$5.00

Coastal Tidal Wetlands Mitigation Site Inventory and Wetlands Banking in New Jersey

West Atlantic City

Volume 2
1988

State of New Jersey, Department of Environmental Protection
Division of Coastal Resources, CN 401, Trenton, New Jersey 08625

V O L U M E   I I

TECHNICAL APPENDICES: REFERENCES, GUIDES AND RESOURCE INFORMAITON

Prepared For:

Division of Coastal Resources
Department of Environmental Protection
Trenton, New Jersey 08625

Prepared By:

IEP, Inc.
and
Coastal and Estuarine Research, Inc.

PREFACE

The information contained in this volume is accompanied by Volume I entitled, "Coastal Tidal Wetlands Mitigation Site Inventory and Wetlands Banking in New Jersey", which contains a detailed description of 65 potential mitigation sites, a ranking of the sites, and mitigation bank feasibility information. It is prepared under contract (ID #R-31237) with the New Jersey Department of Environmental Protection, Division of Coastal Resources, and Bureau of Project Review.

Table of Contents

V O L U M E I I

APPENDIX A - Literature Survey of Coastal Wetland Mitigation Issues
APPENDIX B - Literature Survey of Coastal Wetland Banking Issues
APPENDIX C - Use Guidelines for Tidal Wetland Mitigation Projects: Design, Site Preparation
APPENDIX D - Use Guidelines for Accessing ARC/INFO Coverages and Producing of Maps
APPENDIX E - Summary of Resource Data for Coastal Wetland Mitigation
APPENDIX F - Examples of MOAs and MOUs

APPENDIX A

Literature Survey of Coastal Wetland Mitigation Issues

ANNOTATED BIBLIOGRAPHY
COASTAL WETLAND MITIGATION ISSUES

Allen, H. H., S. O. Shirley, J. W. Webb. 1986. Vegetative stabilization of dredged material in moderate to high wave-energy environments for created wetlands. In: Proceedings of the Thirteenth Annual Conference on Wetland Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 19-35.

The U.S. Army Engineer Waterways Experiment Station has assisted three Corps of Engineers districts during the last 11 years in efforts to vegetatively stabilize dredged material and to create wetlands in moderate to high wave-energy climates in Mississippi. Shore stabilization has been successfully accomplished in several areas by using low-cost structures and materials to protect plantings of smooth cordgrass. Vegetative stabilization of dredged material with marsh grass leads to beneficial use of the disposal area by holding the material in place and by providing marsh habitat. These benefits make dredged material disposal more acceptable to environmental regulatory agencies and concerned citizens. Techniques and costs associated with these low-cost shoreline stabilization techniques are discussed.

Allen, H. H. and J. W. Webb. 1982. The influence of breakwaters on artificial saltmarsh establishment on dredged material. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 18-35.

Saltmarsh grass was planted in a high-energy wind-driven wave climate to stabilize a dredged material dike and to provide marsh habitat. The site is located on a spoil material island, in Mobile Bay, where wind fetches are 4.8 to 6.4 km. Approximately 1.7 ha of Spartina alterniflora sprigs were planted in May 1981 without wave protection. Significant washout of the sprigs occurred within one month. A second planting took place in August, 1981, with two different breakwater systems installed to protect the plants from wave action. Results of a monitoring project are provided, and findings of this study may be of considerable aid to persons attempting to establish salt marsh grasses in high wave energy areas for erosion control or habitat development purposes.

Allen, H. H., E. J. Clairain, R. J. Diaz, A. W. Ford, L. F. Junt, and B. R. Hunt. 1978. Habitat development field investigations - Bolivar Peninsula, marsh and upland habitat development site, Galveston, Texas. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 75 p.

This summary report describes habitat development on dredged spoil material at Bolivar Peninsula, Galveston, Texas. Plantings of marsh grasses and upland vegetation were successful after 2 1/2 years. Plants were protected from wind, waves, and grazing animals. A sandbag dike was constructed, but it is recommended that more cost effective alternatives be considered. For marsh grasses, elevation was the most important determinant of success. Smooth cordgrass thrives best at elevations below mean high tide; salt meadow cordgrass thrives best above mean high tide. Preliminary observations indicate that development of this marsh is associated with increases in benthic organisms, insects and fish; bird diversity and activity in the planted areas has also increased. *

Baca, B. J. and T. W. Kana. 1986. Methodology for restoring impounded coastal wetlands. In: Proceedings of the Thirteenth Annual Conference on Wetland Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 36-44.

This paper describes the methodology used to restore coastal impoundments to their original salt marsh state using examples from the south eastern United States. Methods include: 1) detailed studies of local hydraulics resulting in the production of a numerical flow model, and 2) detailed wetlands transects establishing local elevations for optimal growth of important species. Field studies included a survey to tidal creek and channel cross sections, measurement of current velocities, and tidal elevations at various stations, water quality measurements, and surveys across impounded and natural wetlands to determine species zonation, substrate and species elevation, and sediment type. The resulting numerical flow model was combined with these data to produce a management plant for improvement of wetlands and application to mitigation for developers.

Banner, A. 1977. Revegetation and maturation of restored shoreline in the Indian River, Florida. In: Proceedings of the Fourth Annual Conference on Restoration of Coastal Vegetation in Florida. R. R. Lewis, III and D. P. Cole, editors. Hillsborough Community College, Tampa, FL. pp. 13-43.

The shoreline of a heavily disturbed property along the Indian River, Florida, was restored early in 1976. The original peaty substrate had been disposed of, barren quartz sand was substituted in front of a vertical seawall located landward of original mean high water line. Segments along the 200 m shoreline were planted with newly extracted plugs of saltmarsh cordgrass, juvenile black, white, or red mangroves, or left as controls for natural revegetation. Photographic and written records were made of the growth of the vegetation and of the maturation of the sediments. The findings are directly applicable to subsequent restoration required by governmental agencies.

Banner, A. 1979. Mitigation under the Corps regulatory program. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rock Mountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Fort Collins, CO. pp. 396-399.

Within the Corps of engineers regulatory program, the Fish and Wildlife Service routinely evaluates the environmental effects of development activities in wetlands. Under the Fish and Wildlife Coordination Act, the Fish and Wildlife Service is consulted for its concerns over permit issuance. The Fish and Wildlife Service often requires mitigation for private development in wetlands needing federal permits. Cumulative impact of small projects and expansion of jurisdiction to freshwater wetlands has made this program increasingly important. Mitigation permitted for work and restoration of violations is like project mitigation in using simplified HEP, and off site or structural enhancement but avoids long-term management.

Banner, A. 1982. Florida Keys Environmental Mitigation Trust Fund. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 155-165.

During the prosecution of dredge and fill activities in coastal areas, plans are developed for restoration of marine habitat at the site of the violation. However, sometimes prosecution is delayed and innocent third-party buyers acquire and develop the location originally dredged or filled. In one such case, an "environmental trust fund" was established to carry out enhancement or mitigation in the upper Florida Keys. The fund is administered by the Florida Audubon Society with oversight from Federal agencies. The objectives are to physically restore coastal habitat and water quality. At this time, over twenty enhancement or restoration projects have been identified throughout the Keys, and several are underway.

Barko, J. W., R. M. Smart, C. R. Lee, M. C. Landin, T. C. Sturgis, and R. N. Gordon. 1977. Establishment and growth of selected freshwater and coastal marsh plants in relation to characteristics of dredged sediments. U.S. Army Engineer Waterways Experiments Station, Environmental Effects Lab, Vicksburg, MS. 41 pp.

This study describes a controlled condition laboratory experiment to determine the establishment and growth of several wetland plants in relation to dredged sediment characteristics. Freshwater, brackish, and estuarine (salt marsh) species were *Scirpus validus*, *Cyperus esculentus*, *Distichlis spicata*, *Triglochin maritima*, *Scirpus robustus*, *Spartina alterniflora*, and *Spartina foliosa*. Sediment substrates were clay, silty clay, and sand. Plant biomass and areal density were monitored. Planting occurred through seeds and transplants. Except for *Distichlis* (which was successfully established from seed). All plants were established more successfully from vegetative propagules. While all types of propagules flourished on freshwater sediments, transplants were more successful on estuarine sediments. Growth of all species in sand was nutrient-limited. It is recommended that fine-textured sediments do not need to be fertilized in marsh creation projects. Effects of salinity in terms of limiting plant growth are also discussed.

Baumann, R. H., and R. D. Adams. 1981. Creation and restoration of wetlands by natural processes in the Lower Atchafalaya River system: Possible conflicts with navigation and flood control objectives. In: R. H. Stovall, editor, Proceedings of the Eighth Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL. pp. 1-24.

The Atchafalaya River in Louisiana is creating new wetlands in the Atchafalaya Bay delta, and restoring wetlands in adjacent marshes. This process is documented by examination of Landsat images (1973-1980). During this time period, area trends shifted from wetland losses of 421 HA/Yr to wetland gains of 66 HA/Yr. There is a direct relationship between suspended sediment of influx and wetland creation/restoration; other important factors in this process are river discharge, wetland location, wind direction, and tidal stage. Navigation and flood control projects are discussed in terms of their potential effects on this natural creation process. *

Beeman, S. 1983. Techniques for the creation and maintenance of intertidal saltmarsh wetlands for landscaping and shoreline protection. In: Proceedings of the Tenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 33-43.

Techniques are outlined for the creation and maintenance of landscaped intertidal shorelines. Construction of successful and aesthetically positive salt marsh shoreline systems requires that considerable attention be given to the nature of the substrate, slope of the shoreline, elevation relative to mean high and mean low water, types and sizes of transplant material, and slope protection on the upper and lower edges of the tidal plane. Erosion protection along the upland/wetland interface in the form of a vegetated or armored berm is recommended. Species composition is also discussed relative to combining visual aesthetics with proper zonation within the intertidal zone. Maintenance of the system is addressed with respect to the control of weeds and destructive human utilization of these intertidal areas. Positive aspects of seasonal pruning following annual seed production are considered.

Beeman, S. and L. Greenfield. 1985. Monitoring of two artificial waterway systems in Jupiter, Florida. In: F. J. Webb, editor. Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL. pp. 36-46.

This article summarizes the results of revegetation efforts at artificial waterways in Jupiter, Florida. Spartina alterniflora and Rhizophora mangle proliferated initially; populations then stabilized to comprise 55% of the total plant community. The establishment of proper elevations relative to tidal fluctuations was a significant factor in successful wetland establishment. Fauna in these artificial waterways and marshes were similar to those in nearby natural areas. Dissolved oxygen, temperature, salinity, nutrients, and pH were measured regularly. Heavy metals and protein content were measured in Spartina and the permeability and ion exchange capacity of sediments were also monitored. *

Beeman, S. and R. Bullard. 1980. Plants on Shorelines. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 149-154.

This study reports on alternatives to the traditional erosion control methodology by the design and implementation of techniques and structures which replace or preserve shoreline vegetation. It is found that proper species diversity is the key to long-term stability in a man-made marsh, and emphasis is placed on the placement of each plant species on the shoreline with respect to water levels, tidal ranges, etc. On steep or high-energy shorelines, the proper placement of aquatic or intertidal plants frequently requires some sort of support structure to insure the integrity of the system against erosive forces. The techniques have been found to be quite effective in the control of shoreline erosion over 1-2 years of normal weather conditions.

Berryman, J. H. 1979. Mitigation: The state's viewpoint. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 30-32.

As the fish and wildlife resource managing agencies, the states are concerned with habitat loss and efforts to mitigate losses. They believe the costs of pre-planning studies and post-development operation should be part of the mitigation project costs. They are dissatisfied with mitigation, federal coordination, increasing "federalism", needless delays, and continued losses. The state views the maintenance of habitat as a survival issue and the realistic mitigation of any necessary loss as an absolute necessity. Costs of evaluating impacts on fish and wildlife resources, the costs of mitigation, and the costs of post-development operation should be borne by the developer. At the present time (1979) the states are not satisfied with mitigation and present processes involved in initiating the mitigation procedure.

Birkitt, B. 1983. Considerations for the functional restoration of impounded wetlands. In: Proceedings of the Tenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 44-59.

Almost 40,000 acres of mangrove and marsh areas along the east coast of Florida have been impounded for the purpose of mosquito control since the early 1950's. Recently, there has been an increase in the number of developments proposed in or adjacent to these areas. Review of the proposed developments through the state and federal regulatory process has resulted in renewed interest in the rehabilitation of these impounded wetlands. Significant changes in wetland vegetation have resulted from impounding for the purpose of mosquito control. Also, there is some evidence that the cumulative effect of impounding large areas of coastal wetlands might be detrimental to fisheries and other estuarine resources which depend on the marsh/estuary system.

Management plans are being developed for these impounded areas to restore some of the original functions of the wetlands to benefit fisheries and other estuarine resources as well as to maintain mosquito control. Considerations for the development of management plans include water level regulation, connection of the marsh to the estuary, and improvement in water circulation. Information on two sites for which functional restoration will be attempted in the near future is included.

Bongiorno, S. F., J. R. Trautman, T. J. Steinke, S. Kawa-Raymond, and D. Warner. 1984. A study of restoration in Pine Creek Salt Marsh, Fairfield, Connecticut. In: F. J. Webb, editor. Proceedings of the Eleventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL. pp. 11-23.

A 30-HA salt marsh near Fairfield, Connecticut was cut off from normal tidal flow by a dike. After 11 years, upland plants had invaded to a significant extent. This study examined vegetative response for 3 growing seasons following a breaching of the dike. As normal tidal flow was restored, woody shrubs, Phragmites, and other non-marsh plants decreased dramatically; after 1 year, 12 non-marsh species were no longer found at the site. The percentage decreased to 22.6% in the third growing season following the restoration of normal tidal flow. The marsh quickly became dominated by Salicornia, Spartina, and Distichlis species. The total number of shrubs declined from 194 to 6 in 3 years following the breaching of the dike. *

Boyd, M. 1982. Salt marsh faunas: Colonization and monitoring. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 75-84.

The author emphasis that any consideration of salt marsh restoration and recolonization techniques must begin with an evaluation of the dominant animals found in undisturbed salt marshes. He points out that, unfortunately, most attention has been focused on plant species, with only secondary attention paid to the animals. This paper presents preliminary findings on patterns of colonization and establishment of animal populations at a marsh restoration site on Humboldt Bay, and compares these findings to others for a marsh on San Francisco Bay. The relatively low diversity of animal populations of salt marshes off interesting opportunities to work within communities which may be readily manipulated by experimental approaches.

Breedlove, B. W. and S. R. Adams. 1982. The Delphi Technique as a means of incorporating agency bias in wetland regulatory decision making. In: Proceedings of the Ninth annual Conference on Wetlands Restoration and Creation. F. J. Webb, editor. Hillsborough Community College, Tampa, FL. pp. 181-193.

Wetlands value is the principal criterion used by regulatory agencies in the permitting of wetlands activities and often in making decisions concerning adequate mitigation and reclamation. A major feature of the permitting process is the review of applications by several agencies or departments within an agency, each with its own set of priorities.

To abate conflicts between agencies and to reduce permitting time, an approach for evaluating wetlands was developed, based on the relative importance of functional parameters of wetlands. The Delphi technique was used in combination with the Wetlands Evaluation Procedure, developed by the U.S. Army Corps of Engineers, to standardize decision-making criteria and to eliminate complex negotiations among agencies involved in reviewing or regulating wetlands activities. As a result of this procedure, application of regulatory criteria and control of bias could be of benefit in the permitting process by emphasizing the consensus viewpoint of various agency officials and professionals and by identifying tangential issues.

Broome, S. W., E. D. Seneca, and W. W. Woodhouse. 1986. Long term growth and development of transplants of the salt-marsh grass Spartina alterniflora. Estuaries 9: 63-74.

This paper describes the long-term sampling of S. alterniflora transplants along eroding estuarine shorelines in North Carolina. The effects of transplant spacing (45, 60, and 90 cm) were tested. 45 and 60 cm spacings were more successful on sites near the lower elevation limits of Spartina. Differences between the planted sites and natural marsh were apparent at first, but decreased over time; annual production and decomposition of the below-ground standing crop were nearly equal. After 10 years, the artificial marsh was self-sustaining, successful in shoreline erosion control, and equal in primary productivity to the natural marsh. *

Broome, S. W., W. w. Woodhouse, and E. D. Seneca. 1974. Propagation of smooth cordgrass, Spartina alterniflora, from seed in North Carolina. Chesapeake Science 15(4): 214-221.

This paper discusses the germination and establishment of Spartina alterniflora at various estuarine sites, including dredged material areas along the coast of North Carolina. Successful seed germination and survival were attributed to a combination of techniques including: 1) the storage of seeds at 2-3 degrees C, first in burlap sheets, then in estuarine or sea water over the winter; 2) direct seeding between April and early June. Seedling survival was best in the upper 20-50% of the elevational range of naturally growing Spartina. In one growing season, aboveground standing crop produced from seeds may be similar to that of well established marshes. *

Carangelo, P. D., C. H. Oppenheimer, and P. E. Picarazzi. 1979. Biological application for the stabilization of dredged materials, Corpus Christi, Texas: Submergent plantings. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 243-262.

Small test plots of upland, emergent, and submergent environments on recent and old dredged material and other barren sites in Corpus Christi Bay were transplanted with selected local natural plants. Data from the first year's growing season (1977-1978) is presented. Selection of nursery sites, determination and location of sprig transplant and seed varieties, substrate type, soil amendment, modification, and post-plant monitoring were conducted.

Emergent planting Spartina alterniflora exhibited a high degree of variability relating to differences in elevation, wave energy flux, sediment type, and time of year of planting. The report provides information on the types of plants that can be used to accelerate the rate of revegetation on dredged materials and other non-vegetated estuarine areas with a minimum of cost and effort. For the most part, however, only the submergent portion of the research is reported in this paper. Discussion focuses on growth and establishment of seagrass beds.

Carlson, J. E. 1982. Preliminary report on the restoration of farmed freshwater marshes at Corkscrew Swamp Sanctuary. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 212-227.

Approximately 180 ha of freshwater marshes at Corkscrew Swamp Sanctuary in Florida were modified by vegetable farming operations in the mid 1950's. Ecological impacts of these farmed areas range from localized changes in ground elevation, hyperperiod, and plant communities, to broad alterations of surface water flows. In spring, 1981, earth moving equipment was used to push dike material back into adjacent ditches in an attempt to restore the natural profile of approximately 60 ha of the armed marsh. Preliminary analyses indicate that total organic accumulation on the dikes and ditches was the major factor affecting success of natural profile restoration, and made precise releveling on the site impossible. Vegetative recovery after one growing season was essentially complete on restored ditches, while restored dikes showed minimal recovery.

Carlton, J. M. and Z. Williams. 1980. Vegetation establishment - Fontainbleau State Park, Louisiana. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 63-80.

This study reports on a vegetative shoreline stabilization project which was part of the U. S. Army Corps of Engineers nationwide, 5-year, 8 million dollar program to develop and demonstrate low cost means of preventing shoreline erosion. In addition to engineered structures, this project included a wide range of experimental devices which included plantings, consisting of several nursery grown, native grass species and a spreading native shrub. *Spartina alterniflora* was used in the intertidal zone; *S. patens*, *Phragmites australis*, and *Rosa bracteata* were planted in the upper beach zone. Planting was determined to be moderately successful at the site. Storm damage created the largest problems, as planned protective breakwaters were not in place at the time of the initial planting. Cattle grazing was also a problem. However, sufficient seed production occurred so that recovery was probable.

Clairain, E., Jr., R. A. Cole, R. J. Diaz, A. W. Ford, R. T. Huffman, L. J. Hunt, and B. R. Wells. 1978. Habitat Development Field Investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Summary Report. Technical Report D-77-38, Waterways Experiment Station, U. S. Army Corps of Engineers, Vicksburg, MS. 76 p. NTIS No.: AD-A074-872.

This paper presents the results of a two and a half year field investigation at Miller Sands Island, a tidal freshwater, dredged material disposal site in the Columbia River, Oregon. The field study was conducted to test the feasibility and the impact of developing marsh and upland habitats on dredged material. Summarized in this report are baseline information obtained before habitat development operations and results of post-development operational studies. The study is considered a successful plant habitat creation project. After about one year of development, planted habitats at the field site were expanding and were expected to provide additional future wildlife habitat as plant succession continues.

Clark, J. R. 1979. Mitigation and grassroots conservation of wetlands - Urban issues. In: The Mitigation Symposium: A national workshop on mitigating losses of fish and wildlife habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rock Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 141-150.

Case histories from the New York and Los Angeles metropolitan areas are used as examples of the difficulties that arise in mitigation of impacts in urban coastal wetlands development. Because both the natural values and real estate values of urban wetlands are so high, conflicts between advocates of development and preservation often become extremely serious. Effective mitigation programs are recommended as a potential solution to such conflicts. The case studies showed that danger of an arranged settlement for extremely valuable urban wetlands often interferes with mitigation procedures. The lesson is to engender the widest possible dialog and to make sure that all powerful interests are satisfied with uses, mitigation requirements ad performance standards. This can best be done in the context of formal environmental mediation which is recommended for most wetland mitigation situations.

Coastal Zone Resources Corporation, Wilmington, NC. 1976. Identification of relevant criteria and survey of potential application sites for artificial habitat creation. Volume II. Survey of potential application situations and selection and description of optimum project areas. Contract Report D-76-2, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 375 pp. NTIS No.: AD-A033-526.

This report develops a process for the selection of areas appropriate for artificial marsh construction using dredged material. Detailed explanations of the methodology to be used are set forth. The biophysical and socioeconomic information needed to evaluate potential marsh creation sites are described, and the rationale for the importance of such data is presented. Specific kinds of problems that might arise and theoretical approaches to their solution are also discussed. 50 prime candidate project site areas are described, and may be utilized by the Corps of Engineers.

Coenen, N. L. and B. Cortright. 1979. Mitigation of habitat losses in the estuary of the Hudson River. Suggested goals for long term management. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 103-107.

This paper discusses Oregon's requirement for mitigation through creation, restoration of estuarine areas to compensate for adverse impacts. Implementation of the requirement has been uncertain due to unclear criteria and procedures for making mitigation decisions. Based on the results of a technical study and administrative and legislative action, mitigation should become a more effective tool for protection of estuarine ecosystems in Oregon. The paper discusses a mitigation case study, the development of a mitigation task force, and existing and pending legislation concerning mitigation. The authors cite the challenges ahead to include a better understanding of the ecosystems which are being mitigated for, and to forge the institutional relationships and methods for funding mitigation and restoration projects.

Convisse, M. Mitigation of transportation impacts. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 71-74.

It has long been the policy of the Department of Transportation to seek to avoid adverse impacts on the environment, including specifically impacts on fish and wildlife, and where impacts cannot be avoided - to make every reasonable effort to mitigate these impacts. To implement this policy successfully, the Department of Transportation needs the assistance of fish and wildlife agencies and professionals. These experts must be involved in the mitigation process from the very earliest stages of transportation project planning. The paper outlines the environmental policies and procedures, policy implementation, research, and information that the Department of Transportation utilizes in its environmental mitigation projects and procedures. Emphasis is placed on the early assistance and advice of fish and wildlife agencies at the state and federal level.

Coultas, C. L. 1980. Transplanting needlerush (*Juncus roemerianus*). In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 117-124.

Needlerush (*Juncus roemerianus*) was dug at monthly intervals from a mid-marsh zone in a north Florida tidal marsh. Shoots and rhizomes were cut into approximately 20 cm and 6 cm lengths, respectively. Different treatments of the buds and rhizomes were experimented with. It was found that transplanting in the months of February and March resulted in better growth.

Coultas, C. L., G. A. Breitenbeck, W. L. Kruczynski, and C. B. Subrahmanyam. 1978. Vegetative stabilization of dredge spoil in North Florida. J. Soil and Water Conservation. 33(4): 183-185.

This study was designed to determine the suitability of several grasses for the stabilization of sand dredged material in supertidal areas of Dickerson Bay near Panancea, Florida. The effect of fertilizer on the growth of these plants (specifically sea oats, panic grass, and american beachgrass) was also tested. Results indicated that these three grasses were effective in stabilizing the spoil in the supertidal zone. Where the beach is exposed to high energy wave action, prior mechanical stabilization was necessary for the establishment of intertidal vegetation. Plants were treated with 100 lb./acre of 10-10-10 fertilizer twice during the growing season. All plants benefited, but there was little advantage in applying 200 lb./acre of fertilizer. *

Courser, W. D. and R. R. Lewis, III. 1980. The use of marine revegetation for erosion control on the Palm River, Tampa, Florida. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 126-136.

Due to severe erosion problems along the tidal portion of the Palm River in Tampa, Florida, a trial program to control the erosion using marine vegetation was undertaken. 200 feet of river bank were excavated to a gentle slope and cleared of all vegetation. Marine vegetation, *Spartina alterniflora* and *Paspalum vaginatum*, was planted and the growth monitored. After six months, the *Paspalum* had covered almost 100% of the formerly eroding shoreline. Only about 20% of the *Spartina* survived, but those remaining were spreading rapidly. The vegetative approach to controlling shoreline erosion was considered successful.

Crawford, J. A. and D. K. Edwards. 1978. Habitat Development Field Investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix F: Postpropagation Assessment of Wildlife Resources on Dredged Material. Technical Report D-77-38, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 68 pp.

This paper presents the results of an investigation into wildlife response to plant propagation on a dredged material island in the lower Columbia River (Miller Sands), Oregon, from July 1976-August, 1977. Data on birds, mammals, and terrestrial macroinvertebrates were collected, analyzed, and compared with data from other regions of the United States. Plantings did not have dramatic effects on the populations which were monitored. Avian density and diversity were mostly unaffected. However, in some cases, the number and type of species changed in response to the plantings.

Crawford, J. E., E. C. Roberts, and D. P. Meredith. 1979. Public land management opportunities for mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 488-490.

Scattered tracts of Federal public lands administered by the Bureau of Land Management provide islands of habitat diversity and opportunity for the Nation's wildlife. Public lands are managed under multiple-use charter which specifies commodity production as well as protecting environmental values. Special opportunities are identified for protecting and enhancing diversity through land-use planning, management, and habitat manipulation.

Cutler, M. R. 1979. The need to move from mitigation to multi-objective planning. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 54-58.

A multi-disciplinary team approach is required to insure that concern for the welfare of wildlife is an integral part of project design rather than a reason for mitigation. Many environmental and economic values must be balanced to achieve true and effective mitigation. A multi-objective approach to mitigation projects would include: identification of goals; exchange of experiences and test results; monitoring of conditions and evaluations of actions after construction; and collection and interpretation of data concerning impacts and values in a way that aids, rather than harms, natural resources.

Daiber, F. C. 1986. Dredge material for wetland restoration. In: F. C. Daiber, Conservation of Tidal Marshes. Van Nostrand Reinhold Co., New York, pp. 140-177.

This chapter describes the use of dredge spoil for wetland creation. Appropriate plantings may be determined by salinity, tidal rage, location, and elevation. Plat communities must be able to establish themselves and compete successfully. Site preparation factors (slope, and surface elevation) and plant species selection are described. Plant materials including seeds should be obtained from local marshes similar to the one being established. Propagation methods, plant zonation, role of invading species, fertilization, density, and biomass, sediments, toxic materials and faunal communities are discussed. Estimates for length of time required for a manmade marsh on a spoil site to reach the level of maturity of adjacent natural sites vary from 40 to 30 years (based on organic carbon content). Species evenness/richness and soil structure are other criteria used to evaluate marsh restoration results. *

Darovec, J. E., J. M. Carlton, T. R. Pulver, M. D. Moffler, and G. B. Smith. 1975. Techniques for coastal restoration and fishery enhancement in Florida. Florida Dept. of Natural Resources, Marine Research Laboratory, St. Petersburg, FL. 27 pp.

This report outlines interim guidelines for the reestablishment of sand dune, mangrove, salt marsh, seagrass and artificial reef communities along the Florida coast. Planting guidelines discuss sources of seeds and transplants, spacing, timing of planting, fertilization, planting techniques, seed collection and handling, species selection, and elevation. Community specific guidelines include: stabilization of primary dunes, transplanting of original salt marsh vegetation (smooth cordgrass, black needlerush), and size of mangrove transplants. Permit regulations, construction guidelines, materials, and oyster cultivation techniques are discussed for artificial reef communities.*

deMond, J. D., D. R. Clark, and B. E. Spicer. 1986. A review of wetland restoration enhancement, and creation practices in the Louisiana coastal zone. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 64-74.

