NATIONAL INTERAGENCY WORKSHOP ON WETLANDS: TECHNOLOGY ADVANCES FOR WETLANDS SCIENCE

3-7 APRIL 1995, NEW ORLEANS, LOUISIANA

- SPONSORED BY THE U.S. ARMY CORPS OF ENGINEERS
  WATERWAYS EXPERIMENT STATION
- IN COOPERATION WITH
  DEPARTMENT OF INTERIOR
  US FISH AND WILDLIFE SERVICE
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  DEPARTMENT OF ENERGY
  US ENVIRONMENTAL PROTECTION AGENCY
  US TENNESSEE VALLEY AUTHORITY

MARY C. LANDIN, EDITOR

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3909 HALLS FERRY ROAD
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PREFACE

Wetland research and applications, especially technology advances in wetlands, have progressed at a rapid rate over the past several years. The nearly 200 technical abstracts and summaries presented at this workshop and contained in this proceedings represent many of those latest advances. Acknowledging and practicing sound science and engineering aspects of wetlands has never been more critical, and should be used to make the critical decisions necessary regarding wetlands and natural resources at the federal, state, and local community level.

The national interagency workshop on wetlands was sponsored by the US Army Corps of Engineers, and conducted by the US Army Engineers Waterways Experiment Station. Mr. Richard E. Coleman and Dr. Mary C. Landin were workshop coordinators, and were assisted by Mr. Glenn Rhett, Mr. Harvey L. Jones, Ms. Linda E. Winfield, and other staff members in the Environmental Laboratory.

Federal agencies participating in and involved in helping make this workshop a success are:

DOI US Fish and Wildlife Service
DOI National Biological Service
DOI National Park Service
DOI Bureau of Reclamation
DOI Bureau of Mines
DOI Bureau of Land Management
DOI US Geological Survey
USDA Natural Resources Conservation Service
USDA Forest Service
DOT Federal Highway Administration
DOC NOAA National Marine Fisheries Service
DOE Department of Energy
US Environmental Protection Agency
US Tennessee Valley Authority
DOD US Army Corps of Engineers

This proceedings was rapidly compiled, with light editing, by Dr. Mary C. Landin from information recently provided by authors, in order to have it available for distribution during the workshop. Only 500 copies were initially printed. Any additional printings following this workshop will have a more thorough edit conducted prior to re-printing.

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PROGRAM AND SUMMARIES OF PRESENTATIONS:
NATIONAL INTERAGENCY WORKSHOP ON WETLANDS

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SESSION RE10

RESTORATION, PROTECTION, AND CREATION: GENERAL WETLAND CREATION AND RESTORATION

Suzanne Hawes, Chair

BENEFICIAL USE OF DREDGED MATERIAL FROM THE DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT TO CREATE, RESTORE, AND PROTECT WETLANDS IN THE DELAWARE BAY

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The Delaware River Comprehensive Navigation Study Main Channel Deepening Interim Feasibility Report and Environmental Impact Statement recommended from its feasibility study modification of the existing federal navigation channel from 40 feet at mean low water (MLW) to 45 feet. The proposed project, authorized as part of the Water Resources Development Act of 1992, provides for a full width channel that would follow the existing channel alignment from the Delaware Bay to the Philadelphia/Camden waterfront, a distance of approximately 102.5 miles, appropriate bend widening, and a 2-space anchorage at Marcus Hook. Approximately 50 million cubic yards (MCY) of dredged material will be removed for initial construction over a 5-yr period. Dredged material from the upper river will be confined. Material excavated from the lower river (Delaware Bay) is primarily sand, and will be used for several beneficial purposes, including wetland restoration and protection, underwater sand stockpiling for future shore protection, and possible beach nourishment.

A critical component of this feasibility study is the design of the beneficial use projects at Kelly Island, DE, and Egg Island Point, NJ, wetland sites, and sand stockpile and beach nourishment sites in Delaware. The US Army Engineer District, Philadelphia, and the US Army Engineer Waterways Experiment Station have teamed to develop, design, and implement these beneficial uses.

Egg Island Point

Egg Island Point, NJ, a prime fish and wildlife area, has undergone extensive land and marsh losses due to erosion for many years. Emphasis will be on shore protection and habitat diversity to accommodate a variety of species. An small unconfined sand island would be constructed at the eroding tip of Egg Island Point over a remnant peat bank to approximately +15 ft MLW, with a slide slope of 1:10 to 1:15. This sand area targets use by spawning horseshoe crabs, nesting seabirds, and migrating shorebirds.

Geotextile tubes filled with sand dredged from the project will be placed near the shore for up to two miles on the southeast side of Egg Island Point. In addition, geotextile tubes and/or an unconfined sand beach will be placed for up to two miles on the northwest side of Egg Island Point. Both of these soft structure formations will be used in an effort to hold Egg Island Point to its present size and configuration. Underlying the geotextile tubes will be a sand foundation covered with a geotextile anchored scour blanket built to 0 ft MLW; this foundation will raise the top elevation of the tubes to approximately +5 MLW, near the high tide level for the site. Additional sand will be placed behind the tubes to raise the eroded elevation to a low marsh level.

Kelly Island

Kelly Island, DE, adjacent to the Mahon River and part of the Bombay Hook National Wildlife Refuge, is also eroding severely. In addition to its fish and wildlife value, it also provides some protection for a fishing port and off-loading terminals for Dover Air Force Bay. Emphasis will be on confinement of the 0.9 MCY in the project that is fine-grained, as well as using sand for shore protection and wetland restoration.

Geotextile tubes will be filled with sand dredged from the project near the shore for approximately two miles extending northward from the southern, eroded tip of Kelly Island. A sand foundation will also underlie the tubes, to raise the final elevation to +6 ft MLW, near the high tide level for this site. To ensure confinement of the fine-grained material until it consolidates and marsh is established, an additional tube will be placed on top of the primary tube to raise the elevation to at least +11 ft MLW.

Fine grained material will be placed behind the completed tube structure to a low marsh elevation, and an intertidal connection will be established on the wetland's most protected side. Exact dimensions and elevations will be determined by a detailed engineering analysis. Parts of the wetland will be planted with <u>Spartina</u> <u>alterniflora</u>, with emphasis on areas most vulnerable to interior site erosion.

Beach Nourishment and Sand Berms

Areas of beach nourishment in Delaware will be selected in coordination with the Delaware Department of Natural Resources and Environmental Control, and with the US Fish and Wildlife Service to select areas most beneficial to spawning horseshoe crabs. Delaware Bay has the largest population of this species in the world, and the crabs spawn heavily on the remaining sand beaches and berms in the Bay. Currently, beaches between the Mispillion River and Roosevelt Inlet, and at Port Mahon, are being evaluated.

Approximately 5.8 MCY of the sand material will be placed at a location in the lower Delaware Bay near Lewes, DE, and cover approximately 500-700 acres about one mile from shore. This would decrease bottom depths approximately 7 ft, to a bottom depth of -5 ft MLW. In addition, an underwater sand berm is being considered 0.5 miles offshore at some location between Kelly Island and Murderkill River. Both of these areas will provide a future sand source for the State of Delaware as it addresses continued erosion along the Delaware side of the Bay.

RESTORATION OF SAGINAW BAY COASTAL WETLANDS IN MICHIGAN

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Wetland conversion in the United States resulted in loss of more than 50% of all wetlands with over 11 million acres of wetlands converted by the 1970's (Dahl 1990). Michigan has also lost 50% of its wetlands to development. Efforts to create new wetlands to offset some of these losses have rarely been successful due to insufficient knowledge about wetland structure and function. As experience builds, it has become apparent that efforts to restore areas that were originally wetlands are more likely to succeed than are efforts to create wetlands in upland areas (Kusler and Kentula, 1989).

The Michigan Department of Natural Resources (MDNR) plans to restore several thousand ha of former coastal wetland with emphasis on the wet meadow zones in the former lakeplain prairie on land adjacent to Saginaw Bay within the 585 ft contour to lake level (currently at 579.2 ft) zone (Fig. 1). The land to be restored is on drained, hydric soils that must be actively pumped to keep crops, primarily potatoes, sugar beets, beans, and corn, from flooding.

Wetland restoration techniques are site dependent, and no general predictive model exists that will enable a design of a successful restoration effort. Instead, one must first develop an understanding of the factors that lead to formation of specific wetlands. A regional approach must be taken to include hydrology and soils data for existing wetlands; the impact of soils and water level on development of plant communities; the impact of plant composition and structure on animal uses of wetlands; and the impact of watershed dynamics on water quality and quantity. Site evaluation should include a baseline vegetation survey, water level data including pertinent elevational data, wildlife utilization observations, and general fish and macroinvertebrate data (Erwin, 1990). We are currently collecting these baseline data for Saginaw Bay wetlands.

Vegetative structure of presettlement wetlands ranged from Great Lakes Marsh/Emergent Marsh to Ash, Elm, Maple, and Birch swamps; from Lakeplain Prairie to Shrub Swamp and Bog according to maps of original wetlands prepared by MDNR Natural Features Inventory from surveyors records (Fig. 2). The majority of wetland communities were inland sites dominated by such vegetation as wild rice (Zizania), sedge (Cyperaceae), reeds (Phragmites), sand cherry (Prunus pumila), prairie dock (Silphium terebinthinaceum), northern white cedar (Thuja occidentalis), and tamarack (Larix laticina). Cyclic variations in vegetative composition were not uncommon according to the original land surveys and were largely attributed to Bay water level fluctuations. Most of lakeplain prairie and swamps were lost due to agricultural drainage in the early 1900's. Approximately 70% of the original inland wetlands are now cropland and less than 1% of the lakeplain prairie wetlands remain. Wetland communities that remain are found at sites in shallow areas along the shore that are subject to wave action and ice scour. These sites are dominated by a few species such as cattail (Typha) and bulrush (Scirpus). Variation between such sites is small and diversity is limited to only hearty species that tolerate disturbances such as wave action and extreme water level fluctuations. Avian productivity and muskrat use of these marshes represents a high risk venture due to large shifts in water level related to seiches.

In 1993 and 1994, we developed an initial landscape perspective of the extent of wetlands in the area, and collected data on biota to assess function and value to wildlife in selected, representative wetlands on 7 sites (Fig. 1). Although these data suggest that there is a rich flora and fauna in the existing wetlands that can serve as sources of seeds and immigrants to nearby restored areas, seed bank studies suggest that very few viable seeds of wetland plants remain in agricultural soils. Very little of the original lakeplain prairie vegetation exists and may be the most difficult to restore because of lack of seed sources and a tendency for shallow, disturbed environments to be invaded by purple loosestrife.

Initial data analyses from a 10 year old successional site suggest that wetland flora and fauna will be slow if seeding and/or

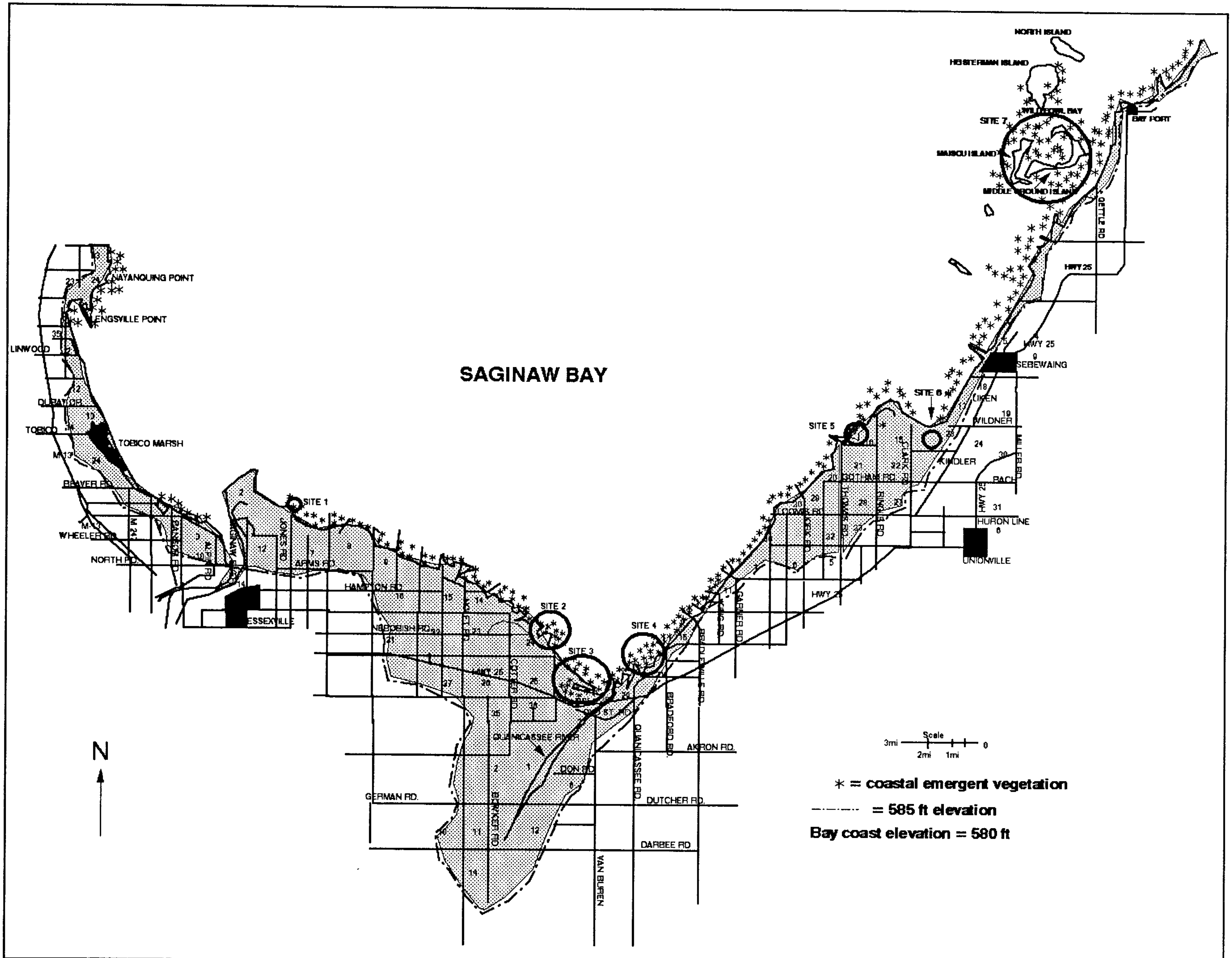

Figure 1. Saginaw Bay wetlands restoration sites. Bay, Tuscola, and Huron Counties. Shaded area represents elevations within 585 ft contour line (approx. 13,823 ha).

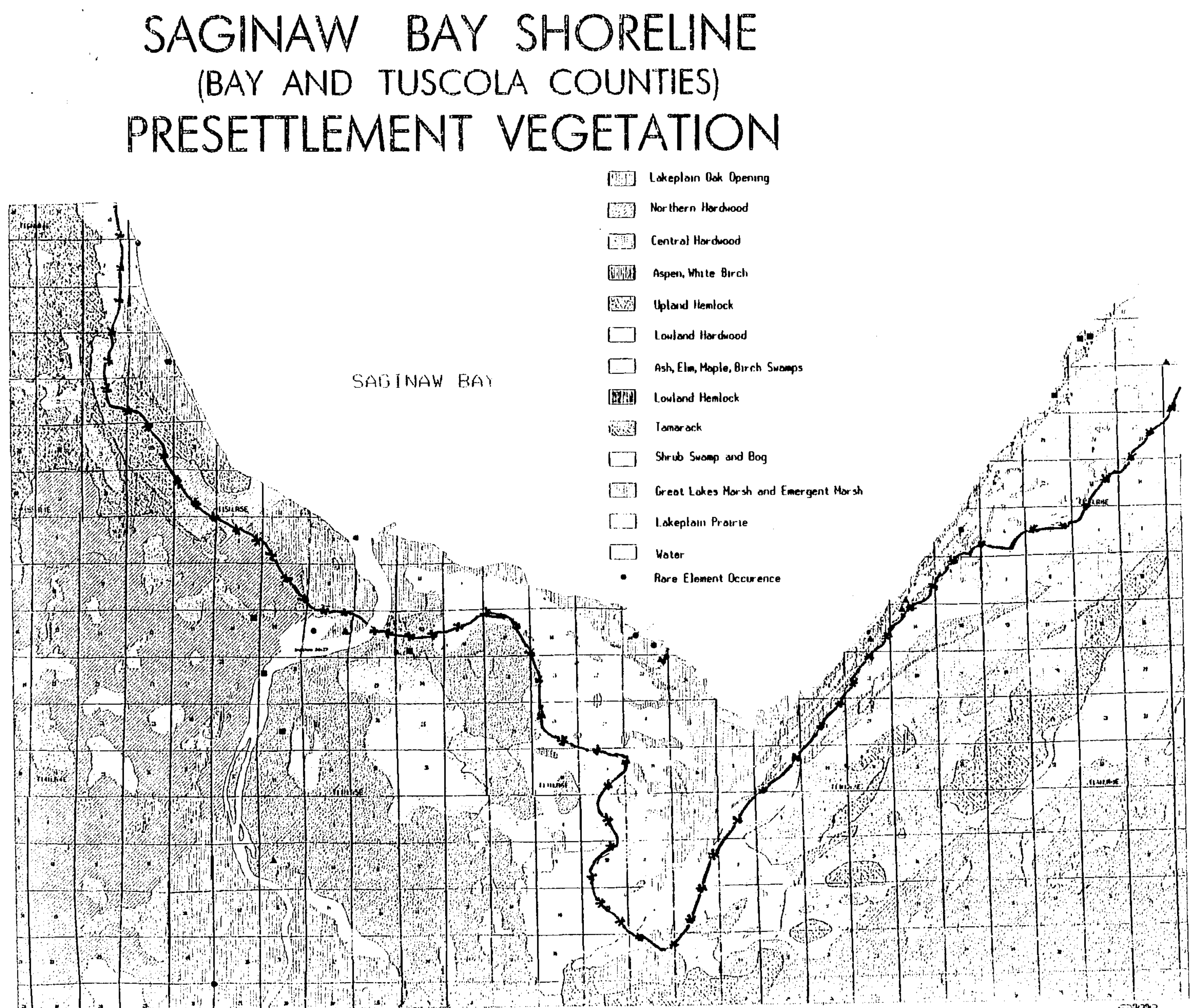

Figure 2. Saginaw Bay presettlement vegetation key. (Dashed line indicateds 585 ft contour).

transplanting of wetland plants are not included in the design. Succession on wet meadow sites appears to be related to depth to ground water. Sites with the water table within 10 cm of the surface in late summer will support obligate wetland species such as Iris versicolor and Acorus calamis and will be dominated by Carex/Calamagrostis, patches of prairie cord grass and the invasive reed canary grass. A mix of facultative wetland and upland species dominate areas with depth to groundwater in late summer > 50 cm.

Data from these representative marshes need to be expanded to a seasonal basis and need to be correlated to hydrology, soils, or elevation for the vegetation and to these same parameters plus vegetation-type for the fauna to allow prediction of the type of wetlands that can be expected on restored areas. We plan to include such studies in our future efforts and also plan to conduct a series of experimental studies to determine ways to enhance recovery of restored areas. Current lake levels are similar to historic levels and the potential for restoration of some of the 70% of the area that was converted is great.

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WETLAND RESTORATION AND MANAGEMENT IN THE CITY OF WEST PALM BEACH, FLORIDA, WATER RESOURCES PROGRAM

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The City of West Palm Beach, Florida is the only large southeast Florida municipality that uses a surface source of potable water. The City's water supply system consists of a 19.3 square mile Water Catchment Area (WCA), which captures rainfall and stores water pumped from a major canal that flows from Lake Okeechobee; the M Canal, which conveys water from the WCA to Lake

Mangonia and Clear Lake; and a water treatment plant that withdraws water from Clear Lake (Figure 1). The City has embarked on a long-range water resources program to ensure that the quantity and quality of water will be adequate to meet the goals of potable water supply and environmental preservation and restoration. Elements of the water resources program that relate to restoration and management of wetlands include: restoring base flow in Loxahatchee Slough, which feeds the federally-designated wild and scenic Loxahatchee River; creation of a wetland buffer system around the WCA; use of reclaimed wastewater and stormwater to restore wetland hydroperiods in the buffer system; eradication of exotic vegetation; and management of the WCA and buffer system to maintain wildlife habitat.

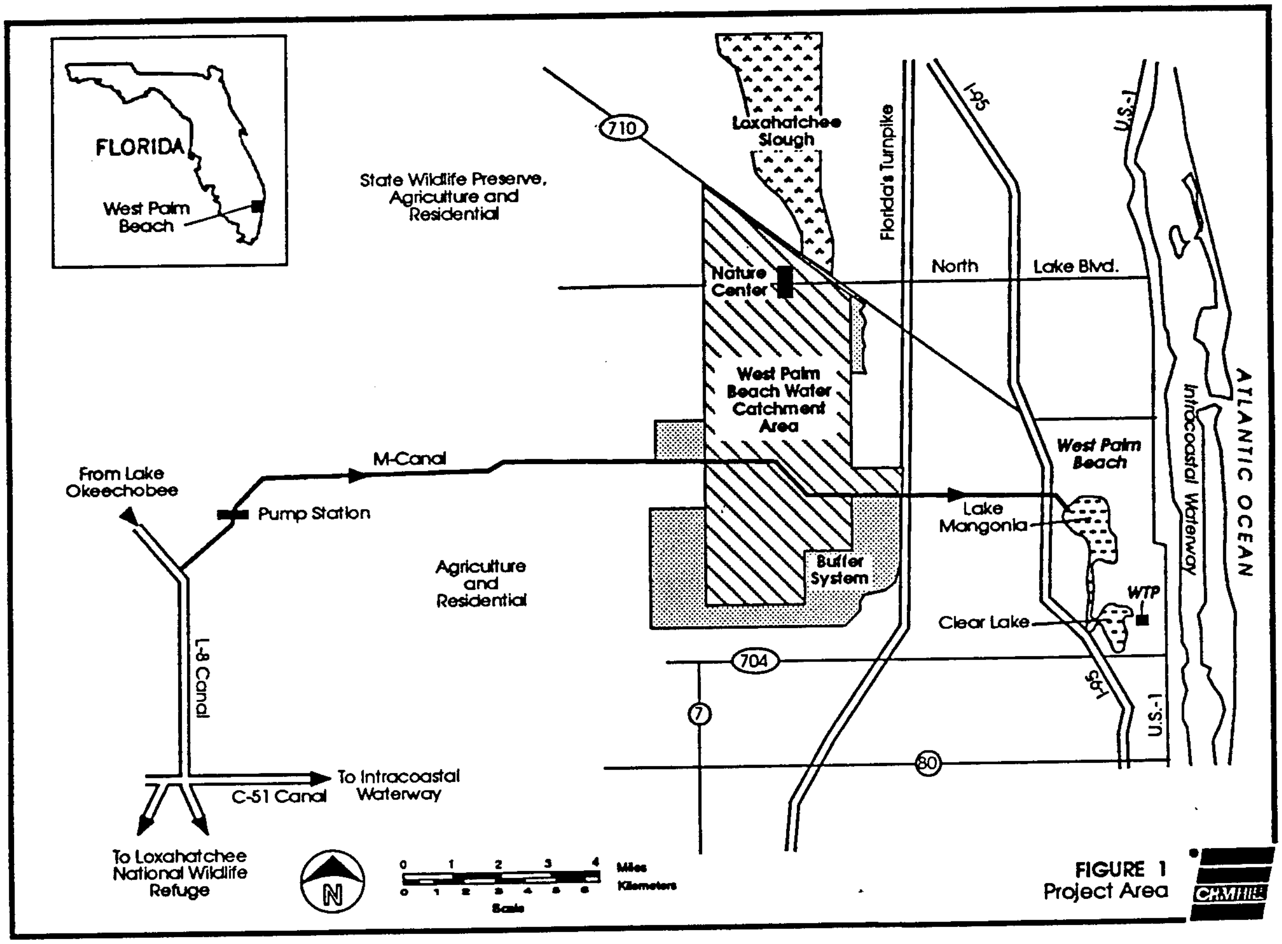

FIGURE 1
Project Area

Development and alteration of flow patterns have reduced base flows in the Southwest Fork of the Loxahatchee River, which has allowed salt water to move upstream, converting cypress swamps to mangrove forests. As part of a regional flood control and environmental restoration project, the City is working with the South Florida Water Management District to use the WCA to augment base flow in Loxahatchee Slough without increasing peak flows. This cooperative effort also includes development of a model that will be used to manage water levels and flows in the WCA, based on considerations of potable water supply, maintenance of wetland communities and wildlife habitat in the WCA, and enhancing base flow in Loxahatchee Slough.

The City is creating a buffer system around the south end of the WCA through land acquisitions and dedication of conservation easements. Many of the seasonally wet emergent marshes in the buffer lands have been altered by drought and lowered groundwater tables, which have allowed melaleuca trees (Melaleuca quinquinervia) to become established. Management plans for those wetlands include initial removal of melaleuca, and restoration of historic hydroperiods using reclaimed wastewater and/or stormwater run-off from adjacent lands. Constructed wetlands will be created in areas of melaleuca monoculture to provide storage and water quality improvement for the supplemental water sources, as well as to create additional wetland area. Less dense melaleuca will be eliminated using manual removal of small trees and chemical treatment of larger trees.

Restored hydroperiod in the buffer wetlands will help prevent the re-establishment of melaleuca, and it will improve wildlife habitat for wetland-dependent species. The WCA and nearby wetlands provided a refuge for endangered snail kites (Rostrhamus sociabilis) during droughts in the 1980s, when traditional habitat in the Everglades was too dry to support the apple snails that are the kite's primary food (Takekawa and Beissinger 1989); snail kites have continued to nest and feed in the WCA since then. Other protected birds that have been documented in the WCA or adjacent wetlands include wood stork (Mycteria americana), little blue heron (Egretta caerulea), and tricolored heron (Egretta tricolor).

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SOIL AS A BIOLOGICAL INTERFACE IN WETLAND CONSTRUCTION

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The author reviews the importance of the soil substrate as a critical component of a wetland ecosystem. The geotechnical aspects of soils are acknowledged as critical to the success of wetland restoration and construction. Nevertheless, in order to

balance the discussion of soils in the context of the constructed or restored wetland setting, the importance of the biological aspects of soils also must be addressed in the wetland planning process. In most cases, the biochemistry and ecology of functioning wetland systems are driven largely by processes associated with wetland soils.

Substrate is critical to the success of the project and the potential functions that can be provided by the wetland system. It is imperative that persons involved in this applied science be cognizant of both the engineering and biological functions of soils as unique but interconnected components of wetland systems. To reinforce this concept, the author suggests that practitioners of wetland science differentiate between soils as structural components of constructed wetlands and soils as biological activity sites.

Two different yet parallel definitions of wetland soil components are offered. It is suggested that the physical properties (geotechnical engineering aspects) of the soils as they apply to site selection and construction be referred to as SUBGRADE elements of the wetland system. Soil chemical and biological properties influence the types of plant communities and other organisms that are planned and anticipated in restored and constructed wetland systems. These properties are recognized as being part of the matrix that provides physical support and anchoring of plants, a medium for macro- and micro-invertebrates, support of microbial communities, and a source/gradient through which nutrients are supplied for plant growth.

The author suggests that the term soil SUBSTRATE be applied to identify the medium that performs these biological functions in wetland systems. Characteristics of functioning wetland substrates are discussed briefly as are strategies to ensure that these same functions are duplicated in the substrates of constructed and restored wetland systems to the fullest extent possible. Organic vs. mineral substrates are discussed, and cautions are offered regarding the application of organic amendments to constructed wetland substrates. The advantages and disadvantages of various potential substrate materials are presented.

Additional research is needed to expand our understanding of the complexity and importance of constructed wetland substrates and to help us establish "mileposts" by which we can gage our success in creating wetlands that readily assume a productive role in local ecosystems. Gone are the days of "let's make it wet and see what happens." Although this axiom is still likely to be playing in the back of some minds, we owe it to our discipline and our science to be able to say how we will make it wet, how we will keep it wet, what it will look like, and what we expect it to do.

SESSION CW1

CONSTRUCTED WETLANDS: WATER AND WASTEWATER TREATMENT

Tommy E. Myers, Chair

CONSTRUCTED WETLANDS FOR STORM WATER MANAGEMENT ON ARMY INSTALLATIONS

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Storm water management is critical to overall water quality. The Clean Water Act includes regulations and required plans intended to improve the nation's water quality by addressing nonpoint (diffuse) sources of pollution--the last major water pollutants left in the country.

U.S. Army installations control and mitigate these industrial pollutants through an active pollution prevention program that includes training and education, a bite-specific storm water pollution prevention plan, and extensive Best Management Practices (BMPS). The U.S. Army Construction Engineering Research Laboratory (CERL) is studying constructed wetlands as an innovative BMP to enhance water quality from storm water run-off on installations.

A constructed storm water wetland is a system designed to mitigate the impacts of storm water run-off quality and quantity, It does so by temporarily storing storm water run-off in shallow pools that create growing conditions suitable for emergent and riparian wetland plants. The run-off storage, complex microtopography, emergent plants, and detritus in the storm water wetland together form an ideal matrix for removing pollutants. It does this through a series of complementary physical, chemical, and biological pathways: sedimentation; adsorption to sediments, vegetation, and detritus; physical filtration of run-off; microbial uptake and transformation; uptake by wetland plants; uptake by algae; and extra detention and/or retention. These systems' performance, under widely different environmental and run-off conditions has been well documented by research.

Constructed wetlands are being used worldwide for a variety of functions. These include treating wastewater streams (domestic, industrial, mining, agricultural, storm water), polishing effluents, enhancing esthetics, providing fish and wildlife habitat and replacing other wetlands.

U.S. Army installations, both small and large, could benefit from constructed storm. water wetlands. Larger installations function like a comparably sized city complete with utilities and amenities. But unlike a city, the Army has excellent control over its real estate and over the behavior of individuals working and living there. Activities like littering and random dumping of trash are rare. Real estate is maintained and the Army is proactive in complying with environmental laws.
within this environment, constructed wetlands could reduce storm water run-off while improving its quality. Target areas on Army installations for treatment by constructed Wetlands include the cantonment (the city proper region); motor pools contaminated with hydrocarbons, trace metals, and sediment,- open burn/open detonation sites; airfields that service rotary and fixed-wing aircraft; training ranges; and more.

Storm water wetlands are very distinct from undisturbed natural wetlands in hydrology, morphology, and ecology. An understanding of these differences is important in designing the storm water wetland.

Constructed storm water wetlands also must address the concerns of adjacent residents. The designer must consider social factors such as mosquitoes and odors, safety, appearance, passive recreational use, access, and maintenance. Operational aspects must be included. For example, on an airfield, will aircraft be jeopardized by migratory waterfowl or other birds attracted to the area? The designer's challenge is to construct a system that simultaneously mimics the functions of a natural wetland yet fully addresses the needs and concerns of the surrounding community.

For more information on storm water wetlands, contact the author at 217-373-3488 or toll-free 800-USA-CERL.

BIODENITRIFICATION OF FRESH WATER BY CONSTRUCTED WETLANDS

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Abstract

Fresh water supplies are susceptible to nitrate contamination from sources including agricultural and industrial operations, and domestic septic tank drainfields. In South- Central Arizona, contaminated groundwater aquifers can have nitrate-nitrogen concentrations ranging from 15 mg/l to more than 400 mg/l, depending on the source of contamination. Surface water is

conveyed by a canal system, from several major river watersheds, to the metropolitan areas located in the southern part of the state. Along the canals, groundwater is pumped from nitrate-contaminated aquifers to partially replenish the supplies for downstream reuse, increasing nitrate concentrations as the water flows along the length of the canal system. Biodenitrification wastewater treatment technologies, such as constructed wetlands, are being designed for treating fresh water contaminated by nitrates. The basic treatment process requires creating anoxic treatment zones in which nitrate-contaminated water and available carbon sources are delivered to support respiration and growth of denitrifying bacteria.

Introduction

Biodenitrification processes applicable to constructed wetlands, were reviewed to develop a treatment process for reducing nitrate concentrations in surface and ground water sources. The goal was to increase treatment efficiency as compared with a conventional free water surface (FWS) constructed wetland and reduce land area requirements. The selected treatment process had to decrease construction and operating costs.

Constructed wetlands are defined as an artificial or engineered complex of saturated substrates, emergent and submergent vegetation, animal life, and water simulating natural wetlands for human use and benefits (EPA and Bechtel, 1994).

Process Selection

Suspended-growth and fixed-growth biological treatment processes were considered, in FWS and subsurface flow system (SFS) configurations. An aesthetic appearance and the feasibility for limited public access, were considered desirable characteristics for siting flexibility. A fixed-growth process was selected for its aesthetic appearance.

A hybrid SFS/FWS system configuration was developed to incorporate the aesthetic characteristics of an FWS with a higher efficiency SFS constructed wetlands. A SFS achieves increased efficiency by physical delivery of the required nutrients (a carbon source and nitrates) to fixed-growth denitrifying bacteria, rather than relying primarily on diffusion as in an FWS wetland.

Discussion

Raw water samples must be analyzed to determine seasonal characteristics, and for establishing design criteria. The pH of the untreated water should be in the range of 7.0 to 8.0 (Tchobanoglous, G., and Burton, F.L. 1991) or buffered to that range, as alkalinity in the treated water increases with the conversion of nitrate to gaseous nitrogen compounds. Denitrifying bacteria respire gaseous compounds (NO, N2O, N2 and CO2), which bubble up through the treated water and escape to the atmosphere. Nutrient supplements including dissolved carbon (BOD) and trace phosphorous, are required to sustain denitrifying bacteria in an anoxic environment.

The rate of biodenitrification decreases with colder water temperature, decreased quality and concentration of BOD, and lack of available trace nutrients. A high quality, BOD source sustains a higher rate of denitrification. Three common supplemental BOD sources, listed in decreasing quality are methanol, acetate, and decomposed natural organic matter.

The hybrid FWS/SFS Constructed Wetlands configuration includes sedimentation, off-line flow equalization, return flow pumping, FWS/SFS treatment, FWS polishing, and slow-sand filtration. FWS/SFS treatment modules use a split-stream concept to treat a portion of the delivered flow in a permeable SFS bed. The SFS zone of the treatment module incorporates a subsurface flow distributor to reduce dissolved oxygen concentrations, a nutrient distributor, a permeable anoxic zone in which various wetlands plants (bulrush, etc.) are rooted forming an environment for denitrifying bacteria, and a subsurface flow collector zone. The remaining water flows through emergent plant growth and plant detritus in the FWS. Following biodenitrification, the surface and subsurface flows are mixed, and then can either be directed to a subsequent FWS/SFS treatment module or discharged to a polishing pond.

Conclusion

The hybrid FWS/SFS Constructed Wetlands provides a reliable, reduced cost alternative for biodenitrification of nitrate-contaminated surface or ground water, in a flexible configuration adaptable to various sites and topography.

Acknowledgments

This work was partially funded by the City of Avondale, Arizona, as a feasibility study for a constructed wetlands in a residential development, under the State's Storage and Recovery Act.

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SUGARCANE FACTORY WASTEWATER TREATMENT IN A DIKED WETLAND

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This study is focused on a diked natural wetland in Louisiana which has been used as part of an inexpensive treatment system for sugarcane factory effluent. Louisiana sugar factories process sugarcane seasonally, producing wastewater from October through December. The heavy solids are removed by sedimentation, then the wastewater is discharged to the diked wetland where it is stored until it is discharged to a bayou by April. The wetland was monitored 3 to 6 months for three grinding seasons. Sedimentation and decay removed more than 95% of the BOD and suspended solids from the wastewater which entered the wetland by the end of the grinding season. The dissolved oxygen concentration in the wastewater was low during the grinding season and it remained low in the stored wastewater. Water pH in the wetland recovered quickly during the grinding season to about 7.0.

To evaluate the wetland's ability to remove nutrients, nitrogen in the forms of total Kjeldahl nitrogen (TKN), ammonia, and nitrate, and total phosphorus (TP) were monitored. This study shows that removal of nitrogen and phosphorus in the wetlands varies seasonally. Conversion of ammonia to nitrate ion started in April, Part of the organic nitrogen was quickly removed from the water by sedimentation. In addition, ammonia is likely to adsorb to the soil. Denitrification was delayed by cool water temperature until the wetlands were nearly empty. Plants took up some nitrogen but without harvesting during the growing season the nutrients would be released back to the wetland water due to decomposition of dead plants and litter; this made annual nitrogen removal small. Phosphorus removal in this wetland treatment system was limited. Even long after the grinding season ended, phosphorus remained in the wetland water.

Damage to wetland trees may occur if flooding depth, duration and frequency exceed the tolerance limits of the vegetation. While it is difficult to quantify the flooding tolerance of the vegetation, early discharge of wetland water would decrease flooding damage. To enable discharge of treated effluent from the wetland at an early date an aeration station was built near a wetland outlet. An aerated effluent meets LADEQ discharge requirements and reduces impact of wetland discharge on receiving water. The aeration system was a simple and feasible engineering approach which increased the dissolved oxygen in the effluent and allowed early discharge from the wetland.

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SESSION SM5

STEWARDSHIP AND MANAGEMENT:
FISH AND WILDLIFE HABITAT MANAGEMENT I
Chester O. Martin, Chair

A SYNOPSIS OF STEWARDSHIP AND MANAGEMENT DEMONSTRATION STUDIES FOR THE CORPS OF ENGINEERS WETLANDS RESEARCH PROGRAM

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Because most U.S. Army Corps of Engineers (CE) projects occur along major waterways, they constitute important landscape features on local, regional, and national scales. These projects often have a human-induced aquatic-terrestrial interface where the natural wetland zone is stressed, reduced, or missing altogether. These circumstances provided an opportunity for investigators to conduct field studies to demonstrate improved stewardship and management on project lands as part of the CE Wetlands Research Program.

Interdisciplinary teams designed and implemented studies on wetland stewardship and management demonstration sites throughout the United States, with emphasis on the Mississippi and Missouri River systems. Demonstration studies were organized into 8 research areas representing different disciplines involved in wetland management. Topic areas investigated were non-point source pollution (NPSP), sediment management, vegetation management, pest management, wildlife habitat management, fisheries habitat management, and natural communities/ biodiversity management.

Demonstration sites were located at the following CE projects: Bowman Haley Reservoir, ND; Ray Roberts Lake, TX; Grenada Lake, MS; Black Butte Reservoir, CA; Harry S. Truman Reservoir, MO; Riverlands Environmental Demonstration Area, MO; Tuttle Creek Lake, KS; Sayers Reservoir, PA; Green Peter Reservoir, OR; Conesus Lake, NY; Buzzard Bayou, MS; Grassy Lake, LA; Lake Okeechobee, FL; Lake Traverse/Mud Lake, MN; Upper Mississippi Pools, MN; and Lake Sakakawea/Williston, ND. Additionally, aquatic biodiversity study sites included Big Cypress Bayou, TX, and two creek systems of the Alabama River, AL.

NPSP and sediment management studies were designed to measure and analyze sedimentation, nutrient levels, and contamination, primarily in constructed wetlands. Atrazine was detected at several locations; thus, mesocosm studies were conducted to determine atrazine retention and degradation in wetlands. This work was accomplished in controlled experiments at the CE Lewisville Aquatic Ecosystem Research Facility, TX.

Vegetation management studies were conducted in cooperation with the Natural Resources Conservation Service (previously Soil Conservation Service) Plant Materials Centers. Emphasis was on vegetation establishment and management in reservoir drawdown zones. Planting trials and greenhouse studies were conducted at the Coffeeville, MS, Plant Materials Center. Pest management studies consisted of field testing control technologies for melaleuca (Melaleuca quinquenervia) and purple loosestrife (Lythrum salicaria). Chemical, mechanical, and biological treatments were investigated for these species in selected wetland systems.

Wildlife habitat management studies were designed primarily to evaluate techniques perceived to have high potential for improving wetlands for waterfowl habitat. Several studies focused on moist-soil management and its application to CE lands. Techniques such as mowing, discing, and burning were evaluated as methods useful for improving habitat diversity for waterfowl and other wetland species. Fisheries habitat management studies included investigations of aquatic areas and associated wetlands as reproductive habitat. At several sites, community composition and relative abundance of larval and adult fishes were compared between created/restored wetlands and adjacent natural systems. Biodiversity management studies were conducted for fish and wildlife in inland freshwater marshes and riverine systems.

Most of the demonstration site work was accomplished through extensive partnering with other agencies and organizations. Cooperators included 12 CE Districts, 8 other Federal agencies, 16 state and local governments, 18 universities, and 11 private organizations.

EARLY LIFE HISTORY OF NORTHERN PIKE IN ARTIFICIAL WETLANDS OF CONESUS LAKE, NEW YORK

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Four artificial wetlands were constructed adjacent to Conesus

Inlet Creek, largest tributary of Conesus Lake. The wetlands were designed to serve as northern pike spawning and rearing habitat. Fishes were collected during the spawning and rearing seasons of 1992, 1993, and 1994 in artificial wetlands, natural wetlands, and Conesus Inlet Creek. Our objectives were to evaluate early life history of northern pike including reproductive success in artificial and natural wetlands, emigration from spawning wetlands, and interactions between larval northern pike in the wetlands. In 1992 fishes were collected using a trap/dip net combination which provided a direct measure of population density. In 1993 and 1994 fishes were collected with larval light traps which provided a relative measure of abundance and sampled a wider range of habitat types than the trap/dip net combination. In 1994 behavior of larval northern pike was observed in artificial wetlands and in experimental arenas to assess intraspecific interactions and migration behaviors.

Density of pike was greatest in late April and declined afterward in all wetlands. Mean peak density was significantly greater in artificial (29.6 pike/sqm) than in natural (11.6 pike/sqm) wetlands. Mean length of pike at that time was also significantly greater in artificial wetlands (11.3 mm) than in natural wetlands (10.1 mm). Density in Conesus Inlet increased steadily through the spring as pike emigrated from wetlands to the lake. Pike began to exhibit behaviors associated with migration ie. deliberate straight line movement, at approximately 14 mm total length. Pike as small as 14 mm total length emigrated from wetlands into Conesus Inlet Creek. While observing 103 larval northern pike, ninety three interactions between larval pike were observed in artificial wetlands. Seven distinct types of encounters were identified, one of which was aggressive and was observed one time.

