GRI-93/0229

PIPELINE CORRIDORS THROUGH WETLANDS — IMPACTS ON PLANT COMMUNITIES: LITTLE TIMBER CREEK CROSSING, GLOUCESTER COUNTY, NEW JERSEY

TOPICAL REPORT

(August 1991-January 1993)

Prepared by

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For

GAS RESEARCH INSTITUTE

Contract No. 5088-252-1770

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December 1994

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REPORT DOCUMENTATION PAGE	1. REPORT NO. GRI-93/0229	2.	3. Recipient's Accession No.
4. Title and Subtitle Pipeline Corridors through Wetlands — Impacts on Plant Communities: Little Timber Creek Crossing, Gloucester County, New Jersey			5. Report Date December 1994 6.
7. Author(s) L.M. Shem, G.D. Van Dyke, R.E. Zimmerman, and S.K. Alsum			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Center for Environmental Restoration Systems Energy Systems Division Argonne National Laboratory 9700 South Cass Avenue Argonne, Ill. 60439			10. Project/Task/Work Unit No. ACK 85872 11. Contract (c) or Grant (G) No. (c) 5088-252-1770 (G)
12. Sponsoring Organization Name and Address Environment and Safety Research Group Gas Research Institute 8600 West Bryn Mawr Avenue Chicago, Ill. 60631			13. Type of Report & Period Covered Topical Report August 1991-January 1993 14.
15. Supplementary Notes			

16. Abstract (Limit 200 words)

The goal of the Gas Research Institute Wetland Corridors Program is to document impacts of existing pipelines on the wetlands they traverse. To accomplish this goal, 12 existing wetland crossings were surveyed. These sites varied in elapsed time since pipeline construction, wetland type, pipeline installation techniques, and right-of-way (ROW) management practices. This report presents results of a survey conducted over the period of August 5-7, 1991, at the Little Timber Creek crossing in Gloucester County, New Jersey, where three pipelines, constructed in 1950, 1960, and 1990, cross the creek and associated wetland. The old side of the ROW, created by the installation of the 1960 pipeline, was designed to contain a raised peat bed over the 1950 pipeline and an open-water ditch over the 1960 pipeline. The new portion of the ROW, created by installation of the 1990 pipeline, has an open-water ditch over the pipeline (resulting from settling of the backfill) and a raised peat bed (resulting from rebound of compacted peat). Both the old and new ROWs contain dense stands of herbs; the vegetation on the old ROW was more similar to that in the adjacent natural area than was vegetation in the new ROW. The ROW increased species and habitat diversity in the wetland. It may contribute to the spread of purple loosestrife and affect species sensitive to habitat fragmentation.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	Unclassified	
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 94-77) (Formerly NTIS-35) Department of Commerce

Research Summary

Title	Pipeline Corridors through Wetlands — Impacts on Plant Communities: Little Timber Creek Crossing, Gloucester County, New Jersey
Contractor	Argonne National Laboratory
Principal Investigators	L.M. Shem, G.D. Van Dyke, and R.E. Zimmerman
Report Period	August 1991-January 1993
Objective	Document the historical impacts of pipeline rights-of-way (ROWs) on wetlands.
Technical Perspective	The impact of pipeline construction in wetlands is a very sensitive issue and one that is under strict regulatory control. Neither the natural gas industry nor the regulatory community has a documented basis for defining the type, value, or environmental consequences of past pipeline activities in wetlands. This report is one of a series documenting these impacts.
Results	Observable impacts of the ROW on hydrology and vegetation were limited to the ROW itself. Modifications in topography of the ROW associated with the installation of the 1960 pipeline, which were made at the landowner's request, resulted in a raised peat bed and an open ditch on the ROW. A raised peat bed and open ditch also resulted on the working ROW from installation of the 1990 pipeline because of unanticipated settling over the pipeline and rebound of peat. The portion of the ROW associated with the 1960 pipeline, although kept free of shrubs and saplings, supported a dense stand of vegetation that was only slightly lower than the adjacent natural area (NA) in terms of species richness and wetland indicator values and that had many species in common with the NA. The portion of the ROW associated with the 1990 pipeline had fewer plant species in common with its adjacent NA, but it contained more plant species with greater fidelity to wetlands than did the ROW associated with the 1960 pipeline. The 1990 ROW had developed a dense stand of native vegetation in the one year following pipeline installation without fertilization, liming, or seeding. Collectively, the number of plant species found on the 1960 and 1990 ROWs was almost the same as the number in the adjacent NA, even though the ROW lacked shrubs and saplings. The presence of the ROW adds

diversity to the site in terms of numbers of plant species present and types of habitats available to animal species. Purple loosestrife, the only aggressive nonnative plant species present, occurred on both ROWs and in both NAs, but it was most abundant on the 1960 ROW.

Technical Approach

A relatively homogeneous study site was selected within a scrub-shrub community about 300 m along the ROW near the western edge of the wetland crossing. Data were collected on soils, hydrology, and plant cover from transect plots within both sides of the ROW and within the NAs on either side of the ROW. Plant data were analyzed to determine similarities and differences between the two sides of the ROW and the two adjacent NAs.

Project Implications

This study shows that within one year after installation of the 1990 pipeline in this wetland, the ROW had developed a dense stand of almost exclusively native vegetation without seeding, liming, or fertilization. The 1960 ROW, having a 3-5-year maintenance cycle, also supported a dense stand of herbaceous vegetation having many species in common with the adjacent NA. The open-water ditches and their associated raised peat beds, created during the installation of the 1960 and 1990 pipelines, provide diversity of habitat for both plant and animal species. Although the 1960 ditch was intentional, the 1990 ditch was the result of unanticipated settling over the pipeline and unanticipated rebound of peat on the working side of the ROW.

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Acknowledgment

Recognition is given to Ted Gordon of Pine Barrens Inventory, Southhampton, New Jersey, for performing the verification of species identification of the plants found at the Little Timber Creek crossing site.

Pipeline Corridors through Wetlands — Impacts on Plant Communities: Little Timber Creek Crossing, Gloucester County, New Jersey

by

L.M. Shem, G.D. Van Dyke, R.E. Zimmerman, and S.K. Alsum

1 Introduction

1.1 Background

Pipelines for the distribution of natural gas traverse all types of terrain, including wetlands. Prior to the wetlands regulatory climate of the late 1980s and the early 1990s, the construction of right-of-way (ROW) corridors through wetlands was often welcomed by landowners and local communities; ROW corridors opened up wetlands, thereby providing public access. With the promulgation of more stringent regulations related to development activities (including no-net-loss wetland policies), an assessment of the historical impacts of pipeline ROWs through wetlands is needed to evaluate construction and reclamation methods, assist in future permit application processes, and evaluate future construction costs.

The Gas Research Institute (GRI) Wetland Corridors Program was designed to evaluate impacts of gas-pipeline construction and subsequent maintenance on wetlands. The data gathered through this GRI program provide a better understanding of the type, degree, and duration of impacts of various pipeline-construction techniques. This information will enable the industry to evaluate current construction practices and provide factual input to regulatory bodies.

Careful evaluation of the impacts of pipeline installation on wetlands is necessary because specific impacts may be beneficial to some plant and/or animal species and detrimental to others. Some impacts may appear to be detrimental when, in fact, they improve conditions for certain sensitive species or provide for greater diversity of species and habitat.

The initial questions addressed by the GRI Wetland Corridors Program are as follows:

1. Do ROW construction and/or management practices lead to differences in ROW plant communities with respect to adjacent wetland communities?

2. Does the ROW alter the diversity of the adjacent wetland community? If so, how far do the impacts extend?

3. Does the ROW enhance species diversity of the wetland?

4. Are there ROW construction and management practices that can enhance the positive contributions of ROWs to wetlands and minimize detrimental impacts?

Answers to these broad questions will provide information related to a number of more specific questions. Data on the type of plant communities that develop on ROWs in various wetlands when specific pipeline construction and management practices are utilized and comparison of the ROW plant communities with the plant communities in areas adjacent to the ROW will provide a basis for comparing environmental impacts of previous and current construction and management practices. Valuable data for such comparisons include numbers of plant species present, species that are dominant, percentage of the species that are native to the area, and fidelity of the plants to wetlands. Other measures of the quality of species present are also valuable, but those data are not available at present.

Concern exists as to whether pipeline corridors provide avenues of access for nonnative and invasive plants. Whether such plants become established along pipeline ROWs and from there invade adjacent areas, and the extent to which such invaders modify the plant communities in adjacent areas, are important to determining potential impacts of pipelines on wetlands.

Potential positive impacts are also important to assess. The degree to which ROWs provide habitat for rare or endangered species and other desirable species that are poorly represented in the adjacent areas is important information. Assessments of impacts of pipeline corridors on wetlands should also include the contribution of corridors to both plant and animal species diversity.

Answers to the above questions will assist the industry and regulatory agencies in evaluating current installation and management practices and making modifications that are beneficial to wetland quality enhancement.

1.2 Goals and Objectives

The goal of the GRI Wetland Corridors Program is to document impacts of existing pipelines on the wetlands they transverse. To accomplish this goal, 12 existing wetland crossings were surveyed. The sites evaluated differed in years since pipeline installation (ranging from 8 months to 31 years), wetland type, installation technology used, and management practices. Each wetland survey had the following specific objectives:

- Document vegetative communities existing in the ROW and in adjacent wetland communities;

- Evaluate similarities and differences between the plant communities in the ROW and in the adjacent wetland communities;

- Document qualitative changes to the topography, soils, and hydrology attributable to ROW construction; and

- Identify impacts caused by ROW construction on rare, threatened, endangered, or sensitive species.

These individual wetland objectives were fulfilled by the collection and analysis of field data and the presentation of those data and their analysis in nine individual site reports. An upcoming summary report further synthesizes and interprets the data from all individual sites.

The following sections constitute a data report of the field survey conducted over the period of August 5-7, 1991, in a scrub-shrub community at the Little Timber Creek crossing in Gloucester County, New Jersey.

2 Description of Study Area

2.1 Site Selection and Location

Staff members from a gas-distribution pipeline company assisted the Argonne National Laboratory (ANL) team in selecting a suitable study site in southwest New Jersey, where gas-transport pipelines traverse several wetlands. The selected study site, along a gas-pipeline ROW that crosses the Little Timber Creek wetland, is located in Woolwich and Logan Townships, Gloucester County, New Jersey. The site is approximately a quarter-mile south of highway I-295, a quarter-mile east of highway 322, and approximately one and one-half miles southeast of Bridgeport, New Jersey. It is classified as "Jurisdictional Wetlands" under Section 404 of the Clean Water Act (Appendix A). The site was selected on the basis of the presence of a wetland extending at least 200 m along the ROW with at least 50 m on each side of the ROW center. The location of the site is shown in Figure 1.

2.2 Soils

The soil type throughout the study area is described as Muck-Alluvial land-Fallsington-Pocomoke association (MAFP) by the U.S. Department of Agriculture and Soil Conservation

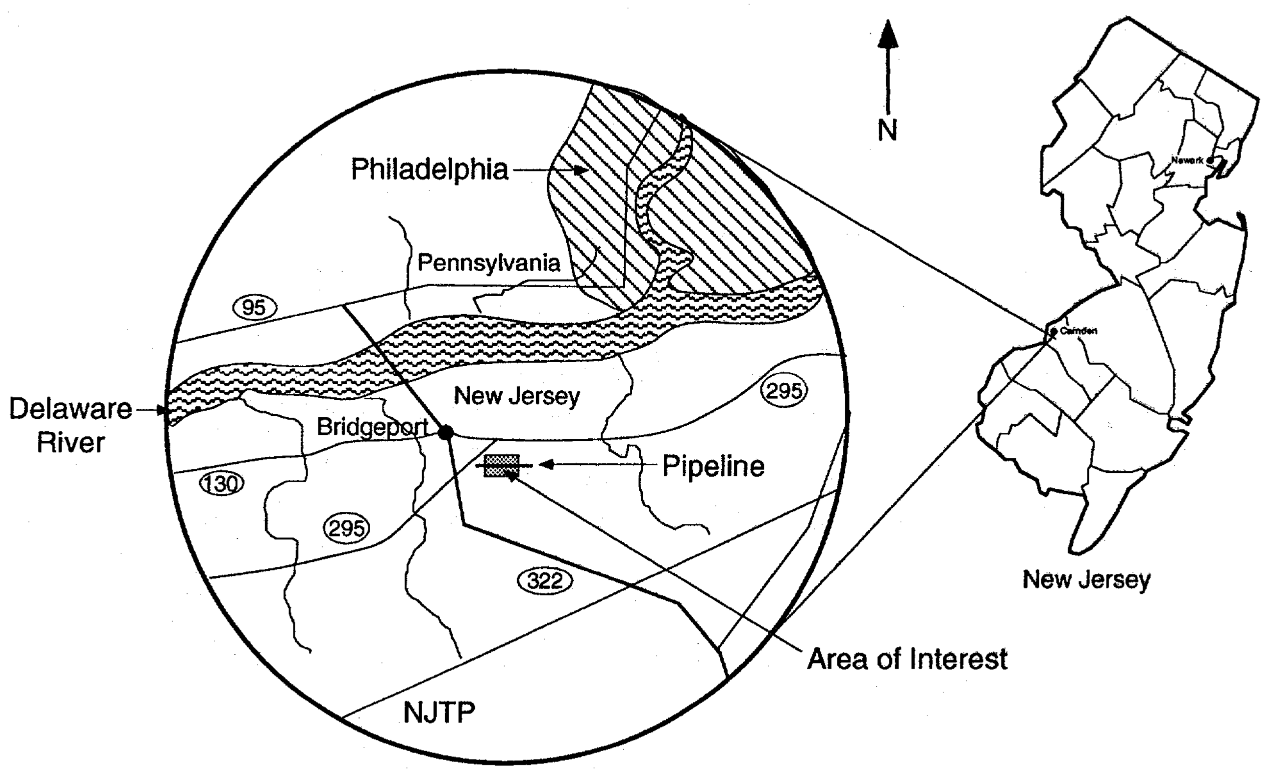

FIGURE 1 Location of the Little Timber Creek Study Site in Gloucester County, New Jersey

Service (SCS) in the Gloucester County, New Jersey, soil survey report (SCS 1962). This soil is generally described as consisting of a heavy, decomposing, organic surface; a loam to sandy loam below the organic stratum; a sandy loam to sandy clay loam subsoil; and a sandy substratum. The organic stratum is described as having a black upper stratum and a gray-brown, less-decomposed, peat lower stratum. This soil type is found in heavily wooded areas along stream flats in poorly drained sites and is usually extremely acidic. Trees common to these sites are Atlantic white cedar (*Chamaecyparis thyloides*) and red maple (*Acer rubrum*). Approximately 50% of the area in Gloucester County described as MAFP is muck, with the other 50% being made up of Fallsington and Pocomoke soils. The soil survey map depicts the entire study site as the muck component of this association. Both the Fallsington and Pocomoke soils are listed in the *Hydric Soils of the United States* (SCS 1991).