The Coastal Management Division is a permit granting authority with the responsibility of administering the Louisiana Coastal Resources Program. In a regulatory context, wetland restoration, enhancement, and creation activities can be categorized as (1) Best Practical Techniques, (2) Restoration Activities, and (3) Preservation, Enhancement and Creation Projects. "Best Practical Technique Activities" are those which result in benefits to the wetland system but are a by-product of a permitted development project, e.g., spoil island construction during channel dredging. "Restoration Activities" are those in which an area is returned to near pre-project condition after an activity has been conducted and/or abandoned, e.g., lowering the elevation of a development site to encourage marsh vegetation reestablishment. "Preservation, Enhancement and Creation Projects" are those activities designed to primarily benefit wetlands, e.g., the installation of water control structures to regulate water levels within an impounded wetland. Areas under marsh management have a potential for revegetation and enhanced productivity. Other currently employed or potential techniques for promoting wetland resources in Louisiana include vegetational plantings, marsh and beach renourishment, backfilling of canals and pipelines, road degradation, waste pit restoration, sediment and freshwater diversion, and shoreline stabilization. The benefits and limitation of these practices are discussed as well as the role of these practices in regulatory strategies.

Dicks, B. 1977. Changes in the vegetation of an oiled Southampton water salt marsh. In: J. Cairns, K. L. Dickson, E. E. Herricks, editors, Recovery and Restoration of Damaged Ecosystems, Univ. Press of Charlottesville, VA. pp. 208-240.

This paper documents a study of the changes in vegetation as a salt marsh recovers from oil pollution damage incurred over a 20 year period. The study site is in Southampton Water, Hampshire, England. Recolonization success depends on effective seeding; although Spartine (Spartinetum) Anglica is the natural dominant vegetation, it reproduces primarily vegetatively, and spreads slowly, compared to other species. Effects of oil on marsh plants is discussed; in some areas where oil remains trapped in the strandline, recolonization may be prevented for some time. The revegetation of some previously denuded areas is a result of both climatic factors and water quality improvement. *

Diets, D. R. 1979. Interdisciplinary developmental and ecological assessment: A prerequisite to effective design of environmental mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 348-354.

This paper discusses the concept that mitigation efforts must be based on detailed knowledge of development plans and predicted environmental consequences by a multidisciplinary team of specialists. Impacts on biotic components and systems are transported mostly by abiotic vectors, i.e., air and water, and thus impact evaluation and mitigation must be based on valid multifunction experimental designs. Mitigation based on baseline data which includes environmental assessment and predicted environmental consequences of the development action has a good change of succeeding, especially when a multi-disciplinary approach has been used for impact evaluation.

Dillman, B. A. 1985. Wetland regulation: An effective approach. In: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 74-83.

Incomplete and, at times, inaccurate definition of wetland types has led to ineffective and inconsistent enforcement and administration of state wetland regulations. Four basic shortcomings of state wetland policies and some of the consequences of these shortcomings are discussed. The Rhode Island Fresh Water Wetlands Act, along with the acts of several other northeastern states, is critically reviewed. Special emphasis is played on the need to fine-tune the legislative definition of wetland types and to improve state mitigation policy. Examples from the wetlands acts of other states, particularly Florida's Henderson Wetland Protection Act of 1984, are used to show the biological and geological detail necessary for successful and consistent implementation of the Act. Necessary components of a successful mitigation policy are discussed.

Dodd, J. D., and J. W. Webb. 1975. Establishment of vegetation for shoreline stabilization in Galveston Bay. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Miscellaneous Paper No. 6-75. Fort Belvoir, VA. 67 pp.

Galveston Bay, Texas, was the site of a study to determine: 1) which resident marsh species were adapted to saline conditions, and 2) which of these species are best suited for revegetation to control shoreline erosion. Soil texture, soil chemistry and water salinity were measured at low, middle, and upper tide zones. A temporary wave-stilling device was erected to protect plantings; mechanical sloping was not successful due to severe natural erosion conditions. The upper zone supported Gulf and smooth cordgrass and giant reed. Valuable species for use in the middle zone were smooth cordgrass, saltgrass and black mangrove for protection and stabilization. Useful species for reduction of shoreline erosion in the lower zone were smooth cordgrass and black mangrove. Soil salinities ranged from 2,500 to 11,000 ppm in the study plots.*

Dunstan, W. M., G. L. McIntire, and H. L. Windom. 1975. Spartina revegetation on dredge spoil in Southeast marshes. J. Waterways Harbors and Coastal Engineering Division 101:269-276.

This article describes experimental planting of Spartina alterniflora on a 20 acre dredge spoil site at ell Gate on Little Don Island, Ossabow Sound, Georgia. Before planting, the silt-clay substrate had dried to a hard, cracked crust. Experimental plots were planted to test seeds, nursery plants, fertilization, and growth of transplants from: 1) a vegetated part of the same island, and 2) a healthy marsh on another island. Elevation ranged from 7-9 feet above mean low water. After 1 1/2 years, the local transplant survival rate was 36.1%, while that of the transported plants was 22.5%. Almost 70% of the Spartina planted at 7-7.5 feet above mean low water survived, while the rate for those planted above 8.5 feet was 8.7%. *

Earhart, H. G. and E. W. Garbisch, Jr. 1986. Beneficial uses of dredged materials at Barren Island, Dorchester County, Maryland. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 75-86.

In 1984, the Corps of Engineers dredged the Federal channel from the Chesapeake Bay to Honga River, Dorchester County, Maryland. Fish and wildlife habitats were developed by controlling the direction of the discharge pipe to provide designed dredged material elevations and configurations and by conducting post-disposal landscaping. Eight months following dredging, approximately 1.6 ha of Spartina alterniflora derived by seeding, 3.0 ha of unvegetated bird habitat, and 0.2 ha of artificially placed sand and shell were added to the existing habitat island created in 1981. The project costs were approximately 30 percent less than the traditional confined dredged material placement option.

Edwards, R. D. and W. W. Woodhouse, Jr. 1982. Brackish marsh development. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 1-17.

Marshes are considered to be valuable natural resources which contribute to the productivity of estuarine systems. Because of their ecologic and economic value, marshes are protected for disturbance by both state and federal regulations. Efforts are being made to minimize destruction of natural marshes. However, if a marsh is destroyed those responsible may be required to mitigate the loss by restoration or by establishing a new marsh.

Through an agreement with Texas Gulf Chemicals Company funding was provided for North Carolina State University to conduct experimental plantings which would lead to the establishment of a new brackish water marsh adjacent to Bond Creek in Beaufort County, North Carolina. Results of data surveys and conclusions drawn concerning wetlands mitigation plantings are discussed in detail.

Eleuterius, L. N. and J. D. Caldwell. 1981. Colonizing patterns of tidal marsh plants and vegetational succession on dredge spoil in Mississippi. In: Proceedings of the Eighth Annual Conference on Wetlands Restoration and Creation. R. H. Stovall, editor. Hillsborough Community College, Tampa, FL. pp. 58-72.

Position and zone of plant colonization and establishment on barren shores of dredge spoil in relation to elevation and slope of the intertidal plane were described from observations ad studies carried out over a 12 year period. *Spartina alterniflora* was consistently observed as the earliest colonizer of dredge spoil. About 30 other plant species subsequently colonized certain spoil areas, but many weedy species also occurred. The rate of succession and the variety of species increased with elevation in stands near the upper edge of the tidal plane. Shrubs and trees first appeared on the most elevated parts of spoil deposits and man-made beaches. The study concluded that if the proper physical environment is provided and created, one which is conducive to plant colonization, the proper plants will eventually colonize the area. Man, however, can often speed up the natural process by transplanting.

Eleuterius, L. N. and J. I. Gill. 1981. Long-term observations on seagrass beds and salt marsh established from transplants. In: Proceedings of the Eighth Annual Conference on Wetlands Restoration and Creation. R. H. Stovall, editor. Hillsborough Community College, Tampa, FL. pp. 74-86.

Tidal marsh plants were transplanted to a spoil area in Jackson County, MS. Preliminary rooting was found to be unnecessary for establishment; 60-80% survival was achieved when shoots were planted between November and February. Transplanting results were tested by 2 restoration projects in Biloxi Bay. *Spartina alterniflora* transplants established at higher elevations eventually spread to low areas on the intertidal plane. *Juncus roemerianus* remained in separate clumps: areas between clumps were colonized by *Distichlis spicata* and *Spartina patens*. It was recommended that *S. alterniflora* be planted between 1.8-3 feet above mean low water in this region. Large areas could be vegetated from one sprig or shoot within a short time. The use of hay bales for containment walls around spoil was recommended. Seagrass transplanted had a survival rate of about 30% after 1 year.*

Eleuterius, C. K. and L. N. Eleuterius. 1983. Numerical-hydrodynamic model use in evaluation of marsh island creation. In: Proceedings of the Tenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 76-93.

A computer-based hydrodynamic assessment system was developed to facilitate locating sites for spoil deposition that would favor marsh establishment in estuaries. The system incorporates a numerical model that is suitable for simulating circulation in vertically well-mixed estuaries. Computer outputs include tabular information on water elevations, water velocity, and descriptive statistics on these parameters. This capability allows detailed examination of current velocities and water levels around the edge of existing or proposed spoil islands.

Substantial hydrological data obtained directly from St. Louis Bay, Mississippi, were used to test and demonstrate the use of the newly developed system. The simulated effect of marsh islands on water circulation and vice versa in different locations in the bay are easily determined. Comparison of graphic ad statistical results allow rapid assessment and evaluation.

Environmental Laboratory. 1978. Wetland habitat with dredged material: Engineering and plant propagation. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, Mississippi. 158 p.

This report synthesizes information regarding marsh habitat development on dredge spoil substrate at 6 field sites: 1) Windmill Point, James River, VA; 2) Buttermilk Sound, Georgia Coast; 3) Bolivar Peninsula, Galveston Bay, Texas; 4) Miller Sands, Columbia River, Oregon; 5) Drake Wilson Island, Apaplachicola Bay, Florida; 6) Salt Pond #3, San Francisco Bay, California. Guidelines for marsh plant selection (location, climate, tolerance, availability, cost, and maintenance) are described. Site selection and construction are discussed. Information on regional occurrence, growth requirements, propagule handling methods, soil, salinity and inundation tolerance are listed for 115 plant species. 28 species are described in greater detail. *

Evans, M., and T. Brungardt. 1978. Shoreline analysis of Sarasota County bay systems with regard to revegetation activities. In: Proceedings of the Fifth Annual Conference on the Restoration of Coastal Vegetation in Florida. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 193-206.

This study involved an analysis of shorelines with respect to revegetation activities. The goals of the study were: 1) to inventory and evaluate the estuarine resources of Sarasota County, 2) to develop techniques for managing and protecting these resources, and 3) to make this information available to the residents of the county. The study results encouraged homeowners to utilize native vegetation for stabilizing their shorelines, and also suggested that native vegetation be used to stabilize public shores.

Faber, P. 1982. Muzzi Marsh restoration, a mitigation project. In: M. Josselyn, editor. Wetland Restoration and Enhancement in California, Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla, CA. p. 100.

One hundred thirty-five areas of diked and partially filled marshland on San Francisco Bay, California, were restored to tidal activity by dike breaching. After 4 years, 50% of the site was covered by *Salicornia virginica*. Between the third and fourth years significant increases in *Spartina foliosa* were noted. Increases in fish and invertebrates are reflected in the observation of active feeding of large flocks of shore birds. This project was developed as mitigation for the loss of 85 acres of mudflats to dredging activities. *

Falco, P. K. and F. J. Cali. 1977. Pregermination requirements and establishment techniques for salt marsh plants. U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, Vicksburg, MS. 35 pp.

This is an overview of pregermination requirements and establishment techniques for salt marsh plants. Seeding and transplanting methods have been used to successfully establish artificial marshes in coastal areas (including dredged spoil deposits). Most frequently the substrate is sand. Physical characteristics of substrate affect growth: elevation and hydrology affect plant distribution and zonation. State-of-the-art reviews cover: 1) factors affecting germination and growth of salt marsh grasses; 2) growth requirements; and 3) artificial marsh establishment. Recommendations for plant material sources, substrate, elevation, hydrology, and natural colonization area also discussed. *

Farmer, A. H. 1979. Development of mitigation alternatives: A process. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 327-330.

Mitigation involves management of existing habitat to offset habitat commitments to development projects. Even with complete mitigation, there will be a net loss of wildlife management opportunities. Given the limitations of mitigation as a wildlife planning tool, the optimal mitigation pathway is the development of mitigation alternatives directed to wildlife resource objectives and priorities. Mitigation planning requires the following planning components to be successful: wildlife planning objectives prioritized and scaled; ranking/scaling techniques with more detail and precision than previously used; quantitative impact assessment tools; and planning regulations that treat mitigation objectively.

Fauer, S. E. and M. Gritzuk. 1979. An environmental assessment of restored salt marshes in New Jersey. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 175-189.

An investigation was made to assess the restoration of seven salt marshes that had previously been disturbed by utilities construction. The seven salt marshes were restored during the summer of 1977 and were examined in 1978 to answer the following: 1) determination of the success of the Spartina alterniflora and S. patens transplants in each salt marsh, 2) an appraisal of the success of the entire project, and 3) an evaluation of whether the project had been a "worthwhile expenditure." The project was determined to be generally successful, however, certain problems resulted in the death of many transplants. The most common problem appeared to be drought induced salt accumulation followed by smothering of young transplants by Zostera marina. It was also determined that the ecological value of some of the marshes could have been improved. It is believed that certain problems which occurred after restoration could have been prevented by pre-restoration ecological surveys. The design for restored marsh should be based on existing conditions and the ecological needs of the area. By performing ecological assessments of the original undisturbed marshes, one can make a judgement based on the existing conditions that will result in a marsh that is compatible with the existing environment (e.g. number of species to be planted, types of species to be planted, and compatibility with surroundings).

The restoration efforts in the seven marshes were determined to have successfully re-established the salt marshes. The prime assets of the marshes were determined to be; 1) they are aesthetically pleasing, 2) the chance of erosion was significantly decreases, and 3) wildlife habitat was re-established.

Fehring, W. K., C. Giovenco, and W. Hoffman. 1979. An analysis of three marsh-creation projects in Tampa Bay resulting from regulatory requirements for mitigation. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 119-206.

Three marsh mitigation/creation projects in the Tampa, Florida, area were examined. The projects were initiated as the result of increasing environmental concern and governmental regulations over projects which impact wetlands, and the consequent increase in situations where developmental impacts are supposed to be mitigated through the creation of new wetlands. The probable success of each of the projects is discussed in terms of the nature of the responsible organization, ownership of the project site, social acceptance of the project, technique used in planting, and physical factors such as wave energy, elevation, and temperature. All three of the projects were found to have experienced technical problems such as site protection problems, elevation and grade problems, and transplant problems. It was also found that man-induced and controlled aspects of the projects created problems that were not as easily corrected or manageable. Among these problems were the reluctance of the developer to undertake the project expeditiously and to obtain and use the expert assistance needed to complete the project successfully. Because the developer would have no future interest in the area, the cheapest approach to complete the project was utilized.

The report concludes by supporting the present policy of state and federal agencies regarding the use of mitigation as a regulatory tool. The authors feel that public projects would be more successful where long-term responsibility for, and management of, the newly created resource would be available. They advise against using mitigation as part of the permit process for private land developers due to lack of long-term commitment to the success of the project.

Fernald, R. T., B. S. Barnett, and T. Gilbert. 1985. Establishment of native hammock vegetation on spoil islands dominated by Australian pines. *In*: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 96-109.

Spoil islands constructed during dredging of the Intracoastal Waterway and other navigable channels constitute a significant man-made habitat type in east-central Florida and offer unique opportunities for upland habitat enhancement. To study the feasibility of native vegetation establishment on these islands, 19 native species and one ornamental exotic species were planted on an upland portion of a spoil island in the Indian River near Vero Beach. Seedlings from two-inch liners were planted beneath the Australian pine (*Casaurina equiseti folia*) canopy, with no soil preparation, or subsequent fertilization or watering. Monitoring studies provided data on species survival rates and growth success of the project is evaluated.

Fowler, B. K., C. S. Hardaway, G. R. Thomas, C. L. Hill, J. E. Frye, and N. A. Ibson. 1985. Vegetative growth patterns in planted marshes on the vegetative erosion control project. *In*: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 64-74.

The Vegetative Erosion Control Project consisted of establishing and monitoring a number of *Spartina* fringes within the Chesapeake Bay system in Virginia during 1981 to 1984. The 24 marsh sites of the project were selected on the basis of maximizing the diversity of environmental conditions under which salt marshes might be established.

Various parameters of vegetative production were measured each year providing information on the early development patterns of our planted marshes. Comparisons of the data (base maps and vegetative samples) resulted in the following observations: (1) marshes of lower energy shorelines are more productive than those of higher energy shores; (2) *Spartina alterniflora* is much more productive in the higher regions of the intertidal zone, and best extends itself into lower elevations through secondary shoot production; (3) stem densities appear to be relatively greater in southerly-facing marshes; (4) culms are thickest in diameter in lower energy environments.

Gallagher, J. L. 1980. Salt marsh soil development. In: J. C. Lewis and E. W. Bunce, editors. Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-80-27. pp. 28-34.

This paper provides an overview of 1) salt marsh soil and its development; 2) characteristics of original marsh sediment; 3) plant selection to facilitate desired substrate changes. While natural marsh soils are tidally deposited with fairly uniform grain size fractionation, dredged materials are variable, and may be more difficult to vegetate. Salt marsh soil stability, acidity, moisture, salinity, and nutrients are discussed in detail. Plants which are tolerant of special soil conditions or which are useful in facilitating desired changes in substrate are described. *

Gallagher, J. L. 1980. Marsh creation: effects of pesticides on the flora. In: J. C. Lewis and E. W. Bunce, editors. Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. U.S. Fish and Wildlife Service, Biological Services Program. Washington, D.C., FWS/OBS-80-27. pp. 136-139.

This paper describes effects of pesticides on wetland vegetation. Various examples of herbicide/insecticide application, sometimes as part of marsh management are described. In other cases, wetlands are non-target recipients of pesticides. The fate of pesticides, including their transfer through food chains, is not well understood. Effects on wetland systems may be direct or indirect. Several examples of pesticide loss from soils are described. *

Garbisch, E. W., Jr. 1977. Recent and Planned Marsh Establishment Work Throughout the Contiguous United States: A survey and basic guidelines. Contract Report D-77-3, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 277p. NITS No.: AD-A041-464.

Information on deliberate marsh establishment work that is planned, underway, or completed throughout the contiguous United States from 1970-1976 is identified through: 1) literature review; 2) interviewing people; and 3) completion of distributed information request forms by various correspondents. From information received and collated, practical guidelines for site preparation, marsh establishment, and site management and maintenance were developed for marsh establishment projects. The two most important factors found for preparing a site for marsh creation are surface slopes and surface elevations. All aspects of marsh creation and establishment must be an integral part of the design and planning of the total project. Detail is provided on marsh planting techniques and methods.

Garbisch, E. W., Jr. 1977. Revegetation and development of tidal marshlands. In: Proceedings of the 32nd Annual Meeting of the Soil Conservation Society of America. New Directions in Century Three: Strategies for Land and Water Use. Richmond, VA., August 7-10, 1977. pp. 179-184.

This paper presents guidelines, techniques and mitigation opportunities for restoring marshlands lost as a result of construction/development activities. Tidal marsh establishment to reduce shoreline erosion and improve wildlife habitat was successful in Chesapeake Bay and Southern New Jersey. Filling and resurfacing with marsh materials was best accomplished in the winter when production was low and plants were dormant. Peat was the least desirable substrate material. Surface slopes were as low as possible. Proper surface elevation was important for successful vegetative establishment. Toxic salt concentrations in the soil can become a major limiting factor, inhibiting growth of marsh plants. Guidelines for establishing wildlife habitat on dredge material is included. *

Garbisch, E. W., Jr. 1978. Wetland rehabilitation. In: Proceedings of the National Wetland Protection Symposium, June 6-8, 1977, Reston, VA. J. H. Montanari and J. A. Kusler, editors. FWS/OBS-78-97, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 217-219.

The results of a survey of marsh restoration projects that was conducted for the Corps of Engineers, Waterways Experiment Station, are presented. From 1970-1978, 110 marsh creation projects were initiated in the United States. Out of 105 totally completed marsh establishment projects, only 9 were totally unsuccessful from causes that can now be controlled or avoided. Despite progress that has been made, the author contends that marsh rehabilitation must be considered a young and developing technology. Although it may be concluded that marsh rehabilitation is feasible and although general guidelines may be helpful, most sites have such unique characteristics that the ultimate design and implementation of the rehabilitation project must be site specific.

Garbisch, E. W., Jr. 1986. Highways and Wetlands: Compensating Wetland Losses. Federal Highway Administration, Office of Implementation. FHWA-1p-86-22. McLean, VA. 60 pp.

This illustrated handbook contains information on wetland restoration, enhancement, and establishment procedures. Specifications for wetland establishment, from final grading to maintenance requirements and costs are described. Factors that limit the success of wetland establishment projects include: improper final grade, poor choice of plant species, inadequate water level control, errors in the timing of plantings, erosion, vandalism, low quality materials, degradation by wildlife or livestock, development of salt stress zone, and litter deposition/accumulation. A guide to perennial wetland plants includes information on range, habitat, seed harvest and storage, recommended propagules, and site seeding potential for over 25 species. *

Garbisch, E. W., Jr., P. B. Woller, W. J. Bostian, and R. J. McCallum. 1975. Biotic techniques for shore stabilization. In: L. E. Cronin, editor. Estuarine Research, Volume II: Geology and Engineering. Academic Press, Inc., New York. pp. 405-426.

This paper describes planting techniques for estuarine shore stabilization. Of seven project sites described, 6 are along Chesapeake Bay's shoreline and one is at Ocean City, New Jersey. These projects have been initiated to establish salt, brackish, and fresh-water marshes on a variety of coastal substrates and shorelines. Each site is described in detail; planting results are summarized. Substrate limitations, fertilizer requirements, effects of stress, recovery of benthos, and methods of vegetative establishment are discussed. *

Gates, S. 1982. An inventory of California coastal wetlands with a potential for restoration and enhancement. In: Wetland Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, Univ. of California, La Jolla. pp. 11-22.

The goal to maintain and restore the remaining wetlands habitats while retaining the diversity of habitats can only be achieved if those institutions and individuals concerned with natural resource protection are aware of the wetland sites where the habitat value is diminishing or currently have high wildlife value and therefore deserve special attention and protection. This paper presents a compilation of wetlands in coastal California that require restoration and also a list of projects that are presently being planned for wetlands restoration.

George, D. H. 1982. Lagoon restoration at Cape Canaveral Air Force Station, Florida. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 84-103.

This paper describes findings from research and observations pertaining to the influence of estuarine tidal flushing on impounded lagoons. The lagoons referenced here were created by the construction of the U.S. Air Force Titan Missile Testing Facility at Cape Canaveral which extends into the North Banana River. The lagoon restoration plan originated from a request by the Air Force for Pan American World Airways, Inc. to submit a conservation/restoration type proposal to qualify a project for funding under Public Law 86-797 (The Sikes Act). The subsequent search for a suitable project, research into the ramifications of each project, and suggestions from the U.S. Fish and Wildlife Service culminated in a proposal submitted to the Air Force for installation of culverts to permit adjacent tidal lagoon waters to flush one of the water-impounded areas. This single lagoon would act as a pilot project to determine effects and favorable conditions resulting from the flushing exercise. Positive indicator which have already been observed and additional benefits to the system which were hypothesized are discussed and compared to literature cited.

Gifford, C. A. 1978. Use of a floating tire breakwater to induce growth of high marsh and foredune plants along a shoreline. In: Proceedings of the Fifth Annual Conference on Restoration of Coastal Vegetation in Florida. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 136-148.

A floating tire breakwater used for shoreline erosion control in Santa Rosa Sound was investigated and was found to have induced volunteer growth of several species of high marsh and foredune plants along the protected shoreline. Accreted detritus apparently contained viable seeds, plant fragments, and nutrients. No planting, fertilizing, or other care was needed. Spontaneous growth of shoreline vegetation occurred along the previously eroding beach following installation of floating tire breakwaters for shoreline protection. Such vegetative growth did not occur on unprotected adjacent beaches. It appeared that burial of organic detritus in accreted sand was a necessary condition for such growth. Rapid successional changes were observed in the vegetative communities which resulted in establishment of common high marsh or foredune plants.

Gonor, J. J. 1979. An evaluation of the ecological basis of mitigation requirements in the Oregon statewide estuarine resources planning. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 93-102.

The basis for estuarine mitigation actions is evaluated from the ecosystem viewpoint. Definition and application of the concept of similar biological potential is discussed. Creation and restoration options and their priority are evaluated, and a third, alteration, suggested. The importance to mitigation of macrophyte production at all tide levels is emphasized. Methods for predicting the outcome, determining areal equivalences, and evaluating adequacy of mitigation are suggested.

Gucinski, H. 1978. A note on the relation of size to ecological value of some wetlands. Estuaries 1(3): 151-156.

This article describes a study that was undertaken to evaluate the relationship between wetland size ad ecological value. The study area was the Mayo Peninsula on the western shore of the Chesapeake Bay, where geologic/hydrologic characteristics and land use effects were relatively homogeneous. Of a total of 59 marshes in this area, 53 are less than 5 acres and comprise 54% of the total area. 68% of the total upland edge length of the marshes is accounted for by marshes less than 5 acres; 73% of the seaward edge length is also associated with these smaller marshes. Several recommendations are listed with respect to the potentially large significance of small marshes, including reasons why they should be afforded greater protection. A cautionary note advises that caution be used if these data are applied to other geographic areas.*

Jolly, W. C. 1979. Congress and the mitigation of fish and wildlife habitat losses. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 520-526.

This paper defines and discusses the authority of Congress for fish and wildlife habitat. It explains the organization of congress for fish and wildlife matters, general congressional considerations affecting fish and wildlife legislation and funding, and the FWCA is reviewed. The need for wildlife managers to address socio-economic and political environments of the fish and wildlife resource is argued.

Josselyn, M., ed. 1982. Wetland Restoration and Enhancement in California. Report T-CSGCP-007. California Sea Grant College Program, University of California, La Jolla. 110 pp.

This volume is a compilation of proceedings developed from a workshop held in 1982 in California. The purpose of the workshop was two-fold: 1) to summarize the existing knowledge on wetland restoration and enhancement in California; and 2) to address current problems and constraints which limit the ability to successfully restore such systems. Eight major presentations were given followed by comments from invited panelists who reviewed the papers. Audience comments are also included in the proceedings.

Hunt, L. J., A. W. Ford, M. C. Landin, and B. R. Wells. 1978. Habitat Development with Dredged Materials. Engineering and Plant Propagation. U.S. Army Corps of Engineers Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 160 p.

The use of dredged material as substrate for upland habitat development proved to be a feasible alternative to standard dredged material operations. Three sites were selected to report research results and development guidelines: Miller Sands in the Columbia River, Oregon; Bolivar Peninsula in Galveston Bay, Texas; and Nott Island in the Connecticut River, Connecticut. Detailed information is provided concerning substrate structure and project feasibility. Tables listing 360 plant species provide information on their suitability and requirements for planting, including soil pH, soil salinity, wildlife value, storage requirements and growth. Costs, contaminants, fertilizers, pests, diseases, and potential problems are also discussed. *

Johnson, L. E. and W. V. McGuinness,Jr. 1975. Guidelines for Material Placement in Marsh Creation. Contract Report D-75-2, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 225 pp. NTIS No.: AD-A010-725.