This study indicates that shallow non-wooded areas with emergent grasses, sedges, and cattails provide ideal pike spawning habitat and that such areas can be constructed to meet spawning requirements of northern pike. To avoid stranding, artificial wetlands should remain flooded until larval pike reach a length of approximately 30 mm at which time most will have emigrated from the spawning wetlands. Wetlands should also slope gradually from shallow to deep water areas to avoid stranding as water levels drop. Larval northern pike should have access to deep water habitats from time of hatching until all have emigrated from the spawning wetlands. Transitional areas between spawning and deep water habitat serve as important rearing habitat and should be incorporated into an artificial wetland system.

RIVERINE-WETLAND CONNECTIONS AND LARVAL FISH DYNAMICS OF BOTTOMLAND HARDWOOD SYSTEMS

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Different floodplain habitats were sampled in the lower Mississippi Basin: 1) connected and isolated backwater lakes including oxbows; 2) seasonally inundated fringes of rivers; 3) reconnected riverine backwater. Larval fishes were collected with Plexiglas light traps, and abundance related to hydrology, geomorphology, or water quality. Spawning chronology was: buffalo > darters > black bass > crappie > carps and shad > sunfishes > nearctic minnows. Spawning began and ended earlier in remote wetlands than in proximate wetlands or rivers. Relative abundance of larvae was highly variable among systems, but provided an opportunity to address four questions:

How do larval fishes differ in permanently connected and normally isolated backwater lakes? High densities of crappie, black bass, and sunfishes occurred in isolated wetlands. Migratory species, including those capable of maintaining lacustrine sub-populations, were uncommon or absent. These included shad, nearctic minnows, and buffalo.

How does frequency of flooding influence larval fishes in backwater lakes? Frequency of flooding was not associated with species richness of larval fish assemblages or with relative abundance of most taxa. Fish assemblages in an isolated oxbow were highly similar to those of a permanently connected oxbow, and both were disparate from that of a seasonally connected oxbow. Spatial distribution of larvae within each lake was non- uniform and varied among lakes, suggesting that habitat features were of greater importance to reproduction than flood frequency.

How do floodplain habitats differ in value for fish reproduction? A bottomland hardwood, connected oxbow, and tributary mouth supported higher densities and diversity of larval fishes than did agricultural and fallow fields. Assemblages in the agricultural field were dominated by larval buffalo and shad, but buffalo also occurred in all other habitats and densities in connected oxbows were nearly six times higher.

What variables are correlated with larval fish abundance? Larval fish of most taxa congregated at the riverine-wetland interface; few taxa predominated in remote parts of the wetland (threadfin shad) or in the river channel (blacktail shiner). Lateral and microhabitat segregation were pronounced, though. Sunfishes and darters occurred very close to shore, minnows and gizzard shad farther from shore, crappie and black bass farther still, and threadfin shad offshore. Minnows and crappie abundances were correlated with turbidity and total dissolved solids, darters with submersed cover, and sunfishes with total dissolved solids and dissolved oxygen.

Several micro- and macrohabitat variables are correlated with abundances of individual taxa of larval fishes, but riverine-wetland connection may provide better characterization of larval fish assemblages. Larval fish are more abundant in permanent floodplain waters, than those that are seasonally inundated. Long-term isolation favors spawning success of recreationally important perciforms fishes, but is apparently deleterious to commercially important suckers. Seasonal interruption in riverine-wetland connections could enhance recreational and commercial fisheries, increase local biodiversity, and control noxious species. Connections early in the spawning season provide access for buffalo, black bass, and some darters; connections late in the season provide access for certain sunfishes and nearctic minnows. Mid-season isolation restricts influx of native forms prone to overcrowding (bluegill, gizzard shad) and exotic species (Asian carps).

MANAGEMENT OF SHALLOW IMPOUNDMENTS TO PROVIDE EMERGENT AND SUBMERGENT VEGETATION FOR WATERFOWL

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Effects of partial drawdowns, drawdown timing, and tilling on vegetation and seed production for waterfowl were tested in ponds at the Lewisville Aquatic Ecosystem Research Facility in north-central Texas. Four ponds were utilized to provide 3 replicate ponds and 1 control pond for each treatment. Vegetation lists, percent cover (PC), and above-ground biomass (AGB) revealed that partial drawdowns produced a typical zonation of wetland plants: submergent macrophytes in deep-flooded zones; cattail (Typha sp.), black willow (Salix nigra), and sedges in shallow-flooded zones; forbs in moist zones adjacent to water; and, grasses in upper, drier zones. Seed production of grasses, sedges, and forbs generally reflected the vegetation present in each soil-moisture zone. Taxon richness of emergent plants was highest in dewatered zones.

Drawdown timing did not affect taxon richness of emergent plants within dewatered zones, but grass AGB, and forb and sedge PC and AGB were highest during 1993 spring drawdown. The majority of grasses and forbs had higher seed production during 1992 late-summer/early-fall drawdown whereas sedges produced more seeds during the spring drawdown. Black willow occurred most frequently and cattail was first recorded during spring drawdown. Most submergent macrophytes were unaffected by drawdown timing.

Soil disturbance with rototilling created diversity in ponds by increasing taxon richness of emergent plants, encouraging annuals, and discouraging perennials. PC, AGB, and seed production of forbs and grasses generally increased and decreased, respectively, with tilling, whereas sedges were not affected. Cattail and black willow occurred most frequently in tilled areas. Most submergent macrophytes were not affected by tilling, except southern naiad (*Najas guadalupensis*), with higher PC in tilled plots.

Finally, observations revealed that waterfowl visiting ponds utilized regions according to water depth and plant communities. Gadwall (*Anas strepera*) and American wigeon (*A. americana*) were most often observed within deep zones supporting submergent vegetation. Although data were not statistically significant, blue-winged teal (*A. discors*) and green-winged teal (*A. crecca*) occurred most often in shallow zones supporting emergent vegetation and seeds. Therefore, partial drawdowns, variations in drawdown timing, and soil disturbance, were effective in providing a variety of vegetation and seeds for a diversity of migrant and wintering waterfowl.

WILDLIFE HABITAT FUNCTIONS IN CREATED WETLANDS

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In the winter of 1991-92 the flow of Spring Creek was diverted through a 21-acre created wetland in an effort to improve the quality of water entering Bowman-Haley Reservoir, ND. The created wetland was designed to maximize shallow-water habitats for use by migratory and breeding waterbirds. In the spring of 1992 data collection was initiated to gather information on waterbird use of Spring Creek and the created wetland. Wildlife use was documented through monthly surveys (May - August) during the 1992 and 1993 field seasons. All wildlife use of the wetland and Spring Creek for 2 km upstream from the wetland was recorded.

Waterbird surveys indicated that the created wetland provided pairing habitat for at least 14 pairs of ducks, and brood-rearing habitat for at least 5 duck broods in 1992, and at least 45 pairs and 14 broods in 1993. In comparison, a 2-km segment of Spring Creek upstream from the created wetland provided habitat for only 5 pairs of ducks, and no broods. Avian species diversity also increased through time in the created wetland.

The created wetland also provided habitat for large numbers of shorebirds during both spring and fall migration, including the endangered interior least tern. However, many species indicative of mature wetlands have been absent; these include red-winged and yellow-headed blackbirds, long-billed marsh wrens, and American bitterns. As the wetland matures and permanent emergent vegetation is established, a more diverse wildlife community should appear.

1992 WATERFOWL PAIR AND BROOD DATA ON SPRING CREEK CREATED WETLAND, BOWMAN-HALEY RESERVOIR, NORTH DAKOTA

	DATE							
	15 MAY		30 JUNE		22 JULY		10 AUGUST	
SPECIES	Pr	Br	Pr	Br	Pr	Br	Pr	Br
Mallard	5	0	3	1	0	3	0	4
Northern Pintail	0	0	1	0	0	1	0	0
Gadwall	2	0	0	0	1	1	0	1
Blue-winged Teal	4	0	0	0	0	0	0	3
Wood Duck	1	0	0	0	0	0	0	0
Canada Goose	1	1	0	0	0	1	0	0
Total Waterfowl	13	1	4	1	1	6	0	8

1993 WATERFOWL PAIR AND BROOD DATA

	13 MAY		26 JUNE		24 JULY		17 AUGUST	
SPECIES	Pr	Br	Pr	Br	Pr	Br	Pr	Br
Mallard	7	0	6	1	0	3	0	2
Northern Pintail	1	0	1	0	0	1	0	0
Gadwall	6	0	7	0	0	3	0	3
Blue-winged Teal	9	0	12	0	0	4	0	3
Green-winged Teal	5	0	5	0	0	1	0	0
Northern Shoveler	6	0	4	0	0	0	0	1
American Wigeon	3	0	6	0	0	0	0	0
Redhead	0	0	2	0	0	0	0	0
Lesser Scaup	2	0	1	0	0	0	0	0
Ruddy Duck	0	0	1	0	2	0	0	1
Total Waterfowl	39	0	45	1	2	12	0	10

BIRDS OBSERVED UTILIZING SPRING CREEK CREATED WETLAND

Pied-billed Grebe	Eared Grebe
Wilson's Phalarope	Greater Yellowlegs
Black Tern	Long-billed Dowitcher
Interior Least Tern[a]	Spotted Sandpiper
Forester's Tern	Sandhill Crane
Ring-billed Gull	Northern Harrier
American Avocet	Cliff Swallow
White Pelican	Barn Swallow
Marbled Godwit	Northern Rough-winged Swallow
Willet	Bufflehead
Long-billed Curlew	Great Blue Heron
American Coot	Canvasback

[a] Interior Least Tern is a federally listed endangered species.

Verification of this species at the Spring Creek created wetland is the first record for least terns at the Bowman-Haley Project.

SESSION MB2

MITIGATION AND MITIGATION BANKING: STRATEGIES IN MITIGATION I

Ms. Lynn R. Martin, Chair

A MITIGATION BANKING PROPOSAL FOR THE PLAYA VISTA PROJECT, LOS ANGELES, CA

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Maguire Thomas Partners-Playa Vista is constructing a 51.1-acre freshwater wetland system and proposing to restore a 191- acre salt marsh system in Los Angeles, California. The Corps of Engineers and California Coastal Commission permits to construct the freshwater wetland system recognize that this system will be used to offset the loss of approximately 24 acres of largely man-made wetlands that could be filled to construct a proposed mixed use development at Playa Vista. The permits also provide for the possibility that a restored salt marsh could be used as a mitigation bank for other projects. Permits for the mixed use development have not been granted. To ensure that this new freshwater wetland system will indeed meet the policy of no net loss of wetlands, Maguire Thomas Partners-Playa Vista has agreed, among other things, that the new wetland system would be established prior to the destruction of other wetlands on site; that the new wetland system would be managed, maintained and remediated in perpetuity; and that plans and funding for restoration of an adjoining 191-acre salt marsh would be completed. This paper discusses the mitigation strategy developed for this project, the limitations imposed by the permitting and resource agencies on this strategy, and the applicability of this strategy to other projects.

FLORIDA'S FIRST FULLY-ENTREPRENEURIAL WETLAND MITIGATION BANK

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The southeastern coastal plain of the United States has abundant wetland resources. These resources frequently comprise 25-35% of the landscape and the wetlands are scattered throughout the landscape. Many private and public development activities require wetland permits. Wetland creation has been much maligned and is very expensive to make work successfully. In late 1993, prior to promulgation of Florida's mitigation banking rule, Mitigation Solutions, Inc. began a search for a privately-owned and operated mitigation bank to restore a 400-acre dairy which comprised mostly wetland soils. This paper discusses the site selection process and permitting effort for the first totally private, wetland mitigation bank permitted for construction under the new rule. Landscape Ecosystem Classification (LEC) and the Hydrogromorphic Method (HGM) were used to assess the site and determine mitigation value of the site, and the project was permitted pursuant to Florida's new mitigation banking rule criteria.

INTEGRATION OF WETLAND RESEARCH AND MONITORING INTO THE WETLAND MITIGATION DESIGN PROCESS: A CASE STUDY

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Increasing growth at the Detroit Metropolitan Wayne County Airport created the need for facility expansion including the extension of existing runways, and construction of two new runways, a mid-field terminal and access roads, Over 300 acres of wetlands would be impacted by the proposed expansion. Regulatory agencies having jurisdiction over the proposed project required that 1,5 acres of wetland be created as compensation for each acre of

wetland that was impacted. A 900-acre site approximately 8 miles southwest of the airport was selected for the wetland mitigation project based on criteria including the presence of prior-converted farmlands, hydric soils, perennial water courses and relatively low population density.

The creation of over 450 acres of wetland mitigation area provided the opportunity to test a number of theories relating to hydrologic modeling, wetland hydrology, construction methods and revegetation techniques, This presentation will describe: 1) how a variety of hypotheses were incorporated into the wetland design and 2) the monitoring program that was developed to gather the data necessary to formulate conclusions regarding the success of different wetland creation techniques.

AN ECOSYSTEM APPROACH TO COMPENSATORY WETLAND MITIGATION

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In 1989, the North Carolina General Assembly ratified House Bill 3499 providing for the establishment of the North Carolina Highway Trust Fund. A portion of the Highway Trust Fund was allocated for the construction of a North Carolina Intrastate System. Recognizing the importance of US 64 to regional commerce, travel and the economic development of northeastern North Carolina, the General Assembly included US 64 on the Intrastate System and mandated the complete four-laning of US 64 from Raleigh to the coast. It was further specified that US 64 be included as freeway construction between I-95 and US 17. Given this mandate, the North Carolina Department of Transportation (NCDOT) developed construction plans for a four-lane divided highway on a new location from the US 64/258/NC 44 interchange south of Tarboro to a location west of Everetts (23 miles) at the US 64/SR 1405 interchange.

Environmental Services, Inc. (ESI) was retained by NCDOT to develop a mitigation plan for wetlands impacted by the US 64 construction (104.7 acres). In addition, this plan provides for wetland impacts due to the construction of a new interchange at the US 64/SR 1225 crossing (3.5 acres).

A systematic search of the Edgecombe, Pitt, and Martin County areas was conducted to locate suitable lands for in-kind mitigation of project-related wetland impacts. Efforts were concentrated within the Tar River Drainage Basin in order to promote in-basin functional replacement for lost wetland functions. Six sites were evaluated for mitigation opportunities.

Based on the ecological evaluation of each mitigation site alternative and the requirement to provide spatial and functional replacement of wetland losses, the 593-acre Mildred Woods site and the 112-acre Huskanaw Swamp site provide the best potential for an ecosystem approach to mitigation. Both sites are located immediately adjacent to the proposed highway along existing ecological corridors.

The project team made detailed analyses of existing ecological and hydrological conditions to provide maximum assurance of project success. Using hydrological modeling (DRAINMOD), it has been predicted that wetland hydrology can be restored to 443 acres at the selected sites. Hydric soils mapping, Hydrogeomorphic Modeling (Brinson et al, 1994), and Landscape Ecosystem Classification (Jones et al, 1984) models were used to predict the extent of the wetland/upland ecotones and appropriate vegetation plantings. After analysis of all data, 399 wetland acres will be restored, 44 acres will be enhanced, and 56 acres will be preserved (McCrain 1994). The balance of the properties, comprising 233 acres of uplands, will also be restored and managed.

This mitigation plan provides for restoration, enhancement and preservation of contiguous natural wetlands, which will ensure the perpetual maintenance of characteristic wetland functions in this region. The integration of contiguous upland and wetland communities will enhance the value of site-specific resources. Future management by the N,C, Wildlife Resources commission will provide for continued improvement and protection of these communities.

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STRUCTURE AND SUCCESSES OF THE OHIO WETLANDS FOUNDATION'S CONSOLIDATED MITIGATION SYSTEM

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In 1992, the Ohio Wetlands Foundation (Foundation) was created by the Ohio Home Builders Association, and a formal partnership agreement was established with the Ohio Department of Natural Resources, Division of Wildlife (DOW). The US Army Corps of Engineers, Huntington District, the US EPA, the Ohio EPA and the US Department of the Interior, and Fish and Wildlife Service, have all provided guidance to ensure that the Foundation's system reflects current regulatory policies. Envirotech Consultants, Inc, (Envirotech) acts as consultants to the Foundation for technical aspects of site selection, general design, landscaping and monitoring.

The goal of the Foundation is to create large, diverse wetland ecosystems through the pooling of resources of entities who are authorized to mitigate wetland impacts under Section 404 of the Clean Water Act. This system provides an alternative when on-site mitigation is not feasible, Sites are selected jointly by Envirotech and the DOW, and a preliminary plan is prepared for review by the agencies. Upon its acceptance, the Foundation is authorized to reserve acreage for clients who are applying to fill wetlands and mitigate on a Foundation site, A final construction plan is prepared for agency review, and construction is initiated upon approval, After construction, the DOW accepts the site for perpetual maintenance; however, the Foundation provides monitoring over a five-year period.

The Foundation provides $1,000 per acre to the DOW's Wetland Habitat Fund for wetland-related activities. The Foundation has managed to keep costs per acre to $7,500 and $12,000 for the two sites which have been constructed. Low costs per acre are maintained primarily by utilizing strict site selection criteria. Sites are sought which are underlain by hydric soils, are restorable with minimal excavation and are easily flooded with the construction of a low berm. Sites are also sought which show evidence of an existing wetland seed bank. The Foundation and the DOW have a strong interest in creating native plant communities which were historically present. Replacement of habitat types filled is the primary goal for the Foundation sites. For both sites already constructed, the plans called for shrub and tree species to be planted, but emergent habitat was allowed to develop from the seed bank.

The first site, located at the Hebron Fish Hatchery in Licking County, Ohio, experienced its first growing season under wetland hydrologic conditions in 1994. Emergent habitat development was exceptional with a total of 80 hydrophytic plant species identified. Wildlife identified on the site included 58 bird species, 6 mammals, 1 reptile and 4 amphibians, highlights of which were Grus canadensis (sandhill crane) and Sistrurus ctenatus (eastern massasauga), The second Foundation site is located at the Big Island Wildlife Area in Marion County, Ohio. 1995 will be the first growing season for this site. As with the Hebron site, large areas of wetlands were documented in historical literature. An excellent seed bank is expected to be present based on existing wetland areas, and additional habitat for several wetland dependent bird species which are state rare and endangered will be created.

SESSION CP5

CRITICAL PROCESSES:
WETLAND PROCESSES, SOILS DEVELOPMENT, CHEMISTRY, AND EROSION
Jack E. Davis, PE, Moderator

MONITORING THE PHYSICAL ENVIRONMENT OF LOW-SALINITY ROOTED AND BOUYANT MARSHES IN COASTAL LOUISIANA

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Monitoring of the physical environment in the low-salinity coastal marshes of the Louisiana Delta plain (soils, hydrological response and porewaters) is complicated in that two physically distinct marsh types are present: those marshes firmly rooted in a non-buoyant substrate and buoyant marshes, those that are not anchored. In the latter, the shallow substrate moves vertically in response to changes in ambient water levels. The exchange of both above- and below-ground is predictably altered in the buoyant marsh compared with the rooted type. Sediments and nutrients carried by surface waters will enter the two marsh types differently. Freshwater will circulate differently in the two marsh types.

Innovative monitoring techniques are required to assess the response of both marsh types in rapid regional subsidence and gradually increasing salinities. In this communication, techniques used to describe and interpret mat buoyance and movement, substrate composition, and porewater responses to open- water forcing are presented, using examples from an on-going three-year interagency study of the intermediate marshes at Jean Lafitte National Historic Park and Preserve, Barataria Unit by the US National Biological Service and the US Geological Survey. The techniques will assist in determining potential impacts of proposed freshwater, sediment, and nutrient diversions of the Mississippi River water on the fresh and intermediate marshes, as well as providing some means of assessing benefits accrued through restoration methods currently being applied coast-wide.

EVALUATION OF FOUR CHEMICAL EXTRACTANTS FOR METAL DETERMINATIONS IN WETLAND SOILS

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Hydric soils [soils formed by wetland conditions] have special characteristics compared to dry mineral soils. Soil color and mottling, which indicate the duration and depth of soil saturation, reveal the hydric condition. Wetland soils receive, hold, and recycle nutrients and other elements which are continually washed from upland regions. Due to the high organic matter content of wetland soils, they normally have a great capacity to complex or adsorb metals and organics, which is responsible for the wetland's potential for pollutant retention (Reddy 1993).

The purpose of this study was to evaluate the suitability of the four most common chemical extractants (Mehlich 1, Mehlich 3, 0.1M HCl, and DTPA) for the determination of metals in wetland soils (Mehlich, 1953, 1984, Lindsey and Norval, 1978).

Constructed wetland cells were lined with 15cm of coal mine spoil from Tennessee and Alabama, or with topsoil from the study area (Abernathy silt loam). The replicated substrates, in separate cells, were saturated with water and planted with the following wetland plant species: cattail (*Typha latifolia*), maidencane (*Panicum hemitomon*), pickerelweed (*Pontederia lanceolota*), and bulrush (*Scirpus validus*).

Soil/spoil samples were extracted and analyzed for metal concentration using the following chemical extractants: Mehlich 1 (at a 1:4 soil/solution ratio); Mehlich 3 (at a 1:10 soil/solution ratio); 0.1M HCl (at a 1:10 soil/solution ratio); and DTPA (at a 1:2 soil/solution ratio). Plant shoots were cut at water level, dried, ground and digested with sulfuric acid and hydrogen peroxide. Mehlich 3 extracted higher quantities of Zn, Ni, Fe, Mn, Cr, Al, Ca, and Mg from topsoil. 0.1M HCl extracted more Pb, Cd, Cr, and Cu (Table 1). All extractants removed very small or zero amounts of Ni, Cr, Pb, and Cd from topsoil. Extractants generally followed the order of - Mehlich 3 > 0.1M HCl > Mehlich 1 > DTPA - with regard to removing most of the metals except for Pb, Cu, and Cd. However, statistically there were no significant differences among Mehlich 3, 0.1 M HCl, and Mehlich 1 extractant except for Al, Fe, and Cu.

A trend similar to that in topsoil was found with regard to the extraction of metals from Alabama and Tennessee spoils. Mehlich 3 was most effective for removal of most of the metals,

TABLE 1. Concentrations of Three Soil/spoil Materials by Four Extractants (June 1994).[a]

Soil/spoil	pH	Extractant	Zn	Pb	Cd	Ni	Fe	Mn	Cu	Cr	Al	Ca	Mg	K
								mg/kg						
Top soil	5.4	Mehlich 1	1.45 a*	0.35 a	0.08 a	0.47 a	197.7 a	199.0 a	1.00 a	0.20 a	170.0 b	390.0 a	33.0 a	29.0 b
		Mehlich 3	2.70 a	— ‡	—	0.50 a	264.8 a	279.7 a	1.00 a	—	310.7 a	516.3 a	49.7 a	109.0 a
		0.1M HCl	1.92 a	0.93 a	0.17 a	0.49 a	260.1 a	240.9 a	1.88 a	0.28 a	223.0 ab	419.0 a	41.4 a	32.0 b
		DTPA	0.28 b	0.67 a	—	—	11.3 b	22.6 b	0.12 a	0.01 a	0.7 c	—	0.63 b	—
Alabama mine spoil	5.8	Mehlich 1	1.60 a	0.81 a	0.04 a	1.30 a	199.0 a	172.0 a	0.70 a	0.10 a	148.0 a	198.0 b	69.0 a	23.7 b
		Mehlich 3	2.70 a	—	—	1.60 a	277.7 a	234.7 a	1.00 a	—	220.2 a	451.8 a	88.5 a	79.3 a
		0.1M HCl	2.20 a	1.20 a	0.06 a	1.42 a	266.7 a	213.0 a	1.90 a	0.18 a	169.8 a	231.0 b	74.0 a	33.7 b
		DTPA	0.33 b	1.83 a	—	0.17 b	43.2 b	45.8 b	0.90 a	—	22.2 b	—	9.3 b	2.0 c
Tennessee mine spoil	4.5	Mehlich 1	2.90 a	0.94 a	0.05 a	1.15 a	183.0 a	21.0 b	1.90 a	0.07 a	200.0 a	161.0 b	57.0 a	32.7 b
		Mehlich 3	4.80 a	—	—	2.00 a	289.0 a	88.2 a	1.50 a	—	270.2 a	367.7 a	74.3 a	106.7 a
		0.1M HCl	3.90 a	1.50 a	0.10 a	1.70 a	201.0 a	36.7 b	2.20 a	0.10 a	228.0 a	176.0 b	64.3 a	35.0 b
		DTPA	2.67 a	1.83 a	—	1.00 a	57.7 b	31.0 b	1.30 a	—	270.2 a	—	5.2 b	3.2 c

a Data points represent the average of three replications.

‡ Not detectable

* Means followed by the same letter in each column within each soil/spoil are not significantly different at the 5% level (Tukey's test).

i.e. Zn, Ni, Fe, Mn, Al, Ca, Mg, and K. In general, DTPA was more effective and removed greater quantities of metals from Tennessee spoil than from Alabama spoil or topsoil. This may be due to the lower pH of the Tennessee spoil. Cadmium, Ni, and Cr concentrations were very low with all extractants. All of the extractants did not correlate with the plant concentration of these metals.

The results of this study showed the complexity and dynamics of metal removal by aquatic plants and chemical extractants from hydric soil. However, the search for an appropriate extractant for routine metal determination of hydric soils is warranted. Mehlich 3 was clearly the most effective in extracting most of the metals in this study, although it did not have the highest correlation with uptake levels in the selected plant species.

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THE USE OF SOIL MORPHOLOGICAL FEATURES TO PREDICT HIGH GROUND WATER TABLES IN PROBLEMATIC SOILS OF SOUTHERN NEW ENGLAND

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The use of soil morphological features to infer soil moisture regime is a practice widely used for urban land use interpretation and the identification and delineation of jurisdictional wetlands. Numerous studies have quantitatively examined the complex interrelationships between soil morphology and hydrology in a number of geologic settings. In New England, various problematic soils occur in Wisconsinan age sediments which do not adhere to standard morphological criteria relating soil color to wetness due to regional differences in bedrock geology or depositional environment (Tiner and Veneman 1987). These soils include soils developed from coarse-textured glacial fluvial sediment which weakly express wetness morphologies; and soils formed in low chroma Carboniferous lodgment till which are inherently gray in color and masks hydromorphic features. Studies were conducted in Rhode Island to examine the physical, chemical, and morphological properties of these problematic soils to determine if there were any relationships which could be used to predict high ground water tables.

Fifty-four soil profiles were investigated at nine hydrosequences developed in coarse-textured, stratified glacial fluvial sediment (Sokolosld 1988); and 19 soil profiles were investigated at four hydrosequences formed in low chroma glacial till developed from Carboniferous parent materials of the Narragansett Basin of eastern Rhode Island (Lesinski 1994). Detailed morphological descriptions were obtained from each pedon, selected laboratory analyses were performed on each horizon or layer, and water tables were measured biweekly for approximately two years at each of the 73 sites. Twenty-one to 27 soil properties which have been shown in previous studies, or otherwise believed to be, related to high ground water levels were statistically analyzed using SAS stepwise regression technique to develop predictive equations (Table 1). The high water level variables used in these equations included those occurring during the growing season, or that period of the year when soil temperature at 50 cm exceeded 5′ Celsius as monitored at each pedon via thermisters.

Four soil properties were selected by stepwise regression as the best indicators of growing season high ground water tables in sandy, stratified glacial fluvial soils (Table 2). These four morphological properties explained 79% of the variability in water tables and included: depth to a chroma of 3 or less and value of 4 or more, thickness of an epipedon meeting umbric requirements, thickness of the B horizons, and thickness of the gibric organic (Oi) horizon. The single-best predictive soil property was the depth to a chroma of 3 or less and value of 4 or more, which exhibited a correlation coefficient of 0.825.

Three soil properties explained 85% of the variability of growing season high ground water tables in low chroma glacial till soils (Table 2). The morphological properties selected as best predictors of growing season high water tables were: depth to redoximorphic features from the bottom of the A horizon, value plus

Table 1. Soil Properties Examined for Significant Relationships to Growing Season High Water Tables		
Glacial fluvial sediments	Low chroma lodgement till	Soil Property
•	•	Combined thickness of all organic (O) horizons
	•	Thickness of hemic organic (Oe) horizon
	•	Thickness of sapric organic (Oa) horizon
	•	Thickness of Oe and Oa horizons combined
•	•	Thickness of O and surface mineral (A) horizons
•	•	Thickness of A horizon
•	•	Thickness of subsurface mineral (B) horizons
•	•	Thickness of the solum (A plus B horizons)
	•	Presence of epipedon meeting umbric requirements
•	•	Value of A horizon
•	•	Chroma of A horizon
•	•	Value plus chroma of A horizon
	•	Value:chroma ratio of A horizon
	•	Value of B horizon
	•	Chroma of B horizon
	•	Value plus chroma of B horizon
	•	Value:chroma ratio of B horizon
	•	Presence of a gleyed (g) horizon
•	•	Depth to any redoximorphic features
	•	Depth to horizon or layer meeting densic requirements
	•	Depth to matrix chroma of 1 or less
•	•	Depth to matrix chroma of 2 or less
•	•	Depth to common or many prominent redoximorphic features
•	•	Depth to matrix hue of 2.5Y, 5Y, or N
	•	Depth to redoximorphic features from the bottom of the A horizon
	•	Chroma index[1]
	•	Chroma:value index[2]
•		Organic carbon (g/m^3)
•		Thickness of fibric organic (Oi) horizon
•		Thickness of epipedon meeting umbric requirements
•		Free iron (g/m^3)
•		Depth to redoximorphic features of chroma 2 or less
•		Depth to redoximorphic features of chroma 3 or less
•		Depth to matrix chroma of 3 or less and value of 4 or more
•		Depth to many redoximorphic features
•		Depth to gleyed (g) horizon

[1]Chroma index: (Evans and Franzmier, 1988)

$$^{m}\Sigma_{i=1} = \frac{(\text{Abundance}^{\text{matrix}}) \times (\text{Chroma}^{\text{matrix}}) + (\text{Abundance}^{\text{redox}}) \times (\text{Chroma}^{\text{redox}})}{\text{Number of subsoil horizons}}$$

[2]Chroma:value index:

$$^{m}\Sigma_{i=1} = \underline{(\text{Abundance}^{\text{matrix}}) \times (\text{Chroma/Value}^{\text{matrix}}) + (\text{Abundance}^{\text{redox}}) \times (\text{Chroma/Value}^{\text{redox}})}$$

Table 2. Contributions of Soil Properties to Predictive Growing Season Mean High Water Table Model

Coarse-textured Glacial Fluvial Soils

Variable Selected	No. in Model	R^2
Depth to Chroma 3 or less and value 4 or more	1	0.68*
Thickness of epipedon meeting umbric requirements	2	0.73*
Thickness of B horizon	3	0.76*
Thickness of Oi horizon	4	0.79*

* Significant at the $P<0.05$ level

Y = 10.31 - 0.54 (Chroma $\leq$ 3) + 0.48 (umbric) - 0.55 (B horizons) - 1.53 (Oi horizons)

Low Chroma Glacial Till Soils

Variable Selected	No. in Model	R^2
Depth to redoximorphic features from the bottom of the A horizon	1	0.673*
Value plus chroma of the B horizon	2	0.801*
Value plus chroma of the A horizon	3	0.850*

* Significant at the $P<0.05$ level

Y = - 3.78 + 0.55 (Depth to redox features) + 3.09 (Value plus chroma of B horizon) - 2.33 (Value plus chroma of A horizon)

chroma of the B horizon, and value plus chroma of the A horizon. The single best predictive soil property was depth to redoximorphic features from the bottom of the A horizon which exhibited a correlation coefficient of 0.820.

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REDOX POTENTIALS ACROSS A TRANSECT FROM HYDRIC TO NON-HYDRIC SOILS

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Introduction

The purpose of this study was to examine redox potentials across an undisturbed forested wetland to upland transect in Southeastern Louisiana to characterize the oxidation-reduction status of the soils. We used a large number of replicate electrodes at each site to examine what differences could be detected in soil redox potentials at three sites differing in elevation, and to look for seasonal changes in soil redox potential.

Materials and Methods

Bright-platinum electrodes were installed at three sites from a non-hydric soil (Site 1) to frequently flooded hydric soils (Site 3) with an intermediate site having occasionally flooded hydric soils (Site 2). Eight electrodes were installed at a depth of 15 cm and 30 cm in replicate plots in each site. Measurements were taken approximately monthly from December 1992 until September 1994. Significant differences in mean redox potential between sites at each depth were determined using SAS with a split-split plot design and multiple comparisons within depths between sites.

Results and Discussion

Mean redox potentials at the 15-cm depth in the three sites (Figure 1) were considerably different during most of the study. Site 1 consistently had higher mean redox potentials whereas the mean redox potential at Site 3 was lower than that of each of the other two sites. Redox potentials at Site 3 were significantly lower than those at Site 1 over most of the study. Redox

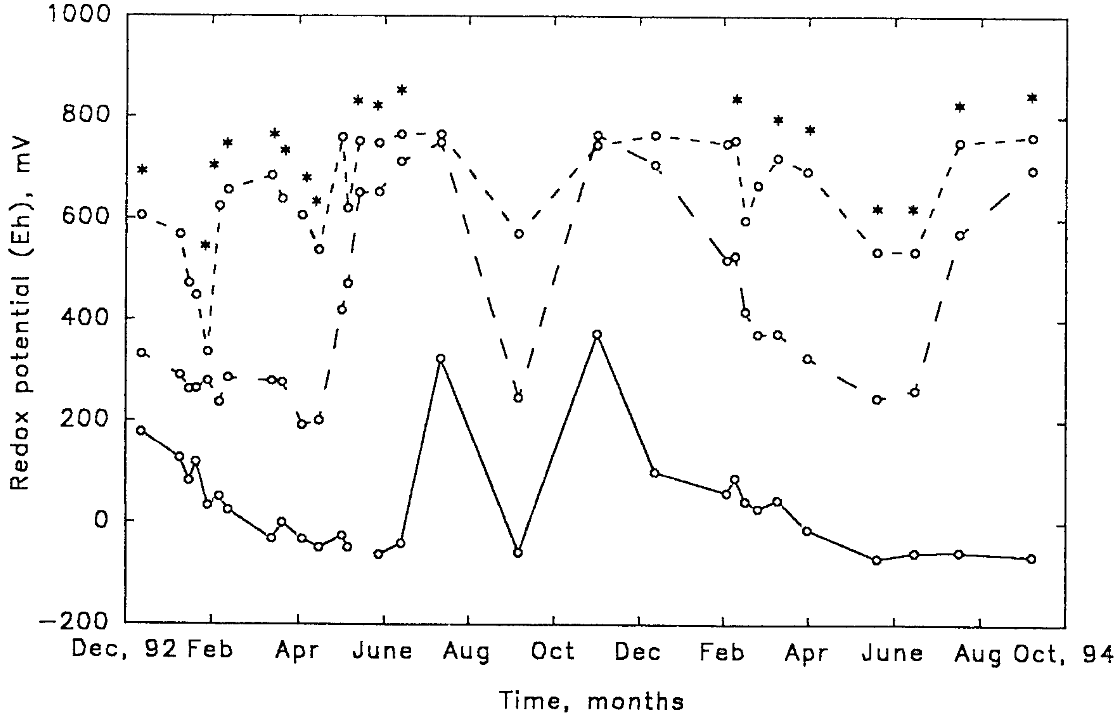

Figure 1. Mean redox potential at Site 1 (- - -), Site 2 (- –) and Site 3 (——) at the 15-cm depth from December 1992 until October 1994. Sampling dates on which there were statistically significant differences between sites are designated by an asterisk above the date.

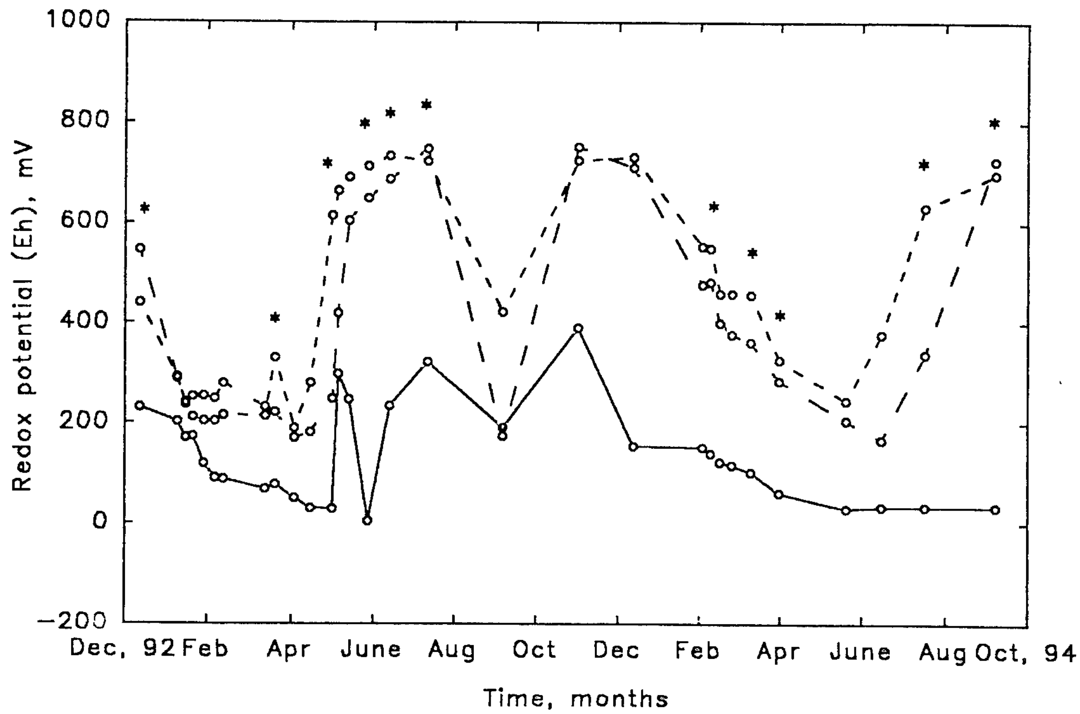

Figure 2. Mean redox potential at Site 1 (- - -), Site 2 (– -) and Site 3 (——) at the 30-cm depth from December 1992 until October 1994. Sampling dates on which there were statistically significant differences between sites are designated by an asterisk above the date.

potentials at Site 2 were intermediate to redox potentials observed at Site 1 and Site 3.

Seasonal trends in redox potential were most apparent at Site 2. Redox potentials were lower during the winter and spring months when the water table was shallower, and higher during the summer and fall months when the water table was deeper. Mean redox potentials at Site 2 were different from those at Site 1 only during the winter and spring months when the redox potential was the lowest. The large decrease in redox potentials observed in September,1993 was due to a heavy rainfall event the day previous to sampling. The heavy rainfall was indicated by drifted litter observed at Site 1 and water remaining in depressions at Site 2.

Redox potentials at the 30-cm depth in Site 1 and Site 2 were not statistically different during most of the study. Redox potentials at Site 1 and Site 2 were significantly different from those at Site 3 during periods when the soil wetness was changing in early summer and early spring. Mean redox potentials at the three sites were more similar at the 30-cm depth than the differences observed at the 15-cm depth (Figure 1 and 2). Redox potentials at the 30-cm depth in Sites 1 and 2 showed more seasonal variation than was observed in the same sites at the 15- cm depth.

Conclusion

Differences were observed among redox potentials at the three sites. The majority of significant differences in redox potential occurred between Site 1 and Site 3 at the 15-cm depth. Redox potentials at Site 2 were intermediate in measurement to the those at Sites 1 and 3 and displayed the largest amount of seasonal variation.

THE WESWAVES PROJECT: WAVE ACTION AND THE ERODIBILITY OF SALT MARSH SOILS

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Over 100 coastal wetland restoration projects affecting thousands of acres are now in various stages of planning, design and construction in coastal Louisiana (Boesch et al. 1994), but few measurements have been made of waves and currents in the shallow marsh / channel / pond settings that are to be restored. Because this information is critical to the design and evaluation of the projects being constructed, CERC researchers with the Army Wetlands Research Program (WRP) joined with colleagues at LSU to augment an ongoing U.S. Geological Survey (USGS) study of marsh loss processes. The USGS effort began in 1988 and was recently completed (Roberts et al. 1994). WRP involvement led to development of a prototype instrument array (WESWAVES) that was used to acquire synoptic measurement of waves, suspended sediments and geotechnical parameters in representative stable and deteriorating salt marsh/pond sites in Louisiana's coastal delta plain.

Vertical accretion is widely understood to be the primary mechanism by which intertidal marshes maintain themselves against the apparent sea level rise (ASLR) caused by the combination of (1) global sea level change, (2) regional subsidence and (3) the net effect of local erosion, deposition and consolidation of the marsh surface. Analysis of aerial imagery from coastal Louisiana showed that conversion of wetlands to small ponds accounted for more than 70 percent of the land loss in three deltaic basins between 1955 and 1978, with the remainder more directly attributable to canal dredging and the retreat of Gulf of Mexico and bay shorelines (Leibowitz and Hill 1987).

Submergence, impoundment, grazing, burning, salinity stress and burial are among the factors that have been implicated in the initial formation of marsh ponds throughout the world. Rip-up, rolling and compression of poorly attached or floating marshes was observed to create new open water areas following passage of Hurricane Andrew in Louisiana. Otherwise, pond formation and expansion in firmly attached marshes does not appear to be explainable as a simple erosion process involving only the removal of sediment by waves or currents.

Our hypothesis was that pond expansion occurred when shear forces produced by waves and currents exceeded the shear strength of the marsh soil matrix. This could occur if forces associated with waves and currents were to increase significantly, or, alternatively, if the shear strength of the soil were to decrease by a similar proportion. We set out to examine these relationships in two representative salt marsh / pond complexes that were being monitored as part of the USGS project.