2.3 Hydrology

Little Timber Creek, a direct tributary to the Lower Delaware River, drains through a large scrub-shrub wetland that was, prior to logging, an Atlantic white cedar swamp (Cowardin et al. 1979). The ROW crosses the creek and approximately 1,400 ft* (425 m) of adjacent wetland near the upper end of the large swamp complex. The water table at the crossing was at or near the surface, depending on the microtopography (i.e., such features as hummocks, raised peat beds, and raised root masses). A heavy peat stratum, alleged to be greater than 15 ft (4.6 m), underlies the vegetational mat. Because of the relatively flat nature of the area, stream flows through the wetland are difficult to detect.

2.4 Climate

Gloucester County has a humid, temperate climate. Average monthly precipitation is about 3.5 in. (8.9 cm), with the most rainfall occurring in July and August (about 4.6-5.0 in./mo [11.7-12.7 cm/mo]). About 5% of the annual precipitation is snowfall of short duration. In winter, temperatures average just above freezing; in summer, the average temperature is 73°F (22.7°C). However, wide fluctuations in precipitation and temperature may occur from year to year. In dry years, irrigation is sometimes necessary for crops. The average growing season is 179 days, with the last killing spring frost in late April and the first killing frost in mid-October, as annual averages.

2.5 History and Management Practices

Area History. The Little Timber Creek wetland was originally an Atlantic white cedar swamp. Extensive logging activity and fires have since eliminated the cedar. The present native

* Measurements are given in metric units except where they were actually taken in English units; in these cases, metric equivalents are given in parentheses.

woody vegetation in the Little Timber Creek wetland is predominantly made up of red maple (*Acer rubrum*), alder (*Alnus serrulata*), buttonbush (*Cephalanthus occidentalis*), and coast pepper-bush (*Clethra alnifolia*). Numerous obligate and facultative wetland species make up the herb stratum.

In addition to logging, other disturbances to the wetland have occurred. Some draining for pasture land has occurred in this wetland. The waters of the wetland have also been used for irrigation of local fields. In more recent years, the water level of the immediate area has allegedly been raised as a result of the construction of interstate highway 295. Because of the wet and mucky nature of the wetlands, the area has no agronomic usage. The adjacent higher elevation lands are predominantly used for agriculture.

Pipeline Construction. Three pipelines traverse the wetlands at the site of the Little Timber Creek crossing.* The oldest, a 12-in. (0.3-m) diameter pipe, was installed in 1950. In 1960, a second pipe, 20 in. (0.5 m) in diameter, was installed (see Figure 2). In response to increased consumer demand for gas, a third pipeline, also a 20-in. (0.5-m) diameter pipe, was installed in 1990.

To allow working room on the ROW without danger of damage to the 1950 pipeline by the load of heavy installation equipment, the 1960 pipeline was placed 50 ft (15.2 m) north of the first pipeline. After installation of the first two pipelines, the width of the ROW was approximately 70 ft (21.3 m). To minimize the impact on the adjacent natural area (NA) during the installation of the 1990 pipeline, the pipe was placed only 25 ft (7.6 m) south of the 1950 pipeline. This placement necessitated the clearing of an additional 55 ft (16.8 m) of the NA to the south to

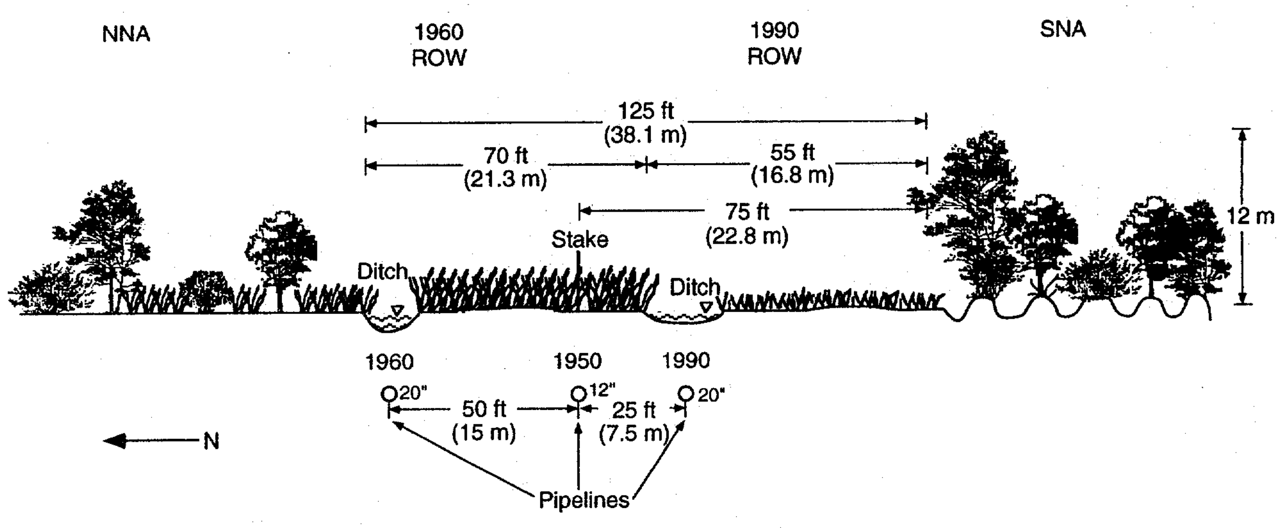

FIGURE 2 Generalized Cross-Section of the Study Site Showing the ROW, Ditches, Pipeline Locations, and Vegetation Types

* Information on the construction of the pipelines was obtained from conversations and notes provided by Stuart A. Buchanan of Transco and from a report prepared by Buchanan and Michael D. Zagata (1991).

provide a workspace width of 75 ft (22.9 m). The resulting ROW now has a width of approximately 125 ft (38.1 m).

Installations of the 1950 and 1960 pipelines were performed using conventional wetland-crossing techniques. Timber pads, natural material for corduroy roads, and possibly the excavated soil were used to support a backhoe for the excavation of the ditch. During the installation of the 1950 pipeline, once the pipe was in place, the ditch was backfilled. During the installation of the 1960 pipeline, the backfill was not replaced at the landowner's request. The owner wanted to use the resulting open, 6-8 ft (1.8-2.4 m) wide ditch for irrigation purposes.

During the time interval between the installations of the 1960 and 1990 pipelines, interstate highway 295 was constructed approximately a quarter-mile north of the site. According to the landowner, the new interstate highway affected the hydrology of the site by altering the flow patterns of Little Timber Creek and raising the water table at the location of the study site.

Construction plans for the 1990 pipeline called for using the same conventional methods used for the first two pipelines. However, initial attempts to enter the wetlands with the backhoe failed because the muck and peat were unable to support the heavy load. The encountering of this difficulty may confirm the effects of construction of the interstate highway on the hydrology of the wetland. Therefore, an alternative construction method was employed. A dragline operating from a floating 30 ft × 42 ft (9.1 m × 12.8 m) barge was used to access the wetland and excavate the ditch. The ditch was excavated to a width of 35 ft (10.7 m) and a depth of 4 ft (1.2 m) to accommodate the barge. An attempt was made to minimize the dimensions of this new canal. The total excavation process for the canal took 20 days.

Another problem encountered during the crossing construction process involved containment of the spoil generated from the canal within the 75-ft (22.9-m) workspace. Complications were caused by the saturated, unconsolidated nature of the muck peat, which had a tendency to flow when deposited on the surface. These problems were managed by stacking the excavated stumps at the south edge of the workspace to contain the excavated soil and by allowing each bucket of soil to drain while suspended over the canal before placing it on the spoil pile.

Assembly and welding of the concrete-coated pipe took place on the west bank. The assembled pipe was pushed into the trench through the use of styrofoam blocks. Pipe assembly and placement took 3 days.

Backfilling of the ditch was performed in reverse sequence to that of the excavation. The dragline replaced the excavated spoil as the barge backed out of the canal, moving in a westerly direction. Care was taken to replace as much of the spoil as possible and to leave the site at the original grade. Backfilling took 6 days. The entire installation process required 47 days.

Post-Construction and ROW Maintenance. The regraded surface of the ROW was left to revegetate naturally after construction of the 1990 pipeline was completed; no seeding, fertilizing, or liming was performed. Some mulch was placed on the west bank, where the bank had been used for accessing the wetland. The construction was completed sufficiently early in the growing season for some vegetation to become stable before winter set in.

A field visit by pipeline company staff a few months after completion of the 1990 pipeline construction revealed that, despite efforts to leave the site at original grade, the peat fill in the pipeline ditch had settled, leaving an open-water ditch. Also, the area where spoil was stockpiled during construction had rebounded to a slightly higher elevation.

Management practices consist of routine maintenance performed on the ROW to maintain access to the pipelines. At Little Timber Creek Crossing, maintenance consists of mowing once every 3-5 years when the ground is frozen and can support mowing equipment. This limited maintenance keeps shrubs and trees from maturing on the ROW.

3 Approach and Methods

3.1 General Approach

The primary objectives listed in the Introduction (Section 1.2) provided the general guidelines for this study. To allow comparison of results across sites, methodologies for site reconnaissance, vegetation data collection, and data analysis used at this site were similar to those used at the other sites.

Because the ROW at this site contained three pipelines that had been installed at different times, the two sides of the ROW were of different ages. Therefore, comparisons of the vegetation were made between each side of the ROW and its adjacent NA as well as between the combined ROW and the combined NAs.

3.2 Habitat Description

The pipelines, and hence the ROW, extend in an east-to-west direction through the study area, as shown in Figure 2. Five areas were defined for sampling purposes. These five areas were chosen to represent three distinct areas on the ROW and two NAs:

1. North natural area (NNA) — the area immediately north of the ROW, undisturbed by the pipeline construction;

2. Old ROW — the northern portion of the ROW created by the installation of the first two pipelines;

3. New ditch — the open-water ditch created by the installation of the 1990 pipeline;

4. New ROW — the southern portion of the ROW created by the installation of the 1990 pipeline; and

5. South natural area (SNA) — the area immediately south of the ROW, undisturbed by the pipeline construction.

Site data on topography, water levels, water flow patterns, soil surface conditions, and structure of the plant communities were recorded during a careful reconnaissance of the site. Soil characteristics (as observed by means of a hand auger) were compared with those listed for the MAFP association (SCS 1962).

3.3 Sampling Design for Vegetational Studies

Transects. Five transects (T1 through T5) were established perpendicular to the ROW and approximately 30 m apart (see Figure 3). Wooden stakes (already on-site) marking the approximate location of the 1950 pipeline were used as reference points for measuring the transects. Each transect extended 30 m north and 41 m south, perpendicular to the line of the stakes. Five sampling plots were established along each transect, one in each of the five areas defined above. The plots representing each area were measured along the transect at uniform distances from the stakes (see Figure 4 for distances). All plots used the transect line as their western edge. Plots of 2 m × 5 m were used for collecting herbaceous data. Shrub and sapling data were collected in plots measuring 5 m × 10 m.

Sampling Procedures. Vegetational data were collected from each of the measured plots. Two specimens of each plant species found on or near the plots were collected as voucher specimens. Region 1 wetland indicator categories, life-forms, and origin were derived from the national list of plant species (Reed 1988). Visual estimates of areal coverage were recorded for each species in each of the two plant strata within the plots: (1) the herb stratum and (2) the shrub and sapling strata combined. Vegetative strata are defined in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (called the 1989 Federal Manual) as herbs, shrubs, saplings, and trees (FICWD 1989). The herbs are defined as herbaceous plants, including graminoids, forbs, ferns, herbaceous vines, and woody species under 3 ft (0.91 m) in height. Shrubs included multistemmed, bushy shrubs and small trees and saplings between 3 and 20 ft (0.91 and 6.1 m). Saplings are defined as having a diameter at breast height (dbh) of 0.4-4.9 in. (1.0-12.4 cm) and as exceeding 20 ft (6.1 m) in height. Trees are defined as having a dbh of