This report presents guidelines that were developed for creating new marsh from dredged material under a variety of situations and constraints. Operational guidelines were established, as well as guidelines for the alleviation of physical environmental problems ad guidelines for disposal site elevation control. Procedural guidelines are established which should be used in sequential fashion: 1) determine if marsh creation warrants significant consideration; 2) determine most likely types of marsh to be created; 3) make preliminary comparison with other disposal alternatives; 4) refine basic properties; and 5) focus on special characteristics.

Hunt, L. J. 1979. Principles of marsh establishment. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 127-142.

This paper summarizes the information that was collected as part of the U.S. Army Corps of Engineers Dredged Material Research Program. Six field sites were investigated, each a marsh established on substrates of dredged material in a variety of locations ad situations: three in salt water, three in fresh water. All of the sites were tidally influenced, and were located in diverse areas of the country: Oregon, California, Texas, Florida, Georgia, and Virginia. The five year study provided information and recommendations on appropriate elevations, plant invasion, need for site protection, need for fertilization, plant species and propagule selection, spacing, and time of planting. It is felt that the principles derived from this research are valid marsh vegetation establishment for reasons of erosion control, marsh restoration, land enhancement, or general ecological benefit.

The project showed that elevation, attendant inundation, and tolerance to flooding of planted ad invading species were the primary determinants of marsh composition. Of secondary importance at one or more sites were site protection, soil fertility, propagule type, and spacing of plantings. Lower intertidal elevations were found to be more difficult to vegetate than higher elevations receiving less tidal inundation. Few species were found to be tolerant of lower level elevations, reducing chances of survival of planted and invading vegetation. Fertilization was unnecessary at most sites, both because the tides apparently caused it to leach, and because the sediments accumulating were nutrient-rich. Seeds are not recommended as a propagule type as tidal ation often dislodges them. A general spacing of 0.5 m-1.0 m between propagules is recommended.

Heilman, P. E., D. M. Greer, S. E. Brauen, and A. S. Baker. 1978. Habitat Development Field Investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. Appendix E: Postpropagation Assessment of Botanical and Soil Resources on Dredged Material. Technical Report D-77-38, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 390 pp. NTIS No.: AD-A062-261.

This report describes the Miller Sands, Oregon, study area, methods, ad results of the habitat development experiments conducted there. The study consisted of investigations and experimental plantings on the older upland portion of the island and on the more recently constructed spit and marsh area. Successful establishment of marsh vegetation was accomplished through use of transplants with direct seeding being largely unsatisfactory. Fertilization appeared to improve growth and development of grasses, but it does not appear that fertilization was an absolute requirement. Benefits to wildlife from the planting in the upland area varied with plant species. Biomass production on the planting areas greatly exceeded that in the control, reference meadow.

Hoffman, W. E. and J. A. Rodgers, Fr. 1980. A cost/benefit analysis of two large coastal plantings in Tampa Bay, Florida. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 265-278.

Between late 1978 and mid-1979, two major coastal vegetation plantings were completed on dredge material in Hillsborough Bay, Florida. This study compared and contrasted the costs and man power requirements for planting dredte spoil areas with Spartina alterniflora, and Avicennia germinans and Laguncularia recemosa (mangroves). On one dredge spoil island, S. alterniflora was planted on 1 m centers, and exhibited 93.4% survival after 14 months. On the other spoil island, mangroves were planted on 2 m centers. After 13 months, this planting exhibited 73.3% survival. The labor requirements for smooth cordgrass were 995 man hours/hectare as opposed to 2541 man-hours/hectare for mangrove transplanting. Smooth cordgrass required $4566/ha for plugs while mangrove transplants cost $11,459/ha. These costs entail primarily labor, and neglect most indirect costs experienced. The planting of smooth cordgrass plugs appeared more cost effective than mangrove transplants both on a unit area and unit plant basis. The time frame for newly planted smooth cordgrass to achieve habitat "usefulness" is shorter than that for mangrove transplants, i.e., the cordgrass is more productive more quickly than the mangroves.

Hasted, S. S. 1980. Growth, sedimentation/erosion, water quality in two marsh restoration projects in Clinton and Stratford, CT. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 81-116.

Restoration studies were conducted on both a high marsh and a low marsh over two growing seasons in Clinton and Stratford, CT, respectively. Different stock forms and plant species were studied for growth response to elevation, substrate texture and nutrients, fertilizer, and water quality. It was found that drainage, controlled partly by elevation and especially by substrate texture, proved the determining influence on plant growth with substrate nutrition and fertilizer having negligible influence. Water quality appeared to be potentially significant to plant growth. Evidence suggests that fertilizer may leach more readily than supposed. The paper provides only an incomplete sampel of the project findings, but gives information where more data can be obtained.

Hefner, J. M. 1982. The National Wetlands Inventory: Tools for wetland creation and restoration. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 265-275.

The National Wetlands Inventory Project of the U.S. Fish and Wildlife Service has developed several products which have direct application in the wetland restoration and creation planning process. The paper identifies these products, describes their preparation, gives suggestions for their use and indicates their availability. Products identified include the Wetland Map Series, the Wetland Soils List, the Wetland Plant List and Data Base, and the Statistical Trend Analysis of Wetland Gains and Losses.

Hardisky, M. A. 1979. Marsh restoration on dredged material, Buttermilk Sound, Georgia, 1978. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 143-173.

This study, part of the Dredged Material Research Program, USACE, consisted of a study to determine the environmental effects of dredging and disposal operations and the development of environmentally and economically feasible disposal alternatives. The project was conducted in 1975 in an estuary at the mouth of the Altamaha River near Brunswick, Georgia. A large, open water, dredged material disposal area was graded to a gently sloping plane extending from mean high to mean low water. Seven marsh plant species were selected and transplanted onto the experimental area. Initial results confirm the feasibility of marsh development on dredged spoil islands. Continued monitoring will result in additional data on biomass (above and below ground), the effects of natural invasion by brackish and freshwater plant species, and potential wildlife habitat value of the created marsh.

Sample data collected through 1978 indicate that the Buttermilk Sound Marsh Habitat development site provided adequate stabilization of the deposited dredged material. The habitat appears to be continually changing, as evidenced by the alteration of the species composition and dominance. It is anticipated that future changes will yield more pronounced dominance by key plants that will continue to be influenced by cyclic changes in the salinity regime as dictated by the flow of the Altamaha River.

Hardaway, C. S., G. R. Thomas, B. K. Fowler, C. L. Hill, J. E. Frye, and N. A. Ibison. 1985. Results of the vegetative erosion control project in the Virginia Chesapeake Bay system. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 143-173.

Reestablishing a marsh grass fringe for estuarine shoreline erosion control is an accepted alternative to construction of bulkheads, revetments and groins. The physical limit of creating a marsh grass fringe is mainly the severity of wave climate acting on a given shore. The main variables used to determine the relative intensity of wave climate are (1) average fetch exposure, (2) shore geometry, and (3) shore orientation.

In the Virginia Chesapeake Bay system, 24 planted marsh grass fringes were monitored from 1981 to 1983. These sites were selected to include a variety of average fetch exposures. Results of the planting project showed that (1) establishing a marsh grass fringe can be accomplished with little or no maintenance planting on relatively low wave energy shores (average fetch exposure less than 1.0 nautical mile). (2) Along medium wave energy shorelines exposed to 1.0 to 3.5 nautical miles average fetch, the establishment of a combination fringe of smooth cordgrass and salt meadow hay is necessary. (3) On straight shorelines with average fetch exposures of 3.5 to 5.5 nautical miles it will be impractical to try and establish a marsh fringe without some type of permanent offshore wave stilling device (i.e., a breakwater). (4) Shorelines exposed to an average fetch greater than 5.5 nautical miles should not be considered for marsh grass implantation unless well protected by a headland, island, or spit. The use of offshore breakwaters in combination with marsh implantation is a consideration but further research is needed.

Haines, E. 1980. Salt marsh creation: impact of sewage. In: J. C. Lewis and E. W. Bunce, editors. Rehabilitation and creation of selected coastal habitats: Proceedings of a Workshop, U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS.OBS-80-27. pp. 148-153.

This paper describes the impacts of sewage on salt marshes; several case studies are described. These impacts include: 1) accumulation of substances; 2) stimulation of biological processes; 3) inhibition of microbial processes. Salt marshes are not very effective as secondary sewage treatment areas, but there may be high monetary value attached to their tertiary treatmetn properties. marsh plants ad benthic algae have high rates of production and can assimilate some nutrients. While some marsh sedimetns transform nitrogen through denitrification, they also accumulate toxic materials. Maximum loading rates have yet to be identified.*

Hall, R. S. and T. R. Vogt. 1979. Mitigation and the multi-objective planning process. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 343-347.

This paper discusses the use of the revised Habitat Evaluation Procedures (HEP) in resource development planning. Federal resource agencies are now considering broader interrelationships when considering mitigation projects, and are developing and analyzing a wider range of alternatives in the decision-making process. As this approach demands a new sophistication in resources development planning, it likewise creates additional resource data requirements. New methods, such as HEP are needed to quantify values through objective, valid, and accepted procedures.

Josselyn, M. and J. Buchholz. 1982. Summary of past wetland restoration projects in California. In: Wetland Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 1-10.

This paper presents a definitive listing of completed wetlands restoration projects in California and provides bibliographic data to direct individuals to appropriate sources. Also included are recommendations to improve information transfer from these sources to agecies and groups planning future restoration projects. The enhancement and/or restoration projects listed usually involve a complete or partial establishment of tidal and/or freshwater flows to stimulate the growth and establishment of wetland vegetation and associated wildlife habitat. Data for the projects came primarily from permit file and through various regulatory agencies.

Josselyn, M. and R. Perez. 1982. Salt marsh restoration from salt evaporation ponds: vegetation establishment and sediment properties. In: M. Josselyn, editor. Wetland Restoration and Enhancement in California Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla, CA. p. 100.

The natural vegetation of Hayward Marsh in south San Francisco Bay is described. This 200 acre site was formerly a solar evaporation pond system, and prior to dike breaching, the sediment salinities ranged from 9-181 ppt. Ten months after tidal flooding, the soil salinity range dropped to 10-22 ppt. Revegetation occurred via airborne and floating seeds, and vegetative growth from drifting plant fragments. Plant establishment has been limited by sediment scouring, inadequate seed stock, season, and distance of seed dispersal.*

Kadlec, J. A., and W. A. Wentz. 1974. State-of-the-art survey and evaluation of marsh plant establishment techniques: induced and natural, Vol. I, Report of Research. U.S. Army Waterways Experiment Station, Environmental Effects Laboratory, Vicksburg, MS. 231 pp.

This report describes techniques and environmental conditions associated with the establishment of plants in saltwater and freshwater wetlands. Propagation, means of dispersal and growth success are included. Environmental conditions that hinder plant establishment include: physically unsuitable material, nutrient deficiencies, polluted sediments, excessive wind or current, turbidity, and unfavorable water depths. Factors affecting plant establishment in specific slatwater or freshwater sites, establishment techniques, and species selection are discussed in detail. *

Kennedy, E. A., K. W. Fucik, and D. C. Mitchell. 1986. Identification of sites and application of a mitigation program along the Texas coast. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 106-117.

Field surveys were conducted during February, May, and October, 1985, to identify at least 120 potential mitigation sites along the Texas coast. These surveys were commissioned by the Texas General Land Office, which has the responsibility for managing submerged lands within the state.

Mitigation sites were selected in areas of ecological similarity on the basis of improving seagrass beds, emergent marshes, rookery areas, and oyster reefs. For each site, a narrative for implementing the recommended mitigation option was presented with supplementary maps and color photographs.

The permit holder agreed to implement a prescribed mitigation plan which included creation of segrass habitat at a depth conducive to growth of shoalgrass (Halodule wrightii). After excavating a slightly emergent tidal flat with a hydraulic dredge in the late summer, shoalgrass was transplanted on approximate 0.91-m (3 ft.) centers during early April of the following year. Delay in the transplanting effort should assure a greater success rate since planting would take place after site stabilization and during the spring growth surge.

Knutson, P. L. and W. W. Woodhouse, Jr. 1982. Pacific Coastal Marshes. In: Creation and Restoration of Coastal Plant Communites. R. R. Lewis, III, editor. CRC Press, Inc., Boca Raton, FL. pp. 111-130.

This paper describes natural plant communities in Pacific coastal marshes, their historic losses, values, and projects of restoration and creation. Pacific coastal areas are prime candidates for marsh restoration. A goal has been expressed by the California Legislature to restore 25% of the state's lost wetlands by the year 2000. Guidelines presented in this paper are based on experimental plantings in the pacific coastal areas and on existing literature. The authors caution that recommendations made may be speculative because of the paucity of actual data. Details and recommendations are made with regard to plant materials to utilize in restoration projects, planting techniques (site preparation, fertilization, spacing, planting season, and maintenance), planting costs, and factors controlling success or failure of a project such as wave stress.

Krone, R. 1982. Engineering wetlands: Circulation, sedimentation, and water quality. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 53-62.

Restoration of diked lands to viable marshes includes the restoration of flooding and draining regimens and importation of fresh sediments that provide conditions for growth of desired plant species. Tidal flows in a marsh are complex, and the methods for computing such flows are approximate. These methods, together with consideration of the properties of soils, sediment transport, and plant species/elevation are adequate to design dike breaches which will achieve conditions for the restoration of desired palnt species. This paper describes methods that have been used in the San Francisco Bay system to design facilities for flooding and sedimentation on dike marshlands for restoration purposes.

Kruczynski, W. L. 1982. Salt Marshes of the Northeastern Gulf of Mexico. In: Creation and Restoration of Coastal Plant Communities. R. R. Lewis, III, editor. CRC Prss, Inc., Boca Raton, FL. pp. 71-88.

This paper reviews the characteristics of the natural marshes which exist along the Gulf of Mexico coastline from Tarpon Springs, Florida, through Mississippi, and summarizes studies on the establishment of marsh communities on dredged spoil in these areas. Existing tidal wetlands are described in detail, including descriptions of plant zonation, productivity, animal communities, and wetland destruction. A generalized discussion of planted species, methods of planting and fertilization, factors affecting success of transplants, and natural colonization is included.

Kruczynski, W. L. and R. T. Huffman. 1978. Use of selected marsh and dune plants in stabilizing dredge materials at Panacea and Apalachicola Bay, Florida. In: Proceedings of the Fifth Annual Conference on Restoration of Coastal Vegetation in Florida. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 99-135.

This study investigated the use of vegetation to establish permanent vegetation areas on various dredge spoil islands in Florida. The attempt to establish an intertidal marsh on Panacea Island failed, probably due to tidal currents and coarse, unconsolidated intertidal sands. Beachgrass, sea oats and panic grass grew well on the supratidal portion of the island, and growth of panic grass was increased by addition of 10-10-10 fertilizer at a rate of 100 lbs./acre applied twice during the growing season.

Spartina alterniflora planted in a protected area on another dredge spoil island grew best when culms were planted 1, 2, and 3 feet apart. Poorer growth in plots with culms spaced 6 and 9 feet apart may have been due to increased currents in these areas. Spartina patens grew in plots planted at 6 and 9 feet intervals, at an elevation of about mean low water.

Kruczynski, W. L., R. T. Huffman, and M. K. Vincent. 1978. Habitat development field investigations, Apalachicola Bay marsh development site, Apalachicola Bay, Florida. U.S. Army Corps of Engineers, Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 39 pp.

Drake Wilson Island, Apalachicola Bay, Florida was the site of a study to determine the feasibility of marsh development on fine and coarse-grained dredged material in a brackish water intertidal environment. Spartina sprigs were planted at 0.3 to 2.7 m intervals with 7-13 cm attached rhizomes and 5-10 untrimmed leaves. Planting at 1.8 to 2.7 meters produced poor cover results. At elevations of 1.0 to 1.4 meters and intervals of 1.8 to 2.7 meters, excellent growth results were achieved. This report recommends a small-scale study of habitat characteristics prior to undertaking a large-scale project. *

Krulitz, L. M. 1979. Federal legal background for mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 19-26.

This paper examines the statutory basis for mitigation of fish and wildlife losses caused by federal or federally approved water projects, discusses the most significant judicial interpretations of those authorities and what impact they have had in practical terms. Also examined are the major unresolved questions about mitigation and likely areas for future discusssion.

Landin, M. C. 1986. Wetland beneficial use applications of dredged material disposal sites. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 118-129.

The U.S. Army Corps of Engineers over the past 15 years has built over 3300 ha of wetlands, and over the past 100 years over 2000 islands in U.S. waterways from dredged material or direct construction. These sites have been built for a variety of reasons, inclduing accidental construction, research, special requests from local sponsors, and mitigation. Case studies on six of these sites are presented, and include Bolivar Peninsula, Texas; Buttermilk Sound, Georgia; Gaillard Island, Alabama; Miller Sands, Oregon; Pointe Mouille, Michigan; and Salt Pond #3, California. Technical information is available from Waterways Experiment Station which identifies principal applications and outlines techiques for project planning design, construction, and management to achieve success in wetlands development, including a state-of-the-science engineer manual on beneficial uses of dredged material.

LaRoe, E. T. 1978. Mitigation: A concept for wetland restoration. In: Proceedings of the National Wetland Protection Symposium, June 6-8, 1977, Reston, VA. J. H. Montanari and J. A. Kusler, editors. FWS/OBS-78-97, Office of Biological Servies, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 221-224.

This paper discusses the legal requirements for mitigation of dredge and fill operations in intertidal and tidal marshes in Oregon. The regulations and guidelines list three general priorities to look for in creating or restoring estuarine areas: 1) highest priority areas are those in close proximity to the fill or dredge sites; 2) if an on-site area is not available, then another part of the estuary may be selected according to the similarity of the following characteristics: salinity, tidal exposure, elevation, substrate, currents, and slope, and 3) if similar areas or those with a similar potential cannot be found, areas to be restored must be those with resources in the greatest scarcity compared to their past abundance and distribution, i.e., those which have been most severely impacted by man's activities.

Leenhouts, W. P. 1985. Soil and vegetation dynamics in a rotary ditched mosquito control impoundment on the Merritt Island National Wildlife Refuge. In: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F.J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 181-192.

From April, 1981, to July, 1984, changes in soil and vegetation occurred relating to the open marsh water management (OMWM) activities on the Merritt Island National Wildlife Refuge (MINWR). During this period, there was a significant decrease ($P > 0.05$) in four soil elements: soluble salts, phosphorus, potassium, and calcium. Vegetation changes occurred as follows: a significant increase ($P > 0.05$) in spike grass (Distichlis spicata) and total cover, a significant decrease ($P > 0.05$) in perennial glasswort (Salicornia virginica), ad significant changes ($P > 0.05$) in annual glasswort (Salicornia biglovii) and saltwort (Batis maritima). Spike grass will respond to soil changes in 1 to 2 years. The data indicated that OMWM strategy had a much greater effect on the soil and vegetation changes than did the rotary ditches. The construction of the rotary ditches had no significant effect on vegetation.

Lewis, R. R., III, ed. 1982. Creation and restoration of coastal plant communities. CRC Press, Inc., Boca Raton, FL. 219 p.

This volume is a collection of papers on creation and restoration of habitats and ecosystems of the various coastal marshes of the United States. Included is a useful compilation of information on creation and restoration of coastal plant communities. The papers provide detailed information and literature reviews. Details on plant materials, methods to be used in restoration, and success of restoration projects are included, as are discussions of coastal sand dunes of the U.S., Atlantic coastal marshes, salt marshes of the Gulf of Mexico, Pacific coastal marshes, mangrove forests, sea grass meadows, and low marshes of both China and Florida.

Lewis, R. R., III. 1982. Low marshes, peninsular Florida. In; Creation and Restoration of Coastal Plant Communities. R. R. Lewis, III, editor. CRC Press, Inc., Boca Raton, FL. pp. 147-152.

This paper discusses the usefulness of smooth cordgrass, Spartina alterniflora Loisel, in situations where it is not the dominant member of the coastal plant community. In southern coastal Florida, the dominant coastal estuarine vegetation is usually mangrove forests composed of mangroves with a narrow band of cordgrass at the fringe of the forest. Attempts have been made to replant mangrove areas with S. alterniflora for several reasons: 1) more rapid coverage and stabilization of substrates; 2) establish preferred nesting habitat for Clapper Rails and Willets; 3) more cost effective; 4) greater value in erosion control; and 5) greater value in trapping sediments. Also, S. alterniflora acts as a nurse species trapping floating propagules of mangroves and eventually being replaced by mangroves as they shade out the grasses.

Lewis, R. R., III. 1982. Restoration of a needlerush (Juncus roemerianus Scheele) marsh following interstate highway construction II. Results after 22 months. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 69-83.

During June-July 1980, 21,000 15.2 cm diameter plugs of Juncus roemerianus Scheele (needlerush) were transplanted from a natural marsh to a 3.0 ha area of disturbed marsh that had been destroyed during a bridge construction project. After 22 months, overall survival of the plugs has been approximately 50%, with the major losses (100%) being in the planted areas shaded by the bridge and in areas that were not graded low enough. Essentially 100% survival and a 25-fold increase in number of culms has occurred in those plugs placed at or slightly below the natural marsh elevation.

Lewis, R. R., III, and C. S. Lewis. 1977. Tidal marsh creation on dredged material in Tampa Bay, Florida. In: Proceedings of the Fourth Annual Conference on Restoration of Coastal Vegetation in Florida. R. R. Lewis and D. P. Cole, editors. Hillsborough Community College, Tampa, FL. pp. 45-67.

Experimental plantings of smooth cordgrass, *Spartina alterniflora*, were undertaken on a 12 year old dredged material island in Tampa Bay, Florida. Thirty-six plants transplanted in September of 1976 increased to 267 plants in 10 months. A control area of similar elevation and substrate showed no natural establishment of any intertidal plant species. Fifteen plants gorwn from Virginia seed and planted in October of 1976 increased to 331 plants by June of 1977. Seed was successfully harvested, germinated, and the plants placed on site during the study. All plants showed excellent survival and spreading ability. It is concluded that active planting efforts will increase the rate of establishment of *S. alterniflora* in protected dredged material sites in Tampa Bay.

Lewis, R. R., III, C. S. Lewis, W. K. Fehring, and J. A. Rodgers, Jr. 1979. Coastal habitat mitigation in Tampa Bay, Florida. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 136-140.

This paper traces the history of land development practices and harbor development in Tampa Bay, Florida, which have resulted in large scale losses of coastal habitat. Cooperative efforts by citizens and regulators resulted in successful mitigation of some of the associated wetland losses by creation of tidal marshes and moving threatened mangroves onto dredged material islands. Avian nesting habitat was also created to mitigate beach development.

Lewis, J. C. and E. W. Bunce, editors. 1980. Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. 162 pp. NTIS No.: PB81-165-649.

Nineteen papers are included in these proceedings of a workshop held at Sapelo Island, Georgia, in 1976. The editors feel that the papers are significant because they contain useful information which may be beneficially applied in the rehabilitation and creation of coastal habitats. Individual topics include techniques for creating salt marshes, creation of marshes on dredged material, planting techniques, marsh soil development, substrate interaction, deterioration of marshes, sand dune creation, mangrove swamp creation, and creation of seagrass beds.

Lewis, R. R., III and R. C. Phillips. 1980. Experimental Sea Grass Mitigation in the Florida Keys. In: Proceedings of the Seventh Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 155-174.

An experimental seagrass mitigation project was initiated in February 1979 at Craig Key in the Florida Keys under the sponsorship of the Florida Department of Transportation. Plugs and short shoots of Thalassia testudinum, Halodule wrightii, and Syringodium filiforme were transplanted and were monitored over a period of two years (monitoring was in progress at the time of the report). After one year, it appeared that plugs of seagrasses yielded the best long-term survival and success. Also, the spacing of plugs on one meter intervals gives the best long-term survival.

Lindall, W. N., Jr., A. Mager, Jr., G. W. Thayer, and D. R. Ekberg. 1979. Estuarine habitat mitigation planning the Southeast. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 129-135.

This paper investigates the problem caused by many of the water-dependent permit projects that are causing a decided loss and alteration of wetland habitat. Unless cumulative impacts are recognized and steps are taken to prevent continued loss, the point eventually will be reached when valuable habitat is irreversibly reduced. To insure that this does not occur, the authors propose a program of zero-habitat loss through mitigation options consisting of preservation, restoration, and generation of habitat. The authors emphasize that adequate documentation, through quantitative and statistically valid data acquisition and analysis, must be provided if mitigation measures are to be accepted and applied. Simultaneously, they recommend that an adequate follow-up system be designed and implemented to insure that mitigation measures stipulated in permits are being carried out.

Lindau, C. W. and L. R. Hosner. 1982. Sediment fractionation of Cu, Ni, Zn, Cr, Mn, and Fe in one experimental and three natural marshes. J. Environmental Quality 11(3): 540-545.

This article compares sediment fractionation of several metals between one artificial and three natural marshes in the vicinity of Galveston Bay, Texas. The artificial marsh was constructed using dredged spoil material. Mineralogical properties of all four marshes were compared, and total concentrations and partitioning of Cu, Ni, Cr, Zn, Mn, and Fe among marsh sediment fractions were examined. The primary factor affecting the distribution and abundance of metals in marsh sediments is elevation. In general, metal concentrations at the study sites increased as marsh substrate elevations decreased.*

Lindau, C. W. and L. R. Hosner. 1981. Substrate characterization of an experimental marsh and three natural marshes. Soil Science Soc. of America. 45:1171-1176.

This article describes the substrate of several marshes near Galveston, Texas. Dredged material was used as the substrate for an experimental intertidal salt marsh. For 16 months its chemical and physical properties were monitored. Spartina alterniflora and S. patens were planted, and various fertilizer treatments were administered. In a separate study comparing the experimental marsh to three nearby natural marshes, it was found that organic matter, total kjeldahl nitrogen and NH4-N were initially lower in the experimental marsh. Elevation was the main factor influencing the distribution and abundance of nutrients and particle size in the marshes. Fertilizer had no significant effects. *

Los Angeles Harbor Depart, Edaw Inc. 1982. Cabrillo salt marsh construction. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 100.

The planning of construction of a 5 acre marsh in the west channel Cabrillo Beach recreational complex in Los Angeles is described. The marsh will be created for biological compensation of Army Corps of Engineers filling activities. Goals include: 1) provision of viable fish habitat; 2) public education and recreation; 3) studies of marsh management techniques; 4) enhancement of intertidal wetland ecosystems. Major features of the planned marsh are described. Standard commercial landscaping methods will be used, so that the project can be bid and built by commercial contractors. Hydro-seeding, transplanting of native salt marsh vegetation, and temporary supplemental irrigation are described as part of the marsh creation plan. *

Lunz, J. D., T. W. Zeigler, R. T. Huffman, R. J. Diaz, E. J. Clairain, and L. J. Hunt. 1978. Habitat development field investigations, Windmill Point Marsh development site, James River, Virginia: Summary Report. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 116 p.

This paper describes the development of marsh habitat on fine-textured, nutrient-enriched dredge material from the James River channel. A sand dike was constructed to contain sediment. Six months after construction, the substrate contained about 75 plant species, and planting was deemed unnecessary. Ecological monitoring and experimental studies were conducted on plants, soils, sediment, and water quality, fish, invertebrates, wildlife, and plant uptake of metals and chlorinated hydrocarbons. The dredged material marsh produced habitat of value to fish and a variety of birds. *

Maguire, J. D. and G. A. Heuterman. 1978. Influence of Pregermination Conditions on the Viability of Selected Marsh Plants. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 103 p.

This study describes the results of laboratory tests to determine the viability, germination, and storage requirements of seeds from 13 marsh plants species. Found in a variety of wetland types throughout the U.S., these plants are considered to be best suited for wetland establishment. Tables provide analyses of effects of storage, salt solution, and temperature on various plant species. Optimum storage conditions, thermoperiods, and seed germination duration periods are also recorded. Direct seeding is a viable method of plant establishment on both dredge material and natural marsh substrate. Seeds may also be used to produce transplants for nursery operations. *

Mason, H. 1980. Techniques for creating salt marshes along the California coast. In: Rehabilitation and Creation of Selected Coastal Habitats. J. C. Lewis and E. W. Bunce, editors. FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 23-24. NTIS No.: PB81-165-649.