Experimental Approach

Although the ponds were about the same depth, marsh surface elevation at the OB site was estimated from water level time-series to be about 10 cm higher than at BC. The OB pond is a stable landscape feature visible in 1940's photography, while the BC pond is of more recent origin and is in an area of rapid marsh break-up and loss. The OB pond did not enlarge or contract during five years of observation which included the passage of Hurricane Andrew. The BC pond margin retreated more than 2 m during the same period and, after the hurricane, opened up to the north to become an embayment of a larger water body, such that it was no longer isolated.

Winds were measured just above the elevation of the marsh grass and wave stress at the pond bed was estimated using pairs of pressure sensors fixed at the bottom that were separated by about 8 m. One sensor was placed in shallower water at the pond margin, while the other was positioned closer to the center of the pond in water that averaged 20 cm deeper. Autosamplers were deployed to collect water samples for suspended sediment analysis from the pond margin and from a marsh surface station located 20 m inland of the edge of vegetation. Sediment-erosion table (SET) stations were established to monitor changes as small as 0.3 cm in local soil surface elevation on the marsh surface and at unvegetated pond margin and bottom stations (Boumans and Day 1993). Eight cm diameter cores, 40 cm long were collected from the same locations. Cores were split and tested for fall cone (penetration) and vane shear strengths. They were then sectioned and analyzed for unit weight, bulk density and organic matter content.

Wave and Suspended Sediment Measurements

Synoptic wind, wave, water level and suspended sediment data were acquired in 1992, 1993 and 1994 from the BC pond on 13 days and at the OB pond on 15 other days for a total of 191 ensemble datasets. The highest wind speed recorded at 1 m was 5 $m\text{-}s^{-1}$. Total wave energy and frequency were extracted from spectra generated from each detrended pressure record to provide an analog of bed shear stress.

Despite the shallow depths of the ponds, the locally generated waves measured were so limited by the 50 m fetch that they were essentially deep water waves that did not impose significant stresses on the bed. The records were examined to see whether an intrusion of lower frequency and perhaps larger waves from outside the pond system occurred when the marsh surface was flooded, but no such intrusion was observed. After Hurricane Andrew, however, the BC pond opened up rapidly along the north side, as has been described. Then, waves with frequencies between 1 and 2 Hz were recorded and provided the highest energy conditions monitored with the bottom mounted sensors.

Total suspended sediment (TSS) concentrations in the ponds ranged from 10 to 200 $mg\text{-}l^{-1}$ at BC and from 20 to 400 $mg\text{-}l^{-1}$ at OB. Mean TSS concentration in the OB pond (107 $mg\text{-}l^{-1}$) was nearly twice that at BC (67 $mg\text{-}l^{-1}$) while values from the marsh surface were similar (83 at BC, 88 at OB). If wave resuspension of sediments within the pond were the primary forcing for TSS concentrations within the pond, a negative correlation with depth would be expected. In fact, the reverse was observed. Water level and TSS data from the pond margin were significantly positively correlated for both the BC and OB sites suggesting that sediments in the pond water column primarily enter the ponds from the bayou via the inlet channel rather than through wave resuspension. TSS in the OB pond was also significantly negatively correlated with the percentage by weight of organic matter in the suspended sediment, indicating that most variation of TSS in the OB pond could be explained by the introduction of inorganic sediments from the bayou. Such a correlation was not significant in the BC pond which received less inorganic sediment from any source.

Soil Elevation, Composition, and Strength Measurements

SET measurements of local surface elevation changes resulting from deposition, erosion and consolidation in the upper 2 m of the sediment column showed a two year loss of 1 cm (+/- 0.3) in the elevation of the pond bottom at the BC site. Elevation at the pond margin dropped 2.8 cm at both sites. The passage of Hurricane Andrew did not alter the elevation trend of the pond margin or bottom. Marsh surface elevation showed no significant change at BC (-0.3 cm) but increased at OB by 1 cm over two years. These results indicate that the BC marsh is not aggrading at a sufficient rate to offset any regional ASLR greater than zero. The OB marsh, in contrast, appears to be building up its surface at a rate close to ASLR estimates for this area.

Saturated soil unit weights are higher at the OB site than at BC. The organic matter contribution to the wet weight was similar at both sites but samples from OB cores had more than twice the mineral matter content . Dry bulk densities at OB were also twice those at BC, averaging 4.0 (0.4 $g\text{-}cm^{-3}$) and 1.9 $kN\text{-}m^{-3}$ (0.19 $g\text{-}cm^{-3}$), respectively. Fall cone penetration tests provided the most repeatable means of estimating cohesive shear strength as the soils were nearly liquid, particularly at BC. The shear strength of the vegetated marsh at the OB site (103 $kN\text{-}m^{-2}$) is two orders of magnitude higher than that at BC (1 $kN\text{-}m^{-2}$). An order of magnitude difference between the two sites was also found in cores from the unvegetated pond edge and bottom.

Discussion

The results of this work do not support the hypothesis that ponds of the median size (0.2 ha) expand through simple erosion due to waves. The wave regime at both sites was similar but pond response was quite different. Marsh and pond soils at the OB site had cohesive strengths that were greater than at BC by one to two orders of magnitude. Process data supplied by the WESWAVES array added an important element to the understanding of coastal marsh loss that has emerged out of the USGS project (Roberts et al. 1994). Because the marsh at BC is lower, it is flooded for longer periods such that infrequent opportunities exist for drainage and consolidation. As waterlogging continues, plants are increasingly stressed, leading to lowered productivity and finally death. The formerly living root mass decomposes rapidly, reducing surface elevation further through a decrease in volume. But plant death also reduces soil strength so that marsh scarps become unstable and fail. Low-cost field methods for surveying in-situ soil strength in marsh soils can be developed that will provide a much needed technique for comparing various sites and assessing performance of restoration projects. While accurate vertical elevation control is difficult to obtain in isolated marshes, the SET technique provides a precise means to monitor elevation response.

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SESSION RE11

RESTORATION, PROTECTION, AND CREATION: GENERAL FRESHWATER WETLAND RESTORATION AND CREATION

Ms. Linda Winfield, Chair

HYDROLOGIC DESIGN AND RESTORATION PLAN FOR THE THREE FORKS MARSH CONSERVATION AREA

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The Three Forks Marsh Conservation Area (TFMCA) is part of a flood control and environmental restoration effort being undertaken jointly by the USACE and the St. Johns River Water Management District (SJRWMD) in Southcentral Florida. It encompasses about 14,000 acres of formerly drained St. Johns river floodplain (Figure 1). The restoration goal is to convert TFMCA to wetlands and to reconnect it hydrologically to the river.

Ground elevations in TFMCA are 2 to 3 feet lower than adjacent areas of the St. Johns Marsh Conservation Area (SJMCA) due to soil subsidence. Therefore, a levee which separates the TFMCA from the SJMCA must be maintained to prevent overdrainage of the SJMCA during dry periods. Hydrologic modeling was used to determine the size of inlet and outlet weirs that would regulate stage to create a natural hydrologic regime in both marshes. Hydrologic statistics used to define a natural hydrologic regime and set restoration goals are: mean depth, inundation frequency, minimum range of yearly fluctuation, timing of fluctuation, water level recession rates and minimum water levels (Miller et al., 1993). Hydrologic statistics are defined relative to a range of critical marsh elevations.

The Upper St. Johns Hydrologic Model (USJM) was used for this study (Suphunvorranop and Tai, 1982). An iterative process, comparing model results of a number of design options to the hydrologic criteria, was used to determine the best restoration plan.

Based on model results, inflows to the TFMCA will occur from the SJMCA over a 350 ft weir with a crest elevation of 19.5 ft NGVD (Figure 1). Downstream, a 600 ft weir with a crest elevation of 20 ft NGVD will discharge back into the SJMCA. A 250 cfs capacity culvert structure will also discharge from the TFMCA back into the SJMCA to create smooth transition to low flow condition when flows over the weir stop.

Simulation runs (1942-1988) indicated that under the plan conditions, all environmental hydrologic criteria for the TFMCA would be met (Table 1). For SJMCA, all criteria will be satisfied except for the mean depth and its inundation frequency at river mile 277.06 (Figure 1). Criteria violation at this river mile can be attributed to rapid drainage through a canal located on the left bank.

Restoration of the TFMCA will establish approximately 7,000 acres of open water habitat in the northern part and 7,000 acres of freshwater marsh habitat in the southern half. After the structural components are built and the project is fully operational, the marsh stage will be monitored to verify if the environmental hydrologic criteria are being met.

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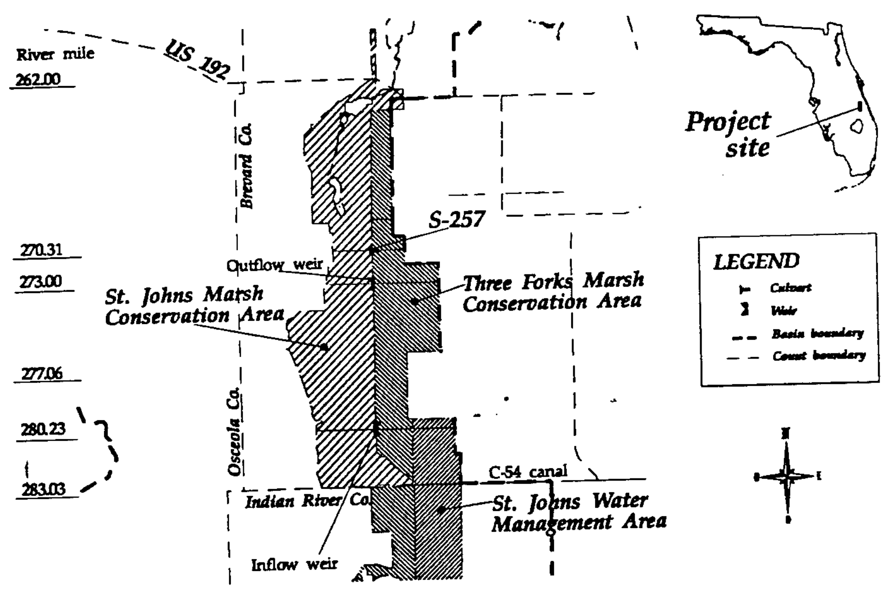

Figure 1. Three Forks Marsh Project Area.

Table 1. Criteria-related performance summary for the TFMCA

Criteria	Goal	Simulated
Mean Depth, ft	18.00	18.73
18.0 ft Inundation	60.0%	68.0%
17.5 ft 30 Day Exposure	50.0%	55.0%
Timing of Fluctuation	Seasonal	Met
Stage Recession Rates		
30 Day	< 1.2 ft	Met
7 Day	< 0.5 ft	Met
16.5 ft Duration	95%	97%

CREATING WETLANDS FROM FARM LAND IN CENTRAL FLORIDA

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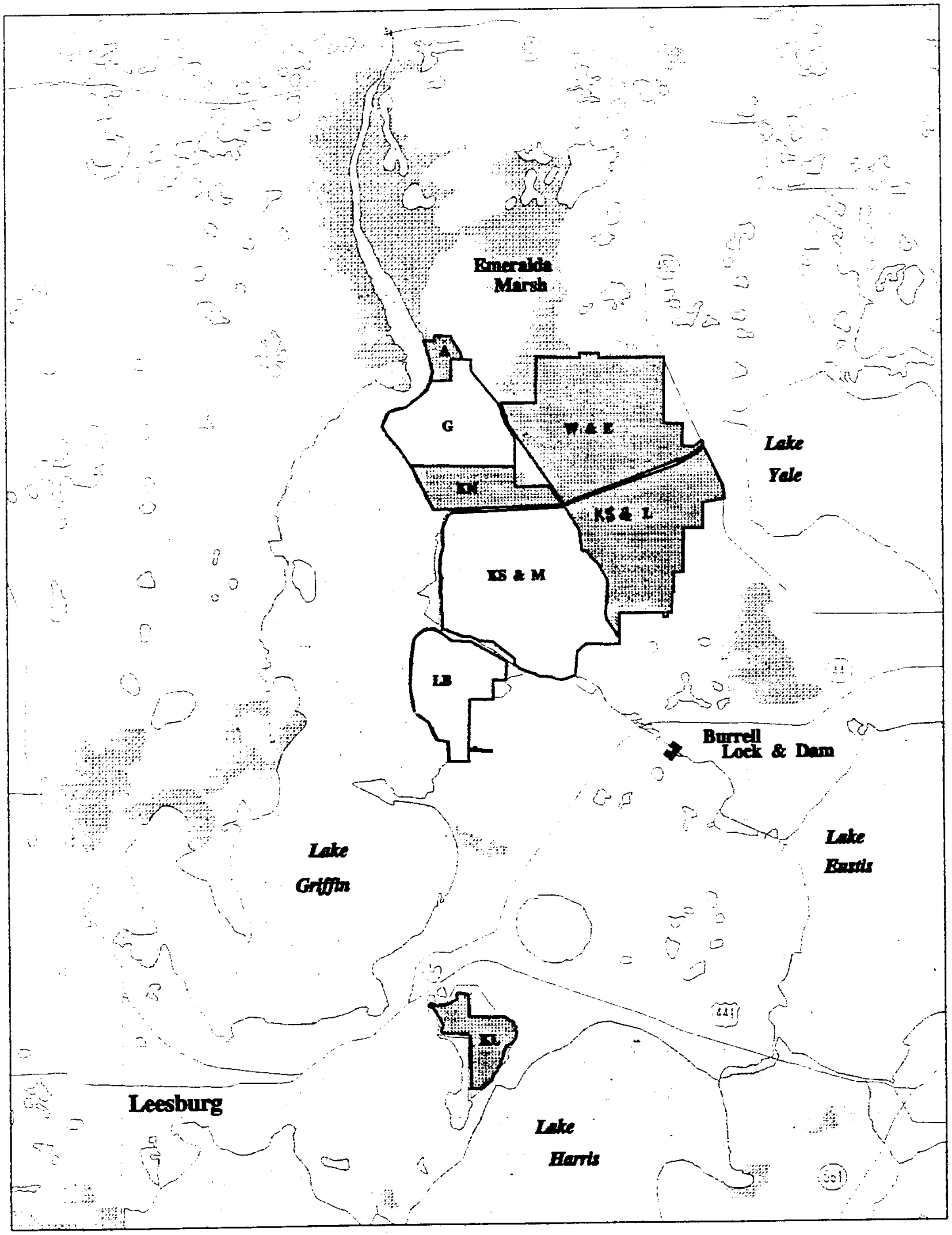
Abstract

Since 1991 the St. Johns River Water Management District has acquired about 8,000 acres of muck farms adjacent to the Ocklawaha River, Lake Griffin, and Lake Harris in Central Florida. Prior to agricultural development the area consisted primarily of shallow emergent marsh dominated by sawgrass interspersed with upland habitat. Water control and land clearing for farming was initiated in the early 1900s and extensive agricultural expansion occurred after World War 11. The muck farms were used to grow vegetables and to provide forage for cattle. Increased eutrophication of waters of the remaining wetlands, Lake Griffin, and minor creeks has occurred due to agricultural nutrient loading. Oxidation of the farmed peat soils resulted in substantial soil subsidence below the level of Lake Griffin. Creation of wetland and aquatic habitat, improvement of water quality, and provision of recreational use are the main goals of restoration and management of the conservation area.

Introduction

The Emeralda Marsh Conservation Area (EMCA) encompasses about 15,000 acres and is located northwest of Orlando in Marion and Lake Counties, Florida (Fig.1). About 8,000 acres are primarily former muck farms and ranches. The Florida Department of Environmental Protection (FDEP) was initially responsible for shared acquisition and management of the area through the Conservation and Recreation of Lands (CARL) program. The majority of the area under public

Figure 1. SJRWMD "Muck Farms"



District "Muck" Farms Flooded or to be Flooded

District "Muck" Farms in Lake Griffin Flow-way Projects

A = Ashley Farm
E = Eustis Muck Farm
G = Getford Farm
KL = S.N. Knight Leesburg
KN = S.N. Knight North
KS = S.N. Knight South
L = Long Farm
LB = Lowrie Brown Farm
M = Mathews Farm
W = Walker Ranch

ownership is managed by the St. Johns River Water Management District (SJRWMD). Funding for restoration and management is provided primarily through the Surface Water Improvement and Management (SWIM) Act authorized in 1987.

The primary management goals for the area are 1) to restore the hydrological and ecological functions of the Ocklawaha River floodplain, which includes the purchased properties; and 2) to reduce agricultural discharge to Lake Griffin and Ocklawaha River Basin (SJRWMD, 1992). The secondary goals are 1) protect and maintain wildlife habitat; and 2) provide public access for recreational and educational uses of the properties.

Description of the Area

The EMCA consists of two management areas that includes muck farms purchased by the District since 1991. The primary management area consists of eight farms located in the floodplain of Lake Griffin in the Ocklawaha Chain of Lakes. The secondary management area consists of a single farm located adjacent to Lake Harris.

During the mid to late 1800s steamboat transportation along the Ocklawaha River initiated agricultural development along the shores of Lake Griffin (SJRWMD, 1988). By the late 1940s extensive agricultural expansion occurred. Through diking and drainage efforts large muck farms ranging from 100 to 2000 acres replaced sawgrass and wet prairie communities. Burning the marsh vegetation was a common practice used to prepare the farms for vegetable production and cattle grazing. The muck soils underwent oxidation and compaction, with a subsequent loss of porosity and water holding capacity (Kushlan, 1992). During the interim between property acquisition and restoration, farming operations have been discontinued.

Restoration Plans

Restoration of the EMCA involves the re-establishment of the floodplain ecosystem. Due to altered hydrology, soils, and nutrient input the wetland and aquatic ecosystems of the EMCA may not return to pre-agricultural conditions. The area, however, may be restored to provide improved habitat for fish and wildlife. Hydrological conditions will be dictated by regulation of lake levels. Existing water control structure determine flow to Lake Griffin to prevent flooding and/or provide water storage for navigation and recreation. The water depths and fluctuation have been dampened, resulting in large areas of the EMCA with permanent inundation.

Six management units have been defined in the EMCA based on topographical elevations, artificial boundaries (ie. roads), hydrological connectivity, and primary function. One or two units will be wetlands used primarily for water quality improvement.

other units will provide aquatic, wetlands and some upland habitat.

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WETLAND RESTORATION TO BENEFIT ENDANGERED FISH HABITAT IN THE UPPER COLORADO RIVER BASIN

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The Colorado River Endangered Fish Recovery Implementation Program is a cooperative, 15-year program of Federal and State agencies, environmental organizations and water development interests aimed at re-establishing self-sustaining populations of endangered Colorado River fish while providing for new water development.

The Recovery Program has five major elements: (1) habitat management through provision of instream flows, (2) habitat development and maintenance through nonflow alternatives, (3) stocking of native fishes, (4) management of non-native species and impacts of sport fishing, and (5) research, monitoring, and data management.

Four native fish species that inhabit the Colorado River Basin are federally listed as endangered: Colorado squawfish, humpback chub, bonytail chub, and razorback sucker (razorback). Each of these four species was once abundant in the Upper Basin; however, they have declined in numbers and are now threatened with extinction from their natural habitat.

Factors accounting for the current status of these species include direct loss of habitat, changes in water flow and temperature regimes, blockage of migration routes, and interactions with introduced (non-native) fish species.

The Floodplain Habitat Restoration Program is a major element of the Recovery Program and is the focus of this paper. The purpose of the Floodplain Habitat Restoration Program is to restore floodplain habitats to assist in recovery of razorback suckers (Xyrauchen texanus), based on the assumption that razorback require floodplain habitats to complete their life cycle.

Historically, razorbacks were abundant and widely distributed in the Colorado River. Most razorbacks captured in recent years in the Green, Colorado, and Yampa Rivers are thought to be more than 20 years old and there is little to no recruitment of young fish into the adult population.

Literature review and field observations indicated that extensive habitat alteration of the Colorado River system occurred due to the timing of several major events. A period of extensive erosion coincided with the invasion of tamarisk (salt cedar) in the early 1900,s and has reduced channel widths by an average of 27% at Canyonlands (Graf, 1978). This was followed by sediment supply reductions in the 1940's as river banks stabilized during alternating climatic cycles and changing land use practices. Subsequent construction of large storage reservoirs in the 1960's reduced both peak discharge and sediment. This sequence of events has resulted in the almost total elimination of habitat for larval razorback.

On the Green River, optimum razorback spawning conditions appear to occurs on the rising limb of the hydrograph about 7 to 10 days before peak flows (Tyus and Karp, 1990). Reduced peak flows as a result of Flaming Gorge Dam combined with channelization by levee construction and other channel morphology changes, have resulted in lack of access to floodplain nursery habitat for both razorback larvae and adults.

The seasonal abundance of zooplankton is also an important food resource for razorback and explains their attraction to flooded bottomland areas. Studies have found that zooplankton concentrations are 14.5 times grater in backwaters and are significantly higher in flooded bottomland habitats.

The mission of the flooded bottomland program was to inventory the flood plain to provide candidate sites for acquisition, restoration and management. The Recovery Program in 1992 began a massive program to identify and restore selected flooded bottomland habitats, with the focus on improving razorback recruitment. The first site selected for restoration was Old Charlie Wash wetland, located on the Ouray National Wildlife Refuge near Ouray, Utah. The wetland had previously been diked off from the river and used as migratory bird habitat. To open up the wetland an alternative outlet/fish passage structure was designed and installed. The structure included stoplogs a fish trap and a rotary fish screen to exclude non-natives.

During 1993, five sites were identified and restoration plans were developed of each site. During 1994 a team of biologists identified all potential sites available on the Colorado and Green River Systems. The biologists used tools such as air photography, aerial videography and oblique 35 mm slide taken during the high flows of 1993 to identify and screen sites. In total, 20 sites were identified and selected for further evaluation. Each site was then visited by screening teams to evaluate each site for contaminates, biological diversity and flood frequency. Conceptual development plans are currently being developed for several high priority sites.

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MITIGATION IN DETENTION BASINS IN HARRIS COUNTY, TEXAS

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Harris County Flood Control District (HCDCD) is creating approximately 20 acres of wetlands and bottomland hardwood forest within stormwater detention basins at two separate project locations. This effort was required by the Department of Army Permits for wetland losses during construction of channel improvements, stormwater detention basins, and a levee. These projects were necessary to control water flow in the channels and to reduce flooding of adjacent homes and businesses.

The Inverness Forest mitigation plan consists of 4.1 acres within three excavated detention basins, including five emergent marshes. In the spring of 1994, a total of 728 15-gallon trees, and 703 5-gallon shrubs were planted on 15-foot centers. The basins are being monitored three times per year for two years to assess the physical condition of the plants and note any required maintenance or replacement needs. According to the permit, a minimal success criteria of 80 percent survival of healthy and

TABLE 1: Summary of current survival rate of trees and shrubs at Inverness Forest and White Oak Bayou mitigation sites.

	Inverness Forest		White Oak Bayou	
Plant Species	Total Quantity	Current Survival Rate (%)	Total Quantity	Current Survival Rate (%)
Cephalanthus occidentalis L.	222	98	NA	NA
Myrica penssylvanica Lois.	94	99	NA	NA
Symphoricarpos orbiculatus Moench	61	71	NA	NA
Halesia diptera J. Ellis	84	56	NA	NA
Callicarpa americana L.	95	93	NA	NA
Rhus copallina L.	48	46	NA	NA
Craetagus spathulata Michx.	99	91	NA	NA
Total Shrubs	**703**	**86**	NA	NA
Taxodium distichum (L.) L.C. Rich.	25	92	298	NA
Carya aquatica (Michx. F.) Nutt.	48	98	302	NA
Fraxinus caroliniana Mill.	46	100	NA	NA
Quercus lyrata Walter	46	100	289	99
Nyssa sylvatica Marshall	46	63	NA	NA
Quercus michauxii Nutt.	39	100	648	96
Betula nigra L.	43	95	680	90
Quercus nigra L.	60	100	464	93
Acer rubrum L.	56	57	NA	NA
Celtis laevigata Willd.	39	0	NA	NA
Liquidambar styraciflua L.	77	52	NA	NA
Quercus shumardii Buckley	75	80	NA	NA
Cornus drummondii C.A. Meyer	37	16	NA	NA
Morus rubra L.	50	98	NA	NA
Juniperus virginiana L.	41	81	NA	NA
Quercus phellos L.	NA	NA	670	90
Quercus nuttallii Palmer	NA	NA	653	98
Quercus alba L.	NA	NA	953	88
Total Trees	**728**	**76%**	**4957**	**93**
TOTAL	**1,431**	**81%**	**4957**	**93**

thriving plants needs to be achieved by the end of the second growing season. The contractor is required to sustain a 100 percent survivability rate during the maintenance period. Considering all three basins collectively, an 82 percent survival rate has been achieved after the first growing season (Table 1). However, only 48 percent of the plants were observed to be in a healthy and thriving condition.

The White Oak Bayou mitigation plan consists of a 12.7-acre excavated basin and an emergent marsh. In February 1994 a total of 4957 1-gallon trees were planted on a 10-foot centers. To comply with the Department of the Army Permits, at the conclusion of the three year maintenance period the mitigation area must have an average density of 400 trees per acre (92% survival) with a minimal plant height of two (2) meters (6.5 feet). After eight months the survival rate achieved in the basin is 93 percent, which meets the minimum 92 percent survival rate specified in the permit, however, only 79 percent or 3983 of the 5030 plants were observed to be in a healthy condition (Table 1).

Primary causes of mortality may be lack of water and/or slope erosion. Other potential causes of mortality may be insect or fungal infestations or the inadvertent basal bark damage incurred during routine maintenance mowing and weed control, which could allow insect and/or fungal disease. The slope erosion is being corrected, the dead plants will be replanted and care will be taken for the damaged ones.

On some monitoring days, no wildlife was observed because of mowing activities in the basins. Disturbance from human movement and equipment noise likely disrupted any normal wildlife use. However, the following species were observed: Northern mockingbird (<u>Minus polyglottos</u>), common grackle (<u>Quiscalus quiscula</u>), mallard (<u>Anas platyrhynchos</u>), mourning dove (<u>Zenaida macroura</u>), great blue heron (<u>Ardea herodias</u>), yellow-crowned night-heron (<u>Nyctanassa violacea</u>), great egret (<u>Casmerodius albus</u>), snowy egret (<u>Egretta thula</u>), Southern leopard frog (<u>Rana sphenocephala</u>), and mud turtle (<u>Kinosternon flavescens flavescens</u>). Wildlife utilization is anticipated to increase as the shrubs and trees continue to grow, providing more food resources, concealment cover, and substrate for nesting.

PHYSICAL EFFECTS OF NAVIGATION ON WETLANDS

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The primary physical effect of navigation on wetlands results from wave activity but other effects, such as water level drawdown, return flows, propellor jet effects, and sediment resuspension, can be significant. Physical effects as discussed herein refer to changes in the elevation and speed of the water as a result of vessel movement. Factors such as fuel spills and waste dumpage are not addressed herein.

Vessels can be broadly classified as confined when the cross-sectional area of the vessel takes up a significant part (defined as greater than 2-5 percent) of the cross sectional area of the waterway in which they are traveling and unconfined for vessels that are not significant relative to the waterway area. While the effects described herein apply to all waterways, specific examples are given for the Gulf Intracoastal Waterway (GIWW).

Confined Vessels: An example of a confined vessel on the GIWW is barge traffic whose cross sectional area can be 1/6 of the cross sectional area. The primary physical effects (Figure 1) of a confined vessel are water level drawdown, slope supply flow, transverse stern waves, return flows, propellor jet effects, and sediment resuspension. Because of their relatively slow speeds, short period wave activity is generally low. Drawdown and return velocity persist during passage of the barge which can be up to two minutes on the GIWW. Return velocity and drawdown magnitudes on the GIWW are up 0,52 m/sec and 0.21 m, respectively based on measurements by Zhang et al (1993). Drawdown over a two minute span can temporarily move water from- adjacent areas toward the main channel. This flushing action may be beneficial in some cases. In many areas, the water that returns to the adjacent areas may have a higher sediment concentration. Drawdown of shallow near shore zones can result in removal of water off of the nearshore slope. This often leaves the adjacent bank in a geotechnically unstable condition. Refilling of this zone after barge passage (slope supply flow) often results in a transverse stern wave which moves along the bank at the vessel speed and appears as a turbulent bore which can erode and suspend sediments.

Unconfined Vessels: Examples of unconfined vessels on the GIWW are recreational boats and commercial shrimp boats. Smaller recreational boats, because they have sufficient power and hull form to achieve a planing attitude, often have an intermediate speed which results in maximum wave height generation. This intermediate speed is generally not the speed at which small recreational boats traverse waterways. Other unconfined vessels which can not achieve a planing attitude, tend to show an increase in wave height with increase in vessel speed. These vessels can cause significant short period wave activity. Zhang et al (1993) measured maximum wave heights of 0.5 m from shrimp boats along the GIWW. Short period waves can resuspend sediments in near shore areas and in shallow water away from shorelines. Short period waves may break directly on the edge of the wetland. If the water level

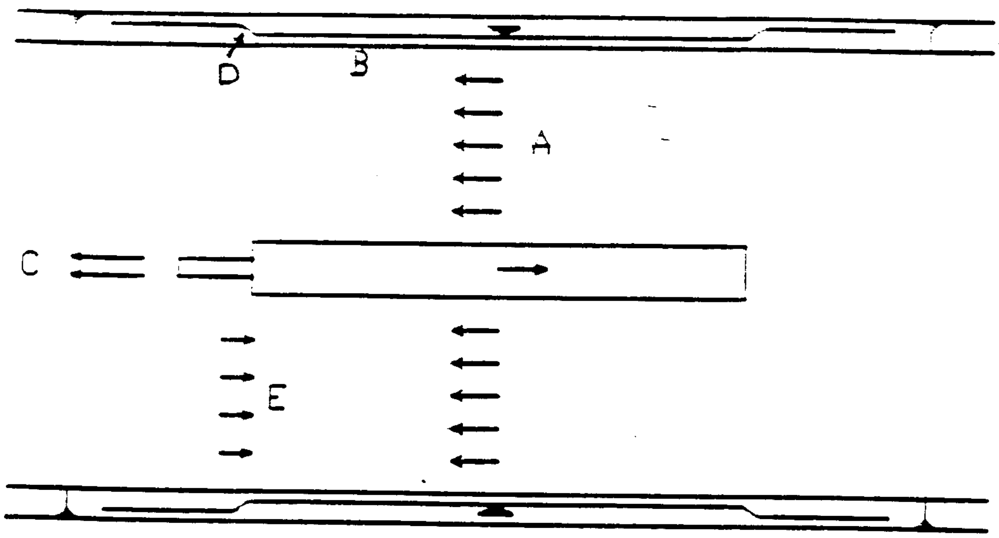

Figure 1. Navigation Effects for Confined Vessels. A is the return velocity, B is drawdown, C is the proepllor jet, D is the transverse stern wave, and E is the slope supply flow.

is low enough, the wetland vegetation may be undermined by erosion depending on soil characteristics and frequency of occurrence.

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SESSION RE12

RESTORATION, PROTECTION, AND CREATION: WETLAND RESTORATION IN COASTAL LOUISIANA AND TEXAS

Dr. Conrad J. Kirby, Chair

VEGETATIVE RESPONSES TO IMPLEMENTATION OF CAMERON-CREOLE IN SOUTHWESTERN LOUISIANA, AN ECOSYSTEM-BASED WATERSHED PROJECT

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The Cameron-Creole Watershed Project incorporates approximately 113,000 acres in Cameron Parish, Louisiana where saltwater intrusion was converting the marsh to open water by killing the vegetation that held the soil in place (SCS 1983). To counter this conversion a cooperative watershed protection project was established for Cameron-Creole through support of local sponsors (SCS 1967).

An ecosystem based planning approach was used to address concerns of the diverse user groups and restore the area to a healthy marsh. To appease estuarine fisheries interests a two-year study was conducted involving paired ponds within the watershed. Study results led to structural design adjustments that allowed for marine organism access.

The major structure at Grand Bayou has four 8-foot wide gated bays set at 4 feet below water level and is designed to also allow access of fishermen through a 10-foot wide boat bay. The structures at Lambert and Peconi Bayous have gated bays set at 4 feet below water level with vertical slots to allow ingress/egress of marine organisms. The structures at Mangrove and Noname Bayous have bays set on fixed-crest weirs with one of the weirs on each structure having vertical slots allowing ingress/egress. In addition to the five main structures, culverts and stoplog structures were installed under La. Hwy. 27 on the eastern edge of the project, and flapgated culverts installed to the north on the Intracoastal Waterway. These structures permit inflow of freshwater to offset salinity intrusion.

The actual operation of the structures are conducted by US Fish and Wildlife Service personnel at Cameron Prairie National Wildlife Refuge. Operation goals are to maintain the 5ppt and 12ppt isohaline lines at 1972 levels within the project.

Baseline data was collected in 1972 involving the mapping of soils and vegetation. To determine structure and operation effectiveness the NRCS is monitoring changes in the vegetative communities. Monitoring is conducted with transects at five year intervals beginning in 1983.

These surveys involved use of a helicopter for transporting two teams of scientists in a leapfrog manner along predetermined sample sites. The 147 sample sites, spaced approximately one mile apart, are plotted on aerial photographs to provide continuity. Sampling entails the determination of the plant species that occurs at each one foot interval along a 100 foot transect line.

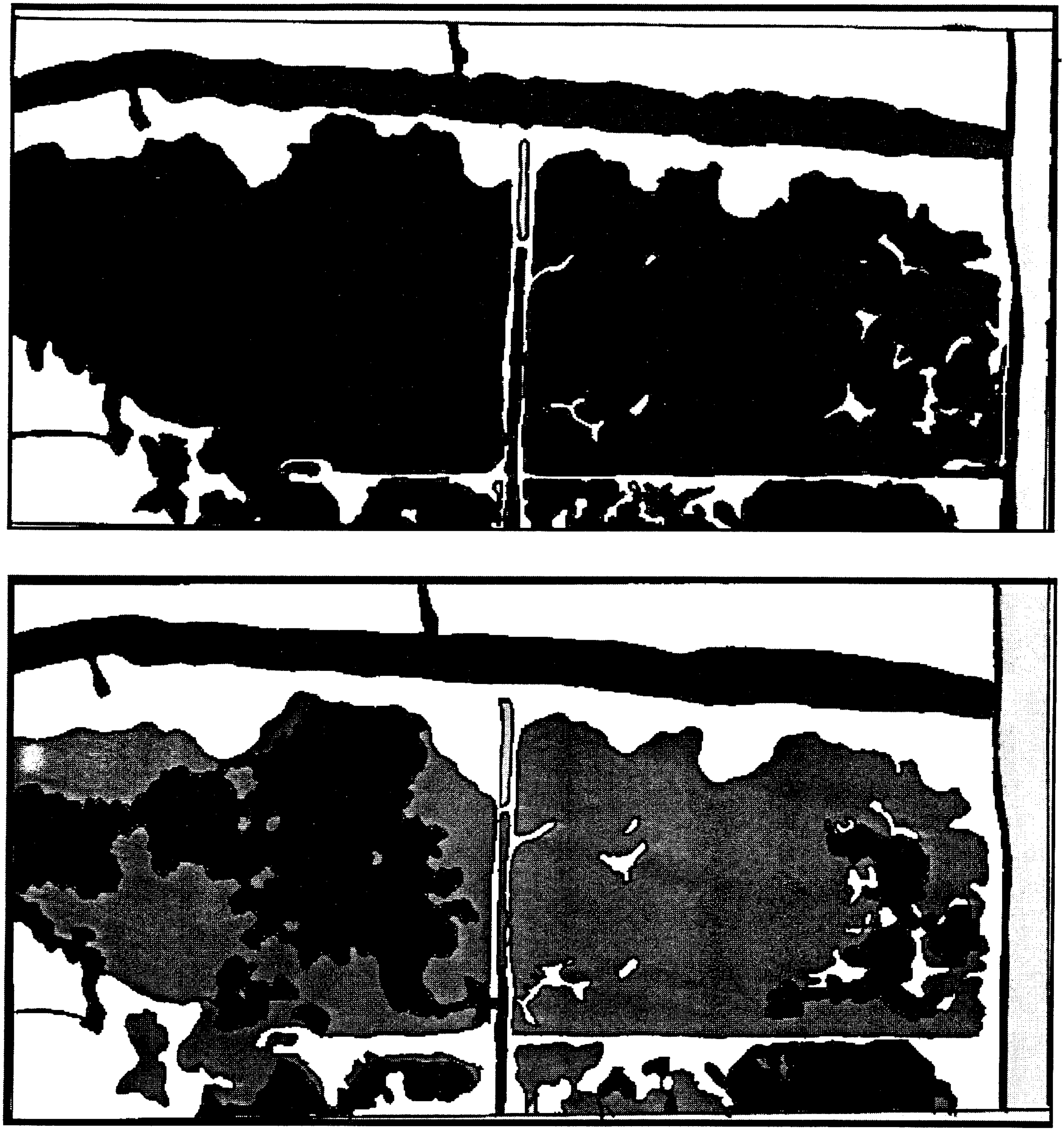
Land and water were digitized from aerial photography taken in 1953, 1978, 1990 and 1993 (Table 1). A digital database will be overlaid with generalized vegetative maps (USFWS 1951; Chabreck, Joanen & Palmisano 1968; SCS 1993) for comparison purposes. A report is currently being written that examines these changes.

TABLE 1

CAMERON-CREOLE WS (Preliminary GIS* Data)

YEAR	LAND	WATER
1953	109,201 ac. (96.95%)	3,441 ac. (3.05%)
1978	95,411 ac. (84.70%)	17,231 ac. (15.30%)
1990	90,158 ac. (80.04%)	22,484 ac. (19.96%)
1993	93,868 ac. (83.33%)	18,774 ac. (16.67%)

*** Base Source: USDA-SCS Digital SSURGO data, USGS 7.5' Mylar Base Quads, Universal Transverse Mercator Projection; Ellipsoid - Clarke66.**



The area adjacent to Gibbstown Bridge and Blind have each experienced rapid growth of aquatic vegetation and increased emergent growth between 1990 (top) and 1993 (bottom).

Figure 1.

Infrared aerial photography shows dramatic improvement in the fresher reaches of the project. The area adjacent to the Gibbstown Bridge (Figure 1) experienced rapid growth of aquatic and emergent vegetation between 1990 and 1993. The project has returned this area to a low energy system that enhances vegetative growth. The ability to protect the area from saltwater surges and tidal scouring has been possible with structural operation. Continued benefits are expected with the project in full operation.

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STATUS REPORT ON THE CREVASSE PROGRAM AT DELTA NATIONAL WILDLIFE REFUGE

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Since 1983 the U.S. Fish and Wildlife Service has been actively involved in the construction of crevasses on Delta National Wildlife Refuge (refuge). These crevasses have resulted in the creation of hundreds of acres of emergent marsh, mud flats and shallow water areas. In an effort to quantify the impact of these crevasses on the natural resources of the area a number of management studies have been initiated over the past 3 years. Results from these studies are still preliminary but crevasses appear to provide positive benefits for a wide range of species.

Land forming the Delta National Wildlife Refuge is a product of sedimentation which originated when a breach known as Cubits Gap occurred in the natural levee of the Mississippi River. The breach or crevasse carried up to 60 million tons of sediment into Bay Rhondo. The result was a rapid filling of the bay, forming a large deltaic splay. The splay created by the crevasse encompassed approximately 100,000 acres of the former Bay Rhondo. Up until the hurricane of 1965, the marsh remained relatively stable. Large expanses of floton or floating marsh covered much of the area and supported a diversity of plant and animal species. The hurricanes of 1965 and 1969 devastated the floton marsh, picking up large mats and rolling the marsh inland. Artificial levees began to line the banks of the Mississippi River to control overbank flooding, and channelization of the river to permit access for large ocean vessels began. The natural processes of sedimentation were hampered, with the river now dumping most of its load into the deep waters of the gulf. These man-made changes, coupled with subsidence, converted approximately 51% of the freshwater marshes in the active delta to open water from 1956 to 1978.

Although reduced, a substantial volume of sediment was still carried from Cubits Gap to gulf waters by three main passes through the refuge. The natural levees of the passes prevented most overbank flooding until 1978, when several natural breaks (crevasses) occurred along Main, Brant, and Octave Pass. During the late winter and spring, floodwaters poured through the crevasses and deposited the sediments in the open water ponds, This resulted in the development of several splays. These subaerial splays quickly became vegetated and the majority of the wintering waterfowl using the refuge quickly began using the splays for feeding and resting areas.

In an attempt to duplicate these natural successes a man-made crevasse was dug through the south bank of Octave Pass in September 1983. The results were rewarding, and since that time 17 additional crevasses have been constructed. These deltaic splays accrete sufficiently to produce emergent vegetation in just a few years.

Attempts to quantify the effects of these splays have resulted in a number of management studies being initiated over the past three years. Such studies include soil fertility, waterfowl use of splay compared to non-splay areas, use of splays by migrating and overwintering shorebirds, fish assemblage characteristics of splays, and habitat use by wading birds. Results of these studies are preliminary but encouraging. Soil samples collected from ten developing splays in areas classified as fresh marsh (Chabreck 1972) were classified as very fine sandy loam, fine sandy loam, silt loam, and silty clay loam. Compared to the findings of Brupbacher (1973), levels of phosphorus and calcium were well above average, sodium and magnesium were below average, and potassium was only slightly below average. Levels of all chemicals listed were above those recorded by Chabreck (1972) for this same area with the exception of magnesium which was below that recorded by Chabreck. Average pH was 7.62 and average percent organic matter was 1.58.

Developing splays provide suitable habitat for a wide range of shorebirds and wading birds while non-splay areas are usually of sufficient depth to preclude use by most birds in these groups. Construction of crevasses appears to have little effect on fish assemblages (preliminary data). Waterfowl use was compared for recently constructed crevasses and established splay areas of comparable size. Over the past three seasons waterfowl use on the recently constructed areas has averaged Beven (7) percent of birds using the refuge while use on the established splays has averaged 23 percent. Overall, an average of 80 - 90 percent of the waterfowl found on the refuge occur on established splays.