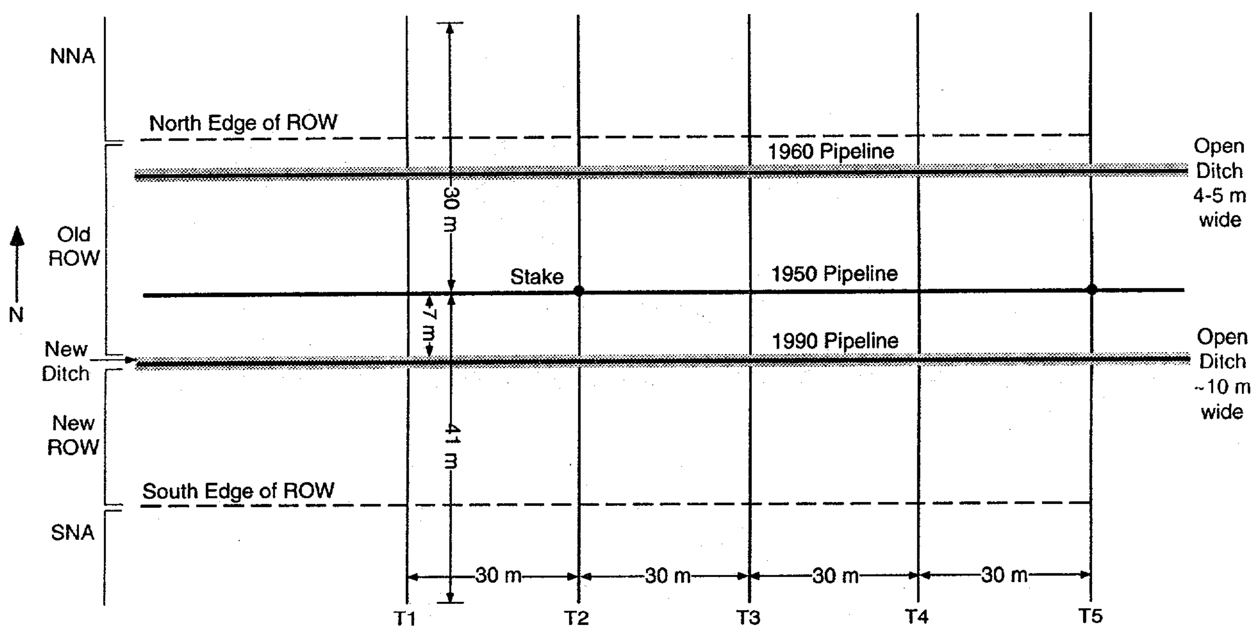

FIGURE 3 Plan View of the Study Site Showing Transect Length and Spacing

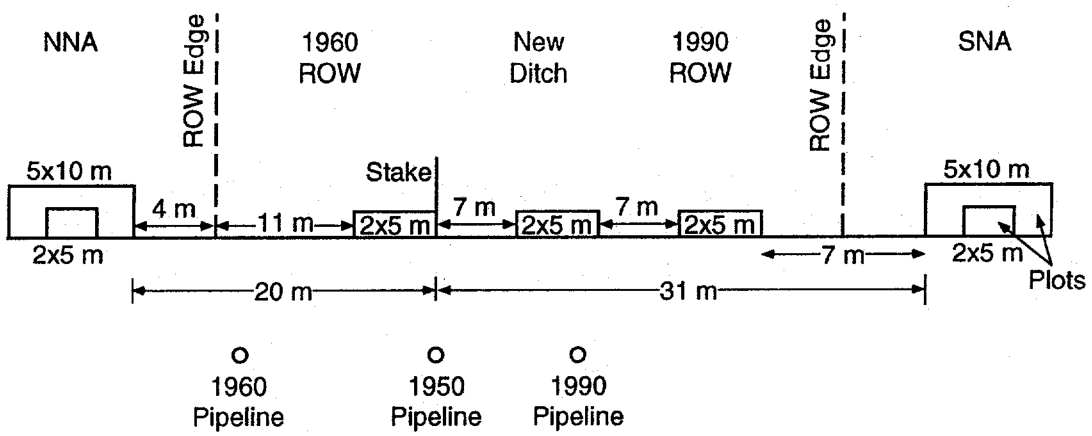

FIGURE 4 Location and Dimensions of Sampling Plots along One Transect

greater than or equal to 5.0 in. (12.7 cm) and as exceeding 20 ft (6.1 m) in height. One plant species could occur in any or all strata. Coverage estimates were also made for surface water and bryophytes in each plot.

3.4 Data Analysis

Analyses of vegetative data collected from sampling plots for all 17 sites studied as part of the GRI Wetland Corridors Program were consistent. Analyses focused on comparing the plant communities on the ROW with those in the NAs and determining hydrophytic characteristics of the plant communities in each area. Particular attention was given to dominant species because they are used in several wetland delineation methods. Although the number of species dominant, species richness, and the variety of plant life-forms present are all aspects of community diversity, no diversity indices were calculated. Diversity indices that use coverage values as measures of species importance were considered, but they were judged inappropriate because of differences in the number of strata in the ROW and NAs for the sites included in the Wetlands Corridors Program and because coverage values are not additive across strata.

Species Richness, Wetland Indicator Categories, and Species Characteristics. The total number of species present (species richness) was determined for each side of the ROW, for the total ROW, for each NA, and for the NAs combined. Wetland indicator categories (Reed 1988) were identified for each species in the study plots. These categories are defined in Appendix B, Section B.1. The number of species in each category was determined for each area by stratum and for all strata combined. Because one plant species could occur in any or all strata, when data from different strata were combined, each species was considered only once, independent of the number of strata in which it occurred. Species characteristics, including life-forms and origins, were also determined from Reed (1988). Symbols for life-forms and species origins are given in Appendix B, Section B.2.

Dominant Species. The definition of and methodology for the determination of dominant species in this study were taken from the 1989 Federal Manual (FICWD 1989). In the manual, dominance refers "strictly to the spatial extent of a species that is directly discernible or measurable in the field," as opposed to number of individuals present. Using this definition, dominant species were identified by plant stratum, rather than by total community. For each area, the dominant species were determined for each stratum by ranking each species in a plant stratum in descending order relative to total areal coverage of all plants in that stratum. The highest ranking species, which make up 50% of the total areal coverage or half of the total relative percent coverage (RPC), are the dominant species for that stratum. Any remaining species with 20% or more RPC are also considered dominant.

Community Similarity Indices. Sørensen's coefficient of community index (CC_S) was used to measure similarity between vegetative communities (Brower, Zar, and von Ende 1990). This index uses the following formula:

$$CC_S = 2c/(a+b) \quad (1)$$

where

a = the number of species in community A,

b = the number of species in community B, and

c = the number of species in common between communities A and B.

A CC_S value of 1.00 indicates 100% similarity in species composition between communities A and B. A value of 0.00 represents no species in common. Community similarity indices that use coverage values as measures of species importance were considered, but they were judged inappropriate because of differences in the strata present in the plant communities on the ROW compared to those in the NAs and because of the nonadditive characteristic of coverage data.

Comparisons were made between the combined ROWs and combined NAs, the two portions of the ROW, each portion of the ROW and its adjacent NA, and the two NAs.

Prevalence Index Values. Prevalence index values (PIVs) were calculated according to methods outlined in the 1989 Federal Manual (FICWD 1989), substituting RPC data from quadrat coverage estimates for relative frequencies from intercept data. This substitution is logical because both relative frequency and RPC are estimates of relative coverage (Bonham 1989). The PIV is an average wetland indicator value ranging from 1.0 to 5.0 and weighted by the RPC. Because areal coverage was determined by stratum, the PIVs were calculated for each area by stratum only. The average RPCs for each species in the five plots in each area were used in calculating the PIV for the area. The equation for calculating a PIV is presented in Appendix B, Section B.3.

Average Wetland Values. Average wetland values (AWVs) (Zimmerman et al. 1991) were calculated for the species in each of the five areas. This index is an average of the wetland indicator values for all plants present. It differs from the PIV in that it is not weighted by RPC; rather, all plants present are represented equally, regardless of their frequency of occurrence. Because areal coverage is not considered, the calculation of an index value is not restricted to one vegetative stratum. An overall site AWV was determined, as well as values for each stratum. See Appendix B, Section B.4, for the equation.

4 Results

4.1 General Ecology

The soil at the study site consisted of a peat muck that was at least 0.9 m in depth and was alleged to be up to 4.6 m. Soil characteristics at the study site were as described for the muck component of the MAFP by the SCS (1962). The water table was at or within the floating mat on the surface, with standing water present in small depressions and ditches left by the construction of the pipelines. The ROW was devoid of trees and shrubs as a result of periodic mowing. The portion of the ROW between the 1950 and 1960 pipelines (the old ROW) had a dense stand of herbaceous plants approximately 2 m tall, and the portion of the ROW south of the 1990 pipeline (the new ROW) was densely vegetated with herbaceous vegetation that was mostly 1 m or less in height.

Two prominent ditches were present on the ROW, as depicted in Figure 2. Both ditches contained standing water. The first ditch, located along the north edge of the ROW, was created for irrigation use when the 1960 pipeline was installed. The spoil was not replaced, leaving a ditch 1-2 m deep. This ditch, which was originally 2.0-2.5 m wide, was now 3.0-4.5 m wide in places and was partially shaded by overhanging vegetation. The old ROW contained a raised peat bed apparently created by the excess of the excavated peat from the ditch. The second ditch (called the new ditch), over the 1990 pipeline, was created by consolidation and settling of the backfill material after construction. This second ditch was approximately 0.15-0.61 m deep and 7-10 m wide. Immediately to the south of this ditch, where the spoil had been stored during construction, a second raised peat bed was present. This raised area apparently resulted from rebounding of peat compressed by the stored spoil. The presence of the ditches and the intervening raised areas did not appear to affect the general hydrology of the area, since water could freely enter and leave the site from the main stream channel to the east. The new ditch, located between the old and new ROWs, had very little vegetation. The areal coverage of open water was estimated to average 82% and exposed unvegetated muck was estimated at 16%. The only plants found in the ditch were those encroaching from adjacent ROW areas. Therefore, the new ditch was considered to be a boundary between the old and the new ROWs, and the data on plants found in the ditch were not considered in the data analyses.

The NNA appeared to gradually slope downward toward Interstate 295, located a quarter-mile from the site. The SNA extended well beyond the ends of the sampling transects before gradually sloping upward toward adjacent upland.

4.2 Plant Community

The SNA consisted of a mature shrub population with interspersed saplings. This area extended more than 100 m to the south of the study area. The NNA contained an open stand of shrubs and scattered saplings with a dense understory of herbaceous plants. The old ROW had a dense stand of herbaceous and small shrubby plants well over 1 m tall, while the new ROW had a dense growth of shorter herbs consisting mostly of grasses. Names of plant species, individual plot coverage estimates by species, and a summary of coverages for each species in each area are given in Appendix C.

Plant Species, Life-Forms, and Species Origins. A complete list of species found at the Little Timber Creek study site is given in Appendix C, Table C.1. Seventy-six species of vascular plants and three species of bryophytes were collected from the study site. All 76 vascular plants were identified to genus. Seventy two of the 76 vascular plants were identified to species, and their regional wetland indicator categories (Reed 1988) were determined. Of these 72 species, 58 occurred within the sampling plots (see Appendix C, Tables C.2 and C.3). Percent areal coverage, species richness, species dominance, and wetland values for the different transects and areas were determined on the basis of these 58 species.

Of the 72 vascular plants identified to species, four are listed as introduced species in the *National List of Plant Species that Occur in Wetlands, Region 1* (Reed 1988). Purple loosestrife *(Lythrum salicaria)* was found in all of the areas. However, it was most abundant in the old ROW, where it averaged 24% total areal coverage in the surveyed plots. It was also abundant in the NNA at 16.4% areal coverage, compared with 3.6% in the SNA and 0.8% in the new ROW. Greater duckweed *(Spirodela polyrhiza)* averaged slightly over 2% coverage in the plots in the NNA and the old ROW. Hairy crabgrass *(Digitaria sanguinalis)* and barnyard grass *(Echinochloa crusgalli)* were found in the new ROW, close to the edge of the wetland but not within the area in which sampling plots were located.

Species Richness and Wetland Indicator Categories. Table 1 shows the number of plant species found in the NAs combined and the two ROWs combined. These species counts are broken down into wetland indicator categories by vegetative stratum. For the NAs at this site, two strata were defined: (1) an herb stratum and (2) a shrub-sapling stratum. One plant species can occur in either or both strata. When data from both strata were combined, each species was considered only once, independent of the number of strata in which it occurred. Definitions of strata can be found in Section 3.3 of this report.

Table 1 gives total numbers of species found in the combined NAs and the combined ROWs (columns 3 and 4), the number of species found in both of the areas (column 5), and the number of species found in one of the areas but not the other (columns 6 and 7). The herb stratum contained a total of 53 species. The NAs contained 35 and the ROWs, 42. Of these 53 species, 45% were present in both areas, 21% only in the NAs and 34% only in the ROWs. Ninty-two percent of the 53 species were either obligate wetland (OBL) or facultative wetland (FACW).

Only 12 species of woody plants occurred as shrubs and saplings in the NAs of the study site. Three of these species were represented by seedlings on the ROWs. Ten of the 12 were either OBL or FACW; the other two were facultative (FAC).

TABLE 1 Number of Plant Species by Wetland Indicator Category Found in the Study Plots in the NAs and the Combined ROWs (by individual stratum and combined strata)

Stratum	Wetland Indicator Category[a]	Number of Species: Occurring in NAs	Occurring in ROWs	Common to Both Areas	Unique to NAs	Unique to ROWs	Total
Herb	OBL	20	25	13	7	12	32
	FACW	12	14	9	3	5	17
	FAC	1	1	1	0	0	1
	FACU	1	1	0	1	1	2
	UPL	1	1	1	0	0	1
	Total	35	42	24	11	18	53
Shrub-sapling	OBL	5	0	0	5	0	5
	FACW	5	0	0	5	0	5
	FAC	2	0	0	2	0	2
	FACU	0	0	0	0	0	0
	UPL	0	0	0	0	0	0
	Total	12	0	0	12	0	12
Combined	OBL	24	25	16	8	9	33
	FACW	16	14	10	6	0	20
	FAC	2	1	1	1	0	2
	FACU	1	1	0	1	1	2
	UPL	1	1	1	0	0	1
	Total	44	42	28	16	14	58

[a] OBL = obligate wetland; FACW = facultative wetland; FAC = facultative; FACU = facultative upland; UPL = obligate upland; see Appendix B for more detailed information on wetland indicator categories.

The total combined strata comprised 58 species. Both the NAs and the ROWs had about the same number of species: 44 and 42, respectively. Forty-eight percent of these 58 species were found in both areas, 26% only in the NAs, and 24% only in the ROWs. All but five of the 58 species (91%) were OBL or FACW. Only one obligate upland (UPL) species was present in the sampling plots.

Table 2 presents species data for the two different ROW areas in the same manner as the data were presented in Table 1 for the combined NAs and combined ROWs. This breakdown was prepared because the two sides of the ROW were of different maturities. Since the installation of the 1960 pipeline, 31 years previous to the study, the soil of the old portion of the ROW had not been disturbed. However, the new portion of the ROW was disturbed just one year before this survey. Of the 42 herbaceous species found in the ROWs, 62% were present in the old ROW and

TABLE 2 Number of Plant Species by Wetland Indicator Category Found in the Study Plots on the Old and New Portions of the ROW (by individual stratum and combined strata)

		Number of Species					
Stratum[a]	Wetland Indicator Category	Occurring in Old ROW	Occurring in New ROW	Common to Both ROWs	Unique to Old ROW	Unique to New ROW	Total
Herb	OBL	15	22	12	3	10	25
	FACW	9	9	4	5	5	14
	FAC	1	1	1	0	0	1
	FACU	0	1	0	0	1	1
	UPL	1	0	0	1	0	1
	Total	26	33	17	9	16	42

[a] Herb stratum was the only stratum present in the ROW.