A dredge spoil area was planted with Spartina in an attempt to learn how to propagate Spartina. Seeds were harvested ad stored in refrigerated water. Cuttings and rhizome plantings were also successful. Salinity in soils, amount of tidal inundation, and consolidation of dredge spoil material were found to be of primary importance in creating marshes on dredge spoil.

McCreary, S. 1982. Legal and institutional constraints and opportunities in wetlands enhancement. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 39-52.

The practice of wetlands restoration is guided by a complex, overlapping set of laws, agency policies, and attitudes. This paper presents an overview of legal and institutional issues confronting wetland restoration in California, including: the evolution of a state policy towards wetlands protection; 2) federal trends in wetland management; 3) institutional issues related to land acquisition; 4) relationship between wetlands protection and watershed management; 5) the role of scientists in enhancement activities; and 6) the perspectives of citizen activists in wetland enhancement.

Meeker, J. F. and S. Nielsen. 1986. Observations concerning the establishment of marsh vegetation (principally *Spartina alterniflora*) by use of the plant roll technique. *In*: *Proceedings* of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 134-144.

From May 21-28, 1985, a total of 666 marsh plants consisting of *Spartina alterniflora*, *Spartina patens*, and *Distichlis spicata* were transplanted at two sites along the Intracoastal Waterway as part of a pilot shoreline stabilization project in Palm Coast, Florida. The Intracoastal Waterway in this area exhibits characteristics of a moderate wave energy environment. Three methodologies were tried, bare root seedlings, plant plugs and plant rolls. The bare root seedlings washed out over a two week period. Plant rolls provided the best overall stabilizing method for plant growth, followed by plant plugs, providing proper substrate was available. Total mortality for the entire group of plantings was 33 percent over a five month period. Plant mortality was impacted by higher than normal tides caused by two hurricanes during the study as well as scouring effects from flotsam, poor substrate for plant stabilization and lack of stability of the Intracoastal Waterway shoreline from channel maintenance operations.

Montanari, J. H. and J. A. Kusler. 1978. Proceedings of the National Wetland Protection Symposium, June 6-8, Reston, VA. FWS/OBS-78-97, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. 255 p.

These proceedings contain the discussions of National leaders in wetland protection, water resources, and environmental law regarding the need for coordinated and strengthened state, local, and federal wetland protection policies to help shape future policies pertaining to wetland management. Papers are presented on wetland hazards and values, development impacts on wetlands, state wetland uses and misuses (case studies), legal issues, and wetland rehabilitation.

Morris, J. H., C. L. Newcombe, R. T. Huffman, and J. S. Wilson. 1978. Habitat development field investigations Salt Pond No. 3, marsh development site, South San Francisco Bay, California. U.S. Army Corps of Engineers Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 22 p.

South San Francisco Bay was the site for a study of marsh development on dredged material. This project sought to determine the optimum elevation and tidal flow necessary for Spartina and Salicornia revegetation and to assess costs of planting methods. Two planting methods were used: planting on foot (walk method), and planting by tractor (tractor-assisted method). Planting was done between April and February on dewatered clay two year old substrate at 0.5 to 1.0 meter intervals. Intervals greater than 1.0 meter did not produce adequate cover over the 2 year study period. Hand-planting by walking was the most successful cost-effective method. Spartina became well established in the lower two-thirds of the intertidal zone, and Salicornia was successful in the upper third. *

Newling, C. J., M. C. Landin, and S. D. Parris. 1983. Long-term monitoring of the Apalachicola Bay wetland. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 164-186.

The Apalachicola Bay wetland habitat development site was created by hydraulic deposition of silty dredged material over existing coarse-grained material. In 1976, intertidal and supratidal zones were planted with smooth cordgrass (Spartina alterniflora) and saltmeadow cordgrass (S. patens). From 1980 through 1982, annual visits were made to the area to observe the physical condition, plant community, and wildlife use at the habitat development site and at three nearby natural marshes used as reference sites. The results indicate that the habitat development site was highly successful because: (1) the vigorous marsh plant community that dominates the site is comparable to those at the natural reference marshes, and (2) the site receives especially heavy wildlife use by numerous bird species, particularly water birds and clapper rails (Rallus longirostris). Wind-driven waves from a long south fetch are eroding the main containment dike on the south side of the site, but the habitat development marsh itself is still intact and is biologically productive.

Norris, R. G. and B. E. Nichols. 1979. Wildlife habitat evaluation and mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 369-377.

A system to evaluate wildlife habitat for mitigation and enhancement purposes that is acceptable to the layman and to professionals is discussed and analyzed. The paper evaluates the Delmarva Wildlife Work Group (modification of Whitaker and McCuen method) method of wildlife habitat numerical system. Numerical values based on the Delmarva study are used by the Soil Conservation Service in Maryland to establish existing conditions for wildlife habitat for specific species. This numerical evaluation may then be used as a guide for mitigation purposes by replacement of enhancement.

Novick, H. and R. Hein. 1982. Bolsa Chica - A coastal wetland restoration project. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 101.

This paper describes the restoration of the Bolsa Chica wetland near Huntington Beach, California. In 1978, tidal influence was restored to 150 acres; containment levels and islands for nesting terns were constructed. An additional 85 acres are scheduled for similar restoration. Three species of fish were present prior to the project. The original marsh was significantly altered by dam construction and other human activities. After three years, 32 species of fish were found in the area. Bird species diversity and abundance have increased; the brown pelican now uses the area and least terns nest there. *

Parenteau, P. 1979. The role of private conservation organizations in mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 33-35.

This paper recounts the importance of private conservation groups in encouraging mitigation efforts and more strict legislation, and in encouraging strict enforcement of existing regulations concerning fish and wildlife habitat loss. Several court cases are cited as examples of where private organizations' concerns went past the point of attempting persuasion on an issue, and actually went to litigation.

Passavant, N. and C. A. Jefferson. 1976. Natural reclamation of filled land, Boca Ciega Bay. In: R. R. Lewis and D. P. Cole, editors. Proceedings of the Third Annual Conference on Restoration of Coastal Vegetation in Florida. Hillsborough Community College, Tampa, Florida. pp. 76-103.

This paper describes the natural revegetation of shoreline fill areas in Boca Ciega Bay, Florida. Plant colonization and succession were studied on 19 dredge and fill areas constructed during the 1950's and 1960's. A natural site on Mullet Key was studied as a control. Soil development, effects of different management practices on undeveloped land, and bird colonization were also noted. shorelines that were not retained by sea walls were stabilized by native plants. Where sea walls were present, salt resistent vegetation grew along them. In some areas, grasses were mowed regularly and spread with sewage sludge; in other areas ponds were dug for mosquito control. Management recommendations for undeveloped fill areas emphasize their use for open space, wildlife habitat, and parks. *

Phillips, R. C. 1977. Seagrass bed development on dredged spoil at Port St. Joe, Florida. In: Proceedings of the Fourth Annual Conference on Restoration of Coastal Vegetation in Florida. R. R. Lewis, III and D. P. Cole, editors. Hillsborough Community College, Tampa, FL. pp. 1-111.

In August 1976, a total of 1488 plugs of vegetative Halodule wrightii were transplanted on two dredge spoil sites in St. Joseph Bay, Florida. Three test plots were installed on each site: one with plugs on 3 ft. centers, one with plugs on 6 ft. centers, and one with plugs on 9 ft. centers. A monitoring study conducted in January 1977, showed survival of the plugs varied from 27% to 97%. Increase of plants over the bottom varied from 4% to 70%. It was determined that the optimum spacing for the plugs was 3 ft. centers.

Pratt, J. R. and J. Cairns, Jr. 1985. Determining microbial community equilibrium in disturbed wetland ecosystems. In: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 201-209.

A great deal of interest exists in developing wetland ecosystems of many kinds, such as small lakes, marshes, wet prairies, bogs, and other related wetlands, on sites disturbed by human activities. This interest has been primarily in response to difficulties in restoring disturbed ecosystems because of the removal of valuable subsurface materials that results in permanent, water-holding depressions. In addition, wetland acreage has been on the decline throughout the history of human settlement of North America.

The purpose of the investigation reported here was to utilize microbial community dynamics as measures of disturbed ecosystem recovery.

Prossier, N. S., R. G. Martin, and R. H. Stroud. 1979. Adequacy and accuracy of fish and wildlife impact assessment at Corps of Engineers projects. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 384-390.

This paper reviews and comments on the lack of quantitative data available for evaluation of water resource development impacts and highlights the inadequacy of past fish and wildlife planning at Corps of Engineers reservoir projects based upon the screening of data availability at 410 projects and case history studies of 10 projects. (Authors are members of the Sport Fishing Institute, Washington, D.C.).

Race, M. S. 1985. Critique of present wetlands mitigation policies in the United States based on an analysis of past restoration projects in San Francisco Bay. Environmental Management 9(1): 71-82.

This article provides: 1) an analysis of past wetland restoration projects in San Francisco Bay, and 2) a critical overview of preset wetland mitigation policies within the United States. Analysis of published information on 13 restoration projects in the bay area leads to questions regarding the actual status and success of these projects. Questions regarding the actual status and success of these projects. Questions regarding the actual status and success of these projects. Problems include: insufficient or inconsistent information, inaccurate reports of success, and premature adoption of mitigation policies ad ideas without adequate supporting data. Natural habitats are being replaced by artificial wetlands of questionable long term value. Recommendations address permit processes, marsh establishment techniques, continued research, and cost effectiveness. *

Race, M. S. and D. R. Christie. 1982. Coastal zone development: mitigation, marsh creation, and decision making. Environmental Management 6(4): 317-328.

This paper provides a overview of mitigation as part of coastal zone development processes. Mitigation requirements in several states are described and evaluated, as are several wetland creation studies. Several major issues that are addressed include the following: 1) some mitigation requirements consider number of wetland units to be created or restored for every unit that is altered or destroyed. However, if equivalent units are measured in terms of productivity, this may not in fact be an equitable trade-off; 2) decisions involving artificial marsh location and the length of time such a marsh is monitored or maintained before it is deemed to be "successful" are often based on insufficient data; 3) bases for comparison between natural and man-made salt marshes underscore the fact that a marsh is more than the presence of vegetation; 4) mitigation is offered as justification for wetland development and destruction. Important criteria such as artificial marsh quality and longevity must be considered if marsh creation and restoration are to be effectively used to mitigate unavoidable loss of natural wetlands. *

Rappoport, A. G. 1979. An evaluation of alternatives for improving the mitigation process. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 378-383.

The primary vehicle for minimizing modification and loss of fish and wildlife habitats from water developments has been the FWCA, but not enough effort has been put into acquisition of land as a mitigation measure. The mitigation of wildlife losses required by FWCA is a complex process, and the purpose of this paper and study is to develop recommendations or improving fish and wildlife mitigation. Two approaches were undertaken to accomplish this purpose: a survey of individuals, and a legislative internship. The focus of this paper is on the mitigation process and terrestrial wildlife losses associated with the Bureau of reclamation water projects. The author concludes that an interagency committee and project funding dependent on FWCA compliance could further improve mitigation measures and implementation.

Redmond, A. M. 1981. Consideration for design of an artificial marsh for use in storm water renovation. In: Proceedings of the Eighth Annual Conference on Wetlands Restoration and Creation. R. H. Stovall, editor. Hillsborough Community College, Tampa, FL. pp. 188-199.

An artificial marsh and a filtration impoundment were designed to function in a series to renovate urban storm water entering Megginnis Arm of Lake Jackson. The storm water is sediment-laden with excess nutrients, heavy metals, and hydrocarbons absorbed to the clay fraction. The sediments pose the greatest problem, but dissolved pollutants contribute to the problem as well. The function of the artificial marsh is to trap the clay fraction and provide uptake for the dissolved pollutants. The study investigated the feasibility and design considerations for creating a successful wetlands area that will be functional for storm water control.

Reed, W. C. And M. C. Heath. 1974. Salt marsh relocation and restoration in Maine. Maine Department of Transportation, Augusta, ME. 54 pp.

This report presents the results of a restoration feasibility study to enhance Maine's salt marshes. Field evaluations were made at sites between Portland and Rockland. Favorable seed production was dependent on 1) the amount of restricted tidal water flow due to channelization, and 2) the amount of gravel substrate exposed. Tidal relationships, substrate types and substrate nutrient supply characteristics of this area are discussed in relation to restoration and other effects on the marshes evaluated.*

Reimold, R. J. 1980. Creation of a southeastern United States salt marsh on dredged material. In: Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. J. C. Lewis and E. W. Bunce, editors, FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 6-22. NTIS No.: PB81-165 649.

The Buttermilk Sound habitat development project is described in detail. The project involved creation of salt marsh habitat on dredge spoil material. The site was graded so that an elevation gradient was established from MHW level to MLW level. Variables that were included in the factorial design included: elevation, vegetation propagules, fertilizer treatments, types of propagules, mineral analyses of soils, and presence and abundance of macro invertebrates and vertebrates. An analysis of the plants and their success in establishment was made.

Reimold, R. J. 1980. Marsh creation: impact of pesticides on the fauna, use of infrared photography, ditching and diking. In: R. C. Lewis and E. W. Bunce, editors. Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. U.S. Fish and Wildlife Service, Biological Services Prog., Washington, D.C. pp. 132-135.

This paper describes a case study of the effects of toxaphene on an estuarine system near Brunswick, Georgia. It includes: 1) the proper use and interpretation of color infrared photography; 2) effects of ditching and diking on habitat creation projects; and 3) comparison of several species diversity indices. Over an 8 year period, nekton was sampled in the polluted estuary ad in a pristine estuary nearby. A second case study involving watershed alterations at Glacial Lake, Hackensack, New Jersey, is described briefly, originally a white cedar swamp and meadowland, the area is now dominated by Phragmites. *

Robinson, H. G. 1979. Corps of Engineers mitigation policy. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 75-77.

This paper is a discussion of fish and wildlife mitigation measures recommended by the Corps of Engineers for inclusion in project plans. These measures are developed in cooperation with the Fish & Wildlife Service under the President's Water Policy (FWCA, 1978), and are discussed within the context of Federal obligations and restrictions when it comes to mitigation policies.

Ross, D., C. Kocur, and W. Jurgens. 1985. Wetlands creation techniques for heavy construction equipment. In: Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 210-220.

An upland site was excavated in October/November, 1984, to create four wetlands totalling 40 hectares adjacent to a natural slough in Desoto County, Florida. Earth-moving equipment (Caterpillar 631 Wheel Tractor-Scrapers and D8 and D9 Bulldozers) was used to excavate the site and haul spoil to a deposit area. Two percent of the return trips from the spoil deposit area were diverted to remove and transport soils and plant material from nearby isolated marshes. The soil from these donor marshes was spread in each of the new wetlands as a mulch and source of propagation material for wetland plant species. One of the four wetlands, comprising 20 hectares, was chosen as the experimental wetland and divided into three areas. Two areas were mulched, each with soil from a different type of donor marsh. The third area was left unmulched as a control. The experimental wetland was subsequently flooded with well water; the other wetlands received no irrigation. Establishment of vegetation in the flooded wetland has been initially successful in the mulched areas, but not successful in the unmulched area. No significant germination has occurred to date in unflooded areas because of the lack of precipitation since construction. Using heavy construction equipment proved successful and economical both for removing mulch from donor wetlands and for spreading it on the excavated site.

Seneca, E. D. 1980. Techniques for creating salt marshes along the East Coast. In: Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. J. C. Lewis and E. W. Bunce, editors, FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 1-5. NTIS No.: PB81-165 649.

This paper presents results of research conducted by Woodhouse, Seneca, and Broome in North Carolina on marsh creation. Included in the discussion are descriptions of their first attempts to create salt marsh on dredge spoil in 1969. Planting procedures and monitoring experiments are described. A description of a vegetative shoreline erosion control project is also included. The author concludes from this experiment that vegetation is in certain situations a logical alternative to man-made structures. Basic techniques are outlined for use of transplants ad seeding to establish a low, regularly flooded, smooth cordgrass salt marsh.

Seneca, E. D., S. W. Broome, W. W. Woodhouse, L. M. Cammen, and J. T. Lyon. 1976. Establishing *Spartina alterniflora* marsh in North Carolina. *Environmental Conservation* 3(3): 185-188.

This paper summarizes a study of the stabilization of dredged material using *Spartina alterniflora* to prevent erosion and to replace salt marsh systems lost through dredging operations. Experimental sites were located along the North Carolina coast. Seeding required fewer man-hours but was successful only in the upper intertidal zone and in protected areas. Transplanting was more expensive but revegetation efforts were successful in exposed sites and at mean sea level. Above ground production of *S. alterniflora* was 1200 to 1300 $g/m^2/yr$ in the third to fifth year. Below ground production was maximum after two years at 900 $g/m^2/yr$ and decreased thereafter. Based on sediment carbon content measurement, a newly planted marsh might take 4-25 years to resemble a natural marsh. *

Seneca, E. D., W. W. Woodhouse, and S. W. Broome. 1975. Salt-water marsh creation. In: L. E. Cronin, editor. Estuarine Research, Volume II: Geology and Engineering. Academic Press, Inc., New York. pp. 427-437.

This paper describes salt-water marsh creation, using *Spartina alterniflora*, at Snow's Cut, North Carolina. Tidal inundation, salinity, elevation gradients, and plant invaders are discussed in the context of the project. An additional experiment involved the collection of seeds from *S. alterniflora* in locations from New England to Texas. The seeds were stored for 3 months in estuarine water and then planted: morphological and physiological differences were apparent. Thus, seeds and plants for transplanting should be gathered from sites that are close to the planting location.

Shabman, L. 1979. Mitigation planning under the Principles and Standards. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 196-202.

Recent water policy reforms stress improved mitigation planning through improved economic and environmental assessment ad stricter application of the Principles and Standards decision framework. While there are practical limits on the use of the assessment tools being developed (such as HEP), the result will be improved mitigation analysis and increased mitigation at Federal projects.

Shisler, J. K. and D. J. Charette. 1984. Evaluation of Artificial Salt Marshes in New Jersey. New Jersey Agricultural Experiment Station. Publication No. P-40502-01-84. 160 pp.

This paper presents an evaluation of thirty artificial salt marsh projects in New Jersey. The research presented in this paper includes a comprehensive examination of artificial salt marshes as compared to natural salt marshes. Management guidelines for artificial marsh creation are also included. Detailed quantitative sampling was conducted at eight artificial marshes and adjacent natural marshes. Variables measured and compared at each sampling site include various detailed parameters of vegetational species, sediment, and macroinvertebrates. Results of those analyses were statistically compared (artificial vs. natural), and results demonstrated that: 1) although artificial *Spartina alterniflora* marshes compared favorably with natural marshes, *S. patens* marshes were not found to be successful; 2) artificial marsh sediments are extremely different from natural marsh sediments; and 3) certain macroinvertebrate species did colonize and populate artificial marsh habitats.

Shisler, J. K. and D. J. Charette. 1986. Evaluation of artificial salt marshes in New Jersey. National Wetlands Newsletter, May-June 1986 8(3):4-5.

This article describes a recently completed study of artificial salt marshes in New Jersey. Eight marshes, each with an adjacent natural salt marsh, were selected for qualitative evaluation. Three variables were measured at each marsh: vegetational species, sediment (sand, dredged material, and original marsh peat) characteristics, and macroinvertebrate populations. Values were statistically compared to natural marsh values. High marsh creation projects using *Spartina patens* were less successful than low marsh projects using *S. alterniflora*. Other comparative data and conclusions are discussed in general terms.

Short, C. and M. Schamberger. 1979. Evaluation of impacts on fish and wildlife habitat and development of mitigation measures. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 331-335.

The paper focuses it's discussion on how mitigation ca be successfully implemented and monitored. Mitigation requires that adequate scientific information is developed so that mitigation measures do not fail. The paper address several aspects of mitigation, including: planning and how mitigation enters into the planning process; and a method to develop quantitative data for use in planning and mitigation. Mitigation of fish and wildlife losses is predicated on the prediction and quantification of project related impacts as they relate to environmental objectives set for the project. The HEP method is a standardized procedure that provides environmental data necessary for the impact assessment. The consideration of this data throughout the pre-project evaluation helps establish environmental quality as an integral goal in resource development.

Smith, H. K. 1980. Coastal habitat development in the dredged material research program. In: Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. J. C. Lewis and E. W. Bunce, editors, FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 117-125. NTIS No.: PB81-165 649.

This paper describes the development of coastal habitat as part of the Army Corps of Engineers dredged material research program objectives. Habitat development field study locations are included, and case studies are described. Because of the nature of a large percentage of dredged material that tends to serve as a natural sink for various forms of pollution, much of it is now confined to land behind dikes. This program is divided into five sections: effects of dredged material on marsh and upland habitat; marsh development; terrestrial habitat development; aquatic habitat development; and island habitat development. *

Snyder, R. M., L. J. Greenfield, D. Shackelford, and S. Beeman. 1983. Wetland vegetation and agronomy preliminary. In: Proceedings of the Tenth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 196-200.

Beginning in the mid-1970's, two adjacent projects in northern Palm Beach County adjoining the Intracoastal Waterway were permitted and constructed. Comprising about 10 miles of canal banks, the projects are unique in that almost the entire shoreline was sculpted and revegetated wit cordgrass and red mangroves. Planting took place over a 12 month period starting in the autumn of 1980. Spartina alterniflora establishment utilized about 650,000 plants, the majority being transplanted clumps from a lease area with nursery grown sprigs used in about 30% of the planting area. Approximately 250,000 Rhizophora mangle nursery seedlings were planted interspersed with the cordgrass. Observation over the next 18 months indicated a wide variation in growth and appearance of the cordgrass. Close scrutiny indicated a number of variables such as soil properties, groundwater flow and shading that might influence growth and survivability of the plants. Many of the variables are not normally considered in permit monitoring requirements. It was concluded that, because of the expanse of the projects ad the fact that more than fifty acres of fringe saltmarsh were created from essentially upland property, there was a unique opportunity to monitor plant response over an extended period with the view of developing agronomic best management practices for use in future projects.

Snyder, S. 1982. Restoration as a method for dealing with unauthorized wetlands alterations: The Mississippi experience. In: Proceedings of the Ninth Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 54-68.

In 1973, the Mississippi Coastal Wetlands Protection Law was enacted by the state Legislature in order to preserve the natural state of the coastal wetlands and prevent their destruction, except where a specific alteration would serve a higher public interest. The Mississippi Department of Wildlife Conservation, Bureau of Marine Resources was designated as the state agency charged with managing and regulating their use.

Smith, D. C. 1979. Shore erosion control demonstrations in Florida. In: Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands. D. P. Cole, editor. Hillsborough Community College, Tampa, FL. pp. 87-98.

Two Florida sites, Stuart Causeway-Jensen Beach Causeway and Basin Bayou State Recreation Area, were selected for study of shoreline erosion control demonstration projects. The project consisted of planning, constructing, operating, evaluating, and demonstrating prototype shoreline erosion control utilizing both structures and vegetation. Vegetative planting at the sites were found to be at least partially successful. Most successful plantings were found in areas where some protection was provided from intense wave action. Species utilized in the plantings included *Spartina alterniflora*, *Rhizophora mangle*, *Paspalum vaginatum*, in areas both above and between tidal zones.

Snyder, R. M. 1978. Revegetation stabilization on erosion prone estuarine beaches. In: Proceedings of the Fifth Annual Conference on Restoration of Coastal Vegetation in Florida. R. R. Lewis, III and D. P. Cole, editors. Hillsborough Community College, Tampa, FL. pp. 162-176.

This paper explains a special method of planting *Spartina alterniflora* and *Rhizophora mangle* that can be used to simplify revegetation of shorefront that is exposed to disturbance by wind, waves, and boat traffic. The method is inexpensive and can be accomplished using unskilled labor. The author explains use of a commercially available filter fabric to prevent erosion on unconsolidated substrates so that natural root systems can develop. Experiments found that the fabric did not prevent the spreading or growth of vegetation.

In carrying out its responsibilities under both the Wetlands Protection Law and the Mississippi Coastal Program, the Bureau has been faced with problems associated with the requiring restoration of wetlands areas damaged by unauthorized alterations. More often than not, the problems associated with the restoration process are regulatory, legal, economic and social in nature rather than ecological considerations. These problems, along with the capability of existing regulations to cope with them are discussed. Specific cases involving restoration efforts in the Mississippi coastal area are presented along with the circumstances surrounding each case which resulted in the success or failure of the plan.

Sorensen, J. 1982. Towards an overall strategy in designing wetland restorations. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 85-96.

This paper describes the techniques the author has developed to systematically assess and discuss a dynamic and complex process such as wetland restoration. The process which is described by a flow chart diagram is designed to develop a wetlands restoration plan for systems that possess the following three conditions: 1) environmentally degraded in respect to its former condition or in respect to other well-functioning wetlands; 2) partly or entirely in private ownership; 3) not likely to be restored without the infusion of private sector funds in a quid-pro-quo arrangement between public agencies and property owners. The general steps involved in this process for developing a restoration plan include: definition of wetland planning area, statewide and regional analyses, determining the present coverage of wetlands and the extent of degradation, determining the historical evolution of the wetland, analyzing ownership of the restoration plan area, determining existing resource values, assessing the present internal and external stresses of the system, calculating each property owner's amount of wetlands and developable uplands, and final design and implementation and evaluation of the restoration site plan.

Stalter, R. 1976. The zonation of vegetation of southeastern salt marshes. In: Proceedings of the Third Annual Conference on Restoration of Coastal Vegetation in Florida. R. R. Lewis, III and D. P. Cole, editors. Hillsborough Community College, Tampa, FL. pp. 24-35.

This paper describes vegetation zonation in salt marshes of the southeastern United States. Plant tolerance to tidal action, flooding, and soil salt content varies; as a result, specific plants occupy certain zones which are described by species association and elevation. The upper high marsh is dominated by baccharis halmifolia, Iva frutescens, Spartina patens, and Panicum virgatum. Lower high marsh contains Borrichia frutescens, Limonium carolinianum, L. nashii, Distichlis spicata and others. The upper low marsh is dominated by dwarf Spartina alterniflora. The lower low marsh is flooded twice daily by tides and is dominated by tall S. alterniflora. Brackish marsh vegetation is also discussed.*

Stalter, R. 1973. Transplantation of salt marsh vegetation II., Georgetown, South Carolina. Castanea 38: 132-139.

Survival and growth rates of transplanted marsh plants were studied to determine the effects of inundation, salinity and conductivity when the species were moved to a typical habitat. Four vegetative zones were chosen at Georgetown, South Carolina. Thirty plants of Spartina, Distichlis, Iva, Baccharis, Salicornia, Borrichia, and Limonium were transplanted to other vegetation zones. Soil samples were taken at 10 day intervals at low tide. Salinity ranged from 3.35 x 10(4) in the upper high marsh to 322.0 in the lower low marsh. Mortality rates of all species were very high. Results indicated that S. alterniflora tolerated the widest range of salinity, highest conductivity and largest inundation period. There may be two forms of S. alterniflora -- a short form occupying upper low marsh and a tall form occupying lower low marsh. *

Thorhaug, A. 1980. Restored major plant communities in the U.S. In: J. Cairns, Jr., editor. The Recovery Process in Damaged Ecosystems, Ann Arbor Science Pub., Inc., Ann Arbor, MI. pp. 113-124.

This paper describes recovery patterns of restored plant communities throughout the United States and summarizes the issues addressed in a restoration symposium held in 1976. Some restoration examples include seagrass communities, mangroves, and marsh grasses. Political and legal issues are part of the process of planning and implementing a restoration project. A list of general principles for restoration is presented, along with a table that depicts recovery results for restoration efforts and compares them to natural recovery rates. *

Truett, J. C. 1979. Pre-impact process analysis: Design for mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 355-360.

This paper discusses the concept of mitigation and the concept of mitigation by replacement - full compensation of in kind habitat and species lost. However, in kind replacement is often difficult or impossible to attain and mitigation might be achievable only by requiring the developer to change the design of the proposed project so that fish and wildlife losses will be minimal. This paper suggests how pre-development ecological information can and should be collected via the impact assessment process so that potential impacts on fish and wildlife resources can be better measured.

