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PALUSTRINE WETLAND CREATION MITIGATION EFFECTIVENESS IN PENNSYLVANIA 1985 - 1989

REPORT

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PALUSTRINE WETLAND CREATION MITIGATION EFFECTIVENESS

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PREFACE

This report assesses the effectiveness of palustrine wetland creation mitigation via the implementation of wetland mitigation policy and the field evaluation of wetland creation sites constructed during the study period. The information presented herein analyzes permanent Clean Water Act section 404 discharges into palustrine wetlands in Pennsylvania as proposed via permit applications issued for review from 1985 through 1989. More specifically, the purposes of the research were to provide information regarding 1) the general purposes of section 404 discharges into wetlands; 2) the rate and frequency of the types of mitigation recommended by the U.S. Environmental Protection Agency and U.S. Fish and Wildlife Service for proposed discharges into wetlands; 3) the classification per Cowardin et al. (1979) of wetland creation accepted by the agencies to mitigate for section 404 discharges into palustrine wetlands; 4) literature review of freshwater wetland creation mitigation and evaluation; and 5) field evaluation of freshwater wetland creation sites.

The records of the U.S. Fish and Wildlife Service, State College, Pennsylvania field office were the primary source of data used to research wetland mitigation, including wetland creation, for the period of study. Additional information was provided by Environmental Protection Agency Region III and the U.S. Army Corps of Engineers District offices. The database emphasized the permit recommendations of the Environmental Protection Agency and the Fish and Wildlife Service rather than the permit decisions of the Corps of Engineers Districts, consequently this report reflects the perspectives of the Environmental Protection Agency and the Fish and Wildlife Service regarding mitigation for Clean Water Act section 404 discharges into wetlands, rather than mitigation implemented via the Corps permit decision process.

ANALYSIS OF U.S. ENVIRONMENTAL PROTECTION AGENCY AND U.S. FISH AND WILDLIFE SERVICE MITIGATION RECOMMENDATIONS FOR SECTION 404 DISCHARGES INTO PENNSYLVANIA WETLANDS

INTRODUCTION

The Clean Water Act (CWA) section 404 program regulates the discharge of dredge or fill material into wetlands and other waters of the United States in order to restore and maintain the chemical, physical, and biological integrity of these waters (Environmental Protection Agency 1980). The section 404 program is administered jointly by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE). The COE processes and issues permit applications. The EPA reviews and provides recommendations regarding the issuance, modification or denial of permit applications. The EPA bases section 404 permit application recommendations in accordance with the Agency's Section 404(b)(1) Guidelines and guidance prepared jointly by EPA and COE (Environmental Protection Agency 1980). In accordance with the Fish and Wildlife Coordination Act, the U.S. Fish and Wildlife Service (FWS) comments in an advisory capacity on the damage a proposed section 404 discharge may have on fish and wildlife resources (Corps of Engineers 1986). Mitigation for section 404 discharges to waters of the United States is required by EPA and Corps regulations, as well as EPA and FWS mitigation policies (Environmental Protection Agency 1980; Ciupek 1986; Corps of Engineers 1986; Holmberg 1988).

EPA and FWS have used the Council on Environmental Quality (CEQ) definition of mitigation (40 CFR 1508.20) in combination with the mitigation sequencing required by the Section 404(b)(1) Guidelines as the basis for their mitigation policies (Ciupek 1986; Holmberg 1988; Kruczynski 1989). The types of mitigation described by CEQ regulations are combined for the purposes of the section 404 program into avoidance, minimization and compensatory mitigation (U.S. Environmental Protection Agency and U.S. Department of the Army 1990). Compensation mitigation entails counteracting for the impact of section 404 discharges by replacing or providing substitute resources or environments. Compensatory mitigation for section

404 discharges into wetlands can include the creation of man-made wetlands and the restoration or enhancement of degraded wetlands.

For discharges into wetlands the Section 404(b)(1) Guidelines require mitigation be implemented in a particular sequence (Kruczynski 1989). First, attempts to avoid discharges into wetlands are to be considered. Second, attempts to minimize the discharges associated with a project are to be considered. Then, if appropriate, compensatory mitigation (i.e., wetland restoration, enhancement or creation) is considered for the unavoidable loss of wetland functions resulting from adverse impacts to aquatic systems (Ciupek 1986; Meagher 1988). This manner of interpreting mitigation has been practiced since the inception of wetland regulation by the CWA (Kusler 1988).

Via the section 404 permit process, EPA and FWS review and comment on a case-by-case basis regarding the potential for adverse environmental impacts by proposed discharges into wetlands. The need for adaptability in application of the Guidelines to the evaluation of proposed section 404 discharges and, hence, the application of mitigation sequencing in keeping with the potential for adverse environmental impact proposed by a section 404 permit application are recognized (Environmental Protection Agency 1980; Meagher 1988). Yet, EPA regulations and policy and FWS policy necessitate mitigation sequencing when making recommendations regarding proposed wetland discharges (Ciupek 1986; Kruczynski 1989). Despite the emphasis placed upon mitigation sequencing, Quammen (1986) has noted the lack of information on mitigation which involves avoidance and minimization of impacts proposed in permit applications.

This research has been undertaken to review CWA section 404 discharges into palustrine wetlands as proposed via COE permit applications and to provide information regarding 1) the general purposes of section 404 discharges into wetlands; 2) the rate and frequency of the types of mitigation recommended by EPA and FWS for proposed discharges into wetlands; and 3) the classification and areas of wetland creation accepted by the agencies for section 404 discharges in order to target wetland creation sites authorized by section 404 permits for field evaluation.

BACKGROUND

Wetlands are characterized by soils, hydrology and vegetation, as well as other factors. Federal regulations define wetlands as semi-aquatic areas that are inundated or saturated by water for sufficient periods of time during the growing seasons to favor the growth of plants adapted to life in saturated soils (EPA 1980; COE 1986). There are two broad categories of wetlands; inland and coastal wetlands. Usually palustrine wetlands are located on the floodplains of rivers and streams, in isolated depressions surrounded by dry land, in the shallow water areas of lakes and ponds (U.S. Environmental Protection Agency 1988) and at the headwaters of streams.

The three most common types of palustrine wetlands in the mid-Atlantic region of the nation are emergent wetlands dominated by grasses, sedges, and other herbaceous vegetation; shrub wetlands vegetated with woody plants less than 20 feet in height; and forested wetlands dominated by trees greater than 20 feet tall. As of 1979, about 2% of Pennsylvania was covered by wetlands. Pennsylvania's nearly one-half million acres of wetlands consisted of emergent wetlands (14.1%), shrub wetlands (28%), forested wetlands (44.4%) and freshwater ponds (13.5%) (Tiner 1987). Almost half of the palustrine emergent, shrub and forested wetlands were concentrated in the northeastern and northwestern corners of Pennsylvania with about 25% and 20% wetlands, respectively (Tiner 1989; Tiner and Finn 1986). The Appalachian highlands of Pennsylvania, excluding the glaciated northeast, contained 46% of the wetlands (Tiner 1989).

Wetlands can provide plant and animal habitat, water quality improvement, flood water storage and abatement, erosion protection, sediment control, food and timber production, habitat for threatened and endangered species, recreation and education opportunities (Conservation Foundation 1988; U.S. Fish and Wildlife Service 1984; Tiner 1987). In recognition of the importance of wetlands as a public resource, the discharge of dredge or fill material into

wetlands has been regulated by section 404 of the CWA since 1977 (Kruczynski 1989). Due to their import and sensitivity, the discharge of dredge or fill material into wetlands is considered one of the "most severe environmental impacts" addressed by the Section 404(b)(1) Guidelines (Environmental Protection Agency 1980; 1989).

The discharges of dredge or fill material into wetlands and other waters of the United States usually requires a section 404 permit from U.S Army Corps of Engineers. Excavation activities in wetlands require a permit under certain circumstances (Perry 1986). Individual permit applications are required for many section 404 discharges. Individual permit applications provide for a case-by-case evaluation of the consequences of proposed discharges to the aquatic environment (Corps of Engineers 1986). Certain discharges into wetlands and other waters of the United States are considered to have minimal individual and cumulative effects and are regulated by general permits (Environmental Protection Agency 1980). Discharges authorized by general permits are not individually assessed by the COE, EPA and FWS.

Generally, EPA and FWS review and comment upon proposed section 404 discharges into wetlands and other waters of the United States via individual permits applications. Individual permit applications can be issued by the COE as Public Notices (PNs) or Letters of Permission (LOPs). In addition, one form of general permit, nationwide permit 26, has an established notification procedure for certain proposed discharges which can result in the issuance of a Pre-Discharge Notification (PDN). EPA and FWS can review PDNs and make recommendations regarding proposed discharges into headwater and isolated waters and their wetlands, or the agencies can request that the COE issue an individual permit application for the proposed discharge. At its discretion, the COE can decide to issue an individual permit for a nationwide permit 26 discharge (Corps of Engineers 1986). The issuance of an individual permit application for discharges into headwater and isolated water wetlands regulated by nationwide permit 26 allows EPA, FWS and COE to review the full environmental effect of the proposed discharge and the compliance of the discharges with the Section 404(b)(1) Guidelines (Corps of Engineers 1986).

METHODS

The files of the U.S. Fish and Wildlife Service in the State College, Pennsylvania field office were the primary source of data for the study. The FWS files provided an accessible, comprehensive, centralized record of section 404 permit applications. Additional information was provided by EPA Region III and the Corps of Engineers. PNs, LOPs and PDNs issued from January 1985 through December 1989 in Pennsylvania were reviewed to identify and collect data on EPA and FWS mitigation recommendations for permit applications which proposed permanent section 404 discharges into palustrine wetlands. As the intent of the research was to describe the application of mitigation policy for proposed section 404 discharges into wetlands, data were not collected from permit applications that dealt solely with discharges into waters of the United States other than wetlands; that did not clearly involve wetland discharges; or that involved temporary discharges into wetlands which the applicant intended to restore. The permit logs maintained by FWS indicated that one PN issued by the Baltimore District COE in 1985 for a section 404 discharge into a open water wetland was missing from the files.

Methods of categorizing the data for EPA and FWS comments on mitigation and discharge characteristics were conducted as described by Ott (1988), Simon (1978), and Runyon and Haber (1977). The types of mitigation -- avoid, minimize, and compensatory (i.e., create, restore, enhance) were defined based on the Guidelines (Environmental Protection Agency 1980), Kusler (1988), Lewis (1989), and empirical experience (N. L. Kline, pers. obs.).

Data collected on the extent of the discharge and the purposes of the proposed wetland discharges were based upon those stated in the PN, LOP, or PDN, unless project files indicated modification of the discharge. The area of wetland impacted by the proposed discharge was considered to be that directly affected. Excavation of a wetland was not considered a section 404 discharge unless the permit application indicated that the excavation resulted in the placement of dredge or fill material regulated by the CWA (Corps of Engineers 1986). If no differentiation was made between wetland discharges and discharges into other waters of the

United States not being considered in this study, then the amount stated was assumed to be for discharges into wetlands. For one project, a range of wetland acreage to be created was recommended, so the average was calculated and tabulated. For another project, two distinct types of wetlands were to be created, but only the acreage for both types was specified. For data analysis the acreage to be created was divided evenly between the two wetland types. The average of the EPA and FWS wetland creation recommendations was used for one permit application on which the agencies' recommendations differed.

Data on EPA and FWS mitigation recommendations for proposed wetland discharges were collected from comments on permit applications submitted by the agencies to the COE. Usually the final comments submitted by an agency were used, unless incorporation of earlier comments contained in the project file was necessary to adequately represent the position of the agency on mitigation. Data were collected on whether an agency recommended mitigation and, if so, the type(s) of mitigation recommended. Mitigation recommendations made for discharges proposed in PDNs were recorded accordingly. EPA and FWS requests for individual permits applications in response to nationwide permit 26 PDNs were not reported, as these requests did not conform to the mitigation categories established by the policies of the agencies.

The types of palustrine wetlands to be impacted by discharges or to be created to compensate for discharges were categorized in keeping with the categories of the classification system developed by Cowardin et al. (1979). The palustrine wetland classes were determined based upon designation in the permit application, agency comments, mitigation plans, site descriptions depicting wetland types and/or associated project documentation. Consequently, the classification of wetland classes did not adhere strictly to the life form compositions defined by Cowardin et al.

Collection of data on projects that involved multiple permit applications was based upon how the Corps processed the applications. Comments on multiple applications for a single project were collected as though they addressed a single permit application when project revision or regulation changes resulted in a different permit application, yet the Corps made a single

decision regarding permit issuance. EPA and FWS comments on multiple applications for a single project were collected for each permit application when the Corps made separate decisions regarding permit issuance for each application, and/or if the permit application was withdrawn by the applicant prior to a final decision by the Corps and the project was not resubmitted. Few of the proposed wetland discharges reviewed involved multiple permit applications.

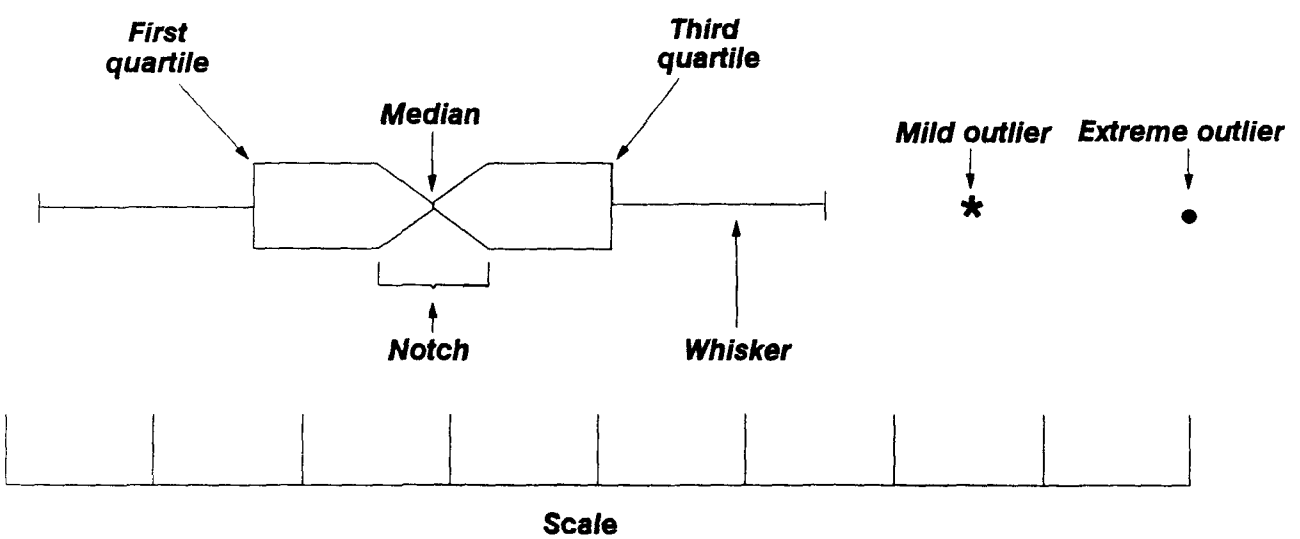
The intent of reviewing all section 404 permit application notices issued from 1985 through 1989 was to collect information on all proposed permanent discharges into palustrine wetlands in Pennsylvania during the period of study. Thus, data analysis and interpretation were based on the assumption the data comprise the population of interest.

Descriptive data analysis was used to interpret the data. Data calculations were performed by hand and using MINITAB statistical software (Minitab, Inc. 1990). Data on mitigation types, wetland types, and purposes of discharges were analyzed within the constraints of nominal data (Simon 1978; Ryan, Joiner and Ryan 1985; Ott 1988). The frequency at which the agencies recommended types of mitigation was determined by combining EPA and FWS recommendations for section 404 discharges into wetlands. As EPA and FWS require mitigation sequencing when making recommendations for proposed wetland discharges, permit application review should result in the avoidance and minimization of discharges into wetlands; and, consequently, the population shape of the sizes of creation sites and section 404 discharges for which permits were issued was expected to have a distribution skewed to the right. Therefore, exploratory and rough confirmatory nonparametric statistics were used to analyze these data, as nonparametric procedures are less influenced by data set extremes and undetected data contamination (T. P. Hettmansperger, The Penn. State Univ., pers. commun.).

Notched box plots were used to describe the sizes of proposed section 404 discharges and the sizes of wetland creation areas recommended for mitigation. Notched box plots display data using the median, quartiles, extremes, and confidence intervals around the median (Figure 1). The box plot can be used to describe data variability, symmetry and distribution (Ott 1988), while the notch provides a rough measure of the significance of difference between the values

of notches of other box plots (McGill et al. 1978). The box of a box plot represents the first and third quartiles or middle 50% of the population (i.e., inter-quartile range). The median (second quartile) is designated by a vertical line within the box. Lines known as "whiskers" extend from the box to data points within 1.5 times the inter-quartile range (IQR) from the median or encompassing 99% of the population. Data points beyond the ends of the whiskers are outliers. The probability of an outlier representing the population of interest is less than 1%. Outliers are designated as individual points in a notched box plot graph (Figure 1).

Figure 1. Configuration of a notched box plot



A data point located beyond 1.5 times the IQR is called a mild outlier and a data point beyond 3 times the IQR is called an extreme outlier. The notch within the box estimates the confidence interval for the median. The notch confidence interval is calculated using the sample size and a selected confidence coefficient (T. P. Hettmansperger, The Penn. State Univ., pers. commun.; Ott 1988; McGill et al. 1978). A 95% confidence coefficient was used to approximate the medians for proposed section 404 discharges and wetland creation areas recommended to compensate for those discharges.

RESULTS AND DISCUSSION

Data were collected from March through May 1990. Appendix A contains a list of the permit applications from which data were collected. Of the 144 permit application files that met initial study criteria 139 (96.5%) were sufficiently complete to be analyzed. A total of 795 acres of wetland discharges were proposed in the 139 permit applications. Proposed discharges ranged in size from 0.01 to 56.8 acres. Eleven permit applications did not specify the acres of wetland impact to result from the proposed discharge.

Mitigation Recommendations

EPA and FWS recommended at least one type of mitigation for 125 (89.9%) of the proposed discharges. More than one type of mitigation was recommended by the agencies for 60 (48%) of the wetland discharges for which the agencies recommended mitigation. Three multiple mitigation recommendations accounted for 72.9% of the 60 such recommendations made by the agencies. In order of rank they were: 1) avoidance and restoration by the removal of existing dredge or fill material, 2) minimize impacts and create wetlands as mitigation, and 3) minimize impacts and restore wetlands impacted by discharges authorized by the section 404 permit process. The high occurrence of EPA and FWS recommendations for mitigation, coupled with the emphasis placed on avoiding and minimizing impacts in combination with the different types of compensatory mitigation, seem to reflect what would be expected by the practical application of prescribed mitigation policy to section 404 permit review.

Of the 290 mitigation recommendations made by the agencies for 139 proposed discharges, avoidance was the most frequent recommendation made by the agencies (Table 1). The combined frequencies of the avoidance and minimization recommendations accounted for slightly less than half (45.9%) of the total recommendations made for proposed wetland discharges. Restoration was the second most frequent recommendation. The frequency of restoration recommendations was high as many of these recommendations were for the removal of discharges that were unacceptable to EPA or FWS. Of the 45 wetland discharges for which the agencies recommended restoration 31 (68.9%) were for wetland discharges that were violations of the Clean Water Act.

TABLE 1

TYPE AND FREQUENCY OF MITIGATION RECOMMENDATIONS MADE BY THE ENVIRONMENTAL PROTECTION AGENCY AND FISH AND WILDLIIFE SERVICE FOR PROPOSED SECTION 404 DISCHARGES INTO PALUSTRINE WETLANDS (1985-1989)

Mitigation Type	Frequency	Percent
Avoidance	89	30.7%
Minimization	44	15.2%
Creation	67	23.1%
Restoration	78	26.9%
Enhancement	12	4.1%
	N = 290	

The agencies recommended compensatory mitigation for 93 (66.9%) of the permit applications and more than one type of compensatory mitigation was recommended for some wetland discharges. Wetland enhancement was recommended for 10 discharges or (10.8%) of the discharges for which the agencies advised compensatory mitigation. The agencies recommended wetland restoration for discharges proposed in 45 permit applications. For 31

(68.9%) of these 45 discharges restoration was recommended to remove existing dredge or fill material. While the rates of recommendation for wetland creation and restoration are similar, these types of mitigation tended to be recommended for different types of discharges into wetlands. Often, wetland restoration was associated with discharges considered avoidable by the agencies. Wetland creation seemed to be associated with discharges for which impacts had been sufficiently minimized or were deemed unavoidable. Statistical testing would be necessary to confirm these apparent associations; however, such testing was outside the scope of the study.

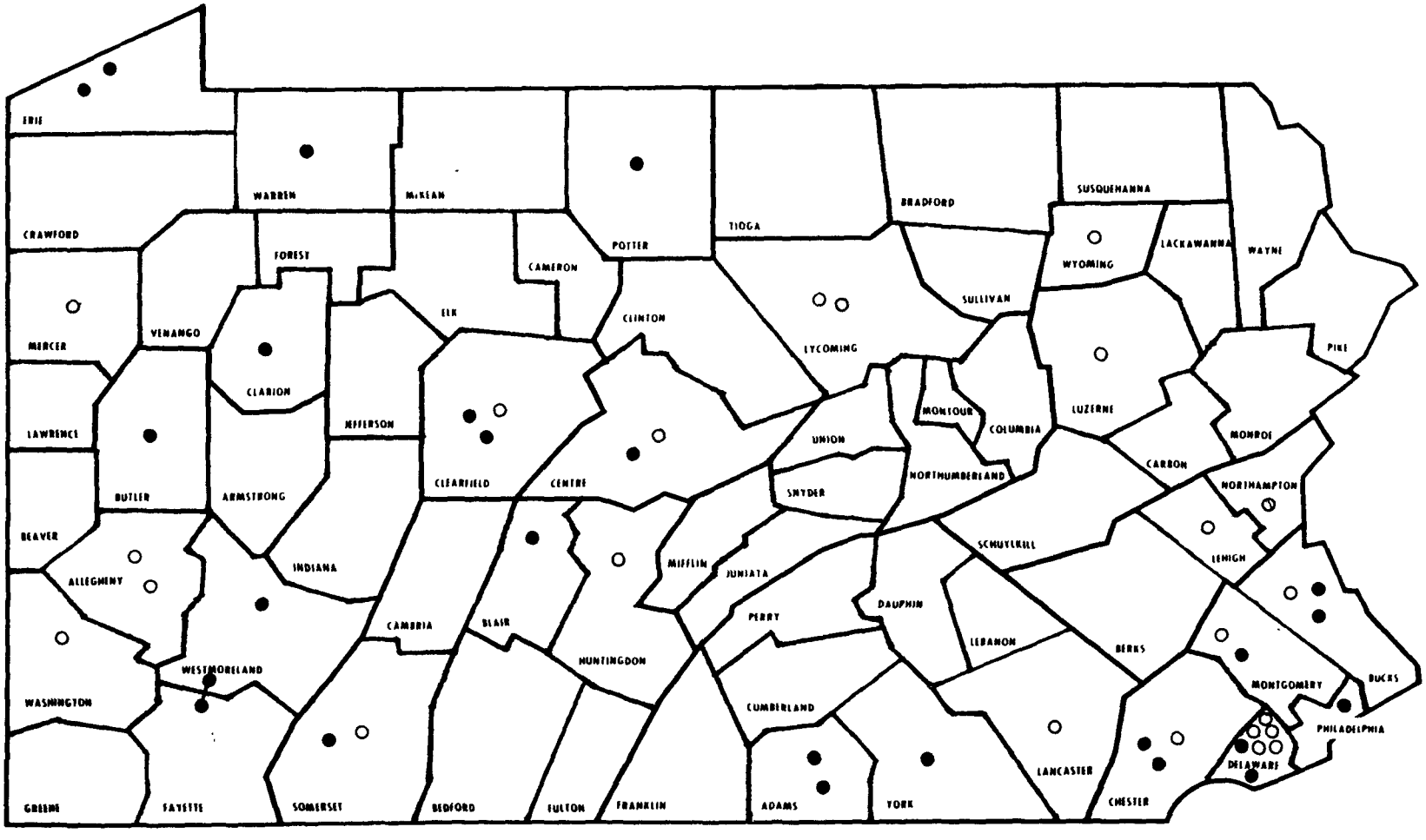
Wetland Creation Mitigation

EPA and FWS recommended wetland creation for 47 discharges into wetlands. This comprised 33.8% of the projects reviewed and 50.5% of all projects for which the agencies recommended compensatory mitigation. Table 2 indicates the total number of acres of palustrine wetland classes that the agencies recommended for creation. The palustrine wetland classification most often recommended by the agencies for wetland creation consisted of a mixture of palustrine wetland classes. The approximate locations of the wetland creation area sites are illustrated in Figure 2.

TABLE 2

TOTAL ACRES OF PALUSTRINE WETLAND CLASSES EPA AND FWS RECOMMENDED AS CREATION MITIGATION FOR SECTION 404 DISCHARGES IN PENNSYLVANIA WETLANDS FROM 1985 THROUGH 1989

Wetland Classification	Total Acres
Palustrine emergent	8.96
Palustrine scrub-shrub	8.33
Palustrine forested	5.56
Palustrine open water	1.16
Mixture of palustrine classes	131.50
Class not specified	19.12
TOTAL	174.63



○ Mixture wetland creation sites
● Other wetland creation sites

Figure 2. Approximate locations of the wetland creation sites in Pennsylvania

Proposed discharges for which EPA and FWS recommended wetland creation (N=46) ranged from 0.03 acres to 40 acres in size. One permit application did not specify the acres of wetland to be filled. The median proposed discharge size was 1.75 acres. A 95% confidence interval for the median was 0.98 to 2.26 acres. The shape of the population of proposed section 404 discharges was skewed to the right. Sixteen or 34.7% of the discharge into wetlands were less than one acre in size and 36 (78.3%) were less than 5 acres in size. The box plot of proposed discharges (Figure 3a) designated five discharges as outliers. One proposed discharge was a mild outlier and four discharges were extreme outliers. Approximately 99% of the discharges for which the agencies recommended permit approval and wetland creation were equal to or less than 7.7 acres in size.

Based upon the information contained in the FWS permit application files, 58 wetland creation areas were recommended to compensate for aquatic impacts resulting from the 46 discharges. The specific number of acres of wetlands to be created was not specified for two of the section 404 discharges. EPA and FWS recommended the creation of 174.6 acres of wetlands. The sizes of the wetland creation areas ranged from 0.03 to 40 acres (Figure 3b). The median size of the total wetland creation sites was 1.08 acres. The 95% confidence interval for the median was 0.80 to 1.85 acres. The shape of the population of all recommended wetland creation areas was skewed to the right. Twenty-three (23) (39.7%) of the wetland creation areas were less than one acre in size; 48 (82.8%) were less than 5 acres in size. The box plot for the total wetland creation areas designated four outliers: three mild outliers and one extreme outlier. Wetland creation areas recommended by the agencies were unlikely to exceed 8.2 acres in size.

Figures 3a and 3b illustrate that the sizes of all the wetland creation areas recommended by EPA and FWS were representative of the sizes of the wetland discharges proposed in the permit applications. These two box plots had nearly identical IQRs, indicating little variation in the data between the two populations (T. P. Hettmansperger , The Penn. State Univ., pers. commun.; Ott 1988). The notches in the box plots overlapped, roughly indicating no significant difference between the medians and supporting a determination that the recommended wetland creation areas reflected the proposed discharges. Inferential statistical analysis of the population

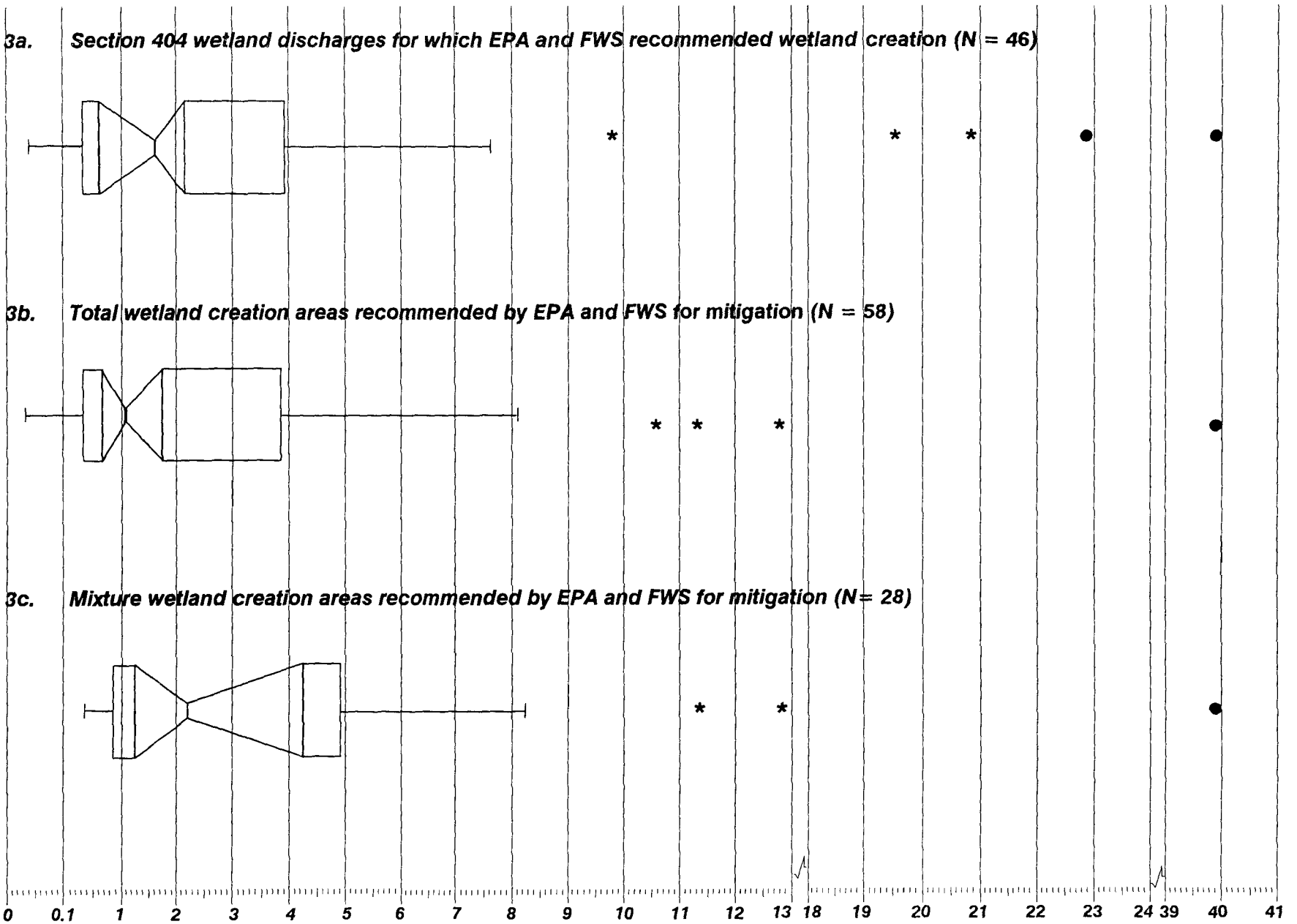


Figure 3. Notched box plots

variances or medians would be required to confirm this determination.

Based on acreage, EPA and FWS most often recommended a mixture of palustrine wetland classes to be created for the mitigation of section 404 discharges into Pennsylvania's wetlands (Table 2). Mixture wetland areas ranged from 0.23 to 40 acres (Figure 3c), however, 99% of the areas were from 0.23 to 8.2 acres in size. The IQR for these creation areas was 1.09 to 4.95 acres. As with the total wetland creation areas, the agencies were unlikely to recommend mixture wetland creation areas in excess of 8.2 areas.

As depicted by the box plot (Figure 3c), the population distribution of mixture wetland creation areas was skewed less to the right than that of all wetland creation areas. About 18 percent of the mixture wetland creation areas were less then one acre in size, as compared to 39.7% for all wetland creation areas. The median for the mixture wetland creation areas was 2.22 acres with a 95% confidence interval of 1.39 to 4.17 acres. Although the overlapping notches of Figures 3b and 3c roughly indicated no significant difference between the estimated medians for the total and mixture wetland creation sites, the narrower notch of Figure 3b indicated a more precise estimate of the median for all the wetland creation areas than the wider notch of the mixture wetland creation areas (T.P. Hettmansperger, The Penn. State Univ., pers. commun.). The IQR and, in particular, the width of the notch illustrated in Figure 3c suggested the mixture wetland creation areas may be larger than the non-mixture wetland creation areas which comprise the balance of the wetland creation recommendations. The project schedule and resources did not permit additional analysis of the data to verify this hypothesis.

Each of the three box plots in Figure 3 were skewed to the right. The outliners for proposed section 404 discharges were in excess of 7.7 acres in size. Outliers for wetland creation areas recommended by EPA and FWS were in excess of 8.2 acres. For all permit applications reviewed the proposed discharges ranged from 0.01 to 56.8 acres. In comparison to all the proposed discharges, the distribution of the discharges and the wetland creation area sizes recommended by the agencies further supported the analysis that EPA and FWS implement mitigation sequencing when making recommendations for regarding section 404 discharges.

It should be noted that the sizes of recommended wetland creation areas may not reflect the size of the wetland(s) actually created for the mitigation of permitted discharges, as one or more wetland sites may need to be created to compensate for the area of wetlands impacted by the permitted discharge.

Purposes of Wetland Discharges

Of the 47 proposed discharges for which the agencies recommended creation to mitigate for wetland impacts, 6 (12.8%) had activities associated with water related discharges (as determined on a case-by-case basis)(Table 3) and 41 (87.2%) had activities associated with non-water dependent discharges (Table 4).

TABLE 3
TYPE AND NUMBER OF ACTIVITIES ASSOCIATED WITH WATER RELATED DISCHARGES* FOR WHICH EPA AND FWS ACCEPTED WETLAND CREATION (N=6)
Boat basin construction (1) Fish pond facility (1) Flood control project (1) Peat mining (1) Waterfowl habitat creation (1) Water reservoir expansion (1)

* This is not to suggest that the below listed activities are always considered to be water related or water dependent as defined in the 404(b)(1) guidelines.

TABLE 4
TYPE AND NUMBER OF ACTIVITIES ASSOCIATED WITH NON-WATER DEPENDENT DISCHARGES FOR WHICH EPA AND FWS ACCEPTED WETLAND CREATION (N=41)
Pennsylvania Department of Transportation (13)
highway construction (9)
bridge replacement (2)
bridge construction (1)
road widening (1)
Road construction (4)
Wastewater treatment plant expansion (4)
Airport expansion (3)
Industrial development (3)
Commercial development (2)
Gas extraction (2)
Residential development (2)
Pennsylvania Turnpike Commission (2)
highway ramps (1)
interchange construction (1)
Creation of aesthetic, spiritual and recreation area (1)
Golf course construction (1)
Municipal waste landfill (1)
School construction (1)
Storage facility expansion (1)
Storm water control structures (1)
Railroad transfer facility expansion (1)

Unlike the water related discharges, the number of activities associated with the different types of non-water dependent discharges were not equally distributed. Pennsylvania Department of Transportation (PennDOT), road construction and wastewater treatment plant expansion projects accounted for slightly more than half (51.2%) of the 41 non-water dependent discharges for which EPA and FWS recommended wetland creation. PennDOT projects accounted for 31.7% of the non-water dependent discharges and for 27.7% of all the section 404 discharges into wetlands for which the agencies recommended wetland creation. Development activities accounted for nearly all the discharges.

Non-water dependent discharges into wetlands were proposed for 74.1% of the 139 permit applications analyzed and water related discharges proposed for the remaining 25.9% of the applications. The percentage of discharges with non-water dependent purposes (87.2%) and water dependent purposes (12.8%) for which EPA and FWS recommended wetland creation mitigation contained a higher percent of non-water dependent discharges than proposed overall.

CONCLUSIONS

Analysis of EPA and FWS comments on 139 section 404 permit applications issued from 1985 through 1989 for permanent discharges into palustrine wetlands located in Pennsylvania suggested that the mitigation recommendations of EPA and FWS for proposed wetland discharges reflect the mitigation precepts of both agencies. Because descriptive statistics were used to analyze the compatibility between agency mitigation requirements and actual mitigation recommendations, confirmatory analysis is required to statistically confirm the association suggested by this study.

Almost 75% of the section 404 permit applications reviewed proposed non-water dependent discharges. Development accounted for nearly all the activities associated with the non-water dependent discharges. The agencies recommended wetland creation for approximately one-third of the section 404 discharges in the permit applications reviewed. Based on acreage a mixture of palustrine wetland classes was most frequently recommended for wetland creation by EPA and FWS to mitigate for discharges into wetlands. The sizes of the wetland creation areas recommended by the agencies to mitigate for section 404 discharges was better approximated by the notched box plot for the total wetland creation areas. Hence, it is recommended that mixture wetland creation areas ranging from 0.8 to 1.85 acres be targeted for the field evaluation of palustrine wetland creation mitigation effectiveness.

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EVALUATION OF PALUSTRINE WETLAND CREATION MITIGATION EFFECTIVENESS

LITERATURE REVIEW

Wetland Creation

Wetland creation has been defined as building a wetland where one did not previously exist (Kusler 1988) and as the transformation by humans of an area of permanent uplands into a wetland (Lewis 1989). While wetland creation has often been required to compensate for CWA section 404 discharges into wetlands, there is a want of information on freshwater wetland creation projects (Quammen 1986; Erwin 1989a; Lowry 1989; Jackson Submitted). Summaries of available research indicate that total failure of wetland creation projects has been rare (Kusler 1988) and partial failure common (Kusler 1988; Kusler and Kentula 1990). Wetland creation is considered a formidable venture. Indeed, the replication of a natural wetland is considered unachievable (Kusler and Kentula 1990). As Ciupek (1986) cautioned, the risk associated with successfully creating wetlands is high.

In part the lack of successful wetland mitigation projects has been attributed to the attempt to implement a new technology with a limited research base (Jackson Submitted). Difficulties associated with wetland creation and its assessment can be complicated by the regulatory process. Low compliance with permit conditions has limited wetland mitigation evaluation (Quammen 1986). Pierce, Landin and Allen (1988) attributed insufficient compliance monitoring, as well as inadequate mitigation objectives and methods to a lack of program personnel and funds. The status of wetland mitigation science necessitates that mitigation plans be scrutinized prior to permit issuance to decide whether the plan counteracts the impacts to wetlands associated with the discharge (Jackson Submitted).

The ability to create different types of wetlands varies (Kusler 1988; Garbisch 1989b; Lowry 1989). Freshwater marshes are considered easier to create that other types of freshwater wetlands (Kusler 1988), although Erwin (1989a) cited several problems with marsh creation projects in the southeast United States. Per Zedler and Weller (1989) nearly all freshwater

restoration and creation projects have been palustrine or open marsh wetlands. Lowry (1989) confirms this was true in the glaciated northeastern United States and that consequently the ability to create forested wetlands, bogs, and fens has been hampered. These reasons have been presented for the focus on open water and marsh wetlands: wildlife values (Lowry 1989; Zedler and Weller 1989), aesthetic values (Zedler and Weller 1989), and the comparative ease and lower cost of creating these types of wetlands compared to other wetland types (Lowry 1989).

The capacity to create different types of wetlands has been correlated to the hydrologic source and hydraulics. Garbisch (1989b) considers the design and construction of wetlands with either 1) constant water flow and water levels or 2) near surface groundwater with seasonal flooding as "straightforward." He acknowledges difficulty in the design and construction of temporarily flooded wetlands and wetlands with fluctuating groundwater as the source of hydrology.

The critical role of hydrology in natural and created wetlands has been repeatedly acknowledged (Gosselink and Turner 1978; Hollands, Hollis and Larson 1986; Kusler 1987; Kusler 1988; Pierce, Landin and Allen 1988; Lowry 1989; Niering 1989; Kentula In press). Hydrology is the key component of any wetland system (Gosselink and Turner 1978; Mitsch and Gosselink 1986). The hydrology determines the vegetative community in a wetland (Tiner Undated; Hollands, Hollis and Larson 1986; Niering 1988). Most wetlands have oscillating water levels resulting in dynamic vegetative communities. Accordingly, Niering (1989) recommended that wetland creation projects contain constant, fluctuating hydrologic regimes to promote self-sustaining wetland communities. The development of the intended plant community requires the creation of the appropriate hydrology. Nonetheless, the success varies for attaining a dominance of hydrophytes at wetland creation sites (Lowry 1989). The establishment of the necessary hydrologic conditions to support the desired plant community should be a goal of wetland creation (Niering and Kraus (1986); Erwin (1989).

Creation of the appropriate hydrology depends upon 1) an accurate analysis of the hydrologic conditions at the creation site, 2) designing and constructing the intended hydrology, and 3) providing plan flexibility to offset design error (Lowry 1989). Understanding the

hydrology and hydraulics of the site and the landscape surrounding the site is important to mitigation success (Vance 1988; Kusler and Kentula 1990).

In addition to creating the necessary hydrology, various recommendations have been made to promote freshwater wetland creation site success:

- The creation site must have suitable soils (Erwin 1989a). The soils and substrate must provide the suitable environment for the planned hydrologic regime and vegetation (Lowry 1989). The substrate surface must be appropriate to the type of wetland being created (Niering and Kraus 1986);

- Lowry (1989) stresses that wetland creation be performed in the same watershed and stream reach as the original wetland. He emphasizes that the proposed hydrologic regime be well documented;

- Creation projects need clear, ecologically sound goals, as well as quantitative methods for goal assessment (Erwin 1989a; Kusler and Kentula 1990). Pre- and post-monitoring requirements are needed. After permit issuance interagency coordination is required (Reimold and Cobler 1986; Erwin 1989b). The import of enforcing and monitoring mitigation project permit conditions has been noted by Quammen (1986) and Kusler (1988);

- Project designs should contain plans for sedimentation control, pollution abatement, etc., particularly in urban areas, as wetlands creation sites tend to be exposed to surface runoff from developed areas and experience severe sedimentation due to high gradient slopes adjacent to the area, and lack of vegetation on slopes. In developed areas sites may be located on nutrient rich streams and streams impacted by human induced sediment (Kusler 1988);

- To construct the type of wetland planned the original wetland must be completely assessed (Erwin 1989a) and the effort must be made to find the best possible site (Reimold and Cobler 1986). A sufficient budget must be available to accomplish the project design (Erwin 1989a);

- The mitigation plan should contain planting details, consisting of the timing, density, elevation, and propagule type (Reimold and Cobler 1986). Mulch, plant materials, and seedbank materials need to be properly handled and applied (Niering and Kraus 1986; Erwin 1989a);

- Problematic exotic vegetation and nuisance animals should not be allowed on site (Kusler 1988; Erwin 1989a);

- Frequent consideration has been given to vegetating the wetland creation site. Lowry (1989) suggests vegetation plans incorporate indigenous species appropriate to the anticipated soil and hydrologic conditions. Transporting the upper 6-12 inches of soil from the original wetland and placing it at the creation site has been recommended to promote colonization (Niering and Kraus 1986; Lowry 1989). To aid the creation of shrub and forested wetland Lowry (1989) suggests transplantation of woody vegetation from the original wetland.

Wetland Creation Evaluation

A lack of wetland mitigation evaluation has been cited (Brooks and Hughes 1988; Lowry 1989; Kusler and Kentula 1990; Jackson Submitted). In the compilation of wetland mitigation literature, Jackson (Submitted) speculates that nowhere is there a consistent, comprehensive, complete information base for the creation projects authorized by the section 404 program nor is there a standardized process for their evaluation. The EPA is in the process of developing standards to characterize mitigation sites, however, the process will not provide standards by which to judge site success or failure (R. Sumner, Environ. Prot. Agency, pers. commun.).

Several difficulties have been encountered evaluating wetland mitigation success:

- In part the evaluation of freshwater mitigation project success is obstructed by a limited data base regarding project goals, site descriptions, construction plans, and evaluator bias (Jackson submitted);

- Zedler and Weller (1989) indicate that it is not necessarily clear whether to evaluate permit compliance or the wetland functions provided by the creation site. A

consequence of this lack of clarity is that project evaluation frequently results in controversy;

- Typically, conceptual mitigation plans prohibit appropriate plan review and lack the detail to enable mitigation plan evaluation (Garbisch 1989a; 1989b); and

- A lack of project specific goals and criteria complicates evaluation of project success (Quammen 1986; Erwin 1989a; Kusler and Kentula 1990).

To provide objectivity in site evaluation, the use of specific guidelines is recommended (Lowry 1989). It is also important to use scientifically defensible standards (Zedler and Weller 1989). Quammen (1986) promoted wetland creation site monitoring via scientific experimentation. Due to a shortage of scientific information on creation or restoration projects Kusler (1988) advises mitigation sites be considered on-going experiments that may require remedial action for an unspecified time period. Niering and Kraus (1986) recommend site monitoring for a minimum of three years.