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SEDIMENT AND VEGETATION CHARACTERISTICS OF SIMILAR-AGED CREATED AND NATURAL WETLANDS IN THE LOUISIANA ATCHAFALAYA DELTA

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Created wetlands are used to mitigate losses of natural wetlands, however, there are limited data documenting the functional attributes and long-term development of these systems. Indeed, there is currently much debate over the appropriate measures of successful wetland creation. Quantitative data directly relating wetland structure (vegetation, soils) to

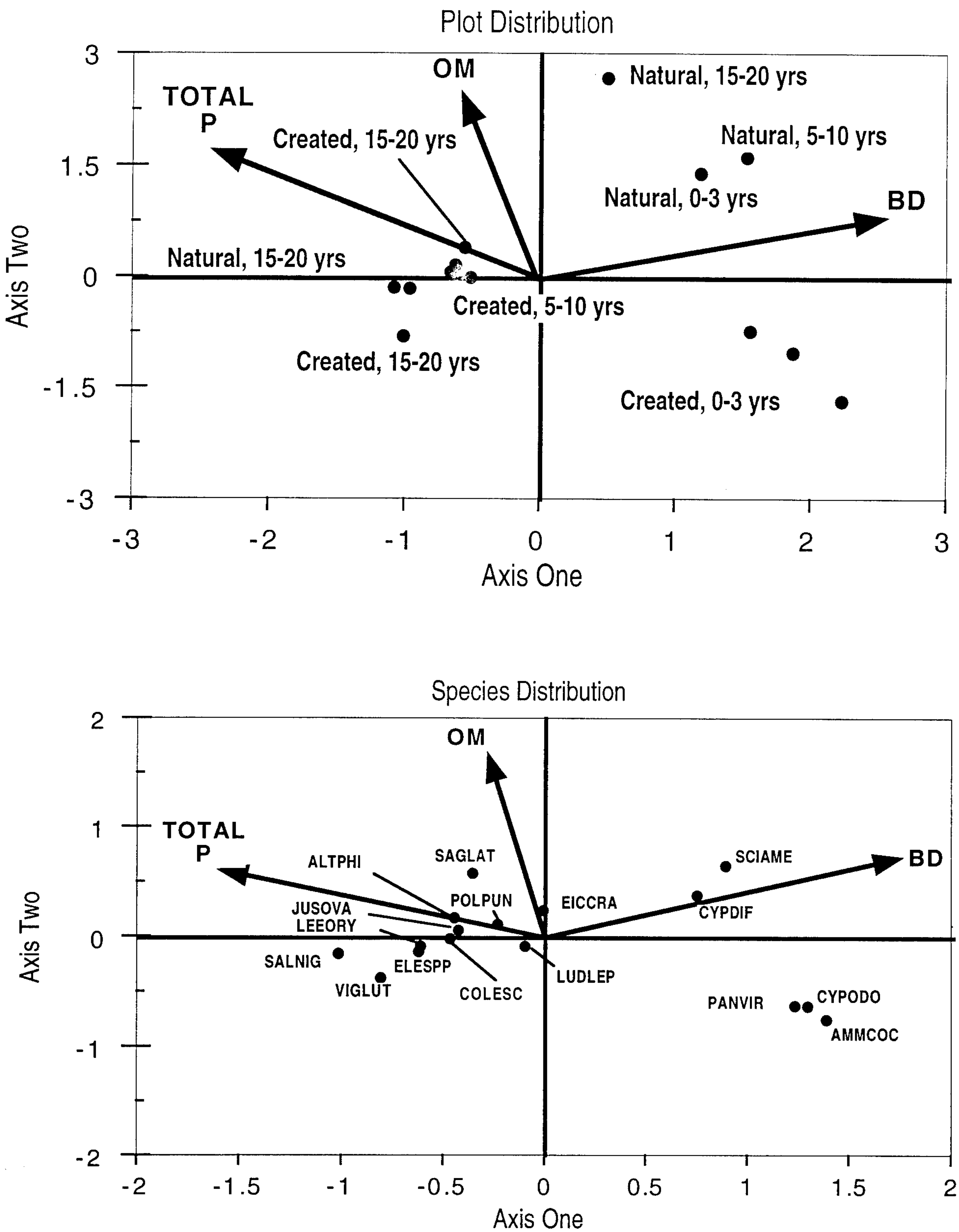

Figure 1. Canonical correspondence ordination diagram of created and natural wetlands of the Atchafalya Delta.

functions (redox reactions, nutrient cycling) in both natural and created wetlands is also urgently needed.

A unique feature of the Atchafalaya Delta in southwestern Louisiana is the availability of naturally created wetlands in the Atchafalaya Delta as appropriately aged analogs for wetlands created through dredge disposal operations. Our objective was to quantify structural and functional changes in both created and natural wetlands through time. Natural and created wetlands were selected within each of the following age groups: 0-3, 5-10, and 15-20 years old. Distinct elevational and vegetational zones were observed on many of the selected wetlands. These areas were separated into low, mid, and high elevation strata. Three permanent plots were randomly established in each strata. Samples were collected from the upper 10 cm of sediment with a hand corer from each plot in October of 1993, and January, May, and July of 1994. These samples were analyzed for bulk density, particle size, total N, total C, $NO3$, $NH4$, available P, pH, and organic matter using standard techniques. Species composition and percent cover of each species were recorded in August and September of 1993 in 1.0 m^{-2} plots adjacent to the permanent soil plots.

There were few differences between natural and created marshes for any of the soil parameters measured. Generally, created wetlands in the 0-3 yr age group had lower sediment nutrient concentrations and organic matter than their naturally created analogs, however, these differences disappeared after 5 years. These differences are graphically illustrated by the ordination diagram produced through canonical correspondence analysis (Fig. 1). The dominant environmental gradients were bulk density (BD), organic matter (OM), and total phosphorus (Total P) (Fig. 1).

Vegetative cover showed no differences between natural and created marshes of similar age and elevation. Differences in species composition between natural and created islands as well as young and old wetlands were found. The 0-3 year old created wetlands had distinctly different species composition than the other wetland types (Fig. 1).

FISHERY UTILIZATION OF ESTABLISHED/RESTORED WETLANDS

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Coastal wetlands are a critical habitat for many important fishery species and the fauna on which they prey. Although casual use of restored and established marshes by such species has been reported, many details, particularly such things as the temporal development of faunal utilization have yet to be examined in detail. As part of the U.S. Army Corps of Engineers Wetlands Research Program, fisheries communities of established and restored marshes were examined at 4 locations on the Atlantic, Pacific and Gulf Coasts of the US. This paper, reporting results for 3 of the sites, represents the collaborative effort of numerous wetland scientists working under contract to the Waterways Experiment Station.

Winyah Bay, SC, Studies

Charleston District placed material dredged from channel maintenance in Winyah Bay to establish a 35-hectare salt marsh. As annual placement was done in spatially discrete areas, the marsh is a mosaic of variously-aged components built in increments of from 0.3 to 8.5 hectares.

In one study, both vegetation and the benthic macro-infaunal community were compared between different-aged marsh areas (about 5, 12 and 16 yrs) to observe species composition and successional changes. The vegetation and infauna were generally similar to those found in nearby natural marshes. With increasingly old sites, the infaunal community reflects vegetation changes, and concomitant changes in substrate physical conditions.

A second study focused on use by fishes and motile macroinvertebrates. The experimental design centered around lift net collections at varying distances from the marsh edge and depth of tidal flooding. The taxonomic composition and relative abundance of the migratory fauna was consistent for similar marsh sites.

Beaufort, NC, Studies

Three dredged material islands in different watersheds were recontoured to identical experimental layouts to examine fish, shrimp and crab utilization of established salt marshes and interaction with adjacent seagrass beds. Animals began to utilize the planted saltmarsh and seagrass beds soon after they were installed. Abundances quickly (<2 yrs) reached that of natural marshes. Faunal densities in the seagrass beds, in contrast, did not resemble those of nearby, natural populations. Further, no linkage between seagrass and saltmarsh utilization was apparent for most species.

Galveston Bay, TX, Studies

Adjacent marshes of varying age (9, 5 and <1 yr) along the Gulf Intracoastal Waterway were examined for faunal utilization. Densities of small fishes, crustaceans and mollusks were measured within the vegetation at two elevations in each marsh using a drop sampler. Four months following planting of the youngest marsh, densities of most organisms were significantly lower compared with the two older marshes and a subsequent sampling 1 yr after planting. In comparisons of the two older sites to nearby natural marshes, there was no significant difference between densities for total fish or total crustaceans with the exception of the blue crab *Callinectes sapidus* which were found in lower abundance in the established marshes in fall samplings. However, in spring samplings, while fish densities were similar; crustaceans were significantly lower in the created marshes which supported only about 1/3 that of natural marshes.

PERFORMANCE OF EROSION CONTROL MEASURES FOR COASTAL WETLAND RESTORATION AND CREATION PROJECTS

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The U.S. Army Corps of Engineer District, Galveston (SWG) constructed three wetland restoration and creation projects using dredged material removed from the adjacent Gulf Intracoastal Waterway (GIWW). The projects provide habit for wildlife and aquatic organisms, and also provide erosion protection for nearby shorelines. Since the wetlands themselves are therefore exposed to erosive forces, erosion protection was designed for their shorelines. The projects provided an opportunity to evaluate techniques for protecting newly placed wetland soils and vegetation.

Three projects are mentioned here. The first wetland restoration project is located in West Bay near Galveston, TX. (The pre-construction design was described in McCormick, Davis, and McLellan, 1992.) A 5000 ft long wetland island was constructed parallel to and south of the GIWW. The island was approximately 225 ft wide providing 20-25 acres. Several treatments were used to protect the dikes of the island including mild slopes (1V:10H and 1V:15H), coconut fiber mats, fiber mats with sprigged vegetation, a dynamic revetment, and a low-crested, offshore, geotextile tube. Site inspections indicated that the milder 1:15 dike side slope was more stable than the 1:10 slope. Most of the coconut fiber mats were destroyed within the first few months. After 2 years, the geotextile tube was undamaged and functioning well. While the dike behind the tube had suffered some erosion, the area was quiescent enough to allow the colonization of Spartina alterniflora. The dynamic revetment is made of small rocks allowed to move under wave forces to an equilibrium position. The revetment is at the tip of the island facing the east from which the largest waves tend to approach. The revetment was damaged during the monitoring period, but is still providing protection benefits. While the island has been modified by the wave climate, wetland vegetation has colonized many areas creating a somewhat random and appealing appearance. The island has also provided the benefit of protecting the shoreline across the GIWW from continued erosion. In this case, the protection has prevented the higher salinity bay waters from breaching the shoreline into the otherwise brackish marsh of Halls Lake.

Another wetland area was constructed by SWG adjacent to False Live Oak Island along the GIWW near the Aransas National Wildlife Refuge (ANWR), TX. The wetland was created from dredged material and a low-crested, rubble-mound breakwater was constructed offshore from the wetland to dissipate erosive wave energy. After one and a half years, the breakwater was unchanged and had provided complete protection for the newly established wetland. Portions of the wetland were planted with Spartina alterniflora and Spartina patens, but the overall vegetative cover is sparse.

The third project was constructed a few miles west of the False Live Oak Island projects adjacent to Ayers Island along the GIWW. The confinement dike for the new wetland was constructed from geotextile tubes which also provide erosion protection. After less than two years of monitoring, the tubes (and wetlands) were undamaged and functioning properly and vegetation was beginning to establish itself. Monitoring of the projects near the ANWR will continue.

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SESSION CW2

CONSTRUCTED WETLANDS: NITROGEN AND PHOSPHORUS REMOVAL EFFICENCIES

Tommy E. Myers, Chair

THE RESPONSE OF A FRESHWATER WETLAND TO LONG-TERM LOW-LEVEL NUTRIENT LOADS

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Total phosphorus (TP) and total nitrogen (TN) mass balance calculations were calculated for Boney marsh, a subtropical constructed freshwater wetland located along the floodplain of the Kissimmee River in South Florida. River water (TP = 0.07 and TN = 1.70 mg/L) was diverted through the marsh for a nine year period (1978-1986). Rainfall contributed 7% and 3& of the total TP and TN budget, respectively, while pumped river water provided the balance of TP and TN supplied to the marsh. Monthly mean nutrient retention rates were 0.03 and 0.41 gm/sqm/month for TP and TN respectively. Nutrient retention was influenced primarily by nutrient loading rates.

Boney Marsh mean annual TP removal efficiency of 72% was comparable to nutrient removal efficiency data from other wetland treatment systems. Total phosphorus removal efficiencies were consistently higher than TN removal efficiencies at all times, and remained relatively unchanged during the entire study period. Unlike wetlands at temperate latitudes, Boney Marsh was a net positive sink for TP year-round but not for TN.

Studies of most constructed wetlands to date have been limited to studying short-term nutrient removal. The Boney Marsh data allowed us to investigate the marsh "aging" process. Cumulative mass retained and mass loading was consistent, as was nutrient retention rates during the study period. In addition, there was no decline in mass export and water volume flowing into and out of the marsh during the study period. Boney Marsh nutrient assimilation capacity remained high and invariable for the period of record for TP but not for TN.

Our analysis showed that studies which derive nutrient removal estimates from reductions in surface water concentrations alone may under-represent mass retention by as much as 5-% and 100%

for TP and TN, respectively.

Removal of nutrients by wetlands can be modeled as a first-order process, where the net settling velocity is governed by nutrient concentration and a settling rate coefficient (K). Total phosphorus settling rate derived from Boney Marsh data (9.93 m/yr) was consistent with reported literature values and in good agreement with the estimated long-term value for WCA-2A. Properly managed wetlands, through careful selection of inflow loading rate, can be very effective at removing nutrients from inflowing water for an extended period of time.

CONSTRUCTED WETLANDS FOR LIVESTOCK WASTE MANAGEMENT

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Introduction

Increasingly, the call is being made to make agriculture more compatible with environmental concerns. Presently, agricultural practices account for the largest single contribution to non-point source pollution. Run-off from cropland, pastures, feedlots, and farmsteads continues to add substantial inputs of nitrogen and phosphorus to the nation's waterways and groundwater. However, the agricultural community has been responsible for many of the advances in pollution abatement that already have been made. Moreover, researchers continue to investigate alternative or non-traditional agricultural practices to minimize these inputs.

Options for use and disposal of wastewater from animal operations, such as dairies and swine operations, are becoming more limited in Indiana and throughout the United States. Discharge of wastewater is prohibited, land application is restricted, and reuse systems are not without problems. Reductions in nutrient loads can enhance wastewater use in rccycle systems and make utilization through land application easier. We are attempting to determine if constructed wetlands are a viable wastewater treatment option for small producers in the climate of Indiana and establish optimal operating conditions for such systems.

Methods

Planting of a 16-cell experimental constructed wetland at the Purdue University Animal Science Farm Swine Facility was completed in early May, 1994. After two months of vegetation establishment, wastewater from the final lagoon in a three-lagoon system was loaded into the system. Three hydraulic loading rates (450 Ld-1, 900 Ld-1, and 1800 Ld-1) and two water depths (15 cm and 30 cm) were tested. Three replicates of each combination tested were conducted, Three cells were used for a wetland plant seed germination study, and one cell was maintained free of vegetation. Water quality of cell influent and effluent was monitored throughout the growing season. Vegetation response to different hydrologic regimes was monitored.

Results

Water quality tests indicate shallow wetlands with dense vegetation and low hydraulic loading rates perform best in treating swine wastewater. However, greatest reductions in ammonia-nitrogen were achieved in the unvegetated cell. This may have resulted from three factors (singly or in combination): 1) pH fluctuation induced by algal photosynthesis could have resulted in precipitation of ammonia compounds; 2) greater exposure to oxygen from algal photosynthesis and exposed water surface might have allowed greater nitrification rates; and 3) volatilization of ammonia into the atmosphere would have been enhanced by open water. Results from two additional studies at Indiana dairies are comparable.

Vegetation performed better at shallower system operating depths. This was true for all plants tested. Broad-leaf cat- tail (*Typha latifolia*) displayed the greatest vigor, both in individual plant health and plant colony density. Softstem bulrush (*Scirpus validus*) had the next best performance. These two species continued to grow when subjected to extended loading with ammonia-nitrogen levels in excess of 250 ppm in late summer and fall. Mature plants continued to grow, but clonal expansion from rhizomes was reduced. Narrow-leaf cat-tail (*Typha angustifolia*), three-square bulrush (*Scirpus acutus*), and common reed (*Phragmites australis*) performed poorly or died out within cells. Both three-square bulrush and common reed were eliminated from cells under continued loading at high ammonia-nitrogen levels.

Discussion

The utilization of biogeochemical processes found in natural wetlands as mechanisms in the treatment of urban, industrial, and agricultural wastewater has been in development for over forty years. We know that constructed wetlands work- where questions remain is under what conditions are wetlands successful and, equally importantly, where do they fail (DuBowy and Reaves 1994). Additionally, design criteria and best management practices need to be developed to help federal and state agencies with the permitting, implementation, and monitoring of projects. This is not to imply that a single blueprint will ever be developed for all constructed wetlands- they will continue to be planned and constructed on a case-by- case basis.

Over 20 constructed wetlands facilities have been built around the country for the treatment of animal waste (DuBowy and Reaves 1994). Constructed wetlands have been shown to be effective for the reduction of nitrates, nitrites, ammonia, phosphates, suspended solids, BOD5, and coliform bacteria in effluent from feedlots and milking parlors. Our three constructed wetlands systems in Indiana consistently have achieved reductions of up to >90% in these parameters (Reaves et al. 1994a, b). Design criteria suggest a knowledge of waste- stream characteristics (water quality parameters), hydraulic loading rates, retention time, and soil porosity (Reaves et al. 1994c) are important when developing constructed wetland systems for livestock waste. Pitfalls and future research needs include system efficacy in cold weather, potential groundwater contamination, and reuse of treated water.

There has been much debate among constructed wetland researchers about the merits of multi-species vegetation assemblages versus monocultures. Because farm wastewater is highly variable, hardy plants that tolerate system stresses appear to be the best choice. This may result in decreased plant diversity, but it makes little sense to establish plants that could easily be killed by an episodic change in wastewater quality. In Indiana the active treatment season only lasts into December. Winter ice-up and declines in microbial transformation rates make system operation through the winter impractical. Systems with established vegetation should be able to be flooded by mid-May. This gives an active treatment period of six months. For constructed wetlands to be viable in northern states, operators need a means of storing wastewater for the other six months.

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CONSTRUCTED WETLANDS FOR SEDIMENT CONTROL AND NON-POINT SOURCE POLLUTION ABATEMENT AT US ARMY CORPS OF ENGINEERS PROJECT: RAY ROBERTS LAKE, DALLAS, TEXAS, AND BOWMAN HALEY RESERVOIR, BOWMAN, NORTH DAKOTA

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Two wetlands recently constructed at Corps of Engineers reservoirs were monitored for their ability to remove non-point source pollutants from storm run-off and possibly improve reservoir water quality. The two sites were the Spring Creek wetlands a 23 acre emergent marsh constructed in 1991 on Bowman Haley Reservoir near Bowman, ND, and a five acre wetland constructed in 1992 as part of a larger wetland complex on Range Creek, a major tributary of Ray Roberts Reservoir near Dallas, Texas. Research sites were selected based on either known or probable water quality problems within the reservoirs and the availability of constructed wetlands at the reservoirs.

Because most non-point source pollutants are delivered to a stream or reservoir after a significant run-off event, sampling efforts focused on storm events, with less emphasis on base or low flows. Intensive sampling of selected storm events was conducted during the period from spring of 1992 to the fall of 1993. Automated sampling systems were used to sample selected run-off events and provided detailed, time varying inflow and outflow pollutant concentrations during and following storm events. Samples were analyzed for suspended sediments, nutrients and selected herbicides. Sampling techniques are indicated in Figure 1 which shows the sampling equipment installation at an inlet culvert. Actual sampling techniques and equipment varied depending upon inlet and outlet configurations. Flow and concentration data were used to determine treatment effectiveness for suspended sediments and nutrients.

Results from the two sites varied, yet the wetlands were generally capable of removing suspended sediments from inflows while being less efficient at removing dissolved non-point source

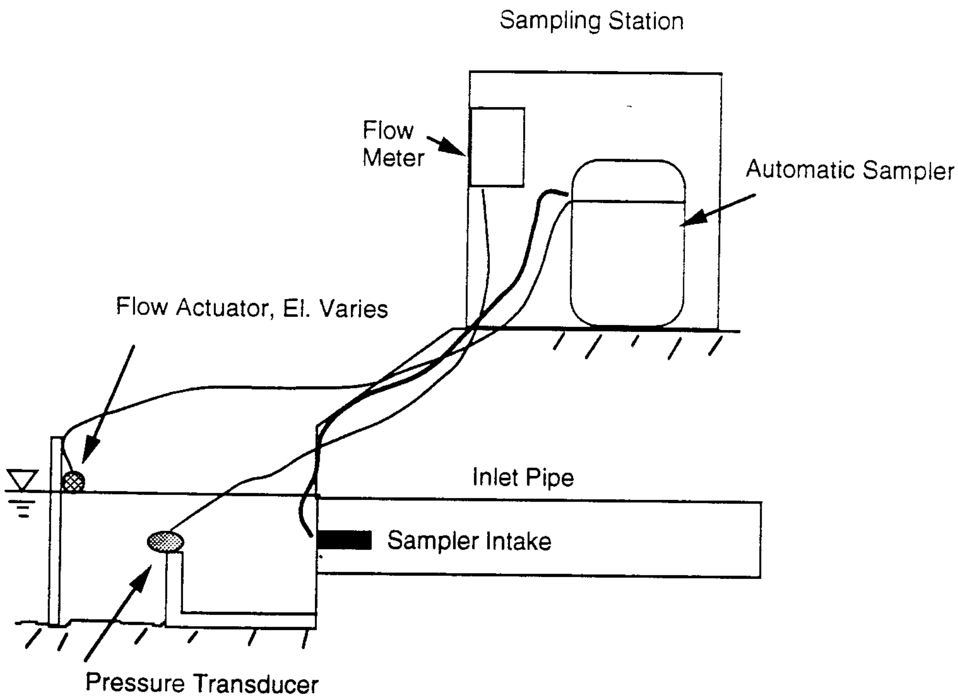

Figure 1 - Sampling equipment installation

pollutants. The Spring Creek wetlands at Bowman Haley Reservoir, was capable of removing a significant portion of total phosphorous, approximately 40 percent. Neither wetland was effective at nitrogen or herbicide removal. Figure 2, shows inflow and outflow total suspended solids (TSS), total phosphorous, and total Kjeldahl nitrogen concentrations from the Spring Creek wetland during a high rainfall period during July 1992. This figure typifies the results at this site, good removal of TSS, fair removal of phosphorous, and poor removal of nitrogen.

Hydraulic retention times of the wetlands were determined by conducting tracer dye studies. Rhodamine WT fluorescent dye was instantaneously released at the wetland inlet and the concentration at the outlet was monitored with a Turner fluorometer. Temperature corrected data were analyzed by Levenspiel's method (Levenspiel 1972). Hydraulic retention times were estimated to be on the order of 5 days for the Spring Creek wetland site at Bowman Haley Reservoir and on the order of 5 hours for the wetland studied at the Range Creek wetland complex at Ray Roberts reservoir. These hydraulic retention times are thought to be insufficient for the removal of herbicides at both sites, and also insufficient for the removal of nutrients at the Ray Roberts site.

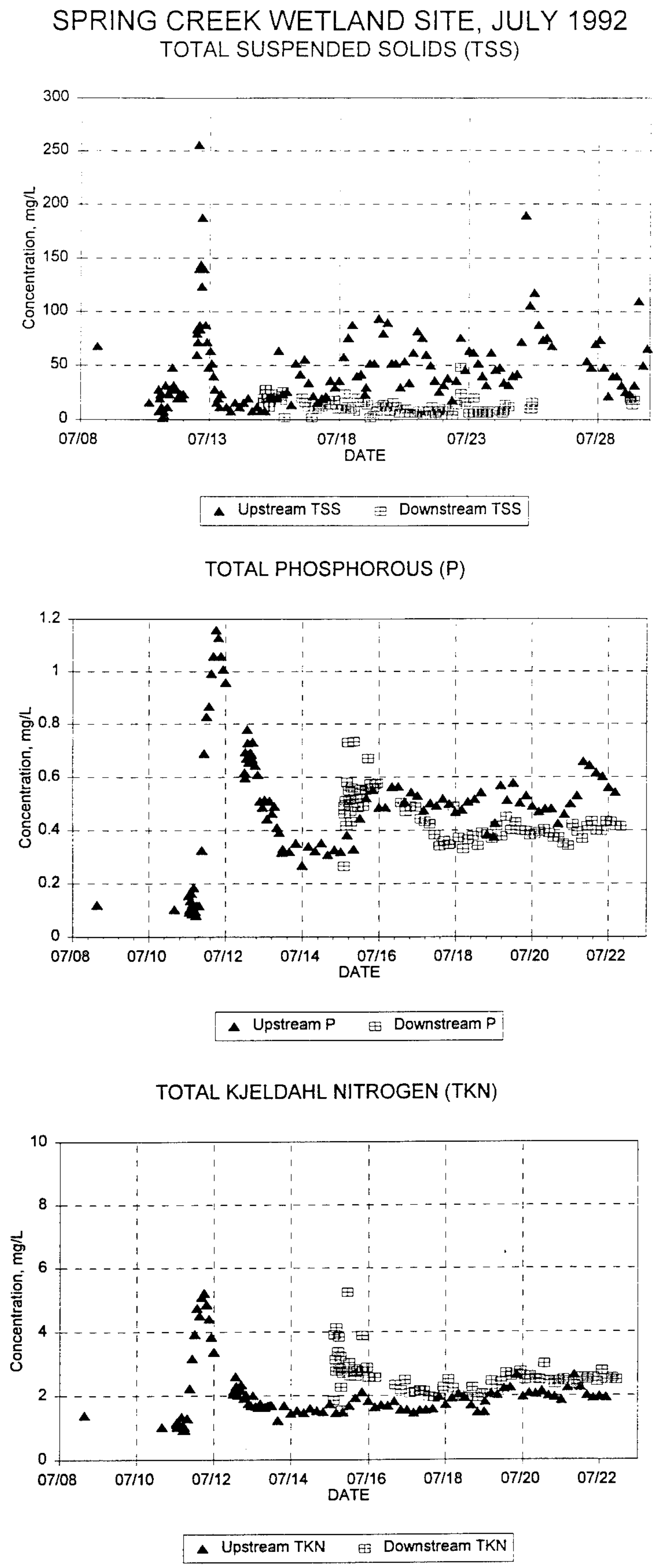

Figure 2 - Example data from Spring Creek Wetland Site

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A PROPOSED AMENDMENT TO THE EXEMPTIONS OF SECTION 404 OF THE CLEAN WATER ACT REAUTHORIZATION

Steven Whitesell, Sharon deMonsabert, PhD, and Deborah Branson

Abstract

Our paper will concentrate on a proposed amendment to the sequencing requirements of §404 of the Clean Water Act. This proposal is provocative because it directly implicates the function/value debate associated with wetlands and how such debate infiltrates both the sequencing strategy of existing §404 and the classification and mitigation schemes outlined in the major reauthorization bills.

This specific type of wetland mitigation involves the construction of a wetland ecosystem for the purpose of non-point source pollutional abatement. Certainly, any concomitant benefits of the wetland are welcome but the objective is to attack a serious problem associated with stormwater run-off.

The legal and policy analysis will show how the wetland regulatory process will need flexibility within the new law to allow innovative approaches that promote and protect wetland resources while offering solutions to site specific environmental problems.

Introduction

Wetlands often improve water quality by filtering out sediments and by absorbing nutrients and pollutants. In addition, wetlands provide rich habitat for a variety of fish and wildlife species. Forested wetlands in particular play a major role in stream ecosystem ecology by moderating water temperatures, contributing food matter, controlling upland run- off into streams, and stabilizing stream banks.ᴙU.S. Department of Interior, 1994.

These beneficial effects are protected under Section 404 of the Clean Water Act which authorizes the Secretary of the Army to issue permits for the discharge of dredged or fill material into the waters of the United States, including wetlands. This section requires a sequencing mechanism through the Corps of Engineers public review process. A developer, whether public or private, must first show that he has avoided wetlands to the extent practicable. After crossing this threshold the developer must show that he has minimized adverse impacts. As a third step, only after the exhaustion of the first two, mitigation is appropriate.

The fundamental purpose of the Clean Water Act is to restore and maintain the chemical, biological, and physical integrity of the nation£s waters. To be true to this purpose, a more balanced approach to the management of wetland resources is in order. For example, a Navy development that impacts wetlands must be in compliance with Section 404 of the Clean Water Act. However, if it can be shown within the Corps public review process that positive environmental impacts can result from a wetland management technique, then such technique should serve as justification for a modification to the sequencing process. Specifically, if wetland restoration or creation on site can be shown to reduce the effects of non-point source pollution, particularly in estuarine areas, then up-front mitigation should be authorized.

Scientific Evidence

In order to treat pollution in a sustainable and relatively inexpensive manner, much exploration into the use of natural or created wetlands has been done in the last 10 years. There are several unanswered questions with the technique. It is certain that wetlands remove pollutants but how long can the system continue to function effectively? Maintenance requirements and intervals needed are being explored. The fate of pollutants and their effect on overall ecosystem are not well understood. Constructed wetlands, just like natural wetlands, fall under section 401 (k) of the Clean Water Act and are subject to regulation by the Environmental Protection Agency (NRC, 1993).

As a function of their design, wetlands can be effective in removing pollutants from stormwater run-off. Removal pathways include sedimentation, adsorption to sediments/vegetation/detritus, physical filtration of run-off, microbial uptake/transformation, uptake by wetland plants, uptake by algae, and extra detention and/or retention (Schueler, 1992). Nitrogen, in all forms, is removed biologically. Dissolved Organic Nitrogen (DON) is taken up biologically as well. Phosphorus in the sediment is removed by interaction with iron, aluminum, and calcium. Metals and suspended solids can be taken up by the roots and translocated. Bacterial action also reduces suspended solids. When conditions are optimal, 80% of the Total Suspended Solids (TSS) are removed by sedimentation. The metals and organics tend to be tightly bound to sediment particles.

NAWC (AD) Patuxent River, Maryland Constructed Wetlands Research Project

In a joint research effort between George Mason University, Public Works Department Patuxent River, MD, and the Chesapeake Division of the Naval Facilities Engineering Command, the ability of a constructed wetland to reduce the effects of sediment and hydrocarbon contaminated stormwater run-off from construction sites, aircraft runways, and parking lots is being evaluated. The purpose of this research is to demonstrate the beneficial uses of a constructed wetland for management of non-point source stormwater run-off. The results of this research should justify a modification to the Corps of Engineers sequencing process.

Proposed Amendment to Section 404
of the Clean Water Act Reauthorization

The ability of wetlands to improve water quality by filtering out sediments and absorbing nutrients and pollutants is protected under section 404 of the Clean Water Act. Actions which encourage the construction of wetlands as a mitigation measure should be encouraged because of the added environmental benefits that can be provided by a well designed and maintained wetland. Many existing wetlands because of their geographical location do not provide significant improvement to the quality of a surface water system. With this in mind it is recommended that the following language be added to the exemptions:

Any activities that are proven to benefit the purpose of this title as stated in section 101 not withstanding discrepancies with section 404."

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SESSION SM6

STEWARDSHIP AND MANAGEMENT: FISH AND WILDLIFE HABITAT MANAGEMENT II

Chester O. Martin, Chair

CONSERVING BIOLOGICAL DIVERSITY: APPLICATIONS TO MANAGEMENT OF FRESHWATER WETLANDS

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The cumulative impacts of 5.5 billion people, a number growing by 95 million each year (260,000 per day) has fragmented, simplified, homogenized, and destroyed many ecosystems to the point that contemporary species extinction rates are estimated to be 1000 to 10,000 times higher than that expected in the absence of human influences (Meffe and Carroll 1994). The field of conservation biology is in part a response by the scientific community to this situation. Although attention has centered on loss of biological diversity (commonly termed biodiversity) in terrestrial ecosystems, especially tropical forests, wetland ecosystems also are important to the biodiversity-conservation effort. For example, although wetlands cover only about 5% of the land area of the United States, about 50% of the animals and 33% of the plant species listed in the U.S. as endangered or threatened are dependent on wetlands (Nelson 1989). Furthermore, wetlands are considered to be endangered or threatened ecosystems in several regions of the U.S. (Noss et al. 1995).

Wetland managers are being asked to place more emphasis on biodiversity and natural-community characteristics, while simultaneously maintaining other wetland functions and values (Laubhan and Fredrickson 1993). Effectively meeting this challenge will require individuals that understand the concepts and guiding principles of conservation biology, and are capable of integrating this knowledge with more traditional information on the ecology, management, status, and biopolitics of wetlands. Unfortunately, confusion exists regarding the application of biodiversity concepts, especially complex theory, to actual management situations. In our opinion, this has created both frustration with and resistance to "biodiversity management."

Biodiversity is the variety of life forms, the ecological roles they perform, and the genetic diversity they contain. The concept of biodiversity has multiple levels of organization (i.e., genetics to landscapes) and includes structural, functional, and compositional components. Ecological and evolutionary processes are also considered part of biodiversity. Conservation biology is an integrative approach to the protection and management of biodiversity. The field differs from traditional resource conservation in being motivated not by single-resource oriented issues, but by the need for conservation of entire ecosystems and all their biological components and processes (Meffe and Carroll 1995).

Wetland management should be based on the following principles of conservation biology: (1) maintain critical ecosystem processes, (2) base management goals and objectives on an understanding of ecological properties, (3) minimize external threats and maximize external benefits, (4) understand and maintain evolutionary processes (i.e., maintain ecological conditions that favor maintenance of genetic diversity), and (5) establish adaptive management strategies. In more specific terms, wetland managers should identify critical wetland processes, understand wetland dynamics and ecological processes controlling a particular system, control invasions of exotic species, minimize disturbance to vulnerable species, incorporate population-level and landscape considerations whenever possible, and use adaptive management to provide feedback on success of management actions.

Managing freshwater wetlands for biological diversity does not necessarily require new management techniques. Traditional methods such as water-level manipulation, prescribed fire, mechanical and chemical treatment of vegetation, and control of non-native species will continue to be used. However, certain techniques likely will become more important as emphasis is placed on maintaining ecosystem integrity and biological diversity. These include strategies and techniques for restoring degraded habitats, recreating lost habitats, re-establishing viable populations of native species, identifying and protecting critical habitat components, and integrating the needs of a diverse assemblage of species (Giudice and Ratti 1995).

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WILDLIFE AND VEGETATION MONITORING OF CONSTRUCTED WETLANDS AT RAY ROBERTS LAKE, DENTON, TEXAS

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Ray Roberts Lake, constructed by the Corps' Fort Worth District, is located in north central Texas, near the Dallas-Fort Worth Metroplex. In an effort to further address environmental concerns in all phases of project planning, design, construction, and operations and maintenance, the Fort Worth District has conducted pre-impoundment and two-year post-impoundment environmental studies at Ray Roberts. The District is currently conducting a five-year post-impoundment study, including environmental studies of wetland cells that were constructed in 1992. Some research has already been conducted at the wetlands, however, there is a lack of detailed, long-term monitoring of vegetation and wildlife utilization of the area. The University of North Texas Institute of Applied Science is conducting vegetation and wildlife research that fills this research gap. This research will provide baseline data for future studies of the Ray Roberts wetlands, and expand our understanding of created wetland systems.

WETLAND RESTORATION AND MANAGEMENT AT THE RIVERLANDS ENVIRONMENTAL DEMONSTRATION AREA, POOL 26 - UPPER MISSISSIPPI RIVER SYSTEM

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The Riverlands Environmental Demonstration Area (EDA) is a 1200-acre restored prairie wetland located in St. Charles County, MO, immediately upstream from the new Melvin Price Lock and Dam in the Upper Mississippi River System. The wetland area was created by connecting a river backwater and floodplain ponds created by construction of the new dam.

Since its creation in 1990, the Riverlands EDA has been the focus of several monitoring and research investigations. Studies focused on water level fluctuations, vegetation, mussels, fish, birds, and mammals have provided much information to guide stewardship of the EDA. The EDA has also been subject to several ecological disturbances that have impacted management activities.

Monitoring revealed several factors important to wetland management in rivers regulated for navigation. Future management of the area will focus on river-wetland interactions that support high productivity and species diversity. Some rare or immobile species may require stocking to become re-established.

MANAGEMENT FOR BIODIVERSITY IN RIPARIAN ECOSYSTEMS ON US ARMY CORPS OF ENGINEER LANDS

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Riparian areas occur throughout the United States as linear areas along rivers, streams, and other aquatic habitats. The most extensive riparian areas in the United States are vast forests of bottomland hardwoods that occur along broad river floodplains in the East. However, riparian areas are also important components of many western landscapes. Riparian areas are among the most diverse, dynamic, and complex biological systems on earth. These areas contribute significantly to regional biodiversity (Naiman et al. 1993) by providing essential habitat for a wide variety of plant and animal species. However, most streams and riparian areas have been significantly altered or destroyed. Riparian areas are often referred to as "wetlands," but these two terms are not necessarily synonymous (Ohmart and Anderson 1986). These ecosystems often extend beyond the boundaries of jurisdictional wetlands.

Riparian zones are considered an important natural resource on Corps of Engineers (CE) civil works projects throughout the United States. The majority of these projects are constructed along streams and rivers having adjacent riparian zones. The construction and operation of projects for flood control, water supply, navigation, and hydropower exert considerable stress on the riparian zone at many CE projects. These projects often modify natural flows and flooding regimes and divert ground and surface waters, thus producing substantial alterations to the riparian zone. Agriculture, timber harvesting, and recreation also affect riparian habitats.

Management of riparian areas typically focuses on maintaining or restoring a stable zone of riparian vegetation adjacent to the aquatic system (Gore and Bryant 1988). Riparian zones provide habitat that influences flora and faunal communities on a variety of scales (e.g., local, landscape) (Knopf and Samson 1994). Local communities are highly influenced by land-uses that occur within the surrounding watershed. Therefore, to properly manage riparian ecosystems for biodiversity, these ecosystems must be considered as an integral part of the watershed. Riparian habitat condition is often a result of the biogeochemical processes occurring among aquatic, riparian, and terrestrial ecosystems (Green and Kauffman 1989). In general, management applied to any one of these ecosystems may subsequently affect the other ecosystems. This is especially true for riparian and aquatic ecosystems when management occurs in upland areas of the watershed because results of the action will ultimately be realized at lower-elevation sites.

Management techniques for biodiversity include proper maintenance of riparian plant communities, and the establishment of buffer zones. Riparian zone width is often positively related to faunal species richness and density. Most notably, the abundance of neotropical migrant songbirds in riparian zones is positively correlated with riparian-zone width.

Future research needs on CE projects include, (1) examining the spatial attributes and dimensions (i.e., length, width), and vegetation characteristics that are required to provide a functional riparian system from a broad ecological perspective, (2) determining how various land uses and activities affect riparian zone biodiversity, and (3) assessing the value of riparian zones to threatened, endangered, and other sensitive plant and animal species.

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SESSION FA1

ASSESSING WETLAND FUNCTIONS: HYDROGEOMORPHIC APPROACHES PERSPECTIVE

R. Daniel Smith, Chair

A COMPARISON OF CURRENT WETLAND ASSESSMENT METHODS

Richard P. Novitzki

Wetland assessment is needed to protect sensitive wetlands, to mitigate for unavoidable loss, and to assess mitigation success. The Wetland Evaluation Technique (WET) developed by Adamus et al. (1987) applies to all wetlands, is accepted by most federal agencies, and is used widely. EPA is developing the wetland component of the Environmental Monitoring and Assessment Program (EMAP) to estimate the condition of wetlands within a specific wetland class in a region, compared to reference conditions (Novitzki 1994). The Corps of Engineers is developing the hydrogeomorphic (HGM) approach for assessing the degree of function occurring in individual wetlands (within one wetland class), also compared to reference (Brinson 1993).

Wetland Evaluation Technique

WET was the first comprehensive approach to wetland assessment, and 17 Federal agencies, the National Wetland Technical Council, and many others helped to revise the method (Adamus et al. 1987). WET assesses function in terms of "social significance, effectiveness, and opportunity;" uses "predictors" of physical, chemical or biological processes (functions); and assigns value to function in terms of Social Significance.

The following functions are evaluated by WET:

Ground Water Recharge
Ground Water Discharge
Floodflow Alteration
Sediment Stabilization
Sediment/Toxicant Retention
Aquatic Diversity/Abundance
Nutrient Removal/Transformation
Recreation
Production Export
Uniqueness/Heritage
Wildlife Diversity/Abundance

WET uses features of the wetland's watershed, topography, vegetation, and others to estimate (using flow charts or computer software such as WETWorks) a probability rating of "High", "Moderate", or "Low" for each function (except recreation) and habitat suitability ratings for fisheries, wildlife, and waterfowl (Adamus 1988).

Adamus (1988) intended that individual wetland assessments be compiled to refine thresholds between Low, Moderate, and High in each region. Although this has not happened, WETWorks software creates an electronic file for each WET assessment performed, and a lead agency could create local or regional databases of WET assessments.

EMAP-Wetlands

EPA initiated the wetlands component of the EMAP to identify indicators of wetland condition, standardize measurement protocols, develop indices of condition, and establish a national network for monitoring wetland condition (Novitzki 1994). Wetland condition is defined as the state of selected characteristics which are associated with wetlands and which are valued by society. EMAP condition estimates will be based on measures obtained from a probability sample of wetlands (one class) in a region. These indicator measures will be compared to reference conditions, a recent approach in wetland assessment.

EMAP-Wetlands has identified the following wetland values:

BIOLOGICAL INTEGRITY--the sustainability of balanced, integrative, adaptive communities of organisms having species composition, diversity, habitat, and functional organization comparable to that of natural wetlands.

HARVESTABLE PRODUCTIVITY--the quantity and quality of service or product that wetlands provide (e.g., food, timber, wildlife, recreation).

FLOOD REDUCTION AND SHORELINE PROTECTION--reduction of flood peaks and dissipation of velocity and energy resulting from conveyance through, or temporary storage or retention of flood waters within, wetlands.