Ternyik, W. E. 1980. Salt marsh creation in the Pacific Northwest: criteria, planting techniques, and costs. In: Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. J. C. Lewis and E. W. Bunce, editors, FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 25-27.

This paper summarizes salt marsh creation work initiated at Miller Sands, an island complex on the lower Columbia River, Oregon. This pilot test program included plant selection, collection, planting, and growth over one growing season (June 1975-Nov. 1975). The sprigging method was used, and all plants were topped to a uniform height before planting. Root cuttings generally included a section of rhizomes containing 1-3 stems. The spacing, planting depth, ad culms per planting stock are recorded in table form for all six species planted. Some of the test plots were fertilized. Ammonia based fertilizers may cause problems for fishery production. *

Thompson, L. S. 1979. Mitigation as management: Strategy and some alternatives. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 222-228.

Mitigation of impact, as well as the related concepts of impact prevention, compensation of impact, and trade-offs may be considered to be types of population management. The optimum strategy should allocate available funds among these types of management, so that the greatest possible benefits to the resource can be achieved at the least cost. Cost-benefit analysis may be used to determine the relative cost-effectiveness of baseline study, impact analysis, mitigation, prevention, and compensation, and can be used to formulate the most cost-effective mix of management strategies. Mitigation is seldom thought of as a management tool, and its relation to the similar but distinct concepts of impact prevention, impact compensation, and trade-offs has not been clarified. However, mitigation can be used as an effective management tool as long as costs are carefully weighed against benefits.

Vincent, M. K. 1978. Habitat development field investigations, Rennie Island marsh development site, Grays Harbor, Washington: Summary report. U.S. Army Corps of Engineers Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. 94 p.

A marsh habitat development project was undertaken at Rennie Island, Grays Harbor, Washington, to evaluate marsh development using fine-grained dredge material in a high-energy, high-tide environment. The original plans were to determine the feasibility of marsh development based on pertinent literature and physical, biological, and chemical assessment of the site. Earthen dikes were to be constructed to protect the development site. Due to the high wave energy conditions, no cost effective, feasible type of structure was found, and the project was terminated. Some data on soil and water chemical content and vegetative composition is included. *

Wakeman, N. 1982. Development of regional wetland restoration goals: San Francisco Bay. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 32-37.

This paper provides a summary overview of San Francisco Bay wetlands in terms of present status and restoration goals. According to the Bay Conservation and Development Commission, the creation or restoration of freshwater marsh, brackish water marsh, habitat for rare or endangered species, ad tidal marsh would enhance the Bay's wildlife resources. Restoration of tidal flow to diked areas should increase the productivity of the Bay. Careful planning, implementation, and monitoring are essential for the achievement of restoration goals and objectives. A suggested project checklist is provided.*

Walke, R. P. 1979. Mitigation - Issues for the 80's. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 44-48.

The author warns of the danger that can result when cooperation is not involved between developers (utility companies in this case) and environmentalists. There is a definite need to overcome confrontation and work in the spirit of cooperation to build utilities while at the same time, consider that appropriate land use and environmental protection are given equal priority. The paper's intent appears to be to assure the audience of industry's serious interest in mitigating real wildlife habitat losses, while cautioning against the exploitation of genuine wildlife issues to stop projects for the sake of advancing other social ad economic issues.

Webb, J. W., Jr. 1982. Salt marshes of western Gulf of Mexico. In: Creation and Restoration of Coastal Plant Communities. R. R. Lewis, III, editor. CRC Press, Inc., Boca Raton, FL. pp. 89-110.

This paper describes in detail the various plant communities found in the area of the western Gulf of Mexico. Included are descriptions of productivity and habitat values for each of the three major ecosystems in the coastal plant communities, and a review of the habitat loss and modification that has occurred in the area. Eleven specific restoration/creation projects are reviewed, including projects for shoreline stabilization, and stabilization of dredge spoil material. Recommended planting and restoration techniques are detailed, including: species selection, digging of plants and transplant material, transplanting, seeding, elevation requirements, time of transplanting, and wave protection.

Webb, J. W. and C. J. Newling. 1985. Comparison of natural and man-made salt marshes in Galveston Bay complex, Texas. Wetlands 4:75-86.

This study describes and compares the vegetation characteristics of three natural marshes and one artificial marsh established on dredged material. The marshes are located at Pepper Grove, Jamaica Beach, and Eight-Mile Road, all in the Galveston Bay area. After two years, plantings established at Bolivar were compared with vegetation of the three other sites. Spartina alterniflora was dominant at lower intertidal elevations below mean high water. Biomass of S. alterniflora declined with increasing elevation, as Salicornia, S. patens, Batis maritima, Sporobolus virginicus, and Distichlis spicata became dominant. All marshes were similar in species composition. Bolivar had higher productivity in terms of biomass, probably due to available nutrients in the accumulating silt layer. The experimental marsh exhibited characteristics that were typical of natural marshes.*

Webb, J. W., H. H. Allen, and S. O. Shirley. 1984. Marsh transplant establishment analysis along the northwest shoreline of Theodore Disposal Island, Mobile Bay, Alabama. In: Proceedings of the Eleventh Annual Conference on Wetlands Restoration and Creation. F. J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 184-200.

This study examined factors correlated with the establishment of Spartina alterniflora and Juncus roemerianus planted on a dike on a spoil disposal island in Mobile Bay. Establishment was most successful in coves where there was less wave action. Establishment of plant cover was affected by elevation, % slope of shoreline, direction and degree of wave exposure, fetch, and sand depth on straight shorelines. In protected areas where sad depth was over 50 mm, there was a greater amount of plant cover. Apparently, roots do not penetrate the underlying clay but require deeper sand for anchoring. *

Webb, J. W., and J. D. Dodd. 1976. Vegetation establishment and shoreline stabilization: Galveston Bay, Texas. U.S. Army Corps of Engineers, Coastal Engineering Center, Fort Belvoir, VA. Technical Paper No. 76-13. 74 p.

The East Bay of Galveston Bay, Texas was the site of a revegetation project to stabilize eroding shoreline. This area experiences high energy wave action ad requires structures to reduce wave impacts and encourage vegetative growth. Wave-stilling devices of pipe, wire, netting, cable and baled hay were used as well as tire and pipe structures. Spartina planted at 0.3 m intervals produced solid stands after two years. Avicennia was initially successful, but all plants died during the winter. Fertilizer applications did not produce significant growth results. Detailed soil and bay water analyses are provided. *

Whitaker, G. A. 1979. NEPA regulations, a new tool for achieving better mitigation. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 532-535.

The paper reviews the background of NEPA regulations and how they can be used to implement mitigation policies. NEPA regulations are binding on all Federal agencies requiring, in part, that agreed-to mitigation be implemented as an integral part of all actions. Agencies must also condition grants, permits, or other approvals to assure implementation of mitigation measures. All Federal agencies must invite other agencies and the public to participate in their planning activities and seriously consider all suggested mitigation measures. The responsibility is with the other agencies and the public to participate in early planing and to provide sound advice. If adequate mitigation is not incorporated in a project plan, the Council on Environmental Quality can be asked to intervene.

Whitesell, D. E. 1979. Mitigation -- Is it the answer? In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 550-552.

The author discusses general concepts behind the term mitigation, and discusses the usefulness and implementation of mitigation procedures. Author states that it is especially important, in terms of waterfowl conservation, that landowner, developer, and the government work together to salvage wetlands whenever possible. Land conservation incentives must not be eroded by arbitrary governmental intervention: half a marsh is better than none. This is viewed as the only kind of mitigation waterfowl will ever benefit from.

Williams, P. B. and H. T. Harvey. 1982. Examples of marsh restoration design practice in San Francisco Bay: a controlled level marsh in Corte Madera. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 102-103.

The design and planning for the restoration of 35 acres of salt marsh on a diked wetland area near Mugzi Marsh in the San Francisco Bay area are described. This marsh creation effort is required mitigation for the filling of 20 acres of the site. The marsh is designed for flood control, water quality improvement, and enhancement of wildlife habitat. The restoration plan also includes implementation scheduling, and costs. The project is expected to begin in 1982. *

Woodhouse, W. W., Jr. 1979. Building salt marshes along the coasts of the continental United States. Technical Report No. 4. Coastal Engineering Research Center, U.S. Army Corps of Engineers, Fort Belvoir, VA. 96 p.

This is a comprehensive report on coastal marsh creation in the United States. Analysis and interpretation of available information on elevation, slope, exposure, and salinity pertaining to marsh creation are discussed. Adaption of marsh plants for the following six coastal regions are listed: Atlantic Coast, Peninsular Florida, Gulf Coast, North Pacific Coast, South Pacific Coast and Great Lakes. Suitable regional culture and planting techniques for selected marsh plants are discussed in detail. *

Woodhouse, W. W., Jr. and P. L. Knutson. 1982. Atlantic coastal marshes. In: Creation and Restoration of Coastal Plant Communities. R. R. Lewis, III, editor. CRC Press, Inc., Boca Raton, FL. pp. 45-70.

This paper describes the vegetation of coastal marshes from New England to Florida, dividing the east coast marshes into three general types: New England, Mid-Atlantic, and South Atlantic. Discussions of historic losses, and general wetland values are included for each type of marsh. Marsh restoration projects are then described, including comments on plant materials to be used, site preparation, fertilization, plant spacing and maintenance, planting costs, factors controlling success or failure of restoration projects, soils, wave climate, and general habitat value of restored marshes.

Woodhouse, W. W., E. D. Seneca, and S. W. Broome. 1972. Marsh building with dredge spoil in North Carolina. Agricultural Experiment Station, Bulletin 445. North Carolina State University, Raleigh, NC. 28 pp.

This report documents a study of the stabilization of sandy dredge material by *Spartina alterniflora* plantings. Experimental sites were located along the North Carolina coast: Oregon Inlet, Pamlico Sound, Hatteras Inlet, Harker's Island and Snow's Cut Dredge Island in the Cape Fear River. Complete cover by *S. alterniflora* was achieved in 2 growing seasons in some areas. Establishment was by seeds or transplants. Direct seeding was less expensive, while transplants were more adaptable to a variety of conditions. *Spartina* cover appears to afford considerable protection from storm induced erosion. Elevation limits are identified for plant survival and optimum growth. Transplants flourished on a range of substrates, but dieback occurred where soil solution salinity exceeded 45 parts per thousand. *

Woodhouse, W. W., E. D. Seneca, and S. W. Broome. 1976. Propagation and use of *Spartina alterniflora* for shoreline erosion abatement. Technical report 76-2. Coastal Engineering Research Center, U.S. Army Corps of Engineers, Fort Belvoir, VA. 72 pp.

This report describes the planting of *S. alterniflora* to stabilize eroding shoreline at Pine Knoll Shores, Bogue Sound, near Morehead City, NC. All plants were germinated from seed collected at Oregon Inlet, NC. Planting specifications for *S. alterniflora* are based on results from several experiments at various locations along the North Carolina coast. Rhizomes without attached culms did not survive in the intertidal zone. Soils that were optimal for growth were characterized by the ammonium form of N and low ambient oxygen. *S. alterniflora* was unable to use nitrate effectively. Responses to fertilization are included. *

Zallen, M. 1979. An analysis of the proposed rules to implement the Coordination Act. In: The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. G. A. Swanson, technical coordinator. GT Report RM-65. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S.D.I., Fort Collins, CO. pp. 527-531.

This paper defines and analyzes the Fish and Wildlife Coordination Act, which is the prime federal statute dealing with mitigation. The recent proposed rules to implement this Act will have a profound effect on conservation of wildlife resources. These rules are discussed in light of the Act, its legislative history, and judicial interpretations. The rules discussed are designed to fill in the details needed to carry out the Congressional intentions in passing the Act.

Zedler, J. B. 1983. Salt marsh restoration: the experimental approach. In: O. T. Magoon and H. L. Converse, editors. Coastal Zone 83: Proceedings of the Third Symposium on Coastal and Ocean Management. San Diego, CA. pp. 2578-2586.

This paper describes experimental procedures and results associated with the re-establishment of salt marsh cordgrass, Spartina foliosa, in Southern California. Herbivory, hypersaline soils, competition and wave action reduced S. foliosa survival and growth. Transplants in highly saline soils (50-60 ppt) died. They were invaded and sometimes out-competed by freshwater marsh species in low salinity areas (0-20 ppt). Once it has become established, cordgrass can tolerate high salinity. Proposed objectives for restoration of coastal marshes in this area are discussed, and recommendations presented. *

Zedler, J., M. Josselyn, and C. Onuf. 1982. Restoration techniques, research, and monitoring: Vegetation. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 63-74.

This paper summarizes the ecological features of wetland vegetation, reviews the data available on vegetation establishment in California wetlands, outlines the ecological considerations which must be made in planning marsh establishment, and suggests research programs to improve marsh restoration efforts.

Zentner, J. 1982. Development of regional wetland restoration goals: Coastal wetlands. In: Wetlands Restoration and Enhancement in California. M. Josselyn, editor. Report T-CSGCP-007, California Sea Grant College Program, University of California, La Jolla. pp. 23-31.

This paper examines in detail the values of restoring different habitat types within wetlands on a state-wide basis. A group of eight values are cited most often as representing the values of wetlands: high primary productivity, shoreline protection, wildlife habitat, water purification, groundwater recharge, flood protection, habitat for commercially important fish and shellfish species, and cultural values such as recreation and education. The author contends that wetland values and restoration goals should focus on the provision of plant and wildlife habitat for the use of wildlife and man, and not any of the other values mentioned. The state-wide goals should become the basis for developing regional restoration plans and goals.

APPENDIX B

Literature Survey of Coastal Wetland Banking Issues

BIBLIOGRAPHY

COASTAL WETLAND MITIGATION BANKING ISSUES

Arnold, Carol, J., 1985. The Arcata Marshes: A Case Study in Wetland Restoration. In: Proceedings of the Third Symposium on Coastal and Ocean Management. Orville T. Magoon, editor, pp. 562-576.

Bierly, K.F., April, 1987. Mitigation Bank Handbook (Draft), Procedures and Policies for Oregon, Division of State Lands.

Boesch, Russell, 1987. Mitigation Banking - A Balance of Interests, Coastal Zone '87, pp. 2515-2529.

Dunham, Fred O., 198_. Mitigation Banking: A State Perspective.

Eliot, Wendy P., 1985. Implementing Policies in San Francisco Bay: A Critique, Coastal Zone '85, pp. 920-940.

Good, J.W., 1987. Mitigating Estuarine Development, Impacts in the Pacific Northwest. From: Concept to Practice. Northwest Environmental Journal, v. 3:1, pp. 93-111.

Hamilton, Stanley, et al., April 1984. Estuarine Mitigation: The Oregon Process, State of oregon, Division of State Lands.

Kinser, G.W., 1985. Mitigation and Its Problems. In: Proceedings of Wetlands of the Chesapeake Conference, April 9-11, 1985, Easton, Maryland. pp. 310-320.

Marcus, Laurel, 1987. Wetland Restoration and Port Development: The Batiquitos Lagoon Case, Coastal Zone, '87, pp. 4152-4166.

McCreary, Scott and John Zentner. Innovative Restoration and Management. In: Coastal Zone '83, pp. 2527-2551.

Nelson, Barry, 1987. Mitigation in San Francisco Bay. California Waterfront Age, v. 3:1, pp. 23-27.

Riddle, Elizabeth P., 1987. Mitigation Banks: Unmitigated Disaster or Sound Investment. California Waterfront Age, v. 3:1, pp. 37-40.

Riddle, E.P. and M.F. Denniger, 1986. Coastal Wetlands Mitigation Banks: The California State Coastal Conservancy Experience. In: Proceedings of National Wetlands Assessment Symposium, June 17-20, 1985, Portland, Maine, pp. 260-264.

Soileau, D.M., D.W. Fruge and J.D. Brown, 1985. Mitigation Banking: A Mechanism for Compensating Unavoidable Fish and Wildlife Habitat Losses. National Wetlands Newsletter, May-June 1985, pp. 11-13.

Sorenson, Jens and Susan Gates, 1983. New Directions in Restoration of Coastal Wetlands, Coastal Zone '83, pp. 1427-1443.

State of Oregon, House Bill 3382, Oregon Wetlands Mitigation Bank Revolving Fund Account.

Zagata, M.D., 1985. Mitigation by "Banking" Credits - a Louisana Pilot Project. National Wetlands Newsletter, May-June, 1985, 99. 9-11.

Zedler, Joy B., 1987. Mitigation Problems on the Southern California Coast: An Ecologist's View. California Waterfront Age, v. 3:1, pp. 32-36.

K.F. Bierly, April 1987, Mitigation Bank Handbook (Draft), Procedures and Policies for Oregon., Division of State Lands

This draft report provides an overall review of Oregon's mitigation requirements with specific emphasis on mitigation banking policies and procedures.

A mitigation bank is defined as either an area in which new estuarine habitat is created, or an area previously a part of the estuary restored to estuarine function, or an existing estuarine area enhanced by more effective resource management. Criteria used to select potential bank sites are: size (> 25 acres), location (near potential development areas), ownership (no more than four owners) and mitigation potential. The credit value is established as a ratio between land and development costs, and mitigation credits available from full development. The credit value is based on the enhancement potential of the site, therefore, the price of mitigation credits will vary from bank to bank.

A mitigation bank is established by means of a <u>Memorandum of Agreement</u> between the bank sponsor and the Division of State Lands. Sponsors may include any local government, interest group, port district or other legal entity. The memorandum of agreement must include a description of the purpose of the bank, identification of how the bank will be protected, establishment of operating procedures and any loan agreements between the Division and the sponsor. Proof of ownership or land use control must be submitted as well.

The restoration or enhancement activities necessary to achieve the mitigation goal are to be specified in a <u>Mitigation Bank Habitat Development Plan</u>. This plan describes and quantifies current conditions of the mitigation bank and potential benefits to the estuary from creation, restoration or enhancement measures. It should include the detailed analysis required to establish the total number and price of mitigation credits available, provide a schedule for mitigation activities and identify a specific monitoring program. Development of the final habitat development plan is primarily the responsibility of the Division of State Lands.

Operation of the bank is the joint responsibility of the sponsor and the Division. The sponsor has the primary responsibility of restoration, monitoring and billing for credits withdrawn. The Division is responsible for auditing the mitigation bank credits. Completion of the mitigation actions identified in the Mitigation Bank Restoration Plan provides the physical creation of credits. Data gathered from the monitoring program will be used for estimating credits in future mitigation banks but will not change the mitigation credits originally established. Upon exhaustion of the mitigation bank credits, the property may be donated to a state resource agency or protected through conservation easements or deed restrictions.

The primary criteria for withdrawing mitigation credits is that it be determined that no on-site mitigation opportunity is available. Priority is given to projects in the immediate vicinity of the mitigation bank. Credits are established at a unitless numerical valve created by summing the relative value of the expected habitat created by the size of the area created. A field investigation of site conditions prior to restoration activities, including topographic and areal information, substrate and existing vegetation, is required to establish credits.

The Division of State Lands administers loan funds provided by NOAA for the establishment of mitigation banks in estuaries projected to be impacted by coastal energy activities. These loans are available on a revolving fund basis.

Russell Boesch, Mitigation Banking - A Balance of Interests, Coastal Zone '87, pp. 2515-2529.

Examines how mitigation banking can address the problems of conflict between developers and regulatory agencies over Army Corps 404 permits. More than a dozen mitigation banks have been established, the majority of which were created for water-dependent industries that have long-term, recurrent permitting needs. Mitigation provides a solution to balancing coastal development and resource conservation.

Problems with mitigation are: whether a man-made habitat equals a natural one, limited liability by permitees for long-term success, lack of specific enforceable standards and criteria in permit conditions, insufficient conditions requiring permittee to monitor and maintain the site for many years, mitigation is piecemeal and not sited within the comprehensive land/estuary management strategy. Also, small mitigation sites are less cost effective. Ninety percent of the Army Corps sites are less than an acre.

From the developers perspective, the Corps is using mitigation requirements to discourage projects since there is no consistent policy guiding permitees developer expectations are unclear.

Examines elements of MOAs: bank habitat credits, restrictions, transfer of credits, operating lifetime.

Mitigation banking gives regulatory agencies control over: conditions are incorporated in the permit, requires compliance with the conditions, maintenance and monitoring controlled, action can be made to correct problems, streamlines the workload of the agencies, expert management is made of the site. Additionally, the cost of mitigation must be evaluated in context of economic benefits resulting from permitted activity.

Areas of concern in banking: that developers may try to "buy" their permit, there is a lag time between monies and mitigation, monies are used for acquisition rather than restoration, and how the money amounts should be determined.

Wendy P. Eliot, 1985. Implementing Policies in San Francisco Bay: A Critique, Coastal Zone '85, pp. 920-940.

Documents and evaluates 58 permits in the San Francisco Bay the required implementation of wetland restoration projects to fulfill mitigation requirements. Assesses the effectiveness of mitigation policies in achieving successful wetland restoration. Recommends alternative institutional policies to increase the success of these mitigation projects.

States that success of mitigation projects depends on two variables: whether successful wetland restoration is physically possible and whether current mitigation policies promote efficient and effective restoration projects. Problems since development of a complete complex wetland ecosystem requires an unknown period of time and permit conditions vary widely in specificity and content. The lack of specific policy or guidelines causes a permit to be judged on a case-by-case basis.

There is dissatisfaction with current mitigation policies for the following reasons:

1. large number of regulations presume a high value for wetlands, but differ in scope and purpose;
2. uncertain success of wetland restoration techniques;
3. increasing scarcity of available mitigation sites;
4. difficulty of ensuring compliance with long-term success through maintenance, monitoring, and management.

Influences on the configuration of the mitigation measures are: availability of a restorable site, nature of the project site, and range and flexibility of mitigation options.

Problems with mitigation are: low compliance rates, mitigation goals are changed to meet project objectives rather than restoration goals, the destruction of non-tidal wetland habitat, questionable success of wetland restoration, mitigation ratios not consistently used to determine acreage of compensating projects, regulatory agencies have accepted in-lieu fees rather than mitigation projects. Current mitigation policies have been largely unsuccessful. Improvement is needed in improving the context of the permit, and improving enforcement effectiveness.

Policy recommendations include allowing only on-site mitigation, in-kind replacement and the use of mitigation banks.

J. W. Good, 1987, Mitigating Estuarine Development Impacts in the Pacific Northwest: From Concept to Practice. Northwest Environmental Journal, vol. 3:1, pp 93-111.

This paper discusses estuarine mitigation in the Pacific Northwest. Overall mitigation strategies and goals for individual projects are outlined, followed by a discussion of regional goals and estuary-wide mitigation planning. Information sources for wetland creation and restoration are presented and design principles are summarized. Experiences in Oregon and Washington are cited and suggestions for improving mitigation technology and procedures are offered. Critical concepts and needs emphasized include: cumulative impact analysis, regional planning, mitigation banking and a need for more complete documentation and monitoring.

Mitigation banking is recommended for small mitigation projects for a number of reasons. It is difficult to justify the significant time needed to design and plan very small projects (< 1 acre). Furthermore, projects of this scale have proved impossible to monitor and evaluate because of limited personnel and funds. Finally, the utility of creating many small, disconnected mitigation areas is questionable. Large wetland areas restored in advance of development and "banked" for future use have the lead time necessary for thorough planning and design. Monitoring for evaluation of success is also easier and more efficient with fewer and larger sites.

G.W. Kinser, 1985, Mitigation and its Problems. in Proceedings: Wetlands of the Chesapeake Conference, April 9-11, 1985, Easton, Maryland. pp. 310-320.

A discussion of wetlands mitigation and mitigation banking from the perspective of the Fish and Wildlife Service. Mitigation banking is defined as "habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable necessary losses from specific future development action." Banking is most appropriate in situations where an agency or group has numerous small unavoidable wetland fills which are not practical to mitigate individually on site, such as the small wetland fills involving habitat losses of substantially less than one acre which often occur in highway projects.

The following points must be addressed when establishing a mitigation banking procedure:

- The losses must be unavoidable and necessary.
- All on-site mitigation alternatives must be pursued first.
- The proposed activity should be water dependent.
- Wetland bank sites should be selected because of a need to establish wetlands in the area.
- FWS will recommend "in-kind" mitigation.
- Mitigation banks should be used primarily for small wetland losses.
- Agreement by each agency as to the applicability of the mitigation bank should be an independent process.
- Banking should involve construction, not purchase, of wetland habitat.

Laurel Marcus, 1987. Wetland Restoration and Port Development: The Batiquitos Lagoon Case, Coastal Zone, '87, pp. 4152-4166.

Summarizes two-year planning effort coordinated by the California State Conservancy in restoring the Batiquitos Lagoon in the City of Carlsbad in San Diego County. Realized restoration of the lagoon would be costly and technically difficult. The Conservancy brought together a partnership between mitigation needs of the Port of Los Angeles and the goal of re-establishing tidal influence to enhance the lagoon.

Stressed the preservation of current wetland values while re-creating historic tidal systems and controlling sedimentation and other problems.

Examines in detail lagoon history and and hydrology, water quality and natural resources, Port of Los Angeles mitigation. Outlines how plans for restoration of lagoon had to resolve conflict between re-creating a large tidal prism and preserving the habitat values of the lagoon.

E.P. Riddle, 1987, Mitigation banks: Unmitigated Disaster or Sound Investment? California Waterfront Age, v. 3:1, p 37-40.

A brief review of the pros and cons of mitigation banking from the perspective of the California State Coastal Conservancy. Several specific mitigation bank projects are discussed.

Advantages of establishing mitigation banks include: elimination of lag time through upfront mitigation; establishment of actual mitigation costs a priori (which in turn may encourage reconsideration of proposed projects); and a framework within which issues of cumulative impacts can be addressed. Small, individual mitigation projects rarely yield significant habitat value and the chance of successful compensation for wetland losses is greater through a mitigation bank sponsored by resource agency with the experience and motivation to complete the project.

Problems encountered in the establishment of mitigation banks include: difficulty in finding appropriate sites, the embryonic state of knowledge about wetland restoration; difficulties in assuring monitoring and maintenance, and coordination between the multitude of agencies and interest groups. Finally, the agency in charge of developing banks may run the risk of becoming a "mitigation broker," finding it difficult to undertake non-banking enhancement or restoration projects.

Banking projects underway in California include the Bracut Marsh banking project in Humbolt County in which a filled former tidal marsh was restored to a high, infrequently inundated marsh; a dune mitigation bank in Humbolt County in which 80 acres will be enhanced as a dune habitat over the next five years and the PacTex pipeline project in Los Angeles Harbor in which Batiquitos Lagoon was selected as a mitigation bank site for the filling of over 100 acres of deep marine habitat.

E.P. Riddle and M.F. Denninger, 1986, Coastal Wetlands Mitigation Banks: The California State Coastal Conservency Experience. In Proceedings: National Wetlands Assessment Symposium, June 17-20, 1985, Portland, ME, pp 260 - 264

This paper provides practical information and recommendations on the planning and management of effective mitigation banks based on the California State Coastal Conservency's involvement in mitigation bank programs in Humboldt Bay, San Francisco Bay, and the Los Angeles area.

Mitigation bank programs are developed on a regional basis in California within the following framework:

1. Establish bank sponsors: Sponsors may include a variety of agencies, organizations or private individuals.

2. Establish a working group: This group should include permitting agencies, resource agencies and may also include environmental interest groups and representatives of permit applicants.

3. Develop program guidelines: The use of mitigation banks is only recommended when project redesign, on-site mitigation and off-site mitigation arranged by the permit applicant are infeasible or inappropriate and when the mitigation bank has the appropriate amount and type of habitat available. Program guidelines should establish regional goals such as restoring historic proportions of wetland types, increasing habitat diversity and creating habitat for endangered species.

4. Establish site-selection criteria and prepare inventory: Site selection criteria should be based in part on historic wetland losses, development trends and predicted rates of wetland losses. Sites should have minimal wetland habitat value prior to enhancement. Large sites are generally more cost effective and more likely to encompass a variety of habitat types, however small sites may be appropriate in heavily developed areas as islands of habitat. Sites should be located as close to anticipated development as possible.

5. Prioritize sites: Sites should be ranked based on regional restoration goals and on the selection criteria. The sponsoring agency should then initiate appraisals on the highest priority sites whose owners are willing to sell.

