DOE/DEIS-0103

DRAFT ENVIRONMENTAL IMPACT STATEMENT

NEW ENGLAND/HYDRO-QUEBEC ±450-kV DC TRANSMISSION LINE INTERCONNECTION

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Title of Proposed Action: Issuance of a Presidential Permit to Vermont Electric Power Company and New England Electric Transmission Corporation

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Abstract: This draft environmental impact statement (DEIS) was prepared by the Economic Regulatory Administration. The proposed action of the Department of Energy is the granting of a Presidential Permit for the construction, connection, operation, and maintenance of 95 kilometers (59.5 miles) of transmission line from the Comerford Substation in Monroe, New Hampshire, to the U.S.-Canadian border in Norton, Vermont. The proposed facilities include an DC/AC Converter Terminal at the southern terminus of the line and overhead ±450 kV DC lines with a design capacity of 2000 MW. The proposed project will connect the Hydro-Quebec System with the New England Power Pool System for the purpose of economic exchanges of power, increased reliability of power supply, and decreased reliance upon imported oil as fuel for electric power generation. The principal environmental impacts of the construction and operation of transmission facilities will be conversion of forestland within the right-of-way to shrubland/grassland vegetation types and impingement into viewsheds in selected areas of Vermont and New Hampshire.

EXECUTIVE SUMMARY

The Vermont Electric Power Company (VELCO) has applied for a permit to construct, connect, operate, and maintain the U.S. portion of a high-voltage, direct-current (DC) electric transmission circuit extending from the Comerford Substation in Monroe, New Hampshire, to a Hydro-Quebec substation near Sherbrooke, Quebec, Canada, a distance of approximately 95 km (59.5 mi). The purpose of the proposed New England Interconnection is to provide reliable transmission for an interchange of electric power between the Hydro-Quebec System and the New England Power Pool System (NEPOOL). The Applicant anticipates that this interchange will increase the reliability of the NEPOOL System as well as decrease NEPOOL's dependence upon imported oil as a fuel for generating electric power.

An electric utility or other entity proposing to build a transmission line crossing a U.S. international border must obtain a Presidential Permit. Regulatory decision-making at both the state and federal levels must comply with environmental review laws. This environmental impact document on the proposed project has been designed to meet the federal requirements of the National Environmental Policy Act (NEPA).

The principal environmental impact of the proposed project will be the clearing of about 480 ha (1200 acres) of forestland during construction. A secondary impact from clearing will be accelerated erosion which would be small relative to that induced by ongoing timber harvesting in the area. During the lifetime of the transmission facility, this cleared forest will be maintained as low-growing shrubland on grassland. The clearing will amount to less than 0.1% of the available forestland in the study area and will not remove any areas of unique or important habitat. Because the area to be cleared represents a minute amount of the forestland in the region, no serious impacts to timber harvesting or wildlife populations are expected.

It is also anticipated that the transmission will have unavoidable, adverse impacts upon visual resources at several points along its route: at the U.S.-Canadian border crossing, several areas in the central stretches of the route, and in the vicinity of Moore Reservoir, near the southern terminus.

The proposed line was found to not pose a hazard to or seriously affect other components of human health and welfare in the project region.

The Applicant considered four principal alternative corridors for routing the interconnection: three in northeastern Vermont and one in nortwestern New Hampshire. The optimal routing was found to be the easternmost corridor through Vermont. A comparison of the environmental impacts along alternative corridor routes found none environmentally preferable to the Preferred Corridor.

Reasonable alternatives to the proposed interconnection include purchase of power from other U.S. utilities, construction of new conventional or unconventional generating capacity, use of decentralized energy sources, and enhancement of conservation. In its analysis of the need for a power interchange with Hydro-Quebec, the Applicant incorporated projected increases in power conservation and use of decentralized sources of energy. Thus, it is unlikely that enhancement of these sources as will preclude the need for the interconnection. For DOE, the "No Action" alternative would be equivalent to denial of a Permit to the Applicant.

Were the DOE to deny a Permit for the proposed interconnection, the Applicant could implement an alternative action for obtaining the necessary capacity to reduce its dependence upon imported oil. Were the status quo maintained the NEPOOL would remain vulnerable to the changes in supply and cost of oil. All alternative sources of power would entail environmental impacts which may differ in quality from those associated with the interconnection. The analysis found no alternative environmentally preferable to the proposed interconnection.

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1. PURPOSE AND NEED

1.1 INTRODUCTION

On December 11, 1981, the Vermont Electric Power Company (VELCO) filed an application with the U.S. Department of Energy (DOE) to install and maintain an electric transmission line that will cross the U.S.-Canadian border. A Presidential Permit is required for the construction, operation, and maintenance of electrical transmission facilities that cross an international border of the United States. The Secretary of Energy has the authority to grant or deny such a Presidential Permit with concurrence by the Secretary of Defense and the Secretary of State.