GROUND WATER CONSERVATION--reduction of ground water discharge resulting from impeded ground water flow through relatively impermeable soils typical in wetlands.

WATER QUALITY IMPROVEMENT--the assimilation of nutrients and other dissolved constituents by plants, retention of sediments and associated materials, and chemical conversions in wetlands that improve water quality.

Indices of wetland condition will relate to one or more of these values, and will be compared to those of the least impacted wetlands in the region (e.g., reference wetlands). One will likely be an index of biological integrity, combining indicators of plant and animal communities, similar to Karr's index of biotic integrity (IBI) for streams (Karr et al. 1986). Other indices may include habitat integrity, hydrologic integrity, and water quality improvement, reported in terms of similarity to reference or to biocriteria (thresholds defined in reference wetlands).

A Hydrogeomorphic (HGW Approach for Assessing Wetland Function and Value)

The U.S. Corps of Engineers began HGM to assess the physical, chemical, and biological functions of wetlands (Brinson 1993). HGM will revise, regionalize, and simplify, the WET approach.

HGM identifies the following functions:

Dynamic Surface Water Storage
Long Term Surface Water Storage
Subsurface Storage of Water
Energy Dissipation
Moderation of Ground Water Flow/Discharge
Nutrient Cycling
Removal of Elements and Compounds
Retention of Particulates
Organic Carbon Export
Maintain Characteristic Plant Communities
Maintain Characteristic Detrital Biomass
Maintain Spatial Habitat Structure
Maintain Interspersion and Connectivity
Maintain Distribution and Abundance of Invertebrates
Maintain Distribution and Abundance of Vertebrates

HGM will identify which functions that an HGM wetland class performs in a region, identify wetland and landscape variables (e.g., plant community, stem density, topography) that indicate a function is performed, and scale the variables to suggest the degree to which the function is performed. Variables in individual wetlands are compared to those of a sample of wetlands in the region (reference domain) to assess the degree to which the assessed wetland performs expected functions. A regional database, containing profiles of wetland variables for each HGM wetland class, will define the range occurring in the reference domain, similar to EMAP-Wetland's reference conditions. HGM represents a combination of the WET and EMAP-Wetland's approaches. If variables can't be measured, indicators of variable conditions may be used.

Conclusions

WET can provide a comparative analysis of all wetlands in a region of interest (e.g., identify sensitive wetlands needing protection). This sets it apart from both HGM and EMAP that allow comparisons only within wetland classes. HGM assesses functions performed by comparing variables observed in the assessed wetland to those observed in reference wetlands in the region. HGM can identify functional loss resulting from wetland modification or loss, as well as compensatory remediation required. EMAP estimates wetland condition in a region, based on indicator measures obtained in a statistical sample of wetlands. Hence, EMAP information could provide the reference conditions database needed by HGM, so long as both programs use comparable wetland classes, use similar measurement protocols, and establish comparable variables (HGM) and indicators (EMAP). Software developed for HGM and EMAP should create standardized electronic copies of assessments for use by both programs and for subsequent analysis.

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A PROCEDURE FOR ASSESSING WETLAND FUNCTIONS BASED ON FUNCTIONAL CLASSIFICATION AND REFERENCE WETLANDS

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Over the past several decades scientists, government agencies, and the general public have become increasingly aware of the important role wetlands play in maintaining environmental quality. At a national level, the Clean Water Act has played an important role in regulating impacts to wetland resources. Section 404 of the Act directs the US Army Corps of Engineers (Corps), in cooperation with the US Environmental Protection Agency, to regulate the discharge of dredged and fill material in "waters of the United States" which by definition include wetlands and other special aquatic sites. As part of the 404 public interest review process, the Corps is required to assess the impact of a proposed project on wetland functions, and utilize the results in deciding whether to issue or deny a permit.

Assessing wetland functions is a challenge because wetlands occur under a wide variety of climatic, geomorphic, and hydrologic conditions. As a result, not all wetlands perform the same functions in the same way. In 404, the challenge is increased because the time and resources available for conducting an assessment are limited. As part of the Wetlands Research Program at the US Army Engineer Waterways Experiment Station, an assessment procedure is being developed for assessing wetland functions that is sensitive to both diversity of wetland types and programmatic constraints of 404.

The assessment procedure has referred to as the "hydrogeomorphic approach" because it begins by classifying wetlands on the basis of geomorphic setting, water source, and hydrodynamics which are the fundamental functional characteristics used in the hydrogeomorphic classification for wetlands developed by Brinson (1 993). Classification identifies groups of wetlands that function similarly. This allows attention to be focused on those functions that a wetland is most likely to perform and the specific characteristics and processes that control those functions. There are five basic hydrogeomorphic wetland classes including riverine, depressional, slope, flat, and fringe (coastal and lacustrine). Within a region, each of these classes may be subdivided into two or more subclasses on the basis of landscape and ecosystem scale factors. For example, the riverine class might include high gradient and low gradient subclasses. The number of regional wetland subclasses depends on the diversity of conditions in the selected region, and the objectives of a project.

For each regional wetland subclass the functions most likely to be performed are identified. For each of these functions an assessment model is developed that defines the relationship between specific characteristics of the wetland ecosystem and the surrounding landscape and the capacity of the wetland to perform the function. During the early stages of development an assessment model may be calibrated using the literature, expert opinion, or even best professional judgment. Eventually, however, model calibration should be based on data collected from reference wetlands representing the range of conditions that exist in the region. Assessment models result in an index that reflects the ability of a wetland to perform a function relative to similar wetlands in the region. The functional indices can be applied in 404 to analyze design/location alternatives, determine project impacts, avoid and minimize, identify compensatory mitigation, and monitor compensatory mitigation.

The assessment procedure consists of a number of documents including a procedural framework, guidebooks for hydrogeomorphic wetland classes, and case studies. Future plans include research to test and refine the assessment procedure and assessment models, and to implement the approach nationally by developing assessment models and indices for additional regional wetland subclasses.

THE HYDROGEOMORPHIC APPROACH AS A BASIS FOR PROCEDURES OF FUNCTIONAL ANALYSIS OF EUROPEAN WETLAND ECOSYSTEMS

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Abstract

The Functional Analysis of European Wetland Ecosystems (FAEWE) project (funded primarily by the European Commission DGXII) is developing science-based procedures for evaluating the functional characteristics of river marginal wetland ecosystems (Maltby et al, 1994). Integral to the FAEWE procedures is the adoption of a hydrogeomorphic approach to facilitate the interpretation of wetland functioning. This approach and the parallel hydrogeomorphic classification of Brinson (1993) maintains that it is possible to make reasonable judgments on how physical properties (geomorphic setting, water source, hydrodynamics) can be translated into wetland functions. The FAEWE project utilizes a different scale and approach because of the greater importance of land use in wetlands within Europe. The FAEWE procedures rely on the successful identification and delineation of hydrogeomorphic units (HGMUs). A HGMU is described as an area of homogeneous geomorphology and hydrology/hydrogeology, and under normal conditions homogeneous soil. Vegetation, whilst integral to the ecosystem, is deemed not to be a primary element of a unit, but may nevertheless give vital information on soil and/or hydrological conditions.

This paper outlines some of the process studies utilized in assessing the performance characteristics of HGMUs along wetland catenas from valley slope to the channel margin at "pristine" and variously impacted sites across a major environmental gradient in Europe. Validation of the hydrogeomorphic approach is interpreted through an appraisal of process relationships. Examples from the study sites in Ireland, UK, France and Spain are provided describing the relationships between HGMUs and physical and biogeochemical processes, Table 1. Redox-water table variations confirm the separation of distinct HGMUs arranged along a catenary sequence, Fig. 1. Surface flooding patterns highlight hydrological differences in floodplain HGMUS. Differences in decomposition assays, measured using the cotton strip method separate floodplain and groundwater maintained units, Fig. 1. Results of studies on N-mineralization and plant production based on similar HGMUs at impacted and non-impacted sites are discussed to emphasize the affects of anthropogenic changes on wetland functioning.

Processes		Location	HGMU	Process relationships and rates
Physical	Redox potential	Torridge, UK	*Levée* *Floodplain backland* *Gentle slope*	WT -50 to -200cm, Redox +200 to +550mV WT 0 to -100cm, Redox -200 to 400mV WT +/- 0cm, Redox -200 to +200mV
	Flooding	Shannon, Eire	*Floodplain depression* *Floodplain elevation*	28.6% annual flood duration* 6.2% annual flood duration*
Biogeochemical	Decomposition	Torridge, UK	*Levée* *Floodplain backland* *Gentle slope*	CTSL per day winter 1.566, spring 2.762, summer 2.794, autumn 2.254 winter 0.916, spring 1.579, summer 2.566, autumn 1.099 winter 0.262. spring 1.316, summer 1.973, autumn 0.497
	N-mineralisation**	Torridge, UK	*Floodplain backland* *Gentle slope*	6.41 gN/m^2/15 weeks 0.83 gN/m^2/15 weeks
	P-release**	Torridge, UK	*Floodplain backland* *Gentle slope*	0.83 gP/m^2/15 weeks 0.58 gP/m^2/15 weeks
	Plant productivity**	Torridge, UK	*Floodplain backland* *Gentle slope*	642 $PROD/m^2$/15 weeks 328 $PROD/m^2$/15 weeks

Abbreviations used: WT water table; CTSL cotton tensile strength loss;PROD production.
* Averaged over 1980-93, figures from Hooyer A. (Maltby *et al,* in press); ** Figures from van Oorschot M.A. (Maltby *et al,* in press).

Table 1. Examples of distinct HGMU - process relationships.

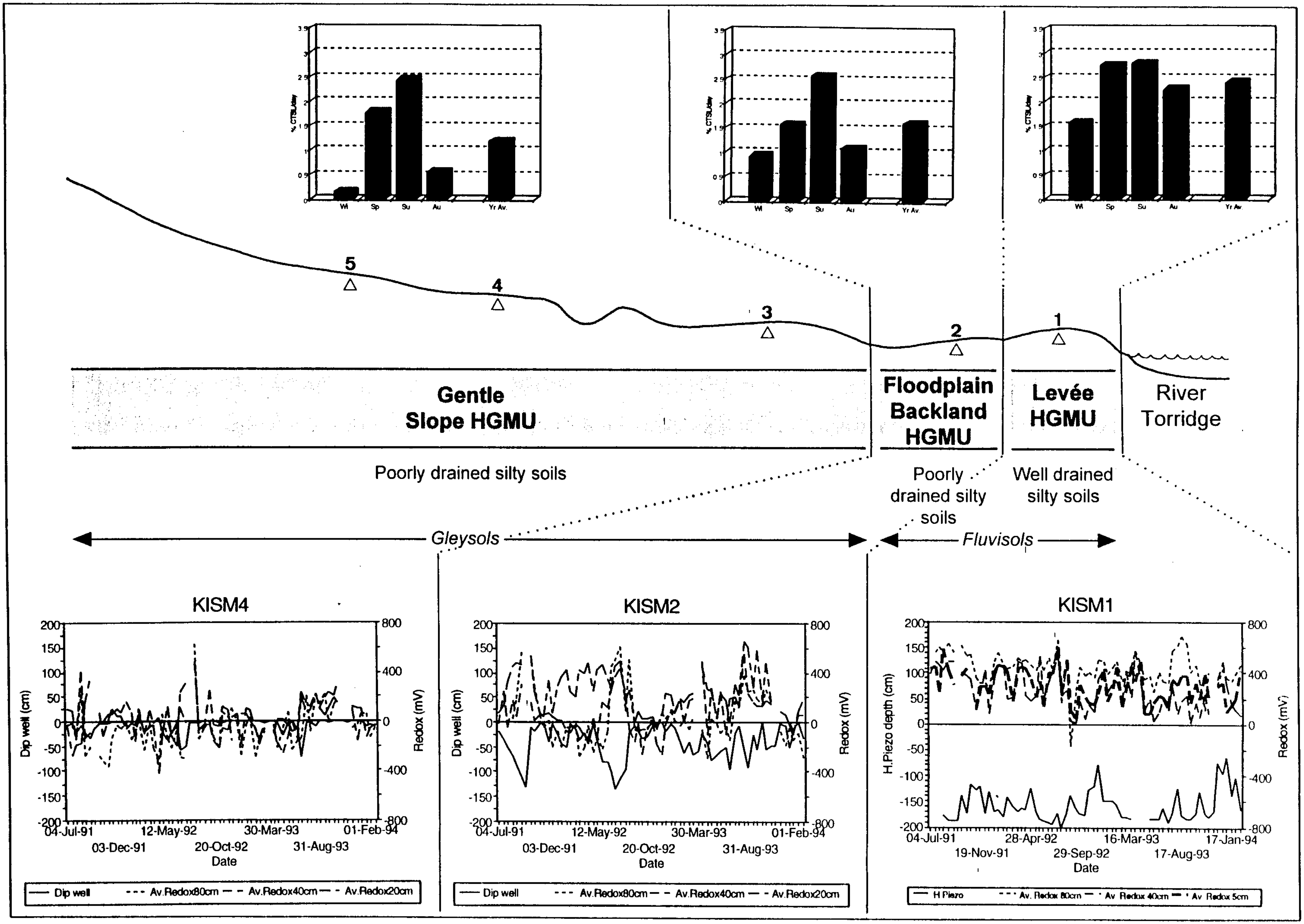

Figure 1. Relationship between HGMUs, redox-water table and decomposition rates, Kismeldon Meadows, River Torridge, UK.

The use and limitation of HGMUs as distinct functional entities is evaluated critically in respect of field trials and the results of extensive process studies. The applicability of the concept for predicting wetland ecosystem functioning within the FAEWE procedures is examined.

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NEW PROCEDURES OF FUNCTIONAL ANALYSIS FOR EUROPEAN WETLAND ECOSYSTEMS

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Abstract

The European Commission (DG XII: Science, Research and Development) is currently funding a major research program (Functional Analysis of European Wetland Ecosystems - FAEWE) to develop science-based procedures for evaluating the functional characteristics of European river marginal wetlands (RMW) ecosystems (Maltby et al, 1994).

The development of the FAEWE Procedures has adopted three approaches: (1) consultation with a potential user group (PUG), composed on government organizations and non-government organizations; (2) assessment, review and field testing of available functional assessment procedures; and (3) utilization of

the complete science-base developed within the FAEWE project.

Fig. 1 shows the overall structure of the FAEWE Procedures. A general Introduction to the FAEWE Project is provided. The User Guidelines are divided into four sub-sections, (i) which function to assess, (ii) which assessment approach to take, (iii) the level of detail of the assessment, and (iv) how to use the FAEWE Procedures. The Desk Study directs the user to existing data sources, advises on field equipment requirements, and assimilates the information into a preliminary assessment of the RMW. The FAEWE Procedures rely on the identification and delineation of hydrogeomorphic units (HGMUs). The HGMU delineation methodology divides the RMW on the basis of geomorphology (slope, depressions, elevations), hydrology/hydrogeology (precipitation, evapotranspiration, surface water, ground water), soil characteristics and vegetation community. Examples of field trials are presented. The Assessment Procedures offer either a qualified or a quantified output. The qualification assessment produces three outputs (i) the function is definitely being performed, (ii) the function is being performed, but only to a small degree, (iii) it is very unlikely the function is being performed. The outcome of the quantification is one of the three qualification outputs supported by a value of the ability of the wetland to perform the function. The third assessment level, modeling and monitoring procedures, details guidelines for long term studies of wetland functioning. It is at this stage that the Procedures become more than a simple functional assessment methodology and expand into a truly integrated set of procedures.

The assessments are based on identification and interpretation of the controlling variables that underpin wetland functions. Examples of the controlling variables for the nutrient removal function (denitrification) are provided in Table 1. 'Decision trees' based on interpretation of the controlling variables, synthesize key findings from the science base and computer models into an 'inference-engine', along with check lists and graphics to produce an accurate, user-friendly assessment format of the specific wetland functions. Examples are examined critically with respect to their practical application.

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Maltby, E., Hogan, D.V., Immirzi, C.P., Tellam, J.H. and Peijl, M.J. van der. 1994. Building a new approach to the investigation and assessment of wetland ecosystem functioning.
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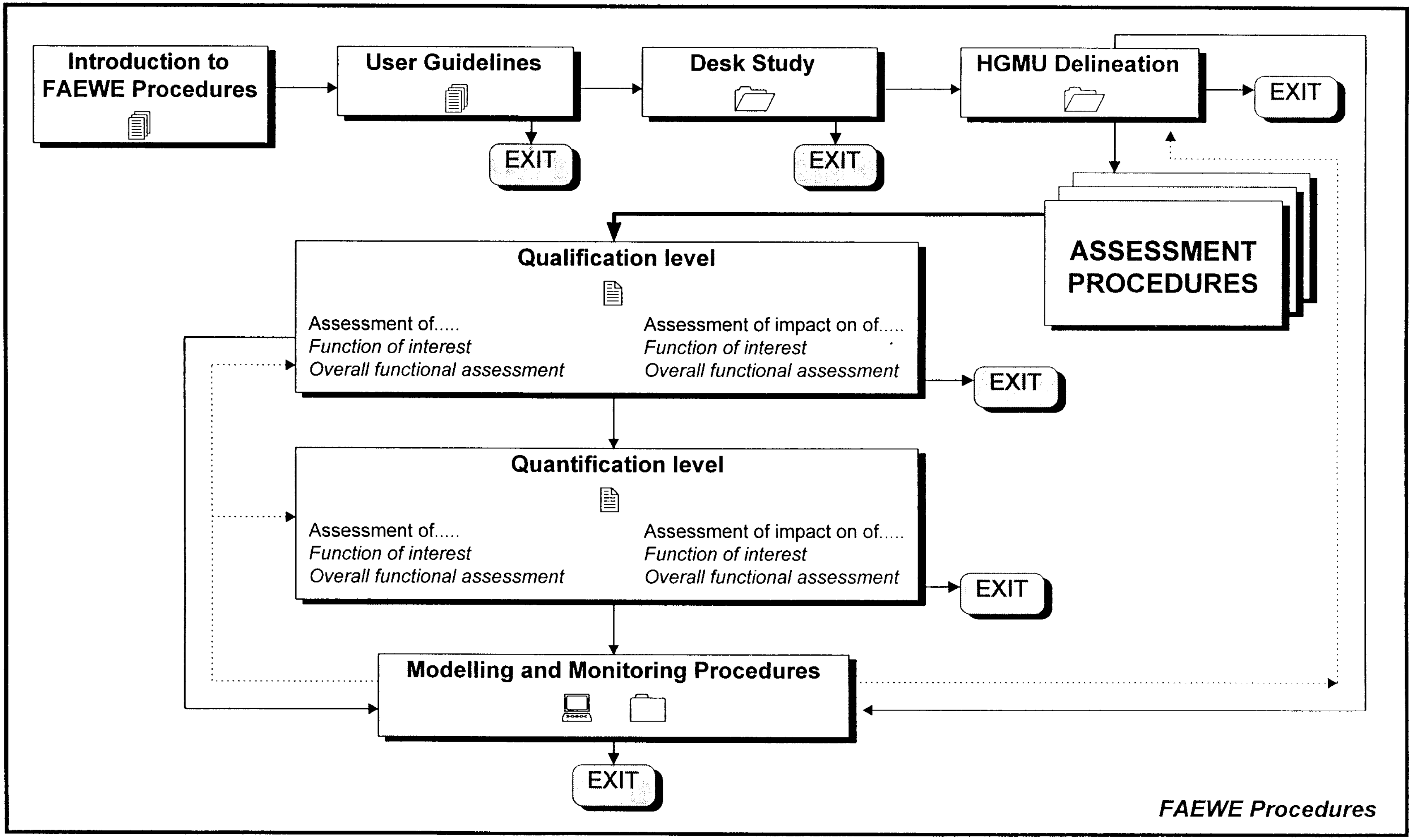

Figure 1. Overall structure of the FAEWE Procedures.

Controlling variable	Background rationale
• **Nitrate (NO_3^-) supply**	The presence or absence of a nitrate supply can often be the limiting factor for denitrification. Nitrate supply can be from sources external to the wetland (e.g. upslope nutrient rich agricultural run off), or from internal sources (e.g. as a result of mineralisation and nitrification). The supply of nitrate is also controlled by the hydrological pathways that are available for the conveyance of nitrate rich waters from the upslope areas into and through the wetland.
• **Soil oxygen (O_2) status (anaerobic vs. aerobic)**	The soil oxygen status will vary spatially and temporally. Highest rates of denitrification occur where alternating anaerobic and aerobic states exist. Nitrification will tend to occur under aerobic conditions and denitrification will tend to occur under anaerobic conditions. If the soil is predominantly anaerobic (e.g. gley soils) low rates of denitrification will exist due to the lack of nitrification. Thus the O_2 status of the soil will influence the internal source of nitrate.
• **Soil carbon (C)**	Soil carbon (organic matter) if not present in readily oxidisable forms may be a limiting factor for denitrification. The presence of carbon can stimulate microbial activity, reducing the O_2 availability and thus favouring denitrifying organisms over aerobic organisms that cannot assimilate C under anaerobic conditions.
• **Soil pH**	In general acid soils (pH < 7) have low rates of denitrification due to inhibited dinitrogen (N_2) production. In more alkaline soils (pH > 7) nitrous oxide (N_2O) is more readily reduced to N_2.
• **Soil temperature**	The optimum range of soil temperature for denitrification is between 60 - 65° However observations indicate that in real terms the highest soil temperatures coincide with the lowest soil moisture conditions, resulting in the occurrence of the maximum rates of denitrification at intermediate temperatures.
• **Environmental history**	The past and present environmental history of the wetland influences the composition of the soils and their microbial populations.
• **Synchronisation**	To achieve the maximum rate of denitrification all the optimum conditions for the above controlling variables must be synchronised in time and space.

Table 1. Controlling variables for nutrient removal (denitrification) function.

A METHOD FOR ASSESSING HYDROLOGIC ALTERATION WITHIN ECOSYSTEMS

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Hydrologic regimes play a major role in determining the biotic composition, structure, and function of aquatic, wetland, and riparian ecosystems. However, human land and water uses are substantially altering hydrologic regimes around the world. Improved quantitative evaluations of human-induced hydrologic changes would greatly benefit the development of ecosystem management and restoration Plans. To facilitate such improved hydrologic evaluations, we propose a method for assessing the degree of hydrologic alteration attributable to human impacts within an ecosystem. This method, referred to as the Indicators of Hydrologic Alteration (IHA), is based upon an analysis of hydrologic data available from existing measurement points within an ecosystem (such as at stream gauges or wells). We use 32 different parameters, organized into five groups, to statistically characterize hydrologic variation within each year. These 32 parameters provide information on some of the most ecologically significant features of surface and ground water regimes influencing aquatic, wetland, and riparian ecosystems. The hydrologic perturbations associated with activities such as dam operations, flow diversion, ground water pumping, or intensive land use conversion are then assessed by comparing measures of central tendency and dispersion for user-defined "pre-impact" and "post-impact" time frames, generating 64 different "Indicators of Hydrologic Alteration." The IHA method is intended to be used conjunctively with other ecosystem metrics in inventories of ecosystem integrity, in planning ecosystem management activities, and in setting and measuring progress towards conservation or restoration goals.

SESSION MB3

MITIGATION AND MITIGATION BANKING:
STRATEGIES IN MITIGATION II
Ms. Lynn R. Martin, Chair

EXPEDITING WATER PROJECTS: BENEFITS ASSESSMENT AND WETLAND MITIGATION BANKING

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On behalf of the American Water Works Association (AWWA), CH2M HILL and King and Associates developed a handbook for water project development. The handbook is entitled "Expediting Water Projects:Benefits Assessment and Wetlands Mitigation Banking,"

The handbook gives practical information for meeting the objectives of both water resource development and environmental protection. The ultimate goal is to help water utility managers bring water resource projects on line quickly and cost-effectively while protecting and enhancing valuable environmental resources.

To help meet these objectives, two permit related activities are addressed:

1. Assessment of the beneficial environmental effects of water supply development

2. Use of wetland mitigation banking for all types of water resource developments

Technical And institutional data and methodologies are presented to assist in performing these activities. The data are from literature, field investigation, and conceptual plans for hypothetical wetland mitigation banks. The methodologies give general approaches as well as specific examples for assessing reservoir benefits and for developing successful wetland mitigation banks.

Examples were selected to bracket a typical range of potential water resource developments.

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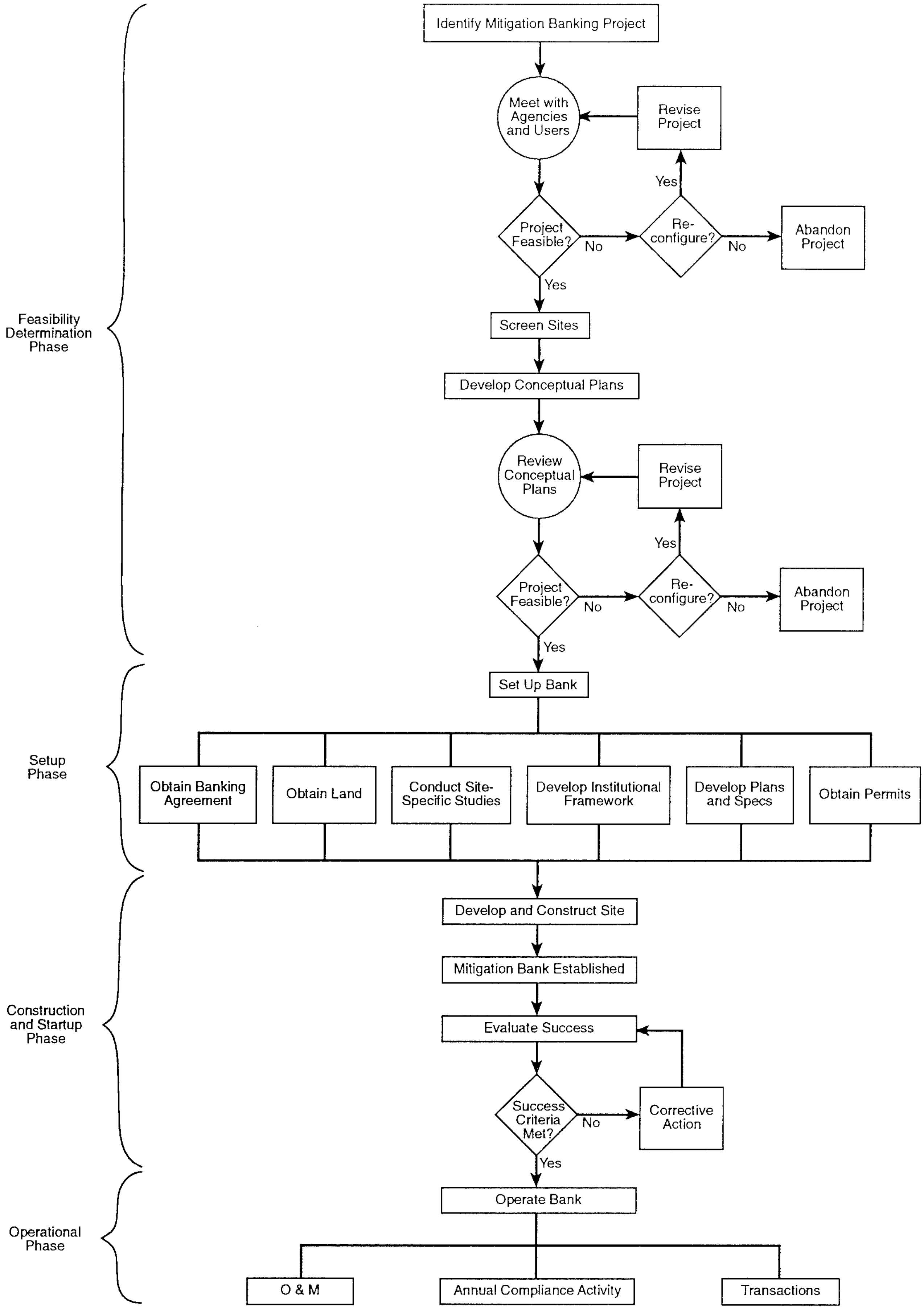

Figure 1. Mitigation Banking Project Activity Flow Chart.

Table 1
Key Features of Institutional Components1

INSTITUTIONAL COMPONENT	FEATURES
Bank Instrument	
The success of a mitigation bank depends on two things: (1) the way in which a mitigation bank is established, and (2) the roles various participants play in managing bank activities.	To establish a mitigation bank, the parties who will participate in the bank must enter into a formal, written agreement with the Corps and other concerned agencies. This agreement, referred to as a banking instrument, presents the guidelines for establishing and using the bank. In many circumstances, a mitigation bank may be established as a condition of a Section 404 permit.
Bank Management and Debiting	
Bank management and debiting is a two-step process. First, bank credits are evaluated for use in particular projects. Then, the resulting transactions are recorded.	For dedicated or single-user banks, the bank sponsor and regulatory agencies agree in advance, as part of the permitting process, on issues relating to the establishment and use of bank credits for future permitted projects. For commercial or general-user banks, regulatory agencies must exercise management oversight separately from the permitting process.
Bank Siting Process	
Regulators typically expect mitigation banks to be located in the same watershed as the wetland impacts they will be used to compensate for. The banks should be as close as possible to those impacts to replace important area-specific wetland functions and values that would be lost to development.	Regulators prefer bank sites in areas free from land uses that might threaten bank wetlands functions and values. Also, large areas of replacement wetlands are preferred because they avoid habitat fragmentation and promote biodiversity and establishment of self-regulating ecosystems.
Allowable Compensation	
The success of a bank is affected by the type of mitigation and by the timing of compensation and the geographical range of the permitted projects. Compensation for each mitigation bank is based on wetland functions lost as determined during the Corps review. The Corps permit will specify how much mitigation is required after avoidance and minimization have been considered.	**Mitigation Type.** Regulators favor restoration of former or severely degraded wetland areas where hydric soils already exist and where the underlying hydrology is intact or can be restored relatively easily. **Mitigation Timing.** Federal regulatory guidance for mitigation banking requires that bank replacement wetlands be "in place and functional" before they can generate usable bank credits.
Credit Valuation and Compensation Ratios	
Credit valuation involves the definition and evaluation of a mitigation bank's currency; compensation ratios establish the types and levels of allowable trades of bank currency for permitted wetland impacts.	The method used to evaluate bank credits is tied to bank- and area-specific wetland goals. The best credit valuation method for any particular bank is to use the simplest method that can achieve the specific wetland goals. Regulators expect compensation ratios to account for risk and uncertainty.
Quality Controls	
Several levels of quality controls must be developed for each mitigation bank as part of the overall bank establishment process. These are:	
Performance Standards and Success Criteria. A methodology acceptable to all parties involved must be established to assess the success of a mitigation bank. This methodology should identify the credits that will be issued at each stage of development and range of wetland functions to be assessed. The bank's functions, and the bank's credits and debits, should be evaluated.	Success criteria can serve one or more purposes. For example, they may be used to: (1) Determine when credits can be used; (2) Adjust compensation ratios at the time of credit use; (3) Guide monitoring and maintenance requirements on mitigation banks after they have generated usable credits; and (4) Define when mitigation failure has occurred after credit use.
Design Standards. On the basis of standards of practice and professional guidelines, project plans and specifications must provide design standards for a successful project.	
Monitoring and Maintenance. After a bank has been used to trade credits for permitted impacts, regulators expect it to be monitored to detect deficiencies in design, construction, or any stated success criteria. These plans should also include maintenance provisions to ensure that problems are corrected promptly.	Monitoring and maintenance programs provide the bank sponsor and regulators with regular and periodic assessments of the status of the bank. Monitoring plans typically address the elements detailed in the performance standards and success criteria.
Contingency Plans. Bank failures sometimes occur. Therefore, bank agreements must contain enforceable liability rules. These rules are important because banks might not provide fully functioning wetlands before credit trades occur. Liability rules assure that compensatory mitigation will be provided for each credit trade that is made.	Mechanisms can be used to reduce the likelihood that the public will have to assume financial responsibility for bank failure. These include surety bonds, trust funds, escrow accounts, collateral banks, and insurance systems. Regulators use several methods to ensure that bank sites will retain their wetland status after bank credits have been used.

MINNESOTA WETLAND CONSERVATION ACT: WETLAND BANKING SYSTEM

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The **MN Wetland Conservation Act (WCA)** is a "no-net-loss" state wetland protection program in effect since 1992. The WCA prohibits the draining and filling of wetlands unless replaced by restored or created wetlands of equal or greater public value under an approved replacement plan. Local government units (LGUS) administer this state program that includes a comprehensive yet simple wetland function and value assessment to achieve wetland replacement. The WCA also was the impetus for the development of a state wetland banking system which allows both public and private sector project sponsors to participate.

The **MN state wetland banking program** is incorporated as part of the WCA regulatory program, and was designed to be simple and flexible while conserving wetland functions and values. The banking program was based on federal models to assure maximum consistency with the mitigation requirements of Section 404 of the Federal Clean Water Act.

Wetland banking is a system of mitigation, or replacement of wetland acres and their associated public values lost due to draining, filling or other disturbance. Wetland banking allows the appropriate amount and type of wetland acreage to be purchased from an accountholder who has developed a "bank" of functioning wetland acres restored from previously drained or filled wetlands or newly created wetlands. Wetland banking is contrasted with project-specific replacement where the project sponsor does the restoration or creation specifically to replace a wetland that is to be drained or filled.

Principles of wetland banking are:

1. Functional wetlands must result. Expertise in site selection and construction techniques is required. Persons who have this knowledge or experience should be involved in the planning stages of banking projects.

2. Public funds cannot be used to subsidize wetland replacement for private projects. If a local government unit uses its property, funding, staff time for design and monitoring, or their resources to complete a wetland restoration or creation project and gain wetland banking credits, it must factor those items into the price it charges for the sale of wetland credits.

3. The resulting wetland area and type must exactly match those

credits in the bank. This means that all wetland size and type determinations (before and after) should be done conservatively.

Projects will be approved, managed, and monitored by LGUs and landowners with the Minnesota Board of Water and Soil Resources providing oversight and central record keeping. Public and private interests can buy and sell credits at costs determined by free-market factors.

WETLAND MITIGATION BANKING: SOLUTIONS THROUGH CONSENSUS BUILDING

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Argonne National Laboratory conducted a mitigation banking workshop sponsored by the Department of Energy, Metarie, LA. The workshop was held in Washington, DC in late March 1995. Invited participants included federal and state agencies that will be impacted by wetland banking regulations, legislative staffers who will be developing wetland banking legislation, industry representatives interested in using banking as a mitigation tool, and environmental groups interested in the effect of banking on wetland issues. The workshop was designed to stimulate discussion of various issues of banking including the environmental, regulatory and economic aspects. The results of the workshop should greatly help the legislative and natural resource agency staffs avoid pitfalls and deal effectively with industry and environmentalists concerns during the development of regulations, thus avoiding non-constructive controversies afterwards. The National Interagency Workshop on Wetlands seems an ideal place to present the results of the ANL/DOE workshop, by providing timely and pertinent information to other agencies, academia and the private sector.

WETLAND MITIGATION AT JORDANELLE WETLANDS AND THE SEEDSKADEE NATIONAL WILDLIFE REFUGE

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Jordanelle Wetlands

Jordanelle Dam and Reservoir, located on the Provo River 5,5 miles north of Heber City in northern Utah, were constructed recently by the Bureau of Reclamation (Reclamation) as part of the Central Utah Project. Mitigation required under the Clean Water Act Section 404 Permit for the project requires new wetlands be established to compensate for the loss of wetlands previously located in and around the reservoir. Riparian vegetation adjacent to the mitigation site, located at approximately 5,900 feet in elevation, is comprised of narrowleaf cottonwood, box elder, dogwood, and a variety of willows.

Objectives for the mitigation include the establishment of 92 acres of wet meadow vegetation; minimizing impacts to existing wetlands and riparian areas; creating and maintaining the maximum habitat diversity that is possible and practical within the operating limits and funding constraints; facilitating low-cost, long-term maintenance and management; enhancing western spotted frog habitat; and accommodating education and research uses of the wetlands.

Construction consists of 36 shallow ponds with low (two to five feet) earthen berms having sideslopes of 5:1 upstream and 3:1 downstream. Berms are constructed from topsoil material having a high clay content. Each pond has an outlet structure to provide regulation of pond elevation and conveyance of water to the next pond downstream. A water supply pipeline has been constructed with a turnout to 24 of the 36 ponds. The design allows for a large variety of operational schemes, one of which would require only five turnouts to operate the entire complex. Additional visual screening ditches, islands, peninsulas and isthmuses were made to provide physical diversity to the newly created habitat. Topsoiled areas of the ponds were planted with tubelings and tubers of hardstem bulrush, sedges, rushes, and sago pondweed.

The mitigation complex will be monitored closely during the next five years to encourage development of four to 10 acres of open water and 82 to 88 acres of wet meadow and riparian vegetation complex. A technical advisory committee, comprised of representatives from government, private, and public concerns provides guidance for the project which will serve as a valuable educational and wetland resource.

Seedskadee National Wildlife Refuge

Located on the Green River, just downstream of Fontenelle Dam in Sweetwater County, Wyoming, the refuge is an oasis amongst a mostly arid terrain. This refuge was constructed as part of the mitigation plan for construction of Fontenelle Dam. The Fish and Wildlife Service has responsibility for operations management and maintenance. One of the major objectives is to create wetland and fish habitat. This year Reclamation, in cooperation with the Fish and Wildlife Service, constructed a river sill with the purpose of modifying the hydraulics of the river in order to divert flows to a historic oxbow (see Figure 2). This will greatly increase the fish habitat in the area and also raise the water table. The elevated water table will enhance wetlands along the oxbow.

FEE-BASED COMPENSATORY MITIGATION: POTENTIAL ROLES OF AND BENEFITS FOR CONSERVATION AGENCIES AND ORGANIZATIONS

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Wetland restoration is frequently required as a condition of 404 permits, as compensatory mitigation for adverse impacts to wetlands. Different approaches to satisfy mitigation requirements include on-site efforts, wetland mitigation banks, and fee-based compensation arrangements. As part of fee-based compensation arrangements, funds can be given to conservation agencies or organizations that facilitate wetland restoration. Programs normally supported by voluntary contributions could coordinate the disbursement of compensation fees. Potentially greater benefits could be achieved through programs designed to pool compensation fees to fund wetland projects that are larger and potentially more successful ecologically, than individual mitigation efforts. Such programs can be attractive to permittees, regulators and conservation interests by enabling consolidation and more timely responses to applications that would otherwise require numerous individualized investigations. Such programs may also be designed to include explicit requirements facilitating long-term management.

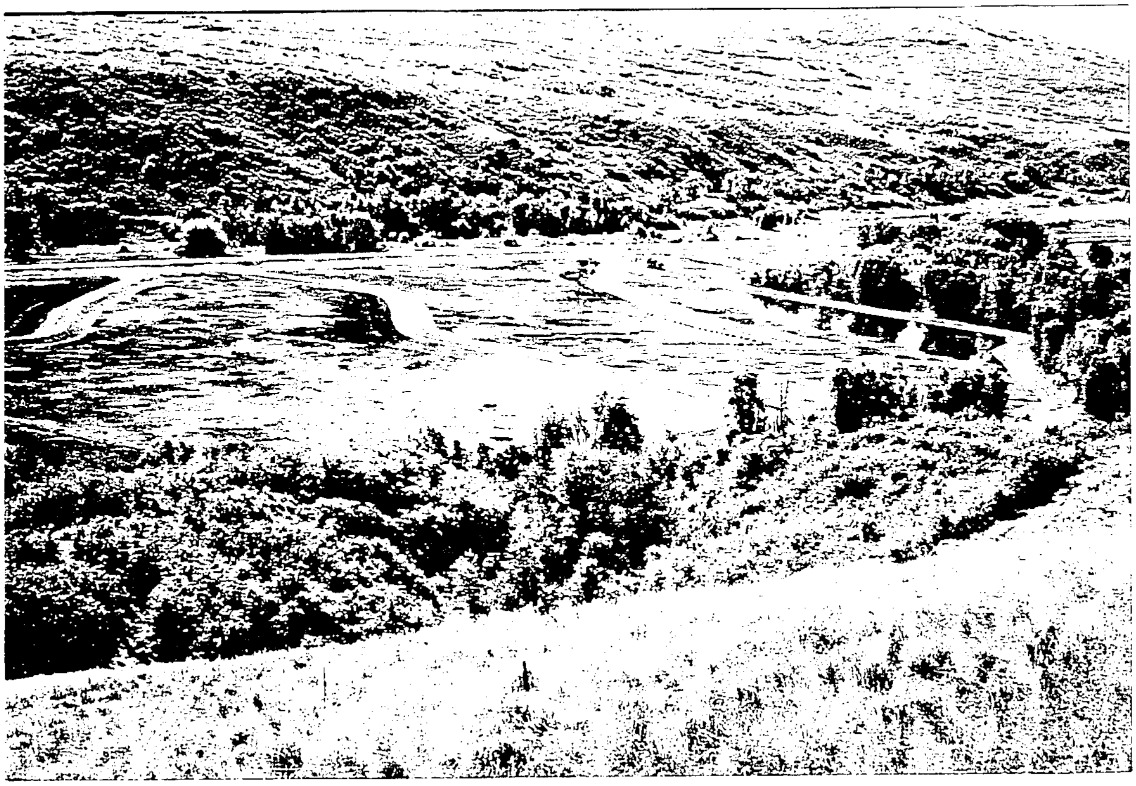

Figure 1. The Jordanelle Wetlands

Figure 2. Seedskadee Wildlife Refuge and McCullen Bluff Oxbow

SESSION RE13

RESTORATION, PROTECTION, AND CREATION: ALASKA AND PACIFIC NORTHWEST RESTORATION PROJECTS

Lloyd H. Fanter, Chair

AN EVALUATION OF THE WETLAND MONITORING PROGRAM OF THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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WSDOT projects involving impacts to wetlands often require compensatory mitigation in the form of wetland creation, enhancement, and/or restoration under the terms of federal, state, and in some instances, local permits. Monitoring provides a systematic means of tracking the development of the wetland and its upland buffer over time, determines compliance with the permits, and can provide a critical source of feedback for future wetland mitigation efforts. WSDOT mitigation sites are typically monitored for five consecutive years. Annual monitoring tasks are conducted from May through September and include three formal breeding bird surveys, aquatic invertebrate collection and identification, soil and water sampling, vegetation identification, and photographic record keeping. WSDOT monitoring protocol is based on methodology described in Guide for Wetland Mitigation Project Monitoring (Horner and Raedeke 1989).