Quammen (1986) urges that evaluation be performed by an independent party and that field measurements be included in the assessment. Kentula (In press) advises the collection of field data on principal biological and chemical variables on site. She has inventoried vegetation, estimated vegetation cover, analyzed site hydrology, soils, and water quality. At a minimum, Lowry (1989) recommends vegetation data collection consist of species composition, density and cover and that the data be collected for an extended length of time. Lowry advises collecting information on the hydroperiod, water chemistry, soils, and habitat use. To varying degrees the data collection recommendations of Kentula and Lowry have been suggested by Quammen (1986), Niering and Kraus (1986), and Erwin (1989a). Additional information related to vegetation has consisted of plant vigor, determination of bare areas on site (Niering and Kraus 1986), site location information (Quammen 1986), and site size (Quammen 1986; Niering and Kraus 1986).

The lack of quantitative data on mitigation site vegetation has received comment (Zedler and Weller 1989). Because of the time needed to establish a plant community, the evaluation of a creation project requires taking into account the time elapsed since construction and the time of year when assessment will occur. Lowry (1986) notes that the growth of wetland vegetation

on creation sites has been used to determine mitigation success. Yet, long-term monitoring of vegetation permanence, plant community life form or function do not exist.

Opinions differ regarding the comparison of wetland creation sites to natural wetland (i.e., reference) sites. Use of reference sites has been advocated by Abbruzzese et al. (1988), Brooks and Hughes (1988), Zedler and Weller (1989), and Kentula (In press). Zedler and Weller (1989) support landscape level comparisons of natural and constructed wetlands in order to comprehend short-term and long-term restoration goals, Kentula (In press) cites a similar approach using statistical methods. Due to the natural variation of individual wetlands even of the same type Pierce, Landin and Allen (1988) questioned attempts to statistically compare natural and man-made wetlands. Erwin (1989a) recommends the comparison of created and natural wetlands only be used to assess structure and function characteristics of created and reference wetlands. Garbisch (1989b) discounts the use of reference wetlands to evaluate creation projects.

A primary focus of EPA wetland mitigation research addresses the extent to which created wetlands replicate natural wetland functions and values (Abbruzzese et al. 1988). Kentula (In press) proposes the comparison of reference and created wetland sites to determine whether over time created sites resemble natural wetlands. Information on how the hydrologic and biological functions of natural and created wetlands compare is needed (Zedler and Weller 1989).

As the ecology of a site is influenced by the ecoregion in which it is located (Omernik 1987) and by the surrounding land use (Urban, O'Neill and Shugart 1987), the selection of reference sites needs to account for these factors. Kentula (In press) questions the comparison of created wetlands located in urban or agricultural land use areas to less disturbed natural areas. Research by Ehrenfeld (1983) supports Kentula. Ehrenfeld comments on a similarity in the vegetation communities of wetlands in developed areas and attributes the similarity to the type of disturbance, including surrounding land use activities, rather than environmental characteristics of the wetland. Brooks and Hughes (1988) also acknowledge the influence development land use patterns could have on a wetland plant community.

When evaluating disturbed wetlands the Federal Manual for Identifying and Delineating

Jurisdictional Wetlands (Federal Interagency Committee for Wetland Delineation 1989) requires the selection of a reference site with vegetation, soils, hydrology and topography similar to the disturbed site. Brooks and Hughes (1988) recommend a ratio of three reference sites per mitigation site and, among other criteria, selecting natural wetlands of the same size, class and in the same ecoregion.

Omernik (1987) defines ecoregions in the conterminous United States based upon distinct regional patterns of climate, soils, geology, vegetation and physiography. He observes that ecosystems within the ecoregions are more likely to be similar with each other than ecosystems in other ecoregions. Kentula (In press) concurs with Omernik. Abbruzzese et al. (1988) have developed a method to compare creation and reference sites using a random selection process to identify natural wetlands of the same class and size in similar ecoregions. The method is being used to compare the hydrology, vegetation, soils and topographic characteristics of the sites. This method is being developed to apply conclusions regarding mitigation success to a broad geographic region and to provide a statistically defensible, objective site selection method. One of the disadvantages of the Abbruzzese et al. (1988) method is the extensive amount of field time required to identify reference sites.

In summary, the development of wetland creation science and technology is still new and largely experimental. The same is true of wetland creation evaluation methods. There is a need to evaluate wetland creation sites to expand on existing information. The need seems equally great to conduct evaluations of wetland creation projects within experimental and quantifiable constraints.

STUDY SITES

Site Selection

The primary criterion for selecting wetland creation sites for field evaluation is that the sites represent the creation mitigation recommendations made by EPA and FWS for section 404 permit applications issued from 1985 through 1989 for permanent discharges into palustrine wetlands. Analysis of the recommendations made by the agencies specified the most frequent wetland classification per Cowardin et al. (1979) and the median wetland creation area size. Based on acreage, a mixture of palustrine wetland classes was most frequently recommended for

wetland creation by EPA and FWS to mitigate for discharges into wetlands. The more statistically accurate approximation of the representative size of wetland creation areas recommended by the agencies for mitigation was the estimated median for all the wetland creation areas which ranged from 0.8 to 1.85 acres. For mixture wetland creation recommendations the estimated median ranged from 1.39 to 4.17 acres. (Refer to Part I for data analysis specifics.)

The other study site selection criteria to be considered were 1) the site must be sufficiently established to permit evaluation of vegetation and comparison of creation site vegetation to reference site vegetation; 2) all creation and reference sites are located in the same ecoregion; and 3) the site owner approve of site evaluation.

After determining the type and size of wetland creation site targeted for field evaluation, the status of the wetland creation sites was investigated. Information on specific wetland sites was requested from each of the Corps of Engineer (COE) Districts, FWS and, EPA (B. Z. D'Angelo, correspondence, Environ. Prot. Agency, Philadelphia, Pa., 5/21/1990; N. L. Kline, correspondence, Bellefonte, Pa., 5/18/1990, 5/25/1990). Information was obtained from the Baltimore, Philadelphia and Pittsburgh COE Districts, the Pennsylvania Department of Transportation, FWS and EPA (L. Zicari, Environ. Prot. Agency, Pers. commun.; R. Hassel, Phila. Dist. Corps of Eng., pers. commun.; F. R. Plewa, Balt. Dist. Corps of Eng., pers. commun.; R. Sobol, Pitts. Dist. Corps of Eng., pers. commun.; C. J. Kulp, Fish and Wildl. Serv., pers. commun.; Kehler 1990; S. Kehler, Pa. Dept. of Trans., pers. commun.; Brown 1988).

The wetland creation sites considered for evaluation were in the Central Appalachian ridges and valleys ecoregion located in central Pennsylvania (Omernik 1987). Within the ecoregion there were 5 creation sites composed of a mixture of palustrine wetland classes that had been permitted 1985 to 1989 and which were constructed. The 11.4 acre site located at the Beaver Meadow Industrial Park, DuBois, Clearfield County did not comply with the site size criterion and required remedial action scheduled for summer 1990 (R. Sobol, Pitts. Dist. Corps of Eng., pers. commun.). The remaining 4 wetland creation sites ranged in size from 0.67 acre to 3.9 acres (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986; Gannett Fleming Transportation Engineers, Inc. 1988; Kehler 1989;

H. K. Fahy, Consultant, pers. commun.). The sizes and ages of the 4 creation sites did not precisely conform to the site selection criteria, however, due to the limited number of wetland creation sites available, each of these sites was considered for evaluation. Field visits took place May 30 through June 1, 1990.

The Borough of Bellefonte wetland creation site was one of the mitigation conditions of a permit issued by the Baltimore District Corps of Engineers in 1988 for discharges required to expand an existing wastewater treatment plant. The approximately four acre creation site was partially constructed in May-July 1989. Delay in site construction resulted from several thwarted attempts to locate a suitable upland site in the Spring Creek watershed. The site was finally located in Bellefonte, Spring Township, Centre County. The primary source of hydrology for the palustrine emergent/open water site was a spring-fed, perennial stream. Hydric soils from the original wetland were placed on site as seedbank material. The stream was relocated through the creation site during April 1990. Emergent vegetation was planted April 28, 1990 (H. K. Fahy, Consultant, pers. commun; F. R. Plewa, Balt. Dist. Corps of Eng., pers. commun.). Based upon the site investigation it was determined that the wetland creation site was not sufficiently established to warrant evaluation of vegetation or compare vegetation on site to a wetland reference site. Exhibits 1a and 1b depict portions of the Borough of Bellefonte wetland creation site.

In October 1988, the Pennsylvania Department of Transportation (PennDOT) received an individual section 404 permit from the Baltimore District Corps of Engineers (State College Field Office, U.S. Fish and Wildl. Serv., unpubl. data) to relocate a portion of Beauty's Run and fill 1.2 acres of palustrine emergent, 1.0 acres of palustrine shrub-scrub wetlands and an unspecified amount of stream bank wetlands for the construction of the Route 15 bypass (L.R. 1036, Section A-11) in Old Lycoming and Lycoming Townships, Lycoming County. The replacement wetland was to be created in a borrow pit immediately south of the original wetland and adjacent to the bypass. The 3.9 acre mitigation plan developed was to replace in-kind the wetlands and stream bank wetlands (Gannett Fleming Transportation Engineers, Inc. 1988). Site construction began in fall 1989 (S. Kehler, PA. Dept. of Trans., pers. commun.). Based on rough estimates made during a May 31, 1990 site investigation, approximately 75% of the site was unvegetated, approximately 15% of the site contained standing water, and approximately 10% of the site was vegetated. Dead saplings and shrubs as well as unplanted saplings were

observed at the site. The condition of the site was reported to PennDOT for remedial action (R. Pugh, Gannett Fleming Trans. Eng., Inc., pers. commun.). The PennDOT Beauty's Run wetland creation site did not meet the site selection criterion requiring established vegetation. Also, the site had been identified as requiring remedial action making further evaluation to promote correction of site conditions unnecessary. Exhibit 2 depicts the PennDOT Beauty's Run wetland creation site.

Use of nationwide permit-26 was authorized by the Baltimore District Corps of Engineers in September 1988 (C. A. Smith, correspondence, Balt. Dist. Corps of Eng., Balt., Md., 9/30/1988) for discharges into 0.4 acre of wetlands adjacent to Mill Race to relocate a section of Route 220 between Hughesville and Picture Rocks, Wolf Township, Lycoming County. The 0.66 acre wetland creation site was located adjacent to the stream and wetlands filled for highway construction (Skelly and Loy Engineers-Consultants 1988a, 1988b; Kehler 1990). The Bryan Mills site was constructed in spring 1989 (R. Burns, Pa. Dept. of Trans., pers. commun.). The site visit determined that vegetation was established on site, the site would be approximately 2 growing seasons old in late summer 1990, and PennDOT approved site evaluation (A. L. Welker, correspondence, Pa. Depart. of Trans., Montoursville, Pa., 6/18/1990). Exhibit 3 portrays the site.

Construction of the 0.67 acre wetland creation site by the Borough of Huntingdon was completed in late 1986. Shrub plantings occurred in September 1987 (J. Coffman, Borough of Huntingdon, pers. commun.). The mitigation site was required for discharges into palustrine scrub-shrub and palustrine open water wetlands adjacent to the Juniata River for the expansion of an existing wastewater treatment plant in Smithfield Township, Huntingdon County (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986). The creation site is located between the Borough of Huntingdon wastewater treatment plant facility and the Juniata River. During the June 1, 1990 site investigation it was determined the site warranted evaluation and the Borough agreed to evaluation of the site (J. Coffman, Borough. of Huntingdon, pers. commun.). Exhibit 4 portrays the site.

While slightly smaller in size than required by the site selection criteria, the Borough of Huntingdon and PennDOT Bryan Mills sites sufficiently met the other criteria to warrant evaluation. From a more practical perspective, the sites were the only ones available in the area

Date: June 1, 1990

Exhibit 1a. Borough of Bellefonte wetland creation site -- north half

Date: June 1, 1990

Exhibit 1b. Borough of Bellefonte wetland creation site -- south half

Date: May 31, 1990

Exhibit 2. PennDOT Beauty's Run wetland creation site

to which study was confined due to schedule and budget constraints. After selecting the 2 wetland creation sites for field evaluation, additional information was obtained to compile case histories of the study sites and to aid in the selection of wetland reference sites.

Borough of Huntingdon Wetland Creation Site

On March 14, 1986 an after-the-fact preliminary public notice was issued which proposed the filling of 2.25 acres of palustrine forested wetland to add secondary treatment facilities to the existing wastewater treatment plant (WTP) (D. W. Roeseke, Public Notice NABOP-RE-86-0435-1, Baltimore District Corps of Engineers, Baltimore, Md., 1986). After the review of alternatives to the proposed discharge by FWS, EPA, COE and Pennsylvania Fish Commission, the discharge was minimized to 0.6 acres of wetlands with wetland creation mitigation required to compensate for the discharge (J. Valentine and R. Tibbot, correspondence, Pa. Fish Comm., Bellefonte, Pa., 2/27/1986; E. Perry, correspondence, Fish and Wildl. Serv., State College, Pa., 2/14/86; C. J. Kulp, correspondence, Fish and Wildl. Serv., State College, Pa., 4/9/1986; G. A. Jones, correspondence, Environ. Prot. Agency, Phila., Pa., 4/14/1986; W. J. Hoffman, correspondence, Environ. Prot. Agency, Phila., Pa., 5/30/1986; R. Tibbot, correspondence, Pa. Fish Comm., Bellefonte, Pa., 6/30/86; D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986). The COE permit issued June 25, 1986 contained a wetland creation plan developed by the COE which incorporated to varying degrees the comments of the other agencies.

The wetland impacted by the section 404 discharge was a 0.6 acre palustrine open water/scrub-shrub wetland located at the WTP. The WTP is located in Smithfield Township approximately 500 feet southeast of the Borough of Huntingdon in Huntingdon County. The wetland was located in an area containing Atkins silt loam soils, which are deep, nearly level, poorly drained soils on floodplains (Merkel 1978).

The wetland creation site is located in the floodway/floodplain between the Juniata River and the Borough of Huntingdon WTP and palustrine forested wetlands located near Snyder Run Road. Figure 4 indicates the creation site location.

Date: May 31, 1990

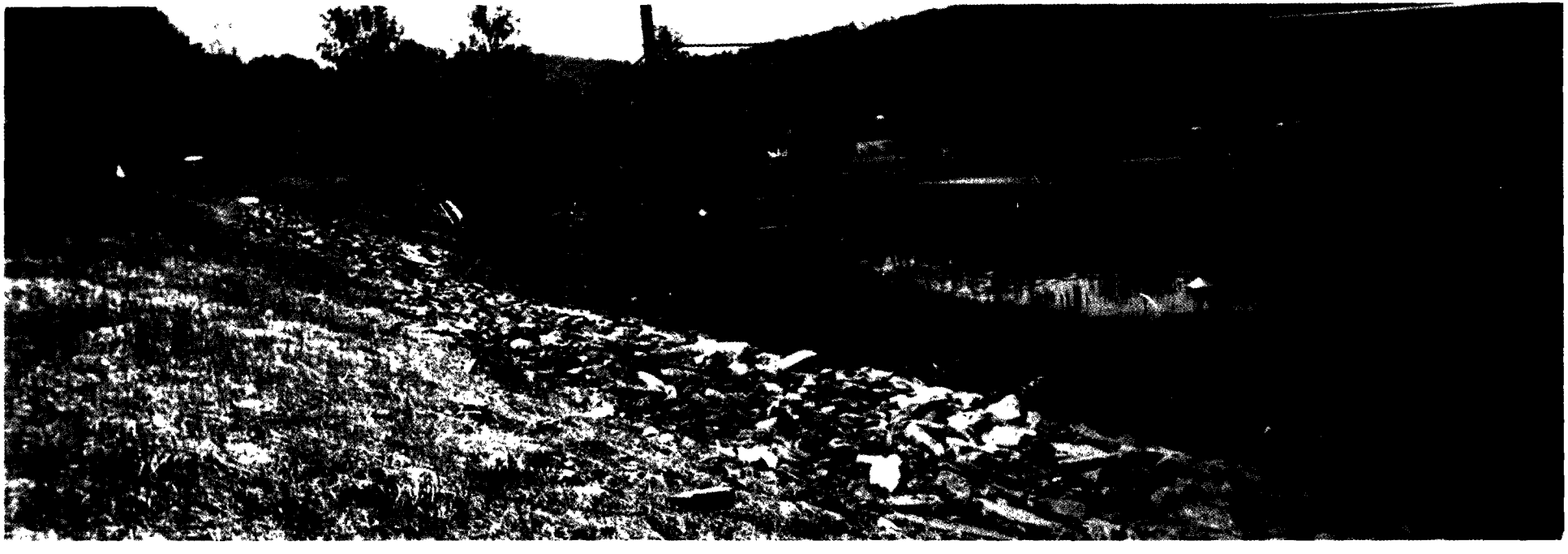

Exhibit 3. PennDOT Bryan Mills wetland creation site

Date: June 1, 1990

Exhibit 4a. Borough of Huntingdon wetland creation site -- west half

Date June 1, 1990

Exhibit 4b. Borough of Huntingdon wetland creation site -- east half

Within a 2,000 foot radius of the wetland creation site (284.7 acres ± 14.2 acres) approximately 45.2% (128.6 acres ± 6.4 acres) is developed; approximately 54.8% (156.1 acres ± 7.8 acres) is undeveloped. Generally, development consisted of highways, primary and secondary roads, WTP, agricultural fields, residential and commercial development. The undeveloped portions consist of palustrine forested wetlands, Snyder Run, the Juniata River, and forested areas. Outside the 2,000 foot radius a major influence on the site is the Borough of Huntingdon located immediately upstream (U. S. Geological Survey 1970a; 1981).

According to item (b) of the remedial plan attached to the June 25, 1986 COE permit, the site is to be a 0.1 acre pond surrounded by a 0.5 acre scrub-shrub wetlands. However, based on the site drawing included with the remedial plan and items b(1) through b(3) of the remedial plan, the creation site is to be approximately 29,500 square feet (0.67 acre) in size. About 5,400 square feet (0.12 acre) is to be a permanent water pool of which 50% is to be about 3 feet deep. Approximately 24,100 square feet (0.55 acre) is to be a palustrine emergent/scrub-shrub wetland, consisting of approximately 0.52 acre emergent wetlands surrounded by 0.03 acre scrub-shrub wetlands (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986). The 0.67 acre site is to be approximately 18% open water, 77% emergent, and 5% scrub-shrub wetlands. Appendix E contains the COE remedial plan for the wetland creation site.

Hydric soils were removed from the original wetland and placed at the creation site as a emergent vegetation seedbank (J. Coffman, Borough of Huntington, pers. commun.). The remedial plan specified the planting of approximately 165 shrubs, consisting of these species: alder (Alnus sp.), willow (Salix sp.), silky dogwood (Cornus amomum), and arrow-wood (Vibernum dentatum). A row of approximately 40 conifers, consisting of eastern hemlock (Tsuga canadensis) or Norway spruce (Picea abies) were to be planted between the palustrine scrub-shrub area and WTP.

The pond shoreline was to be irregularly shaped. About 75% of the open water areas was to be gently sloping with approximately 25% steeply sloped. Approximately 50% of the

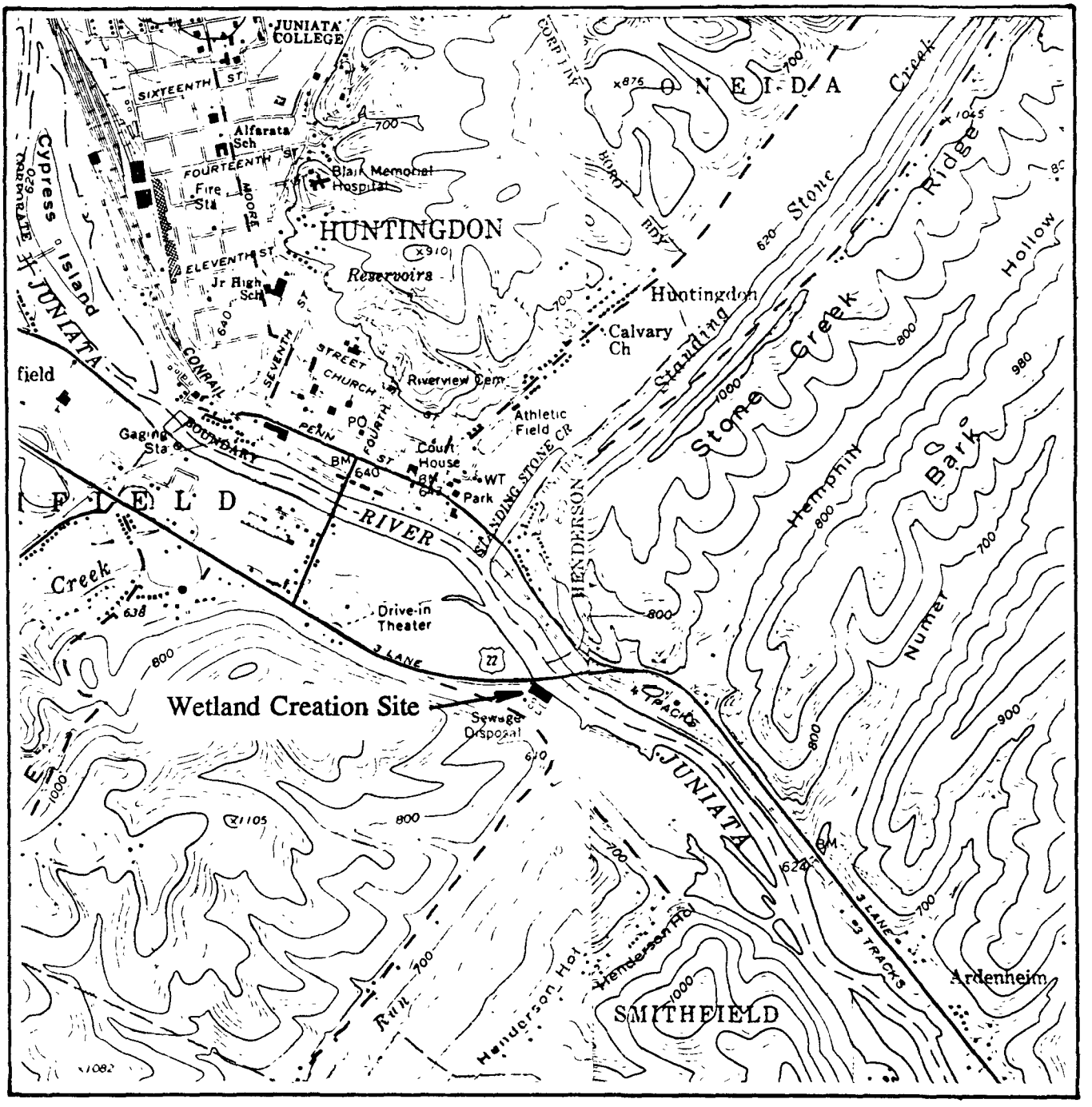

Figure 4. Location of the Borough of Huntingdon wetland creation site

Source: Huntingdon and Mount Union, PA Quadrangles, U.S. Geographic Survey

total pond area was designed to be approximately three feet deep. Provision was made for modification of this design based upon approval by a COE inspector.

As designed, the sources of hydrology for the wetland creation site consisted of 1) surface flow from spring seeps that originate on the opposite side of Snyder Run Road and enter the palustrine forested wetland adjacent to the site as intermittent and perennial streams via culverts under the road; 2) a ditch that directs surface flow from the culvert to the wetland creation site; 3) floodwaters of the Juniata River as the site is located in the floodway and 100-year floodplain of the river; and 4) groundwater, as site excavation was designed to intercept saturated soils (J. Valentine and R. Tibbot, correspondence, Pa. Fish Comm., Bellefonte, Pa., 2/27/1986; D. E. Roeseke, Dept. of Army Permit NABOP-RE- 86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986; J. Coffman, Borough of Huntingdon, Pers. commun.; N. L. Kline, pers. obs.).

Site construction began in the late summer-early fall 1986. Soils removed from the original wetland were placed on the prepared wetland creation site (J. Coffman, Borough of Huntingdon, pers. commun.). The area was stabilized with mulch in November 1986 (J. H. Patten, Earth Disturbance Ins Rep. Pa. Dept. of Environ. Resour., 1986). The site was seeded with Latho flat pea in spring 1987 and the shrubs were planted in September 1987 (J. Coffman, Borough of Huntington, pers. commun.). The 210 shrubs planted were basket willow (60), black alder (40), silky dogwood (60) and arrow-wood (50). Conifers planted were hemlock (20) and Norway spruce (20) (J. C. Geiser, correspondence, Borough of Huntingdon, Huntingdon, Pa., 5/11/1987).

The cost of surveying, constructing and planting the wetland creation project was $16,810. The cost did not include an estimate of COE resources used to design the site (R. Meyers, correspondence, Commonwealth Eng. and Tech., Inc., Harrisburg, Pa., 8/3/1990).

PennDOT Bryan Mills Wetland Creation Site

The purpose of the proposed discharge was to place fill material into Mill Race stream and adjacent wetlands in order to relocate a portion of U.S. Route 220, Section 033 (L.R. 19) (Skelly and Loy Eng. Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988). PennDOT issued a Plan of Study in 1986 (Pennsylvania Department of Transportation 1986). Records indicate that environmental impacts and alternatives to the proposed discharge were considered by PennDOT, FWS, Pennsylvania Fish Commission (PFC), Pennsylvania Game Commission and the Environmental Review Committee. Initially, the PFC and FWS preferred an alternative that would result in less impacts to aquatic resources, however, the agencies agreed to the final alignment given information provided by PennDOT on highway safety design (C. J. Kulp, correspondence, U.S. Fish and Wildl. Serv., State College, Pa., 1/12/1987, 3/23/1988, 4/25/1988; U.S. Dept. of Trans. Fed. Hwy. Adm. and Pa. Dept. of Trans., Undated; Skelly and Loy Eng. Consultants, Lycoming Co. S.R. 0220, Section 033 (L.R. 19) Bryan Mills wetland field view minutes, Harrisburg, Pa., Undated; D. Spotts, correspondence, Pa. Fish Comm., Bellefonte, Pa., 3/17/1988, 4/20/1988; A.L. Welker, correspondence, Pa. Depart. of Trans., Montoursville, Pa., 2/9/1987, 3/28/1988).

A draft mitigation report was submitted for review by the agencies in January 1988 (files, Pa. Dept. of Trans., Montoursville, Pa.). On May 19, 1988 PennDOT submitted a Joint Permit Application for the project. The application contained a site sketch and conceptual mitigation plan (F. W. Bowser, Joint permit application E41-203, Pa. Dept. of Trans., Harrisburg, Pa., 1988). The final wetland mitigation plan was submitted to the Environmental Review Committee for review in July 1988 (S. Kehler, memo, Pa. Dept. of Trans., Harrisburg, Pa., 7/25/1988) and approved by the FWS and PFC in August 1988 (C. J. Kulp, correspondence, U.S. Fish and Wildl. Serv., State College, Pa., 8/15/1988; D. Spotts, correspondence, Pa. Fish Comm., Bellefonte, Pa., 8/4/1988). The Baltimore District COE issued a nationwide permit-26 September 30, 1988 (C. A. Smith, correspondence, Balt. Dist. Corps of Eng., Balt., Md., 9/30/1988).

The environmental losses associated with the authorized discharge were 0.4 acres of direct wetland loss, 0.01 acres of indirect wetland loss, and 632 feet (0.25 acre) of stream loss (F. W. Bowser, Joint permit application E41-203, Pa. Depart. of Trans., Harrisburg, Pa., 1988; Skelly and Loy Eng.- Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988). The wetlands were located adjacent to Mill Race and immediately to the west of the original alignment of S.R. 220. Figure 5 shows the site location. Both Mill Race and the two wetlands impacted by the project were in the headwaters of Muncy Creek, between Picture Rocks and Hughesville, Wolf Township, Lycoming County, Pennsylvania (R. Burns, Pa. Dept. of Trans., pers. commun.). The wetlands and stream were located in an area containing Basher silt loam and Alvira silt loam soils (Skelly and Loy Eng.-Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988). Both soils are included on the Lycoming County list of hydric soils (Soil Conservation Service Undated(b)).

The mitigation plan involved the diversion of the Mill Race into a shallow wetland basin via a relocated stream channel. The wetland basin was to be developed as a palustrine scrub-shrub/emergent wetland with open water through the center of the system. (Skelly and Loy Eng. Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988).

Within a 2,000 foot radius (284.7 acres $\pm$ 14.2 acres) of the creation site approximately 77.4% (220.4 acres $\pm$ 11.0 acres) is developed; approximately 22.6% (64.3 acres $\pm$ 3.2 acres) is undeveloped. Development consists generally of cropland, pasture, highway, roadways, residential and commercial structures. The undeveloped portions consists of Mill Race, Muncy Creek, uncultivated open fields, forested areas, and wetlands adjacent to the streams (U.S. Dept. of Trans. Fed. Highway. Adm. and Pa. Dept. of Trans., Undated; U. S. Geological Survey 1970b).

Calculations based on the final mitigation plan (Skelly and Loy Eng. Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988), site plans provided by PennDOT District 3-0 (Skelly and Loy Eng. Consultants, Wetlands replacement

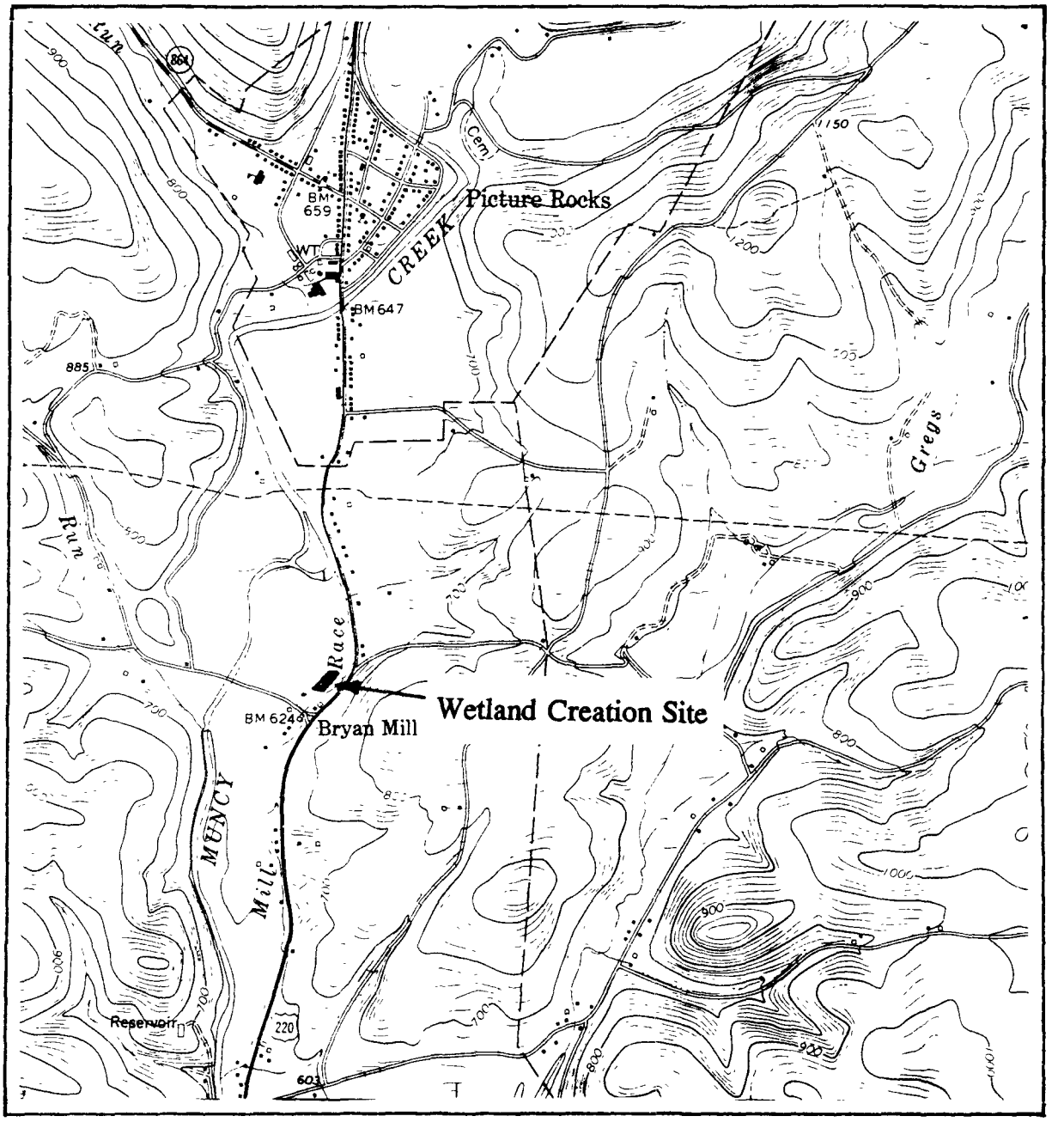

Figure 5. Location of the PennDOT Bryan Mills wetland creation site

Source: Picture Rocks, PA Quadrangle, U.S. Geographic Survey

design T. R. 220-S.R. 0220 site schematic, Harrisburg, Pa., 1988), and the Environmental Assessment (U.S. Dept. of Trans. Fed. Hwy. Adm., and Pa. Dept. of Trans., Undated) were used to determine the size of the wetland creation site, excluding the 0.03-acre stream relocation. The wetland creation site was to be approximately 0.66 acre and was to consist of 0.16 acre (24%) palustrine open water, 0.27 acre (41%) palustrine emergent, and 0.23 acre (35%) palustrine scrub-shrub wetlands. An additional 0.44 acre of terrestrial upland habitat was to be developed due to disturbance associated with stream relocation and grading to create the wetlands. Appendix F contains wetland creation site plans.

The final wetland mitigation report indicated that the soils would be removed from the impacted wetlands and placed in the creation site to a depth of about 6 inches (Skelly and Loy Eng. Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988). The soils were to serve as a seedbank for wetland vegetation (R. Burns, Pa. Dept. of Trans., pers. commun.). The proposed construction schedule was as follows (Skelly and Loy Eng. Consultants, Wetland Mitigation Rep. S.R. 0220-L.R. 19 Relocation, Harrisburg, Pa., 1988):

March-April 1989	-	Basin grading, seed bed preparation, construction of the relocated channel
April-May 1989	-	Construction of channel structure, planting of shrub and emergent species, except common buttonbush and stiff arrowhead
August-September 1989	-	Diversion of Mill Race through wetland system, timing dictated by height of groundwater and degree of establishment by vegetation
September-October 1989	-	Planting of aquatic bed species and common buttonbush
April-May 1990	-	Planting stiff arrowhead and determining year 1 plant survival

A hydrologic and hydraulic evaluation report prepared for the wetland creation site indicated the site would have a reliable source of water consisting of groundwater discharge into both the stream and wetland creation area, flood flows from the stream, and surface runoff into the stream from the 0.27 square mile drainage area surrounding the site (Skelly and Loy Eng. Consultants, Wetland Habitat Replacement S.R. 0220 Relocation, Wolf Twp., Lycoming Co. Hydrologic and Hydraulic Evaluation Rep., Harrisburg, Pa., Undated).

The actual excavation and grading of the entire site started in April 1989 and was completed by July 25, 1989. Plantings were started May 4, 1989 and completed May 19, 1989. Seeding was started in May 1989 and continued during September 1989. The Route 0220-LR 19 Wetlands Replacement Site Update (Skelly and Loy Eng.Consultants, Harrisburg, Pa.,1989) indicated that the following wetland species were planted:

- Shrub-scrub species -- common buttonbush (Cephalanthus occidentalis), silky dogwood (Cornus amomum), red-osier dogwood (Cornus stolonifera), arrow-wood (Viburnum dentatum), and common winterberry (Ilex verticellata);

- Emergent species -- sweetflag (Acorus calamus), rice cutgrass (Leersia oryzoides), three-square bulrush (Scirpus americanus), soft-stem bulrush (S. validus), giant burreed (Sparganium eurycarpum) and stiff arrow-head (Sagittaria rigida).

The emergent and shrub plantings were planted as designed (Skelly and Loy Eng. Consultants, Planting Plan, Lycoming Co., Pa., revised 7/21/1988, Harrisburg, Pa.). The aquatic bed species were not planted as of the last available project report (Skelly and Loy Eng. Consultants, Route 0220-LR 19 Wetlands Replacement Site Update, Harrisburg, Pa.,1989).

The cost of wetland creation site construction was approximately $89,000, or about $130,000 per acre. The cost of plantings was $50,000 and the cost for site preparation was $39,000 (A. L. Welker, memo, Pa. Dept. of Trans., Montoursville, Pa., 12/20/1988). PennDOT and Federal Highway Administration funds were used to construct the site.

WETLAND REFERENCE SITE SELECTION

Methodology

Wetland reference sites were natural wetlands which were not modified or disturbed by human activity (Federal Interagency Committee for Wetland Delineation 1989; Kentula In press). Kentula (In press) defined reference wetland sites as natural wetlands of the same type and approximate size as the mitigation sites, which are located in the same ecoregion and ecological setting.

The project schedule and resources did not permit the extensive reference site selection procedures pursued by Kentula (In press) and Abbruzzese et al. (1988) or the use of the number of sites recommended by Brooks and Hughes (1988). One reference site was selected per wetland creation site. Every attempt was made to assure that the creation and reference sites were as similar as possible. A reference wetland was selected which reflects the vegetation, hydrology, wetland classification per Cowardin et al. (1979), ecoregion, and ecological setting of the respective wetland creation site.

The close association of hydric soils and hydrophytic vegetation demonstrated by Scott et al. (1989) was used to identify hydric soils with groundwater and saturation characteristics similar to those required by the hydrophytic vegetation and site design of each wetland creation site. Both wetland creation sites contained an area of standing water and emergent wetland areas. These site features are indicative of soils that are saturated and the open water area would require a water table at or close to the surface. Soils on county hydric soil lists that have these hydrologic characteristics were used to target possible wetland reference sites.

Land use characteristics within a 2,000 foot radius of the wetland creation site were determined. Important land uses beyond the designated radius were noted (Brooks and Hughes 1988). Estimates of the percent of developed and natural land use activities encompassed by the

2,000 foot radius circle were made for each wetland creation site. Reference sites with a similar percent of developed area and natural area (± 10%) were targeted for selection provided other site criteria were met.

Estimates of developed and natural areas were made using photocopies of the most recent available 7.5 minute USGS topographic map and the topographic map colors and symbols which designate developed and natural areas as defined by Wegweiser et al. (1972) and Kjellstrom (1976). A calibrated compass was used to encircle the approximate center of the wetland creation/reference site (1 inch = 2,000 feet on a 7.5 minute quadrangle). A ± 95% accurate planogrid was used to determine the area within the circle occupied by developed and natural land uses.

To identify a similar reference site, the following characteristics were identified for each wetland creation site: sources of hydrology, site classification per Cowardin et al. (1979) and National Wetland Inventory (Undated(a)), percent of each palustrine wetland class on site, site size, slope, and surrounding land use. National Wetland Inventory (NWI) maps, USGS topographic maps and Soil Conservation Service (SCS) soil survey maps were used to target natural wetlands as potential wetland reference sites. Wetland creation site and surrounding land use characteristics were visually confirmed in the field prior to beginning wetland reference site field investigations.

Information on dominant hydrophytes, indicator of vegetation vigor, and percent bare ground were collected at the wetland creation and reference sites. These site characteristics will be compared to indicate whether the created wetlands resemble the natural wetlands.

Hydric soils used to target potential wetland reference sites were selected based upon:

- Information available regarding the water level requirements (Plewa 1987) of shrubs planted on site and herbaceous vegetation observed on site (R. McCoy, Huntingdon STP Mitigation Site Visit of 9/22/88 Field Notes, Fish and Wildl. Serv., State College, Pa.);

- Wetland creation site design specifications regarding standing water and soil saturation (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986); and

- The seasonal high water table, permeability, and topographical characteristics of the hydric soils listed by the SCS offices of Huntingdon, Juniata and Mifflin Counties (Merkel 1978; Liscomb and Farely 1987; Soil Conservation Service Undated(a), Undated(b)).

- Atkins, Barbour, Pope, Tyler, and Purdy soils were used to target potential references sites. These are hydric soils or soils with hydric components described as nearly level, poorly drained soils in bottomlands with a seasonal high water table at or within 6 inches of the surface (Liscomb and Farely 1987; Merkel 1978).

Results

The Borough of Huntingdon wetland creation site was visited July 10, 1990 to confirm site characteristics needed for reference site selection. The percent of area occupied by each palustrine wetland class on site was determined by averaging three ocular estimates of each class. As the bare ground observed on site had been inundated with water June 1, 1990 the range of the palustrine open water area was estimated by combining the percent of open water area with the percent of area which was bare ground. Sources of hydrology were noted. Site size was estimated by pacing. The vegetation characterizing the site was recorded. The percent of developed and natural land use activities surrounding the site was visually verified.

Based upon site selection methodology and Borough of Huntingdon wetland creation site characteristics, the criteria for selecting the wetland reference site were established as:

- An approximately 0.65 acre palustrine emergent wetland characterized by spikerush, cattail, and burreed with 30% to 60% open water which was located on nearly level soils in bottomlands;

- Land use surrounding the wetland was to be 43%-48% developed area and 52%-58% natural area. The site needed to be located downstream of an urbanized area and, preferably, adjacent to a palustrine forested wetland;

- The wetland should be located in the floodplain and/or floodway of the Juniata River or one of its major tributaries. The site should be as close to the stream as possible as the wetland creation site was about 25 feet from the edge of the Juniata River;

- Site sources of hydrology should consist of soils with a seasonal water table at or near the surface, floodwaters, and surface flow;

The wetlands have not been disturbed or altered by human activity.

Seven (7) potential wetlands reference sites were identified from NWI maps (National Wetland Inventory Undated(a), Undated(b), 1986a, 1986b, 1986c, 1986d, 1986e), USGS topographic maps (U.S. Geographic Survey 1970a, 1971a, 1971b, 1977, 1978, 1979, 1981) and soil survey maps (Liscomb and Farely 1987; Merkel 1978). These sites were located along the Juniata River and Little Juniata River in Huntingdon, Juniata, and Mifflin Counties. Potential reference sites were investigated from July 9 through July 13, 1990. An additional four potential sites were suggested by individuals encountered during the field investigations and nine areas were incidentally encountered. While the later two methods of identifying potential wetland reference sites did not comply with the established methodology, the areas warranted consideration and therefore were considered.

Twenty potential references sites were investigated, but none of the sites met the established criteria.

Of the seven sites identified by research methodology, two sites had been modified by human activities (i.e, agriculture, impoundment); two wetlands were the wrong classification -- palustrine aquatic bed and palustrine scrub-shrub; one palustrine emergent wetland did not comply with reference site hydrology, vegetation or size requirements; one site was inaccessible due to posting; and another site consisted of forested bottomlands.

The four areas recommended as potential reference sites contained palustrine scrub-shrub wetlands or emergent wetlands smaller than required (<0.05 acre).

The other nine areas investigated did not contain sites which conformed to reference site criteria. One site dominated by willow (Salix sp.) was pastured. Another site was a forested wetland. An emergent wetland dominated by sedges (Carex spp.) did not comply with the size, hydrology, vegetation or percent open water criteria. One site may have been filled or was surrounded by an inaccessible thicket of multiflora rose (Rosa multiflora). A mapped palustrine emergent wetland was actually an upland meadow. A forested bottomland area was located on one site with targeted soils, land use, and ecological setting characteristics. The remaining three areas surveyed were portions of the stream bank along the Juniata River which were visible from the car on Route 103 between Newton Hamilton and Mt. Union, Route 333 between Lewistown and Mifflin, and along the Raystown Branch of the Juniata River from the dam to the confluence of the two streams. Little could be observed from the car due to the dense bottomland forest and the proximity of the highways to the rivers.

Discussion and Conclusions

Intuitively, the methods used to target wetland reference sites should have eventually resulted in the identification of a natural wetland that was comparable with the Borough of

Huntingdon wetland creation site. Yet, limitations in methods and approach, and lack of time could account for the inability to locate a reference site. Further, it is possible that the Huntingdon WTP wetland creation site is ecologically unique, and a naturally-occurring comparable wetland does not exist in the study area.

The Borough of Huntingdon wetland creation site was constructed approximately 25 feet from the edge of the Juniata River and therefore subject to floodwaters (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986; J. Coffman, Borough. of Huntingdon, pers. commun.) and alluvial deposition. The alluvial material deposited in the floodplain closest to a stream is coarser than that deposited farther inland (J. J. Eckenrode, Soil Conserv. Serv., pers. commun.). Cunningham et al. (1977) noted that in Pennsylvania floodplains well-drained conditions occur due to permeable layers below the B horizon which allow lateral flow to streams. The well-drained conditions that occur in the floodplain area closest to the stream may not permit the occurrence of a natural palustrine emergent wetland with the vegetation and hydrologic characteristics of the wetland creation site.

Using the same procedure employed for the Borough of Huntington wetland creation site, reference site criteria had been determined for the PennDOT Bryan Mills creation site. However, potential reference sites were not targeted for the Bryan Mills site nor were field investigations conducted due to project constraints resulting from the unsuccessful search for a Borough of Huntingdon wetland reference site. Instead, the project scope was modified to assess wetland creation site effectiveness without comparison to wetland reference sites.