Once a potential banking site has been identified, the following procedure is recommended in order to establish the mitigation bank:

1. Develop management and mitigation bank agreements: The sponsor should secure formal agreements with the resource and permitting agencies. These agreements should detail the terms and conditions under which the management agency agrees to accept title and manage the site in perpetuity as wildlife habitat. These agreements should also commit the permitting agency to use the bank within clearly defined parameters, define the obligations of the sponsoring agency and establish the unit price of banked habitat value.

2. Prepare site enhancement plan: This plan should be developed in light of regional goals and projected wetland losses. Existing and projected wildlife habitat values should be quantified using the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (1983) or an equivalent method.

3. Tally Costs: Costs may include land acquisition, enhancement planning, construction, management, monitoring and up to 10% of the total for administrative costs.

4. Determine unit costs: Unit of cost many be either be per added unit of habitat value or per acre of enhanced wetland. Applicants should only be allowed to use units of habitat value <u>added</u> to compensate for project impacts. A minimum of one acre of bank for each acre of development impact is required.

State of Oregon, Division of State Lands, April 1984; Estuarine Mitigation: The Oregon Process, Principal Author: Stanley F. Hamilton

The State of Oregon requires mitigation as a condition of any permit for filling or removal of material from an intertidal or tidal marsh area of an estuary. "Mitigation" is defined as creation, restoration or enhancement of an estuarine area to maintain functional characteristics and processes of the estuary. Mitigation may be provided either on a site-by-site basis or in the context of a "mitigation bank." Mitigation banks are preferred for small (less than 5 acres) projects.

Mitigation must take place within the same estuary as the proposed project. A system of "relative values" is used to determine how much area of one habitat is required to mitigate each acre of another habitat. Relative values are determined using a matrix of substrate (e.g. mud, sand, cobble) vs. habitat type (e.g. algae, seagrass, low marsh). In-kind mitigation is encouraged wherever possible. A minimum fill/removal to mitigation ratio of 1:1 is required. Maintenance dredging does not require mitigation.

Mitigation needs may be met using "mitigation credits" stored in "mitigation banks." These credits are used to offset mitigation needs of small projects that occur after the bank is created. Mitigation credits for banking are obtained by multiplying the relative value of the created or restored habitat by the number of acres. Mitigation banks are to be used for projects within the same estuary. More than one bank may be permitted within a given estuary. Any legal entity may create a bank by written agreement with the Director. Mitigation banks are administered by the Director. Specific information must be provided to the Director including: location, proof of ownership or control, nature and extent of mitigative action, how and when work will be performed, resulting habitat types and relative value of each type, proposed monitoring, how the bank will be protected, how funded and the maximum price to be charged for credits. Permit applicants must negotiate directly with the owner of the bank.

The Director may establish a Mitigation Trust Fund to provide loans for approved mitigation banks. Banks thus funded may not be used to mitigate more than five acres of any intertidal removal and fill activity.

State of Oregon, House Bill 3382, Oregon Wetlands Mitigation Bank Revolving Fund Account.

This piece of legislation establishes a revolving fund account and specific procedures for mitigation banks in Oregon, to be administered by the Division of State Lands.

No more than four pilot mitigation banks will be funded prior to 1991. Site selection criteria for banks must include historic wetland trends, including the estimated rate of current and future losses, as well as the contribution of wetlands to wildlife, fisheries, water quality and flood moderation, recreation, scientific values and regional economic needs. Mitigation banks may be used only under the following conditions:

- onsite mitigation methods are impracticable;
- permit action occurs within 40 miles of bank;
- permit action occurs within same estuarine ecological system; and,
- fill activity must be less than five acres.

Wetlands functions and valves within each bank site must be evaluated annually and quarterly and annual reports must be provided. Other state and federal agencies to be consulted are specified and a technical scientific committee is to be appointed to assist in review of bank proposals and operations. A total of $235,943 is proposed as funding for the first two years.

D.M. Soileau, D.W. Fruge, J.D. Brown, 1985, Mitigation Banking: A Mechanism for Compensating Unavoidable Fish and Wildlife Habitat Losses. National Wetlands Newsletter, May-June 1985, p. 11-13.

This article provides a discussion of mitigation banking from the perspective of the U.S. Fish and Wildlife Service. The Tenneco Oil Company mitigation bank in Louisiana is briefly and favorably reviewed. Mitigation banking is recommended only in limited circumstances, particularly for small projects where unavoidable habitat losses individually are minor and cannot be fully mitigated on or immediately adjacent to the project site.

The following minimum requirements are recommended before mitigation bank credits should be applied:

- there should be a demonstrated public need for the project;
- the project should be water dependent;
- only projects incorporating the least damaging alternative should be eligible;
- bank credits should be allowed only after all other avenues of impact avoidance and minimization have been exhausted;
- bank credits should be used only when onsite mitigation is impossible.

A mitigation bank should be organized as simply as possible and administered through a formal, interagency agreement defining the bank area; habitat improvement measures; crediting and debiting process; life of the bank; and monitoring and reevaluation provisions. A central coordinator should be designated to maintain the credit/debit account and keep all participants informed. A habitat-based methodology such as the Habitat Evaluation Procedure is recommended, as is the use of "in-kind" credits.

Benefits of a mitigation bank include the opportunity to coordinate mitigation needs with long-range goals for improving fish and wildlife habitat. Banks provide an early planning measure that puts mitigation up-front, thus minimizing developer/regulator conflicts and saving time and money. An opportunity to sell or trade mitigation banking credits affords mitigation bankers an opportunity to recoup expenditures. A major risk of banking involves the possibility of neglecting good project planning and resorting to the use of banked credits before all means of avoiding or minimizing impacts have been exhausted. Further, developers may view mitigation banking as a mechanism for guaranteeing blanket approval of all future permit applications.

Sorenson, Jens and Susan Gates, 1983. New Directions in Restoration of Coastal Wetlands, Coastal Zone '83, pp. 1427-1443.

Outlines reasons why wetland restoration should be viewed from both a regional and a state-wide perspective. Regional assessment of wetland systems in southern California is an example of this approach. Argues that government agencies will have to increasingly rely on private sector cooperation and support if significant advances are to be made in the acreage of wetlands.

Two major problems with wetland restoration; the limited scientific knowledge on existing wetland systems functions and limited knowledge in assessing the ecological benefits of alternative restoration plans.

A regional perspective is needed to understand the following: regional distribution of habitats among a number of wetland systems; need for alternative habitats to accommodate seasonal changes in habitat; inventory of resources to set priorities on habitats to follow the historic types of wetlands; comparative analysis of wetlands to determine the types and mix of environmental factors to create the optimal habitats; baseline analysis of species population and habitat determines the natural fluctuations and to monitor the increase after restoration of wetland resource values; and, list of all potential sites for wetland creation and dredged wetlands.

The boundaries of a region can be determined by the geographical limits of the migration limits of fish and wildlife, the geographical range species are known to inhabit, and the biogeographic extent of wetland types.

Examines in detail the restoration of Los Cerritos wetland (a disturbed wetland system in Los Angeles County), 130 acres of scattered salt flat, freshwater marsh, and tidal marsh over a 244-acre site in highly urbanized environment. Fifteen wetland restoration alternatives were prepared by citizens groups. After 15 workshops, plans were evaluated by citizens groups and narrowed down to three options. Three wetland configurations were discussed: one wetland concentration configuration, two wetland concentration configurations, and a corridor configuration. It was difficult to decide what plan was best due to lack of information regarding wildlife and bird use and behavior. Final plan selection made by wetland biologists and land use planners.

M.D. Zagata, 1985, Mitigation by "Banking" Credits - a Louisiana Pilot Project. National Wetlands Newsletter, May-June, 1985, p. 9-11.

A discussion of mitigation banking, from an industrial point of view, with specific reference to the Tenneco LaTerre pilot program in Louisiana. This paper stresses the need to incorporate economic considerations into federal and state conservation programs by offering incentives that will save industry time and money and, simultaneously, protect wetlands. The problem with the mitigation requirement of Section 404 of the Clean Water Act is that mitigation is considered at the end, rather that at the beginning of the permit process. Thus, industry often perceives mitigation as an additional, non-budgeted source of delay and money.

Establishment of a mitigation bank places mitigation in a more prominent role in the permitting process, putting industries in a better position to plan expenditures and budget for wetlands management. In may cases, because of the large scale of most banking projects, the ecological benefit per dollar invested may be greater than in normal mitigation.

The use of a quantitative methodology, such as the Habitat Evaluation Procedure (HEP) is advocated in order to determine the number of habitat units (HUs) available in a bank. The author suggests a number of ways that the credited HUs could be used by a bankee. Banked credits could serve as collateral, or a bond, to insure an applicant's compliance with a permit stipulation. Permit processing could be expedited since the details of mitigation could be worked out after a permit is granted, rather than standing as a hurdle to its issuance. The applicant could later cash in part of its credits to meet the mitigation requirements or perform some other form of on-site mitigation.

The Tenneco LaTerre mitigation banking project is located south of Houma, Louisiana and includes 5,000 acres of wetlands within Tenneco's property plus an additional 2,200 acres of adjacent wetlands which will also benefit from the project. According to the Memorandum of Agreement, Tenneco will install and maintain, for at least 25 years, a system of weirs, dikes and mud dams to maintain and enhance the 7,200 acres of wetlands, thus reducing the rate of subsidence and enhancing the presently deteriorating wetlands.

As a result, Tenneco will generate 11.9 million HUs on 7,200 acres and will be allowed to use a total of 35,300 HUs over the first 25 years of the bank. Credits will primarily be used to mitigate for oil and gas dredged canals only when the applicant can demonstrate that no on-site alternatives are available.

APPENDIX C

Use Guidelines For Tidal Wetland Mitigation Projects: Design, Site Preparation and Vegetative Establishment

USE GUIDELINES: DESIGN, SITE PREPARATION, VEGETATIVE ESTABLISHMENT

Design

Accurate marsh development techniques have been established for design, construction, and maintenance of man-made marsh systems. With careful attention paid to proper design considerations, man-made marshes can be constructed with a high degree of success. However, there remain many factors which can limit the success of artificial wetlands: construction procedures are still in the experimental stage, and procedures for marsh installation are variable on a site by site basis. Generalities cannot be made. Questions must be addressed concerning actual degree of compensation delivered by mitigation projects, which may not restore all of the lost natural wetland functions and values. Site by site evaluation is necessary, and each marsh establishment project must be designed individually for specific mitigation requirements, site location, and environmental conditions.

The successful establishment of an artificial marsh requires careful project design and implementation (Landin, 1986). The design of the project should be consistent with the goals of mitigation, i.e., development of the desired habitat, vegetation, and biological community with a minimum of environmental perturbation (Shisler and Charette, 1984; Landin, 1986). The mitigation site selection process and criteria outlined above incorporate many of the factors and fixed parameters which enter into a mitigation design plan. Important decisions already made during site selection for this study include physical environmental constraints such as proximity to a water source, salinity, fetch, wave energy, tide range, and existing habitat, ecology, and land use.

A comprehensive design for each wetland mitigation project is essential for successful project planning and implementation. The design plan should serve the purpose, objectives, and goals of new Jersey's Department of Environmental Protection (DEP) wetland regulations and mitigation program. Important DEP policy considerations for mitigation, as outlined by Shisler and Charette (1984) which should be incorporated into the overall mitigation design plan include: 1) examination and characterization of what types of wetland habitats and functions have been impacted by the development; and 2) determination of type and kind of wetland that should be established for mitigation purposes. Once estimates have been made to quantify both temporary and long-term impacts and losses to the natural wetland area, a mitigation plan can be designed to maintain or attempt to "replace" the lost natural area. Design parameters should be developed with the objective of physical and functional replacement of the natural wetland.

Successful mitigation is dependent on an integrated analysis of the hydrology, vegetation, habitat, substrate, and other site specific factors of wetlands. Thus, the mitigation project design should incorporate a comprehensive understanding of what functional and physical aspects of a wetland are/will be destroyed or altered, and what should be replaced through mitigation. This can then be developed into detailed site plans and contract specifications. Considerations to be made in developing wetland mitigation designs include, but are not limited to: hydrology, vegetation, habitat, and substrate.

Hydrology

The hydrology of the natural wetland should be characterized. Analysis or assessment of hydrologic conditions in the area should include consideration of flood frequency and storage potential, ground water storage, stream discharge and circulation, channel configuration, drainage, and interrelationships between the wetland and surrounding water bodies. If required by DEP, specific functional values should be applied to the hydrologic characteristics of the natural marsh.

Vegetation and Habitat

Analysis should be made of the major vegetational communities within the impacted marsh, and estimates should be made of the primary productivity of the natural marsh (Shisler and Charette, 1984). A survey should be conducted to characterize the species and distribution of animals in the wetland. The vegetation to be planted for the mitigation project should be determined, and may or may not be identical to plant species in the impacted marsh, depending on DEP's policy evaluation of the site or physical site conditions. It should be determined if the mitigation vegetative community should be monotypic or diverse, depending on the specific functional objectives of the mitigation project. Other habitats of the impacted wetland site such as tidal creeks, ponds and islands, mud flats, and upland edges should be evaluated. A design plan can then be developed for identical replacement of wetland habitat losses, or to increase habitat function of the new wetland through design for increased wildlife value, ecological diversity, and productivity. Thus, examination and analysis of existing vegetation and habitat type is necessary at the design and planning phase of any mitigation project.

Substrate

Wetland soils are essential for maintenance and protection of many functional values of marshes. They play a major role in nutrient and chemical cycles, and are interrelated to the hydrologic function and general water quality of wetlands. Research involving wetlands soils (Shisler and Charette, 1984) has demonstrated that it is extremely difficult to recreate functionally viable wetland soils. Artificial wetland sediments used as foundations for mitigation projects have been found to demonstrate characteristics of very young sediments, while natural marsh peats have developed complex structure and organic/chemical content over long periods of time (Shisler and Charette, 1984). It is not possible to recreate all functional values associated with well developed wetland soils in a marsh mitigation project, but overtime, careful and proper design can approximate what was lost. Consideration should be given to substrate parameters such as grain size distribution, organic content, porosity, and permeability of sediments used in mitigation projects.

Generally, the overall design for a mitigation project should incorporate: 1) an understanding and evaluation of impacts and losses to the natural marsh that is being "replaced", and 2) detailed plans for site preparation (grading, elevation, slope, soil bed preparation), vegetative establishment (planting season, propagule selection, plant spacing, installation, and maintenance programs. Both general and specific site preparation and vegetative establishment procedures will be discussed in the following sections. Modifications to these recommendations may be necessary on a case-by-case or site-by-site basis, depending on final goals and objectives, as well as financial and political considerations of each mitigation project.

SITE PREPARATION

Elevation

Proper surface elevation is of primary importance for successful wetland creation projects, and various elevation zones of the mitigation site should be delineated in the project design. Correct and exact surface elevations of the marsh substrate must be carefully monitored during construction to ensure successful colonization and growth of desired marsh vegetation. Determination of what the project elevations should be will be dependent upon the type of marsh to be established and a working knowledge of the elevational requirements of the desired plant community. Ultimately, it is the final elevation of the site and associated plant species assigned to the elevational zones on site that determine the success of a mitigation project (Garbisch, 1986).

Both filling and excavation are methods which can be used to achieve desired elevations. Correct elevations can be determined by observation of biological indicators such as zonation of adjacent marshes, or through surveyed locations of known tidal bench marks such as mean low or mean high water. However, final elevation of a newly created marsh substrate is usually affected by settlement and consolidation of material at the construction site (Garbisch, 1977). It has been reported (Landin, 1986; Garbisch, 1977) that sufficient short-term sediment consolidation can usually be achieved in a matter of days or weeks following site preparation, whereas long-term consolidation may not be achieved for months, and may or may not have a significant impact on successful marsh establishment. Therefore, grading and filling operations should be done long enough in advance of planting to allow for consolidation of the disturbed soil

(Woodhouse and Knutson, 1982). The consolidation of fill materials may ultimately affect not only the final surface elevations at the site, but also the stability of plantings in the substrate. Marsh vegetation planted in unconsolidated material may become dislodged quite easily before sufficient root development takes place (Woodhouse and Knutson, 1982).

Woodhouse and Knutson (1982) discuss the potential width of established marshes while considering elevational requirements. He determined that the width of the site at an elevation suitable for plant establishment will ultimately determine the relative stability of plantings made in areas subject to erosion. A minimum planting width of 18 to 20 feet is recommended in areas subject to erosion, as the amount of erosion protection afforded by a marsh is directly related to the width of the marsh. This guideline will only be effective, however, when proper elevations are achieved and maintained across the recommended marsh width.

Other considerations to be made when determining proper elevation of wetlands establishment projects might include the following factors: 1) variation in topography and elevation will produce habitat diversity, provided that the majority of the area is within the desired elevational range (Landin, 1986) salt marshes are generally the most productive in the upper third of the dial range; and 3) studies of mitigation projects have shown that low-marsh projects established between mean high water and mean low water with Spartina alterniflora have exhibited greater success than high marshes colonized with Spartina patens and other species (Shisler and Charette, 1984). These types of considerations should be given to elevational requirements during the design phase of the project.

Slope

Along with elevation, slope of the marsh substrate is generally considered to be one of the most important factors to be properly constructed during site preparation (Garbisch, 1977). Experience and experimentation in marsh creation by Woodhouse and Knutson (1982), Landin (1986), Garbisch (1977), and others have demonstrated that surface slopes should be designed to be as low as possible without impounding water, and should not be designed to exceed slopes that would be considered unstable under normal conditions without vegetative ground cover. Exact specifications for surface slopes cannot be predetermined and generalized, as suitable surface slopes for marsh establishment are site specific, and are dependent on physical characteristics of the project site such as waves, winds, fetch, and sediments. Garbisch (1977) recommends that the upper limits of surface slopes be estimated from the prevailing slope of adjacent, non-eroding shorelines or marshes. The flatter the slope, the greater the probability of small pool formation. Any ponding will kill the vegetation. In large, low slope marsh creation projects, plans should be made for manual ditching of ponds after planting is completed. Uneven sediment consolidation and erosion patterns can also foster the development of small ponded areas.

Shade

In areas where trees and other vegetation over-hang an exposed bank or marsh site, successful establishment of marsh vegetation may be prevented because of shading effects. Spartina alterniflora possesses the C_4 photosynthetic pathway and requires long periods of intense sunlight to operate efficiently. Such areas can be successfully established with marsh vegetation if the overstory is cleared above the planting area and landward a distance of approximately 10 to 12 feet (Woodhouse and Knutson, 1982). Continued control and maintenance of the overstory and associated shading effects is essential to successful growth and establishment of marsh vegetation. Typically, the marsh plantings require 6 to 8 hours of sunlight per day.

Soil Bed Preparation

Sandy substrate is the most frequently used substrate for marsh creation projects. Sandy material can be easily graded to achieve desired slopes and elevations, while finer-grained material such as silt, clay, and mud cannot be easily modified once placed on site (Landin, 1986). Garbisch (1977) reports that although there is no limitation of uncontaminated sediment types to marsh establishment, fine sediment types may present major operational problems to a contractor. Garbisch (1977, 1986) has also determined that peat sediments can be expected to support poor plant growth. He suggests that marsh peat is the least desirable substrate for marsh restoration or development. However, Shisler and Charette (1984) consider a general ranking of sediment suitability to be: 1) marsh peat; 2) clay and silty clays, including dredged material; 3) sand. They recommend that the original marsh peat be utilized wherever possible in marsh establishment projects.

Whichever substrate is used at a project site, it is recommended that an examination of the planting substrate (especially dredge spoil) be conducted to assess the following characteristics: texture, salinity, pH, nutrient level, and potentially toxic levels of metals, pesticides, petroleum products, etc. (Landin, 1986). Such factors must be considered in the determination of any required treatment to the sediment prior to planting.

Fertilization can be important in establishment of man-made wetlands under certain circumstances. Although different sediment types will affect the vegetative response to fertilization, a positive plant response can generally be obtained by fertilizing sandy material which is usually deficient in nutrients, especially phosphorus and nitrogen (Woodhouse and Knutson, 1982; Landin, 1986). On the other hand, finer-grained sediments are capable of storing large quantities of nutrients (Woodhouse and Knutson, 1982). A slow release fertilizer such as osmocote (19-6-12) should be applied at the time of planting. Subsequent applications should be determined according to the success and growth of vegetation at the project site. Once established, few sites require additional fertilization (Landin, 1986). Most coastal estuarine waters carry an ample supply of nutrients.

VEGETATIVE ESTABLISHMENT

Time of Planting

Scheduling and timing of planting is very important to the success of any marsh establishment project. To obtain the maximum vegetative cover within the first year, it is necessary to have the material in place by the beginning of the growing season (Landin, 1986). In the New Jersey coastal areas, planting has been recommended in all but the summer months (Woodhouse and Knutson, 1982). However, fall/winter planting is not recommended for mitigation projects, depending on site location, as severe plant loss may result from erosion of sediments away from root systems before regrowth begins the following spring. During fall and winter months, severe storms may dislodge the plants, especially at sites exposed to high energy wind, waves, and currents. Early spring planting avoids such winter storms, and provides a longer growing season for plant establishment. March, April, May, and early June probably represent the optimum planting season along the mid-Atlantic coast (Woodhouse and Knutson, 1982).

Even when a spring planting schedule is adhered to, care should be taken to ensure proper temperatures acclimation for the plants. To lessen the shock, propagules held in storage inside a nursery or greenhouse should be hardened and should not be planted until temperatures at the planting site are approximately as warm as the storage area (Landin, 1986; Woodhouse and Knutson, 1982). Similarly, plants stored in shady areas should gradually be exposed to sunny conditions to prevent extreme light shock. Propagules should also be acclimated to the salinity that exists at the project site.

It is essential that the site preparation phase of a mitigation project be completed according to a schedule designed to allow for planting during the beginning of the growing season. Scheduling of the work is extremely important, and should be conducted with optimum planting season in mind.

Plant Species Selection

The selection of plant species for a mitigation site must be based on mitigation goals, and characteristics of the region in general, and the site in particular. Success of the project may hinge upon choosing the proper species to plant in the various elevational zones within the project. The design of the site should consider nearby marsh plant communities that occur on sites similar to the one being created, with special attention paid to the distribution and relative abundance of species in the marsh. Selection of a species or mixed group of species for planting at a particular site should be based upon: project goals, location, climate and microclimate, substrate, salinity, plant growth habits, plant availability, maintenance requirements, and costs (Landin, 1986). Garbisch (1986) recommends that, for greatest probability of success, the plant species selected be mostly perennials, endemic, adaptable to the broadest tidal range or depth of water range, and have been successful in wetlands creation projects in the past.

Propagule Selection

The installation of marsh plants at the project site can be achieved by natural invasion of species or by artificial planting. Natural establishment of plants can be expected if proper conditions exist at the site, but natural invasion of plants does not provide assurances of what plant species will invade a site, nor in what time frame colonization will occur (Garbisch, 1977, 1986). A mitigation project design should specify plant type, extent of coverage, and a time frame for planting. Therefore, artificial establishment of vegetation should be the method used at a mitigation site as opposed to allowing natural plant invasions to occur.

Several types of propagules are available for artificial marsh vegetative establishment, including seeds, tubers and rhizomes, peat-potted plants, sprigs, and plugs from natural wetland areas. The criteria used for selecting propagule type are dependent upon: availability; costs; ease of collection, storage, and handling; need for rapid vegetative cover; physical conditions of the site including salinity and degree of exposure to winds, waves, and tides; and goals of the mitigation project (Landin, 1986). Creating wetlands through use of seeds is extremely economical, but its success is reported to be the least predictable of planting methods (Garbisch, 1986). Marsh establishment via seeds is dependent on a number of environmental factors including water temperature and salinity.

Man-made marshes have been created using indigenous soils to provide "seed banks" for vegetative restoration. While this method is inexpensive, it may also be unreliable, and undesirable species may invade the area. Details on seeding marsh vegetation can be found in Garbisch, (1986), but more research on achieving success in seeding should be conducted before this method is used in mitigation projects. Another drawback of seeding is that considerable erosion can occur before the root systems of seedlings become developed enough to retain the substrate.

For mitigation purposes it is suggested that a more controllable method of vegetative establishment be utilized. Although a more expensive technique, the use of transplants in wetlands creation has been proven to be more successful and reliable than use of seeds (Garbisch, 1986; Landin, 1986; Woodhouse and Knutson, 1982). Garbisch (1986) reports that peat-potted nursery stock is the preferred plant material as it may be transplanted any time of the year. Similarly, plugs from natural wetland areas can be planted anytime of year, but it is recommended that plant material excavated from natural wetlands not be used in mitigation projects. Although it is relatively easy to obtain propagules from adjacent natural marshes, damage may occur to the natural marsh unless harvesting is conducted with care by experienced personnel. If harvesting from natural marshes is considered to be an acceptable method for obtaining vegetation for mitigation sites, perhaps permits should be required for such plant collection.

Sprigs, tubers, and rhizomes obtained from plant nurseries may be planted at project sites in spring or late winter. As suggested by Shisler and Charette (1984) only indigenous plant materials, or nursery grown plants with genetic origin from New Jersey marshes or those in the mid-Atlantic region, should be considered for use in mitigation projects. Some plants exhibit varietal differences when planted or established outside their normal geographic range (Seneca, 1980; Woodhouse and Knutson, 1972).

Plant Spacing

Plant spacing is an important consideration for marsh establishment and is high site specific, depending on quality of substrate, wave energy conditions at the site, length of growing season remaining at the time of planting, and type of propagule utilized in planting. Variations in plant spacing can be used in mitigation design, depending on the desired rapidity of plant cover. The more closely plants are spaced, the faster dense marsh coverage will be achieved. Woodhouse and Knutson (1982) determined that vegetative transplants set on approximate 3-foot centers will, under average conditions, provide complete cover by the early spring of the second growing season. Denser spacing (e.g., 1.5-foot centers) may be used on exposed sites, or where early stabilization is desired. As planting costs are almost directly proportionate to the number of plants planted, spacing can be greater than 3 feet if there is no compelling reason to attain full cover within a short time, or one growing season. However, Landin (1986) suggests that if the site is extremely unstable, subject to heavy wildlife pressures or physical stress, or if aesthetics are an immediate concern, more dense plantings may be desirable.

General Maintenance and Protection

Care should be taken to provide periodic maintenance of the planting site through at least one, and if possible, two growing seasons. Debris and litter such as wood, styrofoam, trash, and dead algal mats may accumulate in the planting areas. Unless this debris is removed in both autumn and spring, it is likely that is will smother and damage the new marsh plantings (Woodhouse and Knutson, 1982; Garbisch, 1986).

Wildlife, especially Canada and Snow geese, may destroy a newly planted area by grazing on tender roots and rhizomes of marsh plants. Other herbivores such as muskrats and rabbits, will also graze on the wetlands vegetation. Rope fences constructed around the vulnerable perimeter of the marsh have been used successfully to exclude waterfowl during the first few growing seasons (Woodhouse and Knutson, 1982). The fences are simple and inexpensive to build (wooden posts strung with nylon string at approximately 8-inch vertical intervals) and it is highly recommended that this type of barrier be emplaced at all mitigation sites. If heavy grazing by other animals is judged to be a problem, trapping and other types of fencing should be considered.

Severe storms may also cause damage to newly established wetlands, especially during the first growing season. In low energy areas, storm, wind, and wave erosion may not be a problem. However, at higher energy sites, permanent or temporary protection may be required. Dikes or breakwaters constructed in the shallow offshore areas may give the new marsh area sufficient time to become established. Woodhouse and Knutson (1982, report that remedies that have been tried with varying success are breakwaters (e.g., tires, hay bales, rock), fiberglass, cloth, or net mulch. Unfortunately, such temporary protection may not be cost effective. Well-designed and properly installed breakwaters and sills may afford the best protection against winds, waves, and tides.

Landin (1986) suggest that plants themselves may be used as protective barriers by installing more erosion-resistant, large transplants on the outer fringes of the marsh, with more susceptible propagules such as tubers and seeds in the interior, more protected sections of the marsh.