79% in the new ROW. Forty-one percent of the 42 species were found in both ROWs, 21% only in the old ROW, and 38% only in the new ROW. Because no shrubs were present in the ROW, the combined-strata data are identical to the herbaceous data.

Table 3, which is similar to Tables 1 and 2, presents the data for the NNA and the SNA separately. This tabulation allows comparisons between the two NAs. Of the 44 species found in the NAs, 35 were present in the herb stratum and 12 in the shrub stratum. Of the 35 herbaceous species, the NNA had 60%, and the SNA had 89%. Forty-nine percent of these 35 species were found in both NAs, 11% only in the NNA, and 40% only in the SNA. Ninty-two percent of the 35 species were OBL or FACW. The two NAs differed little in shrub and sapling composition. Of the 12 species in this group, 67% were present in both NAs. The SNA had 11 species and the NNA had 9. Only 8% of the species were unique to the NNA, and only 25% were unique to the SNA. For the combined strata, the SNA had a total of 40 species, and the NNA, 29. Fifty-seven percent of the 44 species were found in both areas, 9% only in the NNA, and 34% only in the SNA.

Total numbers of species in all strata by wetland indicator category are presented in Figure 5 for the combined NAs, the NNA, the SNA, the old ROW, and the new ROW. This figure shows that more species were present in the new ROW than in the old ROW. The number of OBL species in the new ROW (22) is comparable with the number found in the combined NAs (24). However, the percentage of OBL species (compared with total species) is much greater in the new ROW than in the NAs (Figure 6), because the total number of species found in the new ROW is lower than found in the NAs. Of the 44 species found in the NAs, 91% (40 species) were either OBL or FACW.

TABLE 3 Number of Plant Species by Wetland Indicator Category Found in the Study Plots in the NNA and SNA (by individual stratum and combined strata)

		Number of Species					
Stratum	Wetland Indicator Category	Occurring in NNA	Occurring in SNA	Common to Both Areas	Unique to NNA	Unique to SNA	Total
Herb	OBL	12	16	8	4	8	20
	FACW	8	12	8	0	4	12
	FAC	0	1	0	0	1	1
	FACU	0	1	0	0	1	1
	UPL	1	1	1	0	0	1
	Total	21	31	17	4	14	35
Shrub-sapling	OBL	5	4	4	1	0	5
	FACW	2	5	2	0	3	5
	FAC	2	2	2	0	0	2
	FACU	0	0	0	0	0	0
	UPL	0	0	0	0	0	0
	Total	9	11	8	1	3	12
Combined	OBL	16	20	12	4	8	24
	FACW	10	16	10	0	6	16
	FAC	2	2	2	0	0	2
	FACU	0	1	0	0	1	1
	UPL	1	1	1	0	0	1
	Total	29	40	25	4	15	44

Table 4 is a comparison of the numbers of species in each wetland indicator category and stratum for the NNA and for the adjacent old ROW. These two areas had 19 species in common, of which 16 were present in the herb stratum. The NNA had 10 species not found in the old ROW, 5 of which were only in the shrub stratum, a stratum not present in the ROW. The old ROW had 7 species not found in the NNA. Wetland fidelity of species is similar for the two areas, with 90% of the NNA species either OBL or FACW species and 92% of the old ROW species in these two categories (Figure 6). Each area had one UPL species.

Table 5 compares the number of species for the SNA and the adjacent new ROW. These two areas have 20 species in common, with an additional 20 unique to the SNA and 13 unique to the new ROW. Six of the species unique to the SNA were found only in the shrub stratum, a stratum not present in the ROW. The total number of species in the SNA was 40, while 33 species occurred in the new ROW. Ninety percent of the species in the SNA were OBL or FACW species, while 94% of the new ROW species fell in these two categories (Figure 6).

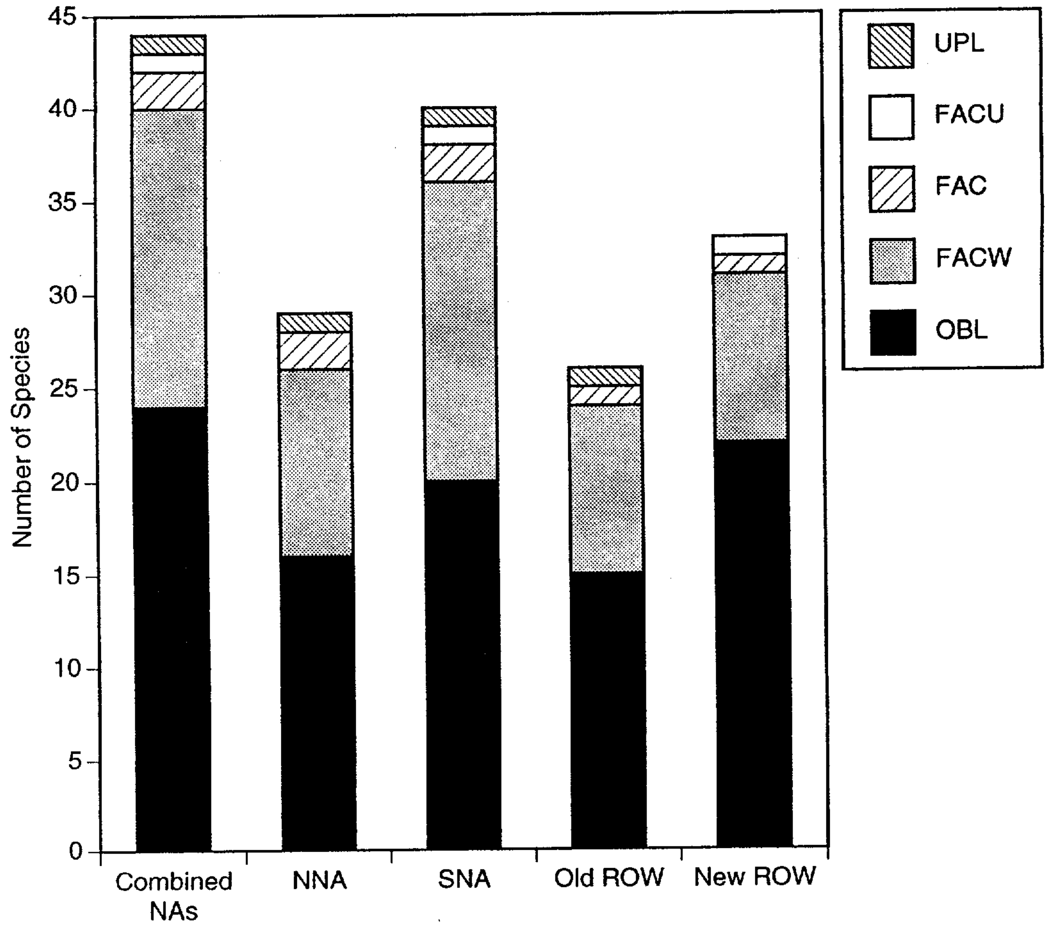

FIGURE 5 Number of Species in Each Wetland Indicator Category by Area

Dominance. The dominant species of each area were determined by vegetative strata (herbaceous and shrub) by a modification of the method described in the 1989 Federal Manual (FICWD 1989) as described in Section 3.4. Table 6 lists the dominant species found for each stratum in the study plots.

For the herb stratum, six species showed dominance in one or more of the study areas. The new ROW was dominated by rice cutgrass *(Leersia oryzoides)*, an OBL species. The old ROW contained four different dominant species. The two most dominant species were OBL; the other two were FACW. The SNA had two dominant species, while the NNA had four. When coverage data from the NAs were combined, four species were shown to be dominant. Three of these species, along with purple loosestrife, were dominant in the old ROW. All dominant species were either OBL or FACW.

A shrub-sapling stratum was present only in the NAs. Two species were dominant in the NNA, while two different species were dominant in the SNA. Combining coverage data for the

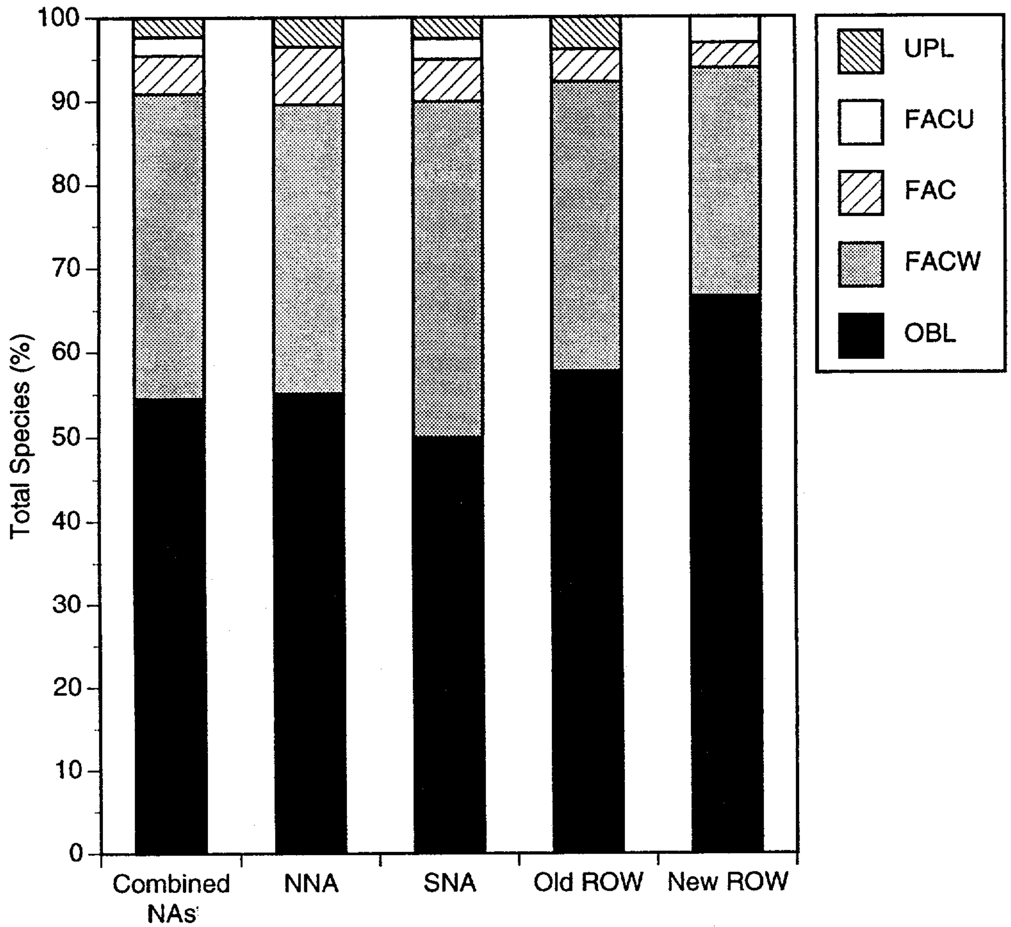

FIGURE 6 Percentage of Species in Each Wetland Indicator Category by Area

NAs yielded three dominant shrub species: the two that were dominant in the SNA and one of the dominant species in the NNA. All dominant species in the shrub-sapling stratum were OBL, with the exception of red maple, which is FAC.

Community Similarity Index. To provide a summary comparison of species found in each of the areas within the study site, we calculated a community similarity index, CC_S (see Section 3.4), on the basis of the species present in the plots within each area. Table 7 presents the results of these calculations. A value of 0.00 indicates no similarity and 1.00 indicates that the two communities are 100% identical in plant species composition. A comparison of the two NAs results in values of 0.65 for the herb stratum, 0.80 for the shrub-sapling stratum, and 0.72 for the combined strata. These relatively high values indicate that a majority of species occurring in the two NAs occurred in both. When the ROW is compared with the NAs, the values are lower: 0.62 for the herb stratum and 0.65 for the combined strata. Comparisons between the shrub-sapling strata of the NAs and the ROWs yield an index of 0.00 because there were no shrub-sapling size plants present on the ROW. The old ROW is much more similar to the NAs than is the new ROW; the CC_S value for the combined strata comparing the old ROW to the NAs is 0.60 and comparing

TABLE 4 Number of Plant Species by Wetland Indicator Category Found in the Study Plots in the NNA and the Old ROW (by individual stratum and combined strata)

		Number of Species					
Stratum	Wetland Indicator Category	Occurring in NNA	Occurring in Old ROW	Common to Both Areas	Unique to NNA	Unique to Old ROW	Total
Herb	OBL	12	15	7	5	8	20
	FACW	8	9	8	0	1	9
	FAC	0	1	0	0	1	1
	FACU	0	0	0	0	0	0
	UPL	1	1	1	0	0	1
	Total	21	26	16	5	10	31
Shrub-sapling	OBL	5	0	0	5	0	5
	FACW	2	0	0	2	0	2
	FAC	2	0	0	2	0	2
	FACU	0	0	0	0	0	0
	UPL	0	0	0	0	0	0
	Total	9	0	0	9	0	9
Combined	OBL	16	15	9	7	6	22
	FACW	10	9	8	2	1	11
	FAC	2	1	1	1	0	2
	FACU	0	0	0	0	0	0
	UPL	1	1	1	0	0	1
	Total	29	26	19	10	7	36

the new ROW to the NAs is 0.49. Comparing the old ROW with the new ROW and with the NAs indicates that the old ROW is slightly less similar to the new ROW, with a CC_S value of 0.58, than to the NAs, with a CC_S of 0.60.

Table 7 also compares each side of the ROW to its adjacent NA. The CC_S for combined strata comparing the NNA to the old ROW is higher than any other CC_S calculated except for that comparing the NNA to the SNA. The CC_S comparing the NNA to the old ROW is even higher than the CC_S comparing the old ROW to both NAs. However, the CC_S comparing the SNA to the new ROW is slightly lower than the CC_S comparing the old and new ROWs.