EVALUATION OF WETLAND CREATION SITE EFFECTIVENESS

Methodology

Most newly created wetland sites are expected to have wetland hydrology and hydrophytic vegetation field indicators (Federal Interagency Committee for Wetland Delineation

1989). Yet, the dynamic nature of hydrology makes this wetland indicator the most difficult to identify (Federal Interagency Committee for Wetland Delineation 1989; Tiner Undated). Hydric soil characteristics are likely to be lacking if the substrate on which the site is constructed contains recently saturated or inundated non-hydric soils. Thus, recently created wetlands may lack the soils and hydrology field indicators used to define wetlands (Federal Interagency Committee for Wetland Delineation 1989).

Cowardin (1982) indicated that in new wetlands the vegetation would provide more information than soils or hydrology and that the dominant vegetation in a wetland is primarily determined by the hydrology. As the dominant species in an ecosystem are more important than non-dominants (Niering 1985), the extent of hydrophytes as dominant vegetation at the wetland creation sites will be used to determine site effectiveness.

Quammen (1986) recommended that wetland creation site evaluation be determined in an experimental manner. Pre-established criteria should be used to determine the project success and to promote objective site evaluation (Quammen 1986; Erwin 1989a; Lowry 1989; Kusler and Kentula 1990). Zedler and Weller (1989) promoted the use of scientifically-based methods to collect the data used to assess constructed wetland success or failure (i.e., effectiveness).

Data collection methods were those in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (Federal Interagency Committee for Wetland Delineation 1989). Using the intermediate-level on-site determination method sampling procedure, the effectiveness of the wetland creation sites were assessed according to the percent of dominant plant species that were hydrophytes. The vegetation unit sampling procedure was used because the wetland creation sites and their vegetation units were too small to use the transect method and the use of vegetation units permitted the calculation of the area of each palustrine wetland class created.

Under normal circumstances, one of the criteria for determining the presence of hydrophytic vegetation is that more than 50% of the dominant species are obligate (OBL), facultative wetland (FACW), and/or facultative (FAC) species (Tiner Undated). Under the less than normal circumstances at a wetland creation area the percent of dominant hydrophytic plant species used to determine wetland creation effectiveness reflected the 75% areal cover vegetation success criteria suggested in the literature (Niering and Kraus 1986; Lowry 1989) and the 85% specified for wetland vegetation cover and/or planting survival at wetland mitigation sites in some Philadelphia District COE permits (R. V. Locurcio, Dept. of the Army Permit NAPOP-R-85-0390-11, Phila. Dist. Corps of Eng., Phila., Pa., 1985; R. V. Locurcio, Dept. of the Army Permit NAPOP-R-86-0298-12, Phila. Dist. Corps of Eng., Phila., Pa., 1986; R. V. Locurcio, Dept. of the Army Permit NAPOP-R-85-1123-DA-NP26, Phila. Dist. Corps of Eng., Phila., Pa., 1986; R. V. Locurcio, Dept. of the Army Permit NAPOP-R-87-0265-1, Phila. Dist. Corps of Eng., Phila., Pa., 1987; R. V. Locurcio, Dept. of the Army Permit NAPOP-R-87-0139-13, Phila. Dist. Corps of Eng., Phila., Pa., 1987; G. W. Quinby, Dept. of the Army Permit CENAP-OP-R-86-1035-11, Phila. Dist. Corps of Eng., Phila., Pa., 1987; G. W. Quinby, Dept. of the Army Permit CENAP-OP-R-87-1451-13, Phila. Dist. Corps of Eng., Phila., Pa., 1987; G. W. Quinby, Dept. of the Army Permit CENAP-OP-R-88-1191-13, Phila. Dist. Corps of Eng., Phila., Pa., 1988; F. J. Cianfranni, Dept. of the Army Permit CENAP-OP-R-89-0025016(NP 7, 14, and 26), Phila. Dist. Corps of Eng., Phila., Pa., 1989; F. J. Cianfranni, Dept. of the Army Permit CENAP-OP-R-89-1659-16(NP26), Phila. Dist. Corps of Eng., Phila., Pa., 1989).

The effectiveness of the vegetation units of the wetland creation sites was evaluated using these criteria:

Effective = $\geq$85% of the dominant plant species are hydrophytes
Partially effective = 75%-84% of the dominant plant species are hydrophytes
Non-effective = <75% of the dominant plant species are hydrophytes.

Hydrophytes were defined as plant species with an obligate to facultative-minus wetland indicator status per the National List of Plant Species That Occur in Wetlands: 1988 Pennsylvania (Reed 1988). Ponded water on site with trace or no emergent or woody species was defined as areas of palustrine open water. Palustrine open water areas were not sampled or evaluated as vegetation units.

Overall wetland creation site effectiveness was based on the percent of hydrophytes dominating each of the vegetation units and the estimated area of wetlands created. If the percent of hydrophytes dominating all vegetation units on the wetland creation site belonged to the percent range of a single effectiveness criterion (e.g., $\geq$85% hydrophytes dominate) the entire site received that rating. When the percentage of hydrophytes dominating the vegetation units included more than one of the effectiveness criteria, the median percent for all the vegetation units was used to represent site effectiveness and to determine the effectiveness rating for the wetland creation site. The median was used to represent hydrophytic vegetation areal cover because the median was less influenced by data set extremes and the data were expected to be skewed (T. P. Hettmansperger, The Penn. State Univ., pers. commun.). The size of the site was measured to estimate the area and composition (i.e., acres per wetland class) of wetland creation in accordance with site design. Vegetation units defined as effective and partially effective were used to calculate the wetland area created.

Field evidence of hydrology was recorded. Soil samples were taken to note soil characteristic changes (i.e. color, mottling) that resulted from recent inundation or soil saturation (B. Z. D'Angelo, Environ. Prot. Agency, pers. commun.), and to observe depth to saturated soil. Munsell Soil Color Charts (Munsell Color 1988) were used to record soil characteristics.

Qualitative information was used to augment data on site effectiveness. Data representing vegetation vigor, percent bare ground, and field evidence of hydrology supplemented the criteria used to evaluate the site. Plant vigor was defined by the percent of vegetation observed yellowing or wilted. Bare ground will be defined as ground area without areal cover by vegetation (Erwin 1989b).

During July 23, 1990 field observations were made of the percent bare ground occurring in areas of four natural wetlands. The areas ranged from 0.23 to 0.6 acre in size and were located within larger palustrine emergent, palustrine scrub-shrub, and palustrine forested wetland systems at Bear Meadows, Harris Township, Centre County, and wetlands on COE property adjacent to Bald Eagle Creek, Boggs Township, Centre County. The average of three ocular estimates at each wetland area was used to approximate the percent bare ground at the site. The percent bare ground at the four sites ranged from 0% to trace (<1%). Due to the difficulty of visually discerning the difference between trace (<1%) and 1%, it was arbitrarily decided that up to 5% bare ground would be acceptable. Percent bare ground was estimated for each vegetation unit.

Wetland site sampling in late July-early August provided the opportunity to observe extreme low water conditions and to collect fruiting vegetation (Brooks and Hughes 1988). Late growing season site assessment has been recommended when field time is restricted (Erwin 1989b). For these reasons data collection was planned for late July-early August. Sampling at this time also permitted assessment of the PennDOT Bryan Mills wetland creation site as late as possible in its second growing season.

Panoramic photos were taken of each wetland creation site during field data collection.

Results and Discussion

Identification of vegetation units and the collection of vegetation data and field hydrology information at the wetland creation sites complied with the federal manual (Federal Interagency Committee for Wetland Delineation 1989). Dominant vegetation was identified using Fassett (1957), Fernald (1989), Peterson and McKenny (1968), Newcomb (1977), Brown (1979), Knobel (1980), Little (1980), and Dix (Dept. of Botany, The Penn. State Univ., Univ. Park, Pa.). Estimates of area and depth were made for open water bodies. Appendices C and D contain the vegetation and hydrology data collected at the Borough of Huntingdon and PennDOT Bryan Mills wetland creation sites.

At the PennDOT Bryan Mills site, the decision was made to collect data on partially dead or dead vegetation in addition to the other indicators of vegetation vigor.

Soil sampling at both wetland creation sites was severely limited by conditions resulting from site disturbance related to project construction. Coarse fragments in the soil made obtaining soils samples to a depth of 18 inches with a soil probe impracticable. Therefore, the intent of soil sampling was modified. The soil samples were taken to a depth of 18 inches or to resistance. Soil characteristics observed on site were used to confirm the expected soils and to note soil saturation. Degrees of soil saturation were defined as follows: saturated -- extracted free water from compressed soil; moist -- compressed soil left a water stain; and dry -- compressed soil exhibited no water content.

The Borough of Huntington wetland creation site contained an extensive area of continuous bare ground. The decision was made to characterize this area of bare ground as a "vegetation unit" due to the size of the area and because the area could not be reasonably incorporated into an adjacent vegetation unit based on vegetation structure or composition. The collected vegetation and hydrology data were analyzed in the same manner as the other vegetation units. Information on vegetation vigor was not collected because only trace vegetation was present.

At the Borough of Huntingdon wetland creation site, measurements of area for the entire site and vegetation units were made by pacing. A compass was used for orientation. The area of open water (Unit D) was determined by subtracting the sum of the vegetation units from the total area. The same procedure was used to estimate the size of the PennDOT Bryan Mills site. Tape measurements were made of site width since standing water in Vegetation Unit D and the open water areas (Unit H) located in the center of the site made measurements by pacing impossible. The area of Vegetation Unit D and Unit H was calculated in the same manner as the open water area at the Borough of Huntingdon site. The area of open water was determined by averaging four visual estimates of the percent of open water within the area occupied by Vegetation Unit D and Unit H. The degree of accuracy for site measurements was determined by calculating the percent for total areas observed divided by the total acres expected.

Borough of Huntingdon Wetland Creation Site

Data were collected at the Borough of Huntingdon site August 7 through August 9, 1990. No precipitation occurred during data collection. From March through July of the 1990 growing season in Huntingdon County, rainfall was below normal each month (Merkel 1978; Rep., Balt. Dist. Corps of Eng.--Raystown Dam, pers. commun.).

During August 7, 1990, Vegetation Units A, B, C, E, F, G, and the open water area (Unit D) were identified and the boundaries were flagged. As necessary, reference was made to site design plans to define site boundaries (D. E. Roeseke, Dept. of Army Permit NABOP-RE-86-0435-1, Balt. Dist. Corps of Eng., Balt., Md., 1986).

The percent of hydrophytic plant species that dominated each vegetation unit ranged from 0% to 100%; the median for the vegetation units was 80% (Table 5). Based on established evaluation criteria Vegetation Units B (0.19 acre) and C (0.14 acre) were effective palustrine emergent wetland creation areas; the 0.01 acre Vegetation Unit E was an effective palustrine scrub-shrub wetland creation area; and Unit D comprised the 0.17 acre palustrine open water area created on site.

Indicators of vegetation vigor at the wetland creation sites are contained in Table 6. Yellowing vegetation was observed in Vegetation Units B and C -- the palustrine emergent components of the wetland creation site. Branching burreed (Sparganium androcladum) was a dominant species in these vegetation units. Branching burreed comprised 80% areal cover in Vegetation Unit B and 25% areal cover in Vegetation Unit C. In Vegetation Unit B approximately 95% of the burreed was yellowing; approximately 75% of the burreed was yellowing in Vegetation Unit C. Regarding the other dominant species in these vegetation units about 15% of the least spikerush (Eleocharis acicularis) in Vegetation Unit B and approximately 10% of the blunt spikerush (Eleocharis obtusa) in Vegetation Unit C were yellowing. Least spikerush comprised 65% areal cover in Vegetation Unit B and blunt spikerush 35% areal cover in Vegetation Unit C. The yellowing exhibited by vegetation on site could be attributed to

TABLE 5

Dominant Vegetation Observed at the Borough of Huntingdon Wetland Creation Site

Vegetation unit/name	Percent dominant vegetation hydrophytes*	Dominant vegetation and wetland indicator status**
A	0%	No dominant species onsite
B	100%	Branching burreed -- OBL (Sparganium androcladum) Least spikerush (Eleocharis acicularis) -- OBL Marsh seedbox (Ludwigia palustris) -- OBL
C	100%	Blunt spikerush (Eleocharis obtusa) - OBL Branching burreed -- OBL Dotted smartweed (Polygonum punctatum) -- OBL False pimpernel (Lindernia dubia) -- OBL Least spikerush -- OBL Marsh seedbox -- OBL
D	Open water	Not applicable -- open water areas defined as ponded water onsite with trace or no vegetation
E	100%	Path rush (Juncus tenuis) -- FAC- Silky dogwood (Cornus amomum) -- FACW Smooth alder (Alnus serrulata) -- OBL Soft rush (Juncus effusus) -- FACW+ Spotted jewelweed (Impatiens capensis) -- FACW
F	60%	Crown vetch (Coronilla varia) -- UPL Silky dogwood -- FACW Smooth alder -- OBL Spotted jewelweed -- FACW Thicket creeper (Parthenocissus vitacea) -- FACU
G	33%	Crown vetch -- UPL Everlasting pea (Lathyrus latifolius) -- UPL Spotted jewelweed -- FACW

* Hydrophytes = wetland indicator status of OBL-FAC-

** Per National List of Plant Species That Occur in Wetlands: 1988 Pennsylvania (Reed 1988)

limited nutrient availability or extended lack of water (J. J. Eckenrode, Soil Conserv. Serv., pers. commun.).

TABLE 6		
INDICATORS OF VEGETATION VIGOR AT THE BOROUGH OF HUNTINGDON WETLAND CREATION SITE		
Vegetation unit/name	Yellowing species	Wilted species
A	Trace vegetation: data not collected	Trace vegetation: data not collected
B	Blunt spikerush, branching burreed,* broad-leaf cattail, least spikerush*	None
C	Blunt spikerush,* branching burreed*	None
E	None	None
F	None	None
G	Sedge, woolgrass	None

* Dominant species

The percent bare ground in Vegetation Unit B exceeded the 5% limit of acceptability (Table 7). The percent bare ground in Unit D represents the soil exposed by a receding open water area. More noteworthy, however, was approximately 0.1 acre of bare ground designated as Vegetation Unit A. Vegetation Unit A comprised about 16% of the entire site. (J.J.Eckenrode, Soil Conserv. Serv., pers. commun.) A lack of organic matter may account for the lack of vegetation in Vegetation Unit A.

Several field indicators of hydrology were observed at the Borough of Huntingdon wetland creation site:

Two areas of inundation were observed. One area approximately 25 feet by 30 feet had standing water which ranged in depth from surface inundation to two inches. The approximately

TABLE 7	
PERCENT BARE GROUND OBSERVED AT THE BOROUGH OF HUNTINGDON WETLAND CREATION SITE	
Vegetation unit/name	Percent bare ground observed
A	>99%
B	8%
C	2%
D	4%
E	<1%
F	2%
G	0%

0.17 acre open water area (Unit D) ranged in depth from surface inundation to greater than 3 feet in depth (Rep., Borough of Huntingdon, pers. commun.);

About 85% of the bare ground surface in Vegetation Unit A was saturated or moist and exhibited cracked, drying mud, coated with dried and/or living algae. Slightly less than half of the 0.19 acre Vegetation Unit B was covered with cracked, drying mud and remnants of algae. These same signs of cracked, drying mud were observed at the boundary of Vegetation Units B and E;

Evidence of surface flow was observed in the ditch entering the south side of the site.

Based on the slope of the WTP property adjacent to the site, overland flow from the WTP enters the west end of the site; and evidence of fluctuating water levels in the open water area (Unit D) was observed during data collection, as well as during earlier site visits. Exhibits 4a and 5a demonstrate the fluctuations in water level. The lower water level illustrated in Exhibit 5a is representative of the conditions observed July 10, 1990. A visit to the site 2 days later, after a day of constant rain, revealed water covering approximately 85% of the site. The water ranged in depth from surface inundation to about 10 inches. During data collection in August 1990 water marks and algal drift lines were observed around the receding open water

area of Unit D. Damp marks on snags anchored in Unit D indicated that the water had recently been 4 inches higher. A WTP employee reported that the open water area was elevated August 6 after heavy, steady rain August 5, 1990 (Rep., Borough. of Huntingdon, pers. commun.).

Barbour high-bottom soils have very poor suitability for pond creation due to substratum permeability and flooding. Atkins silt loam soils are rated as having good suitability for this purpose. However, a limitation of Atkins soils for pond creation is a pervious substratum (Merkel 1978). Compacting Barbour soils would not reduce permeability (J.J. Eckenrode, Soil Conserv. Serv., pers. commun.). Instead, placement of a minimum of 6 inches of impervious material (i.e., clay) would be needed to successfully pond water.

Although soil sampling was severely restricted by site conditions, the evidence of hydrology obtained from soil samples suggested that depth to soil saturation varied considerably on site. No apparent correlation was observed between soil saturation and the bare ground in Vegetation Unit A.

Comparison of the characteristics of soils sampled to soils mapped on site indicated that the wetland creation site was primarily built at the interface of the Atkins silt loam and Barbour high-bottom soils (Merkel 1978). Barbour soils have a poor suitability for creating wetland plant habitat and very poor suitability for creating shallow water areas, while Atkins soils have a good suitability rating for these types of habitat creation (Merkel 1978). Due to the lack of moisture holding capacity and fluctuating water table of Barbour soils, the closer that the wetland creation site was constructed to the transition area between the Barbour and Atkins soils the greater the likelihood of site success (J. J. Eckenrode, Soil Conserv. Serv., pers. commun.).

Table 8 specifies the acres and percent of palustrine wetland classes expected on site and the approximate acres and percent of wetland classes observed. The palustrine open water area was larger than planned, while the palustrine emergent and scrub-shrub areas were smaller. The sum of palustrine wetland classes observed represented 80% of the estimated size of the entire 0.64 acre wetland creation site.

Exhibits 5a and 5b depict the Borough of Huntingdon wetland creation site during data collection.

TABLE 8		
ACREAGE AND PERCENT OF PALUSTRINE WETLAND CLASSES EXPECTED AND OBSERVED*** AT THE BOROUGH OF HUNTINGDON WETLAND CREATION SITE		
Palustrine wetland class	Expected*	Observed**
Open water	0.12 acre (18%)	0.17 acre (33%)
Emergent	0.52 acre (77%)	0.33 acre (65%)
Scrub-shrub	0.03 acre (5%)	0.01 acre (2%)
Total	0.67 acre	0.51 acre

* Source: D.E. Roeseke, Department of the Army Permit NABOP-RE-86-0435-1, Baltimore District Corps of Engineers, Baltimore, MD, 1986

** Sum of effective and partially effective vegetation units

*** Accuracy of estimates for size of observed areas = ± 5%

PennDOT Bryan Mills Wetland Creation Site

Data was collected at the PennDOT Bryan Mills wetland creation site from July 30 through August 2 and August 6, 1990.

During July 30 and 31, 1990, Vegetation Units A through G and the open water area (Unit H) were identified and the boundaries were flagged. Reference was made to site design plans to define site boundaries as needed. (Skelly and Loy Eng. Consultants, Wetlands Replacement Design Planting Schematic Revised 7/21/1988, Harrisburg, Pa.).

Three of the nine dominant species were ruderals -- species that grow in waste places or

Date: August 7, 1990

Exhibit 5a. Borough of Huntington wetland creation site -- west half

Date: August 7, 1990

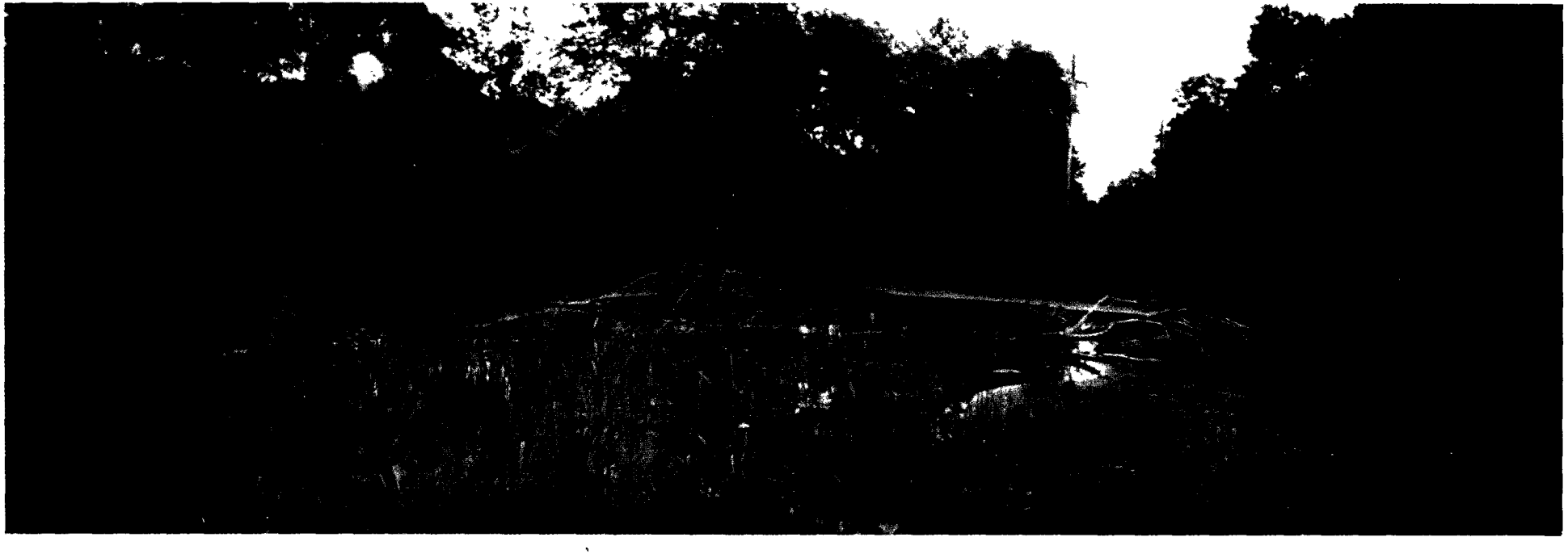

Exhibit 5b. Borough of Huntingdon wetland creation site -- east half

among rubbish (Fernald 1989). The ruderal species were bitter dock (Rumex obtusifolius), common plantain (Plantago major), and birds-foot trefoil (Lotus corniculatus) (Gleason 1952; Gleason and Cronquist 1963; Fernald 1989).

Bitter dock, common plantain, and birds-foot trefoil all have a FACU wetland indicator status (Reed 1988). The presence of at least one of these species as a dominant in Vegetation Units C, E, and F resulted in their designation as non-effective wetland creation areas. There is some evidence (Chambers 1989) that birds-foot trefoil prefers wetter conditions than designated by the wetland indicator status in Reed. However, other sources referenced (Gleason 1952; Gleason and Cronquist 1963; Fernald 1989) regarding the degree of soil saturation preferred by birds-foot trefoil, or bitter dock and common plantain, were inconclusive. Given the lack of consensus regarding the wetness preference of birds-foot trefoil, or the other ruderals, and the extensive resource base used to designate the wetland indicator status of species listed in Reed (1988), the categories assigned by Reed to these species was used to assess the effectiveness of the vegetation units and, consequently, the entire site. To determine whether disturbance due to site construction or hydrologic conditions contributed more to the presence of the dominant ruderal species will require reevaluation of the site after later growing seasons.

At the PennDOT Bryan Mills wetland creation site the percent of hydrophytes as dominant plant species in Vegetation Units A through G ranged from 0% to 100%; the median was 60% (Table 9). Based on the effectiveness criteria, Vegetation Unit D was an effective 0.12 acre palustrine emergent wetland creation area and Vegetation Units A (0.15 acre) and B (0.07 acre) were partially effective palustrine scrub-shrub wetland creation areas. Unit H consisted of the 0.03 acre palustrine open water area created on site.

Table 10 reports the occurrence of yellowing, wilted and partially dead/dead vegetation observed on site. At least one of these indicators of vegetation vigor was evident to varying degrees in each vegetation unit. Extensive evidence of vegetation stress in hydrophytes was observed in Vegetation Units A, B, C, and F at the PennDOT Bryan Mills site. Lack of water was considered the cause of vegetation stress, since non-hydrophytic vegetation did not exhibit these characteristics.

TABLE 9

Dominant Vegetation Observed at the PennDOT Bryan Mills Wetland Creation Site

Vegetation unit/name	Percent dominant vegetation hydrophytes*	Dominant vegetation and wetland indicator status**
A	75%	Arrow-wood (Vibirnum dentatum) -- FAC Common plantain (Plantago major) -- FACU Common winterberry (Ilex verticillata) -- FACW+ Soft rush (Juncus effusus) -- FACW+
B	80%	Arrow-wood (Vibirnum dentatum) -- FAC Birds-foot trefoil (Lotus corniculatus) -- FACU- Red-osier dogwood (Cornus stolonifera) -- FACW+ Redtop bentgrass (Agrostis alba) -- FACW Soft rush -- FACW+
C	50%	Common plantain -- FACU Soft rush -- FACW+
D	100%	Blunt spikerush (Eleocharis obtusa) -- OBL Marsh seedbox (Ludwigia palustris) -- OBL Stiff arrowhead (Sagittaria rigida) -- OBL
E	50%	Birds-foot trefoil -- FACU- Redtop bentgrass -- FACW
F	60%	Arrow-wood -- FAC Birds-foot trefoil -- FACU- Bitter dock (Rumex obtusifolius) -- FACU- Common winterberry -- FACW+ Redtop bentgrass -- FACW
G	0%	Birds-foot trefoil -- FACU- Bitter dock -- FACU -
H	Open water	Not applicable -- open water areas defined as ponded water onsite with trace or no vegetation

* Hydrophytes = wetland indicator status of OBL-FAC-

** Per National List of Plant Species That Occur in Wetlands: 1988 Pennsylvania (Reed 1988)

TABLE 10			
Indicators of Vegetation Vigor at the PennDOT Bryan Mills Wetland Creation site			
Vegetation unit/name	Yellowing species	Wilted species	Partially dead/dead**
A	Arrow wood,* buttonbush, red-osier dogwood, silky dogwood, soft rush	Jewelweed, red-osier dogwood, silky dogwood	Arrow wood,* common winterberry,* red-osier dogwood, silky dogwood
B	Arrow wood*, buttonbush, soft rush*	Jewelweed	Common winterberry, red-osier dogwood,* silky dogwood
C	Burreed, soft rush*	None	None
D	Blunt spikerush,* burreed, cattail, jewelweed, stiff arrowhead*	Jewelweed	None
E	Burreed	Jewelweed	None
F	Arrow wood,* common winterberry*	Arrow wood*	Arrow wood,* common winterberry,* red-osier dogwood
G	Sweetflag	None	None

* Dominant species
** Estimated to be half dead or completely dead

In the vegetation units designed as palustrine scrub-shrub wetlands, major portions of the herbaceous and shrub strata were yellowed. In both Vegetation Units A and B, approximately 85% of the shrubs were yellowing. The incidence of partially dead or dead shrubs was 40% in Vegetation Unit A; 30% in Vegetation Unit B; and 85% in Vegetation Unit F. Wilted shrubs occurred in Vegetation Units A and F. Soft rush (Juncus effusus) comprised 80% areal cover in Vegetation Unit A and 50% areal cover in Vegetation Unit B. Soft rush was a dominant species in both vegetation units. Approximately 75% of the soft rush in Vegetation Unit A and 50% of the soft rush in Vegetation Unit B were yellowing.

Vegetation Units C, D, E, and G were designed and planted as palustrine emergent wetlands. Soft rush was a co-dominant in Vegetation Unit C with 90% areal cover. Approximately 75% of the soft rush in Vegetation Unit C was yellowing. To a lesser extent, yellowing was noted in Vegetation Unit D where about 25% of the vegetation exhibited this characteristic. Two of the three dominant plant species were yellowing -- stiff arrowhead (Sagittaria rigida) and blunt spikerush (Eleocharis obtusa). Each species had 66% areal cover in the vegetation unit. Nearly 15% of the stiff arrowhead and about 5% of the blunt spikerush were yellowing.

The percent bare ground observed at the wetland creation site is contained in Table 11. The percent bare ground in each vegetation unit was within the 5% limit of acceptability.

On July 30, 1990 a local resident indicated there had been no precipitation for about a week. Light rain occurred the day before data were collected on field hydrology. For the Lycoming County 1990 growing season, rainfall was below normal during March, April and June and above normal during May and July (Rep., Natl. Weather Bur.--Williamsport, pers. commun.).

TABLE 11	
PERCENT BARE GROUND OBSERVED AT THE PENNDOT BRYAN MILLS WETLAND CREATION SITE	
Vegetation unit/name	Percent bare ground observed
A	2%
B	0%
C	0%
D	0%
E	0%
F	0%
G	0%

The following indicators of hydrology were observed at the PennDOT Bryan Mills wetland creation site:

- Evidence of hydrology was found at Vegetation Units D and H, which comprised about 22% of the site. Two open water areas (Unit H) located in the center of an inundated palustrine emergent area (Vegetation Unit D) received surface waters from relocated Mill Race and ground water intercepted by excavation (Rep., Pa. Dept. of Trans., pers. commun.);

- There was evidence of limited overland flow entering the western side of the site;

- Approximately 5% of the approximately 0.15 acre Vegetation Unit A contained long, narrow patches and other small patches of ground that were saturated at the surface. The south end Vegetation Unit A contained an area approximately 18 feet by 27 feet which was saturated to the surface;

- A zone of saturation and/or inundation was observed along the boundary of Vegetation Unit D and the adjacent Vegetation Units A, B, C, and E. This zone of saturation/inundation ranged in width from 17 inches to 172 inches and had water depths ranging from surface inundation to 9 inches;

- Another area of surface inundation, approximately 12 feet by 16 feet, occurred in the center of Vegetation Unit B where the relocated stream entered Vegetation Unit D; and

- In Vegetation Unit D inundation ranged in depth from 1 inch to greater than 30 inches.

No field evidence of hydrology was noted in Vegetation Units F and G.

Although soil sampling was severely restricted by site conditions, the evidence of hydrology obtained from soil samples suggested that the depth to soil saturation varied considerably.

Comparison of the characteristics of soils sampled to soils mapped on site (Kohler 1986) indicated the wetland creation site was built as planned on Basher silt loam soil. These soils are rated as having a poor potential for creating wetland plant habitat and shallow water areas, because management requirements are difficult and intensive (Kohler 1986). The permeability of Basher soils results in a fluctuating water table and a lack of moisture holding capacity. Compacting will not reduce permeability. A minimum of six inches of impervious material (i.e. clay) laid on top of Basher soils is required to reduce permeability. (J. J. Eckenrode, Soil Conserv. Serv., pers. commun.).

Table 12 specifies the acres and percent of palustrine wetland classes expected and observed on site. The palustrine open water area and palustrine emergent wetland area were much smaller than planned. The palustrine scrub-shrub area was essentially the same size as designed. All three palustrine wetland classes comprised different percentages of the entire site than planned. The sum of the observed palustrine wetland classes represented 55% of the estimated size of the entire (0.67 acre) wetland creation site.

Exhibits 6a and 6b illustrate the PennDOT Bryan Mills wetland creation site during data collection.

TABLE 12		
ACREAGE AND PERCENT OF PALUSTRINE WETLAND CLASSES EXPECTED AND OBSERVED*** AT THE PENNDOT BRYAN MILLS WETLAND CREATION SITE		
Palustrine wetland class	Expected*	Observed**
Open water	0.16 acre (24%)	0.03 acre (8%)
Emergent	0.27 acre (41%)	0.12 acre (32%)
Scrub-shrub	0.23 acre (35%)	0.22 acre (59%)
Total	0.66 acre	0.37 acre

* Source: Skelly and Loy Engineers-Consultants, Wetland Mitigation Report State Route 0220 - L.R. 19 Relocation, Harrisburg, PA, 1988

** Sum of effective and partially effective vegetation units

*** Accuracy of estimates for size of observed areas = + 1.5%

CONCLUSIONS

Effectiveness of the Wetland Creation Sites

After about 4 growing seasons, the Borough of Huntingdon site was determined to be a partially effective palustrine wetland creation mitigation site. This determination was based upon effectiveness criteria used to assess the percent of dominant hydrophytes observed in the 6 vegetation units on site and supported by the extent of effective wetland acreage created at the site.

The 0.1 acre unvegetated area on site was the primary reason for the determination of partial effectiveness, although two-thirds of the 0.03 acre palustrine scrub-shrub area were considered non-effective.

The observed field hydrology was indicative of the fluctuating water table attributed to Barbour soils. The extent of stress evidenced by one of the dominant emergent hydrophytes

Date: July 30, 1990

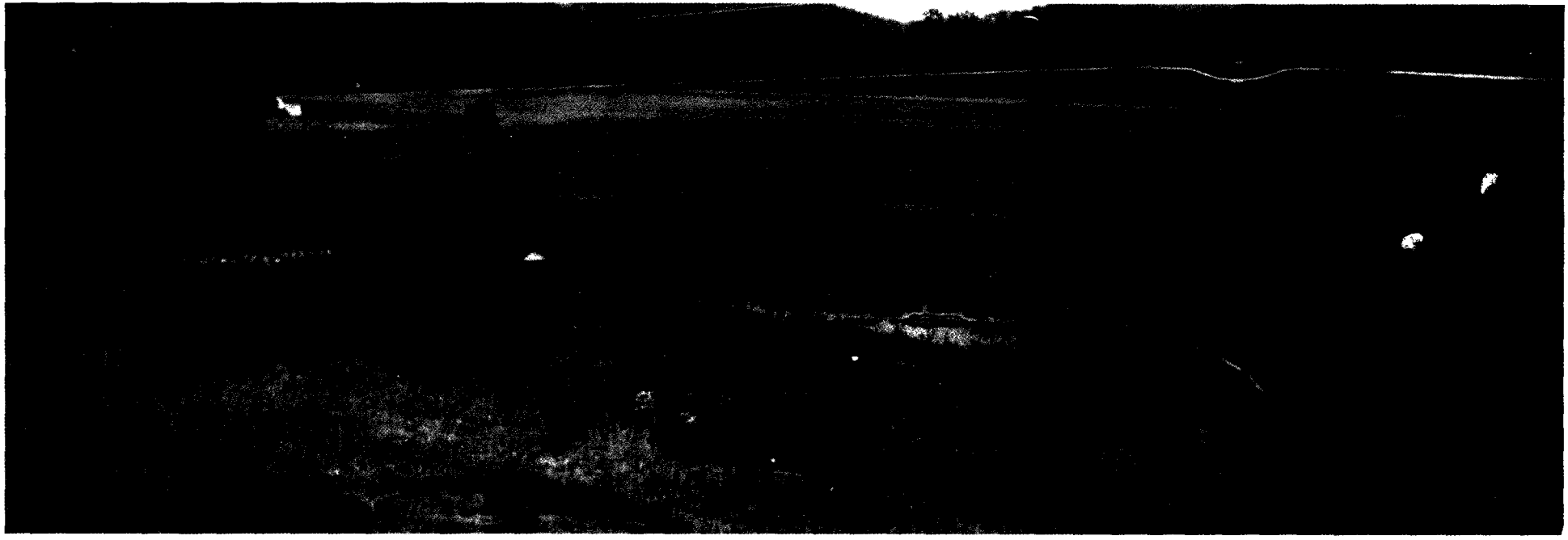

Exhibit 6a. PennDOT Bryan Mills wetland creation site -- south half

Date: July 30, 1990

Exhibit 6b. PennDOT Bryan Mills wetland creation site -- north half

(i.e., branching burreed) suggested nutrient and/or hydrology deficiencies on site. A lack of organic matter has been suggested as the reason for the expanse of bare ground at the wetland creation site.

Possible remedial action needed to improve the wetland creation site includes the placement of impervious material on site to improve water retention and the addition of organic matter to promote vegetation growth. Soil analysis and more extensive sampling of the ground water hydrology is needed to understand how soil content, soil permeability, and ground water fluctuation contribute to site conditions should remedial action be required for the site.

After nearly 2 growing seasons, the PennDOT Bryan Mills site was designated a non-effective palustrine wetland creation mitigation site. This determination was based upon the established effectiveness criteria used to assess the percent of dominant hydrophytes observed in the seven vegetation units and supported by the extent of effective/partially effective wetland

acreage created at the site. The prevalence of yellowing, wilted herbs and shrubs, as well as shrub mortality supports the non-effective site determination.

The presence of FACU ruderal plants as dominant species in the vegetation units was a factor in classifying the site as unsuccessful. If the occurrence of ruderal species was primarily related to site disturbance, rather than as a consequence of site hydrology in addition to disturbance, the extent of areal cover by these species would be expected to decrease with time.

The PennDOT Bryan Mills site did have an area of effective wetland creation which was located at the lowest point on site. The palustrine open water and the adjacent palustrine emergent wetlands appeared to maintain constant standing water and/or surface-saturated soils. The hydrology source for this area was intercepted ground water and the relocated stream.

Site plans specified ground water as a key source of hydrology for the wetland creation site during periods of low streamflow. The fluctuating water table and lack of water retention capacity associated with Basher silt loam soils may account for the extent and severity of hydrophytic vegetation stress observed on a majority of the site and the non-effective rating for 4 of the 7 vegetation units. A deficiency of organic matter/nutrients could also be a source of vegetation stress as extensive surface soil removal was required to construct the site.

If remedial action is required for the site, soil analysis and more extensive information regarding the hydroperiod would be needed to understand how soil content, soil permeability, ground water fluctuations and surface flow contribute to existing site conditions. The placement of impervious material on site to improve water retention may be required to make the entire wetland creation site effective.

Effectiveness of Wetland Creation Evaluation Methodology

The effectiveness criteria and methodology used to evaluate the percent of dominant species at the wetland creation sites were appropriate, given the literature available, limited field evidence of hydric soil characteristics expected at newly created wetlands, and the dynamics of field hydrology. Nonetheless, a change in the method of determining overall site effectiveness is suggested in order to simplify site evaluation. The use of only two effectiveness criteria, effective and non-effective, to assess vegetation units would facilitate evaluating overall wetland creation site success. After using the effectiveness criteria (i.e., percent of dominant hydrophytes) to evaluate each vegetation unit, the total area of the effective vegetation units could be used to determine overall site success. For example: If $\geq$85% of the wetland acreage created is determined to be effective, the entire site would be considered successful.

The data collected on vegetation vigor and percent bare ground contributed significantly to the analysis of site conditions. A detailed soils investigation would enhance the assessment of the growth medium and substrate at the wetland creation site as well.

The comparison of wetland creation sites to natural wetland reference sites could provide information regarding the degree to which creation sites resemble natural wetlands. Yet, the time required to identify and assess reference sites may add a prohibitive cost to wetland creation evaluation projects.

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APPENDIX A

List of Section 404
Permit Applications Reviewed

APPENDIX A

List of section 404 permit applications reviewed

As of May 7, 1990 139 projects were reviewed that involved section 404 permit applications for permanent discharges into palustrine wetlands in Pennsylvania from 1985 through 1989. The 47 projects for which EPA or FWS recommended wetland creation have been marked with an asterisk (*).

Baltimore District

*Altoona City Authority (NABOP-RR-87-0621)
Andrew and Pauline Verost (NABOP-RR-1293)
*Anthony Kenia (NABOP-RE-89-1507-4)
*Borough of Bellefonte (NABOP-RE-87-18-4-3)
Borough of Galeton (CENABOP-RR-89-2767-8)
*Borough of Huntingdon (NABOP-RE-86-0435-1)
Centre Township Supervisors (NABOP-RE-88-2087)
Chad-Mor, Inc. (NABOP-RR-87-0249)
*Deer Creek Business Park (NABOP-RR-86-1431)
Delmar Zeisloft -- Zeisloft Construction Co. (CENAB-OP-RR-87-1831-3)
Dole E. McGuire (NABOP-RR-86-0059)
Donald A. Kegarise (NABOP-RE-89-1562-6)
Francis Burnier (CENABOP-RE-88-1948-4)
*Fred W. Bowser -- PennDOT (NABOP-RR-86-0309)
*Fred W. Bowser -- PennDOT (NABOP-RE-88-0649)
*Fred W. Bowser -- PennDOT (NABOP-RE-89-1968)
Greenfield Township Supervisors (NABOP-RE-89-0759-4)
Hammermill Paper Group (NABOP-RE-87-0023-4)
Hardee's Food Systems, Inc. (NABOP-RR-86-0799)
Hempt Brothers, Inc. (NABOP-RR-86-1193)
John and Grace Nagle (NABOP-RR-86-1204)
Lake Benton Peat Moss Co., Inc. (NABOP-RR-86-0057)

Montdale Association, Inc. (CENABOP-RR-89-3375-4)

*PennDOT -- District 8-0 (NABOP-RR-87-1638-3)

*PennDOT (NABOP-RE-89-1577)

PennDOT (NABOP-RE-87-0243-1)

Pennsylvania Fish Commission (NABOP-RR-86-1388)

*Pennsylvania Fish Commission (NABOP-RE-89-0472)

Pennsylvania Fish Commission (NABOP-RE-88-3783-4)

Pennsylvania Peat Moss, Inc. (NABOP-RR-87-0408)

Philadelphia Electric Power Company (NABOP-RR-86-1389)

Raymond L. Wolfe (NABOP-RR-85-1358)

Richard Bumgard -- Penguard Construction, Inc. (NABOP-RE-85-0833-1)

Richard Kearny (CENAB-OP-R-87-1407-6)

Richard R. Thorpe (NABOP-RR-87-0222-revised)

Reichdrill, Inc. (NABOP-RR-85-1294)

R.N. Fitch & Sons, Inc. (CENAB-OP-RE-88-2907-6)

Robert and Alice Foster (CENAB-OP-RE-87-0777-4)

Robert M. Mumma -- Bobali Corporation (NABOP-RE-85-0407-1)

Scranton Lackawanna Industrial Building Co. (NABOP-RR-86-1192)

Shamokin Dam Borough (NABOP-RR-87-0885-3)

Stonesifer Trust Committee (CENAB-OP-RE-89-1047)

Sugarloaf Peat Co. (NABOP-RR-86-0648)

William L. Schutter -- Atlantic Corporation (NABOP-RE-87-1381-6)

Wissinger's Bellemeade, Inc. (NABOP-RR-87-0369)

Buffalo District

Bureau of State Parks -- DER (NCBCO-S-85-476-7

*Ninth Coast Guard District (LOP -- 85-263-1)

Philadelphia District

Borough of Beaver Meadows (NAPOP-R-85-0047-5)

Buck Hill Falls Co. (CENAP-OP-R-88-0054-16 (NP26)

Burton L. Mott (NAPOP-R-86-0125-12 (NP26)

*Chessie Systems Railroads (NAPOP-R-85-0676-1)

*Chester County Water Resources Authority (CENAP-OP-R-87-1127-16)

*City of Philadelphia (CENAP-OP-R-88-0340-13)

*City of Philadelphia (NAPOP-R-86-0344-12)

*Claude DeBotton (CENAP-OP-R-86-1472-13; originally NAPOP-R-86-1472 (DA-NP26)

Conrad and Barbara Mock (CENAP-OP-R-88-0841-11)

Cross Keys Development Co. (CENAP-OP-R-88-0014-16 (NP26)

Croton Lake Corporation (NAPOP-R-86-0538-13)

Cumru Township (CENAP-OP-R-87-1220-15)

DER -- Bureau of State Parks (NAPOP-R-85-1129-5)

DER -- Bureau of State Parks (CENAP-OP-R-88-0392-16)

E.J. Callaghan & Co. (CENAP-OP-R-88-0536-17 (NP26)

*Ferguson and Flynn (CENAP-OP-R-88-0025-16)

*Fred Bowser -- PennDOT (CENAP-OP-R-86-1035-11)

*Fred Bowser -- PennDOT (NAPOP-R-85-0390-11)

Gene Evans -- Blue Ridge Peat Farms (NAPOP-R-86-0258-12)

George Hatchard (NAPOP-R-86-0418-12 (DA NP26)

Guya and Charles Lloyd (CENAP-OP-R-88-3135-13)

Hyponex Corporation (NAPOP-R-85-0790-12)

*Kode Development Association, Inc. (NAPOP-87-0265-1 (NP26); formerly NAPOP-R-86-1013-1 (DANP26)

James and Edward Strasser (NAPOP-R-86-0169-12)

Lynch Corporation (NAPOP-R-85-0606-11)

Macoby Run Golf Course (CENAP-OP-R-89-0792-16 (PDN)

Midas Realty Corporation (NAPOP-R-86-0486-11)

Naaman's Creek Center (CENAP-OP-R-89-1917-11)

Nicholas Hameza (CENAP-OP-R-88-1418-1)

Nolen Investors (CENAP-OP-R-87-0061-13 (Draft)

*PennDOT (CENAP-OP-89-1659-16 (NP26)

*PennDOT (NAPOP-R-87-0139-13)

*PennDOT (NAPOP-R-86-0298-12)

*Pennsylvania Turnpike Commission (NAPOP-R-85-1123 (DA NP26)

*Pennsylvania Turnpike Commission (CENAP-OP-R-88-0685-11 (PDN)

Philadelphia Industrial Development Corporation (CENAP-OP-R-87-1451-13)

Robert Haase -- International Peat, Inc. (NAPOP-R-85-1023-12)

Robert Smith (CENAP-OP-R-89-1877-24)

Russell Angstadt (NAPOP-R-85-0414)

Saw Creek Club, Inc. (NAPOP-R-85-0009-11)

Seltzer Organization (NAPOP-R-87-0733-12 (NP26); formerly NAPOP-R-86-0080-13)

Thomas Treadway -- Tri-State Transfer Co. (CENAP-OP-R-88-1011-22)

*Toll Brothers, Inc. (CENAP-OP-R-0773-15)

*U.S. Department of the Navy (CENAP-OP-R-89-1231-1)

*Villages and the Makefields, Palmer Farm Village and Laurel Oaks (PDN number not available)

Pittsburgh District

Albert Lang (ORPOP-F-85-71)

Alfred J. Palanky (CEORP-OR-87-116)

*Allegheny County -- Department of Aviation (ORPOP-F-86-14)

Arthur White (ORPOR-F-86-112)

Beacon Truck Stop, Inc. (ORPOP-F-86-26)

Beaver Meadow Industrial Park (CEORP-OR-87-129)

*Borough of Grove City (CEORP-OR-88-53)

Borough of Scottdale (ORPOP-F-85-63)

Burke-Parsons-Bowlby Corporation (ORPOP-F-85-95)

*City of DuBois (ORPOP-85-36)

City of DuBois (CEORP-OR-89-49)

Clyde G. Mostoller (ORPOR-F-86-96)

Coleman Brothers Enterprises (ORPOP-F-86-20)

*Coudersport Area School District (ORPOR-F-87-43)

*County of Westmoreland (ORPOP-F-85-56)

Curtis & Son, Inc. (ORPOP-F-86-107)

D.M. Boyd Co. (ORPOR-F-87-16)

Donald Della (ORPOP-F-86-100)

*Doran and Associates, Inc. (ORPOP-F-85-66)

Doran and Associates, Inc. (ORPOP-F-85-93)

Edwin W. Gott, Jr. (ORPOP-F-86-86)

Erie National Wildlife Refuge (CEORP-OR-89-19)

*Erie National Wildlife Refuge (CEORP-OR-89-40)

*Franklin Township Municipal Sanitary Authority (CEORP-OR-88-97)

*Fred R. Bowser -- PennDOT (ORPOP-F-86-6)

*Fred R. Bowser -- PennDOT (ORPOR-F-87-5)

*Fred R. Bowser -- PennDOT (CEORP-OR-88-31)

*Fred R. Bowser -- PennDOT (CEORP-OR-88-25)

Freeport Terminals, Inc. (ORPOP-F-85-28)

George and Janet Marie Dunlap (CEORP-OR-88-109)

George D. Zamias (ORPOR-F-87-27)

John Kerna (CEORP-OR-87-96)

Kirila Contractors, Inc. (ORPOP-F-85-88)

*Lee-Simpson Associates, Inc. (ORPOP-F-86-3)

Lee-Simpson Associates, Inc. (ORPOP-F-85-105)

*McDonald's Corporation (CEORP-OR-89-70)

Meridian Exploration Corporation (ORPOP-F-86-85)

Midway Coal Company (ORPOP-F-86-5; originally 85-98)

Nace Brothers Chrysler Plymouth (CEORP-OR-87-91)

*Neil Singer -- Sugar Grove Gas Gathering (ORPOR-F-87-2)

OHM Associates (CEORP-OR-87-79)

Pearl E. Mattis (ORPOR-F-86-94)

*Resource Conservation Corporation (CEORP-OR-88-7)

*Rev. F. Thomas Suppa -- St. Leo Church (ORPOP-F-86-106)

Sky Haven Coal, Inc. (ORPOP-F-85-108)

Thomas and Craig Gnagey (87-6)

*Tom McLaughlin (ORPOP-F-85-87)

APPENDIX B

Status of Wetland Creation Sites
that
EPA and FWS Recommended as Mitigation for Section 404 Discharges

The information on wetlands creation sites contained herein was compiled from the records of the U.S. Fish and Wildlife Service and U.S. Environmental Protection Agency Region III. In addition, information was provided by the staff of the Philadelphia District Corps of Engineers, Pittsburgh District Corps of Engineers, U.S. Fish and Wildlife Service, and Pennsylvania Department of Transportation.