Whatever the cause of plant loss or damage, propagules should be replaced throughout the first year of establishment as soon as mortality is noted.

<u>Potential Problems</u>

Potential problems and their solution for mitigation sites include:

1) Scheduling or work/project coordination.
   - o Delays or mismanaged scheduling will affect the success of the project, and may result in vegetative mortality, replanting, increased costs, and increased erosion at the site.

   Solution: Careful planning of a schedule incorporating flexibility to allow for delays without endangering project success.

2) Inexperienced Contractor
   - o Lack of knowledge of wetlands systems, with no appreciation for importance or proper grade, sediments, and/or plant species may result in poor quality work.

   Solution:
   - o Detailed specifications, pre-bid meetings, construction sequence, and maintenance requirements should be established at the onset of the project.

3) Improper Final Elevations, Slope, Plant Species
   - o Final grade will determine success of project.

   Solutions:
   - o Careful inspection of site throughout preparation phase is essential.
   - o Elevations should be monitored and checked continuously. Changes in marsh surface elevation after installation due to causes such as upland runoff of sediment, should be corrected immediately if the changes have a deleterious effect on the vegetation.
   - o Plant species must be installed at proper elevations after substrate is stable.

4) Plant mortality due to predation, diseases, and debris accumulations.

   Solutions:
   - o Maintenance program should be established for at least two years through monthly site inspections.
   - o Construction of fences before planting is complete.

5) Erosion

   Solution:
   - o Installation of temporary or permanent protective barriers. If erosion is a continuing problem, it may mean that the site is located in an area with too high energy conditions.

6) Invasion of non-preferred plant species.

   Solutions:
   - o Should be controlled by establishment of proper grade for desired plant species.
   - o Undesired plants may be removed through maintenance plan, and area replanted with design species.

7) Contaminant uptake by plants.

   Solution:
   - o Substrate should be tested and approved prior to construction and plant installation.

SUMMARY GUIDELINES

Recommended guidelines and procedures for wetlands mitigation purposes include the following:

1) Evaluate the extent of loss from the natural marsh system, including hydrologic and sedimentological functions, habitat loss, impact on floral and faunal communities, and impacts on adjacent estuarine areas.

2) Determine the size, extent, and type of required mitigation.

3) Determine the location of appropriate mitigation sites, based on approved and appropriate site selection criteria. Consider physical characteristics of the site, as well as economic and political factors.

4) Prepare a detailed design of the mitigation project for approval, including details for grading plan (elevation and slope); distribution of plants according to elevational zones; soil bed preparation; installation specifications and techniques; site maintenance program; and a schedule and time frame for each phase of project implementation.

5) Acquire appropriate approvals for design and implementation.

6) Acquire appropriate permits.

7) Conduct preliminary site visit with appropriate DEP authorities to establish access routes for equipment, discuss appropriate soil conservation/erosion and sediment control measures, and identify trees/limbs that need to be removed to provide access and to prevent shading of the wetlands to be planted. Written agreements should be made regarding restoration of access roads, removal of excess debris, etc. Care should be taken to ensure that existing wetlands near or adjacent to the mitigation site are not disturbed. If, during the course of construction, adjacent wetlands are damaged, they should be immediately restored to original condition.

8) Implement site preparation procedures, with required or scheduled inspection by designated authorities. The selected contractor should have sufficient experience to perform excavation and/or filling, and grading to the lines, grades, and limits shown on the design drawings. Earth fill as required, should be native to the area and should be obtained from an approved source. Only earth materials, free of wood, rocks, and debris, should be utilized. Sandy material is recommended (Garbisch, 1977, 1986), but silty estuarine sediments and wetland peats may also be sued on approval (Shisler and Charette, 1984). The contractor should grade all areas shown on the design plans. The finished surface should be smooth, compacted, consolidated, and free of irregular surfaces which could collect water. Final grades should be subject to inspection and approval by an appropriate official. The contractor should also grade all areas which were disturbed by construction activities. These areas should also be stabilized and planted according to an erosion and sediment control plan by an approved agency such as the U.S.D.A. Soil Conservation Service.

9) Stabilize adjacent upland slope.

10) Initiate vegetation on establishment after final inspection and approval of site preparation. All areas that are to be planted should be cleaned of debris and the ground surface should be smooth. After final grading, the position of the mean low water and mean high water lines should be established. Vegetation should be planted at the appropriate spacing and designated elevations. Spacing of rows and plants should have been determined when design specs were established and approved. For dense coverage during the first growing season, rows 1.5 to 2 feet apart, and plants 1.5 to 2 feet apart are recommended. Greater distance between rows and plants may be used if dense coverage is not required immediately. It is recommended that peat-potted plants or sprigs from an approved nursery be used at mitigation sits. Plants should ideally be three to six months old and approximately 12 inches high. Each peat pot should contain three or more plants. Plants should be watered on site if not planted immediately. Plants should not be removed from pots until planting is to proceed since care must be taken to minimize the exposure of bare roots to air and sun. Plantings should be made manually or by machine. Dibbles, spades, shovels, power augers, or transplant machines may be utilized. Plantings should be accomplished by opening the appropriate size hole in the ground, placing the fertilizer 1/2 oz. Osmocote 3-4 month 19-6-12 or approved equivalent slow-release fertilizer) and then the plant into the hole, closing the hole, and firming the soil around the plant. The surface soil level should cover the top of the planting pot by at least 2 inches. In higher energy areas, plants should be planted as deeply as possible, or at least 4 to 6 inches deep. If the soil at the planting site is not wet or damp, the plants should be watered within 4 hours after planting.

11) Determine the need for stabilization/restoration of adjacent areas impacted by wetlands construction. Areas should be restored to pre-construction conditions.

12) Execute maintenance program according to previously approved plan or regulatory requirements.

13) Initiate monitoring program to determine relative success of the project and to measure degree of compliance with mitigation policy regulations. Monitoring information can also be used as data base for other mitigation projects.

RECOMMENDATIONS FOR THE USE OF EXCESS EXCAVATED MATERIAL

Creation of wetlands on some of the designated mitigation sites may require excavation and removal of vast quantities of material in order to bring the elevation to the intertidal level. Removal of material from the site can add greatly to the cost of the mitigation project. There are several alternatives to removal of the excess material:

1) Rather than hauling the material off-site, it can be moved around within the proposed mitigation site, creating a variety of topographic zones and features. The subenvironments can then be vegetated with appropriate plant species, and a diverse habitat utilized by wildlife can be created. The only drawback of this alternative in terms of wetlands mitigation is that only a portion of the acreage of the designated site will actually be converted to wetlands. For example, a 20-acre mitigation site might yield only 10 to 15 acres of wetland.

2) Many of the sites identified in this study consist of a silty, sandy substrate. In some of the cases, the material was derived from dredging of adjacent waterways. Upon further analysis of grain size characteristics, some of this material might prove to be suitable for beach nourishment purposes. This should be given further consideration especially in areas where beach erosion is a major problem and the site is in close proximity to the area of concern. As an example, sand from the Manasquan mitigation site (#8a) and Gull Island (8b) might be considered to nourish the beach north of the inlet, where sand is being lost via longshore transport to the north.

3) Depending on the nature of the substrate, it may be feasible to sell the excess excavated material. Prior to sale, the sediment should be tested and approved for removal, disposal, and intended use, especially if dredge spoil with potential contaminants is involved.

REFERENCES CITED

Garbisch, E.W., Jr. 1977. Recent and Planned Marsh Establishment Work Throughout the Contiguous United States: A survey and basic guidelines. Contract Report D-77-3, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, MS. 277p. NITS No.: AD-A041-464.

Garbisch, E.W., Jr. 1986. Highways and Wetlands: Compensating Wetland Losses. Federal Highway Administration, Office of Implementation. FHWA-1p-86-22. McLean, VA. 60 pp.

Landin, M.C. 1986. Wetland beneficial use applicaitons of dredged material disposal sites. In: Proceedings of the Thirteenth Annual Conference on Wetlands Restoration and Creation. F.J. Webb, Jr., editor. Hillsborough Community College, Tampa, FL. pp. 118-129.

Seneca, E.D. 1980. Techniques for creating salt marshes along the East Coast. In: Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop. J.C. Lewis and E.W. Bunce, editors, FWS/OBS-80/27, Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C. pp. 1-5. NTIS No.: PB81-165 649.

Shisler, J.K. and D.J. Charette. 1984. Evaluation of Artificial Salt Marshes in New Jersey. New Jersey Agricultural Experiment Station. Publication No. P-40502-01-84, 18 p.

Woodhouse, W.W., Jr. and P.L. Knutson. 1982. Atlantic coastal marshes. In: Creation and Restoration of Coastal Plant Communities. R.R. Lewis, III, editor. CRC Press, Inc., Boca Raton, FL. pp. 45-70.

APPENDIX D

Use Guidelines For Accessing ARC/INFO Coverages and Producing Maps of Potential Tidal Wetland Mitigation Sites

INTRODUCTION AND BASIC DATABASE STRUCTURE

The study area covers approximately 1,750 square miles which incorporates 86 USGS quadrangle sheets and 1,019 1:2,400 wetland/tideland maps. Out of the 1,019 maps, 40, containing 35 mitigation/bank sites were digitized.

The database is comprised of five ARC/INFO coverages:

WET	Wetland, Open Water and Mitigation sites
CAFRA	CAFRA boundary
ROADS	Road network with annotation
QUADS	Outline of each quadrangle sheet contained in the study area
GRID	Outline of each wetland and/or tideland maps contained in the study area

Instead of creating separate coverages for each wetland/tideland map, a single coverage was created that encompasses the entire study area. This was done for several reasons.

1) File management is far simpler with the user only having to keep track of five coverages instead of 136 coverages.
2) Far less disk space is required.
3) By simply defining the MAPEXTENT, the user can generate plots of several maps on a single sheet.

In addition to these five coverages, are three coverages that are used in creating a final map product.

FRAME	Contains map information (legend, title, neat line) that remains unchanged from map to map.
FRAME_8x11	Contains map information (legend ,title, neat line) for the page (8.5x11") size map.
INDEX_FRAME	Contains map information (legend, title, neat line) for the index map.

Several support files are used in addition to the coverages:

IEP.SHD	Contains customized shade patterns 30, 42, 66 and 67 which are required to reduce the plot file size and plotting time of the large 1:2,400 scale overlay maps.
LEGEND.SHADE	Data file used to generate the shading patterns in the legend.
LEGEND.LINE	Data file used to generate the line patterns in the legend.
WET.INF	An INFO file that contains criterion description for each mitigation/bank site.

DESCRIPTION OF EACH COVERAGE

WET Wetland, Open Water and Mitigation sites

DESCRIPTION
Polygons define areas that are either wetland, open water or a mitigation site. The "world" polygon (the area outside of enclosed polygons) represents either upland or un-mapped areas. The PAT of WET contains the necessary information to determine what and where a particular polygon is. An additional INFO file has been created called WET.INF which contains further information on each mitigation/bank site. This INFO file can be related to the PAT using the item LABEL which both files have in common.

SOURCE OF DATA
Wetland/Tideland orthophoto maps

ORIGINAL SCALE OF INPUT DATA
1:2,400

CONTACT PERSON FOR INFORMATION ON THE DATASET
Stan Humphries, IEP, Inc., (617) 888-3900

CONTACT PERSON FOR INFORMATION ON DATA INPUT
Timothy Fast, IEP, Inc., (617) 393-8558

TOPOLOGY
Polygon

PAT STRUCTURE

Item	Size	Type	Description
Cover	3	Integer	Identifies the land cover of each polygon where: 1-99 = mitigation and/or bank site 100 = open water 200 = wetland 0 = upland (the world polygon is also upland
Label	4	Character	Labels for each mitigation/bank site
Mitigate	1	Integer	Identifies the type of site where: 1 = mitigation site 2 = bank site 3 = mitigation & bank site

AAT STRUCTURE
None

WET.INF STRUCTURE

Item	Size	Type	Description
Label	4	Character	Labels for each mitigation/bank site
County	20	Character	Name of the county site is located in
Sheet	8	Character	Lower left coordinate of wetland/ tideland map of the site as it appears in the Environmental Information Inventory
Map	30	Character	Name of the wetland/tideland map
Quad	30	Character	Name of the quadrangle sheet
Acres	5	Numeric	Area of site in acres
Type	20	Character	Adjacent wetland type
Feasibility	50	Character	Creation feasibility
Cost	7	Integer	Acquisition cost
Owner#	2	Integer	Number of owners
Historic	5	Numeric	Percentage of historic losses/county
Access	10	Character	Access to the site

ANNOTATION

Water bodies are annotated where such information was available for each map. Each map contained its own annotation level to ensure proper clipping. There are 40 annotation levels.

CAFRA CAFRA boundary

DESCRIPTION
CAFRA contains arcs that define the CAFRA boundary as delineated on 1:24,000 USGS quadrangle maps. The alignment of the boundary on the USGS maps was checked against the legal description in The New Jersey Coastal Area Facility Review Act, Chapter 185.

SOURCE OF DATA
USGS quadrangle maps with information compiled by New Jersey DEP and The New Jersey Coastal Area Facility Review Act, Chapter 185.

ORIGINAL SCALE OF INPUT DATA
1:24,000

CONTACT PERSON FOR INFORMATION ON THE DATASET
Lester Garvin, IEP, Inc., (617) 393-8558
Nancy Palmstrom, IEP, Inc., (617) 393-8558

CONTACT PERSON FOR INFORMATION ON DATA INPUT
Timothy Fast, IEP, Inc., (617) 393-8558

TOPOLOGY
Polygon and Line

PAT STRUCTURE
None

AAT STRUCTURE
None

ANNOTATION
None

ROADS Road Network

DESCRIPTION
Arcs represent all major roads (primary and secondary) within each mapped area. In addition, smaller roads, both paved and unpaved, that lead to or pass very close to a mitigation/bank site are also mapped. Roads are annotated when such information was available. The centerline of the road was digitized.

SOURCE OF DATA
Wetland/Tideland orthophoto maps

ORIGINAL SCALE OF INPUT DATA
1:2,400

CONTACT PERSON FOR INFORMATION ON THE DATASET
Timothy Fast, IEP, Inc., (617) 393-8558

CONTACT PERSON FOR INFORMATION ON DATA INPUT
Timothy Fast, IEP, Inc., (617) 393-8558

TOPOLOGY
Polygon & Line

PAT STRUCTURE
None

AAT STRUCTURE
None

ANNOTATION
Roads are annotated where such information was available for each map. Each map contained its own annotation level to ensure proper clipping. There are 20 annotation levels.

QUADS Outline of the 86 USGS quadrangle maps that make up the study area.

DESCRIPTION
Polygons define the boundaries of each of the 86 quadrangle maps that encompass the study area.

SOURCE OF DATA
Original coverage was digitized by the New Jersey DEP. The original coverage contained all quadrangles that encompass New Jersey. Selected quads were removed by IEP

ORIGINAL SCALE OF INPUT DATA
Contact New Jersey DEP

CONTACT PERSON FOR INFORMATION ON THE DATASET
New Jersey DEP (609) 984-2243

CONTACT PERSON FOR INFORMATION ON DATA INPUT
New Jersey DEP (609) 984-2243
Timothy Fast, IEP, Inc., (617) 393-8558

TOPOLOGY
Polygon

PAT STRUCTURE

Item	Size	Type	Description
Quad-Code	3	Integer	Equal to the number assigned to the quadrangle by the master index map in the Environmental Information Inventory

AAT STRUCTURE
None

ANNOTATION
Each quad is annotated with its name oriented at 45 degrees.

GRID Outline of the wetland/tideland maps that make up the study area.

DESCRIPTION
Polygons define the boundaries of each of the wetland/tideland maps that encompass the study area.

SOURCE OF DATA
Since each map is exactly 6,000 by 8,000 feet, a grid was constructed using the GENERATE command in ARC/INFO. The grid was oriented using the corner coordinates of two maps. The grid was further edited to depict only those maps that fall within the study area.

ORIGINAL SCALE OF INPUT DATA
None, generated by ARC/INFO

CONTACT PERSON FOR INFORMATION ON THE DATASET
Timothy Fast, IEP, Inc., (617) 393-8558

CONTACT PERSON FOR INFORMATION ON DATA INPUT
Timothy Fast, IEP, Inc., (617) 393-8558

TOPOLOGY
Polygon

PAT STRUCTURE

ITEM	SIZE	TYPE	DESCRIPTION
SITE	1	Integer	0 = Map not Digitized 1 = Digitized Map

AAT STRUCTURE
None

ANNOTATION
State plane Northing and Eastings have been annotated along the perimeter of the map outlines. Only coordinates with round numbers (ie: 190, 2460, etc.) have been annotated.

TIC FILE AND FUTURE EXPANSION OF THE DATABASE

For each coverage (except FRAME and INDEX_FRAME) TICS are located in one of two locations. A TIC can be found at every corner of a quadrangle sheet. A TIC is also located at every corner of a wetland/tideland map that has been mapped.

The numbering system for the TICS has been laid out so that if more wetland/tideland maps need to be digitized at a future date, their TICS can be logically added to fit it with the current numbering scheme. The TICS that are located at the corner of each quadrangle map are numbered from 1-140. The numbering starts at the northwestern corner of the northwestern most quad (Paterson) and runs west to east and north to south finishing at the southeastern corner of the southeastern most quad (Wildwood).

The numbering of the TICS that are located at the corner of the mapped wetland/tideland maps is similar to that of the quads. Because of the great number of TICs required to identify every corner of each wetland/tideland map, TICs were added only for those maps that were digitized. However, the TICs are numbered as if all corners of every map had a number assigned to them. The numbering for the TICs associated with wetland/tideland map corners starts at 1,000 and ends with 3,062. This TIC numbering system was adopted to allow more wetland/tideland maps to be digitized at a future date. Since every corner has a number associated with it, TICs that are added to define the new map can be assigned numbers that fall in a logical sequence.

CREATING OUTPUT PLOTS AT 1:2,400

A CPL has been created for each wetland/tideland map that has been digitized. Plot files are typically large and thus having a CPL that contains ARCPLOT commands to generate a plot file results in a far more efficient use of disk space. To generate a final plot from the CPL two steps are needed.

The first step in producing a final plot is to run the CPL. Each CPL is named after the map it depicts (in a shortened form). To run the CPL simply type:

R FILENAME.CPL

After the CPL has run, an intermediate plot file is generated with the name:

FILENAME.NRT

Where .NRT stands for Non-RoTated file. ARC plots files sideways on the plotter. At 1:2,400 the plot is too large for the plotter in the normal ARC orientation. Therefore the intermediate plot file must be rotated 90 degrees. This is done with the ROTATEPLOT command.

ROTATEPLOT FILENAME.NRT FILENAME.PLT

The resulting PLT file is now ready to be sent to the plotter.

The proper pen sequence for the plotter is:

Pen 1 = Black
Pen 2 = Red
Pen 3 = Green
Pen 4 = Blue

Note that the CAFRA boundry only occurs on a single map, Chingarora Creek. To save on processing time, the commands to generate the CAFRA boundary have been omitted from all CPLs except for CHINGA.CPL.

A CPL has also been created to generate an index map of those wetland/tideland maps that have been digitized. The Index plot does not need to be rotated. It can be generated simply by typing:

R INDEX

CREATING OUTPUT PLOTS AT 1:14,400 (Page Size)

A CPL has been created for each wetland/tideland map that has been digitized.

Page size output can only be produced at a Tektronix terminal that is directly connected to a color printer. The first step in producing a page size map is to run the CPL. Each CPL is named after the map it depicts (in a shortened form) plus "_8x11" to differentiate the CPL from the larger format CPL. To run the CPL simply type:

R FILENAME_8X11.CPL

After the CPL has run, a plot file is generated with the name:

FILENAME_8X11.PLT

Once the plot file has been generated draw it on the terminal screen using the following command:

DRAW FILENAME_8X11.PLT XXXX

Where XXXX is the Tektronix terminal model that you are drawing the image on. To output the plot simply press the <HARD COPY> key on the terminal to output the image to the color printer.

GENERATING FUTURE CPLS AND CUSTOMIZATION

All of the CPLs used to generate the Plot files utilize a basic format that can easily be copied to create similar plots for wetland/tideland maps that may be digitized in the future (see listings 1 and 2).

To create a new CPL the following items must be changed:
Line 7: Enter the plot file with an .NRT extension.
Line 30: Enter the wetland/tideland map title.
Line 36: Enter the quadrangle name that the map is located in.
Line 38: Enter the northing and easting coordinate as it appears in the Environmental information Inventory.
Line 45: Enter the lower left and upper right northings and eastings of the wetland/tideland map.
Line 61: Enter the annolevel (if any) of the water bodies for the map.
Line 64: Enter the annolevel (if any) of the roads for the map.

The final plots are 32 by 40 inches. Because of their large size, several items relating to each plot file have been customized and would have to be included in any additional plot files that may be generated at this scale. The first relates to the rotation and clipping of the plot file. As stated earlier, the plots must be rotated 90 degrees before plotting in order for the entire plot to fit on a "D" size plotter (Calcomp 1040 series). In addition, a special clipping instruction must be added to the DISPLAY command in ARCPLOT. Instead of using DISPLAY 1039 to generate a plot file, use:

(Line 3) DISPLAY 1039 5

This prevents ARC from clipping the top portion of the plot. Be aware that an axis crash will occur on the plotter if the plot is not rotated and the DISPLAY 1039 5 command is used. Be sure to rotate the plot.

The second customized addition is the use of the file IEP.SHD for the SHADESET command (Line 10). All of the fill patterns called by ARCPLOT (patterns 30, 42, 66 and 67) have the distances between hatch lines increased. This yields a far smaller plot file size by decreasing the number of hatch lines in each shaded polygon. In addition, plotting time is decreased.

The final customized addition appears on the plot itself. A small "L" shaped line appears on the lower left corner of the sheet. Do not remove this line from the coverage FRAME. The line defines the limit of annotation beyond the neat line of the map. Without it, ARC will clip all of the annotation that falls outside of the neat line (map title, legend, etc.).

To create a new CPL for an 8.5x11" format the following items must be changed:

Line 7: Enter the plot file with "_8X11" added to the filename and a .PLT extension.

Line 26: Enter the wetland/tideland map title.

Line 32: Enter the quadrangle name that the map is located in.

Line 34: Enter the northing and easting coordinate as it appears in the Environmental information Inventory.

Line 41: Enter the lower left and upper right northings and eastings of the wetland/tideland map.

Line 59: Enter the annolevel (if any) of the water bodies for the map.

Line 62: Enter the annolevel (if any) of the roads for the map

Table 1: Site Numbers and Annolevels for each Wetland/Tideland map Digitized

Map Name	CPL Name	Site Number	Wet Annolevel	Roads Annolevel	CAFRA
Alloway Creek West	ALLOWY	35	31	-	-
Artificial Island	ARTIFL	34/35	32	-	-
Barley Point	BARLEY	5	5	4	-
Beach Thorofare South	BEACH	19	18	11	-
Bidwell Ditch West	BIDWELL	27	26	-	-
Cedar Bonnet	CEDRBN	13	12	-	-
Chingarora Creek	CHINGA	3	3	3	Yes
Comptons Creek	COMPT	4	4	-	-
Dyer Creek	DYER	28	30	18	-
Eastern Cross Creek	ECRCK	32	-	-	-
Great Egg Harbor Inlet West	EGGHAR	21	20	13	-
Flat Creek	FLAT	22	21	-	-
Green Creek	GREEN	26	25	-	-
Great Thorofare	GRTHOR	18/19	17	10	-
Havens Cove	HAVENS	10	8	-	-
Hay Gut	HAYGUT	30	29	17	-
Hope Creek West	HOPE	33	33	-	-
Jesses Creek	JESSES	14	13	6	-
Jonathan Thorofare	JONATH	16	15	8	-
Kelly Point	KELPT	39	36	20	-
Little Bay	LITBAY	17	16	9	-
Ludlam Thorofare	LUDLAM	23	22	-	-
Maple Creek	MAPLE	11	10	-	-
Matawan Creek	MATAWN	2	2	2	-
Metedeconk River East	METEDK	9	7	5	-
Maple Creek East	MPLEST	11	9	-	-
Mud Hen Gut	MUDHGT	25	24	13	-
Nantuxent Creek	NANTUX	31	27	16	-
Oldmans Creek East	OLDEST	42	39	19	-
Oldmans Creek	OLDMAN	42	39	-	-
Oldmans Point	OLDMPT	41	38	-	-
Oyster Creek East	OYSTER	12	11	-	-
Ponds Creek	PONDS	27	28	-	-
Raritan Bay West	RARITN	1	1	1	-
Sea Bright	SEABRT	6	6	-	-
Sod Thorofare	SODTHF	20	19	12	-
Stites Sound West	STITES	24	23	14	-
Stony Point	STONY	33	35	-	-
Stony Point West	STONYW	33	34	-	-
Westecunk Creek East	WCUNK	15	14	7	-
Whooping John Creek	WHOOP	40	37	-	-

Listing 1: CPL used to generate a .NRT plot file

```
&DATA ARC
ARCPLOT
DISPLAY 1039 5
/*
/* Enter Plot Name
/*
COMPT.NRT
SYMBOLSET PLOTTER
SHADESET IEP.SHD
MAPEX FRAME
MAPSCALE 1
LINESYMBOL 13
ARCS FRAME
LINESYMBOL 1
ANNOTEXT FRAME
TEXTSYMBOL 41
TEXTSIZE .24
KEYBOX .5 .4
MOVE 8.2 5.35
KEYSHADE LEGEND.SHADE
MOVE 8.2 2.75
KEYLINE LEGEND.LINE
MOVE 2.2 5
TEXTFONT 5
TEXTSIZE .25
/*
/* Enter Map Name
/*
TEXT 'COMPTONS CREEK'
/*
MOVE 2.2 4.5
/*
/* Enter Quad Name
/*
TEXT 'SANDY HOOK'
MOVE 2.2 4
TEXT '581-2160'
MAPPOS LL 3.00 7.2
MAPEX WET
MAPUNITS FEET
/*
/* Enter the LL and UR Map Coordinates
/*
MAPEXTENT 1752000 238000 1758000 245000
MAPSCALE 2400
LINEC 1
ARCS WET
RESEL WET POLYS COVER = 200
```

```
POLYGONSHADES WET 67
ASELECT WET POLYS
RESEL WET POLYS MITIGATE = 1
POLYGONSHADES WET 42
ASELECT WET POLYS
RESEL WET POLYS MITIGATE = 2
POLYGONSHADES WET 30
ASELECT WET POLYS
RESEL WET POLYS MITIGATE = 3
POLYGONSHADES WET 66
ASELECT WET POLYS
ANNOTEXT WET 4
LINESYMBOL 10
ARCS ROADS
ANNOTEXT ROADS 44
TEXTSIZE .75
RESEL WET POLYS MITIGATE > 0
POLYGONTEXT WET LABEL
LINESYMBOL 20
ARCS CAFRA
Q
Q
&TTY
&END
```

Listing 2: CPL used to generate an 8.5x11" plot file

```
&DATA ARC
ARCPLOT
DISPLAY 1039
/*
/* Enter Plot Name
/*
COMPT_8X11.PLT
SYMBOLSET PLOTTER
MAPEX FRAME_8X11
MAPSCALE 1
LINESYMBOL 1
ANNOTEXT FRAME_8X11
TEXTSYMBOL 93
TEXTSIZE .15
KEYBOX .5625 .435
MOVE 6.9 3.35
KEYSHADE LEGEND.SHADE
MOVE 6.9 1.475
KEYLINE LEGEND.LINE
MOVE 6.7 4.65
TEXTFONT 5
TEXTSIZE .2
/*
/* Enter Map Name
/*
TEXT 'COMPTONS CREEK'
/*
MOVE 6.7 4.35
/*
/* Enter Quad Name
/*
TEXT 'SANDY HOOK'
MOVE 6.7 4.05
TEXT '581-2160'
MAPPOS LL 1.512 1.208
MAPEX WET
MAPUNITS FEET
/*
/* Enter the LL and UR Map Coordinates
/*
MAPEXTENT 1752000 238000 1758000 245000
MAPSCALE 14400
LINEC 1
RESEL WET POLYS COVER = 200
POLYGONSHADES WET 71
ASELECT WET POLYS
RESEL WET POLYS COVER = 100
POLYGONSHADES WET 16
```

```
ASEL WET POLYS
RESEL WET POLYS MITIGATE = 1
POLYGONSHADES WET 46
ASELECT WET POLYS
RESEL WET POLYS MITIGATE = 2
POLYGONSHADES WET 34
ASELECT WET POLYS
RESEL WET POLYS MITIGATE = 3
POLYGONSHADES WET 70
ASELECT WET POLYS
ANNOTEXT WET 4
LINESYMBOL 10
ARCS ROADS
ANNOTEXT ROADS 44
TEXTSIZE .15
RESEL WET POLYS MITIGATE > 0
POLYGONTEXT WET LABEL
LINESYMBOL 20
ARCS CAFRA
LINESYMBOL 1
ARCS WET
MAPEX FRAME_8X11
MAPSCALE 1
MAPUNITS INCHES
MAPPOSITION LL 0 0
LINESYMBOL 13
ARCS FRAME_8X11
Q
Q
&TTY
&END
```