Prevalence Index Values and Average Wetland Values. Table 8 presents the results of calculations of PIV and AWV for the NAs, combined and individually, and for the old and new ROWs. Values less than 3.00 indicate wetland vegetation. All values in Table 8 are less than 2.00 except the values for shrubs in the SNA, which are 2.35 or less. For every area, the

TABLE 5 Number of Plant Species by Wetland Indicator Category Found in the Study Plots in the SNA and the New ROW (individual stratum and combined strata)

		Number of Species					
Stratum	Wetland Indicator Category	Occurring in SNA	Occurring in New ROW	Common to Both Areas	Unique to SNA	Unique to New ROW	Total
Herb	OBL	16	22	11	5	11	27
	FACW	12	9	5	7	4	16
	FAC	1	1	1	0	0	1
	FACU	1	1	0	1	1	2
	UPL	1	0	0	1	0	1
	Total	31	33	17	14	16	47
Shrub-Sapling	OBL	4	0	0	4	0	4
	FACW	5	0	0	5	0	5
	FAC	2	0	0	2	0	2
	FACU	0	0	0	0	0	0
	UPL	0	0	0	0	0	0
	Total	11	0	0	11	0	11
Combined	OBL	20	22	13	7	9	29
	FACW	16	9	6	10	3	19
	FAC	2	1	1	1	0	2
	FACU	1	1	0	1	1	2
	UPL	1	0	0	1	0	1
	Total	40	33	20	20	13	53

wetland indicator values for dominant species only in the herb stratum are less than the corresponding values for all species. This finding reflects the fact that all the dominant species are either OBL or FACW species.

The PIVs for the herb strata in the NNA and SNA are similar, whereas the PIVs for the shrub strata of these two areas are less similar. Corresponding PIVs are more similar when all species are considered than when dominants only are considered. The herb strata in the old and new ROWs are more different from each other than are the herb strata in the NAs. The lowest PIVs calculated are those for the new ROW, which had only an herb stratum present. These low values reflect both the greater number of OBL species and the greater dominance of OBL species in this area. PIVs could not be calculated for combined strata, because coverage data are used in the calculations and coverage values are not additive across strata.

AWVs were calculated for both individual and combined strata. Comparing the PIV and AWV for each stratum in each area (considering all species or only the dominant species) revealed

TABLE 6 Dominant Species by Vegetative Stratum for Each Area

Stratum	Area	Field No.	Scientific Name	Common Name	Wetland Indicator Category[a]	RPC	Sum of RPCs
Herb	NNA	20	*Polygonum arifolium*	Halberd-leaf tearthumb	OBL	17.2	
		24	*Peltandra virginica*	Arrow arum	OBL	14.4	
		18	*Impatiens capensis*	Spotted touch-me-not	FACW	12.4	
		44	*Lythrum salicaria*	Purple loosestrife (introduced)	FACW+	9.4	53.4
	SNA	1	*Decodon verticillatus*	Hairy swamp-loosestrife	OBL	35.8	
		24	*Peltandra virginica*	Arrow arum	OBL	18.1	53.9
	Combined NAs	1	*Decodon verticillatus*	Hairy swamp-loosestrife	OBL	20.7	
		24	*Peltandra virginica*	Arrow arum	OBL	16.1	
		20	*Polygonum arifolium*	Halberd-leaf tearthumb	OBL	12.2	
		18	*Impatiens capensis*	Spotted touch-me-not	FACW	7.1	56.1
	Old ROW	1	*Decodon verticillatus*	Hairy swamp-loosestrife	OBL	21.2	
		20	*Polygonum arifolium*	Halberd-leaf tearthumb	OBL	14.6	
		18	*Impatiens capensis*	Spotted touch-me-not	FACW	13	
		44	*Lythrum salicaria*	Purple loosestrife	FACW+	11.1	59.9
	New ROW	6	*Leersia oryzoides*	Rice cutgrass	OBL	74.7	74.7
Shrub-sapling	NNA	74	*Hibiscus moscheutos*	Swamp rosemallow	OBL	43.3	
		32	*Alnus serrulata*	Brook-side alder	OBL	14.6	57.9
	SNA	16	*Acer rubrum*	Red maple	FAC	34.0	
		10	*Cephalanthus occidentalis*	Common buttonbush	OBL	16.4	50.4
	Combined NAs	16	*Acer rubrum*	Red maple	FAC	25.8	
		10	*Cephalanthus occidentalis*	Common buttonbush	OBL	15.3	
		32	*Alnus serrulata*	Brook-side alder	OBL	13.3	54.4

[a] A "+" following a wetland indicator category indicates a frequency toward the high end of the category (more frequently found in a wetland).

TABLE 7 Coefficient of Community Values Comparing Similarity of Species Occurring in Study Plots

	CC_s for Given Comparison						
Stratum	Combined NAs to Combined ROWs	Combined NAs to Old ROW	Combined NAs to New ROW	Old ROW to New ROW	NNA to SNA	NNA to Old ROW	SNA to New ROW
Herb	0.62	0.62	0.47	0.58	0.65	0.69	0.53
Shrub-sapling[a]	0.00	0.00	0.00	NC	0.80	0.00	0.00
Combined	0.65	0.60	0.49	0.58	0.72	0.69	0.55

[a] No shrub-sapling stratum occurred on the ROW.

TABLE 8 Prevalence Index and Average Wetland Values for All Species and Dominant Species Found in the NAs and ROWs (by individual stratum and combined strata)

Stratum	Area	Species	Prevalence Index Value	Average Wetland Value
Herb	NAs combined	All	1.45	1.60
		Dominants only	1.13	1.25
	NNA	All	1.32	1.57
		Dominants only	1.47	1.50
	SNA	All	1.23	1.68
		Dominants only	1.00	1.00
	Old ROW	All	1.69	1.58
		Dominants only	1.40	1.60
	New ROW	All	1.03	1.42
		Dominants only	1.00	1.00
Shrub-sapling[a]	NAs combined	All	1.84	1.75
		Dominants only	1.95	1.67
	NNA	All	1.29	1.67
		Dominants only	1.00	1.00
	SNA	All	2.04	1.82
		Dominants only	2.35	2.00
Combined	NAs combined	All	NC[b]	1.63
	NNA	All	NC	1.62
	SNA	All	NC	1.68
	Old ROW	All	NC	1.58
	New ROW	All	NC	1.42

[a] No shrub-sapling stratum occurred on the ROW.

[b] NC = not calculated; PIVs could not be calculated for combined strata, because areal coverage is used in the calculation.

that corresponding values are similar. Two different schools of thought exist as to which wetland indicator, the weighted (by species coverage) PIV or the unweighted AWV, better represents the condition of the wetland. However, at Little Timber Creek crossing, the two methods give similar results. AWVs can be calculated for all strata combined, and these data are presented in Table 8. As with values for individual strata, the values for all strata combined show little difference between areas, with the new ROW yielding a slightly lower value than the other areas.

5 Discussion

The soil in the study area was a relatively homogeneous, saturated, peaty muck, extending to depths below those attainable by the 36-in. (0.9-m) hand auger used in the survey and reportedly below those excavated for the construction of the pipelines. Thus, the composition of the soil was little affected by the pipeline construction. However, the microtopography and hydrology of the ROW were altered by the creation of open ditches and raised peat beds. The ditch resulting from the construction of the 1960 pipeline was over 1 m deep and devoid of vegetation. This ditch was left open at the time of construction for irrigation purposes. The ditch and the raised peat bed that resulted from unequal settling after site closure following installation of the 1990 pipeline might have been avoided if settling and rebound factors had been taken into account during backfilling. Despite these changes in topography, the raised bed and ditches had no apparent effect on overall hydrology or vegetation in the NAs of the wetland. A greater effect on the hydrology of the site may have resulted from the construction of the interstate highway one-quarter mile north, which is alleged to have raised the water level in the study area.

No rare, threatened, endangered, or sensitive vegetational species were found on the site at the time of this survey. Four species not native to this region were identified, and three of these were found only infrequently. Two of these species, hairy crabgrass *(Digitaria sanguinalis)* and barnyard grass *(Echinochloa crusgalli)*, occurred only on the new ROW outside of the study plots. A third introduced species, greater duckweed *(Spirodela polyrhiza)*, was found occasionally in the NNA and the old ROW plots and also in the ditch on the new ROW, where it was only a minor component. The fourth introduced species, purple loosestrife *(Lythrum salicaria)*, was located in abundance in the NNA and the old ROW. This species is a common invader of disturbed wetlands. Possible factors that may have contributed to its spread here include the logging of the Atlantic white cedars, which both disturbed the habitat and increased the available light to the herb stratum; the lack of initial vegetation following the installation of the 1950 and 1960 pipelines; and the alleged raising of water levels with the building of the interstate to the north of the site as well as the creation of the ROW.

Prior to construction of the 1990 pipeline, the crossing had been delineated as a wetland. Data collected in this study on soils, hydrology, and vegetation indicate that the four areas (the two NAs and the two ROWs) remained wetlands after construction. All the dominant species were wetland species (Table 1). In fact, all but three of the species found in the study plots were wetland species. The PIVs and AWVs presented in Table 8 reflect the presence of the wetland species. Values for all areas were less than 2.5, below the value of 3.0 which is the maximum allowable value for hydric vegetation in delineation of a wetland. The low AWV and PIV for the new ROW indicate an abundance of OBL species. One possible explanation for the low AWV and PIV for the new ROW may be a lack of diversity (i.e., lack of hummocks) in this newly created habitat. The higher values associated with the old ROW and the combined NAs reflect the presence of compact dodder *(Cuscuta compacta)*, which was treated as an upland species according to the guidelines given in the 1989 Federal Manual that stipulate that all plants not listed in the national list of wetland plant species (Reed 1988) should be presumed to be obligate upland species (UPL) (see Appendix B). However, compact dodder is a parasitic species with little relationship to soil hydrology and does not fit the definition of a UPL species. Its occurrence is more likely related to the presence of suitable hosts than to site hydrology or microhabitat. The absence of compact dodder from the new ROW contributes to the low PIV and AWV for this area when all species are considered. At the time of the survey, the new ROW lacked robust forbs that might serve as hosts for the dodder. Thus, the differences in wetland indices between the old and new ROWs and the NAs may reflect differences associated with stages of plant succession rather than hydrological differences.

The NNA and SNA were considered in this study to represent the state of the local wetland area undisturbed by pipeline construction. Reconnaissance in these areas did not reveal differences in vegetation near the edges of the ROW compared to the areas further from the ROW, unless there were corresponding topographic differences. These two areas were considered both as one unit and as separate areas in making comparisons with the ROWs. Because of differences in the two NAs, the NNA was compared with the adjacent old ROW and the SNA with the adjacent new ROW. The pronounced and stable hummocks in the SNA provided more diversity of habitat, which may account for the differences between the two NAs in species diversity and dominance. While 25 of the 29 species found in the NNA were also in the SNA (see Table 3, combined strata), the SNA had 15 species not shared by the NNA. Comparing species dominance (Table 6) in the herb stratum, we see that the NNA had four dominant species, one of these being the introduced purple loosestrife, while the SNA had two dominant species, one of which, arrow arum *(Peltandra virginica)* was also dominant in the NNA. The abundance of the introduced species and the greater number of dominant species in the NNA may indicate greater disturbance due to the close proximity of the NNA to the newly constructed interstate highway. Despite this difference, all dominant herb species in one area were also present in the other, and all these species were either OBL or FACW. In the shrub-sapling stratum, swamp rosemallow *(Hibiscus moscheutos)* made up 43.3% of relative coverage in the NNA but was not present in the SNA. Red maple *(Acer rubrum)*, an FAC species that was the leading dominant species in the SNA with 34% relative coverage, was not present in the NNA. Despite these differences, comparison of the two areas by means of a coefficient of community (CC_S) (Table 7), which compares the number of species in common between the two communities to the total number of species in both communities, indicates that these two areas are relatively similar in species composition.

Because the old and new ROWs lay between these two NAs but are not equidistant from each, comparisons were made between species composition for the ROWs combined and for the NAs combined, as well as between each portion of the ROW and its adjacent NA. As a comparison of the overall ROW community with the overall NA wetland community, the combined species data from the old and new ROWs were also compared with combined data from the two NAs in terms of species richness in each area (Table 1) and community similarity (Table 7). The ROWs had a greater number of species in the herb stratum than did the NAs; however, when species from the shrub-sapling stratum were included in the NA data, the number of species in each area was similar. Three species that occurred only in the shrub stratum in the NAs occurred in the herb stratum in the ROWs. If these total numbers are compared with the number of species shared by both areas, the CC_S of 0.65 is only a little lower that the similarity index comparing the two NAs.

The time lapsed since pipeline construction was significantly different for the two portions of the ROW: 31 years for the old ROW compared with 1 year for the new ROW. These two ROWs were compared separately with the combined NAs, separately with their adjacent NAs, and with each other. In terms of total numbers of plant species present, the old ROW was less similar than the new ROW to the NAs (Figure 5). However, the old ROW was closer to the NNA in both number of plants present and community similarity index ($CC_S = 0.69$) than the new ROW was to the SNA ($CC_S = 0.55$). Individual ROWs might be expected to be more similar to their adjacent NAs than to nonadjacent NAs. However, the NAs were more similar to each other than either NA was to either the new or old ROW. This finding was not only true for the herb strata, but also, to a greater degree, when shrubs were included. The old ROW was only slightly less similar to the NNA than the two NAs were to each other.

The high similarity value resulting from a comparison of the old ROW and its adjacent NA and the low similarity index resulting from a comparison of the new ROW and its adjacent NA likely reflect the greater time the old ROW has had to recover from the pipeline construction disturbance. The number of species that developed on the new ROW within one year may result from general lack of competition at the early stage of succession. With the favorable recovery, given time, the new ROW will most likely increase in similarity to the old ROW and to the NAs.

It is significant that within one year following disturbance, the new ROW had a relatively stable stand of naturally developing vegetation consisting entirely of native species, of which 94% were wetland species. A contributing factor to the rapid revegetation was that construction of the 1990 pipeline was completed in late July, allowing time for the vegetation to regenerate before the end of the growing season. Thus, at the time the field survey was conducted, the new ROW was in its second season of growth. This rapid unassisted recovery supports the idea of allowing such disturbed sites to recover naturally without using seed and fertilizer. It may indicate the importance of the time (with respect to the growing season) when construction is completed. The highly organic soil also may have contributed to the rapid plant recovery.