The information outlined below is based on that obtained as of July 1990. A blank item indicates that information was lacking on this aspect of the project. The individual or agencies that provided information on the status of a wetland creation site has been indicated as the source.

These wetland creation sites are marked with an asterisk (*) designate information obtained subsequent to the preparation of Part I of the report and Appendix A.

Baltimore District

Applicant: Altoona City Authority (NABOP-RR-87-0621)
Location: Logan Township, Blair County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: PEM -- 0.5 acres
Status:

Applicant: Anthony Kenia (NABOP-RE-89-1507-4)
Location: Tunkhannock Township, Wyoming County
Date permit issued:
Permit issued required mitigation: Public Notice contained creation plan
Type and size of wetland: PEM/PAB -- 1.85 acres
Status:

Applicant: Borough of Bellefonte (NABOP-RE-87-1804-3)
Location: Spring Township, Centre County
Date permit issued:
Permit issued required mitigation: Yes
Type of wetland: PEM/POW/PSS -- approximately 4 acres
Status: Site Construction 5-7/1989; stream relocated into site 4/1990; site planted 4/28/1990.
Source: Baltimore District Army Corps of Engineers; Helen K Fay Consultant

Applicant: Borough of Huntingdon (NABOP-RE-86-0435-1)
Location: Smithfield Township, Huntingdon County
Date permit issued: 6/25/1986
Permit issued required mitigation: Yes

Type and size of wetland: POW/PSS -- 0.67 acre
Status: Constructed 1986; shrubs planted 9/1987; see site evaluation in report
Source: Baltimore District Corps of Engineers; Jay Coffman, Borough of Huntingdon

Applicant: Cedarwood Construction Co., Inc.*
Location: East Hempfield and Manheim Townships, Lancaster County
Date permit issued:
Permit issued required mitigation: Yes
Type and size of wetland: Not specified
Status: Constructed -- date unknown; site largely unvegetated in October 1988 due to extensive use by off road vehicles
Source: N. L. Kline

Applicant: Deer Creek Business Park (NABOP-RR-86-1431)
Location: Shrewsbury, York County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: POW -- 4 sites of 0.03 acres each
Status:

Applicant: Fred Bowser, PennDOT (NABOP-RE-88-0649)
Location: Old Lycoming and Lycoming Townships, Lycoming County
Date permit issued: 10/7/1988
Permit issued required mitigation: Yes --Public Notice contained creation plan
Type of wetland: PEM/PSS/PFO -- 3.9 acres
Status: Constructed 1989; shrub/sapling plantings to be completed in spring 1990; reported for remedial action by design consultant; see project narrative for status as of 5/31/90 site visit
Source: Gannett Fleming Transportation Engineers; Pennsylvania Department of Transportation

Applicant: Fred Bowser, PennDOT (NABOP-RR-86-0309)
Location: Lycoming County
Date permit issued:
Permit issued required mitigation:
Type of wetland: PEM/PSS -- acres not specified
Status:

Applicant: Fred Bowser, PennDOT (NABOP-RE-89-1968)
Location: Lancaster, Lancaster County
Date permit issued:
Permit issued required mitigation: Public Notice contained creation plan
Type and size of wetland: POW/PEM/PSS -- 0.75 - 1.0 acre
Status:

Applicant: PennDOT (NABOP-RE-89-1577)
Location: Wilkes-Barre, Luzerne County
Date permit issued: 5/15/1989
Permit issued required mitigation:
Type and size of wetland: PEM/PSS -- 0.75 and 1.5 acres; PSS/PFO -- 3.4 acres
Status:

Applicant: PennDOT (NABOP-RR-87-1638-3)
Location: Harrisburg Township, Adams County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: PEM -- 0.2 acre
Status: Constructed about 1989
Source: Pennsylvania Department of Transportation

Applicant: Pennsylvania Fish Commission (NABOP-RE-89-0472)
Location: Benner Township, Centre County
Date permit issued: Yes
Permit issued required mitigation:
Type and size of wetland: PEM -- 1.0 acre
Status: Project construction and wetland creation mitigation not yet started
Source: Fish and Wildlife Service

Buffalo District

Applicant: Ninth Coast Guard District (LOP - 85-263-1)
Location: City of Erie, Erie County
Date permit issued: 7/11/1985
Permit issued required mitigation: Yes
Type and size of wetland: POW -- 0.4 acre
Status: Wetland constructed; emergent fringes of cattails and burreed; mallards nesting and feeding onsite.
Source: Fish and Wildlife Service

Philadelphia District

Applicant: Caln Township (CENAP-OP-R-88-2747-15)*
Location: Caln Township, Chester County
Date permit issued:10/24/1989
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 0.9 acre
Status: No indication of mitigation status in files
Source: Philadelphia District Corps of Engineers

Applicant: Chessie Systems Railroads (NAPOP-R-0676-1(DA-NP26)
Location: Upper Chichester Township, Delaware County
Date permit issued: 9/15/1985
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 1.13 acres
Status: Constructed 1986; planted 1986
Source: Philadelphia District Corps of Engineers; Fish and Wildlife Service

Type and size of wetland: POW/PSS -- 0.67 acre
Status: Constructed 1986; shrubs planted 9/1987; see site evaluation in report
Source: Baltimore District Corps of Engineers; Jay Coffman, Borough of Huntingdon

Applicant: Cedarwood Construction Co., Inc.*
Location: East Hempfield and Manheim Townships, Lancaster County
Date permit issued:
Permit issued required mitigation: Yes
Type and size of wetland: Not specified
Status: Constructed -- date unknown; site largely unvegetated in October 1988 due to extensive use by off road vehicles
Source: N. L. Kline

Applicant: Deer Creek Business Park (NABOP-RR-86-1431)
Location: Shrewsbury, York County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: POW -- 4 sites of 0.03 acres each
Status:

Applicant: Fred Bowser, PennDOT (NABOP-RE-88-0649)
Location: Old Lycoming and Lycoming Townships, Lycoming County
Date permit issued: 10/7/1988
Permit issued required mitigation: Yes --Public Notice contained creation plan
Type of wetland: PEM/PSS/PFO -- 3.9 acres
Status: Constructed 1989; shrub/sapling plantings to be completed in spring 1990; reported for remedial action by design consultant; see project narrative for status as of 5/31/90 site visit
Source: Gannett Fleming Transportation Engineers; Pennsylvania Department of Transportation

Applicant: Fred Bowser, PennDOT (NABOP-RR-86-0309)
Location: Lycoming County
Date permit issued:
Permit issued required mitigation:
Type of wetland: PEM/PSS -- acres not specified
Status:

Applicant: Fred Bowser, PennDOT (NABOP-RE-89-1968)
Location: Lancaster, Lancaster County
Date permit issued:
Permit issued required mitigation: Public Notice contained creation plan
Type and size of wetland: POW/PEM/PSS -- 0.75 - 1.0 acre
Status:

Applicant: PennDOT (NABOP-RE-89-1577)
Location: Wilkes-Barre, Luzerne County
Date permit issued: 5/15/1989
Permit issued required mitigation:
Type and size of wetland: PEM/PSS -- 0.75 and 1.5 acres; PSS/PFO -- 3.4 acres
Status:

Applicant: PennDOT (NABOP-RR-87-1638-3)
Location: Harrisburg Township, Adams County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: PEM -- 0.2 acre
Status: Constructed about 1989
Source: Pennsylvania Department of Transportation

Applicant: Pennsylvania Fish Commission (NABOP-RE-89-0472)
Location: Benner Township, Centre County
Date permit issued: Yes
Permit issued required mitigation:
Type and size of wetland: PEM -- 1.0 acre
Status: Project construction and wetland creation mitigation not yet started
Source: Fish and Wildlife Service

Buffalo District

Applicant: Ninth Coast Guard District (LOP - 85-263-1)
Location: City of Erie, Erie County
Date permit issued: 7/11/1985
Permit issued required mitigation: Yes
Type and size of wetland: POW -- 0.4 acre
Status: Wetland constructed; emergent fringes of cattails and burreed; mallards nesting and feeding onsite.
Source: Fish and Wildlife Service

Philadelphia District

Applicant: Caln Township (CENAP-OP-R-88-2747-15)*
Location: Caln Township, Chester County
Date permit issued:10/24/1989
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 0.9 acre
Status: No indication of mitigation status in files
Source: Philadelphia District Corps of Engineers

Applicant: Chessie Systems Railroads (NAPOP-R-0676-1(DA-NP26)
Location: Upper Chichester Township, Delaware County
Date permit issued: 9/15/1985
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 1.13 acres
Status: Constructed 1986; planted 1986
Source: Philadelphia District Corps of Engineers; Fish and Wildlife Service

Applicant: Chester County Water Resources Authority (CENAP-OP-R-87-1127-16)
Location: West Caln Township, Chester County
Date permit issued: 12/3/1987
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 11 acres
Status:

Applicant: City of Philadelphia (CENAP-OP-R-88-0340-13 and 86-0322)
Location: Tinicum Township, Delaware County
Date permit issued: 5/23/1988
Permit issued required mitigation: Yes
Type and size of wetland: Tidal wetlands -- 2.6 acres created or enhanced
Status: No indication of status in files
Source: Philadelphia District Corps of Engineers

Applicant: City of Philadelphia (NAPOP-R-86-0344-12)
Location: Philadelphia Airport, Philadelphia County
Date permit issued: 5/21/1986
Permit issued required mitigation: Yes
Type and size of wetland: Tidal wetlands -- 2.2 acres
Status: Most work completed as of 10/19/89
Source: Philadelphia District Corps of Engineers

Applicant: Claude DeBotton (CENAP-OP-R-86-1472-13 (NP26) and 88-1191)
Location: Edgemont Township, Delaware County
Date permit issued: 7/19/88
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 1.4; PEM -- 0.7
Status: Site constructed; Corps has monitoring reports
Source: Philadelphia District Corps of Engineers

*Applicant: Cross Keys Development Co. NP-26
Location: Plumstead Township, Bucks County
Date permit issued: 2/16/1988
Permit issued required mitigation: Yes
Type and size of wetland: PEM or POW in detention basins -- 2.7 acres
Status: No status indicated in files
Source: Philadelphia District Corps of Engineers

Applicant: Ferguson and Flynn (CENAP-OP-R-89-0025-16(NP26); formerly CENAP-OP-88-0025-16(PDN)
Location: Bethel Township, Delaware County
Date permit issued: 4/7/1989
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 1.61 acres
Status: Work in progress as of 9/18/1989
Source: Philadelphia District Corps of Engineers

Applicant: Fred Bowser, PennDOT (CENAP-OP-R-86-1035-11) -- Blue Route Sections 200-600, D3T
Location: Delaware and Montgomery Counties
Date permit issued: 11/23/1987; revised 1/10/1989
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS/POW -- 4.31 acres
Status: Constructed in 1988
Source: Pennsylvania Department of Transportation; Philadelphia District Corps of Engineers

Applicant: Fred Bowser, PennDOT (NAPOP-R-85-0390-11) -- Blue Route Section 100
Location: Ridely Township, Delaware County
Date permit issued: 12/3/1985; amended 4/13/1988
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS/POW -- 6.2 acres
Status: Three (3) acres constructed in 1987; remaining 3.2 acres incorporated into the mitigation for Sections 200-600, D3T due to abandonment of the Paper Products mitigation site
Source: Pennsylvania Department of Transportation

Applicant: Kode Development Associates, Inc. (NAPOP-87-0265-1(NP26)
Location: Borough of Bristol, Bucks County
Date permit issued: 3/25/1987
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 3.52 acres
Status: Date of construction uncertain; partially planted as of 2/1990; remedial work in progress; site being monitored by Fish and Wildlife Service and Philadelphia District Corps
Source: Fish and Wildlife Service; Philadelphia District Corps of Engineers

*Applicant: Oakleigh Farms (CENAP-OP-R-89-0745-22(NP12, 14, 26)
Location: Buckinghanm Township, Bucks County
Date permit issued: 5/22/1989
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS -- 0.5 acres
Status: No status on file
Source: Philadelphia District Corps of Engineers

Applicant: PennDOT (CENAP-OP-R-89-1659-16(NP26)
Location: Horsham Township, Montgomery County
Date permit issued: 8/31/1989
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 0.57 acre
Status: Status not available
Source: Philadelphia District Corps of Engineers

Applicant: PennDOT (NAPOP-R-87-0139-13)
Location: East Whiteland Township, Chester County
Date permit issued: 4/21/1987
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 1.8 acres
Status: No indication of status in files
Source: Philadelphia District Corps of Engineers

Applicant: PennDOT (NAPOP-R-86-0298-12)
Location: Lehigh and Northhampton Counties
Date permit issued: 12/8/1986
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS/POW -- 1 , 2, and 2.9 acre sites per Corps; 1.5, 2, and 3 acre sites per PennDOT
Status: Constructed 1986/1987
Source: Pennsylvania Department of Transportation

Applicant: Pennsylvania Turnpike Commission (NAPOP-R-85-1123(DANP26)
Location: Uwchlan Township, Chester County
Date permit issued: 2/6/1986
Permit issued required mitigation: Yes
Type and size of wetland: PEM/POW/PSS -- 5 acres
Status: Construction completed 9/15/1987; mitigation evaluated by Fish and Wildlife Service (Brown 1988)
Source: Philadelphia District Corps of Engineers; Fish and Wildlife service

Applicant: Pennsylvania Turnpike Commission (CENAP-OP-R-88-0685-11)
Location: Plymouth Township, Montgomery County
Date permit issued:
Permit issued required mitigation: Yes; Site to be selected within 60 days of permit issuance
Type and size of wetland: PEM/PSS -- 2.49 acres
Status:

*Applicant: Philadelphia Industrial Development Corporation (CENAP-OP-R-1451-13)
Location: Tinicum Township, Delaware County
Date permit issued: 12/30/1987
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 2.2 acres
Status:Construction in progress per 4/27/1989 Corps field report
Source: Philadelphia District Corps of Engineers

Applicant: Toll Brothers, Inc. (CENAP-OP-R-0773-15)
Location: Lower Makefield Township, Bucks County
Date permit issued: 7/28/1987
Permit issued required mitigation:
Type and size of wetland: PEM and PSS -- total of 2.17 acres
Status:

Applicant: U.S. Department of the Army (CENAP-OP-R-89-1231-1)
Location: Philadelphia County
Date permit issued:
Permit issued required mitigation:
Type and size of wetland: Not specified
Status:

Applicant: Villages at the Makefields, Palmer Village and Laurel Oaks (PDN No. Unknown)
Location: Makefield and Middletown Townships, Bucks County
Date permit issued:

Permit issued required mitigation:
Type and size of wetland: Type not specified -- 1.88 acres
Status:

Pittsburgh District

Applicant: Allegheny County Department of Aviation (ORPOP-F-86-14)
Location: Enlow, Allegheny County
Date permit issued: 5/5/1986
Permit issued required mitigation: Yes
Type and size of wetland: POW/PEM/PSS -- 6 acres
Status: Not completed
Source: Pittsburgh District Corps of Engineers

Applicant: Borough of Grove City (CEORP-OR-88-53)
Location: Grove City, Mercer County
Date permit issued: 2/2/1989
Permit issued required mitigation: Yes
Type and size of wetland: PFO/PSS -- 1.5 acres
Status: Completed -- needs to be field checked
Source: Pittsburgh District Corps of Engineers

Applicant: City of DuBois (ORPOP-85-36)
Location: City of DuBois, Clearfield County
Date permit issued:
Permit issued required mitigation:Public Notice contained creation plan
Type and size of wetland: PEM/POW/PSS -- 0.57 acre
Status: Site was not developed so mitigation was not constructed
Source: Pittsburgh District Corps of Engineers

Applicant: Coudersport Area School District (ORPOR-F-87-43)
Location: Coudersport, Potter County
Date permit issued: 6/18/1987
Permit issued required mitigation: Yes
Type and size of wetland: PEM -- 0.19 acre
Status: Constructed in 1988; emergent wetland -- diverse wet meadow plant community developed
Source: Fish and Wildlife Service

Applicant: County of Westmoreland (ORPOP-F-85-56)
Location: Westmoreland and Fayette Counties
Date permit issued: 8/1985
Permit issued required mitigation: Public Notice contained creation plan
Type and size of wetland: PSS -- 5 acres
Status: Constructed 1989; to be planted with 5 shrub species during the summer 1990; site borders lake recently built on park land
Source: Fish and Wildlife Service

Applicant: Doran and Associates, Inc. (ORPOP-F-85-66)
Location: Venango Township, Erie County
Date permit issued: Permit number 85079 issued -- date unknown
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 0.11 acre
Status:

Applicant: Erie National Wildlife Refuge (CEORP-OR-89-40)
Location: Guys Mills, Crawford County
Date permit issued: Permit issued -- 3/17/1986
Permit issued required mitigation: Public Notice contained creation plan
Type and size of wetland: POW/PEM -- 6 acres created for waterfowl habitat (0.05 acres filled)
Status: Constructed as a wet meadow that is flooded in fall for waterfowl
Source: Fish and Wildlife Service

Applicant: Franklin Township (CEORP-OR-88-97)
Location: Murraysville, Westmoreland County
Date permit issued: 7/3/1989
Permit issued required mitigation: Yes
Type and size of wetland: Type not specified -- 2.1 acres
Status: Not built -- mitigation plan and site still needed
Source: Fish and Wildlife Service; Pittsburgh District Corps of Engineers

Applicant: Fred Bowser, PennDOT (ORPOP-F-86-6)
Location: Franklin Park Borough and Ohio Township, Allegheny County
Date permit issued: 4/25/1986
Permit issued required mitigation: Yes
Type and size of wetland: PEM/PSS/POW -- 23.7 acres
Status: 8.7 acres constructed about 2 years ago; 15 acres under construction in Spring 1990
Source: Pennsylvania Department of Transportation

Applicant: Fred Bowser, PennDOT (CEORP-OR-88-25)
Location: Fallowfield Township, Washington County
Date permit issued: 5/1988
Permit issued required mitigation: Yes
Type and size of wetland: PEM/POW/PSS/PFO -- 2 and 3 acres
Status: Under construction in spring 1990; mudslide occurred after construction -- wetland being dug out and replanted
Source: Pennsylvania Department of Transportation; fish and wildlife Service

Applicant: Fred Bowser, PennDOT (CEORP-OR-88-31)
Location: Licking and Beaver Townships, Clarion County
Date permit issued: 7/1988
Permit issued required mitigation: No
Type and size of site: Type not specified -- 0.03 acre
Status: No mitigation required as no response from federal agencies (Pittsburgh COE); 0.03 acre creation recommended by Fish and Wildlife Service
Source: Pittsburgh District Corps of Engineers; Fish and Wildlife Service

Applicant: Fred Bowser, PennDOT (ORPOR-F-87-5)
Location: Zelienople, Butler County
Date permit issued: 3/30/1987
Permit issued required mitigation:
Type and size of wetland: PEM/PSS/POW -- 1.0 acre
Status: Constructed early 1987; Replanted 5/1/1990 due to devegetation by waterfowl
Source: Pennsylvania Department of Transportation

Applicant: Lee-Simpson Associates, Inc. (ORPOP-F-86-3)
Location: DuBois, Clearfield County
Date permit issued: 6/27/1986
Permit issued required mitigation: Yes
Type and size of wetland: POW/PEM/PSS -- 11.4 acres
Status: Completed 1989; area south of Beaver Drive was replanted during week of 7/1/1990; 9 acres site never has enough water; 2.5 acres site experiences severe water fluctuations -- will probably develop into solid stand of cattails
Source: Fish and Wildlife Service; Pittsburgh District Corps of Engineers

Applicant: McDonald's Corporation (CEORP-OR-89-70)
Location: Somerset, Somerset County
Date permit issued:
Permit issued required mitigation:
Permit issued required mitigation:
Type and size of wetland: Type not specified -- 1.0 acre
Status: No construction or mitigation as of 7/3/1990; mitigation to be onsite
Source: Fish and Wildlife Service; Pittsburgh District Corps of Engineers

Applicant: Neil Singer, Sugar Grove Gas Gathering (ORPOR-F-87-2)
Location: Sugar Grove Borough, Warren County
Date permit issued: 8/20/1987
Permit issued required mitigation: Yes -- 1:1 creation
Type and size of wetland: PEM -- 0.2 acre
Status: Not constructed as of 4/1990
Source: Pittsburgh District Corps of Engineers

Applicant: Resource Conservation Corporation (CEORP-OR-88-7)
Location: Shade, Somerset County
Date permit issued: Processing suspended pending issuance of DER permits for landfill facility
Permit issued required mitigation: Public Notice contained creation plan; additional plans submitted by applicant
Type and size of wetland: POW/PAB/PEM/PSS/PFO -- 40 acres
Status: Final mitigation plans not approved; DER permits still pending on landfill
Source: Pittsburgh District Corps of Engineers

Applicant: Rev. F. Thomas Suppa, St. Leo Church (ORPOP-F-86-106)
Location: Sandy Township, Clearfield County
Date permit issued: 12/17/1986
Permit issued required mitigation:

Type and size of wetland: PSS -- 0.14 acre
Status: Shrub-scrub wetland developed along edge of pond; fish ladder required by Corps not built
Source: Fish and Wildlife Service; Pittsburgh District Corps of Engineers

Applicant: Tom McLaughlin (ORPOP-F-85-87)
Location: Mill Village, Erie County
Date permit issued: 1/8/1986
Permit issued required mitigation:
Type and size of wetland: PEM/PSS -- 1.95 acres
Status: Wetland discharge never started -- permit expired 12/21/1989
Source: Pittsburgh District Corps of Engineers

Applicant: Willowbrook Mining Co. (Permit No. 86152)
Location: Washington Township, Lawrence County
Date permit issued: 3/31/1987
Permit issued required mitigation: Yes
Type and size of wetland: POW/PSS/PEM/Deepwater -- 27.7 acres
Status: Completed
Source: Fish and Wildlife Service; Norma L. Kline

APPENDIX C

Field Data
Borough of Huntingdon
Wetland Creation Site

Appendix C contains the field data used to evaluate the effectiveness of the Borough of Huntingdon wetland creation site.

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: A (approximately 0.1 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
1. spadderdock	< 1%	T	--	None
2. least spikerush	< 1%	T	--	None
3. marsh seedbox	< 1%	T	--	None
4. blunt spikerush	< 1%	T	--	None

Sum of Midpoints --
Dominance Threshold Number Equals 50% x Sum of Midpoints --
20% of Total Midpoint Value --

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Unvegetated area approximately 25 feet by 30 feet inundated with water ranging from surface to 2 inches in depth.

Approximately 85% of the bare soil surface still saturated or damp from recent inundation.

Approximately 95% of the bare soil surface exhibited drying, cracked mud; about 90% of the same area covered with living/dried algae.

Surface of bare ground bordering Unit D (open water) was saturated in a band ranging from 0 to 38 inches in width (median = 15 inches) indicating the extent of inundation withdrawal since rain of 8/5/90.

The 3 soil samples taken in the unit to characterize soil saturation indicated*:

A1 -- surface: saturated (appeared recently inundated)
~ 2 inches: moist
~ 18 inches: moist

A2 -- ~ 10 inches: dry
~ 16 inches: moist
~ 20 inches: moist

A3 -- surface: saturated
~ 2 inches: saturated
~ 3 inches: moist

*All soil samples taken to a depth of ~ 18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
No dominant species onsite		

Percent of dominant species that are OBL, FACW, and/or FAC 0%

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: B (approximately 0.19 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. branching burreed (Sparganium androcladum)	80	6	85.5	1
*2. marsh seedbox (Ludwigia palustris)	60	5	63.0	2
*3. least spikerush (Eleocharis acicularis)	65	5	63.0	2
4. blunt spikerush	40	4	38.0	3
5. broad-leaf cattail	30	4	38.0	3
6. purple loosestrife	10	2	10.5	4
7. spadderdock	6	2	10.5	4
8. dotted smartweed	6	2	10.5	4
9. bitter dock	6	2	10.5	4
10. spotted jewelweed	5	1	3.0	5
11. grass #1	2	1	3.0	5
12. smartweed #1	1	1	3.0	5
13. ditch stone crop	1	1	3.0	5
14. willow-herb	1	1	3.0	5
15. monkey-flower	1	1	3.0	5
16. arrowhead	< 1	T	--	None
17. bugleweed	< 1	T	--	None
18. St. Johnswort	< 1	T	--	None
19. herb #1	< 1	T	--	None
20. grass #2	< 1	T	--	None
21. herb #2	< 1	T	--	None
22. false pimpernel	< 1	T	--	None
23. redleg	< 1	T	--	None
24. soft-stem bulrush	< 1	T	--	None
25. sedge	< 1	T	--	None

Sum of Midpoints 347.5
Dominance Threshold Number Equals 50% x Sum of Midpoints 173.75
20% of Total Midpoint Value 69.5

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
1. buttonbush	< 1	T	--	None

Sum of Midpoints --
Dominance Threshold Number Equals 50% x Sum of Midpoints --
20% of Total Midpoint Value --

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Approximately 40% of the surface of Vegetation Unit B was covered with cracked, drying mud.

Approximately 45% of the surface covered with a film of living/dried algae.

The 4 soil samples taken in the Vegetation Unit to characterize soil saturation indicated*:

B1 -- surface: saturated
~7 inches: moist
~9.5 inches: moist
~11 inches: moist
~13 inches: moist

B2 -- surface: saturated
~6 inches: moist
~8 inches: dry

B3 -- surface: moist
~6.5 inches: moist
~8.5 inches: moist

B4 -- surface: saturated
~2 inches: moist
~4 inches: moist

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Sparganium androcladum	OBL	Herb
2. Ludwigia palustris	OBL	Herb
3. Eleocharis acicularis	OBL	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 100%

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: C (approximately 0.14 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. least spikerush (Eleocharis acicularis)	66	5	63.0	1
*2. marsh seedbox (Ludwigia palustris)	50	4	38.0	2
*3. blunt spikerush (Eleocharis obtusa)	35	4	38.0	2
*4. dotted smartweed (Polygonum punctatum)	20	3	20.5	3
*5. branching burreed (Sparganium androcladum)	25	3	20.5	3
*6. false pimpernel (Lindernia dubia)	25	3	20.5	3
7. monkey-flower	15	2	10.5	4
8. redleg	15	2	10.5	4
9. bitter dock	15	2	10.5	4
10. willow-herb	15	2	10.5	4
11. ditch stone crop	15	2	10.5	4
12. smartweed #1	10	2	10.5	4
13. rice cutgrass	5	1	3.0	5
14. broad-leaf cattail	5	1	3.0	5
15. spikerush #3	5	1	3.0	5
16. flat sedge	1	1	3.0	5
17. spadderdock	1	1	3.0	5
18. herb #1	1	1	3.0	5
19. jewelweed	<1	T	--	None

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
20. blue vervain	< 1	T	--	None
21. boneset	< 1	T	--	None
22. soft rush	< 1	T	--	None
23. bedstraw	< 1	T	--	None
24. grass #1	< 1	T	--	None
25. bugleweed	< 1	T	--	None
26. smartweed #2	< 1	T	--	None
27. grass #2	< 1	T	--	None
28. grass #3	< 1	T	--	None

Sum of Midpoints	281.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	140.75
20% of Total Midpoint Value	56.3

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

There was no evidence of surface inundation.

The 2 soil samples taken in the Vegetation Unit to characterize soil saturation indicated*:

C1 -- surface: moist
~ 10 inches: moist
~ 18 inches: moist
C2 -- surface: moist
~ 9 inches: moist
~ 18 inches: moist

*All soil samples taken to a depth of ~ 18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Sparganium androcladum	OBL	Herb
2. Ludwigia palustris	OBL	Herb
3. Eleocharis acicularis	OBL	Herb
4. E. obtusa	OBL	Herb
5. Polygonum punctatum	OBL	Herb
6. Lindernia dubia	OBL	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 100%

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Name: Unit D (approximately 0.17 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
1. spadderdock	< 1	T	--	None
		Sum of Midpoints	--	

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Ground surface inundated with water from the surface to greater than 3 feet in depth (Rep., Borough of Huntingdon, pers. commun.).

During August 7, 1990 the open water area (Unit D) was flagged using the edge of surface inundation as the boundary line. During August 8 and 9, 1990, water marks and algae drift lines were observed around the periphery of the receding open water area. Based on water marks on snags anchored in open water area had recently been up to 4 inches deeper.

The soil was saturated at the surface at the edge of Unit D where water had receded since August 7, 1990.

The 1 soil sample taken in the Vegetation Unit to characterize soil saturation indicated*:

D1 -- surface: inundated with water
~ 2 inches: moist
~ 7 inches: moist

*Only 1 sample was taken as inundation made it impossible to find probe hole for a deeper sample.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. No dominant species		

Percent of dominant species that are OBL, FACW, and/or FAC N/A

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: E (approximately 0.01 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. spotted jewelweed (Impatiens capensis)	50	4	38.0	1
*2. path rush (Juncus tenuis)	15	2	10.5	2
*3. soft rush (J. effusus)	8	2	10.5	2
4. woolgrass	5	1	3.0	3
5. herb #1	5	1	3.0	3
6. boneset	5	1	3.0	3
7. purple loosestrife	5	1	3.0	3
8. sedge #1	5	1	3.0	3
9. grass #11	5	1	3.0	3
10. crown vetch	5	1	3.0	3
11. willow-herb	2	1	3.0	3
12. bitter dock	2	1	3.0	3
13. herb #2	2	1	3.0	3
14. false nettle	1	1	3.0	3
15. bugleweed	1	1	3.0	3
16. sedge #2	< 1	T	--	None
17. broad-leaf cattail	< 1	T	--	None
18. monkey-flower	< 1	T	--	None
19. creeper	< 1	T	--	None

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
20. herb #3	< 1	T	--	None
21. willow	< 1	T	--	None
22. goldenrod	< 1	T	--	None
23. teasel	< 1	T	--	None
24. daisy fleabane	< 1	T	--	None
25. clearweed	< 1	T	--	None
26. arrow-leaved tearthumb	< 1	T	--	None
27. ground ivy	< 1	T	--	None

Sum of Midpoint	95.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	47.5
20% of Total Midpoint Value	19.0

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. smooth alder (Alnus serrulata)	30	4	38.0	1
*2. silky dogwood (Cornus amomum)	20	3	20.5	2

Sum of Midpoint	58.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	29.25
20% of Total Midpoint Value	11.7

Woody vine species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
1. grape	< 1	T	--	None
		Sum of Midpoint	--	

Sapling species -- None

Tree species -- None

Hydrology

No surface inundation observed.

Approximately 5% of the soil surface consisted of cracked, drying mud.

Water borne sediment deposited by overflow was observed in a 5 foot wide band adjacent to the ditch designed to convey surface flow into the site.

The 1 soil sample taken in the Vegetation Unit to characterize soil saturation indicated*:

E1 -- ~2.5 inches: saturated
~5 inches: saturated
~7 inches: saturated

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Impatiens capensis	FACW	Herb
2. Juncus tenuis	FAC-	Herb
3. J. effusus	FACW+	Herb
4. Cornus amomum	FACW	Shrub
5. Alnus serrulata	OBL	Shrub

Percent of dominant species that are OBL, FACW, and/or FAC 100%

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: F (approximately 0.02 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. spotted jewelweed (Impatiens capensis)	85	6	85.5	1
*2. crown vetch (Coronilla varia)	30	4	38.0	2
*3. thicket creeper (Parthenocissus vitacea)	35	4	38.0	2
4. clearweed	20	3	20.5	3
5. berry vine	20	3	20.5	3
6. willow-herb	5	1	3.0	4
7. herb #1	5	1	3.0	4
8. goldenrod	5	1	3.0	4
9. bitter dock	5	1	3.0	4
10. thistle	5	1	3.0	4
11. mustard	5	1	3.0	4
12. false nettle	5	1	3.0	4
13. ox-eye daisy	3	1	3.0	4
14. herb #2	3	1	3.0	4
15. rush #1	3	1	3.0	4
16. smartweed #1	3	1	3.0	4
17. bugleweed	2	1	3.0	4
18. cattail	2	1	3.0	4
19. grass #1	1	1	3.0	4

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
20. everlasting pea	1	1	3.0	4
21. mint	< 1	T	--	None
23. true forget-me-not	< 1	T	--	None
24. soft rush	< 1	T	--	None
25. daisy fleabane	< 1	T	--	None
26. monkey-flower	< 1	T	--	None
27. sycamore	< 1	T	--	None
28. cinquefoil	< 1	T	--	None
29. woolgrass	< 1	T	--	None
30. arrow-leaved tearthumb	< 1	T	--	None

Sum of Midpoint	250.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	125.25
20% of Total Midpoint Value	50.1

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. silky dogwood (Cornus amomum)	18	3	20.5	1
*2. smooth alder (Alnus serrulata)	12	2	10.5	2
3. willow	5	1	3.0	3

Sum of Midpoint	34.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	17.0
20% of Total Midpoint Value	6.8

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Vegetation Unit would receive surface water flow from the wastewater treatment plant area.

The 2 soil samples taken in the Vegetation Unit to characterize soil saturation indicated*:

F1 -- ~5 inches: dry
~8-10 inches: dry
F2 -- surface: dry
~5.5 inches: dry
~7 inches: dry
~10 inches: dry

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Coronilla varia	UPL	Herb
2. Impatiens capensis	FACW	Herb
3. Parthenocissus vitacea	FACU	Herb
4. Cornus amomum	FACW	Shrub
5. Alnus serrulata	OBL	Shrub

Percent of dominant species that are OBL, FACW, and/or FAC 60%

Data Form
Intermediate-Level Onsite Determination Method

Site: Borough of Huntingdon
Vegetation Unit: G (approximately 0.01 acre)
Date: August 7 - August 9, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. everlasting pea (Lathyrus latifolius)	60	5	63.0	1
*2. spotted jewelweed (Impatiens capensis)	50	4	38.0	2
*3. crown vetch (Coronilla varia)	40	4	38.0	2
4. smartweed #1	25	3	20.5	3
5. arrow-leaved tearthumb	7	2	10.5	4
6. vine #1	10	2	10.5	4
7. willow-herb	5	1	3.0	5
8. goldenrod	5	1	3.0	5
9. teasel	5	1	3.0	5
10. bugleweed	1	1	3.0	5
11. sedge	< 1	T	--	None
12. mint	< 1	T	--	None
13. boneset	< 1	T	--	None
14. monkey-flower	< 1	T	--	None

Sum of Midpoints	192.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	96.3
20% of Total Midpoint Value	38.5

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Portion of the Vegetation Unit immediately adjacent to Vegetation Unit F would receive surface water flow from the wastewater treatment plant area.

The 2 soil samples taken in the Vegetation Unit to characterize soil saturation indicated*:

G1 -- surface: moist
~ 8 inches: moist
~ 11 inches: moist
~ 14 inches: moist

G2 -- ~ 1 inch: moist
~ 6 inches: moist
~ 14 inches: moist

*All soil samples taken to a depth of ~ 18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Coronilla varia	UPL	Herb
2. Lathyrus latifolius	UPL	Herb
3. Impatiens capensis	FACW	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 33%

APPENDIX D

Field Data
PennDOT Bryan Mills
Wetland Creation Site

APPENDIX D

Appendix D contains the field data used to evaluate the effectiveness of the PennDOT Bryan Mills wetland creation site.

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: A (approximately 0.15 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. soft rush (Juncus effusus)	80	6	85.5	1
*2. common plantain (Plantago major)	30	4	38.0	2
3. bitter dock	25	3	20.5	3
4. English plantain	25	3	20.5	3
5. sedge #1	25	3	20.5	3
6. marsh seedbox	5	1	3.0	4
7. cinquefoil	2	1	3.0	4
8. sedge #2	2	1	3.0	4
9. monkey-flower	1	1	3.0	4
10. boneset	1	1	3.0	4
11. deer-tongue grass	1	1	3.0	4
12. timothy	1	1	3.0	4
13. bugleweed	< 1	T	--	None
14. sedge #3	< 1	T	--	None
15. spotted jewelweed	< 1	T	--	None

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
16. rice cutgrass	< 1	T	--	None
17. arrow-leaved tearthumb	< 1	T	--	None
18. daisy fleabane	< 1	T	--	None
19. grass #1	< 1	T	--	None
20. red clover	< 1	T	--	None
21. blue vervain	< 1	T	--	None
22. grass #2	< 1	T	--	None
23. goldenrod	< 1	T	--	None
24. woolgrass	< 1	T	--	None
25. thistle	< 1	T	--	None
26. soft-stem bulrush	< 1	T	--	None
27. burreed	< 1	T	--	None
28. ditch stone crop	< 1	T	--	None
29. sensitive fern	< 1	T	--	None
30. spikerush	< 1	T	--	None

Sum of Midpoints	206.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	103.0
20% of Total Midpoint Value	41.2

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. arrow wood (Vibirnum dentatum)	30	4	38.0	1
*2. common winterberry (Ilex verticillata)	20	3	20.5	2
3. buttonbush	8	2	10.5	3
4. silky dogwood	8	2	10.5	3
5. red-osier dogwood	8	2	10.5	3
6. shrub #1	1	1	3.0	4

Sum of Midpoints	93.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	46.5
20% of Total Midpoint Value	18.6

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

At the south end of the Vegetation Unit there was an approximately 18 foot by 27 foot area that was saturated to the surface.

There was a band of soil saturation/inundation along the boundary of Vegetation Units A and D which ranged in width from 17 inches to 54 inches (median = 34 inches).

Water stains were noted on < 1% of the vegetation.

Long, narrow pockets (possibly equipment tracks) of saturated soil and small patches of of saturated soils were observed. These areas comprised about 5% of the Vegetation Unit.

The 3 soil samples taken in the unit to characterize soil saturation indicated*:

A1 -- ~3.5 inches: moist
repeated sampling attempts ranged from dry to saturated

A2 -- surface: dry
~3 inches: moist

A3 -- ~1.5 inches: dry
~3.5 inches: moist
~8.5 inches: moist

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Juncus effusus	FACW+	Herb
2. Plantago major	FACU	Herb
3. Vibirnum dentatum	FAC	Shrub
4. Ilex verticillata	FACW+	Shrub

Percent of dominant species that are OBL, FACW, and/or FAC 75%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: B (approximately 0.07 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Class Cover	Midpoint of Cover Class	Rank
*1. birds-foot trefoil (Lotus corniculatus)	95	6	85.5	1
*2. soft rush (Juncus effusus)	50	4	38.0	2
*3. redtop bentgrass	50	4	38.0	2
4. jewelweed	10	2	10.5	3
5. sedge #1	5	1	3.0	4
6. boneset	2	1	3.0	4
7. timothy	< 1	T	--	None
8. bitter dock	< 1	T	--	None
9. rice cutgrass	< 1	T	--	None
10. grass #1	< 1	T	--	None
11. monkey-flower	< 1	T	--	None
12. soft-stem bulrush	< 1	T	--	None
13. St. Johnswort	< 1	T	--	None
14. sedge #2	< 1	T	--	None
15. deer-tongue grass	< 1	T	--	None
16. goldenrod	< 1	T	--	None
17. forget-me-not	< 1	T	--	None
18 mash seedbox	< 1	T	--	None

Sum of Midpoints	178.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	89.0
20% of Total Midpoint Value	35.6

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. arrow wood (Vibirnum dentatum)	25	3	20.5	1
*2. red-osier dogwood (Cornus stolonifera)	8	2	10.5	2
3. buttonbush	5	1	3.0	3
4. silky dogwood	3	1	3.0	3

Sum of Midpoints	37.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	18.5
20% of Total Midpoint Value	7.4

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

The relocated stream enters the site via Vegetation Unit B.

At the boundary of Vegetation Units B and D there was an approximately 12 foot by 16 foot area containing standing water from 1 to 5 inches in depth.

There was a band of soil saturation/inundation along the boundary of Vegetation Units B and D which ranged in width from 18 inches to 82 inches (median = 60 inches). This band incorporates the 12 foot by 16 foot area containing standing water cited in the previous paragraph.

The 3 soil samples taken in the unit to characterize soil saturation indicated*:

B1 -- surface: moist
~ 16 inches: moist

B2 -- surface: saturated

B3 -- surface: saturated

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Juncus effusus	FACW+	Herb
2. Lotus corniculatus	FACU-	Herb
3. Agrostis alba	FACW	Herb
4. Cornus stolonifera	FACW+	Shrub
5. Vibirnum dentatum	FAC	Shrub

Percent of dominant species that are OBL, FACW, and/or FAC 80%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: C (approximately 0.05 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. soft rush (Juncus effusus)	90	6	85.5	1
*2. common plantain (Plantago major)	25	3	20.5	2
3. sedge #1	15	2	10.5	3
4. English plantain	10	2	10.5	3
5. giant burreed	10	2	10.5	3
6. cinquefoil	5	1	3.0	4
7. soft-stem bulrush	5	1	3.0	4
8. boneset	5	1	3.0	4
9. deer-tongue grass	5	1	3.0	4
10. goldenrod	2	1	3.0	4
11. jewelweed	1	1	3.0	4
12. bugleweed	1	1	3.0	4
13. rough cinquefoil	1	1	3.0	4
14. St. Johnswort	1	1	3.0	4
15. rush #1	1	1	3.0	4

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
16. herb #1	1	1	3.0	4
17. bitter dock	< 1	T	--	None
18. common three square	< 1	T	--	None
19. clover	< 1	T	--	None
20. daisy fleabane	< 1	T	--	None
21. forget-me-not	< 1	T	--	None
22. arrow-leaved tearthumb	< 1	T	--	None
23. sedge #2	< 1	T	--	None
24. blue vervain	< 1	T	--	None
25. grass #1	< 1	T	--	None
26. rice cutgrass	< 1	T	--	None
27. monkey-flower	< 1	T	--	None
28. sweetflag	< 1	T	--	None
29. woolgrass	< 1	T	--	None
30. grass #2	< 1	T	--	None
31. timothy	< 1	T	--	None

Sum of Midpoints	179.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	89.75
20% of Total Midpoint Value	35.9

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. buttonbush	< 1	T	--	None
		Sum of Midpoints	--	

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

There was a band of soil saturation along the boundary of Vegetation Units C and D which ranged in width from 24 inches to 134 inches (median = 63 inches). Within this band of saturated soils there were limited areas of inundation ranging from 3.3 inches to 6.5 inches. in depth.