Three factors underscored the need for an evaluation of the WSDOT monitoring program: 1) the number of sites more than tripled since the inception of the program in 1988, (nineteen sites in 1994, with an expected increase to twenty-five sites in 1995), 2) the costs of wetland monitoring have increased by almost twenty-five percent over the same period, averaging $5000.00 per site in 1994, and 3) the criteria by which the mitigation sites are judged have evolved from broad-based, generically applied standards to directives tailored to the individual site. The combination of increased costs, higher standards for mitigation site development, and the increase in the number of sites monitored made it necessary to assess the monitoring program for efficiency and effectiveness.

Problem areas were found within each of the major components of the monitoring program: field methodology, data analysis, data interpretation and discussion, format of the annual report, and use of the results as feedback for future site design.

Specific problems with field tasks include: lack of standardization in number and location of soil and water samples collected; unavoidable bias in the collection of aquatic invertebrates; the need for additional wildlife surveys beyond bird surveys; and difficulties encountered in establishing a clear cut boundary between wetland and upland on a site where two of the three technical criteria necessary for wetland delineation often cannot be established. Specific recommendations were proposed with the intent of promoting standardization within the monitoring program, as well as providing a means by which to most efficiently gather the level of data necessary to comply with permit requirements.

The overriding problem found with the analysis of the monitoring data is the lack of a clear cut question to guide the collection of data. WSDOT wetland monitoring has been primarily motivated by the need to satisfy wetland regulation, not wetland research needs. The effect has been that the collection of data lacks focus; monitoring tasks are perfunctorily conducted and reported, which in turn gives a lack of continuity and depth to the discussion of the results in the annual monitoring report.

In any document report format is a critical component to facilitating the understanding of the contents by the reader. Minor changes to current report format will vastly improve the presentation of and reception of the monitoring results. To date the data analysis presented in the annual report have not been fed back into to the overall wetland mitigation program. Lack of time, difficulty with the report layout, and being unaware of the existence of the monitoring report are several of the reasons cited by WSDOT personnel for not utilizing information generated by the monitoring program.

It is important that the WSDOT monitoring program remain flexible; further refinements to the methodology may be necessary in the future if (or as) the mitigation requirements for impacts to wetlands change. Time constraints will become a limiting factor if the total number of sites monitored one season continue to increase. Potential budget restrictions may also become a factor affecting the program. To be the most efficient and effective in monitoring its created wetland mitigation sites, WSDOT should continue to work with federal, state, and local agencies in an effort to establish common ground on the expectations for and the focus of the monitoring program. There should be a consensus on where the emphasis of monitoring is placed, developed out of a realistic assessment of what can be achieved.

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PARTNERSHIPS IN MANAGEMENT BY EXPERIMENTATION FOR GRAVEL PAD REHABILITATION ON ALASKA'S NORTH SLOPE

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US Army Corps of Engineers
Anchorage, Alaska

Christopher J. Herlugson
BP Exploration (Alaska) Inc.

Alaska encompasses 403 million acres with 174.6 million acres (43.3%) classified as wetlands. The 20 million acre Arctic Coastal Plain contains 16.6 million acres of wetlands. Most North Slope oil and gas development activities occur in these permafrost wetlands. Since 1979, over 900 U.S. Department of Army (DA) permits authorized placement of fill material on over 32 square miles of the North Slope. Over 21,000 acres of North Slope wetlands have been filled for petroleum and related development activities, including the Trans-Alaska Pipeline System (TAPS) and the Dalton Highway north of the Brooks Range. Approximately 2 percent (5,400 acres) of the 232,190 acre Prudhoe Bay Unit and 0.8 percent (2,530 acres) of the 326,592 acre Kuparuk oil field wetlands have been covered by fill material.

Many DA general and individual permits issued for placement of fill material on the North Slope stipulate that upon abandonment the area shall be rehabilitated to the satisfaction of the District Engineer. Where not specifically conditioned, DA permit general condition 2 states that upon abandonment, restoration may be required. The State of Alaska takes a longer term and larger scale view in conditioning leases by stipulating that upon abandonment the total lease tract (which may contain multiple DA permit sites) will be rehabilitated to the satisfaction of the State. No definitive standards have been established for determining what constitutes it satisfaction" for compliance with permit or lease conditions by the regulatory agencies. Currently, on DA permits, requirements for rehabilitation of wetlands are determined on a case-by-case basis.

Determinations of agency satisfaction and wetland rehabilitation success can be: problematic, controversial when individual Federal and State agency's responsibilities conflict, and compounded when a third party is financially responsible. Conflicts arise even in the use of the simple terms, e.g. restoration vs. rehabilitation, conservation vs. preservation, etc.

Does creating beneficial upland habitat preclude wetland rehabilitation requirements? Even the issue of short vs. long term rate of recovery is problematic, let alone considering natural vs. enhanced recovery.

Agency satisfaction and rehabilitation success can be achieved when regulators, land managers and permit holders are committed to mutual goals. These partnerships in management by experimentation by regulatory agencies and industry (e.g. Corps of Engineers, BP Exploration (Alaska) Inc., etc.) provide valuable data in determining appropriate rehabilitation goals and development of practicable/cost effective techniques. Annual results from BP Pad (rehabilitation, figure 1), X-Pad (corrective action) and Pebble Creek (restoration, figure 2) are being used in developing and improving specific rehabilitation goals, design criteria, and performance standards that will maximize the environmental and economic efficacy in future large scale rehabilitation efforts. Partnerships provide the necessary framework to facilitate successful rehabilitation within environmental constraints while meeting both the spirit and intent of regulatory compliance requirements.

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EVALUATION OF LIQUID CALCIUM (LCA-11) IN REDUCING SALINITY FOR ARCTIC TUNDRA REHABILITATION

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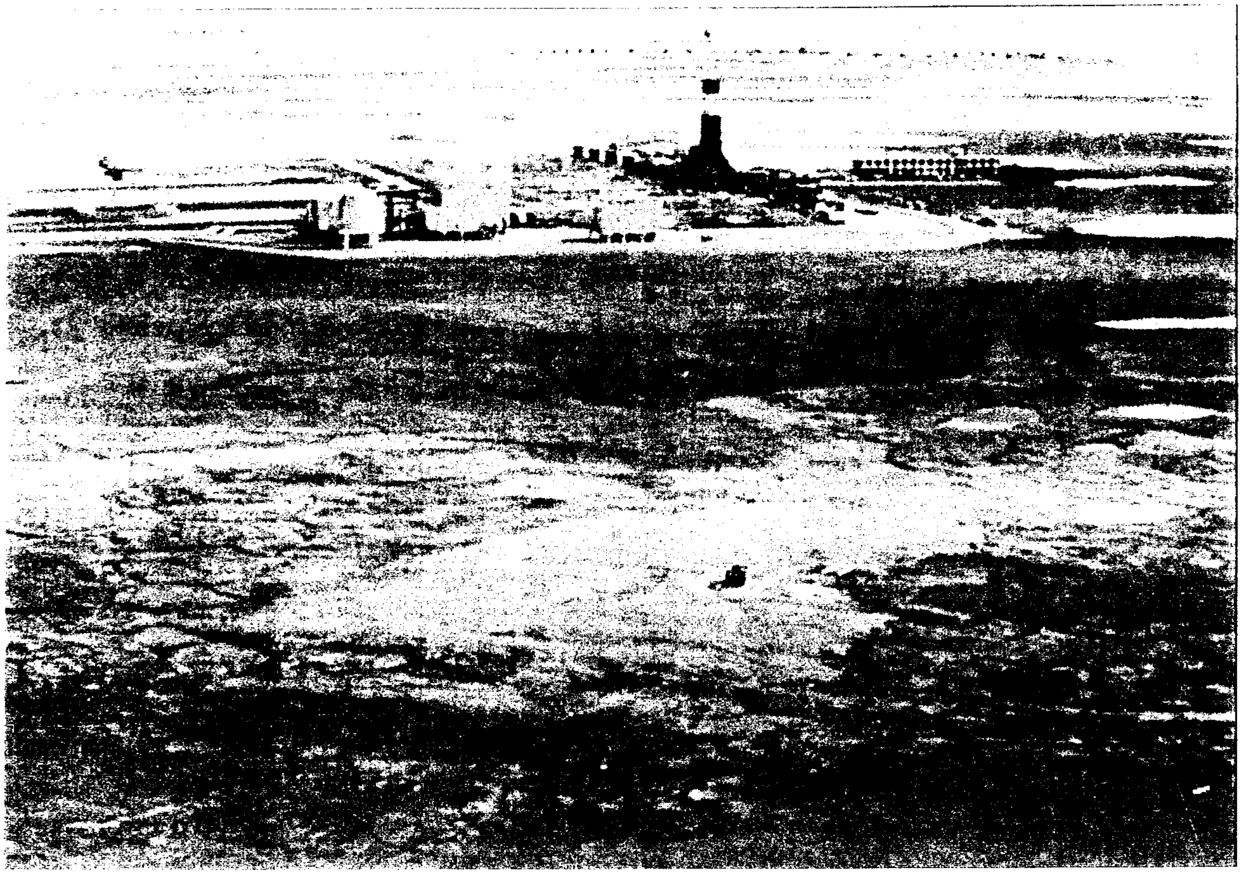
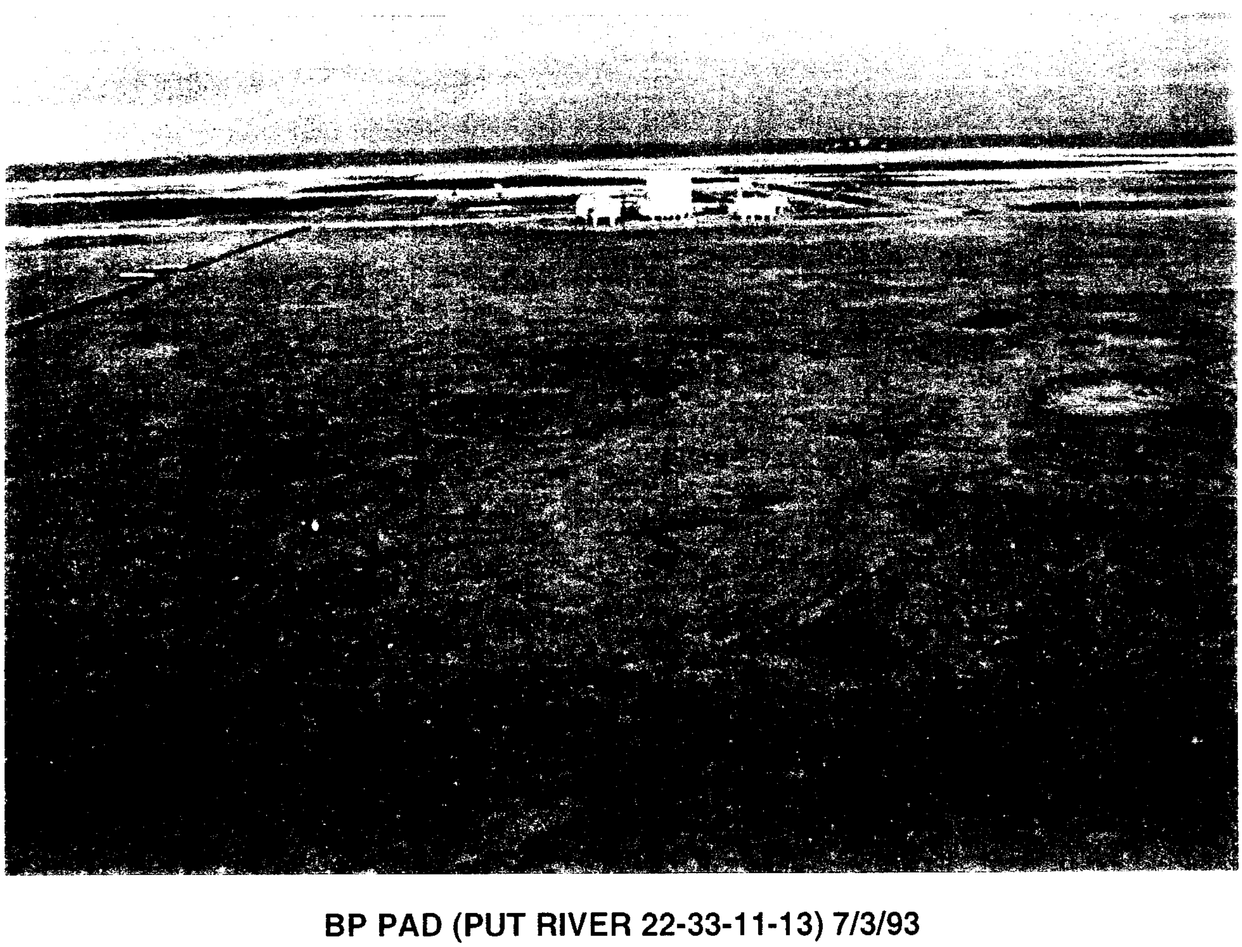
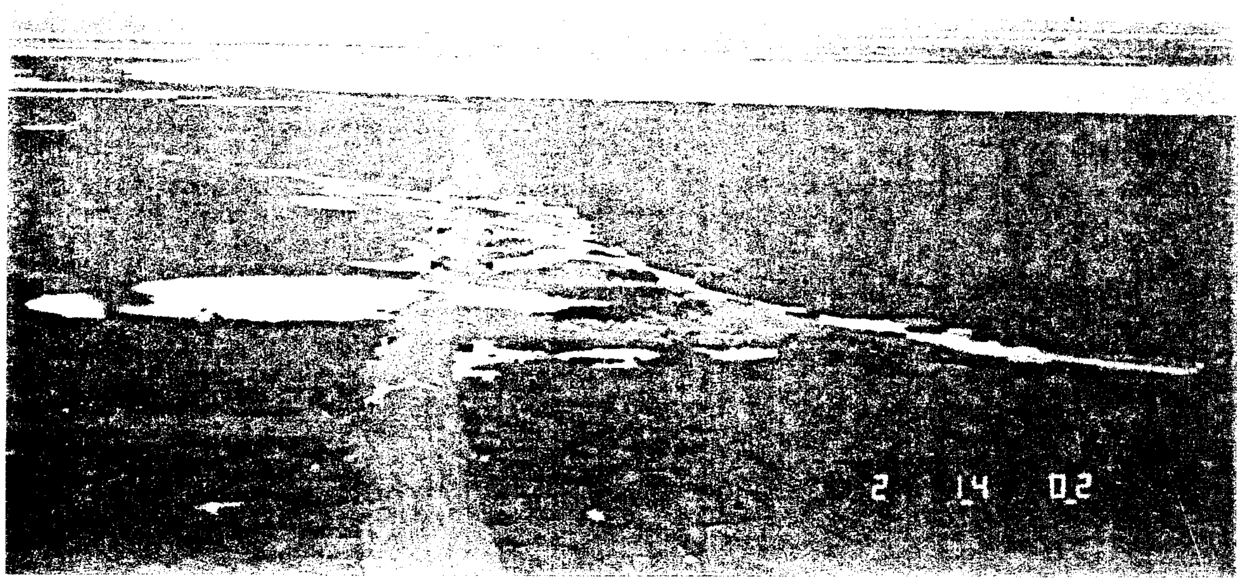
A revegetation project at an unused 93,000 sq. ft. flare pit (gravel-fill construction) was undertaken during the winter of 1989



BP PAD (PUT RIVER 22-33-11-13) 7/3/88



BP PAD (PUT RIVER 22-33-11-13) 7/3/93



PEBBLE CREEK 8/7/89

PEBBLE CREEK 7/1/91

to remove the gravel and revegetate the site. The site was seeded with a mixture of three tundra grasses (Arctagrostis latifolia, Festuca rubra, and Poa glauca) and fertilized. Following additional site work in 1990-9 1, the site was again seeded and monitoring continued. During the 1992 growing season it became clear that the revegetation project was failing. Soil tests indicated elevated salinity was the most likely reason for revegetation failure. It was theorized that the salinity of the soil was elevated prior to the flare pit rehabilitation project. The salts had migrated to the surface of the added layer of topsoil and were interfering with seedling establishment.

A joint experimental corrective action plan was formulated in 1993 by the United States Army Corps of Engineers-Alaska District (USACE) and BP Exploration (Alaska) Inc. (BPX) for the X Pad flare pit. The plan was developed to test the effectiveness of LCA-11, a calcium nitrate solution, as a treatment for rehabilitating saline soils. Testing and monitoring was scheduled for 1 September 1993 through 31 August 1996. Four field experimental plots (Blocks 1-4) were established. LCA-11 was applied to three plots which were seeded with native tundra grasses. A fourth block of plots was established to test the chemical on live plants, which had naturally colonized the flare pit area.

Soil salinity and vegetation response to the treatment were quantified after the 1994 growing season. Because some natural recolonization was occurring on the site, the entire area was sampled to measure plant cover and community composition. Photo plots were established to monitor vegetation changes over time.

Results

Average conductivity (salinity) of the soil surface decreased about 34% front 1993 to 1994. There was no statistically significant difference between salinity in control and treated soils. Total plant canopy cover, based on transact sampling within Blocks 1-4, averaged nearly 26% and total cover, including vascular plant basal cover, moss and algae, was about 63%. Treatment with LCA-11 increased cover of established plants and did not inhibit germination of native species, such as Puccinellia langeana. The decision was made to continue monitoring the site through 1996 without further LCA-II treatment. The current reduction in salinity and recolonization by native vegetation were prime factors in this decision.

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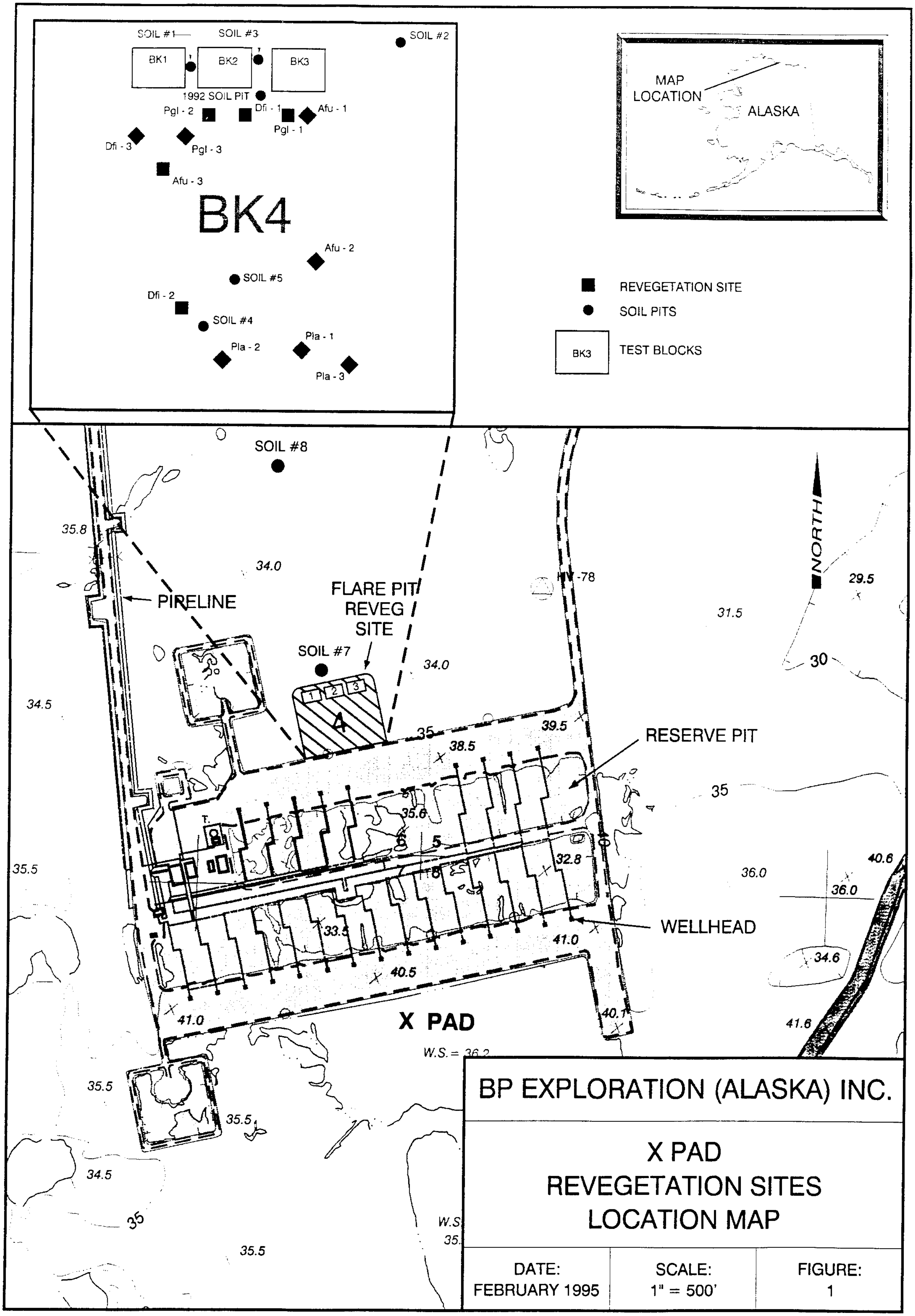
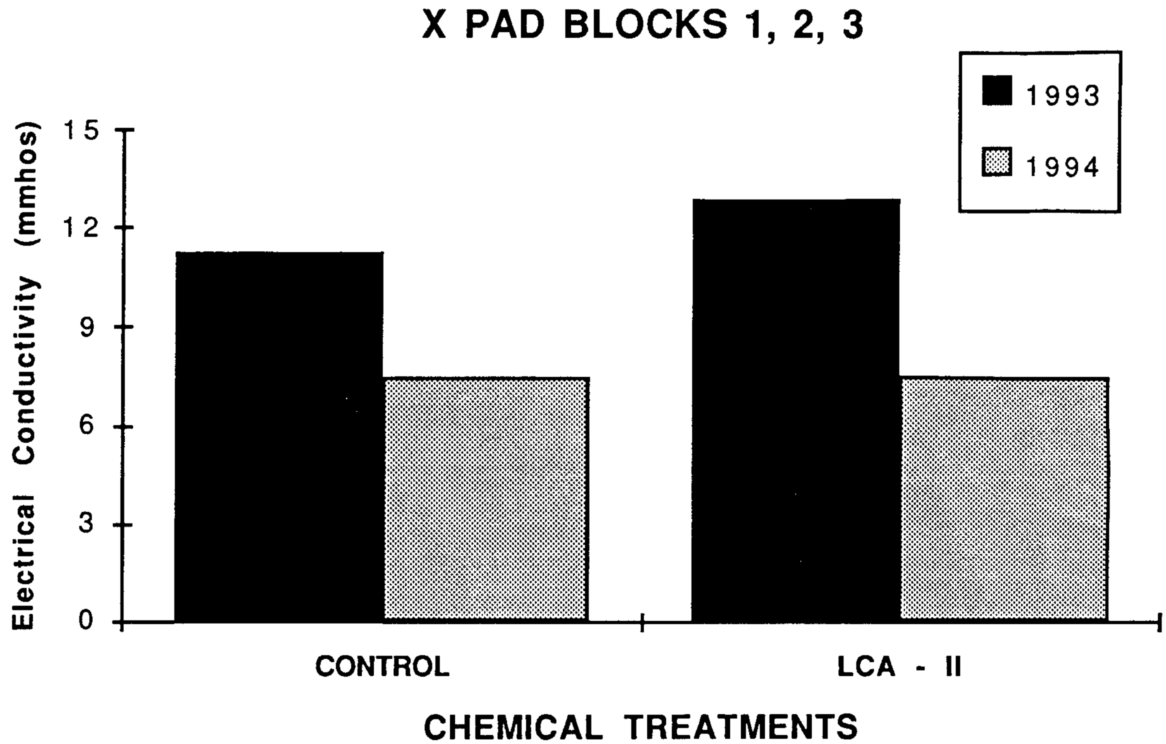

SOIL #1
SOIL #3
SOIL #2
BK1
BK2
BK3
1992 SOIL PIT
Pgl - 2
Dfi - 1
Afu - 1
Pgl - 1
Dfi - 3
Pgl - 3
Afu - 3
BK4
Afu - 2
SOIL #5
Dfi - 2
SOIL #4
Pla - 1
Pla - 2
Pla - 3
MAP LOCATION
ALASKA
REVEGETATION SITE
SOIL PITS
BK3
TEST BLOCKS
SOIL #8
35.8
34.0
PIPELINE
FLARE PIT REVEG SITE
SOIL #7
34.0
HV-78
31.5
29.5
30
NORTH
34.5
1
2
3
4
35
39.5
38.5
RESERVE PIT
35
35.6
5
6
8
32.8
36.0
40.6
36.0
35.5
33.5
41.0
WELLHEAD
34.6
40.5
41.0
40.1
X PAD
41.6
W.S. = 36.2
35.5
35.5
34.5
35
35.5
BP EXPLORATION (ALASKA) INC.
X PAD
REVEGETATION SITES
LOCATION MAP
DATE:
FEBRUARY 1995
SCALE:
1" = 500'
FIGURE:
1

vg12579.dgn

SOIL E. C. LEAST SQUARE MEANS 1993 VS 1994



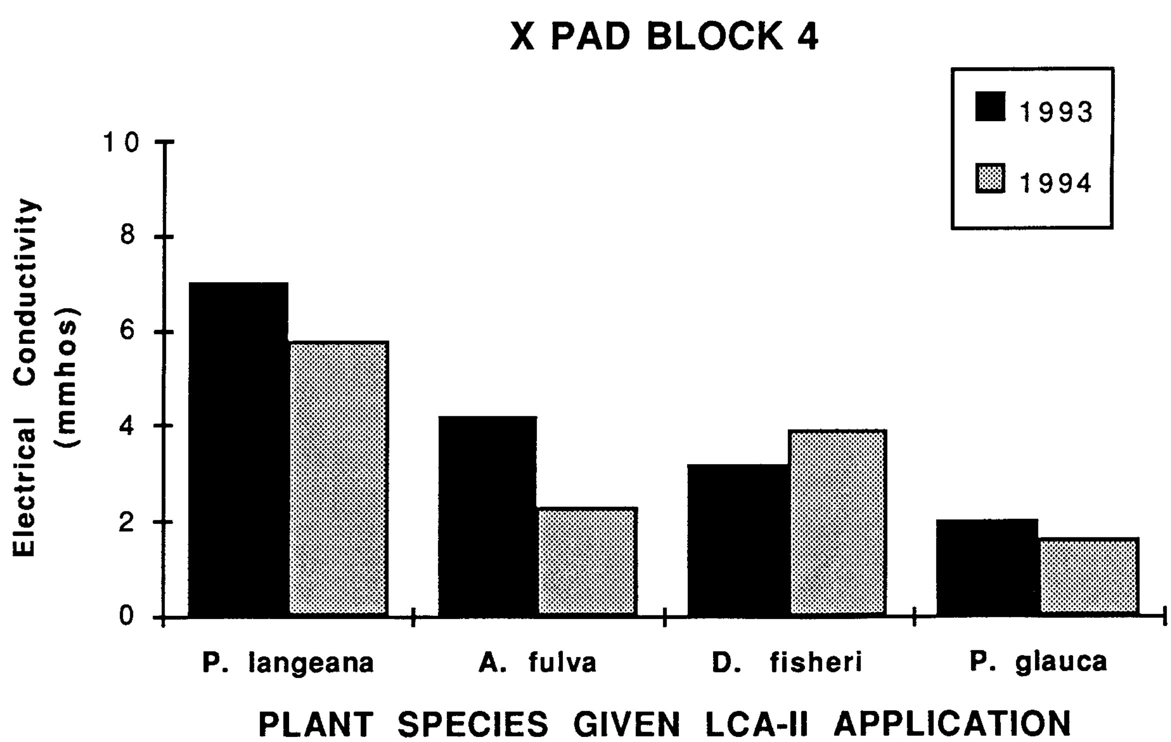


Figure 2

Agroborealis 8:25-29.

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LONG TERM ARCTIC WETLAND REHABILITATION RESEARCH

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Federal and state permits for North Slope oil development stipulate that sites used for exploration and production operations must eventually be returned to a condition acceptable to the regulating agencies and the landowner, for example, the US Army Corps of Engineers permits. Rehabilitation of abandoned gavel pads and roads used for oil and gas exploration and production is an important issue because compliance standards have not yet been established; permits simply require each site to be rehabilitated to the satisfaction of the permitting agency. It may not be feasible to return gravel to the original mine sites because many of the gravel sites are being converted to overwintering habitat for fish. In consultation with the Corps of Engineers and other Federal and state agencies in Alaska, BP Exploration (Alaska) Inc. (BPX) is researching and testing rehabilitation measures for arctic wetland sites in the North Slope oil fields.

The Put River No. 1 revegetation project, located on one of BPX's early drilling pads in the Prudhoe Bay area, is the first long-term study undertaken on environmental rehabilitation in the Alaskan Arctic. The results from this ten-year study and other studies of wildlife use of disturbed and abandoned sites will be used to evaluate options that enhance the wildlife value of the site while retaining adjacent wetland functions and values. The study will identify native plants which survive on gravel sites and provide guidelines for optimum conditions for plant establishment and survival. A total of 144 study plots have been established using seed from 33 native plant species. The project will be monitored until 1998 for species composition, percent cover, and the physical and chemical condition of this substrate. Variables being tested on the 144 study plots include gravel thickness, use of overburden, tillage, and grass seeding levels.

Another rehabilitation study is testing the feasibility and several approaches to using Arctophila fulva (arctic pendant grass) to re-establish or increase habitat value in wetlands. In cooperation with the US Fish and Wildlife Service and the Corps of Engineers, BPX has begun a five-year program to evaluate the feasibility of using Arctophila fulva to increase the habitat value of impoundments created by altered drainage patterns from gravel placement in Arctic wetlands. Research efforts at over 100 North Slope sites will help regulators assess how best to rehabilitate wetland habitats. Additional research on wildlife use of natural and man-made gravel sites and impoundments may help determine the usefulness of these sites for wildlife. Results to date indicate that a number of approaches can achieve the ultimate goal of re-establishing or perhaps enhancing wildlife habitat while retaining adjacent wetland functions and values.

Results from these long-term studies will help both permit applicants and regulatory agencies to develop and to evaluate options for Arctic wetlands rehabilitation.

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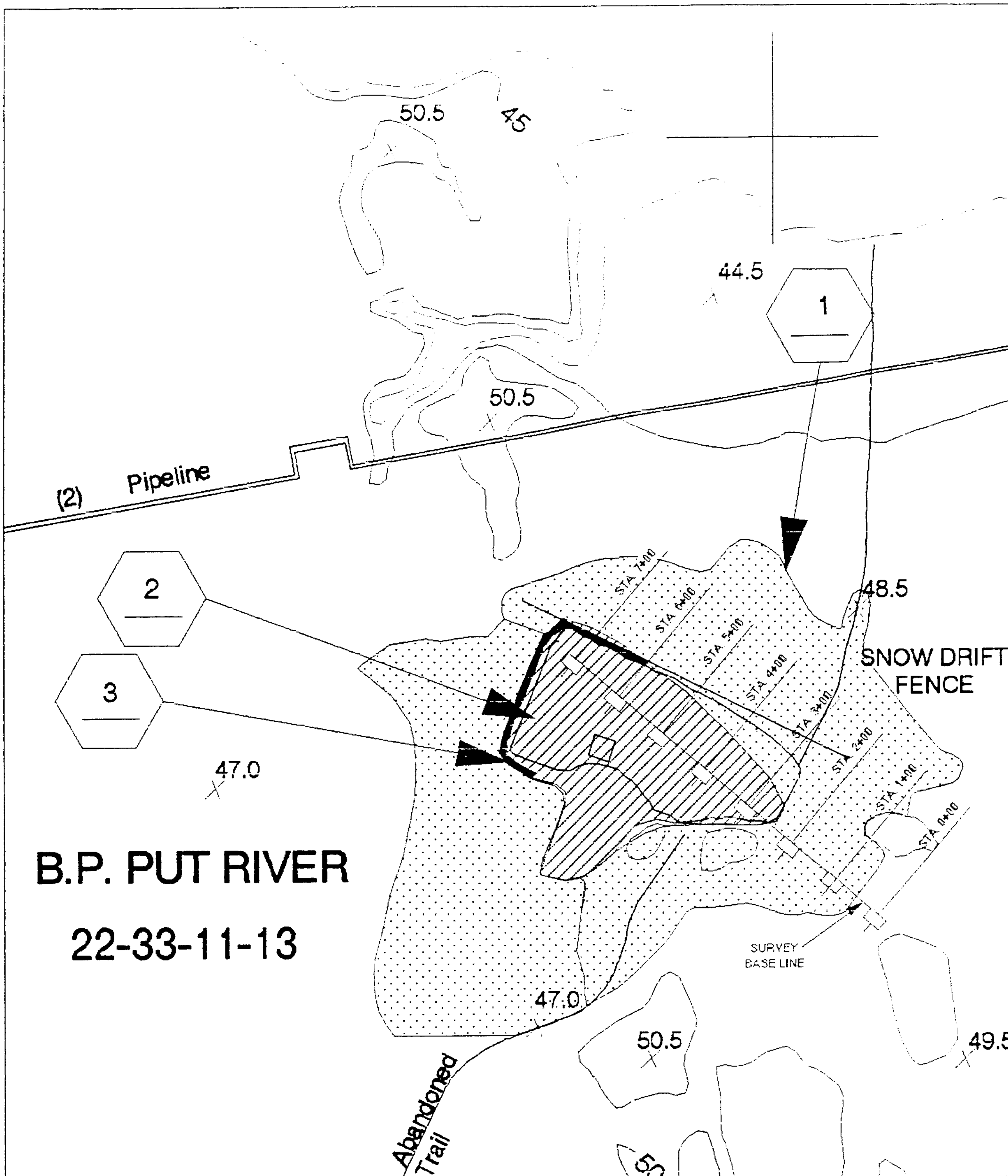


EXPLANATION

- (1) FALL 1988 DORMANT SEEDED AREAS
- (2) GRAVEL REMOVAL SPRING 1989 DORMANT SEEDED AREAS
- (3) MAY 1990 ADDITIONAL GRAVEL REMOVAL, ACTIVE SEEDED JUNE 1990
- PHOTO TEST PLOT, STATION LOCATIONS
- 1968 WELL LOCATION, REMOVED 1989

NOTE:
AREA 1 FERTILIZED SEPT. 88 & SEPT. 89
AREA 2 FERTILIZED MAY 89 & SEPT. 89

Meets Nat. Map Standards for 1" = 300' and smaller

BP EXPLORATION (ALASKA) INC.

B.P. PUT RIVER
(22-33-11-13)
REVEGETATION (1988-89)
LOCATION MAP

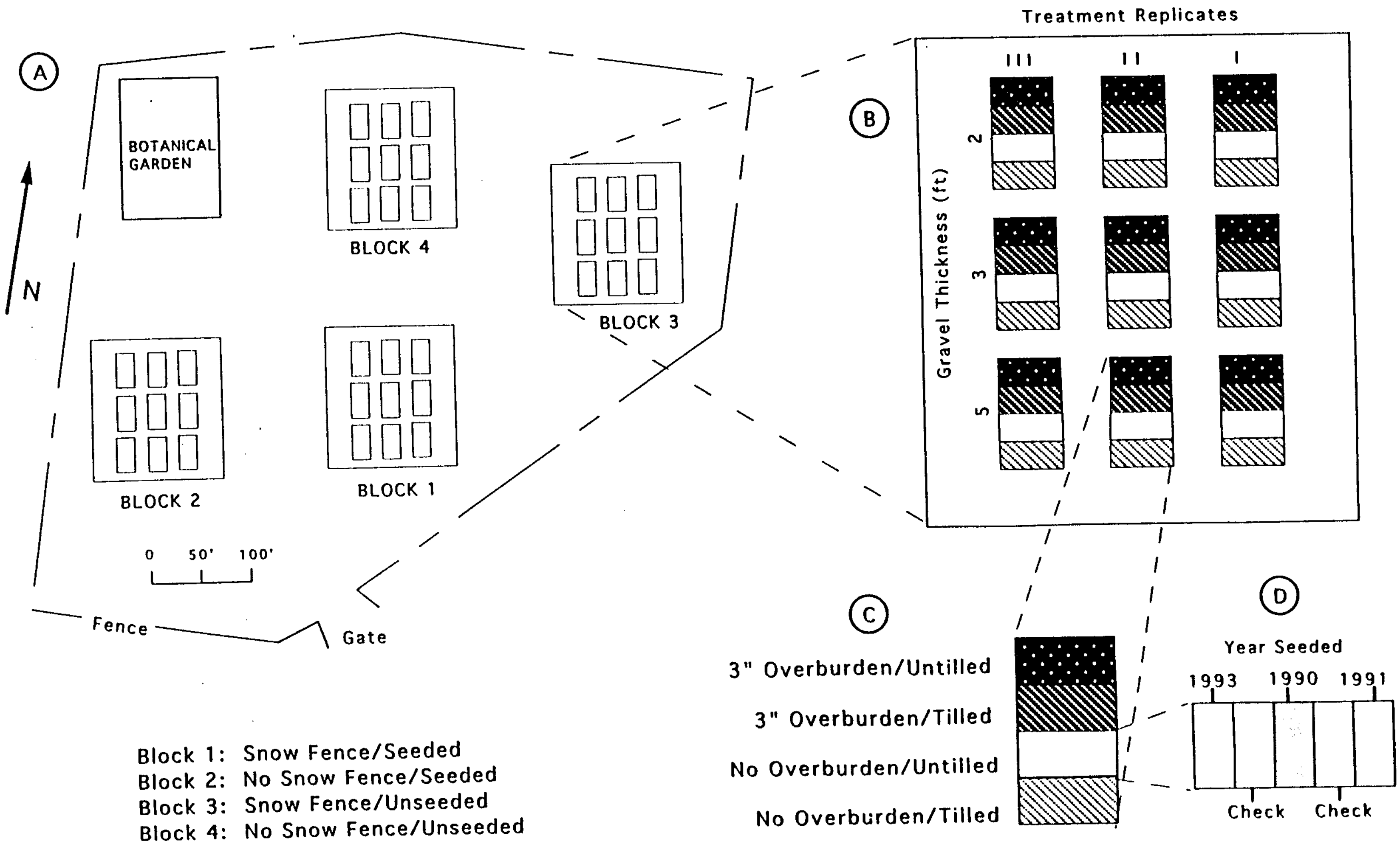
DATE DRAWN	DATE REVISED	CHECKED BY	SCALE	SHEET
12-7-90		SCL / EJK	1" = 250'	2 OF 3

Translated from BPREVEG.DGN

Base Map from 1973 Photography updated 1988

Gravel Vegetation Experiments —

Alaska North Slope



SESSION RE14:

RESTORATION, PROTECTION, AND CREATION: BENEFICIAL USES OF DREDGED MATERIAL

Dr. Mary C. Landin, Chair

PHOSPHORUS CHARACTERISTICS OF CREATED DREDGED MATERIAL MARSHES AS COMPARED TO SIMILARLY AGED NATURAL MARSHES

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Created wetlands generally are not similar to natural wetlands due to their relatively young age. This has led to speculation on how long it will take a created wetland to function as a natural wetland. However, no research has been conducted to determine if created wetlands are similar to comparably aged natural wetlands. The objective of this study was to determine if surface sediments of marshes created from dredged material have phosphorus concentrations similar to those of comparably aged natural marshes in the Atchafalaya River Delta. Delta marshes were split into three age classes, young (1-3 yrs), intermediate (5-10 yrs), and old (15-20 yrs). One created and one natural marsh was chosen from each age class. An additional natural marsh was chosen from the 15-20 yr age class. Where possible, marshes were stratified by elevation (low, mid, and high). Three plots were established within each strata. Soil phosphorus concentrations were determined by chemical extraction of sediment samples (Olsen and Sommers, 1982; APHA, 1985) collected from each plot in November and December of 1993 and in January, May and July of 1994.

Because no seasonal trends in soil phosphorus were apparent, all data for each phosphorus form was combined to obtain overall means (Tables 1 and 2). At mid elevations, old and intermediately aged created marsh sediments had mean phosphorus concentrations which were similar to or greater than mean concentrations in comparable aged natural marsh sediments (Table 1). Except for organic phosphorus, mean phosphorus concentrations in young created marsh sediments tended to be lower than in natural marsh sediments and lower than in other created marsh sediments (Tables 1 and 2). Mean phosphorus concentrations in the old created marsh were similar to mean concentrations in old natural marshes at low elevations but not at high elevations (Table 2). Also in both created and natural old marsh sediments, mean phosphorus concentrations were highest at the high elevation for all phosphorus forms except calcium-bound phosphorus which was lowest

Table 1. Mean concentrations of soil phosphorus (P) forms at mid elevation in natural (N) and created (C) marshes which belong to three different age classes.

Marsh (Age)	Fe, Al-P * ug P/g soil	RS-P ug P/g soil	Ca-P ug P/g soil	Org-P ug P/g soil	Total P ug P/g soil
N (15-20 yrs)	88 (8.7)#	52 (5.0)	303 (7.6)	83 (11.5)	524 (18.5)
C (15-20 yrs)	62 (5.8)	31 (5.4)	316 (8.6)	92 (19.7)	501 (23.4)
N (5-10 yrs)	92 (10.5)	52 (9.5)	252 (9.5)	71 (15.6)	463 (24.2)
C (5-10 yrs)	102 (5.8)	49 (7.7)	241 (6.6)	165 (19.4)	557 (15.2)
N (<1-3 yrs)	85 (6.8)	45 (6.3)	236 (5.3)	65 (10.9)	430 (14.8)
C (<1-3 yrs)	37 (4.3)	17 (4.1)	155 (2.7)	49 (5.3)	258 (8.9)

* Soil phosphorus forms are iron-and aluminum-bound P, reductant-soluble P, calcium-bound P, organic P and total P.