The greater number of species found on the new ROW compared with the old ROW may have resulted from several factors: an environment with little initial competition due to the relatively complete disturbance on the new ROW; the accessibility of the cleared ROW to species from adjacent NAs, the old ROW, and other local seed sources; and the environment of the raised peat bed being ideal for germination of wetland species. With time, competition may eliminate some species, and the new ROW's plant community may begin to resemble that of the old ROW.

The abundance of rice cutgrass *(Leersia orizoides)* on the new ROW, compared with the old ROW and NAs, seems to be an indication of an especially opportunistic species. The initial abundance of rice cutgrass on the new ROW may have resulted partially from the point in time during the growing season when final grading of the ROW was completed. Frequently, the point in time during the growing season at which the last disturbance occurs affects the composition of the initial vegetation. The buoyancy of the seeds available may also have helped to determine which plants formed the pioneer stage of succession. Even though rice cutgrass achieved 100% coverage, it did not prevent the establishment of other species.

With time, species of larger plants, such as the hairy swamp-loosestrife *(Decodon verticillatus)*, halberd-leaf tearthumb *(Polygonum arifolium)*, spotted touch-me-not *(Impatiens capensis)*, and purple loosestrife, which are abundant on the old ROW, may increase and reduce the abundance of rice cutgrass. Two of these species, the hairy swamp-loosestrife and the purple loosestrife, are perennials that spread vigorously. The hairy swamp-loosestrife forms extensive, spongy corky tissue below water and at the tips of arching stems where they contact water and thus may function to help maintain the floating mat.

The wetland indicator values for the shrub-sapling stratum in the SNA being higher than those for any other stratum correlates with general observations indicating that the SNA is the most mesic of the four studied at this site. Also, the SNA had hummocks that were well above water level, providing well-drained microsites. The extremely low wetland indicator values for the adjacent new ROW relate to the absence of hummocks and the conditions following final grading, the initial period of seed germination, and seedling establishment.

6 Summary and Conclusions

6.1 Summary

The primary goal of the GRI Wetland Corridors Program is to identify and evaluate the impacts of pipeline construction and ROW maintenance on the wetlands they traverse. To accomplish this goal, pipelines crossing various wetlands throughout the eastern United States were surveyed. The objectives for each study site were to document the vegetative communities on the ROW and on adjacent NAs that had not been disturbed by pipeline construction; to evaluate the similarities and differences between the plant communities on the ROW and those in the NAs; to document changes to the topography, soils, and hydrology attributable to ROW construction; and to identify impacts caused by ROW construction on rare, threatened, endangered, or sensitive species.

This study involved collecting and analyzing data at the Little Timber Creek crossing in Gloucester County, New Jersey. At this site, no rare, threatened, endangered, or sensitive species were found during the survey. Some minor disturbances to the local topography and hydrology due to construction were noted. These disturbances included open-water ditches above the 1950 and 1960 pipelines and raised peat beds on the ROWs between pipelines. Both ditches are still present and devoid of emergent vegetation, although the new ditch, which is only 0.15-0.61 m deep, may develop a vegetative growth with time. The old ditch, 1-2 m deep, was left in place after pipeline construction for irrigation purposes. These changes did not appear to have effects beyond the ROW edges. The ditches could be beneficial in that they provide access to water for irrigation and open an area for usage by waterfowl.

Results of the vegetational survey indicate that the study site remains a wetland. Ninety-five percent of all species in the surveyed plots in the NAs and the ROW were wetland species. Four introduced species were present within the study site. One species, purple loosestrife *(Lythrum salicaria)*, was found in abundance only in the NNA and the old ROW. Its presence may have been augmented by the presence of the ROW, but other disturbances, such as the logging of the original cedar forest and the building of a new interstate highway immediately downstream, may also have contributed to the presence of this species. The combined NAs and the combined ROWs were similar in species numbers and were shown to be similar by the community similarity index. The old ROW, which had 31 years since construction to recover, was much more similar to the NAs than was the new ROW. Three of the four dominant species of the NAs were also dominant in the old ROW, and the similarity index was high, indicating close similarity between these two areas. The vegetation on the new ROW had only one year to develop the high diversity of species that was found. The absence of nonvegetated surface indicated that this area was recovering rapidly despite the lack of seeding or fertilization after construction. The time of year when construction was completed for this new ROW, as well as the highly organic soil and available seed sources, may have contributed to the quick rebound. It can be speculated that, with time, the new ROW will become similar to the old. If left undisturbed, both portions of the ROW will likely undergo succession toward the natural state, with shrubs and trees. Low-level maintenance, however, is necessary to keep open access to the pipelines for repairs and maintenance.

6.2 Conclusions

Impacts on the Little Timber Creek wetland due to the construction of gas pipelines and ROW maintenance appear to be limited to the ROW and its immediate edges. Two open-water ditches were created as a result of the 1960 and 1990 construction activities. Two raised peat beds associated with the two ditches remain on the ROW. The new ditch and raised peat bed from the 1990 construction resulted from settling and rebound of peat in these areas after backfilling. Difficulty had been encountered in working with the unconsolidated peat because of the liquid nature of the peat. Although the site had been left at grade immediately after backfilling, not all the peat in the spoil pile had been backfilled into the ditch; with time, the peat in the ditch had settled and the peat on the pile had rebounded. Different construction practices, such as the use of geotextile to contain the spoil and to indicate true grade or the anticipation of rebound and settling by "overfilling" the pipeline excavation when backfilling, may help to avoid the development of these grade differences over time. Despite the presence of these grade changes, no apparent effects on vegetation or hydrology were noted beyond the ROW edges.

One possible detrimental effect of pipeline-related activities within the site is the spread of purple loosestrife. Although purple loosestrife is most abundant on the old ROW and in the adjacent NNA, its origin is undetermined. Purple loosestrife is a common aggressive invader of wetlands. It may have entered this site as a result of pipeline-associated disturbance, but it also may have invaded as a result of such other disturbances as the construction of the nearby interstate highway, the logging of white cedar, or some other unidentified reason.

The fragmentation of the natural habitat by the presence of the ROW can have both beneficial and detrimental impacts. While fragmentation is detrimental to species requiring large contiguous habitats or species lacking mobility to cross this narrow strip of modified habitat, fragmentation is beneficial in that it creates edges and habitat diversity, thereby creating habitat for species requiring the resources of both herbaceous and woody plant communities. At this site, the open-water ditches on the ROW contained frogs and provided habitat and food for waterfowl. Another beneficial aspect of the presence of the ROW at this site was an increase in species richness, an aspect of diversity. A total of 14 species were encountered on the ROW that were not in the NAs of the site, increasing the total number of species in the study area by 24%.

These detrimental and beneficial effects of the ROW on this wetland community are suggested on the basis of observations within the study site and of general ecological knowledge regarding habitat modification. The determination of the importance of these effects at this site requires a more extensive investigation of plant and animal communities throughout this wetland.

The rapid development of vegetative cover on the new ROW and the high degree of species richness in this cover support the decision not to seed this habitat, in particular, not to seed it with nonnative species. This rapid revegetation may also indicate the importance of the timing for completion of construction. In this case, construction was completed in late July, early enough in the growing season for native vegetation to germinate and become established before the winter.

Current maintenance activities consist of mowing every three to five years (in winter months while the wetland is frozen), which allows a more or less stable community of robust native herbaceous species to exist on the old ROW. It is anticipated that the new ROW will develop a community similar to that on the old ROW with time. If mowing were to be discontinued, it is anticipated that the ROW would eventually become more similar to the adjacent NAs.

7 References

Bonham, C.P., 1989, *Measurements for Terrestrial Vegetation,* John Wiley and Sons, New York, N.Y.

Brower, J., J. Zar, and C. von Ende, 1990, *Field and Laboratory Methods for General Ecology, Third Edition,* Wm. C. Brown Publishers, Dubuque, Iowa.

Buchanan, S.A., and M.D. Zagata, 1991, *Wetland Construction through Tamarack Swamp and Little Timber Creek: Impacts Avoided and Lessons Learned,* unpublished report for Transcontinental Gas Pipe Line Corp., Houston, Texas.

Cowardin, L.M., et al., 1979, *Classification of Wetlands and Deep Water Habitats of the United States,* U.S. Fish and Wildlife Service, U.S. Geological Survey, and U.S. National Oceanic and Atmospheric Administration, Washington, D.C.

Federal Interagency Committee for Wetland Delineation, 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands,* U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture, Cooperative Technical Publication, Washington, D.C.

FICWD: see Federal Interagency Committee for Wetland Delineation.

Reed, P.B., Jr., 1988, *National List of Plant Species that Occur in Wetlands, Region 1,* U.S. Department of the Interior, Biology Report 88 (26.1), Washington, D.C.

SCS: see Soil Conservation Service.

Soil Conservation Service, 1991, *Hydric Soils of the United States,* U.S. Department of Agriculture, in cooperation with the National Technical Committee for Hydric Soils, Washington, D.C.

Soil Conservation Service, 1962, *Soil Survey: Gloucester County, New Jersey,* U.S. Department of Agriculture, Washington, D.C.

Zimmerman, R.E., et al., 1991, *Pipeline Corridors through Wetlands — Impacts on Plant and Avian Diversity: Boreal Wetlands, Oconto County, Wisconsin,* GRI-91/0046, prepared by Argonne National Laboratory, Argonne, Ill., for the Gas Research Institute, Chicago, Ill.

Appendix A:

Definition of Jurisdictional Wetlands

Appendix A: Definition of Jurisdictional Wetlands

Wetland identification and delineation necessary to implement Section 404 of the Clean Water Act and the "Swampbuster" (Subtitle B) provision of the Food Security Act of 1985 involves four agencies: the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the Soil Conservation Service (SCS). On January 10, 1989, these agencies, which had operated with slightly different definitions of wetland, adopted a uniform definition based on hydrology, vegetation, and soils.

The joint agreement stipulates that to be classified as a Jurisdictional Wetland, an area must have hydrotrophytic vegetation, hydric soils, and a wetland hydrology. All three criteria are mandatory; without any one criterion, the area is not a Jurisdictional Wetland. A schematic diagram of this delineation process is shown in Figure A.1. See the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* for a more detailed discussion of the various terms and criteria (FICWD 1989).

Problems uncovered during field trials of the 1989 Federal Manual and disagreement among the four agencies on revisions in 1991 resulted in the EPA and the COE reverting to use of the 1987 *COE Wetlands Delineation Manual*, which also defines wetlands on the basis of vegetation, hydric soils, and hydrology, but with slightly different definitions of these parameters. In January 1994, the four agencies entered into a joint Memorandum of Agreement, "Concerning the Delineation of Wetlands for Purposes of Section 404 of the Clean Water Act and Subtitle B of the Food Security Act," which, in broad terms, stipulates that the EPA and the COE will accept SCS procedures for delineating wetlands (SCS 1988) on agricultural lands and that SCS will use the 1987 *COE Wetlands Delineation Manual* (COE 1987) for areas that are not agricultural lands.

The individual reports on the pipeline crossings through wetlands that are part of the GRI Wetland Corridors Program use the definition and criteria of the 1989 Federal Manual that were in effect during 1990 and 1991, the first two years of these studies. The use of the rigorous criteria of the 1989 manual should provide sufficient information for application to other procedures in the evolving field regulatory procedures for delineation and preservation of jurisdictional wetlands.

References

COE: see U.S. Army Corps of Engineers.

Federal Interagency Committee for Wetland Delineation, 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands,* U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture, Cooperative Technical Publication, Washington, D.C.

FICWD: see Federal Interagency Committee for Wetland Delineation.

SCS: see Soil Conservation Service.

Soil Conservation Service, 1988, *National Food Security Act Manual*, U.S. Department of Agriculture, Washington, D.C.

U.S. Army Corps of Engineers, 1987, *Corps of Engineers Wetlands Delineation Manual*, Technical Report Y-87-1, Waterways Experiment Station, Vicksburg, Miss.

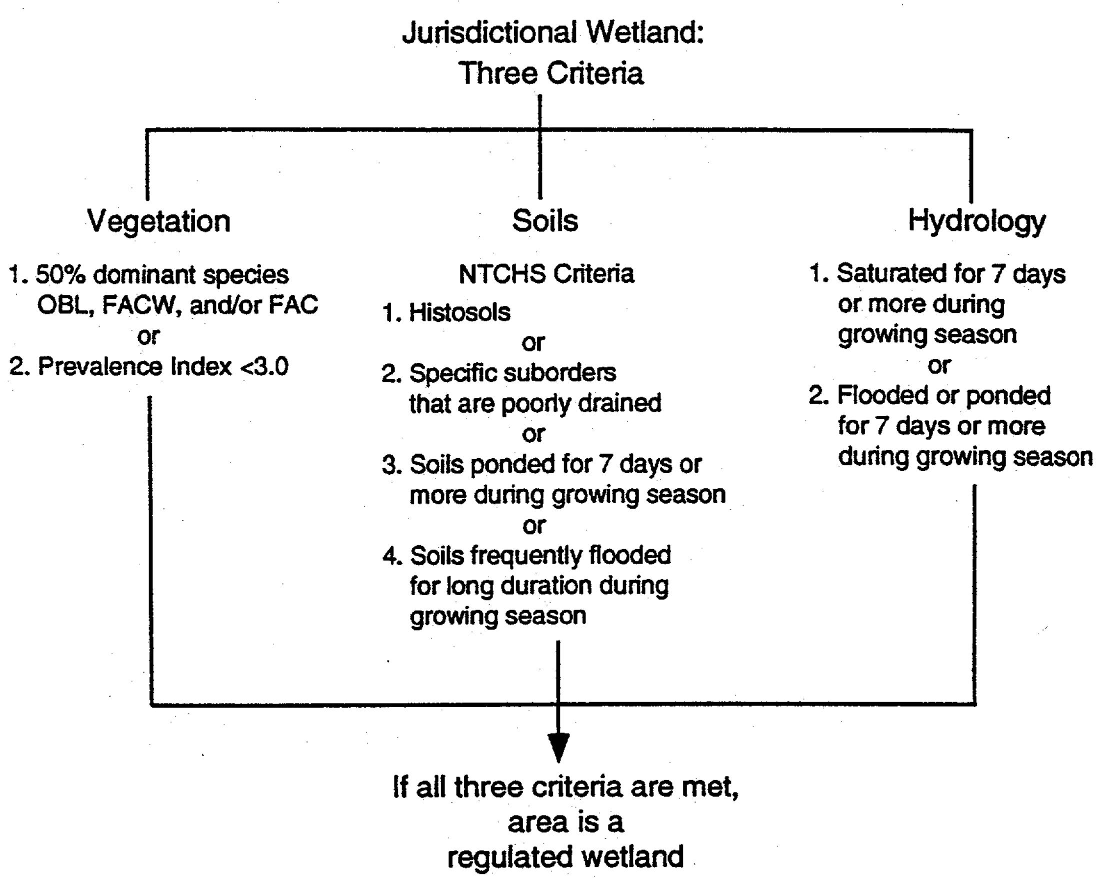

FIGURE A.1 Schematic Diagram of the Wetland Delineation Process (Source: FICWD 1989)