The 2 soil samples taken in the unit to characterize soil saturation indicated*:

C1 -- ~2.5 inches: moist
~6 inches: moist
~8 inches: moist

C2 -- ~8.5 inches: moist

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Juncus effusus	FACW+	Herb
2. Plantago major	FACU	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 50%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: D (approximately 0.12 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. marsh seedbox (Ludwiga palustris)	80	6	85.5	1
*2. stiff arrowhead (Sagittaria rigida)	66	5	63.0	2
*3. blunt spikerush (Eleocharis obtusa)	66	5	63.0	2
4. giant burreed	25	3	20.5	3
5. soft rush	6	2	10.5	4
6. broad-leaf cattail	8	2	10.5	4
7. rice cutgrass	8	2	10.5	4
8. smartweed #1	6	2	10.5	4
9. jewelweed	6	2	10.5	4
10. smartweed #2	5	1	3.0	5
11. sedge #1	2	1	3.0	5
12. sweetflag	1	1	3.0	5
13. boneset	< 1	T	--	None
14. monkey-flower	< 1	T	--	None
15. green bulrush	< 1	T	--	None
16. sedge #3	< 1	T	--	None
17. flatsedge	< 1	T	--	None
18. dwarf St. Johnswort	< 1	T	--	None
19. herb #1	< 1	T	--	None
20. ditch stone crop	< 1	T	--	None
21. deer-tongue grass	< 1	T	--	None
22. water plantain	< 1	T	--	None

Sum of Midpoints	293.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	146.75
20% of Total Midpoint Value	58.7

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Ground surface of the entire unit was inundated with water ranging in depth from 1 to 9 inches (median = 5 inches) at the boundary of Vegetation Unit D with Vegetation Units A, B, C, and E to a depth greater than 30 inches at the boundary of Vegetation Unit D with the open water areas.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Ludwigia palustris	OBL	Herb
2. Sagittaria rigida	OBL	Herb
3. Eleocharis obtusa	OBL	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 100%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: E (approximately 0.16 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. birds-foot trefoil (Lotus corniculatus)	95	6	85.5	1
*2. redtop bentgrass (Agrositic alba)	75	5	63.0	2
3. giant burreed	8	2	10.5	3
4. soft rush	12	2	10.5	3
5. bitter dock	15	2	10.5	3
6. boneset	5	1	3.0	4
7. sedge #1	5	1	3.0	4
8. common plantain	1	1	3.0	4
9. smartweed #1	1	1	3.0	4
10. smartweed #2	1	1	3.0	4
11. deer-tongue grass	1	1	3.0	4
12. rice cutgrass	1	1	3.0	4
13. English plantain	1	1	3.0	4
14. grass #1	< 1	T	--	None
15. forget-me-not	< 1	T	--	None
16. St. Johnswort	< 1	T	--	None
17. rush #1	< 1	T	--	None
18. spikerush	< 1	T	--	None
19. arrowhead	< 1	T	--	None
20. marsh seedbox	< 1	T	--	None
21. monkey-flower	< 1	T	--	None

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
22. bugleweed	< 1	T	--	None
23. sensitive fern	< 1	T	--	None
24. daisy fleabane	< 1	T	--	None
25. smartweed #3	< 1	T	--	None
26. duckweed	< 1	T	--	None
27. arrow-leaved tearthumb	< 1	T	--	None
28. annual ryegrass	< 1	T	--	None
29. timothy	< 1	T	--	None

Sum of Midpoints	204.0
Dominance Threshold Number Equals 50% x Sum of Midpoints	102.0
20% of Total Midpoint Value	40.8

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

There was a band of soil saturation along the boundary of Vegetation Units E and D which ranged in width from 20 inches to 172 inches (median = 54 inches). Within this band of saturated soils there were limited areas of inundation ranging from the surface to 5 inches.

The 4 soil samples taken in the unit to characterize soil saturation indicated*:

E1 -- surface: moist
~ 16 inches: moist

E2 -- surface: saturated

E3 -- surface: saturated

E4 -- ~1 inch: dry
~2 inch: dry

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Agrostis alba	FACW	Herb
2. Lotus corniculatus	FACU-	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 50%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: F (approximately 0.07 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. birds-foot trefoil (Lotus corniculatus)	98	7	98.0	1
*2. redtop bentgrass (Agrostis alba)	40	4	38.0	2
*3. bitter dock (Rumex obtusifolia)	30	4	38.0	2
4. English plantain	15	2	10.5	3
5. timothy	< 1	T	--	None
6. clover	< 1	T	--	None
7. boneset	< 1	T	--	None
8. morning glory	< 1	T	--	None
9. cinquefoil	< 1	T	--	None

Sum of Midpoints	184.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	92.75
20% of Total Midpoint Value	36.9

Shrub species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. arrow wood (Vibirnum dentatum)	50	4	38.0	1
*2. common winterberry (Ilex verticillata)	20	3	20.5	2
3. red-osier dogwood	< 1	T	--	None

Sum of Midpoints	58.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	29.25
20% of Total Midpoint Value	11.7

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

No field indicators of field hydrology were observed.

The 2 soil samples taken in the unit to characterize soil saturation indicated*:

F1 -- ~1 inch: dry
~3 inches: dry

F2 -- surface: dry
~3 inches: dry

*All soil samples taken to a depth of ~18 inches or resistance.

Summary

Dominant Plant Species	Indicator Status	Stratum
1. Agrostis alba	FACW	Herb
2. Lotus corniculatus	FACU-	Herb
3. Rumex obtusifolia	FACU-	Herb
4. Ilex verticillata	FACW+	Shrub
5. Vibirnum dentatum	FAC	Shrub

Percent of dominant species that are OBL, FACW, and/or FAC 60%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Vegetation Unit: G (approximately 0.02 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
*1. birds-foot trefoil (Lotus corniculatus)	80	6	85.5	1
*2. bitter dock (Rumex obtusifolia)	30	4	38.0	2
3. English plantain	20	3	20.5	3
4. redtop bentgrass	20	3	20.5	3
5. timothy	1	1	3.0	4
6. sweetflag	< 1	T	--	None
7. deer-tongue grass	< 1	T	--	None
8. annual ryegrass	< 1	T	--	None

Sum of Midpoints	167.5
Dominance Threshold Number Equals 50% x Sum of Midpoints	83.8
20% of Total Midpoint Value	33.5

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

No field indicators of field hydrology were observed.

The 1 soil sample taken in the unit to characterize soil saturation indicated*:

G1 -- surface: dry
~2 inches: dry

*All soil samples taken to a depth of ~18 inches or resistance.

Summary Sheet

Dominant Plant Species	Indicator Status	Stratum
1. Rumex obtusifolia	FACU-	Herb
2. Lotus corniculatus	FACU-	Herb

Percent of dominant species that are OBL, FACW, and/or FAC 0%

Data Form
Intermediate-Level Onsite Determination Method

Site: PennDOT Bryan Mills
Name: Unit H (approximately 0.03 acre)
Date: July 30 - August 2 and August 6, 1990

Vegetation Unit Sampling

Herb species

Species	Percent Areal Cover	Cover Class	Midpoint of Cover Class	Rank
1. stiff arrowhead	< 1	T	--	None
2. marsh seedbox	< 1	T	--	None
		Sum of Midpoints	--	

Shrub species -- None

Woody vine species -- None

Sapling species -- None

Tree species -- None

Hydrology

Unit H consists of 2 open water area located at the center of Vegetation Unit D. The water ranged in depth from approximately 2 feet to more than 3 feet (N. L. Kline, pers. obs.; Skelly and Loy Eng.-Consultants, Bryan Mills Grading Plan, Harrisburg, Pa., 1988).

Summary

Dominant Plant Species	Indicator Status	Stratum
No dominant species		

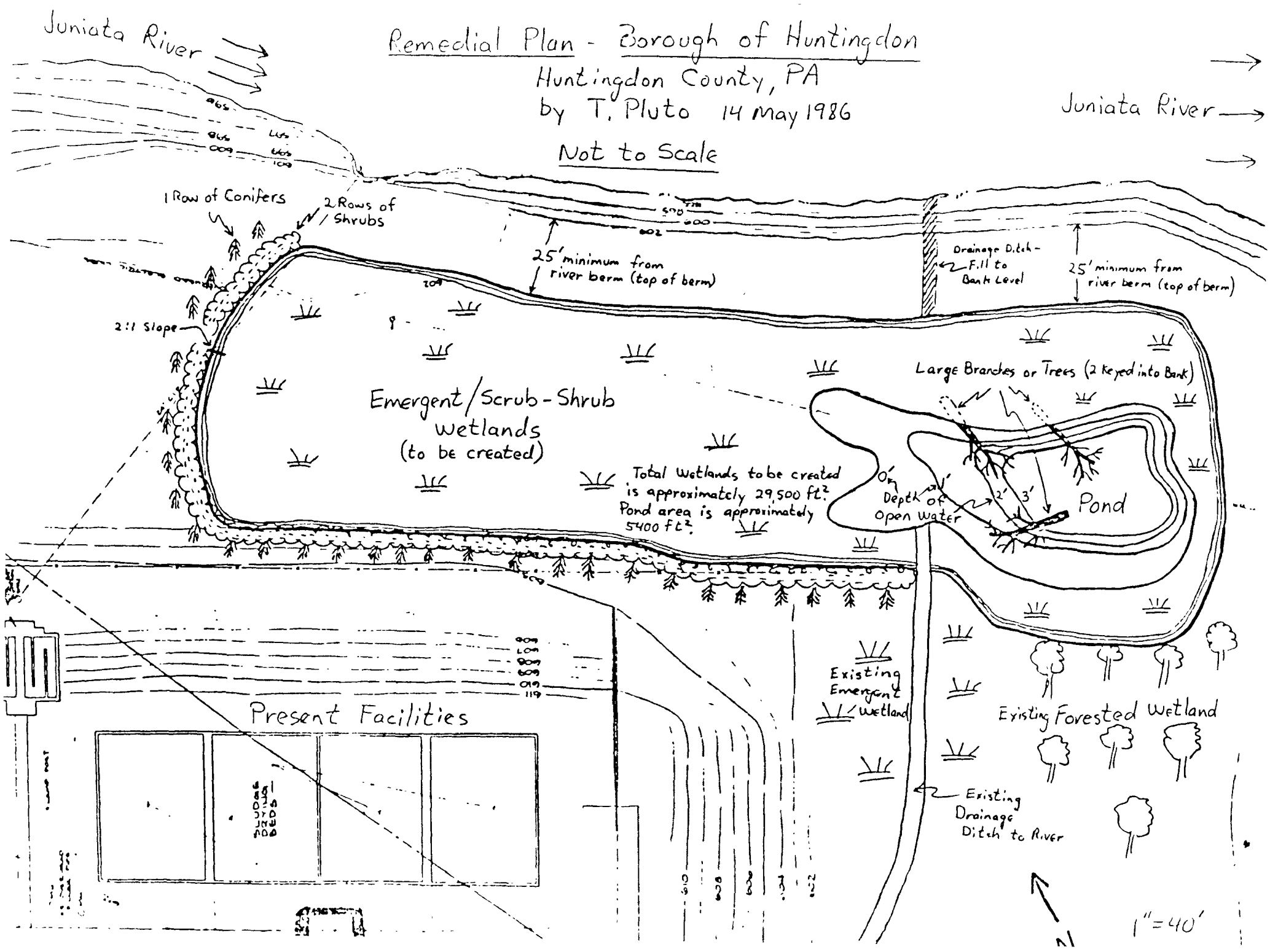
Percent of dominant species that are OBL, FACW, and/or FAC N/A

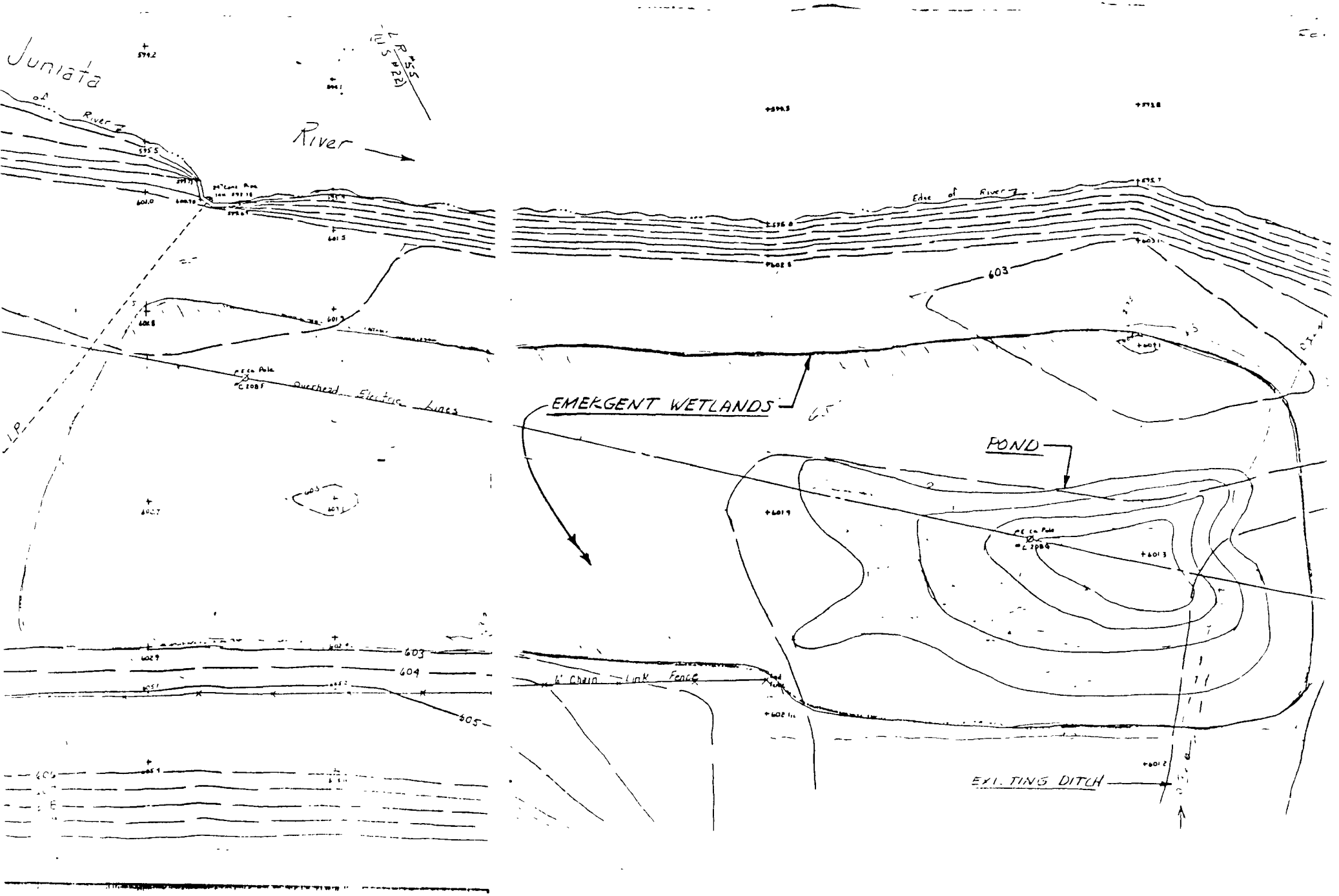
APPENDIX E

Design Plans for the Borough of Huntingdon Wetland Creation Site

The source of the design plans contained in Appendix E was:

D.E. Roeseke, 1986, Department of the Army Permit NABOP-RE-(Borough of Huntingdon)-86-0435-1, U.S. Army Engineer District, Baltimore Corps of Engineers, Baltimore, Maryland.


Remedial Plan - Borough of Huntingdon
Huntingdon County, PA
by T. Pluto 14 May 1986
Not to Scale
Juniata River
Juniata River
1 Row of Conifers
2 Rows of Shrubs
25' minimum from river berm (top of berm)
Drainage Ditch - Fill to Bank Level
25' minimum from river berm (top of berm)
2:1 Slope
Large Branches or Trees (2 keyed into Bank)
Emergent/Scrub-Shrub wetlands (to be created)
Total Wetlands to be created is approximately 29,500 ft²
Pond area is approximately 5400 ft².
0'
1'
2'
3'
Depth of Open Water
Pond
Existing Emergent Wetland
Existing Forested Wetland
Present Facilities
Existing Drainage Ditch to River
1" = 40'


Juniata
River
River
Edge of River
603
EMERGENT WETLANDS
POND
Overhead Electric Lines
603
604
605
6' Chain Link Fence
EXISTING DITCH

APPENDIX F

Design Plans for the PennDOT Bryan Mills Wetland Creation Site

The sources of the design plans contained in Appendix F were:

Skelly and Loy Engineers-Consultants, 1989, Route 220 - L.R. 19 Wetlands Replacement Update, Harrisburg, Pennsylvania; and

Skelly and Loy Engineers-Consultants, 1988, Grading Plan revised 7/21/1988, Harrisburg, Pennsylvania.

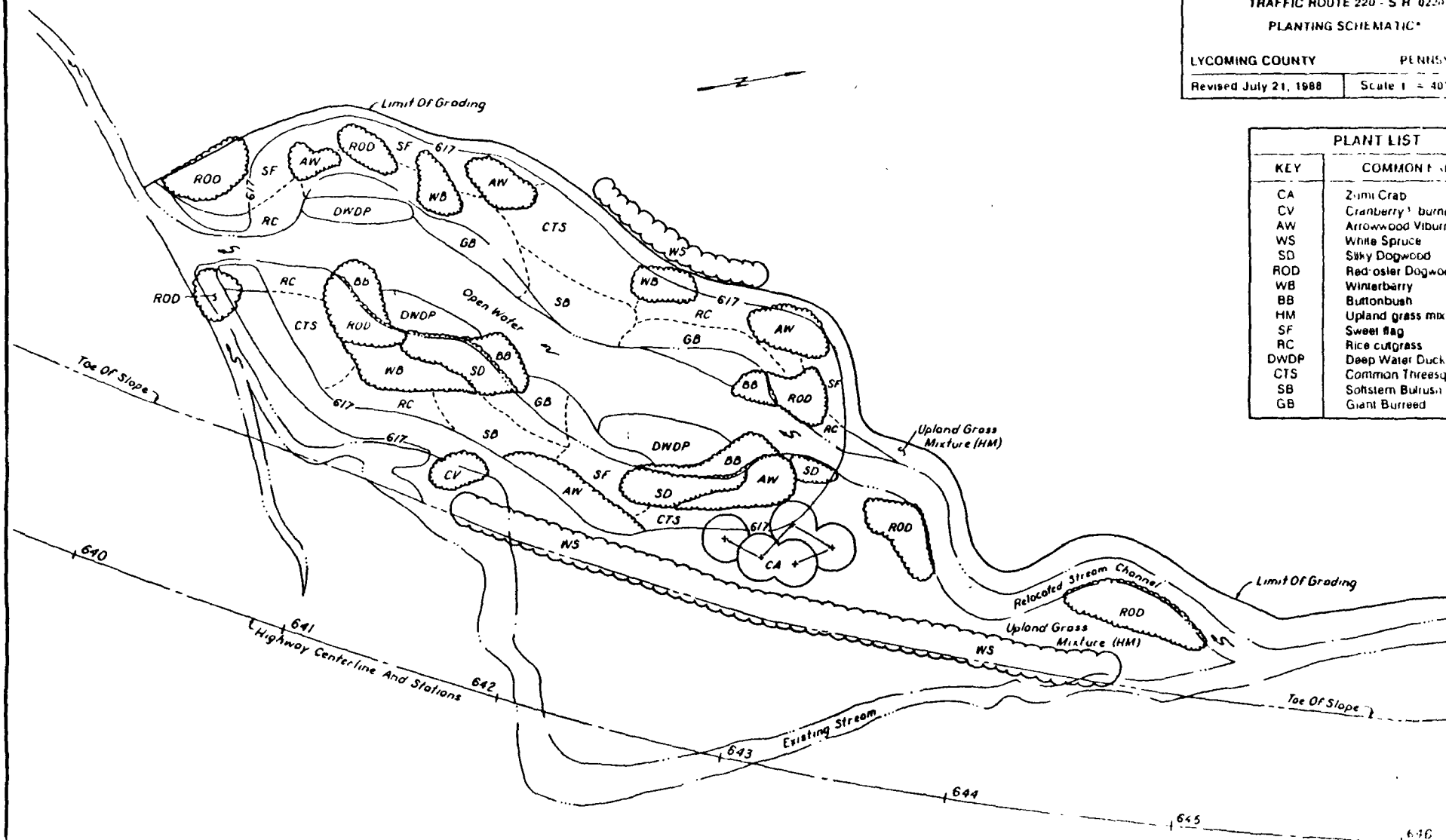
WETLANDS REPLACEMENT DESIGN

TRAFFIC ROUTE 220 - S.R. 0220

PLANTING SCHEMATIC*

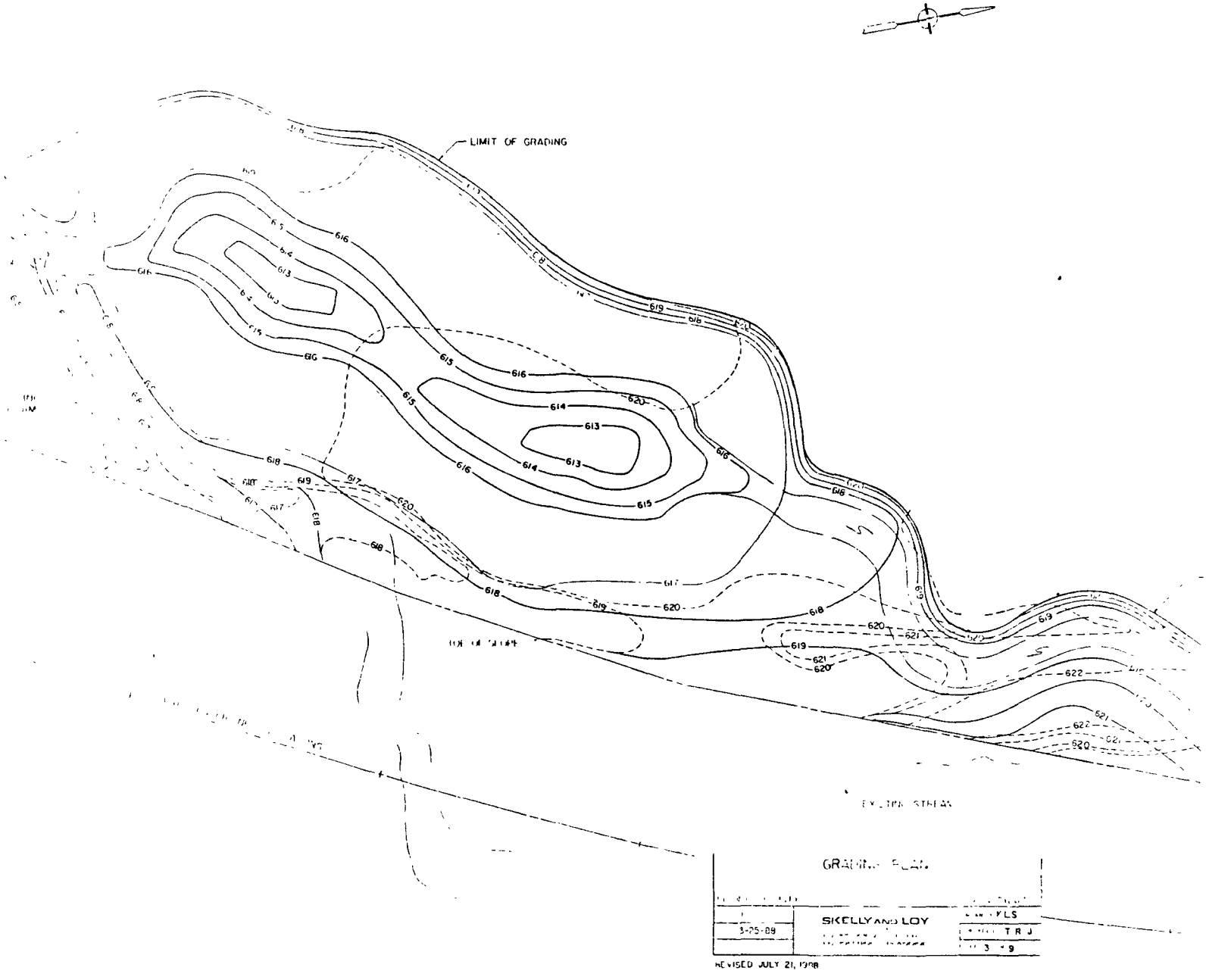
LYCOMING COUNTY — PENNSYLVANIA

Revised July 21, 1988 — Scale 1" = 40' Approx.



PLANT LIST	
KEY	COMMON NAME
CA	Zumi Crab
CV	Cranberry viburnum
AW	Arrowwood Viburnum
WS	White Spruce
SD	Silky Dogwood
ROD	Red-osier Dogwood
WB	Winterberry
BB	Buttonbush
HM	Upland grass mix
SF	Sweet flag
RC	Rice cutgrass
DWDP	Deep Water Duck Potato
CTS	Common Threesquare
SB	Softstem Bulrush
GB	Giant Burreed

*Planting schematic not a working form but was developed from final planting plan used to complete revegetation of wetland mitigation site


LIMIT OF GRADING
616
615
614
613
618
619
620
621
622
617
EXISTING STREAM
GRADING PLAN
SKELLY AND LOY
3-25-89
REVISED JULY 21, 1988

ACKNOWLEDGMENTS

Many people have contributed to the completion of this project. The willingness of the Borough of Huntingdon and the Pennsylvania Department of Transportation to allow evaluation of their wetland creation sites made the field research possible. The staff of the U.S. Fish and Wildlife Service, Philadelphia District Army Corps of Engineers, Pittsburgh District Army Corps of Engineers, Environmental Protection Agency--Region III, and Pennsylvania Department of Transportation contributed significantly by providing information on the status of wetland creation sites. Barbara Z. D'Angelo, U.S. Environmental Protection Agency, provided vital assistance by coordinating information acquisition with the other federal agencies. Charles J. Kulp deserves special mention for providing access to the records of the U.S. Fish and Wildlife Service which made mitigation policy analysis possible. and content of the reportance in acquiring the information provided by EPA.

APPENDIX G

Mitigation Effectiveness: Recap of the Existing Literature

THE STATUS OF NONTIDAL, FRESHWATER WETLANDS CREATION, RESTORATION, AND ENHANCEMENT IN THE UNITED STATES

MITIGATION EFFECTIVENESS: RECAP OF THE EXISTING LITERATURE

Report to:

Environmental Protection Agency, Region III
Wetlands and Marine Policy Section
842 Chestnut Building
Philadelphia, Pennsylvania 19107

Submitted by:

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Desert Research Institute
P.O. Box 60220
Reno, Nevada 89506

April 16, 1990

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INTRODUCTION

The quantity and quality of wetlands in the United States are increasingly at risk from development activities involving human-induced disturbances such as dredging, filling, clearing, draining, or flooding. In effort to offset deleterious impacts imposed by these activities, the Clean Water Act of 1977 requires restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters. Section 404 of the act provides the primary legislative authority behind Federal efforts to control practices that are destructive to the Nation's wetlands. Control of pollution from discharges of dredged or fill material into wetlands is administered by the Corps of Engineers through Section 404 of the Act.

The Environmental Protection Agency (EPA) has the authority to prohibit, withdraw or restrict the specification of a Section 404 discharge site to prevent the unacceptable adverse impact of a project. During the last decade, compensatory replacement mitigation has become a standard option within the 404 process for offsetting destruction and alteration of wetlands. Over the past decade, EPA has encouraged compensatory mitigation efforts such as wetlands creation if there are no alternatives. However, current experience and knowledge of wetlands creation, restoration and enhancement has indicated that consideration of whether a proposed mitigation plan actually prevents or offsets significant impacts must be carefully considered prior to issuance of permits. The roles and responsibilities of the United States Corp of Engineers and Environmental Protection Agency (EPA) in overseeing the mission of the program is recently reviewed by Kruczynski (1989).

The use of wetland creation, restoration, and enhancement as mitigation for development and other environmental impacts is a currently popular means for attempting to offset unavoidable destruction or disturbance of wetlands. There are many uncertainties and problems associated with the effectiveness of wetland creation, restoration, and enhancement as compensatory mitigation. The extent and nature of these uncertainties has been the subject of a recent two-volume document produced by the Environmental Protection Agency's (EPA) Environmental Research Laboratory in Corvallis, Oregon (EPA 1989), as well as many recent national symposia and conferences; for example: the Hillsborough Community College annual proceedings on Wetlands Restoration and Creation (Webb, 16 volumes, 1973-1989); "Proceedings: National Wetland Symposium, Mitigation of Impacts and Losses" (Kusler *et al.* 1986); "Increasing our Wetland Resources" (Zelazny and Feierabend 1987); "Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base" (Larson and Neill 1986); "Proceedings of the Society of Wetland Scientists' Eighth Annual Meeting: Wetland and Riparian Ecosystems of the American West" (Mutz and Lee, 1987); "Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West (Mutz *et al.* 1988); and others. In addition, The U.S. Fish and Wildlife Service has recently completed an extensive bibliography of wetlands creation and restoration which provides abstracted references to bibliographic information contained in their digital Wetland Creation/Restoration Data Base (Schneller-McDonald *et al.* 1989).

EPA's Region III Office of Wetlands and Marine Policy is in the process of formulating guidelines to be used in mitigation decision making. This report has been prepared in association with EPA Region III's efforts to provide background information for this endeavor. The report condenses and summarizes the voluminous information on the subject of non-tidal, freshwater wetlands creation, restoration and enhancement, and attempts to draw conclusions about the state of the science. Many of the projects reviewed for this report are not a result of Section 404 permitting, however, they provide a basis for evaluating the extent to which freshwater creation, restoration and enhancement has succeeded.

STATE OF THE SCIENCE

The status of the science of freshwater wetland creation, restoration, and enhancement in the United States has been thoroughly reviewed and analyzed (see, for example, EPA, 1989). A substantial number of projects have been planned and/or implemented throughout the United States. While the specific circumstances of many of these projects are documented in the scientific literature and government documentation, information on many projects is restricted to in-house, unpublished reports that are difficult to obtain.

Although creation, restoration, and enhancement are a popular means of mitigating for loss of wetlands, there are few documented conclusions about overall success in the field. This disparity in the literature is related, in part, to the relative infancy of the science, and lack of technological sophistication associated with many ongoing projects. The extensive efforts of EPA's Environmental Research Laboratory in Corvallis, Oregon has resulted in a region-by-region assessment, yet most conclusions drawn by the multiple authors of this work point to the reporting of nebulous successes and the needs for further research and more funding.

The U.S. Fish and Wildlife Service's recent evaluation of the "biological effectiveness" of mitigation measures implemented since 1984 (Roelle and Manci, 1989) concluded that comprehensive efforts to evaluate mitigation effectiveness are largely subjective and should be interpreted cautiously for the following reasons:

- Quantitative studies of complex mitigation efforts can be technically difficult, expensive, and time consuming;
- Appropriate standards of comparison may be difficult to define;
- Pre-project baseline data are often lacking or insufficient, rarely covering the range of variability innerent in natural systems;
- Suitable control sites may not exist, especially in heavily developed areas;
- The responsibilities for mitigation evaluation may fall into an "institutional gap" among the resource management agencies.

The Environmental Protection Agency reached similar conclusions in their comprehensive evaluation effort:

- Practical experience and the available science base on restoration and creation are limited for most types and vary regionally.
- Most wetland restoration and creation projects do not have specified goals, complicating efforts to evaluate "success".
- Monitoring of wetland restoration and creation projects has been uncommon.
- Restoration or creation of a wetland that "totally duplicates" a naturally-occurring wetland is impossible; however, some systems may be approximated and individual wetland functions may be restored or created.
- Partial project failures are common.
- Success varies with the type of wetland and target functions including the requirements of target species.
- The ability to restore or create particular wetland functions varies by function.
- Long term success may be quite different from short term success.
- Long-term success depends upon the ability to assess, recreate, and manipulate hydrology.
- Success depends upon the long term ability to manage, protect, and manipulate wetlands and adjacent buffer areas.
- Success depends upon expertise in project design and upon careful project supervision.
- "Cook book" approaches for wetland restoration or creation will likely be only partially successful.

METHOD OF EVALUATION

The scope of this investigation did not permit the evaluation of all freshwater wetland creation, reclamation, or enhancement projects in the United States. The major constraint associated with the investigation was the availability of reference materials detailing the extent of success on a project-by-project basis. A representative sample of information was thus examined for information describing the types of projects implemented over the past decade, and the level of success obtained. Materials examined during this process included two basic perspectives: 1) The perspective of members of the project team (typically consisting of the developer, consulting firm and local regulatory official) responsible for the implementation of the project; and 2) The perspective wetland scientists who have attempted to review the wetland creation, restoration and enhancement efforts of these teams, typically on a regional basis. This report attempts to provide a profile and summary of conclusions of the teams and reviewers.

Determining the overall effectiveness of freshwater wetlands creation, restoration, and enhancement has typically involved consideration of a variety of parameters. Although small successes may be claimed based on the creation or restoration of wetlands for a given purpose, many

wetland scientists believe that overall success is achieved with creation, restoration, or enhancement of all of the specific functions of wetlands. These functions, as identified in the Federal Highway Administration's wetland assessment methodology (Adamus and Stockwell, 1983) are:

- Groundwater recharge and discharge;
- Flood storage and desynchronization;
- Shoreline anchoring and dissipation of erosive forces;
- Sediment trapping;
- Nutrient retention and removal;
- Food chain support;
- Habitat for fisheries;
- Habitat for wildlife;
- Active recreation, and;
- Passive recreation and heritage value.

REGIONAL ASSESSMENT OF FRESHWATER WETLAND CREATION, RESTORATION, AND ENHANCEMENT EFFORTS

The following regional assessments provide a review of the extent to which non-tidal, freshwater wetland creation, restoration, and enhancement projects have been planned and/or implemented on a regional basis. The regions discussed in this section correspond to the EPA's ten regions, and provide an overview of the extent to which freshwater wetlands creation, restoration, and enhancement occur throughout the United States.

REGION I

This region encompasses the states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Freshwater wetland creation, restoration, and enhancement projects in these states are not well documented. Lowry provides a summary of creation and restoration projects associated with the riverine systems of the glaciated northeast (Lowry, 1989), and Hollands (1989) reviews creation and restoration of kettle and pothole wetlands, some of which occur in this region. Larson and Neill's (1987) assessment of the science base for mitigating freshwater wetland alterations also provides a limited amount of information on actual projects. Reimold and Cobler (1986) report on the success of three freshwater wetland mitigation sites. Lowry (1989) notes that, for the glaciated northeast United States, "There has been no compilation of the experience obtained from most of the wetland creation projects in the region and there appears to be a general lack of detailed monitoring which would provide data necessary for assessment of results".

Table 1 provides a partial list of representative freshwater wetland creation and restoration projects in the region for which documentation was available. This list is far from complete. Lowry

Table 1. Example of representive freshwater wetland creation, restoration, and enhancement projects documented for EPA Region I (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
I-495/Route 25, Bourne, Mass.	Hollands 1989	1987	9 Ac	Wetlands capable of renovating highway runoff.
Coulter Drive, Concord, Mass.	Hollands 1989	1984	12,000 ft.^{2}	Creation of a wetland capable of providing flood storage and wildlife habitat.
Andover Business Park, Andover, Mass.	Lowry 1989	1984	1.5 Ac	Creation of a palustrine emergent marsh to offset construction of office park.
Sky Meadow, Dunstable, Mass. and Nashua, NH	Lowry 1989	1988	9 Ac	Creation of a mosaic of emergent, scrub-shrub and open water to offset development.
Digital Equipment Corp. Littleton, Mass.	Lowry 1989	1985	1 Ac	Creation of palustrine emergent marsh to offset construction of office park.
Fafard Companies, Milford, Mass.	Lowry 1989	1985-87	1 Ac	Creation of palustrine emergent marsh to offset consruction of office park.
Portsmouth Hospital, Portsmouth, NH	Lowry 1986	1986	4 Ac	Creation of palustrine emergent marsh to offset hospital copnstruction.
Syfeld, Keene, NH	Reimold & Cobler 1986	1984	5 Ac	Creation of palustrine emergent marsh to offset development.
Tamposi and Nash, Nashua, NH	Reimold & Cobler 1986	1984	1.7 Ac	Creation of palustrine emergent marsh to offset development.
Central Connecticut Expressway	Reimold & Cobler 1986	1984-85	22 Ac	Creation of palustrine emergent marsh to offset highway construction.

(1989), for example, reports that over 200 small-scale projects have been created in Massachusetts since 1983. Other efforts in this region may also be undocumented. Few projects are reported for New Hampshire, and only one project is known from Rhode Island (Lowry 1989). Butts (1986) provides an overview of the status of wetlands creation/mitigation projects related to state highway construction in Connecticut. Freshwater wetland projects in Vermont and Maine have not been documented. In general, most of the projects created in this region are small-scale mitigation efforts designed to offset the consequences of highway construction and development.

Reimold and Cobler (1986; also see Reimold and Thompson 1986) conducted an evaluation of freshwater wetland mitigation effectiveness for this region, which included evaluations of three created freshwater wetlands. The Syfeld site in Keene, New Hampshire, which was intended to create 5 hectares of freshwater palustrine emergent wetland, resulted in the excavation and planting of 2 hectares for a freshwater emergent wetland. The site was rated "marginally successful", based partly on faulty design criteria (i.e. steep banks, deep water, sparsely established vegetation). The Tamposi and Nash site in Nashua, New Hampshire, a 0.7 hectare mitigation project, was rated "ineffective" because of sparse vegetation, steep banks, and construction site drainage into the wetland area. The third freshwater project evaluated was a Connecticut Department of Transportation effort to create 9 hectares of wetlands in five separate basins. Although partial success was noted, an overall "ineffective" rating was assigned to the project, based on steep slopes and poor location. Reimold and Cobler concluded that mitigation effectiveness is dependent on proper site choice, detailed ecological evaluation, and explicit permit conditions.

With respect to the overall extent of success in this region, there are indications that project managers frequently claim success for projects based on short term restoration of a single wetland function. In general, long term success has not been considered, and project planning does provide a basis for monitoring and evaluation over the long term. Successful creation, restoration, and enhancement must be dependent on 1) the ability to understand the hydrogeologic conditions and model and control the water budget of the wetlands; 2) the ability of site contractors to understand and carry out plans 3) Flexibility in project design to allow for mid-course corrections (Lowry 1989). It is possible that in many cases, these guidelines have not been followed.

REGION II

This region includes the states of New Jersey and New York. The territories of Puerto Rico and Virgin Islands also fall within the Region II domain but are not considered in this analysis. Little information is available on projects in this region, however, a number of undocumented projects are known for the state of New York, and New Jersey is in the planning stages of several large replacement wetlands (Lowry 1989).

The largest freshwater wetland mitigation effort in this region is the 32 hectare Southern Tier Allegheny River Valley project, New York (Southern Tier Consulting 1987). Another large scale effort in the planning stages is the wetland mitigation plan for the Manasquan Reservoir System, which

would develop and enhance wetland values lost as a result of reservoir construction (Hinkle 1987). Other work concerning wetlands creation in the region includes the success achieved in upstate New York in natural establishment of vegetation in draw-down zones. This work indicates that species which flourish naturally in draw-down zones may be useful in efforts to revegetate the barren draw-down zones at other reservoirs (Burt 1987).

In effort to standardize tracking procedures and create an effective means to monitor success, the New Jersey Department of Environmental Protection has created a computerized monitoring system for the state's wetlands mitigation projects. This project has been implemented after examination of the results of over 170 salt marsh and tidal freshwater wetland projects completed in the state. Based on this information, it was apparent that evaluation, tracking, and enforcement of mitigation efforts was ineffective. The purpose of the system is to provide a centralized data record that will help to avoid repeating past failures and increase regulatory enforcement (Kantor and Charette 1986).

REGION III

This region encompasses the states of Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and also includes Washington D.C. The information available on freshwater wetlands creation, restoration, and enhancement includes overviews of 32 Section 404 compliance wetlands in Virginia (CE Maguire 1985); 17 Section 404 compliance wetlands in the COE Baltimore District (Princeton Aqua Science 1985), an overview of the effectiveness of coal mine reclamation in western Pennsylvania (Brooks 1984) and miscellaneous reports describing specific projects (Table 2).

Brooks et al (1987) note that there is great potential for wetland creation, restoration, and enhancement on coal mined lands, and abundant opportunity for establishment of various wetland functions, including erosion and sedimentation control, abatement of mine drainage, wildlife habitat, and landscape enhancement. Surface coal mining plans may include the creation of wetlands with little additional cost. Adobe Mining Inc. in northwestern Pennsylvania developed numerous palustrine wetlands at several mine sites, and reported early indications that the ecological diversity of the sites has improved and that wildlife response is occurring (Branch 1987). Wieder *et al.* (1985) report that the use of *Sphagnum* dominated wetlands to treat mine drainage may be effective for sites where drainage water have a pH of 4 or less. Sand and gravel operations also present opportunities for wetland creation in this region.

A variety of other wetlands creation, restoration, and enhancement projects have been implemented in this region. An experimental effort at the University of Maryland determined the potential for improvement of the water quality of storm runoff through artificial wetlands (Athanas 1987). The treatment of wastewater by created wetlands in Iselin, Pennsylvania demonstrates consistent compliance with EPA's secondary treatment standards (Watson *et al.* 1987). Wetlands construction along the Patuxent River by the Maryland State Highway Administration incorporated

Table 2. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region III (Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and Washington, D.C.).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
May's Chapel, Maryland	Athanas, 1988	----	0.7 ha	Created wetland to treat storm runoff from a 40 ha watershed
John Hopkins University, Maryland	Bowers 1988	1987	2.5 ha	Replacement of a multi-function palustrine emergent wetland to mitigate for recreation complex
Patuxent River, Maryland	Branch 1985	1984	5 ha	Maryland State Highway Administration Design and construction of a palustrine emergent wetland
Guarnieri and Edwards Mine Pennsylvania	Brenner 1985	----	22 ha	Adobe Mining Company mitigation - creation of palustrine emergent wetlands
Pennsylvania Power & Light, Lucerne, Penn.	Buck & Houston 1986	----	----	Experimental revegetation using fly ash as a soil amendment
Friendship Hill Site, Natural History, Penn.	Kleinmann & Fink 1987	----	----	Prototype wetland to improve water quality in stream affected by acid mine drainage
Iselin, Pennsylvania	Watson *et al.* 1986	----	----	Low cost marsh system for wastewater treatment
McHenry Mine, Maryland	Wieder *et al.* 1985	----	600 m^2	Wetland constructed to remove iron from seeps & springs adjacent to coal mine

flood conveyance and storage, erosion and pollution control, wildlife habitat, and recreation functions into the project design (Branch 1987). The project has been completed, however the extent to which success was achieved has not been documented.

Results in this region are mixed, but generally indicate that progress is being made towards development of the technology and management potential required to successfully create, restore or enhance wetlands.

REGION IV

This region encompasses the southeastern portion of the United States and includes the states of North and South Carolina, Tennessee, Alabama, Florida, Georgia, Kentucky, and Mississippi. A large number of freshwater wetland creation, restoration, and enhancement projects have been implemented in this region. Clewell (1989) and Erwin (1989) provide summaries of forested wetland and emergent marsh creation, restoration and enhancement. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region IV are provided in Table 3.

Many of the projects in the region are conditions of Section 404 permit and Surface Mining Act reclamation requirements. The State of Florida requires compensatory reclamation as a permit condition for all surface mining activity. Many efforts have thus been accomplished by the phosphate mining industry, which has been engaged in advancement of the technique of reclamation since the early 1970's.

Forested Wetlands

There have been two major efforts to replace bottomland forest wetlands in the southeastern United States. Reforestation of bottomlands originally cleared for agriculture is particularly apparent in the Mississippi Delta, where the emphasis has been on restoration by revegetation with oaks and other heavy-seeded trees. These projects generally emphasize restoration of forest canopy. The largest project of this type is a 1,821 hectare site near Monroe, Louisiana (Harris 1985). Other sizable projects include the 445 hectare Panther Swamp National Wildlife Refuge (NWR) in Mississippi, the 405 hectare Malmaison Wildlife Management Area, and 218 hectares at the Tensas River NWR. In addition, numerous restoration projects have been implemented at 12 NWRs region-wide (Haynes and Moore 1987).