Mean with one standard error in parentheses.

Table 2. Mean concentrations of soil phosphorus (P) forms at low and high elevations in natural (N) and created (C) marshes.

Marsh (Age)	Elevation	Fe, Al-P * ug P/g soil	RS-P ug P/g soil	Ca-P ug P/g soil	Org-P ug P/g soil	Total P ug P/g soil
N (15-20 yrs)	Low	103 (4.7)#	60 (7.2)	285 (6.4)	98 (11.0)	543 (11.9)
C (15-20 yrs)	Low	74 (5.3)	44 (5.2)	282 (5.5)	88 (13.1)	489 (16.8)
C (<1-3 yrs)	Low	54 (4.4)	29 (4.8)	176 (5.6)	34 (8.5)	289 (11.3)
N (15-20 yrs)	High	194 (19.4)	111 (14.7)	261 (6.6)	171 (23.7)	737 (43.8)
C (15-20 yrs)	High	107 (7.5)	68 (20.0)	221 (10.1)	174 (22.5)	556 (20.7)
C (<1-3 yrs)	High	35 (4.2)	19 (4.3)	162 (4.0)	34 (7.5)	247 (7.5)

* Soil phosphorus forms are iron-and aluminum-bound P, reductant-soluble P, calcium-bound P, organic P and total P.

Mean with one standard error in parentheses.

at the high elevations (Table 2). Calcium-bound phosphorus was the dominant fraction for all sediments accounting for 33% to 67% of the total soil phosphorus (Tables 1 and 2).

These results indicate that in the Atchalalaya Delta, the young created marsh sediments do not have similar phosphorus characteristics as natural marsh sediments. However, sediments from mid elevations in the created marshes do develop phosphorus characteristics which are similar to those of natural marsh sediments after three to five years (Table 1). Adams (1978) found that a two-year-old tidal freshwater marsh created from dredged material had similar total phosphorus concentrations as a nearby natural marsh while Craft et al. (1988) concluded that a saltmarsh created from dredged material would take greater than 15 years to develop similar phosphorus pools as a nearby natural marsh. Results from this study suggest that created marshes in the Atchafalaya Delta develop natural phosphorus characteristics due to sediment deposition during river flooding. This hypothesis is currently being tested.

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CONSTRUCTION OF A DEMONSTRATION MARSH USING LARGE-SCALE CUTTER HEAD DREDGING EQUIPMENT IN GALVESTON BAY, TEXAS

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Abstract

The proposed Houston Ship Channel (HSC) Modernization Project and the Recommended Beneficial Use Disposal Plan (the BUG Plan) for the bay reach of the HSC will entail the removal and disposal of approximately 67,232,000 cubic meters of dredged material over the 50-year life of the project. Approximately 1,720 hectares(ha) of marsh habitat is proposed to be created from the dredged material. To evaluate the technical feasibility of the plan, the Beneficial Uses Group (the BUG) recommended that a large-scale demonstration project be constructed using materials, equipment and techniques that would replicate those that are envisioned for the BUG Plan.

Introduction

The purpose of the Demonstration Marsh Project is to identify essential elements of environmental and engineering design practices and management requirements needed for the establishment, growth, and survival of created marsh. These include identification of the key operating requirements for typical dredging equipment most likely to be utilized for the future placement of new work and maintenance dredged materials for beneficial uses. To this end, the Port of Houston Authority (the PHA) and the U.S. Army Corps of Engineers (the Corps) constructed a 100 ha demonstration site in Upper Galveston Bay.

Project Design

The essential elements of the marsh design for construction are: 1) construction of a hydraulically-placed containment levee using suitable materials such as stiff clays, sand and shell; 2) placement of fill material for marsh substrate typically using fine-grained materials associated with maintenance dredging; and 3) construction of levee protection measures to prevent erosion and protect the marsh interior. Accordingly, numerous types of geotechnical investigations are required to successfully construct these elements in the open waters of Galveston Bay.

Geotechnical Investigations

Subsurface investigations of the HSC in the form of core borings performed by the Corps in 1962, 1963, 1972 and 1992 were analyzed by the Joint Venture for evaluation of the dredgeability, transport, and construction uses of the subsurface material. A large portion of the new work materials were identified as medium to stiff clays, stiff to hard clays, sands, and shell suitable for hydraulic placement of containment levees. Results of this analysis indicated that suitable quantities of levee materials below the channel prism of the HSC were available near the proposed demonstration marsh site. Detailed geotechnical investigations were completed.

Development of Bioengineering Criteria

One approach to designing marshes that function similar to natural marshes is to create marshes with physical attributes (i.e., elevation, geomorphology) that approximate those of existing marshes. It is well established in the scientific literature that physical attributes of marshes influence the distribution of plants and animals. For example, marsh plants tolerate only a narrow elevation range in Galveston Bay. Therefore, to ensure that vegetation established in created marshes is similar to natural marshes, the dredged material must have the approximate elevation range exhibited in nearby existing (reference) marshes.

Design criteria for creating marshes that are similar to natural marshes in Galveston Bay are not widely known. The National Marine Fisheries Service (NMFS) under contract with PHA undertook a study to:

- Characterize existing (reference) marshes near the beneficial use sites by measuring a variety of habitat attributes from aerial photography and in- field surveys;

- Measure and compare various aquatic species usage for different types of habitats present in the reference marshes; and

- Determine which habitat features of the reference marshes should be constructed and tested in the Demonstration Marsh for application to the design of beneficial use sites recommended in the Beneficial Use Disposal Plan.

Results and Summary

Construction of the Demonstration Marsh site has fulfilled its purpose many times over as several key operational, engineering and environmental design elements are being refined and/or developed from construction and monitoring of the site.

The benefits derived from construction of the demonstration marsh are many; some of these are discussed below.

1. Construction of a 100 ha Demonstration Marsh provided the BUG with the opportunity to observe construction, planting, and biological utilization of a created marsh on a scale equivalent to the individual marsh cells proposed in the Beneficial Use Disposal Plan for the HSC Widening and Deepening Project.

2. Refinement of construction techniques for marsh creation, both for levee construction and fill placement, were achieved.

3. Utilization of data obtained from the NMFS survey of natural reference marshes enabled the BUG to develop and implement bioengineering parameters to create a marsh that is functionally equivalent to natural marshes in Galveston Bay.

4. New habitats such as resting, nesting and feeding areas created by the construction of the clay and sand levee and de- watering and consolidation of the fill material have been heavily used by both shorebirds and colonial waterbirds for nesting, resting and feeding.

Future Work Items

To complete development of the Demonstration Marsh, ditching of the site will be carried out to assist the natural shrinkage and consolidation of the fill material to the desired elevation range established by the NMFS survey of natural marshes in the local area. Once the fill area reaches a favorable elevation range, the marsh area will be planted using a planting design developed by the BUG to assist in the development of final plans and specifications for marsh creation proposed in the BUG Plan. Monitoring and evaluation of marsh development will be continued to further the lessons learned to date.

CONSTRUCTION OF A MARSH IN THE LABRANCHE PONDS OF LOUISIANA

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Abstract

This paper describes creation of a marsh in 360 acres of ponds in southeastern Louisiana. This is the first project funded under the Coastal Wetlands Planning, Protection and Restoration Act. Within a year, wildlife usage was high and fishery utilization began. The project will be monitored for 20 years.

The flotant marsh on the south shore of Lake Pontchartrain, Louisiana was part of a plantation, but uncultivated, for many years. From 1905-1910, a land developer bought and drained over 8,000 acres of these wetlands. In September 1915, a hurricane pushed large volumes of water into Lake Pontchartrain and flooded these drained lands.

In 1990, the Corps with its experience in using dredged material to build wetlands, suggested creation of marsh in these ponds as one of the first projects to be funded under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Even though this project was expensive in terms of cost per habitat unit, the CWPPRA Task Force selected it because they felt it was a showcase project, sure to succeed.

Biologists surveyed adjacent marshes and determined the optimum marsh elevation was from 0.75 to 1.34 feet NGVD. They recommended that the 360-acre area be 70 percent marsh and 30 percent water after five years. Plans called for pumping 2.5 million cubic yards (cy), filling the area to + 4 feet NGVD. Originally, borrow was to have been taken from lake bottoms directly adjacent to the Bonnet Carre Floodway (Figure 1). Analysis showed this material to be heavy sand. The lake bottoms in front of the area were a lighter material, more suitable for marsh creation. The design called for a containment levee around the entire area. Plans provided for the dredged material to flow across the area, dropping its sediment, then exiting nearly devoid of sediment.

T. L. James and Co. Inc. started construction of containment dikes in December 1993, began pumping began in March 1994, and completed their work in early April. They used a much larger dredge than expected, which lowered project costs. However, faster pumping filled the area more rapidly than anticipated and sediment began depositing in a canal outside the marsh creation site. A closure at the southern end of this canal was breached. The sediment filled a deep area in the canal, still within the easement. Due to the loss of this sediment, the contractor had to pump 2.7 million cy. In July 1994, a crop duster dropped 8,000 pounds of Japanese millet seed. The site had a heavy cover of millet by August. For the next 20 years, habitat types, sediments, water elevations, and vegetation will be monitored.

Once the area was vegetated, the CWPPRA Task Force held a news conference. The project got excellent local publicity, including a front page story in the New Orleans paper. High numbers of waterfowl used the site during the winter. By spring, natural ponds and bayous formed within the site and small fish were observed. Wading birds, alligators, nutria and endangered species such as brown pelicans and bald eagles use this marsh. Numerous motorists view the newly-created marsh as they travel I- 10 between Baton Rouge and New Orleans. This project is a true CWPPRA success story.

INNOVATIVE ALTERNATIVE FOR WETLANDS RESTORATION: TRANSPORT AND DISTRIBUTION OF DREDGED MATERIAL BY LARGE HOVERCRAFT

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Abstract

Thin layer placement of dredged material in wetlands areas

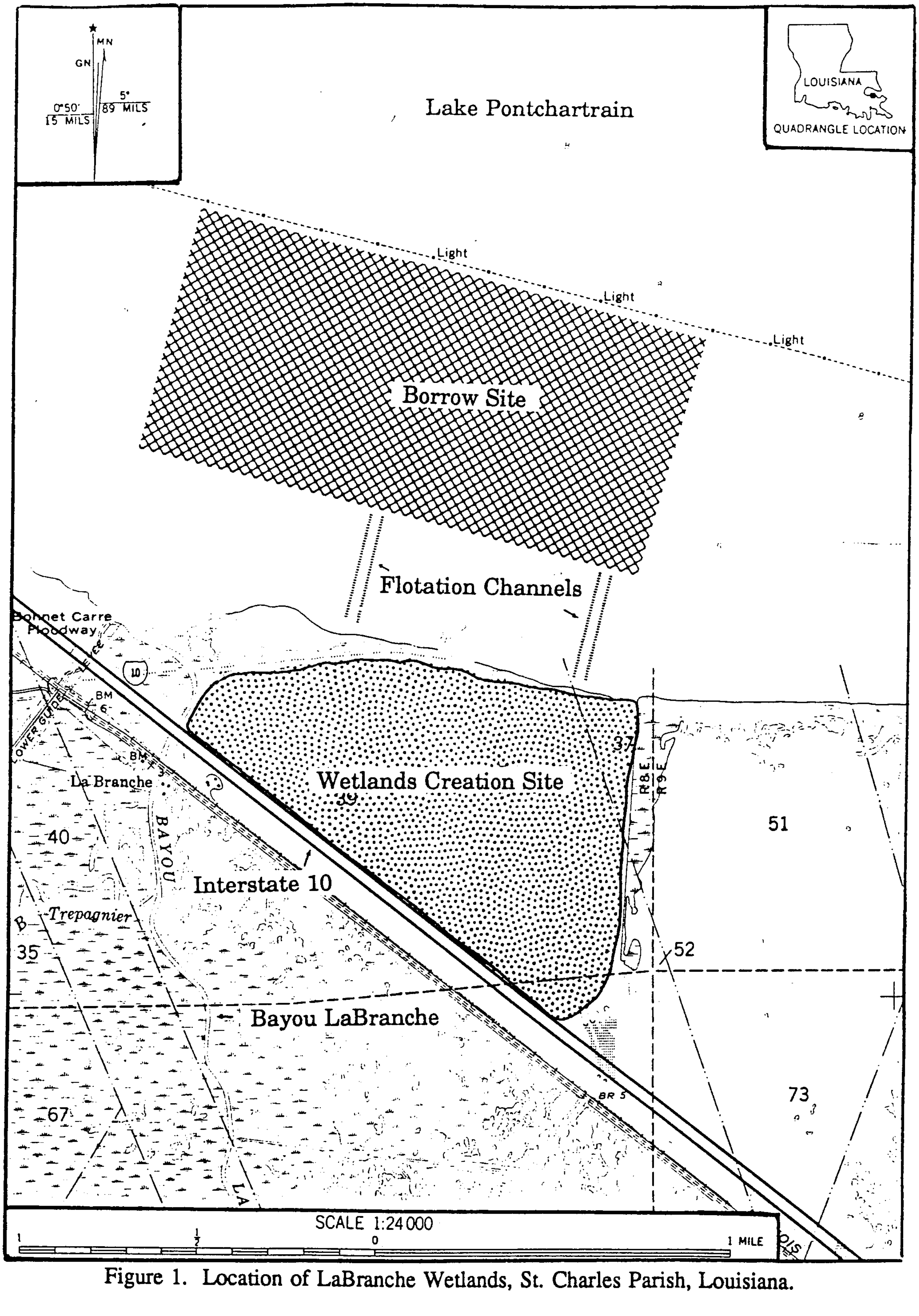

Figure 1. Location of LaBranche Wetlands, St. Charles Parish, Louisiana.

has been proposed as a viable disposal alternative that could address the need for sediment and nutrient resources for deteriorating wetlands. The focus of this study addresses the technical and economic feasibility of a conceptual "hoverbarge" as a transport mechanism for dredged material nourishment of wetlands.

Transport and distribution of dredged material in coastal wetlands is motivated by the need to address severe and ongoing losses due to subsidence and impacts of anthropogenic activities. Hovercraft have been proposed as an environmentally sensitive transport alternative. The scope of the study was constrained by limited available data pertaining to environmental effects of hovercraft traffic on wetlands and lack of actual performance and cost data.

Environmental Effects

Studies of the impact of hovercraft on wetland soils and vegetation are limited but generally seem to indicate that effects are minimal and temporary, except under certain circumstances (Planning Systems Inc. 1984). However, the effects of continuous operation over a restricted area has not been evaluated.

Technical and Economic Feasibility

Technical Feasibility. At the time of this study, a hoverbarge prototype had not been developed. The technical feasibility of hovercraft transport of dredged material into wetlands was evaluated based on identifiable technical issues, status of the current technology, necessary physical and operational modifications, and potential interfaces with dredging operations. The principal technical issues include: load capacity, stability, loading/offloading operations, performance, and environmental considerations.

The load capacity of hovercraft is limited; currently 75 tons maximum domestically. The maximum feasible payload size is projected to be 300 tons, according to industry experts. A 300 ton payload corresponds to a volume of approximately 247 cuyd, depending upon the material and solids concentration, as compared to the 1500 to 4000 cuyd capacities of conventional barges. Interim storage of sediments would be required because typical dredged material production far exceeds foreseeable utilization rates. The stability of hovercraft in transporting bulk cargo is unknown. Trim and balance problems have been reported under certain conditions. Modifications of the craft to address this concern, as well as to facilitate loading, offloading and distribution of materials, would be required. Operating performance in a low speed, high capacity application has not been demonstrated.

Economic Feasibility. The economic analysis of the hoverbarge concept was based on actual capital and operating costs of military hovercraft, the LCAC and the LACV30, and industry estimates. Because significant differences exist between the proposed hoverbarge prototype existing hovercraft, the cost analysis cannot be considered to be definitive. However, an estimated cost range was established which was compared to pipeline transport, the most economical conventional transport alternative for the volumes and distances projected (Souder, Paul S., Tobias, Leo, Imperial, J.F., Mushal, Frances C. 1978).

Conclusions

From a technical perspective, the hoverbarge concept appears to be viable but the load capacity of hovercraft is limited and the volume of sediments that can be transported is small relative to conventional means of transport. Estimates indicate that due to high capital and operating costs, the use of hovercraft to transport and distribute slurried sediments will be significantly more expensive than other methods available. Environmental justification as a compensating factor has not been adequately demonstrated at this time.

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RESTORATION OF FORESTED HARDWOOD WETLANDS FOLLOWING DREDGE MINING FOR MINERAL SANDS ON RELICT BEACH IN NORTHEAST FLORIDA

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The forested hardwood wetland reclamation site at RGC are reclaimed following dredge mining for mineral sands on relict beach ridged in NE Florida. Wetlands are replaced as "acre for acre" - "type for type" for wetland disturbed by our operation. RGC utilizes extensive detailed surveying during critical stages in wetland site preparation to create appropriate gradients to insure proper hydrology within the site, delineation of appropriate wetland vegetation planting zones and to create microtopography including hammocks within these zones. Additionally, RGC collects seeds from wetland species on-site which are utilized to grow the three gallon nursery stock planting in our sites.

SESSION SM7

STEWARDSHIP AND MANAGEMENT: OTHER MANAGEMENT TECHNOLOGIES I

Ms. Mary J. Flores, Chair

DEVELOPMENT OF A REGIONAL WETLAND PRESERVATION PLAN FOR VERNAL POOLS IN THE SANTA ROSA PLAIN, SONOMA COUNTY, CALIFORNIA

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Vernal pools are seasonal wetlands that are formed in depressions on soils that have either clay or silicate indurated layers. In California, an extremely diverse flora has evolved in association with vernal pools. These areas may represent the most floristically diverse habitats in western North America relative to their aerial coverage and include 69 vernal pool endemic species many of which have federal or state protection under the federal and state Endangered Species Acts. In addition, these areas are diverse with respect to invertebrates, including solitary bees that have co-evolved with some of the vernal pool endemic plant species.

Over the past four decades vernal pool habitats in the Santa Rosa Plain, Sonoma County, California have declined in area due to a combination of more intensive urban development, changes in agriculture from open pasture land used by dairies to intensive land use in the form of vineyards, orchards, and a variety of row crops. As much as 80 percent of the vernal pool and other seasonal wetland habitats may have been lost during the changes in land use over the recent past. Implementation of Clean Water Act for wetland fills and the loss of populations of three species of federally- and state-listed plant species has recently caused a conflict between local land development, City and County Planning Departments, local wastewater agencies, private land owners, farm and agricultural interests with federal and state regulatory agencies. As a result of these conflicts and issues of cumulative impacts to wetlands and wetland dependent resources such as the rare plant species, the San Francisco District of the Corps of Engineers temporarily suspended issuing nationwide 26 permits. This suspension of the nationwide permit created significant controversy, but has lead to the recognition by most parties that a plan could be developed to address the issues.

In order to resolve the conflicts with land use and wetland resources a Vernal Pool Task Force was formed and was composed of federal, state, and local agencies, local development and agricultural interests, and local environmental groups. The Task Force was resolved to develop a Vernal Pool Ecosystem Preservation Plan that would identify areas for wetland and rare species protection, and areas wetland creation, restoration, or enhancement. Further the Plan would develop a regulatory permitting process that would streamline permitting for those proposing to develop in areas that were considered to be low quality wetlands where impacts would to the resources would be minimal.

A contract was awarded to CH2M HILL in April 1994 to work with the Task Force in developing the plan. The Plan included: 1) development of ground rules that the Task Force could operate under to develop consensus of the process, 2) a set of goals and objectives, 3) collection of biological data from existing sources on the wetland resources and rare plant and animal species and develop a conservation strategy for the rare plant populations, 4) describe the existing regulatory environment and how the current regulatory process has not been adequate, 5) describe the historical and existing land use conditions, 6) develop an evaluation criteria of wetland areas and categorize lands in the study area in terms of vernal pool habitat quality, then develop a potential preserve system, 7) identify non- regulatory mechanisms that could potentially be used to preserve vernal pool ecosystem resources, 8) outline a regulatory process that would streamline permitting for low quality areas while achieving specific conservation goals, 9) outline future areas of research needs, regulatory implementation, and establishment of preserves such as through mitigation banks.

RESOURCE MANAGEMENT AND PLANNING FOR CALIFORNIA'S CENTRAL VALLEY GRASSLAND/VERNAL POOL RANGELANDS

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Future growth of the Central Valley's population centers will inevitably result in continued urbanization of rangelands. These grasslands also support shallow seasonal ponds, often called vernal pools, that have been effectively managed by livestock operators for centuries. Since the mid-1980's, vernal pools have been regulated under the Clean Water Act. With the recent listing of the "fairy shrimp", they are now also regulated under the Endangered Species Act. The combined effect of regulation from different federal and state agencies complicates continued range management, and has resulted in planning and regulatory processes which often have significant economic impacts without corresponding environmental benefits.

Federal regulation under the Clean Water Act (CWA) and the Endangered Species Act (ESA) is a significant concern for agricultural managers and has made local land use planning particularly difficult. The perceived inflexibility of both the CWA and the ESA has caused constant controversy regarding land use decisions. A review of both laws indicates that the flexibility inherent in both can allow for reasonable solutions. In addition, the current Administration has indicated a willingness to return to workable solutions that are based on incentives as opposed to punitive measures.

Vernal pools, considered by resource agencies to be rare until recently, are known to be widespread along the valley's eastern terrace landscapes. Habitat distribution data developed recently for twenty counties indicates significant opportunities for resource management and conservation of the habitat without affecting historic ranching practices.

A case study is presented to model a resource management plan for vernal pool/grassland habitat to use the flexibility available in CWA and ESA policy. In this scenario, mitigation funds from urbanizing areas that have traditionally been applied to on-site solutions can be applied to a management strategy that includes acquisition of conservation easements, mitigation banking, habitat restoration, and habitat enhancement through agricultural management practices. Livestock grazing has proven over centuries to be a sustainable use of California rangelands relative to vernal pools. Ranchers that wish to sell conservation easements can therefore be provided with financial incentives to continue to manage lands for livestock, while preserving desired biodiversity in the grassland/vernal pool landscapes. Economic development within urban planning areas can then proceed without significant delay or the forgone economic opportunity currently associated with preservation of small habitat preserves isolated by urban uses.

This new approach to CWA and ESA mitigation is sound from a conservation standpoint, as it optimizes the use of required mitigation funds to acquire easements and restore habitats, while reducing red tape, maintenance and monitoring costs, and directing financial resources to the historic land stewards who have preserved these rangelands historically.

EVALUATION OF MECHANICAL AND CHEMICAL METHODS FOR CONTROL OF MALALEUCA (<u>MELALEUCA QUINQUENERVIA</u>) IN SOUTHERN FLORIDA, USA

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It has been estimated that melaleuca trees have invaded and occupy thousands of hectares in southern Florida and are spreading to new areas at a rate of about 1,000 ha/ year; stands with as many as 5,000 stems per ha have been reported (DiStefano and Fisher, 1983/1984). Attempts to control mature melaleuca at Lake Okeechobee have resulted in re-establishment of dense stands of seedlings (Stocker, 1982). A factor in the aggressive colonizing ability of this species is that trees are often multistemmed and flower up to three times per year. Numerous flowers are borne on the current season's branch growth, the branches continue to grow and leaves are formed beyond the flowers (Meyers, 1983). Approximately 250 very small seeds may be formed in each closed, woody capsule (Woodall, 1982). Woodall reported that seed release occurs when the moisture supply to the capsule is interrupted by fire, frost, wind, natural pruning or human activities. Alexander and Hofstetter (1975) estimated that a single 10 m tall tree could store over 20 million seeds in its capsules.

Woodall (1983) studied the establishment of melaleuca seedlings in the pine-cypress ecotone of southwest Florida. He found that seeds were long-lived on or in the soil and lost no germination ability after 10 months of shallow burial in a swamp but seeds buried in a well drained area lost two-thirds of their viability in this time span. He also reported that burial prevented germination. Moist to saturated soils for several months, but rarely flooded, provide optimum conditions for tree establishment (Myers, 1983).

The objectives of this study were to determine the effects of selected treatment methods on vegetation regrowth and to assess their results in control of melaleuca. Seven approximately 3.3 ha plots were established near Moore Haven, Florida along the southwest Lake Okeechobee levee road. After mechanical uprooting, stacking and burning all melaleuca trees, the areas were harrowed with a disk. Two plots were treated with Rodeo herbicide, two with Velpar L, one planted with common baldcypress (<u>Taxodium distichum</u> (L.) Richard) and red maple (<u>Acer rubrum</u> L.), one was a control with no further treatment and one had regrowth melaleuca manually removed. One and two years later, results of the these treatments were assessed using transect lines and quadrats. A total of 106 species of plants were found, 90 species each study year were within the quadrats, 16 new in 1993, 16 absent from the 1992 study.

Frequency of species and percent cover increased from 1992 to 1993. Dog- fennel (Eupatorium capillifolium (Lam.)) small and eastern baccharis (Baccharis hamilifolia L.) were cover dominant and most frequent in 1992; these two species were most frequent in 1993 with a variety of species cover dominant. Soil analyses indicated that the control plot differed from the planted and Rodeo herbicide plot in higher percent organic matter and sulfur content. The berm area where the trees were burned was higher in phosphorus and potassium than other areas of the plots. The control plot had the most melaleuca regrowth. The fewest melaleuca trees (3) were counted in the study area of Plot 1, which was not treated with herbicide, it is possible that the 1992 high water level in this plot may have prevented tree regrowth. The highest concentration of Velpar L herbicide treatment plot had 11 trees, the second fewest.

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SELECTIVE CONTROL OF PURPLE LOOSESTRIFE WITH TRICLOPYR

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Purple loosestrife is an invasive plant that threatens biodiversity of natural wetlands in over 40 states. This exotic species can displace native vegetation through rapid growth and heavy seed production, resulting in monotypic stands that dramatically reduce vegetative diversity, while providing little food or habitat for associated wildlife. Purple loosestrife can establish and thrive in areas where natural and man-made disturbances (including plant control techniques) eliminate native wetland plant communities. Use of conventional, non- chemical management techniques, e.g., flooding, draining, cutting, burning, are inherently non-selective and seldom result in long- term control of purple loosestrife infestations. Approved herbicides offer a selective technique for reducing purple loosestrife levels, eradicating pioneer colonies of the plant, and restoring native wetland communities. The objectives of this study were to evaluate effectiveness of the herbicide triclopyr on purple loosestrife, and to monitor changes in the associated wetland plant community following triclopyr treatment. This research resulted in a chemical technique for controlling purple loosestrife in wetland communities that includes minimizing damage to non-target plants, particularly monocots, while offering a potential for restoring a diverse plant community. Results from this work will be used to provide initial guidance for the selective control of purple loosestrife using triclopyr. Data will also be used to support the National aquatic registration of that herbicide.

INCORPORATING ECOLOGICAL MOSQUITO CONTROL INTO MANAGED WETLANDS

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Abstract

As a natural component of wetland ecosystems, mosquitoes can become a perceived or a real public annoyance/public health problem. A lack of understanding and communication between wetlands biologists and mosquito abatement personnel has sometimes led to a polarization of viewpoints on the wisdom of wetland mitigation (especially in urban areas) and on proper wetlands management techniques. We propose that an understanding of mosquito biology and use of available control technologies can help wetlands managers minimize mosquito annoyance and mosquito- borne disease threats. A brief overview of the varied life cycles of several important Midwestern mosquito species will be integrated into a discussion of wetland design and management techniques for minimizing mosquito production potential. The informed use of bio-rational mosquito control agents such as insect growth

regulators and pesticidal pathogens will be discussed. Information on mosquito abatement programs in the Midwest and contacts for further information on integrated mosquito management within wetlands will be provided.

Introduction

Wetlands pose many dichotomies and paradoxes both technically and politically. Herein lies one person's attraction to them and another's aversion. One question is this.... Are wetlands breeding sites for disease vectors or sublime ecosystems providing a myriad of benefits to humans? The answer can sometimes be both, but, of course, we would prefer to maximize benefits while minimizing health risks. This is phenomenon helps explain why the governmental policy pendulum has swung from subsidizing the draining and filling of wetlands to encouraging their preservation and restoration.

Let's take a short walk through history. Up through the 1920s in the Carbondale, Illinois' area (Jackson County), there were over 2,500 cases of malaria a year that resulted in 50 to 100 deaths. In response to this health threat, a multi-agency campaign drained 60 acres of swamps and ponds, lowered a lake to provide a clear water edge, regraded 45 miles of streams, oiled natural breeding sites, stocked ponds and open wells with top minnows, and conducted extensive inspections and educational measures. The resulting number of malaria cases dropped the following year to 19.

Today, the policies of no net loss and preferred on-site mitigation force the issue of creating wetlands in relatively dense human population areas. Various perspectives arise from the history of human relationships to wetlands. Some people would like to see a revival of presettlement acreage of wetlands, while others decry any creation of wetlands.

We propose an understanding and coordination that deals with the reality of the need to conserve wetland resources while considering disease and mosquito annoyance concerns. Many such efforts are occurring between mosquito control practitioners and wetland managers. For the purpose of focus, we center our discussion on conditions in the Midwest. The situations where it is most important to consider mosquito control design features are in the creation of mitigative wetlands in urbanizing settings. Another sensitive area can include zones of higher horse populations because of concerns with equine encephalitis. The development of ecologically responsible, least-toxic mosquito control techniques requires the identification of target species, an understanding of their natural history, and their vector potential.

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Table 1
Ecological Management Summary
for Control of Mosquitoes*

Taxon	Primary Health Concern	Habitat Requirements	Life Cycle	Targeted Management
Aedes/Psorophora	Aggressive human biters, no major viruses	Flood pools and other temporary water sources. Often in urban settings	Female lay eggs on detritus, in cracks in soils above high water level. Eggs hatch in water with low dissolved oxygen.	• Maximize flow through • Minimize soil-exposing drawdowns during times of high adult mosquito populations • Raise water levels • Maximize oxygenation
Woodland Aedes	*A. triseriatus* is vector of LaCrosse Encephalitis virus	Seasonal woodland pools, tree holes, and artificial containers	Females lay eggs on leaf litter and other periodically-inundated detritus. Small mammals are hosts.	• Eliminate incidental water containers. Not a threat in typical created wetland • Use BTI early in spring on ephemeral pools
Culex pipiens	St. Louis Encephalitis virus	Any waters high in organic matter	Female lay egg rafts on water surface. larvae are mostly bottom feeders. Adults prefer avian hosts.	• Reduce nutrient inputs • Discourage wading bird hosts • Cover water surface with floating plants
Coquillettidia perturbans	Eastern Equine Encephalitis virus	Vascular aquatic plants Abundant in freshwater marshes around Great Lakes	Eggs on underside of floating leaves. Larvae and pupae use plant stems as sources of oxygen. Avian and mammalian hosts.	• Drawdowns early in season strand larvae on plants (thrive in constant water level) • Manage vegetation (reduce/eliminate cattails)
Anopheles ssp.	Malaria	Cleaner, sunlit waters with some floating vegetation Good water quality	Eggs laid singly on water surface Larvae are surface feeders	• Drawdowns strand larvae and expose them to increased wave action and predators • Maximize windfetch, but shade water where possible • BTI not as effective use methoprene

*Characterization and integrated control of specific problems requires the assistance of a mosquito control professional.

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SESSION CW3

CONSTRUCTED WETLANDS: MINING OPERATIONS

Tommy E. Myers, Chair

OVERVIEW OF WETLANDS RESEARCH AT THE TENNESSEE VALLEY AUTHORITY CONSTRUCTED WETLANDS RESEARCH FACILITY

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Muscle Shoals, Alabama

The Tennessee Valley Authority has constructed a wetlands research facility that was completed in 1992 in Muscle Shoals, AL. The facility consists of a greenhouse, laboratory/office complex, and 32 outdoor mesocosm research cells. Research over the last two years consisted of quantifying plant oxygen transport and nitrogen and phosphorus removal in domestic wastewater. Research is also being conducted on the potential to improve nitrogen by reciprocating water from one wetland cell to another to improve oxygen transport. Future research at the facility will involve remediation of acid mine drainage. A greenhouse study has been initiated to quantify Mn, Cu, Zn, Pb, and Ni removal in acid mine drainage in successive anaerobic and aerobic wetlands.

WETLAND TREATMENT OF MINE DRAINAGE

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Division of Minerals
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Drainage from a mine in northeastern Minnesota contains elevated concentrations of copper, nickel, cobalt, and zinc. A test program was devised to investigate the feasibility of using wetlands to remove the metals from the drainage. Four test plots were built to determine the effect of water level, contact time, vegetation, and surface alterations on metal removal. Optimum removal occurred with low water levels (<5 cm), long contact times (.48 hours), and with a surface amendment of peat and a peat screening material generated as a by-product of commercial peat harvesting. Nickel, which is the major contaminant in the drainage, was generally reduced from 1-2 mg/L to around 0.2 mg/L.

Based on the pilot scale results, 2 full scale treatment systems were built. These systems cover 1.5 to 3 acres and have been in operation since 1992. Although these systems have been successful in removing about 90% of the nickel, only one of the systems has been in complete compliance with NPDES permit requirements. In 1993 and 1994, changes were made to the systems which was not in compliance. The hydraulic gradient was reduced and flow was dispersed. Treatment efficiency has improved, and in 1994, nickel concentrations in the outflow decreased by over 50%, and the system has generally met water quality standards.

SEDIMENT ACCUMULATION RATES IN TVA CONSTRUCTED ACID DRAINAGE TREATMENT WETLANDS AND THE IMPLICATION ON SYSTEM LONGEVITY

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Introduction

The Tennessee Valley Authority is using constructed wetlands to treat acid mine drainage (AMD) at abandoned coal mines in northeastern Alabama. During AMD treatment Fe and Mn oxyhydroxides form a floc sediment layer on the wetland bottom. Little research exists on the long term processing capacity of AMD wetlands. Intuitively, the capacity for retaining this metal floc sediment layer is finite. This study estimates floc accumulation rates and predicts long term capacity for three TVA AMD treatment wetland systems.

Site Descriptions

Wetland systems Impoundment 1 (IMP 1), Impoundment 4 (IMP 4) and Rocky Top 2 (RT 2) were investigated. The three systems are similar in design but vary in water parameters. IMP 1, a four-cell system, collects seepage below an old slurry pond. IMP 4, a three cell system, collects seepage from a reclaimed slurry pond with a pretreatment anoxic limestone drain. RT 2 collects seepage from a reclaimed strip mine. It consists of a pond followed by two wetland cells. Water parameters are described in Table 1.

Table 1. Wetland Characteristics and Water Quality Summary

Wetland System	Age (yrs)	Area (m^2)	Influent Water Parameters (mg/L)				
			pH	Fe	Mn	TSS	Flow (gal/min)
IMP 1	10	5627	6.1	69	9.0	10	13
IMP 4	10	1984	6.5	20	7.0	35	5
RT 2	8	3562*	5.7	45	13	-	68

* does not include pond

Methods and Materials

Each wetland cell was sampled using a 6.1 sqm (20 sq.ft.) grid. Sediment samples and water column depth measurements were taken at each node of the grid. Sediment consists of two visually distinct floc layers. Fe and Mn oxyhydroxide precipitates form a loose "fluffy" floc (FF) layer on the sediment layer surface. Subsequent precipitation causes the layers to de-water forming a compacted floc (CF) layer, representing the long term sediment volume. Sediment samples were visually characterized for metal floc layer depths and selected samples were analyzed chemically for total Fe and Mn (mg/Kg), % total residue in sediment and % volatile residue in sediment.

The compaction rate of the fluffy layer is unknown. This study assumed a conservative one-year compaction rate. Samples were collected June - August 1993. In summer 1993 northern Alabama received a significant decrease in average annual rainfall. In 1993 average rainfall was 38.4 in./yr. compared to 1988-1993 average of 63 in./yr.

Discussion

For each wetland system cell, volumes and accumulation rates of floc, wetland cell volume remaining and operative years remaining were calculated for each wetland system cell (Table 2.).

Table 2. Wetland Cell Floc Accumulation Rates

Wetland System	Area (m^2)	CF Volume (m^3) [a]	FF Volume (m^3)[a]	CF Accumulation Rate (m^3/yr) [b]	FF Accumulation Rate (m^3/yr) [c]	Wetland Cell Volume Remaining [d]	Operative years Remaining [e]
IMP 1							
Cell 1*	2267	18.2	28.36	2.0	28.4	248.7	8
Cell 2	850	9.1	12.3	1.0	12.3	79.5	6
Cell 3	1093	15.6	17.1	1.7	17.1	1 50.7	8
Cell 4	1417	11.2	10.2	1.2	10.2	58.8	5
IMP 4							
Cell 1*	850	13.7	13.6	1.5	13.6	63.3	4
Cell 2	567	17.6	5.9	1.9	5.9	16.5	2
Cell 3	567	25.0	13.9	2.8	13.9	20.7	7
RT 2							
Cell 2*	890	51.9	9.9	7.4	9.9	473.1	27
Cell 3	2672	76.1	91.2	10.9	91.2	1292.7	13

* Influent cell

[a] Compacted and Fluffy Floc Volume based on the following equation: m^3 = [Sum of (X m of floc/sample) x 11.33 m^2]

[b] Compacted Floc Accumulation Rate = Total Compacted Floc Volume in cell / Age - 1 year

[c] Fluffy Floc Accumulation Rate = Total Fluffy Floc Volume in Cell / 1 year

[d] Wetland Cell Volume Remaining (m^3) = [Sum of X m of water column per sample x 11.33 m^2 + Fluffy Floc Volume/Cell]

[e] Operative Years Remaining =[Wetland cell Volume Remaining / (Compacted Floc Accumulation Rate + Fluffy Floc Accumulation Rate)]

As anticipated, excepting cell 3, IMP 1 CF and FF volume decreased in successive cells. In IMP 1, Cell 3 has an additional AMD seep that may explain the higher floc volumes. IMP4 and RT 2 cells showed successive increases in CF volume. NaOH was used at IMP4 Cell 1 outflow until 1990. The slow settling characteristics of the NaOH may explain the higher floc volumes in Cell 2 and 3. 0 During sample collection, Cell 2 was also relatively dry resulting in decreased FF volume. The significant size difference between RT 2 Cell 2 and 3, 890 and 2672 sqm respectively, also contributes to the difference between floc volumes. RT2 Cell 2's low retention time decrease floc formation and settling.

Average operative years remaining are conservative based on the estimated one year FF compaction rate and the low measured water surface elevations due to the drought. The only non-conservative factor in the longevity estimates is scouring. Before cells exceed calculated retention capacity, storm events will potentially cause scouring of the floc. However, other studies have shown vegetation acts as a velocity dissipater stabilizing sediments during storm events (Taylor, 1991).

Conclusion

By directly measuring floc volumes accumulated over a ten year period, this study has demonstrated a tool for predicting the effective longevity of AMD wetlands. Studies have shown that the potency of AMD decreases after 25 years (Brodie, 1995). Current TVA design methods appear to produce systems that last for 20-30 years, yielding adequate system life.

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CREATING WETLANDS ON LANDS DISTURBED BY IRON MINING

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The Mesabi Iron Range, located in northern Minnesota, produces about two thirds of the nation's iron ore. Much of this area is covered by shrub and forested wetland. Since the iron mines typically disturb thousands of acres, it is inevitable that large acres of wetlands are disturbed. Legislation, both state and federal, requires that any wetland disturbed as a result of mining be replaced.

In order to develop an approach to replace these wetlands, a survey of wetlands that have developed on mining lands was conducted. These wetlands were not planned but developed "incidental" to the mining process. Twenty seven wetlands were surveyed and over 50% of these were located on tailings, which are the finely ground waste product produced by the ore processing. Tailings basins cover thousands of acres, and at the completion of mining, could provide an area for wetland creation.

Tailings are comprised of fine silt and clay sized particles, have a pH of around 8.0, and are low in organic matter and nutrients. Despite these characteristics, wetlands did develop in these areas, although vegetation density and diversity was lower than nearby natural wetlands. Vegetation density and diversity in the tailings wetlands, increased during the first 10 years and increased with decreasing distance to natural wetlands.

A series of small test plots (100 square feet) and 1/2 acre demonstration plots were built in two tailings basins in the fall of 1994 to examine: the amount of watershed needed to support a wetland; and the effect of soil amendments, seed mix, and water level on the vegetation type, density, and diversity.

SESSION FA2

ASSESSING WETLAND FUNCTIONS: REGIONAL APPROACHES

R. Daniel Smith, Chair

A GIS-BASED LANDSCAPE SCALE WETLAND FUNCTIONAL ASSESSMENT PROCEDURE

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As part of a wetlands conservation plan for the North Carolina coastal area, the NC Division of Coastal Management has developed a GIS-based wetland functional assessment procedure. The assessment is based on watershed analysis and divides wetlands into both hydrogeomorphic and vegetative cover classes. Functional parameters include wetland type, size, soil characteristics, landscape position, water sources, land uses, and landscape patterns. Parameters are combined to assess the wetland's relatively significance in performing water quality, hydrology, and habitat functions and in contributing to watershed quality. Unlike site-based methods, the procedure allows functional assessment of wetlands over large geographic regions for planning purposes.

WETLAND FUNCTIONS AND VALUES: A DESCRIPTIVE APPROACH

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Abbreviated Paper

For some years now the Regulatory Division of the US Army Corps of Engineers, New England Division (NED), has recognized the limitations of wetland assessment methodologies that generate numerical weightings, rankings and/or averaging of dissimilar wetland functions, which thus unnecessarily bias a project reviewer. For many of these local or national methods the base data is not reported, and it is thus difficult for the reviewer to reconstruct the indicators that were considered to predict the functions of a wetland. This is because the output is conclusive and not descriptive, As a result, NED advocates an approach that includes a qualitative description of the physical characteristics of the wetlands, including the principal functions and values exhibited, and most importantly the basis for the conclusions using "best professional judgment". All readily available data are presented to an interdisciplinary team for evaluation and consensus recommendations to the Corps decisionmaker.