Appendix B:

Data Analysis — Definitions and Equations

Appendix B: Data Analysis — Definitions and Equations

B.1 Wetland Indicator Categories

Wetland indicator categories used in this report to classify the types of plant species were taken from Reed (1988). The five basic categories, commonly called the "wetland indicator status," are based on frequency of occurrence in wetlands. They are defined as follows:

Category	Value	Definition
Obligate wetland (OBL)	1.0	Plants that almost always occur in wetlands under natural conditions (estimated probability >99%)
Facultative wetland (FACW)	2.0	Plants that usually occur in wetlands (estimated probability 67-99%) but occasionally are found in nonwetlands
Facultative (FAC)	3.0	Plants that are equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%)
Facultative upland (FACU)	4.0	Plants that usually occur in nonwetlands (estimated probability 67-99%) but occasionally are found in wetlands (estimated probability 1-33%)
Obligate upland (UPL)	5.0	Plants that almost always occur in nonwetlands under natural conditions (estimated probability >99%)

B.2 Life-Form and Origin

The life-form and origin symbols are used for describing plant characteristics. The following symbols are used:

Symbol	Life-Form or Origin
A	Annual
B	Biennial
E	Emergent
F	Forb
F3	Fern
G	Grass
GL	Grasslike
H2	Horsetail
I	Introduced
N	Native
P	Perennial
S	Shrub
T	Tree
V	Herbaceous vine
WV	Woody vine

Symbols are combined to describe the life-form and origin; for example, ANG means annual native grass and PIEF means perennial introduced emergent forb. For further description refer to the report by Reed (1988).

B.3 Prevalence Index Value

The prevalence index value (PIV) was determined by using the method outlined in the 1989 Federal Manual (FICWD 1989). The PIV, modified for this report to use relative percent areal coverage instead of relative frequencies as described in the 1989 Federal Manual, is defined as

$$PIV = \frac{RPC_o + 2RPC_{fw} + 3RPC_f + 4RPC_{fu} + 5RPC_u}{100} \qquad (B.1)$$

where

RPC_o = Relative percent coverage (RPC) of obligate wetland species,

RPC_{fw} = RPC of facultative wetland species,

RPC_f = RPC of facultative species,

RPC_{fu} = RPC of facultative upland species, and

RPC_u = RPC of upland species.

B.4 Average Wetland Value

The average wetland value (AWV), defined in Zimmerman et al. (1991), differs from the PIV in that it is not coverage data or frequency of occurrence that is used in determining the AWV, but rather the total number of species present. Thus, all species present are represented equally in the AWV. The AWV is defined as

$$AWV = \frac{N_o + 2N_{fw} + 3N_f + 4N_{fu} + 5N_u}{N_o + N_{fw} + N_f + N_{fu} + N_u} \tag{B.2}$$

where

N_o = number of obligate wetland species,

N_{fw} = number of facultative wetland species,

N_f = number of facultative species,

N_{fu} = number of facultative upland species, and

N_u = number of upland species.

B.5 References

Federal Interagency Committee for Wetland Delineation, 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands,* U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture, Cooperative Technical Publication, Washington, D.C.

FICWD: see Federal Interagency Committee for Wetland Delineation.

Reed, P.B., Jr., 1988, *National List of Plant Species that Occur in Wetlands, Region 1,* U.S. Department of the Interior, Biology Report 88 (26.1).

Zimmerman, R.E., et al., 1991, *Pipeline Corridors through Wetlands — Impacts on Plant and Avian Diversity: Boreal Wetlands, Oconto County, Wisconsin,* GRI-91/0046, prepared by Argonne National Laboratory, Argonne, Ill., for the Gas Research Institute, Chicago, Ill.

Appendix C:

Plant Species List, Areal Coverage Data, and Species Distribution

Appendix C: Plant Species List, Areal Coverage Data, and Species Distribution

TABLE C.1 Plant Species List for Little Timber Creek Crossing

Field No.	Scientific Name and Authority	Common Name	Region 1 Wetland Indicator Category[a]	Life-Form/ Origin[b]
16	*Acer rubrum* L.	Red maple	FAC	NT
55	*Alisma plantago-aquatica* L.	Broad-leaf water-plantain	OBL	PNEF
32	*Alnus serrulata* (Ait.)Willd.	Brook-side alder	OBL	NT
72	*Ambrosia artemisiifolia* L.	Annual ragweed	FACU	ANF
27	*Apios americana* Medic.	American potato-bean	FACW	PNF
41	*Asclepias incarnata* L.	Swamp milkweed	OBL	PNF
54	*Bidens frondosa* L.	Devil's beggar-ticks	FACW	ANF
25	*Boehmeria cylindrica* (L.)Swartz	Small-spike false-nettle	FACW+	PNF
33	*Carex alantica* Bialey	Prickly bob sedge	FACW+	PNEGL
61	*Carex canescens* L. var. disjuncta Fern.	Hoary sedge	OBL	PNEGL
28	*Carex howei* Mackenz.(2)	Howe sedge	OBL	PNGL
62	*Carex lurida* Wahlenb.	Shallow sedge	OBL	PNEGL
50	*Carex tribuloides* Wahlenb.	Blunt broom sedge	FACW+	PNGL
10	*Cephalanthus occidentalis* L.	Common buttonbush	OBL	NT
76	*Cinna arundinaceae* l.	Stout wood-reedgrass	FACW+	PNG
31	*Clethra alnifolia* L.	Coast pepper-bush	FAC+	NS
9	*Cuscuta compacta* Juss.	Compact dodder	UPL	+ANF
4	*Cyperus erythrorhizos* Muhl	Red-root flatsedge	FACW+	APNEGL
1	*Decodon verticillatus* (L.) Elliot	Hairy swamp-loostrife	OBL	PNF
22	*Digitaria sanguinalis* (L.)Scop.	Hairy crabgrass	FACU-	AIG
80	*Dioscorea villosa* L.	Yellow yam	FAC+	PNV
56	*Echinochloa crusgalli* (L.)Beauv.	Barnyard grass	FACU	AIG
47	*Echinochloa walterii* (Pursh) Heller	Coast cockspur	FACW+	ANEG
17	*Eleocharis obtusa* (Willd.)J.A. Schultes	Blunt spikerush	OBL	APNEGL
26	*Erechities hieracifolia* (L.)Raf.	American burn	FACU	ANF
57	*Eupatorium leucolepsis* (DC) Torry & Gray.	White-bract thorough-wort	FACW+	PNF
53	*Eupatorium serotinum* Michx.	Late-flw thorough-wort	FAC-	PNF
63	*Fraxinus pennsylvanica* Marshall	Green ash	FACW	NT
11	*Galium tinctorum* L.	Stiff marsh bedstraw	OBL	PNF
43	*Glyceria obtusa* (Muhl.)Trin.	Atlantic manna grass	OBL	PNG
74	*Hibiscus moscheutos* L.	Swamp rosemallow	OBL	PNEF
51	*Ilex verticillata* (L.)Gray	Common winterberry	FACW+	NST
18	*Impatiens capensis* Meerb.	Spotted touch-me-not	FACW	ANF
71	*Iris versicolor* L.	Blueflag	OBL	PNF
3	*Juncus acuminatus* Michx.	Taper-tip rush	OBL	PNEGL
5	*Juncus canadensis* J. Gay	Canada rush	OBL	PNGL
48	*Juncus effusus* L.	Soft rush	FACW+	PNEGL
6	*Leersia oryzoides* (L.)Swartz	Rice cutgrass	OBL	PNG
59	*Lemna minor* L.**	Lesser duckweed	OBL	PN/F
35	*Leucothoe racemosa* (L.) Gray	Fetter-bush	FACW	NS
29	*Lobelia cardinalis* L.	Cardinal flower	FACW+	PNF

TABLE C.1 (Cont.)

Field No.	Scientific Name and Authority	Common Name	Region 1 Wetland Indicator Category[a]	Life-Form/ Origin[b]
15	*Ludwegia palustris* (L.)Elliott	Marsh seedbox	OBL	PNEF
37	*Lycopus uniflorus* Mixhx.	Northern bugleweed	OBL	PNF
19	*Lycopus virginicus* L.	Virginia bugleweed	OBL	PNF
44	*Lythrum salicaria* L.	Purple loosestrife	FACW+	PIF
75	*Myosotis laxa* Lehm.	Bay forget-me-not	OBL	PNF
38	*Nuphar lutea* (L.) Sibth & Smith	Yellow cow-lily	OBL	PNZ/F
52	*Onoclea sensibilis* L.	Sensitive fern	FACW	PNEF3
13	*Osmunda cinnamonea* L.	Cinnamon fern	FACW	PNEF3
12	*Osmunda regalis* L.	Royal fern	OBL	PNF3
24	*Peltandra virginica* (L.)Kunth	Arrow arum	ONL	PNEF
49	*Penthorum sedoides* L.	Ditch-stonecrop	OBL	PNF
65	*Pilea pumila* (L.)Gray	Canada clearweed	FACW	ANF
20	*Polygonum arifolium* L.	Halberd-leaf tearthumb	OBL	ANEF
21	*Polygonum sagittatum* L.	Arrow-leaf tearthumb	OBL	APNF
8	*Polygonum setaceum* Baldw	Swamp smartweed	OBL	PNEF
67	*Quercus* sp. seedling			
40	*Rhododendron viscosum* (L.) Torr.	Swamp azalea	OBL	NS
46	*Rorripa palustris* (L.)Besser	Bog yellow-cress	OBL	ANEF
30	*Rosa palustris* Marshall	Swamp rose	OBL	NS
70	*Rubus* sp.(cf enslenii) Tratt	Enslen's dewberry	FACU	NS
64	*Salix niger* Marshall	Black willow	FACW+	NT
2	*Scirpus cyperinus* (L.)Kunth	Wool-grass	FACW+	PNEGL
7	*Scutellaria lateriflora* L.	Blue skullcap	FACW+	PNF
14	*Sparganium americanum* Nutt.	American burreed	OBL	PNEF
68	*Sphagnum affine* Ren. & Card	Sphagnum moss		
83	*Sphagnum fimbriatum* Wils.	Sphagnum moss		
36	*Sphagnum lescurii* Sull.	Sphagnum moss		
60	*Spirodela polyrhiza* (L.)Schleid.	Greater duckweed	OBL	PI/F
77	*Symplocarpus foetidus* (L.)Salisb.	Skunk-cabbage	OBL	PNF
34	*Thelypteris thelyptroides* (Michx.)J.Holub	Marsh fern	FACW+	F3
58	*Triadenum virginicum* (L.)Raf.	Marsh St. John's-wort	OBL	PNEF
45	*Typha latifolia* L.	Broad-leaf cattail	OBL	PNEF
66	*Vaccinium corymbosum* L.	Highbush blueberry	FACW-	NS
79	*Viburnum nudum* L.	Possum-haw viburnum	OBL	NTS
78	*Viburnum recognitum* Fernald	Northern arrow-wood	FACW-	NS
0	*Vitis riparia* Michx.	River-bank grape	FACW	NWV
73	*Wolfia* sp.	Water-meal	OBL	PN/F
69	*Woodwardia virginica* (L.) J. E. Smith	Virginia chainfern	OBL	PNF3

[a] Wetland indicator categories are assigned to plants in the United States on a regional basis. New Jersey is located in Region 1. A "+" following an indicator category indicates a frequency toward the high end of the category (more frequently found in wetlands), while a "-" indicates a frequency toward the low end (less frequently found in wetlands).

[b] See Appendix B for definitions of life-forms and origins.

TABLE C.2 Coverage Estimates by Stratum for Each Plot

Field No.	Species	Areal Coverage (%)																			
		NNA					Old ROW Area					New ROW Area					SNA				
		T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
	Standing surface water	2	30	80	80	25	10	10	5	40	40	-	-	-	-	-	10	20	15	0	0
	Exposed much/peat surface	10	30	5	5	30	30	50	50	40	40	-	-	-	-	-	10	25	50	60	70
	Bryophte stratum																				
	All mosses[a]	5	0.5	0.5	0.5	0.5	10	2	10	10	0.5	-	-	-	-	-	2	2	1	10	15
68	*Sphagnum affine*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-
36	*Sphagnum lescurii*	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	2	0.5	-	-	7
	Herb stratum																				
16	*Acer rubrum*	-	-	-	-	-	3	-	-	-	-	1	0.5	0.5	0.5	0.5	2	0.5	0.5	0.5	0.5
32	*Alnus serrulata*	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
27	*Apios americana*	20	10	4	10	5	0.5	10	10	2	-	0.5	-	-	-	-	10	0.5	1	10	7
54	*Bidens frondosa*	-	3	1	1	0.5	3	0.5	0.5	2	0.5	-	-	-	-	-	-	-	-	2	1
25	*Boehmeria cylindrica*	10	3	3	5	5	20	40	10	7	2	0.5	-	0.5	0.5	0.5	30	20	10	20	5
61	*Carex canescens*	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
28	*Carex howei*[b]	-	-	-	-	-	35	-	-	-	-	5	1	1	-	0.5	56	0.5	-	0.5	-
62	*Carex lurida*	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	2	-	-	-
50	*Carex tribuloides*	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
10	*Cephalanthus occidentalis*	-	-	-	-	-	-	-	-	-	-	0.5	0.5	-	1	-	-	-	-	-	-
76	*Cinna arundinacea*	-	-	-	-	-	-	-	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-
9	*Cuscuta compacta*	5	20	1	5	5	30	5	8	20	30	-	-	-	-	-	15	10	2	5	-
4	*Cyperus erythrorhizos*	-	-	-	-	-	-	-	-	-	-	5	2	-	-	0.5	-	-	-	-	-
1	*Decodon verticillatus*	20	15	20	3	10	60	20	60	60	30	20	3	1	10	20	70	60	80	55	2
17	*Eleocharis obtusa*	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-
26	*Erechtities hieraclifolia*	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
11	*Galium tinctorium*	0.5	0.5	2	0.5	0.5	0.5	5	0.5	0.5	0.5	-	-	0.5	-	-	1	0.5	4	0.5	-
43	*Glyceria obtusa*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
74	*Hybiscus moscheutos*	2	40	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	*Ilex verticillata*	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-

TABLE C.2 (Cont.)