The other major effort is associated with surface mining of phosphate in Florida and North Carolina. Individual efforts have been small scale, but geared towards creation of totally functional forested wetlands. The first project considering forest creation was Sink Branch in 1980 (Robertson 1984). This project is considered successful based on the establishment and growth of trees. Restoration at Dogleg Branch in 1983 was designed to restore undergrowth as well.

Table 3. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region IV (North and South Carolina, Tennessee, Alabama, Florida, Georgia, Kentucky, and Mississippi).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
Tennessee Valley Authority, Alabama	Brodie *et al.* 1987	1985–87	8.3 ha (11 sites)	Wetland construction for treatment of acid mine drainage
Piney Creek Watershed, Tennessee	Byerly *et al.* 1978	Pre–1978	174 ha	Revegetation of coal mined land
Corkscrew Swamp Sanctuary, Florida	Carlson 1982	1981	----	Restoration of marshes disturbed by dikes and ditches
Brewster Phosphates, Florida	Clewell 1983	1979	----	Experimental procedures to determine feasibility of forested wetland restoration
Agrico Swamp, FL	Erwin & Best 1985	1981–82	148 ha	Creation of freshwater marsh, hardwood swamp and open water habitat
Four-corners Mine, FL	Ford 1983	1978	271 Ac	Evaluation of the most efficient method for wetland construction
Campbell County, TN	Fowler *et al.* 1985	----	----	Coal surface mine sediment ponds
Peace River, FL	Gilbert *et al.* 1983	Pre–1981	----	Wetland reclamation on a phosphate mine
Barstow, FL	Gilbert *et al.* 1980	1979	----	Evaluation of wetland creation techniques on a phosphate mine.
Palm City, FL	Gilio 1984	Pre–1984	----	Conversion of drowned wet prairie to a biologically diverse, aestetically pleasing marsh.
Hudson, FL	Goldley *et al.* 1984	Pre–1984	----	Creation of wetlands for stormwater retention
Lake Coral, FL	Knight *et al.* 1985	1978	21 ha	Constructed wetlands for wastewater treatment

Table 3. continued

Ravenwood Shellrock Mine	Posey *et al.* 1984	----	----	Wetland creation to offset residential development
Sink Branch, FL	Robertson, 1984	1979	----	Stream relocation onto reclaimed mine land
Desota County, FL	Ross *et al.* 1985	Pre-1985	40 ha	Wetland creation for application of experimental heavy construction techniques
Big Four Mine, FL	Sandrik & Crabill 1983	Pre-1983	76 Ac	General reclamation of phosphate mined lands
Alderman Creek, FL	Swanson & Shuey 1980	1977	----	Constructed wetlands to compare various reclamation methods.
Lake Jackson, FL	Tuovila *et al.* 1987	1983	2.5 ha	Artificial marsh creation to provide filter system for Lake Jackson
L Lake, Savannah River Plants, South Carolina	Wein & McCort 1986	1987	472 m of shoreline	Wetland plantings along lake shoreline
Kathwood Lake	Wein & McCort 1988	1987		Replacement of wood stork foraging habitat

Clewell's evaluation of forested wetland creation, restoration, and enhancement concludes that "forested wetland creation/restoration projects that are carefully planned and executed will be successful in terms of plant species establishment and physiognomic traits. Success in terms of functional equivalency to natural forested wetlands has not, however, been documented." (Clewell 1989). There is some debate as to whether attainment of forest structure indicates that other functional attributes have been achieved during the creation process.

Palustrine Wetlands

The majority of non-forested freshwater wetland projects in Region IV are in Florida, and include mitigation for residential development, surface mining; highway, marina and dock construction; wastewater treatment, and storm water runoff. Ruesch (1983) provides an overview of 35 wetland reclamation projects on phosphate mined lands in Florida.

One of the best examples of marsh creation in this region is the Agrico Fort Green Phosphate Mine Reclamation Project, Agrico Swamp West in central Florida. This area, created in 1981, is comprised of 60 hectares of marsh and 88 hectares of upland. The goal of this project was to provide a high quality wetland ecosystem with the creation of a mosaic of freshwater marsh, hardwood swamp, open water, and upland habitat. Various reclamation techniques were used in creating the marsh, and an experiment was built into the design to compare the effectiveness of marsh establishment using mulch from a nearby existing marsh versus creation with overburden materials. Monitoring has been in progress since Fall of 1982, and preliminary results indicate that mulching provides the most efficient means of establishing rapid cover of preferred species. Monitoring data collected at the Fort Green wetland indicate that "the marsh and macroinvertebrate community is well developed and positively reacting to natural environmental stresses." (Erwin 1989). Water quality and wildlife values are also satisfactory. The "Agrico 8.4 acre wetland", which was created in the Agrico Swamp vicinity in 1986 also appears to be fully functioning. A 20 hectare marsh near the Charlotte County Correctional Facility was created in 1988 using similar techniques. This site also looks promising.

Two large enhancement projects presently underway in Florida are the Kissammee River project and the Everglades project, both of which are intended to restore previous wetland functions by structural reconstructions and flow enhancement.

Successful creation, restoration, and enhancement of non-forested wetlands in the southeastern United States has high potential for success because in general the region offers abundant plan materials, adequate rainfall, and a long growing season. These characteristics may provide for the attainment of a functioning marsh in three to five years. However, there are questions as to whether created marshes can remain functional over the long term, and whether they can attain functionality within the context of the overall landscape. An evaluation of mitigation effectiveness by the Department of Environmental Regulation in Florida, concluded that of eight freshwater projects, one was successful, 3 provided some benefit, and 4 were failures (Walker 1986). The results of this

evaluation suggest that conclusions drawn by the creators of the project should be interpreted with caution.

REGION V

This region includes the states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. Created wetlands in this region include both emergent and forested palustrine wetlands. Fringe wetlands; palustrine and lacustrine wetlands characterized by flows perpendicular to the zonation patterns of vegetation; are also recognized as a distinct wetland type.

A diversity of freshwater wetland creation, restoration, and enhancement projects have been implemented in this region, including a number of experimental efforts and mitigation permit requirements (Table 4). Goals and objectives of these projects include storm water retention, water quality improvement, wastewater treatment, habitat creation, and recreational use. Many projects are a function of Section 404 requirements. Attainment of long-term success through these projects has not been judged.

Wetland establishment on coal mine slurry impoundments in the midwest has been demonstrated by the Cooperative Wildlife Research Laboratory's Mined Land Reclamation Program (Nawrot and Yaich, 1982; Nawrot *et al.* 1987). Reclamation activities by this program include reclamation of more than 570 hectares of inactive slurry ponds since the late 1970's. The work of the Mined Lands Reclamation Program indicate that wetland establishment on inactive coal mine slurry impoundments "represents an economically desirable and environmentally acceptable alternative to current reclamation requirements" (Warburton *et al.* 1985; Nawrot *et al.* 1987). These wetlands are also a valuable source of wildlife habitat and to a limited extent, have offset the losses of natural wetlands. However, Lawrence *et al.* (1985) suggest that reclamation laws need to become more flexible to allow for flexible planning to provide better opportunities for wetland habitat creation.

Many "kettle" wetlands have been created inadvertently as a result of creation of farm, gravel pit, quarry, and irrigation ponds, as well as through road construction, and other types of excavation. In western Minnesota, a pilot wetland restoration effort has been designed and implemented by US Fish and Wildlife Service and Ducks Unlimited to provide farmers with financial incentives to restore drained wetlands (Madsen 1987). This project, which is part of the Mid-Continent Waterfowl Management Project, is critical to increasing the quantity of wetlands in this region.

The Des Plaines Restoration Project in Illinois is a long-term effort that was extensively planned prior to implementation. The goal of the project is to restore the drainage characteristics of the original creeks and floodplains in northeastern Illinois. This plan for the project includes construction of irrigated river terraces, floodway marshes, and aquatic shelves and associated revegetation. Much of this project is still in the planning phases, however, high rates of success are anticipated given the considerable amount of planning and goal-setting involved. Long terms planning efforts with high probabilities for success, such as the Des Plains Project may set an example for future regional planning efforts.

Table 4. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region V (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
El Dorado Marsh, Wildlife Area, Wisconsin	Beule 1979	Pre-1979	----	Experimentation to open monotypic wetland stands
The Hanover Project Sandusky Bay, Ohio	Levine and Willard 1989	1982	37 ha	Wetland creation to mitigate for dredging and marina construcion
Carlyle Lake, Illinois	Levine and Willard 1989	1987	0.37 ha	Wetland creation to mitigate for marina development
Lake Puckaway, Wisconsin	Levine and Willard 1989	---	---	Restoration of lacustrine wetlands affected by poor water quality
Mississippi R. Navigational pool 8, Wisconsin	Levine and Willard 1989	---	---	Wetland creation to establish wild celery for staging canvasbacks
Waukesha County, Wisconsin	Larson and Stearns 1986	Pre-1986	1 ha	Experimental sedge meadow restoration
Western Minnesota	Madsen 1988	---	1,490 Ac	USFWS program to restore drained wetlands on private land
Max McGraw Wildlife Foundation, Illinois	Olderberg *et al.* 1982	Pre-1982	---	Wetland creation for habitat development
West Central, Minnesota	Piehl 1986	---	400 Ac	USFWS Mid-Continent Waterfowl Management Project
Pinhook Bog, Indiana	Wilcox and Buchholz 1986	Pre-1986	2 ha	Revegetation of a road salt impacted bog
Fox River Project, Illinois	Willard *et al.* 1989	1988	1.75 Ac	Mitigation for habitat destroyed during development

Table 4. Continued

Des Plains Restoration Project, Illinois	Willard *et al.* 1989	---	250 Ac	Long term experimental site to restore drainage characteristics of original creeks and floodplains
Buffalo Grove, Illinois	Willard *et al.* 1989	1988	18 Ac	Wetland creation as mitigation for floodway filling and floodplains
DuPage Tollway, Illinois	Willard *et al.* 1989	---	117 Ac	Wetland creation as mitigation for highway construction
Galum Creek Restoration, Illinois	Willard *et al.* 1989	1989	130 Ac	Wetland creation and restoration for hardwood bottomland forest destroyed by stream diversion for coal mine.
Kaskaskia wetland Reclamation, Illinoisr	Willard *et al.* 1989	1986	200 Ac	Wetland creation for coal mine reclamation
Crane Marsh, Indiana	Willard *et al.* 1989	1987	10 Ac	Creation of wetlands for habitat and water treatment
Maple River State Game Area, Michigan	Willard *et al.* 1989	1986	200 Ac	Restoration of wetland habitat through management
Milli-Ander wetlands, Michigan	Willard *et al.* 1989	1984	270 Ac	Restoration of wetland habitat through management
Shiawassee NWR, Michigan	Willard *et al.* 1989	1983	500 Ac	Restoration and creation of wetland habitat through management
Bengel Marsh restoration, Michigan	Willard *et al.* 1989	1985	2,000 Ac	Restoration of wildlife habitat

REGION VI

This region includes the states of Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. There have been few documented attempts to create, restore or enhance wetlands in this region (Table 5). Actual efforts may be more widespread than the literature indicates.

Projects known from this region include the Lake Texoma experimental field studies of revegetation along fluctuating shorelines (Klimas, 1981, Lester 1986), a 1982 reclamation plan for Gifford-Hill's Sibley Mine Site in Webster Parish near Sibley, Louisiana (Ettinger 1982), and planned compensatory mitigation to replace a bottomland hardwood destroyed by highway construction near Pine Bluff, Arkansas (Richardson 1988).

In Louisiana, mitigation for loss of forested wetlands has been accomplished by creation of artificially flooded hardwood wetlands called "greentree reservoirs". This type of mitigation has been successfully accomplished on 11 hectares in the East Carroll watershed, 32 hectares in the Walnut Roundaway watershed, and was projected in 1986 for 12 hectares in the Lake Verret watershed (Simmering 1986). These areas, which are flooded after trees become dormant and are drained before the growing season begins, provide habitat for wintering ducks.

REGION VII

This region encompasses the states of Iowa, Kansas, Missouri, and Nebraska. Wetland creation projects that have been implemented in this region are typically accomplished through various construction efforts such as impoundments, detention dikes, water control structures, excavation and dredging. Many of these projects involve revegetation, and the overall goal is typically to provide wildlife habitat, particularly for waterfowl. Table 6 provides a list of representative wetland creation projects for this region. The majority of projects in this region are reportedly successful in providing new habitat.

The proposed reclamation of 650 hectares of palustrine emergent wetland in the Grand Pass Wildlife Area will be a major restoration effort for improvement of waterfowl habitat in Missouri. Major development and high intensity management is envisioned in order to control the hydrology on this site. Construction will include nine miles of levee, four miles of water distribution canal, 45 water control structures, three inlet pumps, and two outlet pumps (Baskett 1987).

REGION VIII

This region comprises the states of Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming. Wetlands creation, restoration, and enhancement in this region has been conducted by local, state and the Federal government; and by private organizations. Many of the projects and plans for new projects are discussed in two recent symposia proceedings: "Proceedings of the Society of Wetland Scientists' Eighth Annual Meeting: Wetland and Riparian Ecosystems of the American West" (Mutz and Lee 1987) and "Restoration, Creation, and Management of Wetland and Riparian

Table 5. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region VI (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
Lake Texoma, Texas	Lester *et al.* 1986	----	----	Field study to examine revegetation of fluctuating shorelines
Pine Bluff, Arkansas	Richardson 1988	----	----	Replacement of bottomland hardwoods as mitigation sites for construction of highway
Green tree reservoirs, Louisiana	Simmering 1986	----	137 Ac	Mitigation for agriculture impact through flooding of hardwood forests

Table 6. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region VII (Iowa, Kansas, Missouri, and Nebraska).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
Elk Creek Marsh, Iowa	Willard *et al.* 1989	Pre-1979	600 Ac	Major creation effort to increase waterfowl habitat and hunting activities
Sweet Marsh, Iowa	Willard *et al.* 1989	Pre-1977	1098 Ac	First Iowa attempt to create marsh habitat for wildlife habitat.
Dubuque Packing Co., Iowa	Willard *et al.* 1989	Pre-1980	2.5 Ac	Mitigation; waterfowl habitat
Saylorville Wildlife Area, Iowa	Willard *et al.* 1989	Pre-1985	100 Ac	Waterfowl habitat, flood control
Otter Creek Marsh, Iowa	Willard *et al.* 1989	Pre-1977	100 Ac	Wildlife habitat, hunting areas
Fountain Grove Wildlife Area, Missouri	Willard *et al.* 1989	In progress	2200 Ac	Large-scale plan to create waterfowl habitat
Shore Creek Project, Missouri	Willard *et al.* 1989	Pre-1981	41 Ac	Mitigation; excavation only
Riverport Associates, Missouri	Willard *et al.* 1989	In progress	13 Ac	Mitigation; waterfowl habitat
10-mile Pond Wildlife Management Area, Missouri	Willard *et al.* 1989	In progress	1) 400 Ac 2) 650 Ac	Development of multiple wetland units providing a mosaic of harbeceous vegetation for wildlife habitat

Ecosystems in the American West: A Symposium of the Rocky Mountain Chapter of the Society of Wetland Scientists" (Mutz *et al.* 1988). Other freshwater wetland creation, restoration, and enhancement projects known from this region are reported in Table 7. Many of these projects are 404 permit requirements or other types of mitigation efforts. Most projects in this region have not been fully evaluated for success, however, most show evidence of some local wildlife habitat enhancement.

A very early wetlands creation effort over half a century ago resulted in substantial quantities of new wetlands through the diking of the Bear and Weber Rivers on the eastern shore of the Great Salt Lake in Utah. The rise of the Lake as a result of heavy precipitation during the winter of 1983–1984 resulted in the loss of most of these highly valued wetlands. Indications as to whether there are plans to restore the area were not found in the literature.

Countless wetlands creation projects are known from the prairie pothole lands of this region. The US Fish and Wildlife Service (1986) has evaluated the effectiveness of mitigation wetlands along US Highway 83 in North Dakota. Based on examination of 216 temporary, seasonal, and permanent ponds for wildlife, this evaluation concludes that there are no apparent differences between ponds created by excavation or impoundment and ponds connected to or separated from natural basin wetlands. The Great Plains Regional Office of Ducks Unlimited has been responsible for the restoration of numerous wetlands for waterfowl habitat. Waterfowl production success has been noted for southwestern North Dakota, and a 135 hectare marsh created at Benton Lake NWR near Great Falls, Montana has provided outstanding habitat for ducks (Hoffman 1987). Rossiter and Crawford (1981) surveyed 18 artificial wetland constructed as part of highway projects in North Dakota. They noted that wetland bird use was comparable to natural basins, but that plant and animal species diversity and abundance was frequently lower than natural basins, possibly because of the age. Over the short term, however, these types of created wetlands have been considered successful in terms of regional habitat restoration (Crawford and Rossiter 1982).

REGION IX

Region IX encompasses the states of Arizona, California, Nevada, Hawaii, and the territory of Guam. Information on freshwater wetlands creation, restoration, and enhancement in Guam and Hawaii was not available. The states of Arizona and California have hosted an abundance of freshwater wetland creation, restoration, and enhancement projects (Table 8).

In Arizona, many projects have provided compensatory mitigation for impacts on riparian habitat along the lower Colorado River and its tributaries, primarily for US Bureau of Reclamation damming and channelization projects. A number of experimental planting and seeding efforts on Cibola NWR resulted in initial rapid growth of riparian habitat composed of native species. Over time, however, many of planted stands of trees have become decadent.

Table 7. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region VIII (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
Boulder Reservoir, CO	Buckner and Wheeler 1988	1987	12 Ac	Wetland mitigation to offset the effects of reservoir construction
Chatfield Arboretum, CO	Cooper and Smith 1987	1986	----	404 permit requirement or filling 17 acres of wetlands at Massey Draw for highway construction, Jefferson Countyf
Tongue River, Montana	Gregory *et al.* 1984	1977-81	----	Examination of coal mining wastewater for fish and wildlife habitat enhancement, Big Horn County
Sawhill and Walden Ponds, CO	Koopman 1982	1974	1) 15 Ac 2)	Creation of wildlife habitat from abandoned gravel pits, Jefferson County
Texas Creek, CO	Prichard & Upham 1986	----	----	Riparian habitat enhancment
San Miguel River, CO	Rink and Windell 1988	1987	0.5 mi	404 permit requirement for riparian habitat enhancement
Blue River Reclamation Project, CO	Roesser 1988	1984-1989	1 mi	404 permit requirement to restore over a mile of devastated river channel in exchange for disturbance of 70 Ac of wetlands
Ogden Nature Center, Utah	Sempek & Johnson 1987	----	9 Ac	Excavation of 2 ponds and reseeding of 5 acres of upland habitat
Beaver Creek, CO	Tupa *et al.* 1988	1985	----	Stream relocation to offset impacts of Plaza Lodge construction

Table 8. Examples of representative freshwater wetland creation restoration, and enhancement projects documented for EPA Region IX (Arizona, California, Nevada).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
Cibola NWR, Arizona	Anderson & Ohmart 1985	1978	50 Ac	Mitigation for impacts to riparian wildife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Cibola NWR - Dredge Spoil, California	Anderson & Ohmart 1985	1978	70 Ac	Mitigation for impacts to riparian wildife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
BLM Safford District, Arizona	Carothers *et al.* 1989	1982–present	----	Habitat enhancement through a largely volunteer effort
Modoc County, California	Clay 1984	----	----	Experiment to repair stream erosion and eventually restore meadow vegetation
Mountain View Sanitation District, California	Demgen 1980	----	15 Ac	Use of wetlands for wastewater treatment and habitat enhancement
Santee, California	Gersberg *et al.* 1985	----	----	Creation and monitoring of wetlands for wastewater treatment
Ballona Wetland Project, California	Metz 1987	Present	36 Ac	Urban wetland habitat conservation for wildife and education -- (Coastal system but contains 25 acreas freshwater)
Bankline studies, Colorado River, Arizona	Mills & Tress 1988	1986	2.5 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
A-10 Backwater, Colorado River, California	Murphy 1988	1984–86	5 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ

Table 8. Continued

Beal Slough, Colorado River, Calfiornia	Murphy 1988	1980–81	15 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Fort McDowell, AZ	Murphy 1988	1985	---	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Fortuna Wash, Colorado River, California	Murphy 1988	1986	8 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Mitty Lake, Colorado River, California	Murphy 1988	1986	50 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
No-Name Lake, Colorado River, California	Murphy 1988	1987	41 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Palo Verde Oxbow I, II, III Colorado River, CA	Murphy 1988	1983–86	13 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
River Mile 151, Colorado River, California	Murphy 1988	1987	1 Mi	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Tacna marsh, Gila River, AZ	Murphy 1988	1986	139 Ac	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ

Table 8. Continued

Topock Marsh, Colorado River, California	Murphy 1988	1986	----	Mitigation for impacts to riparian wildlife habitat from streamflow and floodplain changes on the Colorado River, CA and AZ
Arcata Marsh, California	Price 1987	----	----	Creation of wastewater marsh for habitat
Santa Barbara vernal pools, California	Prichett 1987	----	----	Restoration and maintenance of sensitive habitat
Glen Echo Creek, CA	Stanley 1989	1986	300 ft both banks	Mitigation for habitat losses due to construction in Alameda County
Strawberry Creek Park, California	Stanley 1989	1983	4 Ac	Urban creek riparian restoration for creation of city park in Berkeley
Sacramento River, CA	Stanley 1989	1988	2 Ac	Mitigation for loss of valley Elderberry Longhorm Beetle habitat due to installation of rock slope protection, Princeton, CA
Tryon Creek Restoration Project, CA	Stanley 1989	1987	15 Ac	Riparian restoration, Del Norte County, CA
Lost Canyon Rehabilitation, CA	Stanley 1989	1983-85	90 Ac	Rehabilitation of erosion and habitat loss caused by pipeline rupture, Wishon Reservoir near Fresno
Bayshore Mall, CA	Stanley 1989	1986	15 Ac	Mitigation for mall construction -- riparian, saltwater marsh and freshwater marsh creation, Humboldt County, CA
McDonald Creek Restoration Project, CA	Stanley 1989	1983-86	9 Ac	Restoration of riparian streambanks caused by grazing, Humboldt County, CA
Prairie Creek Restoration Project, CA	Stanley 1989	1986	8 Ac	Restoration of riparian zone, Humboldt, County, CA

Table 8. Continued

Kern River Preserve, CA	Stanley 1989	1986–87	85 Ac	Creation of riparian habitat for Yellow-billed cuckoo, Kern County, CA
Crescent Bypass Restoration Project, CA	Stanley 1989	1986–87	6 Mi both banks	Riparian revegetation of flood control channelization project, Kings County, CA
Big Tujunga, CA	Stanley 1989	1977	14 Ac	Mitigation for highway construction impacts, Los Angeles, County
Bass Lake Shoreline Revegetation, California	Stanley 1989	1987-present	20 Ac	Riparian revegetation after riprap installation, Madera County
Novato Creek Flood Control Project, California	Stanley 1989	1987–present	7 Ac	Mitigation for flood control channel improvements through riparian revegetation, Marin County
Clark Canyon Riparian Demonstration Area, CA	Stanley 1989	1984–87	1 Mi	BLM riparian and wetland enhancement, Mono County
Carmel River Riparian Revegetation, California	Stanley 1989	1984–present	75,000 ft	Riparian revegetation to reduce erosion losses, Monterey County
Spanish Bay Resort, California	Stanley 1989	1984–87	5 Ac	Mitigation for hotel/golfcourse construction, Monterey County
San Joaquin Marsh Mitigation Bank, California	Stanley 1989	1987–present	30 Ac	Off-site mitigation for numerous industrial/commercial developments -- riparian creation, Orange County
Red Clover Creek Erosion Control Demonstration Project, California	Stanley 1989	1986–87	1 Mi	Test restoration techniques to be used to control erosion, Plumas County
Cosumnes River Preserve, California	Stanley 1989	1988–present	71 Ac	Riparian habitat restoration on abandoned farm land

Table 8. Continued

Elderberry plantings	Stanley 1989	various	----	Restoration of habitat for Valley Elderberry Longhorn Beetle through revegetation along the Sacramento River
Sacramento River Maintenance Area 9, California	Stanley 1989	1981	11 Mi	Revegetation efforts by California Department of Water Resources
I8/I15 Mitigation	Stanley 1989	1982	6 Ac	Mitigation for riparian habitat losses from freeway interchange construction, San Diego River
Morena Street site, California	Stanley 1989	1985–88	5 Ac	404 Mitigation for habitat loss, San Diego
Sweetwater Bridge, CA	Stanley 1989	1987	2 Ac	Mitigation for loss of Least Bell's Vireo habitat, San Diego, County
Alamito Creek Revegetation Project, California	Stanley 1989	1984	21 Ac	Mitigation for riparian habitat loss from flood control and water pipeline projects, Santa Clara County
Guadalupe River, California	Stanley 1989	1981	1 Ac	Mitigation for riparian habitat loss from flood control project, Santa Clara County
Llagas Creek watershed, California	Stanley 1989	1984–87	22 Ac	Mitigation for riparian habitat loss from flood control project, Santa Clara County
Lower Coyote Creek, CA	Stanley 1989	1986–87	4 Ac	Mitigation for riparian habitat loss from flood control impacts, Santa Clara County
Saratoga Creek Flood Control Project, CA	Stanley 1989	1986–present	10 Ac	Mitigation for riparian habitat loss from flood control impacts, Santa Clara County
Lyons Reservoir, California	Stanley 1989	1986	10 Ac	Pacific Gas and Electric riparian and meadow habitat enhancement, Stanislaus County

Table 8. Continued

Sespe Creek Revegetation, California	Stanley 1989	1983	8 Mi	Riparian revegetation to offset clearing by road crew, Ventura county
Elkhorn Regional Park, California	Stanley 1989	1985	1 Ac	Riparian habitat restoration, Yolo County
Putah Creek, California	Stanley 1989	1988	----	Riparian corridor enhancement, Yolo County
Apache-Sitgreaves NF, Arizona	Stanley 1989	1979	113 Ha	Creation of emergent marshes for wastewater treatment

Effectiveness of these projects is based on enhancement of wildlife values, and several of the larger scale projects are considered successful. Many of the surviving revegetation projects have not exhibited reproductive success, however, and the longevity of these planted forests may be a function of the life span of the individual plantings. It is generally agreed that further work is needed to determine the conditions driving successful revegetation (Carothers *et al.* 1989).

In California, several hundred riparian restoration projects have been implemented in the past ten years (Stanley 1989). These projects are typically a result of mitigation, and include wildlife habitat creation and enhancement efforts through revegetation and stream restoration construction projects. In general, the short-term results of these projects have indicated success, given clearly defined goals and with considerable pre-planning efforts. Many projects involve riparian restoration and enhancement efforts, which are typically more successful than creation on sites where riparian habitat was not originally found. Effectiveness of these sites has been measured by the extent of persistence of vegetated areas over time. Many projects have shown immediate planting failure, and have been re-planted.

A highly visible restoration project presently in progress is the Ballona Wetland Project habitat restoration, a National Audubon Society effort aimed at integrating habitat preservation with opportunities for environmental education. The plan includes the creation of 10 hectares of freshwater wetlands within a 87 hectare coastal system in the southern California urban metropolis. The long-term goal of the project is to "create a representative southern California wetland system, . . . which includes a range of native communities typically associated with coastal wetlands. . . The Ballona Wetland will be restored in phases leading to a cohesive, dynamic, diverse, and productive coastal habitat area" (Metz 1987). Careful planning and an understanding of the cumulative experience gained through western creation and restoration efforts may benefit this and other future large-scale projects.

REGION X

Region X encompasses the northwestern portion of the United States and includes the states of Alaska, Idaho, Oregon, and Washington. Many freshwater wetland creation, restoration, and enhancement efforts in this region have been geared towards stream restoration to enhance fisheries and aquatic habitat. Efforts to establish riparian vegetation have also been common and widespread both east and west of the Cascades. The extent and level of success of wetland creation and restoration in the Pacific Northwest has been documented by Kentula (1986), Kunz *et al.* (1988), Jenson and Platts (1989), and Platts *et al.* (1987). Table 9 provides a representative cross section of projects implemented in this region.

Fifteen Mile Creek, Wasco County, Oregon provides an example of a typical restoration project for this region (Newton 1981). The area had deteriorated as a result of grazing, agriculture, timer harvest and stream flow diversions. A restoration and stabilization project encompassing structural improvements and revegetation completed in 1974 has shown encouraging results over the long term.

Table 9. Examples of representative freshwater wetland creation, restoration, and enhancement projects documented for EPA Region X (Alaska, Idaho, Oregon, and Washington).

PROJECT	REFERENCE	DATE of EST.	SIZE	OBJECTIVE
John Henry Mine, Washington	Abernathy *et al.* 1985	----	----	Mitigation to stabilize wetland area created by mining operations – plan only
Raft River, Idaho	Breckenridge *et al.* 1983	1981	0.25 Ha	Evaluation of feasbility of developing a wetland with geothermal effluent
Bears Creek, Oregon	Elmore & Beschta 1987	1976	3 Mi	Stream improvements and exclusion of grazing to improve riparian habitat
Delta Ponds, Oregon	Gallagher 1982	----	----	Restoration of gravel mines for wildlife and recreation benefits
Spring Meadow, Idaho	Gebhardt *et al.* 1988	1987–90	----	Provide habitat and recreational values through enhancement of an urban wetlands
Birch Creek, Idaho	Jenson *et al.* 1987	1986	----	Riparian and fisheries habitat creation to mitigate for stream diversion for a hydroelectric facility
Chena Lakes, Alaska	Johnson *et al.* 1981	1978	----	Revegetation of a flood control dam – experimental plantings
Felt, Teton R., Idaho	Johnson 1987	----	----	Mitigation to restore fish and wildlife habitat disturbed by road construction
Pigeon Cove, Snake R., Idaho	Johnson 1986	1987	3.8 Ha	Habitat restoration to mitigate for highway construction
15-Mile Creek, Oregon	Newton 1981	1974	10 Mi	Restoration of a severely eroded creek
Columbia River, Washington	USFWS 1983	1982	600 Ac	Restoration of riparian vegetation disturbed by emergency channel filling

Many portions of this region contain geothermal developments. The disposal of geothermal effluent has been a problem in the past, and recent efforts have been made to examine the potential for using this water to create wetlands. The Raft River valley in south central Idaho provided a site for a 0.25 hectare wetland creation project which indicated that the potential exists to effectively use geothermal waste water for this purpose (Breckinridge *et al.* 1983).

CONCLUSIONS

Evaluation of the extent of success of freshwater wetland creation, restoration, and enhancement projects in the United States is constrained by a limited data base with respect to project goals, site descriptions, construction plans, and author bias. Conclusions about the success of projects is frequently indicated by hopeful project managers after only one or two growing seasons, or based on the establishment of vegetation without regard to attainment of other wetland functions. In general, when the satisfactory accomplishment of engineering needs, such as storm water retention, wastewater treatment or erosion control is determined to be a measure of success, than many wetland projects have been successful.

It has been suggested that many early creation efforts may have missed the mark on restoring functional wetlands over the long term. Larson (1987) notes that "the main criterion of wetland replication success today appears to be growth of wetland plants on man-made sites. But with respect to artificially creating detritus and grazing food chains to replicate the full suite of food chain, wildlife and fisheries habitat functions of natural wetlands, science cannot offer guidelines with low risk and high certainty".

Kunz *et al.* (1988) summarized attempts to evaluate wetlands mitigation in the state of Washington. "There has been no consistent, standardized, process for negotiating, planning, implementing, or evaluating wetland mitigation projects. No single agency, federal or state, has maintained comprehensive records of mitigation projects. The information contained in the federal agency 404 project files is dispersed and incomplete. Monitoring results are sparse, construction/restoration completion dates are inconsistent, and the degree of functional success has rarely been documented". Based on the extensive information reviewed for this report, it appears that this unfortunate set of circumstances may be representative of the situation nation wide.

Another recent assessment of wetlands mitigation success (Quammen 1986) supports the conclusion that achievement of fully functional wetland ecosystems through creation efforts appears to have been few, and that compliance with permit conditions is low. Quammen further notes that the assessment of success is presently difficult and will continue to be difficult until project objectives and design criteria are clearly stated as part of permit conditions, and monitoring becomes a standard part of the assessment protocol.

Ischinger and Schneller-McDonald (1988), in their appraisal of western restoration and creation, noted that "We do have the technology to restore a wetland site that will potentially perform some

limited ecosystem functions (wildlife habitat)". However, the authors as well as other reviewers acknowledge that creation or restoration of wetland ecosystems over the long term is undocumented in many parts of the United States. Furthermore, monitoring of wetland functional restoration has been largely non-existent or of such short duration that long term claims to restoration or creation success are largely speculative.

Because Section 404 projects rarely state specific goals for mitigation through wetland creation, criteria for determining success cannot be developed. A concise statement of project goals and design considerations prior to permitting would provide for future evaluation of the likelihood for success. Levine and Willard (1989) recommend the following information on project goals and design considerations be provided prior to permitting:

- Justification for site location;
- Description of pre-project site conditions, including substrate characteristics, elevations, water levels, and fluctuations;
- Detailed construction plans;
- Species lists, planting methods, and other details of the revegetation plan;
- Long-term management plan detailing management, identification of the responsible party and financing sources; and
- Comprehensive monitoring plan.

The inclusion of this information with the permit application will provide the permitting agencies with a solid basis for determining the probabilities of success and failure of the proposed project.

The extensive efforts of the EPA Environmental Research Laboratory in compiling regional summaries of creation and restoration efforts elucidates the fact that "The creation and restoration of wetlands is a complex and often difficult task. This points to the need for setting clear, ecologically sound goals for projects and developing quantitative methods for determining if they have been met. To validate the goal setting process, wetland science must progress and the role of wetlands in the landscape must be understood" (EPA 1989).

APPENDIX A

The following bibliography presents references to the scientific literature, government documentation, and other reports pertaining to freshwater wetlands creation, effectiveness, and restoration for the period 1979-1989. The intent of the bibliography is to provide a comprehensive listing on state-of-the-art information. Therefore, a few references, although dated prior to 1979, were considered relevant enough to include in the list. The majority of references deal specifically with non-tidal, freshwater wetlands. A few citations may pertain to coastal wetlands but may also contain information applicable to freshwater wetlands.

The bibliography is accompanied by a list of key words to illuminate the subject matter presented in each of the citations. The key word list is broken down into six categories to present the full range of topics. The categories are:

EMPHASIS:

This category includes key words such as Creation, Restoration, Enhancement, Revegetation, Reclamation, Overview, Effectiveness, Mitigation, Technique, Management, Policy, Plan only, Monitoring, Design, and Feasibility. These descriptive terms describe the overall emphasis of the reference. In particular, an emphasis of "Effectiveness" indicates that the article describes the level of success associated with a specific project, while "Plan only" indicates that the article describes a project that has not yet been implemented.

REGION/STATE:

This category includes information on region, state, county, or other location information.

WETLAND TYPE:

Wetland type is usually delimited as Palustrine, however, Palustrine emergent, Riparian, Lacustrine, and other distinct types of wetlands are noted if this information is known.

IMPACT:

The Impacts category includes descriptive terms such as Mining (including type), Highway construction, Development, Dredging, Damming, and Channelization.

WETLAND USE:

Wetland Use refers to the primary function desired after creation, restoration or enhancement of the wetland. This category includes key words such as Habitat, Wastewater treatment, Stormwater drainage, Recreation, and Aesthetics.

SCIENTIFIC THEME:

Scientific Theme describes the scientific emphasis of the article. Categories include Vegetation, Wildlife, Soils, Hydrology, and Engineering. Many of the citations have no scientific theme, particularly those dealing with policy and technique.

A double dash indicates that the citation is general in nature, or that the information presented in the article is not directly applicable to the subject category.

This bibliography is presented as an appendix to the report, *"The Status of Non-Tidal, Freshwater Wetlands Creation, Restoration, and Enhancement in the United States — Mitigation Effectiveness: Recap of the Existing Literature"*. This report provides an assessment of information available on mitigation effectiveness, as well as an assessment of overall efforts to create, restore, and enhance wetlands in the United States in the past ten years.

Abernathy, MC, DJ Morris, and R Van Wormer. 1985. Wetland reclamation planning at the John Henry Mine in Western Washington. Pages 153-159 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School for Resources, University Park.

EMPHASIS:	Restoration, Plan only
REGION/STATE:	Washington (John Henry Mine)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Adamus, PR. 1988. Criteria for created or restored wetlands. Pages 369-372 IN: D.D. Hook, ED. The Ecology and Management of Wetlands, Vol. 2. Timber Press, Portland, OR.

EMPHASIS:	Creation, Restoration, Effectiveness, Evaluation, technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Wetland evaluation technique

Adamus, PR and LT Stockwell. 1983. A method for wetland functional assessment, Vol 1. Report No. FHWA-IP-82-23. U.S. Department of Transportation, Federal Highway Administration, Washington, DC.

EMPHASIS:	Creation, Restoration, Evaluation
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Function

Ambrose, RE, CR Hinkle, and CR Wenzel. 1983. Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the southcentral U.S. US Fish and Wildlife Service FWS/OBS-83-11. 229 pp.

EMPHASIS:	Technique, Management, Reclamation
REGION/STATE:	Southcentral
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

American Fisheries Society—Western Division. 1982. The best management practices for the management and protection of western riparian stream ecosystems. American Fisheries Society, Western Division, Orem, UT. 45 pp.

EMPHASIS:	Management, Technique
REGION/STATE:	Western
WETLAND TYPE:	Riparian
IMPACT:	Grazing, Mining, Water development, Road construction, Agriculture, Urbanization, Timber harvest
WETLAND USE:	—
SCIENTIFIC THEME:	—

Anderson, BW, J Disano, DL Brooks, and RD Ohmart. 1984. Mortality and growth of cottonwood on dredge spoil. Pages 438–444 IN: R.E. Warner and K.M. Hendrix, EDS., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Anderson, BW and RD Ohmart 1979. Riparian revegetation: an approach to mitigating for a disappearing habitat in the Southwest. Pages 481–487 IN: G.A. Swanson, Technical Coordinator, The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitat. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, General Technical Report RM-65.

EMPHASIS:	Mitigation, Revegetation, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Anderson, BW. and RD Ohmart. 1985. Riparian revegetation as a mitigating process in stream and river restoration. Pages 41–79 IN: J.A. Gore, ED., The Restoration of Rivers and Streams. Butterworth Publishers, Boston, MA.

EMPHASIS:	Mitigation, Revegetation, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Anderson, BW. and RD Ohmart. 1984. Avian use of revegetated riparian zones. Pages 626–631 IN: IN: R.E. Warner and K.M. Hendrix, EDS., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Avian use

Anderson, BW and RD Ohmart. 1982. Revegetation for wildlife enhancement along the lower Colorado River. U.S. Department of Interior, Bureau of Reclamation, Boulder City, NV., Contract No. 7-07-30-V0009. 215 pp.

EMPHASIS:	Revegetation, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Wildlife

Anderson, BW, RD Ohmart, and J. Disano. 1979. Revegetating the riparian floodplain for wildlife. pages 318–331 IN: R.R. Johnson and J.F. McCormick, Technical Coordinators, Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. USDA Forest Service, Washington, DC, General Technical Report WO-12.

EMPHASIS:	Revegetation, Technique, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Wildlife

Andrews, NJ, M. Penko , MD Mattson, and DC Pratt. 1981. The establishment of cattails on a northern Minnesota peatland. Minnesota Department of Natural Resources and Minnesota Energy Agency, Minnesota Peat Program, St. Paul, MN 79 pp.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Minnesota (Zim)
WETLAND TYPE:	Palustrine (Peatland)
IMPACT:	Agriculture
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Soils

Anonymous. 1983. Build your own bog to neutralize acid mine drainage. Coal Age, (June) 77.

EMPHASIS:	Research: Technique
REGION/STATE:	Eastern
WETLAND TYPE:	Palustrine (Bog)
IMPACT:	Coal mining
WETLAND USE:	Neutralization of acid drainage
SCIENTIFIC THEME:	Water quality

Apple, LL, BH Smith, JD Dunder, and BW Baker. 1984. The use of beavers for riparian/aquatic habitat restoration of cold desert, gully-cut stream systems in southwestern Wyoming. Page 109-116 IN: D.L. Archer, Ed., Proceedings of the Bonneville Chapter of the American Fisheries Society. Bonneville Chapter of the American Fisheries Society, Salt Lake City, UT.

EMPHASIS:	Technique, Management
REGION/STATE:	Wyoming (southwest)
WETLAND TYPE:	Riparian
IMPACT:	Grazing
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Athanas, C. 1988. Wetlands creation for stormwater treatment. Pages 61-66 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation
REGION/STATE:	Maryland (May's Chapel)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Stormwater Treatment
SCIENTIFIC THEME:	Vegetation, Water quality

Atkins, K. 1981. Biotic response to drawdown and reflooding in a clay settling pond. Pages 169-187 IN: R.H. Stovall, Ed., Proceedings of the Eighth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Reclamation, Effectiveness, Technique,
REGION/STATE:	Florida (Polk County)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Atkins, K. 1987. A qualitative assessment of wetlands reclaimed as natural system habitat. Pages 17-36 IN: F.J. Webb, Jr., Ed. Proceedings of the Fourteenth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Plant City, FL.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	Florida (Polk and Eastern Hillborough Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Auble, GT, DB Hamilton, JE Roelle, J Clayton, and LH Fredrickson. 1988. A prototype expert system for moist soil management. Page 137-143 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Management, Monitoring
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Computer Modelling, Hydrology

Banner, A. 1979. Mitigation under the Corps Regulatory Program. Pages 396-399. IN: G.A. Swanson, Technical Coordinator, The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitat. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, General Technical Report RM-65.

EMPHASIS:	Mitigation, Policy, Regulations
REGION/STATE:	United States (Florida examples)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

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

EMPHASIS:	Mitigation, Creation, Restoration, Guidelines
REGION/STATE:	Florida (Key Largo)
WETLAND TYPE:	—
IMPACT:	Dredge and fill
WETLAND USE:	—
SCIENTIFIC THEME:	—

Barko, JW, RM Smart, CR Lee, MC Landin, TC Sturgis and RN Gordon. 1977. Establishment and growth of selected freshwater and coastal marsh plants in relation to characteristics of dredged sediments. US Army Engineers Waterways Experiment Station, Environmental Effects Laboratory, Vicksburg, MS. Technical Report D-77-2. 41 pp.

EMPHASIS:	Research (Laboratory)
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Dredging
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Soil chemistry

Baskett, RK. 1988. Grand Pass Wildlife Area, Missouri: Modern wetland restoration strategy at work. Pages 220–224 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Restoration, Management, Technique, Plan only
REGION/STATE:	Missouri (Grand Pass Wildlife Area)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Bates, AL, E Pickard and WM Dennis. 1979. Tree plantings—a diversified management tool for reservoir shorelines. Pages 190–194 IN: R.R. Johnson and J.F. McCormick, Eds., Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. USDA Forest Service, Washington, DC, General Technical Report WO-12.

EMPHASIS:	Revegetation, Effectiveness
REGION/STATE:	Alabama, Tennessee, North Carolina
WETLAND TYPE:	Lacustrine (reservoir)
IMPACT:	Damming
WETLAND USE:	Mosquito control
SCIENTIFIC THEME:	—

Bauer, AM. 1982. Manipulating mining operations to create wildlife habitats: a pre-mining planning process. Pages 41–43 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Misc. Publication 17-1982.

EMPHASIS:	Reclamation, Technique, Planning
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Gravel Mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Best, CR and KL Erwin. 1984. Effects of hydroperiod on survival and growth of tree seedlings in a phosphate surface-mined reclaimed wetland. Pages 221-225 IN: D.H. Graves, Ed., Proceedings of the 1984 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky, OES Publication, Lexington, KY.

EMPHASIS:	Revegetation
REGION/STATE:	Florida (Southwest Polk County)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Beule, JD. 1979. Control and management of cattails in southeastern Wisconsin wetlands. Wisconsin Department of Natural Resources, Madison Technical Bulletin No. 112. 39 pp.

EMPHASIS:	Management, Enhancement, Technique
REGION/STATE:	Wisconsin (Eldorado Marsh Wildlife Area, Horicon Marsh)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Bouldin, DR, DJ Lathwell, EA Goyette, and DA Lauer. 1973. Changes in water chemistry in marshes over a 12-year period following establishment. New York Fish and Game Journal. 20(2):129-149.

EMPHASIS:	Research, Monitoring
REGION/STATE:	New York (20 marshes)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Water Quality

Boule, ME. 1987. Wetland creation and enhancement in the Pacific Northwest. Pages 130-136 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Creation, Enhancement, Design, Management, Monitoring, Planning
REGION/STATE:	Pacific Northwest
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Bowers JK. 1988. John Hopkins University non-tidal wetland mitigation area. Pages 314–317 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Creation, Technique
REGION/STATE:	Maryland (John Hopkins University)
WETLAND TYPE:	Emergent
IMPACT:	Urbanization
WETLAND USE:	—
SCIENTIFIC THEME:	—

Bowers, K. 1988. Non-tidal, emergent wetland transplant. Restoration and Management Notes 6(1):41–42.