Listing 3: CPL used to generate INDEX.PLT

```
&DATA ARC
ARCPLOT
DISPLAY 1039
INDEX.PLT
SYMBOLSET PLOTTER
MAPEX INDEX_FRAME
MAPSCALE 1
ARCS INDEX_FRAME
RESEL INDEX_FRAME POLYS INDEX_FRAME-ID = 4
POLYGONSHADES INDEX_FRAME POLYS
ANNOTEXT INDEX_FRAME
MAPPOS LL 2 .5
MAPEX QUADS
MAPUNITS FEET
MAPSCALE 300000
LINEC 2
ARCS QUADS
ANNOTEXT QUADS
LINEC 3
ARCS GRID
RESEL GRID POLY SITE = 1
POLYGONSHADES GRID 2
ASEL GRID POLY
ANNOTEXT GRID
Q
&TTY
&END
```

APPENDIX E

Summary of Resource Data
For Coastal Wetland Mitigation

I. The following is a summary of resource data available for analysis at the Division of Coastal Resources, NJDEP, Trenton, NJ:

A. National Wetland Inventory Maps

a) 1972 b/w (PAN) photomaps labelled with vegetation species (1:2400 and keyed to USGS topomaps)

i) 1981 overlays indicating upper wetland boundaries and subsequent revisions (1983, 1986) of the 1972 maps to include the 1981 information

ii) property line overlays prepared from local tax maps and tax records; keyed to a master list

b) 1:24,000 maps covering USGS topo sheet quads detailing wetlands after Cowardin et al., 1977

c) ongoing work making new 1:2,400 photomaps of 1977 photos indicating areas now or formerly below high water: overlays

B. 1986 Photoquads

transparent b/w (PAN) photoquads at 1:24,000 of USGS topo sheets

C. Cape May County (Cape May point to Great Egg Harbor Inlet)

1:48,000 map with vegetation, soils, use, wildlife, and fish

D. Atlantic County land-use overlays

1:63,360 overlays of urban, agricultural, and natural land use

E. Submerged Aquatic Vegetation (1979)

1:24,000 photomaps with submerged aquatic vegetation distribution and percent coverage mapped and species identified

F. Pinelands (1979-1981)

1:24,000 topo quads with vegetation and soils mapped

G. Soils Maps

a) variety of 1:20,000 and 1:15,840 soils maps with aerial photo transparencies

b) land capability/use photomaps compiled by the Soil Conservation Service of the USDA 1948-1953: indicate soils and use at 1:15,840

H. Historical Maps

various topo sheets from 1880-1883 original surveys to revisions up to 1972 at 1:63,360

I. Aerial Photos

1985, Hackensack Meadowlands, 1:2,400

1977, Atlantic County, 1:6,000 and 1:12,000

1930, state wide, 1:12,000

1986, state wide, color IR, 1:58,000

II. Additional resource data relevant to New Jersey Wetlands:

A. Wetlands Maps

1) National Wetlands Inventory Maps (1977-83)

Agency: US Fish and Wildlife Service

Wetlands Mapped: coastal and inland

Comments: two series of wetlands maps, 1:100,000 and 1:24,000; large-scale maps (1:24,000) combine NWI wetland data with USGS topographic maps; minimum mapping unit = 1-3 acres; small-scale maps (1:100,000) cover 32 1:24,000 USGS quads

Availability: Maps and Publications
Bureau of Collections and Licensing
CN-402
Trenton, NJ 08625
(609) 292-2578

order by name on USGS index
$2.00 per map

2) Wetland Vegetation Maps (1980)

Agency: NJ Pinelands Commission

Wetlands Mapped: coastal and inland within Pinelands

Comments: 1:24,000 maps showing wetland types; minimum mapping unit = 2 acres

3) Tidelands (1979-ongoing)

Agency: NJ DEP Office of Environmental Analysis

Wetlands Mapped: all lands now or formerly flowed by the tides at or below mean high water

Comments: 1:2,400 maps; current and former tidelands that are state-owned unless the Tidelands Resource Council has granted or sold them

4) <u>Submerged Vegetation (1979)</u>

Agency: NJ DEP Division of Coastal Resources

Wetlands Mapped: coastal submerged aquatic beds

Comments: 1:24,000 maps showing submerged vegetation species

5) <u>Hackensack Wetlands (1975)</u>

Agency: Hackensack Meadowlands Development Commission

Wetlands Mapped: Hackensack coastal wetlands

Comments: generalized map of wetland biozones showing mudflat, low and high salt marsh, diked and mixed marsh

6) <u>Marsh Loss (1973)</u>

Agency: NJ DEP Division of Fish, Game, and Shellfisheries

Wetlands Mapped: coastal wetlands

Comments: study reporting 24% coastal wetlands loss in 20 years (1953-73)

7) <u>Inland Wetlands (1973)</u>

Agency: NJ State Museum

Wetlands Mapped: inland wetlands of the Pine Barrens

Comments: 1:24,000 vegetation and land use maps showing wetland types; min. mapping unit = 20 acres

8) <u>Wetlands (Delaware Bay) (1973)</u>

Agency: Rutgers, Univ. of DE, and Philadelphia Academy of Natural Sciences

Wetlands Mapped: coastal wetlands in Delaware Estuary

Comments: 1:24,000 wetlands maps; min. mapping unit = 0.5 acres

9) NJ Wetlands Act Maps (1972)

Agency: NJ DEP

Wetlands Mapped: coastal wetlands

Comments: 1:2,400 wetlands maps surveyed for NJ Wetlands Act of 1970; min. mapping unit = 1-5 acres

10) Hackensack Wetlands (1972)

Agency: NJ DEP

Wetlands Mapped: Hackensack wetlands

Comments: identified 6870 acres of wetlands; categorized according to ecological value

11) Coastal Wetlands (1954, 1959, 1965)

Agency: US Fish and Wildlife Service

Wetlands Mapped: coastal (1954 survey included inland)

Comments: noted marsh loss during intervening years; 1954 survey concerned with wetlands important to waterfowl only

B. AERIAL PHOTOGRAPHS

1) Aerial photography available from ASCS (Agricultural Stabilization and Conservation Service) of the Dept. of Agriculture:

NJ coverage consists of b/w panchromatic film flown at 1:20,000 and 1:40,000; enlargements available at various scales

NJ flights made in 1940, 1947, 1956, 1957, 1963, 1970, 1971, 1972, 1978, 1979

check with local, county ASCS offices for specific photo coverage

OEA AERIAL PHOTO LIBRARY

This is a listing of our most useful photography

1932-36 PAN - National Ocean Service

covers coastal area of the state

1940 PAN - Aero Service Corp.

covers most of the state

1947 PAN - Defense Intelligence Agency

covers coastal area of the state, Toms River to Trenton. There are gaps.

1947 PAN - US Dept. of Agriculture

Monmouth, Middlesex, Mercer Counties

1951 PAN - Aero Service Corp.

covers most of the state

1953-54 - Petroleum Information Service

sporadic coastal coverage

1956-57 - US Dept. of Agriculture

coastal coverage excluding Ocean County

1958 - Aero Service Corp.

Ocean County coastal area

1961 - Aero Service Corp.

covers most of the state

1971-72 IRC, COL - Mark Hurd Corp.

coastal wetlands mapping photos.

1972 IRC - Mark Hurd Corp.

quad centered high altitude photos covering the entire state

order from: US Dept. of Agriculture
ASCS
Aerial Photography Field Office (APFO)
2222 West, 2300 South
P. O. Box 30010
Salt Lake City, Utah 84130
(801) 524-5856

photos from 1941 and earlier should be ordered from:

National Archives and Records Service
Cartographic Archives Division
General Services Administration
Washington, DC 20408

2) Aerial photos available from the National Ocean Survey (NOS)

a) Photo index available from:

US Dept. of Commerce
National Oceanic and Atmospheric Administration (NOAA)
NOS
Charting and Geodetic Services
Rockville, Maryland 20852

request NJ index number 132-J (Northern NJ) and 133-C-D (Southern NJ)

b) scales range 1:10,000 to 1:40,000 b/w and color positive and b/w infrared

specific inquiries:

Photographic Branch
Nautical Charting Division
NOS/NOAA
Rockville, Maryland 20852
(301) 443-8601

3) The following aerial photographs are available for use from:

NJ DEP
Office of Environmental Analysis (OEA)
CN 410
Trenton, NJ 08625
(609) 292-8206

1973 IRC - Mark Hurd Corp.

coastal area coverage of NJ CAFRA Zone

1977 IRC - Mark Hurd Corp.

Pinelands area coverage

1977-78 IRC, COL - Mark Hurd Corp.

Tidelands mapping photography

1979 COL - Keystone Aerial Survey

winter coverage of the coastal area from Manasquan to Trenton

1983 IRC - NASA

U-2 panoramic coverage of entire state

1986 IRC, PAN - Mark Hurd Corp.

quad centered high altitude photos covering the entire state

(List supplied by Office of Environmental Analysis, Department of Environmental Protection)

C. HISTORICAL MAPS

The NJ Map Collection of the Dept. of Special Collections and Archives at Rutgers - New Brunswick consists of 1,690 maps dating back to 1677. An index and guide to this collection has just been published and includes listing under "marshes".

D. OTHER

1) Topographic Maps

Agency: USGS

Comments: 1:24,000 maps (7.5 minute quadrangles)

Availability: order from:

Eastern Distribution Branch
USGS
1200 South Eads Street
Arlington, VA 22202

State index free on request

Information also available from:

National Cartographic Information Center (NCIC)
Eastern Mapping Center
USGS
536 National Center
Reston, VA 22092
(703) 860-6336

2) Nautical Charts

Agency: NOAA and NOS

Comments: 1:40,000 and 1:80,000

Availability: Order from:

Distribution Division
(OA/C44)
National Ocean Survey
Riverdale, Maryland 20737
(301) 436-6990

APPENDIX F

Examples of MOAs and MOUs

MEMORANDUM OF UNDERSTANDING
AMONG
THE BOARD OF HARBOR COMMISSIONERS OF THE CITY OF LONG BEACH,
THE CALIFORNIA DEPARTMENT OF FISH AND GAME,
THE NATIONAL MARINE FISHERIES SERVICE, AND
THE FISH AND WILDLIFE SERVICE,
TO
ESTABLISH A PROCEDURE FOR COMPENSATION
OF MARINE HABITAT LOSSES
INCURRED BY PORT DEVELOPMENT LANDFILLS
WITHIN THE HARBOR DISTRICT OF THE CITY OF LONG BEACH,
BY MARINE HABITAT CREATION AT ANAHEIM BAY.

THIS MEMORANDUM OF UNDERSTANDING (MOU) is entered into by the UNITED STATES OF AMERICA, acting by and through the FISH AND WILDLIFE SERVICE, UNITED STATES DEPARTMENT OF THE INTERIOR, ("FWS"), and the NATIONAL MARINE FISHERIES SERVICE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, UNITED STATES DEPARTMENT OF COMMERCE, ("NMFS"), and the STATE OF CALIFORNIA, acting by and through the DEPARTMENT OF FISH AND GAME, RESOURCES AGENCY, ("CDFG"), and the CITY OF LONG BEACH, acting by and through its BOARD OF HARBOR COMMISSIONERS, ("BOARD").

WHEREAS, the BOARD is mandated to foster the orderly and necessary development of the Port of Long Beach, including the creation of new land in the Harbor District of the City of Long Beach ("Harbor District") by landfill; and

WHEREAS, the FWS has as its primary mandate, in this matter, the conservation, protection, and enhancement of marine fish and migratory birds and their habitats, including the planning of biological loss avoidance, minimization, and compensation; the CDFG has as its primary mandate, in this matter, the conservation, protection, and enhancement of marine fish and migratory birds and their habitats, including the prevention of project-caused losses to fish and wildlife resources; and the NMFS has as its primary mandate, the conservation, protection, and enhancement of marine fisheries resources, including the planning of biological loss avoidance, minimization, and compensation; and

WHEREAS, port development landfills are subject to State regulation pursuant to the California Coastal Act and the California Environmental Quality Act (CEQA) and Federal regulation pursuant to the River and Harbor Act and Clean Water Act and the National Environmental Polict Act (NEPA); and

WHEREAS, the BOARD contemplates an imminent harbor development within the Harbor District, consisting of a landfill at Pier J, totaling approximately 135 acres; and

WHEREAS, the contemplated Harbor District landfill is expected to be necessary and a water-dependent port improvement, and the minimum landfill to fulfill the purpose; and

WHEREAS, the contemplated Harbor District landfill will eliminate marine habitat value that FWS, CDFG, and NMFS want to be replaced; and

WHEREAS, delay in implementing port developments and their mitigation serves no public interest and the parties would like to facilitate permit processing for the contemplated landfill, which would permanently eliminate marine habitat, by providing habitat loss compensation for the impacts on the marine environment in advance of or concurrently with the habitat losses predicted for the contemplated landfill; and

WHEREAS, the parties concur that creation of appropriate fish and wildlife habitat values in advance of or concurrently with the loss would require an accounting procedure whereby habitat losses which will be incurred by specified landfill developments in the Harbor District could be charged against the habitat credits; and

WHEREAS, the parties concur that creation of new habitat value within the Harbor District to offset habitat losses within the Harbor District could render some other future, necessary harbor developments more difficult; and

WHEREAS, shallow, estuarine coastal embayment habitat in Southern California, with its relatively high value to marine fishes and migratory birds, has been reduced in area at a greater rate than that of deep water habitat, NMFS, CDFG, and FWS judge that compensation for adverse project impacts upon the marine ecosystem should emphasize the creation of shallow water, coastal embayment habitat;

NOW, THEREFORE, IT IS AGREED THAT:

1. The habitat evaluation reported in Exhibit "A", attached hereto and by this reference made a part hereof, has established the fish and wildlife habitat value losses to result from the 135-acre Pier J landfill construction (measured at +4.8 feet Mean Lower Low Water, MLLW) and the fish and wildlife habitat value gains to result from the coastal embayment creation at Anaheim Bay. No net loss of habitat values shall occur.

2. The BOARD, at its cost, shall restore tidal influence to three specified areas in Anaheim Bay, along the northern and northeastern regions of the FWS Seal Beach National Wildlife Refuge ("SBNWR"), located within the Seal Beach Naval Weapons Station, County of Orange, California, as shown as Area A, Area B, and Area C on Exhibit "B", attached hereto and by this reference made a part hereof.

3. The BOARD'S work conducted in Areas A, B, and C of Exhibit "B" will restore to tidal influence, wetland areas of approximately 20, 50, and 50 acres, respectively. The perimeter boundary of each site will be the contour line at +2.5 feet MLLW. Restoration work within this boundary of each site will result in not less than 50 percent of the area being excavated to an average elevation of -3.0 feet MLLW, not more than 15 percent of the area will remain as islands with elevations between +2.5 and +5.5 feet MLLW, and not more than 35 percent of the area will form slopes within +2.5 feet and -3.0 feet MLLW, between the

islands and deeper portions of each site. In addition, not less than 6 mounds, with a base diameter of about 10 feet and a height of about +8.5 feet MLLW shall be constructed on each of the islands. Culverts will be constructed under existing roadbeds to provide permanent unimpeded flushing of each parcel by tidal waters. Exhibits "C", "D", and "E", attached hereto and by this reference made a part hereof, depict the tidal elevation contours and culvert locations and dimensions for each area.

4. The BOARD shall be responsible for all aspects of the restoration work including sediment sampling, appropriate archeologic survey, environmental documentation (CEQA and NEPA) acquisition of permits and contractor selection and supervision. The FWS, the NMFS, and the CDFG agree to cooperate with and assist the BOARD, procedurally, with the acquisition of permits or approvals for the restoration work and for an appropriate dredge spoil disposal site.

5. All restoration work performed by the BOARD at SBNWR pursuant to this MOU will be conducted in accordance with a FWS Refuge Use Permit and with the approval of the Commander, U.S. Navy, Seal Beach Naval Weapons Station, subject to a U. S. Navy Siting Approval.

6. The BOARD agrees that its work will be scheduled and conducted so as not to incur significant habitat loss or degradation elsewhere within the SBNWR and so as not to adversely

impact any State or Federal endangered species which utilizes the SBNWR, including the California Least Tern, the Light-footed Clapper Rail, California Brown Pelican, Belding's Savannah Sparrow, or Salt Marsh Bird's Beak.

7. Construction of the Pier J landfill, including the rock containment dike and its associated activities, may not begin before construction of the SBNWR restoration site has begun. However, should the BOARD decide to use the fill excavated from the restoration site to provide partial fill at the Pier J site, construction of the first phase of the rock containment dike may precede the start of wetland restoration. The completion of the SBNWR restoration work, as certified below, shall be on the same date or prior to the date which the BOARD accepts as completed the fill phase of the Pier J landfill thereby authorizing the final payment of the fill contract, and shall precede any surface improvement work on the fill. The SBNWR restoration work shall be inspected and certified complete and consistent with the conditions of this MOU, by the Director of Engineering, Design and Development of the Harbor Department of the City of Long Beach and the FWS, and approved by the directorate of CDFG and NMFS.

8. In order to offset the predicted fish and migratory bird habitat value loss of the 135-acre Pier J landfill (measured at +4.8 feet MLLW), not less than 102.5 acres shall be restored in Anaheim Bay (see Exhibit "A") in accordance with paragraphs 2 through 7 above and Exhibits "B" through "E", inclusive.

9. The BOARD, at its option and with the approval of the FWS, may restore more than the required 102.5 acres within Areas A, B, and C, which would create additional excess habitat units, in accordance with the values set forth in Exhibit A. These excess habitat value units would be credited to the BOARD and will be based upon the actual additional acreage restored, as determined by a final as-built survey.

10. Excess habitat value units (those habitat value units not required to offset the impacts of the Pier J Landfill) may be used, with the approval of all parties, to offset fish and migratory bird habitat losses calculated in accordance with Exhibit A, which may result from other port development landfill projects proposed by the BOARD within the Harbor District that are shown to be necessary, the minimum possible, and water dependent and port related. Such approval shall be indicated in an official and public manner, during completion of the environmental review process required under the California Environmental Quality Act, National Environmental Policy Act, and/or the regulatory process required under the California Coastal Act, the River and Harbor Act, or the Clean Water Act.

11. The BOARD may be allowed to transfer excess habitat value units to other Port Districts in the Southern California Bight that are applicants for a Corps of Engineers permit or California Coastal Act permit or Master Plan Amendment after such district has consulted with FWS, CDFG, and NMFS and obtained a written approval for the use of those units from each agency. The habitat value units thus transferred may only be used to

compensate for fish and wildlife losses incurred as a result of port district projects. Responsibility for habitat value assessment and tradeoff analysis rests with FWS, CDFG, NMFS. Such approval is to be granted in accordance with the applicable policies and guidelines of each agency. Transfer and use of such habitat value units shall not result in the net loss of fish and wildlife values. These habitat value units shall not be used to offset the impacts of any project which fills or otherwise adversely affects wetlands. (Wetlands are defined according to FWS publication FWS/OBS-79/31, Classification of Wetlands and Deepwater habitats of the United States, L. Cowardin, V. Carter, F. Golet, E. LaRoe, Dec. 1979). The BOARD shall notify all parties of this MOU, officially and publicly, in writing of acceptance or rejection of any such proposal to transfer habitat value credits.

12. The BOARD shall have no responsibility for maintenance or monitoring of the SBNWR restored area following completion, since it has been determined by the FWS that, in this case, the operation and maintenance of the restoration sites would not add significantly to the present management costs of the SBNWR.

13. Should the SBNWR restoration work be completed and should the Pier J Landfill not be initiated, all habitat value gains shall be considered excess and may be used in accordance with paragraphs 10 and 11. This MOU shall remain valid until the balance of habitat value credits has been consumed or until rescinded by written consent of all parties.

THIS MEMORANDUM OF UNDERSTANDING SHALL BE IN FULL FORCE AND EFFECT FROM THE DATE WHICH ALL PARTICIPANTS HAVE SIGNIFIED AGREEMENT BY SIGNATURE OF THE DESIGNATED REPRESENTATIVE.

THE CITY OF LONG BEACH, acting by and through its Board of Harbor Commissioners

By: ______________________ 8 Jan 86
James H. McJunkin
Executive Director

Date

THE FISH AND WILDLIFE SERVICE,
U.S. Department of Interior

By: ______________________ 2-12-86
for Richard J. Myshak
Regional Director, Region I

Date

THE DEPARTMENT OF FISH AND GAME,
The Resources Agency of California

By: ______________________ 1-16-86
E. C. Parnell
Director

Date

THE NATIONAL MARINE FISHERIES SERVICE,
NOAA, U.S. Department of Commerce

By: E C Fullerton 1-13-86
E.C. Fullerton
Regional Director

Date

MEMORANDUM OF AGREEMENT

BETWEEN

OREGON DIVISION OF STATE LANDS

OREGON DEPARTMENT OF FISH AND WILDLIFE

OREGON DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT

U.S. FISH AND WILDLIFE SERVICE

NATIONAL MARINE FISHERY SERVICE

U.S. ENVIRONMENTAL PROTECTION AGENCY

AND

U.S. ARMY CORPS OF ENGINEERS

TO

ESTABLISH PROCEDURES AND CREDITS FOR OPERATION OF THE

ASTORIA AIRPORT MITIGATION BANK

This Memorandum of Agreement (MOA) is entered into to establish the interagency operating procedures and credits for operation of the Astoria Airport Mitigation Bank. A more detailed analysis of estuarine benefits of the mitigation bank is contained in the attached "Astoria Airport Mitigation Bank Resource Credit Evaluation" prepared by the Oregon Division of State Lands.

BACKGROUND

The Astoria Airport Mitigation Bank is available for projects that have been approved in the state and federal permitting process and found to be consistent with the Oregon Coastal Zone Management Plan. The mitigation bank will be available to offset impacts of estuarine intertidal and subtidal, water dependent development as specified below. Each eligible project will have been reviewed to eliminate all but unavoidable and necessary losses and all measures will have been taken to minimize or eliminate impacts prior to consideration of mitigation bank use. Prior to use of the mitigation bank, mitigation at the site of the project shall be explored and utilized to the maximum extent practicable. Federal or State requirements to mitigate for unique functions and values not available at the mitigation bank may require action by the development interest on other sites. This agreement does not eliminate the applicant or agencies responsibilities under applicable laws and/or regulations.

UNDERSTANDING

The interagency team that evaluated the Astoria Airport Mitigation Bank identified that there is uncertainty concerning the natural resource trade offs involved in mitigation. It has also been recognized that there has been significant loss of high marsh and tidal swamp in the Youngs Bay estuary. The historical diking has created some freshwater wetlands which provide resource values. Resource values lost or altered by the mitigation action were evaluated utilizing the Division of State Lands relative value system and a modified version of the U.S. Fish and Wildlife Service HEP procedure. The Oregon mitigation policy established in law is to create, restore or enhance estuarine areas to maintain the functional characteristics and processes of Oregon's estuaries. To balance state emphasis on estuarine resources with federal consideration of wetland environments in general, habitat based credit values were established at a .evel less than that developed by applying Oregon's rating alone.

MITIGATION BANK CREDITS

It has been agreed that there are 70.0 credits in the Astoria Airport Mitigation Bank. The Division of State Lands habitat relative value system (OAR 141-85-240 to 141-85-266) shall be utilized in withdrawing credits.

MITIGATION BANK PROPOSAL

The proposed mitigation bank is being constructed on property owned by the Port of Astoria and Oregon Division of State Lands. Approximately 33 acres of diked land will be exposed to tidal inundation by the mitigation action. The title of lands held by the Port of Astoria will be conveyed to the Oregon Division of State Lands upon construction of the mitigation bank. The bank area will be retained by Oregon Division of State Lands in perpetuity for natural resource production purposes.

OPERATIONAL PROVISIONS

It is mutually agreed that:

1. The bank shall be available for projects that require mitigation, are otherwise approvable under Oregon's Removal-Fill Law (ORS 541.605 - 541.695) and Corps of Engineers permit requirements under the authority of Section 10 of the Rivers and Harbors Act of 1899 and/or Section 404 of the Clean Water Act (Public Law 95-217) and have met the impact elimination and reduction requirements. Only projects involving unavoidable and necessary impacts which have been approved under the local comprehensive plan will be eligable for the Astoria Airport Mitigation Bank.

2. The bank shall be available for projects only where on-site mitigation is unavailable or where on-site mitigation only partially mitigates for project impacts.

3. The bank shall be available to all water dependent projects between the tip of Tongue Point and the west bank of the Skipanon River along the Oregon side of the Columbia River estuary.

4. The bank shall be operated according to Oregon Division of State Lands administrative rules for mitigation banks (OAR 141-85-260).

5. The Division of State Lands shall maintain a balance sheet of credits and debits for the mitigation bank. No debits or credits can be applied until all parties to this Agreement concur with the DSL data sheet analysis. Such concurrence, substantiations of the reasons for nonconcurrence or request for additional time to consider the data sheets must be forwarded to the Salem office of the Division of State Lands within 15 working days after receipt of the data sheets. Failure to respond within 15 days shall be deemed to indicate concurrence. Copies of signed transaction data sheets shall be held as a

permanent record by the Division of State Lands. The Division of State Lands shall prepare and provide to all parties, on a calendar year basis, an annual summary of debits and credits to the mitigation bank.

6. The mitigation requirement for proposed projects will be determined by utilization of Oregon Division of State Lands mitigation rules OAR 141-85-240 through 141-85-258.

7. The Division of State Lands will prepare an annual monitoring report and provide copies to the agencies executing this agreement.

8. The Division of State Lands will conduct habitat enhancement actions as necessary to achieve estuarine resource benefits.

9. It is recognized that the Astoria Airport Mitigation Bank is a pilot program. After five (5) years, the Division of State Lands will convene an interagency review of the site and conduct a complete evaluation of the mitigation bank using HEP, or a mutually agreeable and credible methodology. Whenever significant operational and/or structural changes are made to improve success, another complete evaluation should be made in three (3) to five (5) years following those changes.

10. Modification to this Agreement can be proposed at any time, but shall not be adopted unless agreed to by all parties to this Agreement. The parties recognize that revisions may become necessary. In such event, the parties shall consult to attempt to resolve the issues and amend this Agreement accordingly. If, however, such revisions are not agreed to within one (1) year after proposed, then the party proposing the revision may elect to terminate its participation in this agreement.

11. This agreement becomes effective on the date of the last signature of the parties involved.

Ed Zajonc, Director Division of State Lands	1-30-87 Date
Randy Fisher, Director Oregon Dept. of Fish and Wildlife	2/6/87 Date
Jim Ross, Director Oregon Dept. of Land Conservation and Development	1-30-87 Date
Colonel Gary A. Lord U.S. Army Corps of Engineers	Date

David F. Riley, Asst. Regional Director
U.S. Fish and Wildlife Service

2/11/87
Date

Mr. Robie Russell, Reg. Administrator
U.S. Environmental Protection Agency

Date

Mr. Dale Evans, Columbia River Program
National Marine Fisheries Service

Date

Let's protect our earth

New Jersey, Department of Environmental Protection