There was an initial concern by applicants and consultants that this approach to wetland evaluation would be unorganized, unpredictable, not legally defensible and difficult to document, In response, NED developed a format to collect and display this information. The format includes a summary wetland evaluation form and backup reference attachments. (Refer to the attached figures and table.) The completed form typically provides the Corps with sufficient wetland information on a single page needed to make permit decisions (i.e. selection of least damaging alternatives, mitigation goals, significance, etc.).

One key advantage of the method is flexibility in terms of documented rationale to predict the occurrence of various functions . This supports the use of best professional judgment. The approach can be used with varying degrees of information (i.e., office vs. field data). The reviewer can easily recover the source of information used to predict the occurrence of a function and/or value. This approach has been used by NED for numerous projects for several years with positive results. In addition, it was well received by the federal resource agencies. The process is not time consuming and averages 1-2 hours per site. NED is currently preparing an informational color booklet that describes this method in detail and illustrates ways to graphically display wetland information to further aid in the regulatory decision making process.

Acknowledgments

We are pleased to acknowledge the efforts of several individuals who have made significant contributions towards the development of the New England (NED) Wetland Evaluation "Descriptive Approach." Lynn Clements, Michael Sheehan and Kevin Slattery offered valuable technical assistance both in the field and in the development of the evaluation form. William F. Lawless, Chief, NED Regulatory Division, Operations Directorate, developed the wetland evaluation guidance from which the approach originated. Torger Erickson, whose skill with Computer Aided Drafting and Design and Geographic Information Systems was a vital contribution to the graphical representation of statistical application of this wetland evaluation. Both Tina Mah and Mark McInerney provided the

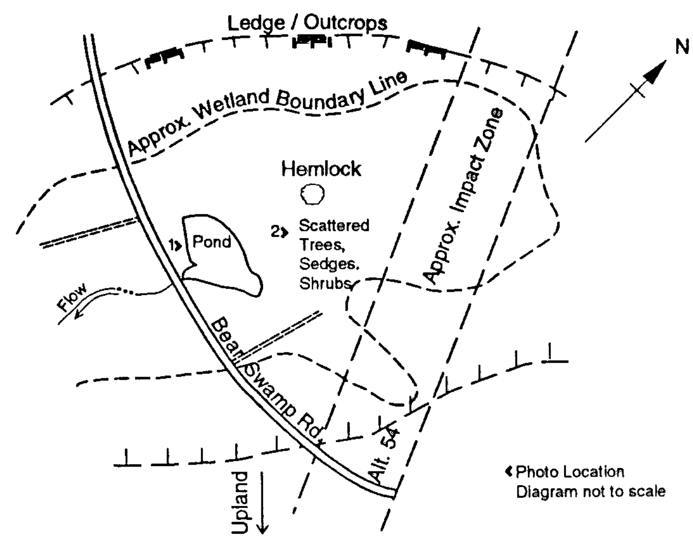
Species List WD1-1
Vegetative

Common Name	Scientific Name
Slippery Elm	Ulmus rubra
Yellow Birch	Betula lutea
Poplar	Populus sp.
White Oak	Quercus alba
Shagbark Hickory	Carya ovata
Grey Birch	Betula populifolia
Ash	Fraxinus sp.
Speckled Alder	Alnus rugos
American Hornbeam	Carpinus caroliniana
American Hop Hornbeam	Ostrya virginiana
Winterberry	Ilex verticillata
Maleberry	Lyonia ligustrina
Hazelnut	Corylus americana
Highbush Blueberry	Vaccinium corymbosum
Sweet Pepperbush	Clethra alnifolia
Azalea	Rhododendron sp.
Dogwood	Cornus sp.
Sensitive Fern	Onoclea sensibilis
Cattail	Typha latifolia
Meadowsweet	Spiraea latifolia
Sphagnum Moss	Sphagnum sp.
Skunk Cabbage	Symplocarpus foetidus

Wildlife

Common Name	Scientific Name
Blue Jay	Cyanocitta cristata
White-tailed Deer	Odocoileus virginianus
Muskrat	Ondatra zibethicus
Raccoon	Procyon lotor
Black-capped Chickadee	Parus atricapillus
Tufted Titmouse	Parus bicolor
American Goldfinch	Cardeulis tristis

WD1-1 Vegetation and wildlife species list



Photographs of WD1-1 wetland

Wetland Function-Value Evaluation Form

Total area of wetland 11.3ac. Human made? No Is wetland part of a wildlife corridor? Yes or a "habitat island"? No

Adjacent land use Forest, Residential Distance to nearest roadway or other development 0'

Dominant wetland systems present POWH, PFO1E Contiguous undeveloped buffer zone present No

Is the wetland a separate hydraulic system? No If not, where does the wetland lie in the drainage basin? Mid

How many tributaries contribute to the wetland? 1 Wildlife & vegetation diversity/abundance (see attached list)

Wetland I.D. WD1-1

Latitude 41°44'54.86 Longitude 41°44'54.86

Prepared by: LDC, JCL Date 12-7-92

Wetland Impact:
Type Fill Area 4.9 AC

Evaluation based on:
Office ✓ Field ✓

Corps manual wetland delineation completed? Y ✓ N ___

Function	Occurence Y	Occurence N	Rationale (Reference #)*	Principal Function(s) & Value(s)	Comments
Groundwater Recharge/Discharge	X		2,6,7,9,10,11,12,13		A layer of organic soil blankets the thin glacial till overburden in this area, this wetland is an expression of groundwater discharge.
Floodflow Alteration	~~X~~	X	~~2,3,6,7,8,9,11,13,14~~		Water flow constricted by culvert, some detention occurring in this ponded, well-saturated area. Portion of wetland at impact area does not store floodwater.
Educational Scientific Value		X	2,3,5,8,9,10,11,12,13		Potential for pond study to occur. No known educational use.
Sediment/Toxicant Retention	X		3,4,5,6,7,8,9,10,12		Sediments can drop out in the ponded section.
Nutrient Removal	X		2,3,5-13		Potential for sediment and nutrient removal exists, logging activities have occurred adjacent to wetland.
Production Export		X	1,2,4,5,6,7,9,10,12,14		Outflow is constricted, little transport occurs via wildlife, wetland is predominantly attenuating nutrients.
Sediment/Shoreline Stabilization		X	4,6,9,10,12,13,14,15		Low flow velocities.
Wildlife Habitat	X		1,2,4,5,6,7,8,(13),16,17, 18,19,21	X	Except for minor road, this wetland is well buffered, and directly connected to the Hop River. Good amphibian habitat.
Recreation		X	2,4,5,6,8,9,10		Wetland is easily accessible, and has some potential to function as educational and recreational area.
Fish and Shellfish Habitat		X	1,5,(6),9,10,14,15,16,17		Culvert restricts access, wetland is relatively small, fisheries site #15.
Uniqueness/Heritage	X	~~X~~	7,(14),17,18,20,22,29	X	Prehistoric archaelogic sensitive sites adjacent to wetlands. Archaelogic artifacts found adjacent to wetland by local archeologist.
Visual Quality/Aesthetics	X		1,2,3,4,5,6,7,8,9,10,11,12		Direct view of wetland exists from roadway. Open water contrasts with surrounding forest land.
ES Endangered Species Habitat		X	None		None found or known to occur here.
Other					

Notes: Additional vegetative species noted at 3/24/93 Wetland Delineation field visit (Refer to Wetland Delineation Form). Phase II wetland assessment is relatively indicative of functions present at impact area.

graphic art work integral to portraying the results of this approach. We also gratefully acknowledge the administrative and technical staffs of the Departments of Transportation of New Hampshire and Connecticut for providing the opportunities to develop ideas and to acquire experience which this paper reflects, as well as review input. Responsibility for any errors which may remain in this paper are the authors' alone.

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RAPID ASSESSMENT OF VERNAL POOL FLORISTICS

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Vernal pools are depressional wetlands in California grasslands that are inundated during winter and spring but are dry the remainder of the year. These wetlands support a flora that includes many endemic species (Whitney et al., 1994), unusual in a grassland community dominated by non-native species. Fill of vernal pools has been regulated under the Clean Water Act since 1985, and mitigation for fill typically requires construction of new vernal pool habitat.

In constructing and monitoring over 900 vernal pools in the Sacramento, California region, Sugnet & Associates has worked to develop vernal pool monitoring methods that are efficient, yield meaningful data and analysis, and accurately reflect habitat quality. The Vernal Pool Floristic Index (VPFI), a measure based on floristic quality, was developed by Sugnet & Associates to assess vernal pool function. This index measures the contribution of known vernal pool species to the overall species composition of vernal pools. The VPFI yields a ranking of wetlands that reflects floristic gradients (and the underlying hydrologic gradients) consistent with other analytic methods.

Calculation of the Vernal Pool Floristic Index

The vernal pool floristic index was modeled after Jaccard's Index, a commonly used similarity index. Using Jaccard's Index with species richness data yields values ranging from zero to one, reflecting the proportion of common species between the two samples. The VPFI compares the species richness of an individual vernal pool against a rule-based list of known vernal pool species, the Vernal Pool Species List (VPSL). The VPFI is calculated as follows:

$$VPFI = \frac{a}{a+b}$$

where "a" equals the number of species occurring in a vernal pool that are on the Vernal Pool Species List, and "b" equals the number of species occurring in a vernal pool that are not on the VPSL. As with Jaccard's Index, VPFI values range from zero to one. VPFI represents the proportion of wetland species found in a vernal pool that are known to occur in that habitat. VPFI values of 0.6 or greater are judged to represent a "successful" vernal pool.

A species is included on the VPSL if it:

1. Is listed as or meets the criteria of a FAC, FACW, or OBL species in the "National List"; AND

2. It meets any one of the following conditions;

   a. It is reported as occurring in vernal pools in the refereed literature; OR

   b. It has been collected or observed in vernal pools; OR

   c. It has been reported as occurring in vernal pools in a regional or state-wide flora.

Comparison to Prevalence Index

Figure 1 is a scatter diagram comparing VPFI and Prevalence Index (PI) values for 520 reference (naturally occurring) vernal pools, while Figure 2 presents a similar comparison for 841 constructed vernal pools. These graphs demonstrate that the species richness-based VPFI closely approximates the variation demonstrated by the species abundance-based PI. Alone, the VPFI offers a method for rapid assessment of vernal pool quality.

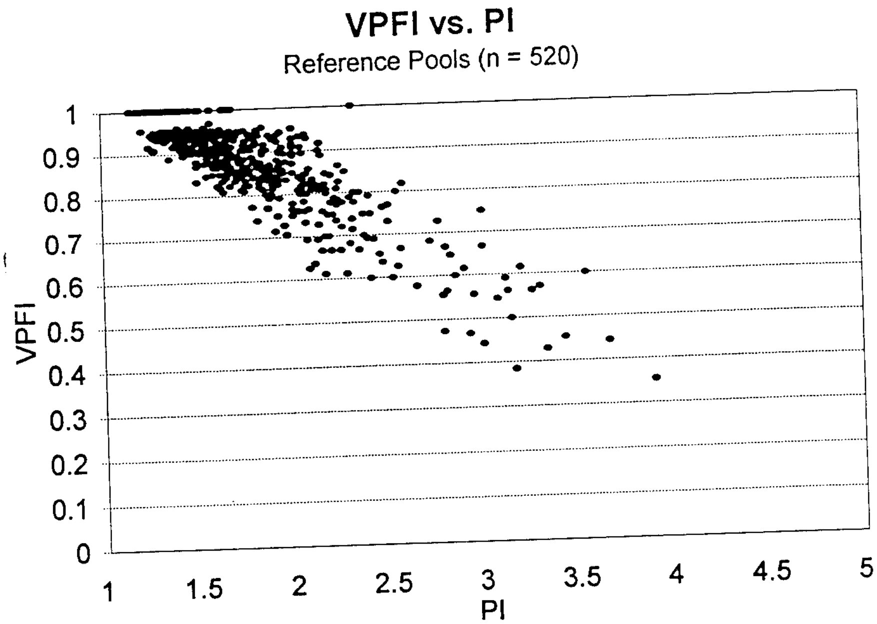

Figure 1

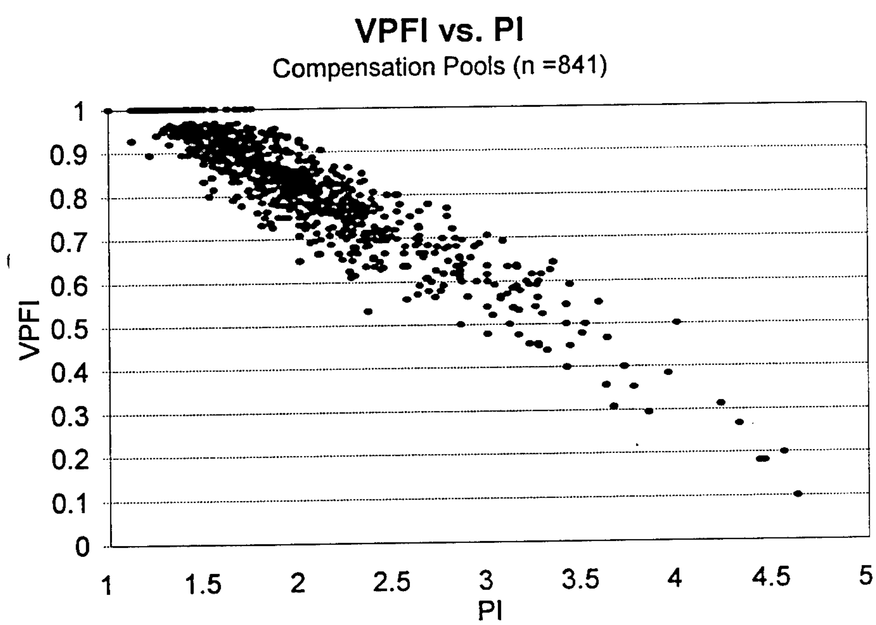

Figure 2

Combined with the use of Prevalence Index and other measures, the VPFI is an important component of a suite of constructed vernal pool performance measurements.

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THE WISCONSIN DNR RAPID ASSESSMENT METHODOLOGY: A SIMPLE QUALITATIVE APPROACH FOR ASSESSING WETLAND FUNCTIONAL VALUES

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The Wisconsin DNR developed and is using a rapid assessment technique for making qualitative evaluations of wetland functional values and decisions about the significance of wetland impacts. In 1991, Wisconsin adopted Wetland Water Quality Standards, which created a definitive process for making decisions regarding projects that affect wetlands. Each year the agency makes permit and water quality certification (under section 401 of the Clean Water Act) decisions on over 500 projects. In most cases staff do not have the time to collect necessary data and implement extensive wetland evaluation models/methodologies. Our goal was to develop a simple, time- efficient methodology that is defensible (both legally and scientifically) and can be completed after limited site visits.

The Rapid Assessment Methodology is a field checklist that requires investigators to focus on important indicator attributes of the wetland and watershed. The methodology takes the form of a field checklist that provides space to document a complete field visit. Some users, including consultants who provide reports to the Department, have employed an electronic version of the checklist that makes for a very concise report format. The evaluator can document location information, wetland type, seasonal conditions, hydrologic setting, soils, vegetation communities and surrounding land-uses in the watershed. The functional value assessment portion requires the evaluator to examine site conditions that provide evidence that a given function is present and to assess the significance of the wetland to perform those functions. The methodology looks at the following functional values:

- Special Features (located in or near state natural areas, state parks, wild and scenic rivers, etc.)
- Floral Diversity
- Wildlife and Fishery Habitat
- Flood and Stormwater Storage/Attenuation
- Water Quality Protection
- Shoreline Protection
- Groundwater Recharge and Discharge
- Aesthetics/Recreation/Education and Science

Positive answers to questions indicate the presence of factors important for the function. The questions are not definitive or exhaustive and are only provided to guide the evaluation. That is, the methodology recognizes that not all wetlands will perform all functions, and thus the evaluator need not be constrained by the questions on the checklist. This flexibility allows the input of new research findings in wetland science into decisions without the need for alterations to a model. For certain functions, the checklist may indicate a need for more in-depth study to make an evaluation. After completing each section, the evaluator should consider the factors observed and use best professional judgment to rate the significance (exceptional, high, medium, low or not applicable) of the wetland for a given function. The result is a listing of the important wetland functional values and documentation of the landscape features that led the evaluator to that decision.

We have shared our simple checklist with neighboring states and several agencies in foreign countries. In the next year we plan to work with the International Crane Foundation to develop an educational tool that uses the checklist to show how the wetland characteristics and the nature of the surrounding watershed are important for understanding the importance of a given wetland system. The Rapid Assessment Methodology has proved very useful and usable for field staff.

SESSION MB4

MITIGATION AND MITIGATION BANKING: LEGAL AND REGULATORY

Robert W. Brumbaugh, Chair

AN OVERVIEW OF LEGAL AND REGULATORY ISSUES IN WETLAND MITIGATION BANKING

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Mitigation banking is a recognized part of the Clean Water Act is section 404 permit process. It offers a mechanism to ensure that the totality of environmental costs of activities detrimental to wetlands are offset. Basic public and private mitigation banking concepts have been developed and a few banks exist. While there are some difficulties in quantifying losses and in restoring or creating wetlands, if private mitigation banking is to become an accepted part of the 404 permit process then regulatory practices and interagency agreements must provide clear procedures for the concept. To avoid or minimize litigation, guidance is needed for prospective bankers in establishing a bank and for borrowers on how to utilize banks in the permit process. While flexibility is needed to accommodate local and regional issues, there must be some regulatory mandates to direct agencies and guide the development, permitting, and monitoring of private mitigation banks.

WETLAND CREATION AND MITIGATION BANKING: AN INDUSTRY VIEWPOINT

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The Bush administration created a policy of "No Net Loss of Wetlands". The Clinton administration has embraced this policy and expanded its scope. The creation of mitigation banks was proposed as a compliance option for the "No Net Loss" policy.

On August 25, 1993, the Corps of Engineers (COE) revised their definition of dredge and fill activities. Under this new (Tulloch) rule, a 404 permit will be required for mechanized land clearing, ditching, and other excavation activities that destroy, degrade, or have an adverse effect on any aquatic function of the waters of the US, including wetlands.

The Tulloch rule will bring increased scrutiny to all mining operations which are conducted below the elevation of the regional groundwater table. Since created wetlands need only hydrology and wetland vegetation to be considered a wetland by the COE, companies will be at risk of violating the law if their mining areas or tailings ponds with appropriate hydrology develop wetland vegetation.

The COE considers the created wetlands non-jurisdictional when they are part of the active mining operation; however, as soon as they go "inactive" they become jurisdictional with COE authority. Since jurisdictional wetlands cannot be used for mitigation, the mining industry will not only lose the use of these areas for future mitigation purposes, but will also be at risk of violating the law during the restoration and reclamation of former mining areas.

Successful mitigation banking will require cooperation from the governing agencies to exclude wetlands created by mining from jurisdictional authority until after they are reclaimed and banked. Mining companies must become more proactive by entering into Memorandum of Agreements (MOAS) with the COE, US EPA, US Fish and Wildlife Service and the states that define when created wetland areas are considered inactive and jurisdictional and to convert the reclaimed wetlands into mitigation banks.

Unimin has attempted to enter into just such a MOA. Letters of our intent concerning wetland creation and mitigation banking were mailed to each of the 14 COE districts of our 25 mining operations. To date, Unimin has only received five responses to our letters.

The mitigation banking process has several problems which will need to be addressed if it is to work:

1. A standard quantifiable method needs to be developed to evaluate wetlands, mitigation credits, and the corresponding mitigation ratios.

2. There are too many restrictions on how mitigation banks are to be created and on where the credits from the banks can be use.

3. Dealing with three different agencies and conflicting agendas during the mitigation banking process can result in unreasonable compliance solutions for the regulated community.

4. Created wetlands should be bankable regardless of when they were created.

The regulatory agencies must be more flexible in their

The regulatory agencies must be more flexible in their interpretation of the "No Net Loss Policy" and on how mitigation banks are created and used. If not, the regulated community will be left without a reasonable way to comply with the new rules and policies.

AN OVERVIEW OF WETLAND MITIGATION BANKING: THE NATIONAL WETLAND MITIGATION STUDY FINDINGS AND ONGOING STUDIES

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The findings of the first phase of the National Wetland Mitigation Banking study being conducted by the US Army Corps of Engineers Institute for Water Resources (IWR) have been presented in a series of 6 reports. Wetland mitigation banking, although practiced for more than 15 years, is a concept still in its infancy. However, banking is very much in an exponential growth phase in terms of implementation. Most of the more than 40 banks in operation by summer 1992 were less than five years in existence (see Figure 1). These banks represented a variety of institutional arrangements. For the most part, however, the banks were single-client banks (in which the user is also the client) sponsored by state agencies. Very few banks offered compensatory mitigation credits for general development use. Such general use banks have also been referred to as commercial banks (or credit ventures). In early 1992, all operating commercial banks were sponsored by public agencies. However, in the past three years numerous privately-sponsored commercial banks (also known as entrepreneurial banks) have been proposed and several implemented. Among the most critical issues that affect the financial success of banks, and thus the willingness on the part of the prospective banker to get involved in banking, is the timing of debiting versus accrual of credits in the bank.

The overall evaluation of banking presented in the National Wetland Mitigation Banking First Phase Report (IWR, 1994) was as follows: (1) when properly planned and executed, wetland mitigation banks may provide effective means to mitigate unavoidable loss of wetlands, essentially by providing practicable mitigation alternatives; (2) while there have been a significant number of banks with substantial problems or that have failed, in general existing banks have been ecologically successful or are expected to be successful; and (3) the Corps, as the principal regulatory authority, should assume a more direct role in bank establishment and the certification of credits, while providing continuous oversight in their operation.

The second phase of the national banking study is focusing on commercial banks (and similar credit ventures) and on utilization of banks to facilitate watershed-based management, and vice-versa. Many innovative approaches to producing compensatory mitigation in the form of banks have been proposed. The national study is preparing a taxonomy of commercial banks based on a review of operation and proposed commercial efforts. Requirements for economic and ecologic success for each type of commercial bank will be described.

There is increasing recognition by regulatory and resource agencies and other experts that banking can best meet the nation's wetland goals if carried out within a context of recognized comprehensive or watershed based plans. The Clinton Administration's wetland policy statement (White House Office on

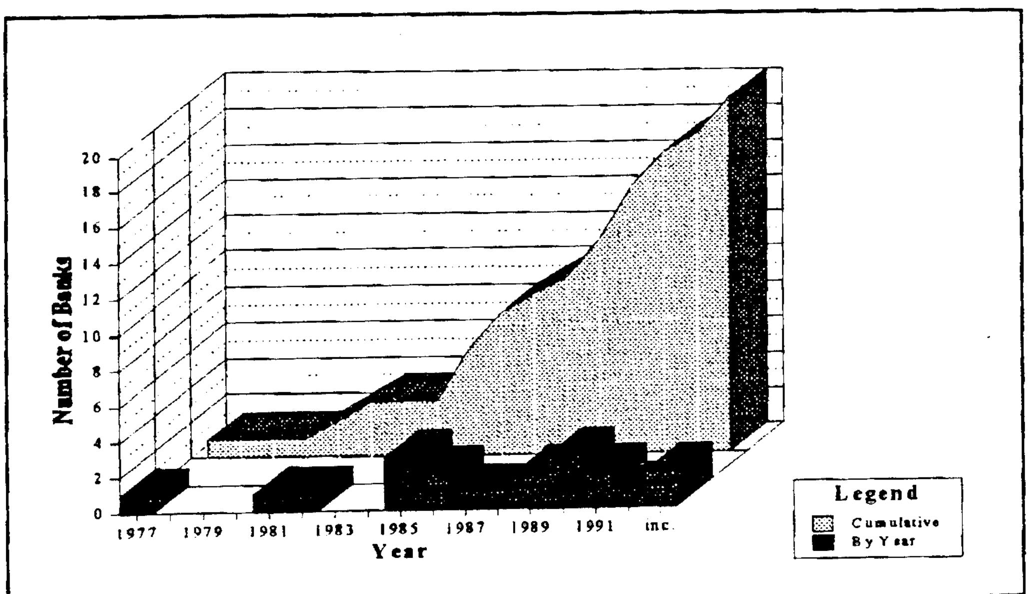

Figure 1. Date of Implementation for Case Study Banks for 20 operational banks, approximately one-half of population in 1992)

Environmental Policy, August 1993) supports wetland mitigation banking in the context of wetland planning as does the proposed Federal Guidance for the Establishment, Use and operation of Mitigation Banks (Federal Register, March 6, 1995). The national study is examining a number of watershed planning efforts that involve wetlands to identify success and barriers to success and applications to banking.

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COMMERCIAL CREDIT VENTURES: A REVIEW OF RECENT EXPERIENCES

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Private entrepreneurs have begun to restore and create wetland acres and functions in anticipation of being able to sell "credits" to permit applicants in need of mitigation. As part of the National Wetland Mitigation Banking Study being conducted by the Corps of Engineers Institute for Water Resources, these private sector efforts were examined. The different forms of wetland mitigation banking are described with particular emphasis on banks developed to make "commercial sales" to permit applicants. After presenting a taxonomy of commercial banks, this paper reviews the experience to date with private credit sales and explains the regulatory safeguards that have been used to assure that private credit sales secure successful mitigation. A list of regulatory requirements is then presented that can simultaneously secure successful mitigation and a positive economic return for private entrepreneurs. Particular attention will paid to the use and design of performance bonds.

STATEMENTS ON THE PROPOSED FEDERAL INTERAGENCY GUIDANCE ON MITIGATION BANKING

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Proposed Federal interagency guidance on mitigation banking was published in the Federal Register on March 6, 1995, to solicit public comment. This guidance represents the consensus of five agencies -- Army/Corps of Engineers, Environmental Protection Agency (EPA), Natural Resources Conservation service, Fish and Wildlife Service, and National Marine Fisheries Service -- regarding policy for the establishment, use and operation of mitigation banks. It signifies an important accomplishment among these agencies endorsing mitigation banking in support of the Administration's Wetlands Policy Plan (August 1993).

This effort was undertaken for the purpose of providing guidance to the field operating activities of the involved agencies as a means to achieve consistency regarding decisions on mitigation banking. In achieving this stated purpose the policy fully supports and encourages mitigation banking in the private sector. The agencies recognize the important contributions the private sector can make to mitigation banking, and hence toward achieving the Nation's goal of a no net loss of wetlands, and furthering the goal of a net gain over the long term.

Clearly, mitigation banking offers an alternative to project-specific mitigation under the Clean Water Act Section 404 Regulatory Program. Under the "Swampbuster" provisions of the Food Security Act, mitigation banking can contribute significantly toward restoration of prior-converted wetlands as a means to mitigate for wetland losses due to agricultural activities/conversions. It is the intent of the policy guidance to address mitigation banking as it is applied to these programs.

The proposed Federal guidance maintains the sequencing established in the Memorandum of Agreement between the Department of the Army and EPA (February 1990) -- first, avoid impacts; second, minimize impacts; and third, compensate for remaining unavoidable impacts to wetlands and aquatic resources. Mitigation banking should be used when opportunities for on-site compensation are not practicable or when use of a mitigation bank is environmentally preferable to on-site compensation. The guidance is specific on key policy issues at the national level, flexibility has been maintained to allow field operating activities latitude in interpreting the guidance to address regional needs and interests. It is not designed to hold mitigation banks to higher standards than those for project- specific mitigation sites.

With respect to the issues of on-site versus off-site, and in-kind versus out-of-kind mitigation, the policy emphasizes the importance of practicability and environmental desirability. There exists a preference to compensate for the loss of wetland functions on-site, and a recognition that some functions such as flood control or water quality may best be replaced on-site. As with all compensatory mitigation, it is essential, on a case-bycase basis, to distinguish between wetland functions that are critical to on-site replacement, and those which may net greater environmental benefits through off-site replacement. Mitigation banks increase the opportunity for successful mitigation through off-site compensation of some functions, such as habitat, Banks may also offer opportunity for out-of-kind compensation, These decisions are directly tied to the permit evaluation process and are driven by the determination as to what is appropriate and practicable mitigation. Similarly, decisions accepting out-ofkind mitigation may result in greater environmental benefits.

The policy guidance covers a broad range of issues germane to mitigation banking; some of the more salient ones are mentioned here. In addition to any required Section 404 permits, all mitigation banks need to have a banking instrument to document interagency concurrence as to how the bank will be established and operated. All participating agencies are signatory to the banking instrument. The Mitigation Bank Review Team is comprised of the signatory agencies, and its primary role is to facilitate the establishment of mitigation banks through the development of banking instruments on a consensus basis.

The Federal guidance endorses (1) watershed planning for integrating mitigation banking goals and objectives,
(2) preservation of wetlands, (3) self-sustaining design,
(4) flexibility in the timing of withdrawal of credits as an incentive to private sector interests, and (5) long-term management and protection strategies. The document provides guidance on establishing (1) goals and objectives, (2) site selection, (3) bank service areas, (4) monitoring and remedial action, and (5) financial assurances.

Consistent application of this policy guidance by the agencies will serve to further the goals of no net loss and a net gain in the country's wetlands resource base. Isn't it about time?

SESSION RE15

RESTORATION, PROTECTION, AND CREATION:
CHESAPEAKE BAY WETLAND RESTORATION
Ms. Trudy Olin, Chair

HART-MILLER AND POPLAR ISLANDS: RESTORATION OF LOST FISH AND WILDLIFE HABITATS IN CHESAPEAKE BAY, MARYLAND

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Hart-Miller Island (HMI), an 1100-acre confined placement island for dredged material in Chesapeake Bay, Maryland, was constructed in the early 1980's. The island's destiny is to become a wildlife and wetland habitat, which is used for education and research as well as passive recreation such as bird watching. The island is nearing completion, with little remaining capacity, and a draft design is in review for HMI's South Cell that includes combinations of shallow aquatic, wetland, upland, and island habitats. As soon as the North Cell is completed, a design for it will also be completed. The current operations and testing facility will be converted to a research, education, and museum visitors center. Other user- friendly features will be added over time: hiking trails, a boardwalk into the wetlands, covered benches, observation towers and hills, and an additional boat dock near the visitors center.

The HMI project has been carefully coordinated since 1974 with three groups: (a) Citizens Committee, (b) Governor's Advisory Committee, and (c) Technical Advisory Committee. The project was a joint effort of three agencies in the State of Maryland and the US Army Corps of Engineers; its primary funding was by the Maryland Port Administration (MPA), its sponsor.

The HMI holds 62 million cubic yards of dredged material. The MPA and Corps has no new placement sites on-line, but a major new approved site is being rapidly planned and designed. This is Poplar Island (PI), off Maryland's Eastern Shore. The site has very strong support and coordination of the State, the Corps, and the US Fish and Wildlife Service, and has been approved by the NOAA National Marine Fisheries Service and the US Environmental Protection Agency.

PI is a natural island of several hundred acres that has eroded to less than 6 acres in the past 150 years; it was an intensely used wildlife site, and was fringed by important fish nursery salt marshes. The Technical Advisory Committee for PI is working out details on an island design of approximately 1500 acres with MPA's engineering contractors that will build back an island on roughly the same footprint of the old island using reinforced and armored dikes to prevent erosion. It is being positioned to avoid active and dead oyster and other shellfish areas, and will be connected to four remnants of existing islands (mostly submerged at high tide).

Concepts call for (a) baseline engineering and environmental data collection; (b) combinations of intertidal marshes and perched wetlands, transition zones, and uplands; (c) innovative engineering on the dikes, crossdikes, and cells that will allow maximum placement of dredged material within the island to form the habitats. Two primary goals have emerged from the Committee's work: (a) maximize fish and wildlife biodiversity in the overall design, and (b) achieve maximum placement and dewatering/ management of the dredged material that will provide the MPA and Corps with a long-term placement site and gain a favorable benefit/cost ratio for the project. Objectives based on general project goals are being developed.

PI will begin construction in 1995, and will follow the general approach developed for HMI. Its ultimate destiny will provide a badly needed increase in Chesapeake Bay fish nursery areas and waterbird/waterfowl nesting and migratory use.

EASTERN NECK NATIONAL WILDLIFE REFUGE SALT MARSH: INNOVATIVE STRUCTURES AND BIOENGINEERING

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The shorelines at Eastern Neck National Wildlife Refuge, on Chesapeake Bay's Eastern Shore, have been steadily eroding for many years. In an attempt to hold the line, the US Fish and Wildlife Service invested in armoring along the shore. Part of this riprap was used innovatively in combination with dredged material from the Chester River to (a) prevent future erosion, and (b) restore salt marsh and fish nursery areas.

In 1993, a line of 100-ft-long, with 100-ft-spacings, detached riprap structures were installed from a shore point at Eastern Neck out into 4-ft-deep Bay water to provide a stillwater area approximately 300-ft-wide. At the end of the detached riprap breakwaters, two geotextile tubes were filled with sand dredged material to continue the breakwater line and so that most of the dredged material being placed behind the structures would be protected. Sandy dredged material was pumped between the structures and the eroding shoreline to an intertidal elevation. The area was planted with _Spartina alterniflora_ and _Spartina patens_ in summer 1993, and finished planting in summer 1994.

Several engineering and environmental tests were conducted at Eastern Neck: (a) use of detached riprap structures to protect shorelines in Chesapeake Bay; (b) use of detached sediment-filled geotextile tubes to protect shorelines in Chesapeake Bay; (c) ability of erosion control matting grown with _S. alterniflora_ to withstand a more than 30-mile windfetch; (d) survival and growth of individual transplants of both species at the site; (e) the movement, consolidation, and stability of the dredged material under conditions of partial protection; and (f) fish and wildlife use of the new wetland area. This was an interagency project, with funding by the US Fish and Wildlife Service and the US Army Corps of Engineers (Baltimore District and Waterways Experiment Station's Wetlands Research Program), and cooperation by two state agencies, private citizens' groups, and other federal agencies. Much of the planting work was accomplished with volunteers.

Results and success of tests were mixed, and monitoring is continuing. In 1993-1994, Chesapeake Bay endured one of the coldest winters on record, and the site had 14-ft-high ice floes rafted on it. Meanwhile, wave energy moving through the openings in the detached breakwaters sorted and moved much of the dredged material and washed out the low tidal zone individual plantings. The substrate is visible only a low tide in many parts of the site. The high marsh (_S. patens_) survived waves and winter storms, and is thriving. The ice did no damage to either the hard structures or the geotextile tubes. Erosion control matting tried in late 1993 without well-established plant material did not survive, and was re-tested in 1994. As winter 1994-1995 began, the mat test areas and high marsh were surviving well. Fish seines have pulled in large numbers of small fish using the salt marsh and shallow water areas behind the breakwaters. Numerous waterbirds and other species have been observed on the site, including bald eagles, white-tailed deer, and small mammals.

At this writing, efforts are being made to close most of the open areas between the riprap structures to afford more protection to the new wetland. The information from Eastern Neck was also being used to design placement of geotextile tubes at Barren Island, a similar Chesapeake Bay project being constructed in December 1994. The 100-ft spacings used at Eastern Neck are being reduced to 10-ft spacings at Barren Island, and several configurations of tube placement are being tested.

This highly-visible project has been closely watched and visited by coastal engineers, biologists, agency headquarters, and Congress. There are many lessons to learn from the tests conducted at Eastern Neck that will be applied in future wetland restoration and shoreline protection projects in Chesapeake Bay.

KENILWORTH MARSH: A CLASSIC WETLAND RESTORATION SUCCESS STORY IN THE NATION'S CAPITOL

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Kenilworth Marsh, a 35-acre area located in the National Aquatic Gardens in Washington, DC, was restored in 1992-1993. A combination of engineering and environmental techniques, including (a) temporarily placed, large water-filled geotextile tubes that were removed after dredged material had sorted and consolidated and marsh establishment had occurred, (b) anchored hay bale structures that separated low marsh from high marsh planting areas, (c) compartmentalization of planting units within two large cells, (d) bringing the substrate to an intertidal elevation with dredged material sediments, and (e) planting of potted seedlings (both herbaceous and woody fresh marsh species) were used to restore the wetland.

Species planted in the wetland included: <u>Nuphar advena</u>, Sagittaria latifolia, Sparganium americanum, Sparganium eurycarpum, Scirpus americanus, Scirpus validus, Carex stricta, Iris versicolor, Peltrandra virginica, Polygonum spp., Pontederia cordata, Sauruus cernuus, Leersia oryzoides, Hibiscus mosheutos, and Cephalanthus occidentalis. By the end of the second growing season, stands of Typha latifolia and Zizania aquatica had colonized both cells and were spreading. The marsh at two years of age is still quite diverse, but is beginning to be dominated by the more aggressive species. When it was planned and designed, an objective was to let ecological succession take the marsh to a climax stage without further management, which would finally result in wooded riverine habitat interspersed with fresh marsh and shallow open water.

Design features also include canoe channels, recreational trails, and overlooks. Work was funded by the US Army Corps of Engineers, and its partners were the National Park Service, the DC Council of Governments, and the US Fish and and Wildlife Service. Long-term environmental and engineering monitoring by an interagency group is part of the overall plan of action. Data collected through the fall of 1994 show the marsh densely growing with planted and colonizing species and project goals, which were largely based on functions to be achieved, being successfully met. The dredged material colonized so rapidly with a broad variety of wetland plants that planting of the site was unnecessary; however, planting was done to (a) help compete against any possible invasion of common reed, and (b) to ensure rapid wetland development.

Using lessons learned at the restored wetland, a similar wetland will be built using dredged material at Kingman Marsh across the Anacostia River from Kenilworth Marsh. Kenilworth Marsh has been observed and visited by various agencies' headquarters officials, Congressmen, and District of Columbia elected officials. It received the Army's Environmental Design Award for 1994.

SHORELINE STABILIZATION AND WETLAND RESTORATION AT BARREN ISLAND AND HISTORIC SMITH ISLAND, CHESAPEAKE BAY, MARYLAND: INNOVATIVE GEOTEXTILE TUBE TECHNOLOGY

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Chesapeake Bay is undergoing extensive erosion along its shorelines, but especially, its islands are eroding and disappearing at an alarming rate. The US Army Corps of Engineers has undertaken protection and restoration of two such islands, one manmade and the other natural, in the Bay using innovative technology with a combination of geotextile tubes and aprons, use of sand dredged material, and restoring intertidal elevations for wetland restoration.

Barren Island is located near the Honga River, in Chesapeake Bay, Maryland. A section of Barren Island was constructed of dredged material by the US Army Corps of Engineers several decades ago; it was added to during a dredging cycle in the early 1980's for black duck and least tern nesting habitat. That application of dredged material was designed to include planted salt marsh areas surrounding the island (Spartina alterniflora and Spartina patens), and a bare crown capped with shell cultch to provide optimum substrate for nesting terns. The least tern design was highly successful, with colonies still occurring on Barren Island. Black ducks and other waterbird/waterfowl species also use the planted salt marsh.

Neither prior habitat construction project provided shoreline protection for the island. As a consequence, it has continued to erode. Using lessons learned from four other geotextile tube projects by the Corps conducted at Eastern Neck National Wildlife Refuge and Smith Island in Chesapeake Bay, and at West Bay and Aransas National Wildlife Refuge in the Texas Intercoastal Waterway, a project using tubes at Barren Island to stop erosion was designed. The US Fish and Wildlife Service (FWS) is contributing funding for the tubes, and the Corps is providing the dredged material for filling them, funding and supervising the work, and conducting follow-up monitoring.

Construction of the project began in December 1994 and is still underway. Along the approximately 1.5-mile stretch of tubes, the Corps and FWS are testing two tube configurations: (a) single-line 100-ft-long tubes placed 10-ft apart at ends, and (b) staggered double-line 100-ft-long tubes placed with approximately a 10-ft overlap, with spacings for intertidal connection between the two lines. Other promising configurations may be tested while the project is under construction. Any remaining sand dredged material may be placed between the tubes and the shoreline to hasten wetland recovery.

Smith Island, a natural island in Chesapeake Bay, was settled in the early 1700's by Englishmen; many of the residents speak with an Old English dialect and there are only a few surnames existing there. Smith Island is also eroding badly, and erosion has reached the point of jeopardizing the airport, homes, and other historic features of the island.

The US Army Corps of Engineers has installed a permanent frontline protective structure made from geotextile tubing. The double-lined woven-fabric tube is being filled with sand dredged material. It is the largest sediment-filled tube tested in the United States to date, and is 2000-ft long, 20-ft wide, and 7-ft high. The geotextile fabric used to construct the tube has a 20-30 year life under ultra-violet conditions. Dredged material is being placed between the tube and the eroding shoreline to recover some of the island's lost salt marsh.

The tube was filled in November-December 1994. Problems were encountered when the contractor used too small a dredge; he used a 10-inch dredge, which would not maintain enough of a head to shape the tube into the correct configuration. Work had to be stopped until a larger dredge could be mobilized and used to complete filling the tube. The tube and site will be monitored for stability, settling, and other engineering considerations. It is very important to document all aspects of this large-size tube, because large tubes are being considered for other Corps and state projects, both in Chesapeake Bay and other estuaries.

Several other wetlands in Chesapeake Bay have been protected and restored using similar technology, and lessons learned from these are being applied to wetland restoration projects in Galveston Bay in Texas, Delaware Bay in New Jersey and Delaware, the Hudson River in New York, and other sites in Chesapeake Bay.

SURVIVAL AND GROWTH OF NURSERY-STOCK WOODY PLANTS IN CONSTRUCTED FORESTED WETLANDS IN CENTRAL MARYLAND

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The survival and growth of 1841 nursery-stock woody plants that were planted in 3 constructed forested wetlands in fall 1992 were evaluated during 1993 and 1994. The wetlands were constructed as mitigation areas to offset losses of natural wetlands due to highway construction. All trees and shrubs were 2-year old, balled-root stock and were tagged during the spring of 1993. Tagged transplants were measured (height, diameter, canopy) in the fall 1993, spring 1994, and fall 1994. Signs of animal damage by deer, rodents, or insects were recorded. Percent moisture of the soil at the base of each transplant was determined in the fall 1994 with a hand-held battery-operated moisture probe.