EMPHASIS:	Mitigation, Creation, Technique
REGION/STATE:	Maryland (John Hopkins University)
WETLAND TYPE:	Palustrine
IMPACT:	Urbanization
WETLAND USE:	—
SCIENTIFIC THEME:	—

Branch, WL. 1985. Design and construction of replacement wetlands on lands mined for sand and gravel. Pages 173–179 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School for Resources, University Park.

EMPHASIS:	Creation, Design, Technique, Effectiveness
REGION/STATE:	Maryland (Patuxent River)
WETLAND TYPE:	Palustrine
IMPACT:	Sand and Gravel Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Breckinrdge, RP, LR Wheeler, and JR Ginsberg Jr. 1983. Biomass production and chemical cycling in a man-made geothermal wetland. Wetlands 3:26–43.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Idaho (Southcentral)
WETLAND TYPE:	Palustrine
IMPACT:	Geothermal development
WETLAND USE:	Geothermal effluent cycling
SCIENTIFIC THEME:	Nutrient cycling

Breedlove, BW. 1983. Wetlands reclamation: A drainage approach. Pages 90–99 IN: D.J. Robertson, Ed., Reclamation and the Phosphate Industry: Proceedings of the symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Restoration, Guidelines
REGION/STATE:	Florida (Central and Northern)
WETLAND TYPE:	—
IMPACT:	Phosphate Mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Breckenridge, RP, LR Wheeler, and JF Ginsburg. 1983. Biomass production and chemical cycling in a man made geothermal wetlands. Wetlands, Vol. 3, 1983, pp. 26–43.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Idaho (Raft River)
WETLAND TYPE:	Emergent
IMPACT:	Geothermal development
WETLAND USE:	Vegetation establishment, Chemical cycling
SCIENTIFIC THEME:	—

Brenner, FJ. 1988. Surface mine reclamation: an opportunity for wetland development. Pages 338–343 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Reclamation, Technique
REGION/STATE:	East, Midwest, Pennsylvania (Northwest)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Brodie, GA, DA Hammer, and DA Tomljanovich. 1986. Man-made wetlands for acid mine drainage control. Paper presented at Eight Annual National Abandoned Mine Lands Conference, Billings, Montana, August 10–15.

EMPHASIS:	Mitigation, Creation, Monitoring
REGION/STATE:	Alabama (Jackson County)
WETLAND TYPE:	—
IMPACT:	Coal Mining
WETLAND USE:	Acid Drainage Treatment
SCIENTIFIC THEME:	—

Brodie, GA, DA Hammer, and DA Tomljanovich. 1987. Constructed wetlands for acid drainage control in the Tennessee Valley. Pages 173-180 IN: J. Zelazny and J.S. Feierabend, Editors. Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, D.C.

EMPHASIS:	Mitigation, Creation, Design, Operation, Monitoring, Overview
REGION/STATE:	Alabama (Jackson Co.); Tennessee (Roane Co.); 11 wetlands
WETLAND TYPE:	—
IMPACT:	Coal Mining
WETLAND USE:	Acid Drainage Treatment
SCIENTIFIC THEME:	—

Brodie, GA, DA Hammer, and DA Tomljanovich. 1987. Treatment of acid drainage from coal facilities with man-made wetlands. Pages 903-912 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Creation, Technique
REGION/STATE:	Alabama (Northeast)
WETLAND:	Palustrine
IMPACT:	Coal Mining
WETLAND USE:	Acid Drainage Treatment
SCIENTIFIC THEME:	—

Brooks RP. 1984. Optimal designs for restored wetlands. Pages 16-29. IN: J.E. Burris, Ed., Treatment of Mine Drainage by Wetlands. Pennsylvania State University, University Park, Contribution No. 264.

EMPHASIS:	Creation, Restoration, Design, Assessment
REGION/STATE:	Pennsylvania (western)
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Acid drainage treatment, Habitat
SCIENTIFIC THEME:	—

Brooks, RP. 1986. Mitigating the impacts of coal mining on wetlands. Pages 179-181 IN: J.A. Kusler, M.L.Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Creation, Restoration, Feasibility, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Sediment removal, Floodwater retention, Pollution control, Habitat, Aesthetics
SCIENTIFIC THEME:	—

Brooks, RP, JP Hepp and JB Hill. 1988. Wetland creation opportunities on coal mined lands. Pages 181-184 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Guidelines
REGION/STATE:	Pennsylvania (western)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Acid mine drainage, Habitat, Erosion and sedimentation control
SCIENTIFIC THEME:	Vegetation, Water quality

Brooks, RP and RM Hughs. 1986. Guidelines for assessing the biotic communities of freshwater wetlands. pages 276–282 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Monitoring, Assessment
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Brown, MT, F Gross, and J Higman. 1984. Studies of a method of wetland reconstruction following phosphate mining. Pages 24–25 IN: F.J. Webb, Jr., Ed., Proceedings of the Eleventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique
REGION/STATE:	Florida
WETLAND TYPE:	—
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Soils

Buck, JK and RJ Houston. 1986. Direct revegetation of four coal waste sites in Pennsylvania—four approaches. Pages 385–429 IN: C.L. Carlson and J.H. Swisher, Eds., Innovative Approaches to Mined Land Reclamation. Southern Illinois University Press, Carbondale.

EMPHASIS:	Restoration, Technique
REGION/STATE:	Pennsylvania (Lucerne)
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Fly ash amendments
SCIENTIFIC THEME:	Soils

Buckner, DL and RL Wheeler. 1988. Construction of cattail wetlands along the east slope of the front range of Colorado. Pages 126–131 IN: IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Colorado
WETLAND TYPE:	Palustrine emergent
IMPACT:	Reservoir construction
WETLAND USE:	Fly ash amendments
SCIENTIFIC THEME:	Soils

Bureau of Land Management. 1983. Environmental assessment on state of reclamation techniques on phosphate-mined lands in Florida and their application to phosphate mining in the Osceola National Forest. USDI, Bureau of Land Management, Eastern States Office, Alexandria, VA. 82 pp.

EMPHASIS:	Reclamation, Technique
REGION/STATE:	Florida (Osceola National Forest)
WETLAND TYPE:	"Hardwood wetlands"
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Butts, MP. 1986. Status of wetlands creation/mitigation projects on state highway projects in Connecticut. Pages 185–187 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Creation, Effectiveness
REGION/STATE:	Connecticut (state highway projects)
WETLAND TYPE:	Palustrine
IMPACT:	Highway construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Byerly, DW, JB Maddox, CS Fletcher and DT Eagle. 1978. Reclamation of mined land in the Piney Creek Watershed—an interim report. Pages 267–275 IN: D.E. Samuel, J.R. Stauffer and C.H. Hocutt, Eds., Proceedings of a Symposium: Surface Mining and Fish/Wildlife Needs in the Eastern United States. US Fish and Wildlife Service. FWS/OBS-78/81.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Tennessee (Van Buren County)
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Soil and water quality improvement
SCIENTIFIC THEME:	Vegetation, Soil and water quality

Byron, GJ. 1985. Man-made wetlands as a post-mining land use: regulatory issues and conflicts. Pages 181-183 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forestry Resources, University Park.

EMPHASIS:	Regulations
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Surface mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Cairns, J. Jr. 1985. Facing some awkward questions concerning rehabilitation management practices on mined lands. Pages 9-17 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forestry Resources, University Park.

EMPHASIS:	Overview: Restoration, Management, Feasibility
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Surface mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Cardamone, MA. 1985. Wetlands and the surface mining of coal: protection and values assessment. M.S. Thesis, University of Kentucky, Louisville. 148 pp.

EMPHASIS:	Mitigation, Management, Restoration, Protection, Assessment
REGION/STATE:	Eastern interior (Kentucky, Indiana, Illinois)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Carlson, JE. 1982. Preliminary report on the restoration of farmed freshwater marshes at Corkscrew Swamp Sanctuary. Pages 212-227 IN: F.J. Webb, Jr., Ed., Proceedings of the Ninth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique, Monitoring, Effectiveness
REGION/STATE:	Florida (Corkscrew Swamp)
WETLAND TYPE:	—
IMPACT:	Agriculture
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Carlson, JR. 1979. Streamside vegetation. USDA Soil Conservation Service, Portland, Oregon Technical Notes. Plant Materials-55. 9 pp.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Pacific Northwest
WETLAND TYPE:	Riparian
IMPACT:	Human activities
WETLAND USE:	Habitat, Human use, Aesthetics
SCIENTIFIC THEME:	—

Carothers, SW, GS Mills, and RR Johnson. 1989. The creation and restoration of riparian habitat in southwestern arid and semi-arid regions. Pages 359-376 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Carson JD. 1982. Progress report of a reclaimed wetland on phosphate mined land in central Florida. Pages 243-250 IN: F.J. Webb, Jr., Ed., Proceedings of the Ninth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Reclamation, Revegetation, Monitoring, Effectiveness
REGION/STATE:	Florida (Polk County)
WETLAND TYPE:	—
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

CE Maguire, Inc. 1985. Wetland replacement evaluation. U.S. Army Corps of Engineers., Norfolk, VA. Unpublished Report. 186 pp.

EMPHASIS:	Mitigation, Evaluation, Creation, Effectiveness
REGION/STATE:	Virginia (32 wetlands)
WETLAND TYPE:	—
IMPACT:	Various (404 compliance)
WETLAND USE:	—
SCIENTIFIC THEME:	—

CH2M Hill. 1981. Feasibility of using geothermal effluents for waterfowl wetlands. U.S. Fish and Wildlife Service FWS/OBS-81/44 236 pp.

EMPHASIS:	Evaluation, Effectiveness, Feasibility
REGION/STATE:	Seven states, including Montana, Idaho, and Nevada
WETLAND TYPE:	—
IMPACT:	Geothermal development
WETLAND USE:	Geothermal effluent
SCIENTIFIC THEME:	—

Chamison, JF. 1984. Riparian vegetation planting for flood control. pages 120–123 IN: R.E. Warner and K.M. Hendrix, Eds., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Technique, Effectiveness
REGION/STATE:	California (Sacramento River)
WETLAND TYPE:	Riparian
IMPACT:	Channelization
WETLAND USE:	Erosion control, Sediment stabilization
SCIENTIFIC THEME:	—

Chapman, RJ, TM Hinckley, LC Lee, and RO Teskey. 1982. Impact of water level changes on woody riparian and wetland communities. Volume X: Index and Appendum to Volumes I-VIII. US Fish and Wildlife Service FWS/OBS-82/23. 111 pp.

EMPHASIS:	Research
REGION/STATE:	—
WETLAND TYPE:	Riparian, palustrine
IMPACT:	Water level changes
WETLAND USE:	—
SCIENTIFIC THEME:	Water level change impact on vegetation

Chironis NP. 1982. Reedgrass greens slurry ponds. Coal Age (April): 86–91.

EMPHASIS:	Revegetation, Technique, Effectiveness
REGION/STATE:	Illinois (Monterey Coal Slurry Impoundment)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Stabilization
SCIENTIFIC THEME:	Vegetation

Clark, JR. 1986. Assessment for wetlands restoration. Pages 250–253 IN: J.A. Kusler and P. Riexinger, Eds., Proceedings of the National Wetland Assessment Symposium. Association of State Wetland Managers, Chester, VT.

EMPHASIS:	Restoration, Overview, Policy, Assessment
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Clay, DH. 1984. High mountain meadow restoration. Pages 477–479 IN: R.E. Warner and K.M. Hendrix, Eds., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Restoration, Technique, Revegetation
REGION/STATE:	California (Modoc County)
WETLAND TYPE:	Meadow
IMPACT:	Stream erosion
WETLAND USE:	—
SCIENTIFIC THEME:	—

Clewell, AF. 1981. Vegetational restoration techniques on reclaimed phosphate strip mines in Florida. Wetlands 1:158–170.

EMPHASIS:	Creation, Restoration, Technique, Effectiveness
REGION/STATE:	Florida
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Clewell, AF. 1983. Riverine forest restoration efforts on reclaimed mines at Brewster Phosphates, central Florida. Pages 122–133 IN: D.J. Robertson, Ed., Reclamation and the Phosphate Industry: Proceedings of the Symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Florida (Polk and Hillsborough Counties)
WETLAND TYPE:	Forested
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Clewell, AF and R Lea. 1989. Creation and restoration of forested wetland vegetation in the southeastern United States. Pages 199-237 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Southeast
WETLAND TYPE:	Forested wetland
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Conservation Consultants Inc. 1979. Wetland reclamation pilot study for W.R. Grace and Company. Annual Report for 1978. Conservation Consultants, Inc., Palmetto, FL. 56 pp.

EMPHASIS:	Creation, Monitoring, Pilot study
REGION/STATE:	Florida (Hillsborough County)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Soils

Cooper, DJ. 1988. Mountain wetland vegetation dynamics. Pages 23-25 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Research, Restoration assessment
REGION/STATE:	Rocky Mountains
WETLAND TYPE:	Mountain wetlands
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation dynamics

Cooper, DJ and B Smith. 1987. First annual report Chatfield Arboretum Wetland Creation Project. Colorado School of Mines, Department of Environmental Science and Engineering Ecology, Golden, CO. Unpublished Report. 79pp.

EMPHASIS:	Creation, Monitoring, Effectiveness
REGION/STATE:	Colorado (Chatfield Arboretum, Jefferson County)
WETLAND TYPE:	Palustrine
IMPACT:	Highway construction (404)
WETLAND USE:	—
SCIENTIFIC THEME:	—

Disano, J, BW Anderson, and RD Ohmart. 1984. Irrigation systems for riparian zone revegetation. Pages 471–476 IN: R.E. Warner and K.M. Hendrix, Eds., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Southwest (Colorado River)
WETLAND TYPE:	Riparian
IMPACT:	Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Irrigation

Dobie, B. 1986. Private financing for wetland restoration. Pages 14–28 IN: J.L. Piehl, Ed., Proceedings, Wetland Restoration: A Techniques Workshop. Minnesota Chapter of the Wildlife Society, Fergus Falls.

EMPHASIS:	Economics, Restoration
REGION/STATE:	Minnesota
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Dougherty, ST, CA Berry, and MA Deimel. 1987. Hydrology and vegetation in montane and subalpine wetlands of Colorado. Pages 81–84 IN: K.M. Mutz and L.C. Lee, Technical Coordinators, Wetland and Riparian Ecosystems of the American West: Eighth Annual Meeting of the Society of Wetland Scientists, Wilmington, NC.

EMPHASIS:	Scientific overview
REGION/STATE:	Colorado (Williams Fork River, Holy Cross Wilderness)
WETLAND TYPE:	Montane, Subalpine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Vegetation

Dunn, WJ, and GR Best. 1983. Enhancing ecological succession—survey of seed bank composition in marsh ecosystems and potential of seed bank establishment as an alternative for restoration of native marshes. Pages 100–114 IN: D.J. Robertson Ed., Reclamation and the Phosphate Industry: Proceedings of the Symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Research: Restoration
REGION/STATE:	Florida (central)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Dunn, WJ and GR Best. 1983. Enhancing ecological succession: 5. Seed bank survey of some Florida marshes and role of seed banks in marsh reclamation. Pages 365–370 IN: Proceedings of the 1983 Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation. University of Kentucky, Lexington.

EMPHASIS:	Research: Restoration
REGION/STATE:	Florida, Iowa, New Jersey, Ontario
WETLAND TYPE:	Palustrine
IMPACT:	Mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Eckert JW, ML Giles, and GM Smith. 1978. Design concepts for in-water containment structures for marsh habitat development. US Army Engineers Waterways Experiment Station, Vicksburg, MS. Technical Report D-78-31. 69 pp.

EMPHASIS:	Creation, Design, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Elmore, W and RL Beschta. 1987. Riparian areas: Perceptions in management. Rangelands: 9(6):260–265.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Oregon (Bear Creek, Crook County)
WETLAND TYPE:	Riparian
IMPACT:	Grazing, Sedimentation
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Environmental Laboratory. 1986. Field guide for low maintenance vegetation establishment and management. US Army Engineers Waterways Experiment Laboratory, Vicksberg, MS. Instruction Report R-86-2. 111 pp.

EMPHASIS:	Scientific overview: Revegetation, Management
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Soils, Water quality

Erwin, KL. 1983. Fort Green Reclamation Project: First annual report. Agrico Chemical Company, Mulberry, FL. 120 pp.

EMPHASIS:	Reclamation, Monitoring, Techniques
REGION/STATE:	Florida (Southwest Polk County)
WETLAND TYPE:	Palustrine, Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Invertebrates, Water quality, Vegetation

Erwin, KL. 1984. Fort Green Reclamation Project: second annual report. Agrico Chemical Company, Mulberry, FL. 253 pp.

EMPHASIS:	Reclamation, Monitoring, Techniques
REGION/STATE:	Florida (Southwest Polk County)
WETLAND TYPE:	Palustrine, Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Invertebrates, Water quality, Vegetation

Erwin, KL. 1985. Fort Green Reclamation Project: third annual report. Agrico Chemical Company, Mulberry, FL. 362 pp.

EMPHASIS:	Reclamation, Monitoring, Techniques
REGION/STATE:	Florida (Southwest Polk County)
WETLAND TYPE:	Palustrine, Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Invertebrates, Water quality, Vegetation

Erwin, KL. 1986. Fort Green Reclamation Project: fourth annual report. Agrico Chemical Company, Mulberry, FL. 296 pp.

EMPHASIS:	Reclamation, Monitoring, Techniques
REGION/STATE:	Florida (Southwest Polk County)
WETLAND TYPE:	Palustrine, Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Invertebrates, Water quality, Vegetation

Erwin, KL. 1986. A quantitative approach for assessing the character of freshwater marshes and swamps impacted by development in Florida. Pages 295-297 IN: J.A. Kusler, M.L.Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

WETLAND TYPE:	Riparian, palustrine
EMPHASIS:	Assessment, Monitoring, Techniques
REGION/STATE:	Florida
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Hydrology, Water quality, Vegetation

Erwin, KL. 1989. Freshwater marsh creation and restoration in the southeast. Pages 239-271 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Southeast
WETLAND TYPE:	Palustrine emergent
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Erwin, KL and FD Bartleson. 1985. Water quality within a central Florida phosphate surface mined reclaimed wetland. Pages 84-95 IN: F.J. Webb, Jr., Ed., Proceedings of the Twelfth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Monitoring
REGION/STATE:	Florida (Polk County, Agrico Swamp)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Water quality, Hydrology, Vegetation

Erwin, KL and GR Best. 1985. Marsh community development in a central Florida phosphate surface-mined reclaimed wetland. Wetlands 5:155-166.

EMPHASIS:	Creation, Revegetation, Techniques
REGION/STATE:	Florida (Polk County)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Erwin KL, GR Best, WJ Dunn, and PM Wallace. 1985. Marsh and forested wetlands reclamation of a central Florida phosphate mine. Wetlands 4:87-104.

EMPHASIS:	Reclamation, Creation, Technique
REGION/STATE:	Florida (Polk County, Agrico Swamp)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Ettinger W and C Yuill. 1982. Sand and gravel pit reclamation in Louisiana: creation of wetlands habitats and its integration into adjacent undisturbed bayou. Pages 109-114 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Reclamation, Revegetation, Plan only
REGION/STATE:	Louisiana (Sibley)
WETLAND TYPE:	—
IMPACT:	Sand and gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Exum JH and BW Breedlove. 1986. Habitat evaluation and postdevelopment site design on a central Florida site proposed for development. Pages 298-304 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Assessment
REGION/STATE:	Florida (Orange County)
WETLAND TYPE:	—
IMPACT:	Development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Wildlife, HEP

Fischel M. 1988. Wetland restoration/creation and the controversy over its use in mitigation: an introduction. Pages 127-129 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Creation, Restoration, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Ford KV. 1983. Wetland restoration at Four Corners Mine. Pages 134–137 IN: D.J. Robertson Ed., Reclamation and the Phosphate Industry: Proceedings of the Symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Restoration, Revegetation, Monitoring, Technique, Effectiveness
REGION/STATE:	Florida (Hillsborough, Polk, Hardee and Manatee Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Fowler DK, DM Hill, and LJ Fowler. 1985. Colonization of coal surface mine sediment ponds in southern Appalachia by aquatic organisms and breeding amphibians. Pages 261–285 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Revegetation, Monitoring
REGION/STATE:	Tennessee (Campbell County; 9 sites)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Water quality, Aquatic organisms

Gallagher TJ. 1982. Eugene's urban wildlife area: Delta Ponds. Pages 122–126 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17–1982.

EMPHASIS:	Design, Effectiveness, Management plan
REGION/STATE:	Oregon (Eugene)
WETLAND TYPE:	Palustrine
IMPACT:	Gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Garbisch EW. 1977. Recent and planned marsh establishment work throughout the contiguous United States—a survey and basic guidelines. US Army Engineers Waterway Experiment Station Environmental Effects Laboratory, Vicksburg, MS. Contract Report D–77–3. 48 pp.

EMPHASIS:	Creation, Effectiveness, Techniques
REGION/STATE:	United States (105 Projects)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Garbisch EW. 1986. Highways and wetlands: compensating wetland losses. Federal Highway Administration, Office of Implementation, McLean, VA. FHWA-1P-86-22. 60 pp.

EMPHASIS:	Scientific overview: Restoration, Creation, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Gebhardt KA, J Gebhardt, G Koonce, B O'Brien and RB Tiedmann. 1988. Created wildlife and wetland amenities in an urban environment. Pages 157-161 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Creation, Effectiveness, Technique
REGION/STATE:	Idaho (Boise)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Hydrology, Engineering

Gersberg RM, R Brenner, SR Lyon, and BV Elkins. 1987. Survival of bacteria and viruses in municipal wastewaters applied to artificial wetlands. Pages 237-245 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Monitoring
REGION/STATE:	California (Santee)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Bacteria

Gersberg RM, BV Elkins, and CR Goldman. 1985. Wastewater treatment by artificial wetlands. Water Science Technology. 17(4/5):443-450.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	California (Santee)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water Quality

Gersberg RM, BV Elkins, and CR Goldman. 1983. Nitrogen removal in artificial wetlands. Water Resources 17(9):1009-1014.

EMPHASIS:	Monitoring, Effectiveness
REGION/STATE:	California (Santee)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water quality

Gersberg RM, BV Elkins, SR Lyons, and CR Goldman. 1986. Role of aquatic plants in wastewater treatment by artificial wetlands. Water Research. 20(3):363:368.

EMPHASIS:	Monitoring, Effectiveness
REGION/STATE:	California (Santee)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Vegetation, Water quality

Gilbert T, T King, and B Barnett. 1981. An assessment of wetland habitat establishment at a central Florida phosphate mine site. US Fish and Wildlife Service FWS/OBS-81/38. 96 pp.

EMPHASIS:	Restoration, Monitoring, Effectiveness
REGION/STATE:	Florida (Peace River)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Soils, Water quality, Vegetation, Wildlife

Gilbert T, T King, B Barnett, JN Allen, and RS Hearson. 1979. Wetlands reclamation technology development and demonstration for Florida phosphate mining. Pages 87-101 IN: D.P. Cole, Ed., Proceedings of the Sixth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Florida (Polk and Hillsborough Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Hydrology, Vegetation, Water quality

Gilbert T, T King, and L Hord. 1980. An assessment of wetlands establishment techniques at a Florida phosphate mine site. Pages 245-263 IN: D.P. Cole, Ed., Proceedings of the Seventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique, Effectiveness, Monitoring
REGION/STATE:	Florida (Bartow)
WETLAND TYPE:	—
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Water quality, Soils, Vegetation, Wildlife

Gilio JL. 1984. Conversion of an impacted freshwater wet prairie into a function aesthetic marshland. Pages 94-111 IN: F.J. Webb, Jr., Ed., Proceedings of the Tenth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Florida (Palm City, Martin County)
WETLAND TYPE:	Palustrine
IMPACT:	Drowned prairie
WETLAND USE:	Aesthetics, Habitat
SCIENTIFIC THEME:	Vegetation

Gilio JL. 1984. Design and attainment of water quality and chemical free maintenance through ecological balance in a man-made condominium lake in south Florida. Pages 93-107 IN: F.J. Webb, Jr., Ed., Proceedings of the Eleventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Florida (South)
WETLAND TYPE:	Lacustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Water quality

Girts MA and RLP Kleinmann. 1986. Constructing wetlands for treatment of mine water. Society of Mining Engineering, Fall Meeting, St. Louis, MO, Unpublished Paper. 23 pp.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Eastern (25 sites)
WETLAND TYPE:	Sphagnum
IMPACT:	Mining
WETLAND USE:	Mine water treatment
SCIENTIFIC THEME:	Water quality

Glass S. 1987. Rebirth of a river. Restoration and Management Notes. 5(1):6–14.

EMPHASIS:	Restoration, Effectiveness, Technique, Plan only
REGION/STATE:	Florida (Kissimmee River)
WETLAND TYPE:	Palustrine
IMPACT:	Channelization
WETLAND USE:	Flood control, habitat
SCIENTIFIC THEME:	—

Goldley JS and RG Callahan. 1984. Creation of wetlands in a xeric community. Pages 112–129 IN: F.J. Webb, Jr., Ed., Proceedings of the Tenth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	Florida (Pasco County)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Stormwater retention
SCIENTIFIC THEME:	Vegetation, Hydrology

Goldner BH. 1984. Riparian restoration efforts associated with structurally modified flood control channels. Pages 445–451 IN: R.E. Warner and K.M. Hendrix, Eds., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Technique, Effectiveness
REGION/STATE:	California (Santa Clara County)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Flood control
SCIENTIFIC THEME:	Vegetation

Goldstein AL. 1982. Utilization of a recreated freshwater marsh for detention and reduction of nutrients in rural nonpoint source runoff. Pages 194–211 IN: F.J. Webb, Jr., Ed., Proceedings of the Ninth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Florida (Kissimmee River)
WETLAND TYPE:	Palustrine
IMPACT:	Drainage and channelization
WETLAND USE:	Demonstration
SCIENTIFIC THEME:	Water quality

Golet FC. 1986. Critical issues in wetland mitigation: a scientific perspective. National Wetlands Newsletter 8(5):3-6.

EMPHASIS:	Mitigation, Regulatory, Policy
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Gottfried PK. 1985. Environmental design guidelines for manmade lakes in Florida. Pages 135-143 IN: F.J. Webb, Jr., Ed., Proceedings of the Twelfth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Mitigation, Revegetation, Technique
REGION/STATE:	Florida
WETLAND TYPE:	Lacustrine
IMPACT:	—
WETLAND USE:	Stormwater retention, Habitat, Water quality Improvement, Aesthetics, Recreation
SCIENTIFIC THEME:	—

Grabowicz GJ. 1985. Regulatory requirements for construction and use of wetlands on mined lands in Pennsylvania. Pages 185-190 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Creation, Policy, Regulatory
REGION/STATE:	Pennsylvania
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Gregory RW, AA Elsner and T Lenhart. 1984. Utilization of coal mine wastewater for construction of a northern pike spawning/rearing marsh. US Fish and Wildlife Service FWS/OBS-84/03. 44 pp.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Montana (Big Horn County)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat, Wastewater treatment
SCIENTIFIC THEME:	—

Hammer DE and RH Kadlec. 1983. Design principles for wetland treatment systems: project summary. US Environmental Protection Agency EPS-600-S2-83-026. 7 pp.

EMPHASIS:	Design, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Wastewater
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Hydrology, Water quality, Engineering

Harrington RA. 1986. Environmental controls on clonal willow growth (Wisconsin). Restoration and Management Notes. 4(1):30.

EMPHASIS:	Research
REGION/STATE:	Wisconsin
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Hydrology

Harvey HT, MN Josselyn and MS Race. 1986. Forum: Wetlands restoration and mitigation policies: comment and reply. Environmental Management. 10(5):567-572.

EMPHASIS:	Mitigation, Restoration, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Haynes RJ. 1984. Summary of wetlands reestablishment on surface-mined lands in Florida. Pages 357-362 IN: D.H. Graves, Ed., Proceedings of the 1984 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington.

EMPHASIS:	Restoration, Effectiveness, Technique
REGION/STATE:	Florida
WETLAND TYPE:	—
IMPACT:	Surface mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Ecology

Haynes RJ and F Crabill. 1984. Reestablishment of a forested wetland on phosphate-mined land in central Florida. Pages 51-63 IN: P.E. Pope, Compiler, Proceedings of the Fourth Annual Better Reclamation with Trees Conference. Purdue University, West Lafayette, IN.

EMPHASIS:	Revegetation, Technique, Plan only
REGION/STATE:	Florida (Hillsborough County)
WETLAND TYPE:	Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Haynes RJ and L Moore. 1987. Reestablishment of bottomland hardwoods within National Wildlife Refuges in the Southeast. Pages 95-103 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Restoration, Revegetation, Technique, Effectiveness
REGION/STATE:	Southeast
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

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

EMPHASIS:	Scientific overview
REGION/STATE:	United States
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Mapping, Soils, Vegetation

Henderson S, AB Allen, B Abbruzzese, ME Kentula and RM Hughs. 1987. A method for the selection of reference wetlands. Pages 289-291 IN: K.M. Mutz and L.C. Lee, Technical Coordinators, Wetland and Riparian Ecosystems of the American West: Eighth Annual Meeting of the Society of Wetland Scientists, Wilmington, NC.

EMPHASIS:	Research: Effectiveness, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Herkowitz J, S Black, and W Lewandowski. 1987. Listowel artificial marsh treatment project. Pages 247-254 IN: IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Canada (Listowel)
WETLAND TYPE:	Paustrine
IMPACT:	—
WETLAND USE:	Wastewater treatement
SCIENTIFIC THEME:	Water quality

Hey DL. 1987. The Des Plaines River Wetlands Demonstration Project: developing and implementing goals. Pages 89-91 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Restoration, Technique, Plan only
REGION/STATE:	Illinois (Lake County)
WETLAND TYPE:	Palustrine
IMPACT:	Agriculture, Mining
WETLAND USE:	Various
SCIENTIFIC THEME:	—

Hey, DL and NS Philippi. 1985. The Des Plains River Wetlands Demonstration Project: Volume III: Design, construction specifications and site management. Wetlands Research Inc., Chicago, IL.

EMPHASIS:	Creation, Restoration, Technique, Plan only
REGION/STATE:	Illinois (Lake county)
WETLAND TYPE:	Palustrine
IMPACT:	Agriculture, Mining
WETLAND USE:	Various
SCIENTIFIC THEME:	—

Hey, DL and NS Philippi. 1985. The Des Plains River Wetlands Demonstration Project: Volume II: Baseline survey. Wetlands Research Inc., Chicago, IL.

EMPHASIS:	Creation, Restoration, Technique, Plan only
REGION/STATE:	Illinois (Lake county)
WETLAND TYPE:	Palustrine
IMPACT:	Agriculture, Mining
WETLAND USE	Various
SCIENTIFIC THEME:	—

Hey, DL, JM Stockdale, D Kropp and G Wilhelm. 1982. Creation of wetlands in northeastern Illinois. Illinois Department of Energy and Natural Resources, Springfield, Document No. 82109. 117 pp.

EMPHASIS:	Creation, Restoration, Technique, Plan only
REGION/STATE:	Illinois (Lake county)
WETLAND TYPE:	Palustrine
IMPACT:	Agriculture, Mining
WETLAND USE:	Various
SCIENTIFIC THEME:	—

Hinkle, RL. 1988. Wetland mitigation plan development for the Manasquan Reservoir System Project. Pages 355-361 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Creation, Enhancement, Plan only
REGION/STATE:	New Jersey (Monmouth and northern Ocean Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Reservoir development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Hoffman, GR, SG Shetron, CV Klimas and HH Allen. 1986. Lakeshore revegetation studies at Lake Oahe, South Dakota. US Army Engineers Waterways Experiment Station, Vicksberg, MS. Technical Report E-86-3. 18 pp.

EMPHASIS:	Revegetation, Effectiveness, Demonstration
REGION/STATE:	South Dakota (Lake Oahe)
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Hoffman, RD. 1988. Ducks Unlimited's United States Construction Program for enhancing waterfowl production. Pages 109-113 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Enhancement, Effectiveness, Technique
REGION/STATE:	Great Plains
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME :	—

Hollands, GG. 1988. Assessing the relationship of groundwater and wetlands. Pages 240–242 IN: J.A. Kusler and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Wetland Hydrology. September 16–18 1987, Chicago, Illinois Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Scientific overview
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

Hollands, GG. 1989. Regional analysis of the creation and restoration of kettle and pothole wetlands. Pages 287–304 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Midwest, Northeast
WETLAND TYPE:	Palustrine emergent
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Hollands, GG, GE Hollis, and JS Larson. 1986. Science base for freshwater wetland mitigation in the glaciated northeastern United States: Hydrology. Pages 131–143 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview, Mitigation
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

Holmberg, ND and R Misso. 1986. Mitigation: Determining the need. National Wetlands Newsletter, Sept-Oct. 1986. Pages 10–11.

EMPHASIS:	Mitigation, Effectiveness, Policy
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Holtz, S. 1986. Bringing back a beautiful landscape. Restoration and Management Notes 4(2):56–61.

EMPHASIS:	Creation, Technique, Plan only
REGION/STATE:	Illinois (Des Plaines River Wetlands Demonstration Project)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Flood control, Water quality improvement
SCIENTIFIC THEME:	—

Homblette, DJ. 1983. Wetland restoration: a model characterization approach using aerial photography and field analysis. Pages 149–163 IN: F.J. Webb, Jr., Ed., Proceedings of the Tenth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Technique, Plan only
REGION/STATE:	Wisconsin (Madison)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Aerial photography

Hook, DD. 1987. Criteria for creating and restoring forested wetlands in the southern United States. Pages 51–60 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Restoration, Criteria, Technique
REGION/STATE:	Southeast
WETLAND TYPE:	Forested
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Howard K. Bell Consulting Engineers Inc. 1986. Preliminary engineering study for artificial wetlands wastewater treatment facility, City of Pembroke, Kentucky. Howard K. Bell Consulting Engineers, Inc., Lexington, KY. 18 pp.

EMPHASIS:	Creation, Evaluation, Plan only
REGION/STATE:	Kentucky (Pembroke)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water quality

Hubbard, DE, JL Richardson, and DD Malo. 1988. Glaciated prairie wetlands: soils, hydrology, and land-use implications. Pages 137-143 IN: J.A. Kusler and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Wetland Hydrology. September 16-18 1987, Chicago, Illinois Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Scientific overview
REGION/STATE:	Prairie states
WETLAND TYPE:	Palustrine (Prairie potholes)
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

Hunt, LJ. 1979. Principles of marsh establishment. Pages 127-142 IN: F.J. Webb, Jr., Ed., Proceedings of the Sixth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	Six U.S. Sites
WETLAND TYPE:	—
IMPACT:	Dredging
WETLAND USE:	—
SCIENTIFIC THEME:	Engineering

Hunt, LJ, AW Ford, MC Landin, and BR Wells. 1978. Habitat development with dredged material: Engineering and plant propagation. US Army Engineers Waterways Experiment Station, Environmental Laboratory, Vicksberg, MS Technical Report DS-78-17. 160 pp.

EMPHASIS:	Creation, Feasibility, Technique, Effectiveness
REGION/STATE:	Three U.S. Sites
WETLAND TYPE:	Upland
IMPACT:	Dredging
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Soils, Vegetation

Ischinger, LS, and K Schneller-McDonald. 1988. Wetland restoration and creation in the west: What do we really know? Pages 29-36 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Overview: Creation, Restoration
REGION/STATE:	Western
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Jenson, SE, J Griffith, and M Vinson. 1987. Creation of riparian and fish habitat, Birch Creek hydroelectric facility, Clark County, Idaho. Pages 144–149 IN: K.M. Mutz and L.C. Lee, Technical Coordinators, Wetland and Riparian Ecosystems of the American West: Eighth Annual Meeting of the Society of Wetland Scientists, Wilmington, NC.

EMPHASIS:	Mitigation, Technique, Effectiveness
REGION/STATE:	Idaho (Birch Creek)
WETLAND TYPE:	Riparian
IMPACT:	Stream Diversions
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Jenson, SE and WS Platts. 1989. Restoration of degraded riverine/riparian habitat in the Great Basin and Snake River regions. Pages 377–415 IN: Wetland Creation and Restoration: The Status of the Science, Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Great Basin, Snake River regions
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Johnson, LA, SD Rindge and DA Gaskin. 1981. Chena Lakes Project revegetation study: Three-year summary. US Army Corps of Engineers, Alaska District, Anchorage, Creel Report 81-18. 59 pp.

EMPHASIS:	Revegetation, Technique, Feasbility
REGION/STATE:	Alaska (Fairbanks)
WETLAND TYPE:	—
IMPACT:	Damming
WETLAND USE:	—
SCIENTIFIC THEME:	—

Johnson, CK. 1987. Final mitigation plan for the Felt Hydroelectric Project. FERC No. 5089. Ecosystems Research Institute, Logan, Utah.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Idaho (Felt, Teton River)
WETLAND TYPE:	Riparian
IMPACT:	Road construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Johnson, CK. 1986. Final off-site mitigation plan for LQ/LS Drain (Pigeon Cove) Hydroelectric Project. Ecosystems Research Institute, Logan, Utah.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Idaho (Snake River Canyon)
WETLAND TYPE:	Riparian
IMPACT:	Road construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Jordan, WJ, RL Peters, and EB Allen. 1988. Ecological restoration as a strategy for conserving biological diversity. Environmental Management 12(1):55–72.

EMPHASIS:	Overview, Restoration, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Kadlec, RH. 1983. The Bellaire Wetland: wastewater alteration and recovery. Wetlands 3:44–63.

EMPHASIS:	Effectiveness
REGION/STATE:	Minnesota (Bellaire)
WETLAND TYPE:	Palustrine
IMPACT:	Wastewater discharge
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water quality, vegetation

Kadlec, RH. 1987. Monitoring wetland responses. Pages 114–120 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Scientific overview: Monitoring
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Soils, Vegetation

Kantor, RA and DJ Charette. 1986. Computerized monitoring system for wetlands mitigation projects in New Jersey. Pages 266–269 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Monitoring, Technique
REGION/STATE:	New Jersey
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Kentula, ME. 1986. Wetland creation and rehabilitation in the Pacific Northwest. Pages 119–149 IN: R. Strickland, Ed. Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of our Understanding. Washington State University, Department of Ecology, Olympia, Publication No. 86–14.

EMPHASIS:	Overview: Creation, Effectiveness
REGION/STATE:	Pacific Northwest
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

King, T, L Hord, T Gilbert, F Montalbano, and F Allen. 1980. An evaluation of wetland habitat establishment and wildlife utilization in phosphate clay settling areas. Pages 35–49 IN: D.P. Cole, Ed. Proceedings of the Seventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Natural Restoration
REGION/STATE:	Florida (Polk County)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Wildlife, Water quality

Kleinmann, R and W Fink. 1987. Artificial wetland for mitigating acid mine drainage impacts. Restoration and Management Notes. 5(1):33.

EMPHASIS:	Creation (prototype)
REGION/STATE:	Pennsylvania (Friendship Hill National Historic Site)
WETLAND TYPE:	Palustrine
IMPACT:	Mining (acid drainage)
WETLAND USE:	Water quality improvement
SCIENTIFIC THEME:	Water quality

Klimas, CV and HH Allen. 1981. Approaches to revegetate reservoir shorelines of Lake Texoma. Pages 2-3 IN: Environmental and Water Quality Operational Studies. US Army Engineering Waterways Experiment Station, Vicksburg, MS. Information Exchange Bulletin, Volume E-81-2.

EMPHASIS:	Revegetation, Effectiveness
REGION/STATE:	Texas/Oaklahoma (Lake Texoma)
WETLAND TYPE:	Lacustrine
IMPACT:	Flooding
WETLAND USE:	—
SCIENTIFIC THEME:	—

Klimstra, WD and DR Nawrot. 1986. Wetlands/wildlife habitat development. Pages 187-222 IN: C.L. Carlson and J.H. Swisher, Eds., Innovative approaches to mined land reclamation. Southern Illinois University Press, Carbondale.

EMPHASIS:	Overview: Reclamation, Restoration, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Klimstra, WD and JR Nawrot. 1982. Water as a reclamation alternative: an assessment of values. Pages 39-44 IN: D.H Graves, Ed., Proceedings of the 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky, OES Publications, Lexington.

EMPHASIS:	Restoration, Technique
REGION/STATE:	Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Koopman, RW. 1982. Pits, ponds and people: reclamation and public use. Pages 127-131 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	Colorado (Boulder)
WETLAND TYPE:	Palustrine
IMPACT:	Gravel mining
WETLAND USE:	Wildlife, Aestetics
SCIENTIFIC THEME:	—

Knight, RL, and BH Winchester, CH2MHill. 1985. Ecology, hydrology, and advanced wastewater treatment potential of an artificial wetland in north-central Florida. Wetlands 5:167-180.

EMPHASIS:	Effectiveness
REGION/STATE:	Florida (Lake Coral, Ocala)
WETLAND TYPE:	Lacustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	—

Kosowatz, JL. 1987. Wetlands establish their worth. Engineering News Record. (October):30-41.

EMPHASIS:	Policy, Mitigation, Effectiveness
REGION/STATE:	U.S.
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Krause, J, B Mahan, and M Harding. 1985. Waterfowl management and wetland development on Peabody Coal Company surface mines in Illinois, Indiana, and Kentucky. Page 327 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Creation, Management, Effectiveness
REGION/STATE:	Illinois, Indiana, Kentucky
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Kruczynski, WL. 1989. Mitigation and the Section 404 Program: A perspective. Pages 137-142 IN: Kusler, JA and ME Kentula, Editors, Wetland Creation and Restoration: The Status of the Science, Volume II. EPA/600/3-89/038.

EMPHASIS:	Policy, Mitigation
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Kunz, D, M Rylko and E Somers. 1988. An assessment of wetland mitigation practices in Washington state. National Wetlands Newsletter, May-June, 1988, Pp. 2-4.

EMPHASIS:	Overview: Mitigation, Effectiveness
REGION/STATE:	Washington
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Kusler, JA. 1986. Wetland restoration/creation: a summary of science views and perspectives. Pages 440–446 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Overview, Effectiveness
REGION/STATE:	U.S.
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Kusler, JA, ML Quammen, and G Brooks. 1986. Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY. 460 pp.

EMPHASIS:	Symposium: Mitigation, Creation, Restoration, Enhancement, Effectiveness, Policy
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Landin MC. 1982. Habitat development at eight Corps of Engineers sites: Feasibility and assessment. US Army Engineers Waterways Experiment Station, Environmental Laboratory, Vicksberg, MS, Misc. Paper D-82-1. 244 pages.

EMPHASIS:	Overview: Effectiveness, Feasibility
REGION/STATE:	Eight sites in U.S. (inc. several freshwater sites)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Landin, MC. 1978. Annotated tables of vegetation growing on dredged material throughout the United States. US Army Engineers Waterways Experiment Station, Environmental Laboratory, Vicksberg, MS, DMRP Work Unit No. 4F05. 155pp.

EMPHASIS:	Scientific overview
REGION/STATE:	U.S.
WETLAND TYPE:	—
IMPACT:	Dredging
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Landin, MC. 1984. Habitat development using dredged material. Pages 907-917 IN: R.L. Montgomery and J.W. Leach, Eds., Dredging and Dredged Material Disposal: Proceedings of the Conference Dredging '84. American Civil Engineering, New York.

EMPHASIS:	Creation, Effectiveness, Technique
REGION/STATE:	U.S.
WETLAND TYPE:	—
IMPACT:	Dredging
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Landin, MC, and HK Smith. 1982. Reclamation of wetlands. Pages 195-206 IN: W.T. Mason, Jr., and S. Iker, Eds., Research on Fi sh and Wildlife Habitat. US Environmental Protection Agency, Washington. DC. EPA-600/8-82-022.

EMPHASIS:	Overview: Reclamation, Policy
REGION/STATE:	U.S.
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Larosa, R. 1984. Environmental resource conservation: Riparian system enhancement through water reclamation. Pages 459-464 IN: R.E. Warner and K.M. Hendrix, Eds., California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press, Berkeley, California Water Resources Report No. 55.

EMPHASIS:	Revegetation, Technique, Plan only
REGION/STATE:	California (Escondido Creek)
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Larson, JL, and F. Stearns. 1986. Restoration of a woolgrass-dominated sedge meadow (Wisconsin). Restoration and Management Notes 4(2):77.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Wisconsin (Waukesha County)
WETLAND TYPE:	Sedge meadow
IMPACT:	Mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Larson, JS. 1987. Wetland creation and restoration: An outline of the scientific perspective. Pages 73–79 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Scientific overview, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Soils, Vegetation

Larson, JS. 1986. Wetland mitigation in the glaciated northeast: risks and uncertainties. Pages 4–16 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Soils, Vegetation

Larson, JS, and C Neill. 1986. Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Soils, Vegetation

Lawrence, JS, WD Klimstra, WG O'Leary, and GA Perkins. 1985. Contribution of surface-mined wetlands to selected avifuana in Illinois. Pages 317-325 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Illinois
WETLAND TYPE:	—
IMPACT:	Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Leitch, JA. 1980. Economic aspects of wetland restoration in the prairie pothole region. Pages 279-293 IN: D.P. Cole, Ed., Proceedings of the Seventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Policy, Economics
REGION/STATE:	North Dakota
WETLAND TYPE:	Palustrine (Prairie pothole)
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Economics

Lejcher, T. 1986. Hydrology and watershed considerations. Pages 4-9 IN: J.L. Piehl, Ed., Proceedings, Wetland Restoration: A Techniques Workshop. Minnesota Chapter of the Wildlife Society, Fergus Falls.