Field No.	Species	Areal Coverage (%)																			
		NNA					Old ROW Area					New ROW Area					SNA				
		T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
18	*Impatiens capensis*	50	3	5	10	40	1	50	30	50	10	0.5	-	-	0.5	1	-	0.5	3	0.5	3
71	*Iris versicolor*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
48	*Juncus effusus*	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
6	*Leersia oryzoides*	15	40	2	1	10	10	5	5	15	20	100	100	100	100	100	-	0.5	0.5	2	0.5
59	*Lemna minor*[c]	0.5	0.5	30	0.5	2	0.5	0.5	0.5	0.5	5	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5
29	*Lobelia cardinalis*	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	0.5	0.5	-	-	-
15	*Ludwegia palustris*	-	-	-	-	-	-	-	-	-	-	0.5	5	0.5	1	-	-	-	-	-	-
37	*Lycopus uniflorus*	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	1	-	-	-	-
19	*Lycopus virginicus*	-	-	-	0.5	-	-	-	-	-	-	1	0.5	0.5	-	-	-	0.5	-	-	-
44	*Lythrum salicaria*	2	5	5	40	30	-	40	20	20	40	-	0.5	2	0.5	1	-	-	8	10	-
75	*Myosotis laxa*	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	*Nuphar luteam*	-	-	-	-	-	5	3	-	-	-	-	0.5	-	-	-	-	-	-	-	-
52	*Onoclea sensibilis*	3	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	2	3	-	2
12	*Osmunda regalis*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	15
24	*Peltandra virginica*	10	25	15	45	30	10	2	10	15	25	0.5	-	0.5	0.5	2	15	35	20	35	30
49	*Penthorum sedoides*	-	-	-	-	-	-	-	-	-	-	0.5	0.5	-	-	-	-	-	-	-	-
65	*Pilea pumila*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	3	0.5
20	*Polygonum arifolium*	80	-	-	-	70	40	40	3	60	15	-	0.5	-	-	-	-	-	25	20	2
21	*Polygonum sagittatum*	-	-	-	-	-	-	-	-	-	-	-	0.5	2	-	-	-	1	-	1	-
8	*Polygonum setaceum*	-	-	-	-	-	-	5	-	-	-	3	0.5	0.5	3	3	-	-	-	-	-
46	*Rorripa palustris*	-	-	-	-	-	-	-	-	-	-	-	0.5	1	-	-	-	-	-	-	-
30	*Rosa palustris*	-	-	-	-	-	5	-	-	3	-	-	0.5	-	-	-	-	-	-	-	-
70	*Rubus* sp.(cf enslenii)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
2	*Scirpus cyperinus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
7	*Scutellaria lateriflora*	-	0.5	-	-	0.5	0.5	1	1	0.5	-	-	-	-	-	-	0.5	0.5	2	-	-
14	*Sparganium americana*	-	-	-	-	-	2	-	-	-	-	2	5	4	8	5	-	-	-	-	-
60	*Spirodela polyrhiza*	-	0.5	2	3	0.5	-	-	0.5	0.5	1	-	-	-	-	-	-	-	-	-	-
34	*Thelypteris thelyptroides*	0.5	-	-	-	1	15	10	-	-	-	-	-	-	-	-	-	-	3	2	-
58	*Triadenum virginicum*	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-

TABLE C.2 (Cont.)

Field No.	Species	Areal Coverage (%)																			
		NNA					Old ROW Area					New ROW Area					SNA				
		T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
45	*Typha latifolia*	-	-	-	-	-	-	-	-	-	3	-	10	15	1	2	-	-	-	0.5	-
66	*Vaccinium corymbosum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5
73	*Wolffia* sp.	0.5	0.5	30	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	*Woodwardia virginica*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Shrub Stratum[d]																					
16	*Acer rubrum*	2	0.5	1	0.5	0.5	-	-	-	-	-	-	-	-	-	-	2	10	12	30	60
32	*Alnus serrulata*	10	5	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	8	20	15
10	*Cephalanthus occidentalis*	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	2	1	10	30
31	*Clethra alnifolia*	5	0.5	-	-	3	-	-	-	-	-	-	-	-	-	-	10	10	-	5	1
63	*Fraxinus pennsylvanica*	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
74	*Hibiscus moscheutos*	0.5	40	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	*Ilex verticillata*	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	6
35	*Leucothed racemosa*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	10	-	5	-
40	*Rhododendron viscosum*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	2	-	2	-
30	*Rosa palustris*	2	1	1	3	6	-	-	-	-	-	-	-	-	-	-	2	12	5	-	3
64	*Salix niger*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-
66	*Vaccinium corymbosum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	6	0.5	1	-
Plants not occurring in plots but present in-site																					
55	*Alisma plantago-aquatica*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	*Ambrosia artemisiifolia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	*Asclepias incarnata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	*Digitaria sanguinalis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	*Dioscorea villosa*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	*Echinochloa crusgalli*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	*Echinochloa walteri*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	*Eupatorium leucolepis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	*Eupatorium serotinum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE C.2 (Cont.)

Field No.	Species	Areal Coverage (%) NNA T1	NNA T2	NNA T3	NNA T4	NNA T5	Old ROW Area T1	Old ROW Area T2	Old ROW Area T3	Old ROW Area T4	Old ROW Area T5	New ROW Area T1	New ROW Area T2	New ROW Area T3	New ROW Area T4	New ROW Area T5	SNA T1	SNA T2	SNA T3	SNA T4	SNA T5
3	*Juncus acuminatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	*Juncus canadensis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	*Osmunda cinnamonea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	*Quercus* sp. seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	*Sphagnum frimbriatum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	*Symplocarpus foetidus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	*Viburnum nudum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78	*Viburnum recognitum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	*Vitis riparia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a] Includes the two species of *Sphagnum* as listed.

[b] Includes some *Carex atlantica,* which could not be distinguished in the field.

[c] Includes small amounts of *Spirodela polyrhiza* and *Wolffia* sp., which could not be distinguished in the field.

[d] Includes a few saplings and small trees of *Acer rubrum* and *Fraxinus pennsylvanica.*

TABLE C.3 Average Percent Coverage, Absolute Frequencies, and Distribution of Species by Stratum

Field No.	Species	Average Percent Coverage/Absolute Frequency NNA	Old ROW	New ROW	SNA
	Standing surface water	43/5	21/5	0	9/5
	Exposed muck/peat surface	16/5	42/5	0	43/5
	Bryophyte stratum				
	All mosses[a]	1.4/5	6.5/5	0	6/5
68	*Sphagnum affine*	0	0	0	1.6/1
36	*Sphagnum lescurii*	0	0.1/5	0	1.9/3
	Herb stratum				
	Plants found in both NAs and both ROW portions				
27	*Apios americana*	9.8/5	4.5/4	0.1/1	5.7/5
25	*Boehmeria cylindrica*	5.2/5	15.8/5	0.4/4	17/5
1	*Decodon verticillatus*	14/5	46/5	10.8/5	53.4/5
11	*Galium tinctorium*	0.8/5	1.4/5	0.1/1	1.2/4
18	*Impatiens capensis*	22/5	28.2/5	0.4/3	1.4/4
6	*Leersia oryzoides*	14/5	11/5	100/5	0.7/4
59	*Lemna minor*[b]	6.7/5	1.4/5	0.3/3	0.5/5
44	*Lythrum salicaria*	16/5	24/4	0.8/4	3.6/2
24	*Peltandra virginica*	25/5	12.4/5	0.7/4	27/5
20	*Polygonum arifolium*	30/5	31.6/5	0.1/1	9.4/3
	Plants found in both NAs and the old ROW				
54	*Bidens frondosa*	1.1/4	1.3/5	0	0.6/2
52	*Onoclea sensibilis*	0.6/1	1/2	0	1.4/3
7	*Scutellaria lateriflora*	0.2/2	0.6/4	0	0.6/3
34	*Thelypteris thelyptroides*	0.3/2	5/1	0	1/2
9	*Cuscuta compacta*	7.2/5	18.6/5	0	6.4/4
	Plants found in both NAs and the new ROW				
19	*Lycopus virginicus*	0.1/1	0	0.4/3	0.1/1
	Plants found in both NAs only				
12	*Osmunda regalis*	0.4/1	0	0	4/2
	Plants found in the NNA and the old ROW				
60	*Spirodela polyrhiza*	1.2/4	0.4/3	0	0
	Plants found in the NNA only				
74	*Hybiscus moscheutos*	13/3	0	0	0
75	*Myosotis laxa*	0.1/1	0	0	0
73	*Wolffia sp.*	6.8/5	0	0	0

TABLE C.3 (Cont.)

Field No.	Species	Average Percent Coverage/Absolute Frequency NNA	Old ROW	New ROW	SNA
	Plants found in the SNA and both ROW portions				
16	*Acer rubrum*	0	0.6/1	0.6/5	0.8/5
28	*Carex howei*[c]	0	7/1	1.5/4	11.4/3
45	*Typha latifolia*	0	0.6/1	5.6/4	0.1/1
	Plants found in the SNA and old ROW				
62	*Carex lurida*	0	0.1/1	0	0.4/1
	Plants found in the SNA and new ROW				
29	*Lobelia cardinalis*	0	0	0.1/1	0.2/2
37	*Lycopus uniflorus*	0	0	0.1/1	0.2/1
21	*Polygonum sagittatum*	0	0	0.5/2	0.4/2
	Plants found in the SNA only				
43	*Glyceria obtusa*	0	0	0	0.1/1
71	*Iris versicolor*	0	0	0	0.1/1
65	*Pilea pumila*	0	0	0	0.8/2
70	*Rubus sp.(cf enslenii)*	0	0	0	0.1/1
2	*Scirpus cyperinus*	0	0	0	0.4/1
66	*Vaccinium corymbosum*	0	0	0	0.1/1
69	*Woodwardia virginica*	0	0	0	0.2/1
	Plants found in both old ROW and new ROW				
38	*Nuphar luteam*	0	1.6/2	0.1/1	0
8	*Polygonum setaceum*	0	1/1	2/5	0
30	*Rosa palustris*	0	1.6/2	0.1/1	0
14	*Sparganium americana*	0	0.4/1	4.8/5	0
	Plants found in old ROW only				
32	*Alnus serrulata*	0	0.6/1	0	0
76	*Cinna arundinacea*	0	0.2/2	0	0
	Plants found in new ROW only				
61	*Carex canescens*	0	0	0.1/1	0
50	*Carex tribuloides*	0	0	0.1/1	0
10	*Cephalanthus occidentalis*	0	0	0.4/3	0
4	*Cyperus erythrorhizos*	0	0	1.5/3	0
17	*Eleocharis obtusa*	0	0	0.02/1	0
26	*Erechtities hieraclifolia*	0	0	0.1/1	0
51	*Ilex verticillata*	0	0	0.1/1	0
48	*Juncus effusus*	0	0	0.4/1	0
15	*Ludwegia palustris*	0	0	1.4/4	0
49	*Penthorum sedoides*	0	0	0.2/2	0

TABLE C.3 (Cont.)

Field No.	Species	NNA	Old ROW	New ROW	SNA
		Average Percent Coverage/Absolute Frequency			
46	*Rorripa palustris*	0	0	0.3/2	0
58	*Triadenum virginicum*	0	0	0.1/1	0
Shrub stratum[d]					
	Plants found in both NAs				
16	*Acer rubrum*	0.9/5	0	0	22.8/5
32	*Alnus serrulata*	3.6/4	0	0	8.6/3
10	*Cephalanthus occidentalis*	3/1	0	0	11/5
31	*Clethra alnifolia*	1.7/3	0	0	5.2/4
63	*Fraxinus pennsylvanica*	1.2/2	0	0	0.8/1
51	*Ilex verticillata*	0.8/2	0	0	2/2
40	*Rhododendron viscosum*	0.2	0	0	1.2/3
30	*Rosa palustris*	2.6/5	0	0	4.4/4
	Plants found in NNA only				
74	*Hibiscus moscheutos*	11/4	0	0	0
	Plants found only in the SNA				
35	*Leucothed racemosa*	0	0	0	3.4/3
64	*Salix niger*	0	0	0	6/1
66	*Vaccinium corymbosum*	0	0	0	1.6/4
	Plants collected from site but not occurring in sampling plots				
55	*Alisma plantago-aquatica*	Collected from new ROW			
72	*Ambrosia artemisiifolia*	Collected from new ROW			
41	*Asclepias incarnata*	Collected from SNA			
22	*Digitaria sanguinalis*	Collected from new ROW			
42	*Dioscorea villosa*	Collected from SNA			
56	*Echinochloa crusgalli*	Collected from new ROW			
47	*Echinochloa walteri*	Collected from new ROW			
57	*Eupatorium leucolepis*	Collected from new ROW			
53	*Eupatorium serotinum*	Collected from new ROW			
3	*Juncus acuminatus*	Collected from new ROW			
5	*Juncus canadensis*	Collected from new ROW			
13	*Osmunda cinnamonea*	Collected from SNA			
67	*Quercus sp. seedling*	Collected from new ROW			
39	*Sphagnum fimbriatum*	Collected from SNA			
77	*Symplocarpus foetidus*	Collected from SNA			
79	*Viburnum nudum*	Collected from SNA			
78	*Viburnum recognitum*	Collected from SNA			
23	*Vitis riparia*	Collected from NNA			

[a] Includes the two species of *Sphagnum* listed.

[b] Includes small amounts of *Spirodela polyrhiza* and *Wolffia* sp., which could not be distinguished in the field.

[c] Includes some *Carex atlantica*, which could not be distinguished in the field.

[d] Includes a few saplings and small trees of *Acer rubrum* and *Fraxinus pennsylvanica*.