can cause habitat damage and disturb breeding and spawning areas of amphibious and aquatic species. However, naturally occurring woody debris is necessary to many stream functions and should be left undisturbed.

Avoid felling trees into nonforested wetlands. When such felling is unavoidable, remove the tree to high ground before limbing. Slash from trees felled on upland sites is considered fill material under the Clean Water Act and may not be deposited on wetland sites.

Keep slash resulting from the logging operation out of streams and wetlands with standing water unless specifically prescribed for fish or wildlife habitat purposes. Normally, slash left in these areas uses oxygen needed by fish and other aquatic animals. Slash can also limit access of certain species to wetlands.

Review the section on vernal pools and temporary ponds for exceptions to these guidelines.

SILVICULTURE

Distribute the size, timing and spacing of regeneration cuts, including clearcuts, to minimize changes in ground surface and water temperature over the wetland as a whole. Maintain a crown cover of 50 percent or more during selection and thinning cuts. Exceptions may occur in very cold climates where low water temperatures are a habitat limitation.

On organic soils, conduct site preparation operations such as shearing and raking only when the ground is sufficiently frozen to avoid machinery breaking through the root mat.

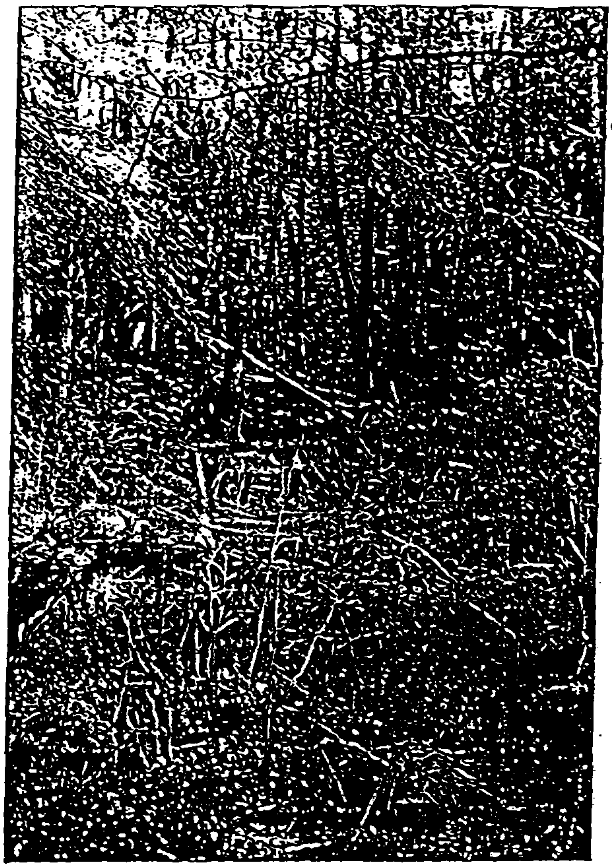
Do not deposit slash and other residues from upland operations in wetlands.

WILDLIFE AND FISH

GENERAL CONSIDERATIONS

Timber activities in forested wetlands should be avoided during the breeding period of threatened and endangered fish and wildlife species known to inhabit the wetland.

Preserve areas where hummocks of thick sphagnum moss abut small or large pools of water as a unique habitat combination required by the four-toed salamander.

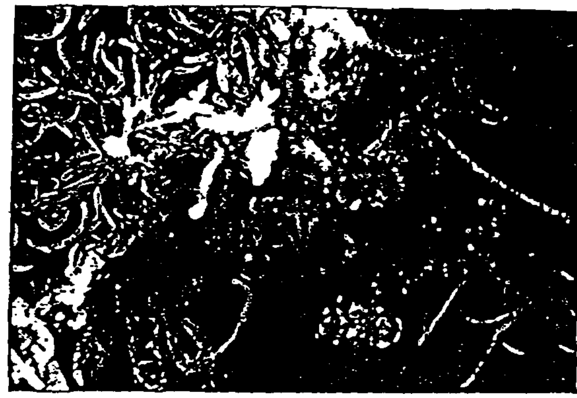


Scott Jackson

▲ An area of sphagnum humps; a critical nesting habitat for the four-toed salamander.

Scott Jackson

▲ Four-toed salamander, *Hemidactylium scutatum*



Scott Jackson

▲ In order to survive, four-toed salamander eggs must be nested so that the newly hatched salamanders will drop into the water.

Cornell Ornithology

▲ A wood duck chick about to jump from a nest box.

Avoid harvesting trees in wetlands April through June to protect breeding birds including neotropicals.

Leave as many as 15 dead and live nesting cavity trees per acre within 200 feet of water as nesting sites for wood ducks.

Avoid sedimentation of areas known to support spawning populations of brook trout, particularly during the October–December spawning season.

Adult male wood duck, *Aix sponsa*, inhabits freshwater marshes, wooded swamps and creeks. ▶

Cornell Ornithology