EMPHASIS:	Restoration, Planning, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME :	Hydrology, Engineering

Lester, JE, CV Climas, HH Allen, and SG Shetron. 1986. Shoreline revegetation at Lake Texoma on the Red River, Texas-Oklahoma. US Army Engineers Waterways Experiment Station, Environmental Laboratory, Vicksberg, MS. Technical Report E-86-1. 49 pp.

EMPHASIS:	Revegetation, Feasibility
REGION/STATE:	Texas/Oaklahoma (Lake Texaoma)
WETLAND TYPE:	Lacustrine
IMPACT:	Reservoir fluctuation
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Levine, DA and DE Willard. 1989. Regional analysis of fringe wetlands in the midwest: Creation and restoration. Pages 305-332 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Midwest
WETLAND TYPE:	Palustrine and lacustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Lowry, DJ. 1989. Restoration and creation of palustrine wetland associated with riverine systems of the glaciated northeast. Pages 273-286 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Northeast
WETLAND TYPE:	Palustrine emergent
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Madsen, C. 1986. Wetland restoration: A pilot project. Journal of Soil and Water Conservation. 41(3):159-160.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Minnesota (western)
WETLAND TYPE:	Palustrine
IMPACT:	Agriculture
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Madsen, CR. 1988. Wetland restoration in western Minnesota. Pages 92-94 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Restoration, Policy, Management
REGION/STATE:	Minnesota
WETLAND TYPE:	Palustrine (prairie potholes)
IMPACT:	Agriculture
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Maguire, JD, and GA Heuterman. 1978. Influence of pre-germination conditions of the viability of selected marsh plants. US Army Engineers Waterways Experiment Station, Environmental Laboratory, Vicksberg, MS. Technical Report D-78-51. 106 pp.

EMPHASIS:	Laboratory investigation
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Pre-germination conditions

Maltby, E. 1986. Soils science base for freshwater wetland mitigation in the northeastern United States. Pages 17-52 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview, Mitigation
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Soils

Matter, WJ and RW Mannan. 1988. Sand and gravel pits as fish and wildlife habitat in the southwest. US Fish and Wildlife Service Resource Publication 171. 11 pp.

EMPHASIS:	Reclamation, Technique
REGION/STATE:	Southwest
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Wildlife

McCaffrey, PM, JB Cruce, J Hall, M Palmer, and L Perrin. 1985. Comments on the Kissimmee River restoration project and responses. Pages 3-26 IN: F.J. Webb, Jr., Ed., Proceedings of the Twelfth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Plan only
REGION/STATE:	Florida (Kissimmee River)
WETLAND TYPE:	—
IMPACT:	Channelization
WETLAND USE:	—
SCIENTIFIC THEME:	—

McCluskey, DC, J Brown, D Bornholdt, DA Duff, and AH Winward. 1983. Willow plantings for riparian habitat improvement. USDI, Bureau of Land Management, Denver, CO. 20 pp.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	—
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

McCreary, S. 1982. Legal and institutional constraints and opportunities in wetland enhancement. pages 39-52 IN: M. Josselyn, Ed, Wetland Restoration and Enhancement in California. University of California, California Sea Grant College Program, La Jolla, Report T-CSGCP-007.

EMPHASIS:	Restoration, Management, Policy
REGION/STATE:	California
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

McKendrick, JD. 1987. Arctophila fulva for revegetating arctic wetlands. Restoration and Management Notes 5(2):93.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Alaska
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

McMullen, JM. 1988. Selection of plant species for use in wetlands creation and restoration. Pages 333-337 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Planning, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Meyer, JL. 1985. A detention basin/artificial wetland treatment system to renovate stormwater runoff from urban, highway, and industrial areas. Wetlands 5:135–146.

EMPHASIS:	Creation, Technique, Feasibility
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water quality

Metz, ED. 1987. The Ballona Wetland Project: Habitat restoration and environmental education. National Wetlands Newsletter, Jan–Feb 1987, pp. 16–18.

EMPHASIS:	Restoration, Plan
REGION/STATE:	California (Los Angeles County)
WETLAND TYPE:	Emergent
IMPACT:	Urban development
WETLAND USE:	Habitat, Education
SCIENTIFIC THEME:	—

Michalski, MFP, DR Gregory, and AJ Usher. 1987. Rehabilitation of pits and quarries for fish and wildlife. Ontario Ministry of Natural Resources, Aggregate Resources Section, Land Management Branch, Ontario, Canada. 59 pp.

EMPHASIS:	Restoration, Technique
REGION/STATE:	Canada (Ontario)
WETLAND TYPE:	—
IMPACT:	Sand and gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Miller, HA, JG Sampson, CS Lotspeich. 1985. Wetlands reclamation using sand–clay mix from phosphate mines. pages 193–200 IN: F.J. Webb, Jr., Ed., Proceedings of the Twelfth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique
REGION/STATE:	Florida (Hardee County)
WETLAND TYPE:	Forested
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Miller, RJ and EE Macintosh. 1987. Sand and gravel rehabilitation in northern Ontario. Ontario Ministry of Natural Resources, Aggregate Resources Section, Land Management Branch, Ontario, Canada. 24 pp.

EMPHASIS:	Restoration, Policy
REGION/STATE:	Canada (Ontario)
WETLAND TYPE:	—
IMPACT:	Sand and gravel mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Miller, TS. 1987. Techniques used to enhance, restore, or create freshwater wetlands in the Pacific Northwest. Pages 116–121 IN: K.M. Mutz and L.C. Lee, Technical Coordinators, Wetland and Riparian Ecosystems of the American West: Eighth Annual Meeting of the Society of Wetland Scientists, Wilmington, NC.

EMPHASIS:	Creation, Restoration, Enhancment, Techniques
REGION/STATE:	Pacific Northwest
WETLAND TYPE:	Palustrine, Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Miller, W. 1988. Plants for man-made wetlands: A growth industry. Florida Environment. (April):1, 17.

EMPHASIS:	Overview (vegetation), Technique
REGION/STATE:	Florida
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Monsen, SB. 1983. Plants for revegetation of riparian sites within the intermountain region. Pages 83–89 IN: S.B. Monson and N. Shaw, Compilers, Managing Intermountain Rangelands—Improvement of Range and Wildlife Habitats. USDA Forest Service Intermountain Forest and Range Experiment Station, Ogden, Utah. General Technical Report Int-152.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	Intermountain
WETLAND TYPE:	Riparian
IMPACT:	Grazing
WETLAND USE:	Erosion control
SCIENTIFIC THEME:	—

Montalbano, F, KJ Foote, MW Olinde, and LS Perrin. 1979. The Kissimmee River channelization: A Preliminary evaluation of fish and wildlife mitigation measures. Pages 508–515 IN: G.A. Swanson, Technical Coordinator, The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitat. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, General Technical Report RM-65.

EMPHASIS:	Mitigation, Restoration, Effectiveness
REGION/STATE:	Florida (Kissimmee River)
WETLAND TYPE:	Palustrine
IMPACT:	Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Murphy, S. 1988. Documentation of revegetation efforts in the Lower Colorado River Region. Draft Report, US Bureau of Reclamation, Boulder City, NV

EMPHASIS:	Mitigation, Creation, Restoration, Enhancement, Effectiveness
REGION/STATE:	California and Arizona (lower Colorado River)
WETLAND TYPE:	Riparian
IMPACT:	Damming, Channelization
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Mutz, KM and LB Dalton. 1986 Mitigating impacts of coal mining in Utah. Pages 182-184 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Creation, Effectiveness
REGION/STATE:	Utah
WETLAND TYPE:	Riparian
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Mutz, KM and LC Lee. 1987. Wetland and riparian ecosystems of the American West: Eighth anuual meeting of the Society of Wetland Scientists. May 26–29, 1987, Seattle, Washington.

EMPHASIS:	Symposium: Creation, Restoration, Enhancement, Effectiveness
REGION/STATE:	Western US
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Mutz, KM, DJ Cooper, ML Scott, and LK Miller. 1988. Restoration, creation, and management of wetland and riparian ecosystems in the American West: A symposium of the Rocky Mountain Chapter of the Society of Wetland Scientists. 14–16 November, 1988, Denver, Colorado.

EMPHASIS:	Symposium: Creation, Restoration, Enhancement, Effectiveness
REGION/STATE:	Western US
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Nawrat, JR. 1985. Wetland development on coal mine slurry impoundments: Principles, planning, and practices. Pages 161–172 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Editors, Wetlands and Water Management on Mined Lands, Proceedings of a Workshop, Pennsylvania State University, School of Forest Resources, University Park.

EMPHASIS:	Creation, Technique
REGION/STATE:	Illinois
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	—
SCIENTIFIC THEME:	Soils, Water quality

Nawrat, JR. 1981. Stabilization of slurry impoundments without soil cover: Factors affecting vegetation establishment. Pages 469–475 IN: D.H. Graves, Ed. Proceedings of the 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, OES Publications, Lexington.

EMPHASIS:	Feasibility investigation
REGION/STATE:	Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Soils

Nawrot, JR, DM Downing, and ML Fuson. 1981. Reedgrass and slurry pond reclamation. Mining Congress Journal. 67(9):23–28.

EMPHASIS:	Reclamation, Effectiveness
REGION/STATE:	Illinois (Carlinville; Mine No. 1 Monterey Coal Company)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Soils

Nawrot, JR, and WD Klimstra. 1985. Mined land wetlands: Research activities of the cooperative wildlife research laboratory. Mineral Matters 7(2):1-2.

EMPHASIS:	Reclamation, Effectiveness, Overview
REGION/STATE:	Indiana, Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat, Recreation
SCIENTIFIC THEME:	—

Nawrot, JR, and WD Klimstra. 1986. Wetland habitat reclamation: It's a wonder we have any. Mineral Matters 8(3):3-4.

EMPHASIS:	Reclamation, Policy
REGION/STATE:	Illinois
WETLAND TYPE:	—
IMPACT:	Coal Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Nawrat, JR and DB Warburton. 1986. Wetland habitat development techniques for coal mine slurry impoundments. Pages 587-612 IN: Proceedings of the National Mined Land Reclamation Conference, October 28-29, St. Louis, MO.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Coal Mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Nawrot, JR, A Woolf, and WD Klimstra. 1982. A guide for enhancement of fish and wildlife on abandoned mine lands in the eastern United States. U.S. Fish and Wildlife Service FWS/OBS-80-67. 101 pp.

EMPHASIS:	Overview: Reclamation, Feasibility
REGION/STATE:	Eastern
WETLAND TYPE:	—
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Nawrot, JR and SC Yaich. 1982. Slurry discharge management for wetland soils development. Pages 11-18 IN: D.H. Graves, Ed. Proceedings of the 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, OES Publications, Lexington.

EMPHASIS:	Reclamation, Monitoring
REGION/STATE:	Illinois, Indiana
WETLAND TYPE:	—
IMPACT:	Mine slurry ponds
WETLAND USE:	—
SCIENTIFIC THEME:	Soils, vegetation, water quality

Nawrot, JR and SC Yaich. 1982. Slurry pond forestation: Potential and problems. Pages 180–194 IN: P.E. Pope, Ed., Proceedings of the Third Annual Better Reclamation with Trees Conference. Perdue University, Department of Forest and Natural Resources, West Lafayette, In.

EMPHASIS:	Reclamation, Technique
REGION/STATE:	Illinois, Indiana
WETLAND TYPE:	Forested
IMPACT:	Mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Nawrot, JR. and SC Yaich. 1982. Wetland development potential of coal mine tailings. Wetlands 2:179-190.

EMPHASIS:	Revegetation, Technique, Plan
REGION/STATE:	Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Newton, J. 1984. Fifteenmile Creek Riparian Recovery, Wasco County, Oregon. Pages 80–83 IN: Proceedings, Pacific Northwest Range Management Short Course: Range watersheds, riparian zones, and economics. Interrelationships in management and use. Oregon State University, Corvallis.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Oregon (Wasco County)
WETLAND TYPE:	Riparian
IMPACT:	Channelization
WETLAND USE:	—
SCIENTIFIC THEME:	—

Niering, WA and ML Kraus. 1986. Science base for freshwater wetland mitigation in the northeastern United States: Vegetation. Pages 122-130 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Norrgard, R. 1986. Additional comments on wetland restoration. Pages 38–48 IN: J.L. Piehl, Ed., Proceedings, Wetland Restoration: A Techniques Workshop. Minnesota Chapter of the Wildlife Society, Fergus Falls.

EMPHASIS:	Overview: Restoration, Planning
REGION/STATE:	Minnesota
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

O'Brien, AL. 1986. Hydrology and the construction of a mitigating wetland. Pages 82-100 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87-1.

EMPHASIS:	Scientific overview: Mitigation
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

O'Donnell, A. 1987. The policy implications of wetland creation. Pages 141-144 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Overview: Policy, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

O'Leary, WG. 1980. Waterfowl habitats provided by surface mine wetlands in southwestern Illinois. M.A. Thesis, Southern Illinois University, Carbondale. 141 pp.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	Illinois (Perry County)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

O'Leary, WG, WD Klimstra, and JR Nawrot. 1984. Waterfowl habitats on reclaimed surface mined lands in southwestern Illinois. Pages 377-382 IN: D.H. Graves, Ed. Proceedings of the 1981 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, University of Kentucky, OES Publications, Lexington.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Surface mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Soils, Water quality, Vegetation

Odum, WE. 1987. Predicting ecosystem development following creation and restoration of wetlands. Pages 67-70 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Restoration, Monitoring
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Ogawa, H, AM Asce, and JA Male. 1985. Simulating the flood mitigation role of wetlands. Journal of Water Resources, Planning and Management. 112(1):114–128.

EMPHASIS:	Overview: Mitigation, Evaluation
REGION/STATE:	Massachusetts
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Flood mitigation
SCIENTIFIC THEME:	Hydrology

Oldenberg, RC, RA Montgomery, TM Harder, and GV Burger. 1982. Gravel pits as fish and wildlife habitat at the Max McGraw Wildlife Foundation. Pages 215-220 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	Illinois (Kane County)
WETLAND TYPE:	Palustrine
IMPACT:	Gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Pandit, AK and DN Fotedar. 1982. Restoring damaged wetlands for wildlife. Journal of Environmental Management 14:359-368.

EMPHASIS:	Restoration, Technique, Management, Plan only
REGION/STATE:	India (Srinagar)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Wildlife, Vegetation

Patchett, JM. 1982. Conservation, recreation, mining, and rehabilitation in Story County, Iowa. Pages 89-94 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Reclamation, Planning
REGION/STATE:	Iowa (Storey County)
WETLAND TYPE:	Riparian
IMPACT:	Gravel mining
WETLAND USE:	—
SCIENTIFIC THEME:	—

Perkins, GA and LA Lawrence. 1985. Bird use of wetlands created by surface mining. Transactions of the Illinois State Academy of Science. 78(1-2):87-95.

EMPHASIS:	Natural Restoration, Effectiveness, Monitoring
REGION/STATE:	Illinois (west-central)
WETLAND TYPE:	Palustrine
IMPACT:	Surface mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Wildlife

Pesavento, BG. 1984. Factors to be considered when constructing wetlands for utilization as biomass filters to remove minerals from solution. Pages 45–49 IN: J.E. Burris, Ed., Treatment of Mine Drainage by Wetlands. Pennsylvania State University, University Park, Contribution No. 264.

EMPHASIS:	Overview: Creation, Design criteria
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Mine drainage
WETLAND USE:	Water treatment ("Biomass filters")
SCIENTIFIC THEME:	Water quality

Peters, CR. 1986. The significance of hydrogeology to the mitigation of functions in freshwater wetlands of the glaciated northeast. Pages 337–339 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Overview: Creation, Mitigation, Assessment, Design criteria, Monitoring
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology, Hydrogeology

Piehl, J. 1986. Restoration of drained wetlands. Pages 33–37 IN: J.L. Piehl, Ed., Proceedings, Wetland Restoration: A Techniques Workshop. Minnesota Chapter of the Wildlife Society, Fergus Falls.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Minnesota (west-central)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Pierce, GJ. 1986. In kind vs. out-of-kind wetland replacement. Pages 287–288 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation, Success evaluation criteria
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Pierce, GJ. 1986. Succession and stability in freshwater marshes in the northeastern United States. Pages 323-324 IN: J.A. Kusler, M.L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Scientific overview
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Wetland dynamics

Pierce, GJ and AB Amerson. 1981. A pilot project for wetlands construction on the floodplain of the Allegeny River in Cattaraugus County, New York. Pages 140-153 IN: R.H. Stovall, Ed., Proceedings of the Eighth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Mitigation, Creation, Technique, Planning
REGION/STATE:	New York (Cattaraugus County, Allegheny River)
WETLAND TYPE:	Palustrine
IMPACT:	Highway construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Platts, WS, C Armour, GD Booth, M Bryant, JL Bufford, P Cuplin, et al. 1987. Methods for evaluating riparian habitats with application to management. USDA Forest Service Intermountain Research Station, Ogden, Utah. General Technical Report. INT-221. 177 pp.

EMPHASIS:	Overview: Evaluation, Monitoring, Technique, Management
REGION/STATE:	—
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Platts, WS, SE Jenson, and C Johnson. 1987. Mitigation through restoration of degraded riverine/riparian ecosystems in the Great Basin hydrographic region and Snake River hydrographic subregion. Environmental Protection Agency, Corvallis, Oregon, Unpublished Report. 104 pp.

EMPHASIS:	Mitigation, Restoration, Planning, Effectiveness
REGION/STATE:	Great Basin, Snake River
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Posey, DM, DC Goforth and P. Painter. 1984. Ravenwood Shellrock Mine: Wetland and upland restoration and creation. Pages 127-134 IN: F.J. Webb, Jr., Ed., Proceedings of the Eleventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Restoration, Technique, Effectiveness
REGION/STATE:	Shellrock Mine, Ravenwood
WETLAND TYPE:	Palustrine
IMPACT:	Residential development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Price, JW. 1987. The marsh that Arcata built. Sierra 72(3):51-53.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	California (Arcata)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment, Habitat, Recreation, Aestetics
SCIENTIFIC THEME:	Water quality

Prichard, DE and LL Upham. 1986. Texas Creek riparian enhancement study. Transactions of the North American Wildlife and Natural Resources Conference. 51:298-303.

EMPHASIS:	Enhancement, Technique, Effectiveness
REGION/STATE:	Colorado (Texas Creek)
WETLAND TYPE:	Riparian
IMPACT:	Grazing
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Princeton Aqua Science. 1985. Compliance, mitigation, and marsh creation survey and report. U.S. Army Corps of Engineers, Baltimore, Maryland.

EMPHASIS:	Creation, Mitigation, Effectiveness
REGION/STATE:	COE Baltimore District (17 projects)
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Pritchett, DA. 1987. Creation, restoration, and enhancement of vernal pools. Restoration and Management Notes 5(2):92.

EMPHASIS:	Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	California (Santa Barbara)
WETLAND TYPE:	Vernal pools
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, Hydrology

Quammen, ML. 1986. Measuring the success of wetlands mitigation. National Wetlands Newsletter. 8(5):6–8.

EMPHASIS:	Overview: Mitigation, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Quammen, ML. 1986. Summary of the conference and information needs for mitigation in wetlands. Pages 151–158 IN: R. Strickland, Ed. Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of our Understanding. Washington State University, Department of Ecology, Olympia, Publication No. 86–14.

EMPHASIS:	Overview, Mitigation, Creation, Restoration, Monitoring
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Raisanen, DL, SD Leimer, and GN Textor. 1988. Hydroperiod prediction for four new palustrine wetlands. Pages 144–151 IN: J.A. Kusler and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Wetland Hydrology. September 16–18 1987, Chicago, Illinois Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Research: Creation, Monitoring
REGION/STATE:	Illinois (Du Page River)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrologic modelling

Redmond, AM. 1981. Considerations for the design of an artificial marsh for use in stormwater renovation. Pages 188–199 IN: R.H. Stovall, Ed., Proceedings of the Eighth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique, Plan only
REGION/STATE:	Florida (Lake Jackson)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Water quality improvement
SCIENTIFIC THEME:	—

Reed, SC, EJ Middlebrooks, JC Corey, CW Hall, WE Odum, and JM Davidson. 1987. Research and development needs for utilization of aquatic plants for water treatment and resource recovery. Pages 1009–1022 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Scientific overview
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Vegetation, Soils, Water quality, Engineering

Reimold, RJ and SA Cobler. 1986. Wetland mitigation effectiveness. U.S. Environmental Protection Agency, Boston, MA. 139 pp.

EMPHASIS:	Creation, Mitigation, Effectiveness
REGION/STATE:	Northeast, five sites (two freshwater)
WETLAND TYPE:	—
IMPACT:	Development
WETLAND USE:	—
SCIENTIFIC THEME:	—

Reimold, RJ and DA Thompson. 1986. Wetland mitigation effectiveness. 1986. Pages 259–262 IN: J.A. Kusler, L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Creation, Mitigation, Effectiveness
REGION/STATE:	Northeast, five sites (two freshwater)
WETLAND TYPE:	—
IMPACT:	Development
WETLAND USE:	—
SCIENTIFIC THEME:	—

Richardson, B. 1988. Highway wetland mitigation—everyone can be a winner. Pages 149-153 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Creation, Plan only
REGION/STATE:	Arkansas (Pine Bluff)
WETLAND TYPE:	Bottomland hardwoods
IMPACT:	Highway construction
WETLAND USE:	Floodwater storage capacity, habitat
SCIENTIFIC THEME:	—

Rink, LP and JR Windell. 1988. Riparian wetland enhancement in the San Miguel River Valley, Telluride, Colorado. Pages 102-108 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Enhancement
REGION/STATE:	Colorado (Telluride)
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	Buffer zone, Water quality improvement, Habitat
SCIENTIFIC THEME :	—

Roberts, C. and J. Graves. 1978. Sand and gravel mining and reclamation to benefit wildlife. Colorado State University Department of Natural Resources, Fort Collins. 59 pp.

EMPHASIS:	Overview: Reclamation, Technique, Planning
REGION/STATE:	Colorado (Timnath, Cache La Poudre River)
WETLAND TYPE:	—
IMPACT:	Sand and gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Robertson, D, R Garcia and K Piwowar. 1987. Comparison of wetland habitat in undisturbed and reclaimed phosphate surface-mined wetlands. Pages 180-193 IN: F.J. Webb, Jr., Ed., Proceedings of the Fourteenth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Reclamation, Effectiveness, Technique
REGION/STATE:	Florida (South Prong Alafia River)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Food Chain

Robertson, D. 1988. Project documents recovery of reclaimed stream, forest community (Florida). Restoration and Management Notes 2(2):80.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Florida (central, Sink Branch)
WETLAND TYPE:	Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Robertson, DJ. 1984. Sink Branch—stream relocation and forested wetland reclamation by the Florida phosphate industry. Pages 135-151 IN: F.J. Webb, Jr., Ed., Proceedings of the Eleventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	Florida (central, Sink Branch)
WETLAND TYPE:	Riparian
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Food chain, Vegetation

Robertson, SB. 1988. Hydrology of arctic wetlands. Pages 262-269 IN: J.A. Kusler and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Wetland Hydrology. September 16–18 1987, Chicago, Illinois Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Scientific overview
REGION/STATE:	Arctic
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

Roelle, J.E. and K.M. Manci. 1989. Postproject analyses of fish and wildlife mitigation. Presentation to "The Scientific Challenge of NEPA: Future Directions Based on 20 Years of Experience". October 24–27, 1989.

EMPHASIS:	Mitigation, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Roesser, JC Jr. 1988. Blue River Reclamation Project, Breckinridge, Colorado. Pages 94–101 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Restoration, Technique
REGION/STATE:	Colorado (Breckinridge)
WETLAND TYPE:	Riparian
IMPACT:	Mining, Development
WETLAND USE:	—
SCIENTIFIC THEME:	—

Ross, D, C Kocur, and W. Jurgens. 1985. Wetlands creation techniques for heavy construction equipment. Pages 21-220 IN: F.J. Webb, Jr., Ed., Proceedings of the Twelfth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	Florida (Desota County)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Rossiter, JA and RD Crawford. 1981. Evaluation of constructed ponds as a means of replacing natural wetland habitat affected by highway projects in North Dakota. University of North Dakota, Department of Biology, Grand Forks. U.S. Department of Transportation. FHWA-ND-RD-(2)-79A. NTIS. 169 pp.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	North Dakota (Pembena, Pierce, and Barnes Counties, 18 sites)
WETLAND TYPE:	Palustrine
IMPACT:	Highway construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Rossiter, JA and RD Crawford. 1984. Evaluation of artificial wetlands in North Dakota: Recommendations for future design and construction. Transportation Research Record. 948-21-25.

EMPHASIS:	Overview: Design, Technique
REGION/STATE:	North Dakota
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Ruesch, KJ. 1983. A survey of wetland reclamation projects in the Florida phosphate industry. Florida Institute of Phosphate Research, Bartow. 59 pp.

EMPHASIS:	Reclamation, Effectiveness, Monitoring
REGION/STATE:	Florida (35 sites)
WETLAND TYPE:	—
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME :	—

Rushton, BT. 1983. Examples of natural wetland succession as a reclamation alternative. Pages 148–169 IN: D.J. Robertson Ed., Reclamation and the Phosphate Industry: Proceedings of the Symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Natural restoration, Effectiveness
REGION/STATE:	Florida
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation succession

Sandrik, SR, and RF Crabill. 1983. Natural systems reclamation at the Amax Chemical Corporation Big Four Mine. Pages 227-231 IN: D.J. Robertson Ed., Reclamation and the Phosphate Industry: Proceedings of the Symposium. Florida Institute of Phosphate Research, Bartow, FL.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Florida (west central, Big Four Mine)
WETLAND TYPE:	Palustrine, forested
IMPACT:	Phosphate mining
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Sapa, AJ. 1979. Restoration of wildlife habitats to offset project losses, Garrison Diversion Unit, North Dakota. Pages 318–321 IN: G.A. Swanson, Technical Coordinator, The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitat. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, General Technical Report RM–65.

EMPHASIS:	Mitigation, Restoration, Plan only
REGION/STATE:	North Dakota (Garrison Diversion Unit)
WETLAND TYPE:	Prairie wetland
IMPACT:	Water development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Schneller-McDonald, K, LS Ischinger, and GT Auble. 1989. Wetland creation and restoration: Description and summary of the literature. US Fish and Wildlife Service. Biological Report 89( ).

EMPHASIS:	Bibliography: Creation, Restoration, Enhancement
REGION/STATE:	US
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Schwartzmeier, J. 1977. Opening statement on wetland restoration. Pages 129-131 IN: C.B. Dewitt and E. Soloway, Eds., Wetlands Ecology, Values, and Impacts. Proceedings of the Waubesa Conference on Wetlands. University of Wisconsin, Institute of Environmental Studies, Madison.

EMPHASIS:	Overview: Restoration, Effectiveness
REGION/STATE:	Wisconsin (Waukesha County)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Sempek, JE, and CW Johnson. 1987. Wetlands enhancement at the Ogden Nature Center in Ogden, Utah. Pages 161-165 IN: K.M. Mutz and L.C. Lee, Technical Coordinators, Wetland and Riparian Ecosystems of the American West: Eighth Annual Meeting of the Society of Wetland Scientists, Wilmington, NC.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Utah (Ogden)
WETLAND TYPE:	Palustrine
IMPACT:	Water Pollution
WETLAND USE:	Recreation, Education, Habitat
SCIENTIFIC THEME:	Vegetation

Shuey, AG and LJ Swanson, Jr. 1979. Creation of freshwater marshes in west central Florida. Pages 57-76 IN: F.J. Webb, Jr., Ed., Proceedings of the Sixth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Restoration, Techniques
REGION/STATE:	Florida (Four Corners Mine, Hillsborough, Manatee Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Water quality, vegetation

Simmering, RW. 1986. Mitigating impacts of Louisiana SCS watershed projects. Pages 142–144 IN: J.A. Kusler, L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation: Creation
REGION/STATE:	Louisiana
WETLAND TYPE:	Forested wetlands
IMPACT:	Agriculture
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Smith, LM and JA Kadlec. 1983. Seed banks and their role during drawdown of a North American Marsh. Journal of Applied Ecology. 20:673–684.

EMPHASIS:	Scientific overview
REGION/STATE:	Utah (Ogden Bay Waterfowl Management Unit)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Seedbanks, Vegeation, Soils

Smith, RD and JH Sather. 1985. The Des Plains River Wetlands Demonstration Project, Vol. IV: Research Plan. Wetlands Research, Inc., Chicago, Illinois.

EMPHASIS:	Restoration, Technique, Plan only
REGION/STATE:	Illinois (Lake County)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Snyder, BD and JL Snyder. 1984. Feasibility of using oil shale wastewater for waterfowl wetlands. U.S. Fish and Wildlife Service. FWS/OBS-84/01. 290 pp.

EMPHASIS:	Creation, Feasibility, Technique
REGION/STATE:	Rocky Mountains
WETLAND TYPE:	Palustrine ("waterfowl wetlands")
IMPACT:	Oil shale wastewater
WETLAND USE:	Water quality improvement, habitat
SCIENTIFIC THEME:	—

Snyder, CD and EC Aharrah. 1984. The influence of the Typha community on mine drainage. Pages 149-153 IN: D.H. Graves, Ed., Proceedings of the 1984 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky. OES Publication, Lexington.

EMPHASIS:	Research
REGION/STATE:	Pennsylvania (Clarion County)
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Water quality improvement
SCIENTIFIC THEME:	Water quality, Vegetation

Sorenson, J. 1982. Towards an overall strategy in designing wetland restorations. Pages 85-96 IN: M. Josselyn, Ed, Wetland Restoration and Enhancement in California. University of California, California Sea Grant College Program, La Jolla, Report T-CSGCP-007.

EMPHASIS:	Overview: Restoration, Design, Monitoring
REGION/STATE:	California
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Southern Tier Consulting. 1987. Wetland demonstration project. New York Department of Transportation, Albany, Contract No. D250336-CPIN5119-01.321.

EMPHASIS:	Mitigation, Creation, Effectiveness
REGION/STATE:	New York (Cattaraugus County)
WETLAND TYPE:	Palustrine
IMPACT:	Highway construction
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Spence, DHN. 1982. The zonation of plants in freshwater lakes. Pages 37-125 IN: A. MacFadyen and E.D. Ford, Eds., Advances in Ecological Research. Volume 12. Academic Press, New York.

EMPHASIS:	Research
REGION/STATE:	European lakes
WETLAND TYPE:	Lacustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Plant zonation

Spencer, DF. 1987. Tuber size and planting depth influence growth of Potomogeton Pectinatus L. American Midland Naturalist. 118(1):77-84.

EMPHASIS:	Research: Greenhouse
REGION/STATE:	California (Solano County)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation growth

Stanley, JT. 1989. Riparian wetland creation and restoration in the far west: A compilation of information. Pages 417-464 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	West
WETLAND TYPE:	Palustrine emergent and Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Steiner, GR, JT Watson, DA Hammer, and DF Harker Jr. 1987. Municipal wastewater treatment with artificial wetlands—A TVA/Kentucky Demonstration. Pages 923-932 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Creation, Design, Effectiveness
REGION/STATE:	Kentucky (southwest)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Engineering, Water quality, Vegetation

Street, M. 1982. The Great Linford Project: Waterfowl research in a gravel pit wildlife reserve. Pages 170-180 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Enhancement, Technique, Management, Effectiveness
REGION/STATE:	England
WETLAND TYPE:	Lacustrine
IMPACT:	Gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Wildlife

Strickland, R. 1986. Wetland functions, rehabilitation, and creation in the Pacific Northwest: The state of our understanding. Washington State Department of Ecology, Olympia, WA.

EMPHASIS:	Symposium Proceedings: Creation, Effectiveness
REGION/STATE:	Pacific Northwest
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Swanson, LJ, and AG Shuey. 1980. Freshwater marsh reclamation in west central Florida. Pages 51–61 IN: F.J. Webb, Jr., Ed., Proceedings of the Seventh Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	Florida (Hillsborough County, Alderman Creek)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Swenson, EA. 1988. Progress in the understanding of how to reestablish native riparian plants in New Mexico. Pages 144–150 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators. Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	New Mexico
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Swenson, EA and CL Mullins. 1985. Revegetating riparian trees in southwestern floodplains. Pages 135–138 IN: R.R. Johnson et al., Technical Coordinator, Riparian Ecosystems and their Management: Reconciling Conflicting Uses. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, General Technical Report RM-120.

EMPHASIS:	Revegetation, Technique
REGION/STATE:	New Mexico (Albuquerque)
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation

Szafoni, RE. 1982. Wildlife considerations in the development of riparian communities. Pages 59-66 IN: W.D. Svedarsky and R.D. Crawford, Eds., Wildlife Values of Gravel Pits. University of Minnesota, Agricultural Experiment Station, St. Paul, Miscellaneous Publication 17-1982.

EMPHASIS:	Overview: Creation, Technique
REGION/STATE:	—
WETLAND TYPE:	Riparian (gravel pit lakes)
IMPACT:	Gravel mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Tetreault, TE. 1988. Wetland replacement: Design, construction, and monitoring considerations. Pages 362-363 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Overview: Creation, Design, Monitoring, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Thompson, CS. 1984. Experimental practices in surface coal mining: Creating wetland habitat. National Wetlands Newsletter (March-April):15-16.

EMPHASIS:	Reclamation, Technique, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	Palustrine
IMPACT:	Coal Mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Water quality

Tuovila, BJ, TH Johengen, PA Larock, JB Outland, DH Esry, and M Franklin. 1987. An evaluation of the Lake Jackson (Florida) filter system and artificial marsh on nutrient and particulate removal from stormwater runoff. Pages 271-278 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Creation, Effectiveness, Monitoring
REGION/STATE:	Florida (Lake Jackson)
WETLAND TYPE:	Lacustrine
IMPACT:	Water pollution
WETLAND USE:	Water quality improvement
SCIENTIFIC THEME:	Water quality

Tupa. M, E Olgeirson, and M Stevens. 1988. Beaver Creek stream relocation and restoration, Beaver Creek Ski Area, Avon, Colorado. Pages 112-114 IN: K.M. Mutz, J.J. Cooper, M.L. Scott and L.K. Miller, Technical Coordinators, Restoration, Creation, and Management of Wetland and Riparian Ecosystems in the American West. Society of Wetland Scientists, Rocky Mountain Chapter, Denver, CO.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Colorado (Avon)
WETLAND TYPE:	Palustrine
IMPACT:	Development
WETLAND USE:	Aestetics
SCIENTIFIC THEME:	—

U.S. Army Corps of Engineers. 1986. Beneficial uses of dredged material: Engineering and design. U.S. Army Corps of Engineers, Office of the Chief Engineer, Washington, D.C. EM 1110-2-5026. 272 pp.

EMPHASIS:	Overview: Planning, Design, Management
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	Dredged material
WETLAND USE:	—
SCIENTIFIC THEME:	—

U.S. Fish and Wildlife Service. 1983. Carrols Channel Restoration Project, Columbia River, Cowlitz County, Washington. U.S. Fish and Wildlife Service, Portland, Oregon, Unpublished Report. 13 pp.

EMPHASIS:	Restoration
REGION/STATE:	Washington (Cowlitz County, Columbia River)
WETLAND TYPE:	Riparian
IMPACT:	Filling
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

U.S. Fish and Wildlife Service. 1986. A status report: Operation of an interagency agreement for replacing easement wetlands affected by highway projects in North Dakota. U.S. Fish and Wildlife Service, Bismark, ND, Unpublished Report. 22 pp.

EMPHASIS:	Overview: Policy
REGION/STATE:	North Dakota
WETLAND TYPE:	—
IMPACT:	Highway Development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

U.S. Fish and Wildlife Service. 1985. Evaluation of mitigation wetlands: U.S. Highway 83 between Bismark and Minot. U.S. Fish and Wildlife Service, Bismark, ND, Unpublished Report. 10 pp.

EMPHASIS:	Mitigation, Creation, Effectiveness
REGION/STATE:	North Dakota (Highway 83)
WETLAND TYPE:	Palustrine
IMPACT:	Highway development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Wildlife, Hydrology

U.S. General Accounting Office. 1988. Public rangelands: some riparian areas restored but widespread improvements will be slow. U.S. General Accounting Office, Washington, D.C. GAO/RCED-88-105. 85 pp.

EMPHASIS:	Restoration, Effectiveness
REGION/STATE:	West (22 areas)
WETLAND TYPE:	Riparian
IMPACT:	Rangeland use
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Uebelhoer, G. 1979. Problems associated with the successful recreation of wetlands in mined areas of Desoto and Manatee Counties, Florida. Pages 102-126 IN: D.P. Cole, Ed., Proceedings of the Sixth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Research: Existing wetlands
REGION/STATE:	Florida (Desoto and Manatee Counties)
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation, Soils, Hydrology

Ulrich, KE and TM Burton. 1985. The establishment and management of emergent vegetation in sewage-fed artificial marshes and the effects of these marshes on water quality. Wetlands (4):205-220.

EMPHASIS:	Research
REGION/STATE:	—
WETLAND TYPE:	Palustrine
IMPACT:	Wastewater
WETLAND USE:	—
SCIENTIFIC THEME:	Plant growth, Water quality

Vance, HA. 1988. Hydrology and hydraulic requirements of successful wetlands. Pages 283–286 IN: J.A. Kusler and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Wetland Hydrology. September 16–18 1987, Chicago, Illinois Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Overview: Creation, Effectiveness
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Hydrology

Vaught, R and J Bowmast... 1983. Missouri wetlands and their management. Missouri Department of Conservation, Jefferson City. 23 pp.

EMPHASIS:	Creation, Management, Technique
REGION/STATE:	Missouri
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Veneman, PLM. 1986. Science base for freshwater wetland mitigation in the Northeast United States: Soils. Pages 115–121 IN: J.S. Larson, and C. Neill, Eds., Mitigating Freshwater Wetland Alterations in the Glaciated Northeastern United States: An Assessment of the Science Base. University of Massachusetts, Environmental Institute, Amherst, Publication No. 87–1.

EMPHASIS:	Overview: Mitigation
REGION/STATE:	Northeast
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Soils

Walker, R. 1988. Phosphate mining and wetlands creation: A company perspective. Pages 37–40 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Technique, Effectiveness
REGION/STATE:	Florida, North Carolina
WETLAND TYPE:	Palustrine
IMPACT:	Phosphate mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	—

Walker, S. 1986. A review of past mitigation projects in Florida. Pages 256–258 IN: J.A. Kusler, L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Mitigation: Effectiveness
REGION/STATE:	Florida
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Warburton, DB, WD Klimstra, and JR Nawrot. 1985. Aquatic macrophyte propagation and planting practices for wetland development. Pages 139–152 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Creation, Technique, Monitoring
REGION/STATE:	Illinois
WETLAND TYPE:	Palustrine
IMPACT:	Coal mining
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Watson, JT, FD Diodato, M Lauch. 1986. Design and performance of the artificial wetlands wastewater treatment plant at Iselin, Pennsylvania. Pages 263–270 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Pennsylvania (Iselin)
WETLAND TYPE:	Palustrine
IMPACT:	Water Pollution
WETLAND USE:	Wastewater treatment
SCIENTIFIC THEME:	Water quality

Webb, FJ. 1973–1989. Proceedings of the Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College, Environmental Studies Center.

EMPHASIS:	Symposia Proceedings: Creation, Restoration, Effectiveness
REGION/STATE:	United States
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Wein, GR, S Kroeger, and GJ Pierce. 1987. Lacustrine vegetation establishment within a cooling reservoir. Pages 206–218 IN: F.J. Webb, Jr., Ed., Proceedings of the Eighth Annual Conference on Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL.

EMPHASIS:	Mitigation, Revegetation, Effectiveness
REGION/STATE:	South Carolina (Savannah River, L-Lake)
WETLAND TYPE:	Lacustrine
IMPACT:	Energy development
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation

Wein, GR and WD McCort. 1988. Sources of complexity in wetland mitigation. Pages 41–50 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Mitigation, Policy, Effectiveness
REGION/STATE:	South Carolina (Savannah River, L-Lake, Kathwood Lake)
WETLAND TYPE:	Lacustrine
IMPACT:	Energy Development
WETLAND USE:	Habitat
SCIENTIFIC THEME :	—

Weller, MW. 1981. Freshwater marshes: Ecology and wildlife management. University of Minnesota Press, Minneapolis. 146 pp.

EMPHASIS:	Scientific overview: Restoration, Management, Technique
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

White, JM, and LR Sinclair. 1979. Effect of plant spacing on growth and yield of transplanted cattails. Proceedings of the Soil and Crop Society. Florida 38:18–20.

EMPHASIS:	Research
REGION/STATE:	Florida (Laudermilk Muck)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Plant growth

Wieder, RK, GE Lang, and AE Whitehouse. 1985. Metal removal in Sphagnum-dominated wetlands: Experience with a man-made wetland system. Pages 353-364 IN: R.P. Brooks, D.E. Samuel, and J.B. Hill, Eds., Wetlands and Water Management on Mined Lands, Proceedings of a Workshop. Pennsylvania State University School of Forest Resources, University Park.

EMPHASIS:	Creation, Effectiveness
REGION/STATE:	Maryland (McHenry)
WETLAND TYPE:	Sphagnum bog
IMPACT:	Coal mining
WETLAND USE:	Water quality improvement
SCIENTIFIC THEME:	Water quality

Wilcox, DA, and RW Buchholz. 1986. Vegetation restoration in a road salt impacted bog (Indiana). Restoration and Management News 4(1):28.

EMPHASIS:	Revegetation, Technique, Effectiveness
REGION/STATE:	Indiana (LaPorte County, Pinhook Bog)
WETLAND TYPE:	Bog
IMPACT:	Salt contamination
WETLAND USE:	—
SCIENTIFIC THEME:	Vegetation, water quality, soils

Wilhelm, M, SR Lawry, and DD Hardy. 1988. Creation and management of wetlands using municipal wastewater in Northern Arizona: A status report. Pages 154-159 IN: J. Zelazny and J.S. Feierabend, Eds., Increasing our Wetland Resources, Proceedings of a Conference. National Wildlife Federation, Washington, DC.

EMPHASIS:	Creation, Effectiveness, Technique
REGION/STATE:	Arizona (Apache-Sitgreaves National Forest)
WETLAND TYPE:	Palustrine
IMPACT:	—
WETLAND USE:	Wastewater treatment, habitat
SCIENTIFIC THEME:	—

Willard, DE, VM Finn, DA Levine, and JE Karlquist. 1989. Creation and restoration of riparian wetlands in the agricultural midwest. Pages 333-358 IN: Wetland Creation and Restoration: The Status of the Science. Vol. 1. EPA 600/3-89/038a.

EMPHASIS:	Overview: Creation, Restoration, Enhancement, Technique, Effectiveness
REGION/STATE:	Midwest
WETLAND TYPE:	Riparian
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Willard, DE and RB Reed. 1986. The use of native species to restore and create wetland habitat for mitigation. Pages 340–342 IN: J.A. Kusler, L. Quammen, and G. Brooks, Eds., Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Berne, NY.

EMPHASIS:	Overview: Native plant species
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Wolverton, BC. 1979. Engineering design data for small vascular aquatic plant wastewater treatment systems. Pages 179–192 R.K. Bastian and S.C. Reed, Eds., Aquaculture Systems for Wastewater Treatment: Seminar Proceedings and Engineering Assessment. U.S. Environmental Protection Agency, Washington, D.C.

EMPHASIS:	Research
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Wastewater treatment

Wolverton, BC. 1987. Artificial marshes for wastewater treatment. Pages 141–151 IN: K.R. Reddy and W.H. Smith, Eds., Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publications, Orlando, FL.

EMPHASIS:	Overview
REGION/STATE:	—
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	Wastewater treatment

Zedler, J. 1986. Wetland restoration: Trials and errors of ecotechnology? Pages 11–16 IN: R. Strickland, Ed. Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of our Understanding. Washington State University, Department of Ecology, Olympia, Publication No. 86–14.

EMPHASIS:	Overview: Feasibility
REGION/STATE:	California
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Zelazny, J and JS Feierabend. 1988. Proceedings of a conference: Increasing our wetland resources. October 4–7, 1987. Washington D.C. National Wildlife Federation, Washington, DC.

EMPHASIS:	Symposium: Creation, Restoration, Enhancement
REGION/STATE:	US
WETLAND TYPE:	—
IMPACT:	—
WETLAND USE:	—
SCIENTIFIC THEME:	—

Zimmerman, JH. 1983. The revegetation of a small Yahara Valley prairie fen. Wisconsin Academy of Science, Arts, and Letters 71(2):87–102.

EMPHASIS:	Restoration, Technique, Effectiveness
REGION/STATE:	Wisconsin (Madison, Cherokee Marsh City Park)
WETLAND TYPE:	Fen
IMPACT:	Dredging
WETLAND USE:	Habitat
SCIENTIFIC THEME:	Vegetation