The line will be jointly constructed by the Vermont Electric Transmission Company (VETCO), a wholly owned subsidiary of VELCO, and the New England Electric Transmission Corporation (NEET). It will be used to transmit electric power between Hydro-Quebec in Canada and New England Power Pool (NEPOOL) in the United States. NEPOOL is a regional power pool of which VELCO is a member.

DOE has determined that issuance of a Presidential Permit for the proposed international transmission line would be a major federal action that could have a significant impact on the environment. Therefore, an Environmental Impact Statement (EIS) is required. The DOE initially intended to process concurrently this application and an application for a similar line in New Hampshire submitted by NEET. One EIS covering the two applications was planned. However, in the wake of a decision by the state of New Hampshire Siting Evaluation Committee, which essentially denied state approval for the main portion of the New Hampshire route (the lower 11 km [6.7 mi] and the converter station site and design were common to both applications), NEET officially withdrew its application from further DOE consideration on January 3, 1983. Therefore, the EIS covers the Vermont route option (i.e., the VELCO application) as the proposed action. The New Hampshire route option (i.e., the original NEET application) is covered in the EIS as an important alternative.

It is DOE's intent to consider issuing a Presidential Permit for the proposed transmission line pending completion of an acceptable EIS and satisfactory completion of other elements of the Permit review process.

1.2 PROJECT SUMMARY AND PURPOSE

The proposed transmission facilities will be a ± 450,000 volt (V), bipolar, overhead, direct-current (DC) line with a thermal rating of 2000 megawatts (MW). The United States terminus of the line will be in the town of Monroe, New Hampshire, where a convertor station will be installed to convert the direct current to alternating current (AC) and thus permit connection to the existing NEPOOL AC transmission system. The line initially will be limited to transmitting 690 MW of electric power because this will be the capacity of the convertor stations. The project is described in greater detail in Section 2.1.

The purpose of the proposed facilities is to reduce the rate at which the cost of electric power has increased in the New England area and to reduce the dependence of this region on imported oil for the production of electric energy. The proposed project will connect NEPOOL* with Hydro-Quebec (HQ), thereby providing NEPOOL members with access to low-cost hydroelectric energy produced by the HQ generating plants in the Province of Quebec, Canada. The Applicant will obtain benefits from the proposed action through the execution of the following agreements.

1.2.1 Energy Contract

Under the Energy Contract Agreement, HQ has established a target of 33 million MWh of surplus hydro energy sales to NEPOOL over an 11-year period. Each 2/3 of the total energy estimated to be available would be prescheduled on a monthly basis at a price equal to 80% of the NEPOOL weighted-average fossil fuel cost. The remaining 1/3 would be made available on a hour-by-hour basis and priced at 80% of the cost of NEPOOL energy that it would displace.

1.2.2 Energy Banking Agreement

According to the Energy Banking Agreement, NEPOOL will sell energy to HQ during NEPOOL off-peak hours when this energy is likely to come from the lowest-cost, most-efficient generating units on the NEPOOL system. This will allow HQ to save or "bank" its low-cost hydro energy for use during peak load time when the energy would be returned to NEPOOL, thus reducing NEPOOL's need to run some of its highest-cost, least-efficient, oil-fired generating units. The fuel cost savings would be split 60% to NEPOOL and 40% to HQ for the first six years. Thereafter, savings would be divided 50%-50%.

1.2.3 Interconnection Agreement

The Interconnection Agreement provides for the daily coordination of operation between NEPOOL and HQ. There are five basic areas of coordination covered by the agreement:

a. Economy Energy - This provides for the hour-by-hour sale of nonemergency thermal energy for the purpose of replacing one system's high-cost generating units with the other system's lower-cost units.

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*The Applicant belongs to the New England Power Pool (NEPOOL). NEPOOL membership is comprised of 64 utilities in the New England region. Five of the 64 utilities are major investor-owned utilities, three are small investor-owned utilities, and the remainder are municipals and co-ops (ER, Vol. 1--Chapters I and II). NEPOOL is an operating entity within the Northeast Power Coordinating Council (NPCC), which is one of nine regional reliability councils in North America. All planning, construction, and operation of generating and transmission facilities is highly coordinated among NEPOOL members. Generating units are centrally controlled, and NEPOOL members share in the economies achieved through all pool ventures.

b. Operating Reserve - Each party to the agreement will maintain adequate operating reserve, but may arrange to obtain these reserves, if available, from the other party at a price.

c. Emergency Capacity and Energy - Each party agrees to make available to the other party excess generating capacity and energy during times of emergencies.

d. Maintenance and Development - Scheduled maintenance of existing facilities and the development of new facilities will be coordinated.

e. Fuel Replacement Energy - Energy from renewable sources will be sold to replace the energy derived from nonrenewable sources. This energy is priced at 80% of the buyers' avoided costs.

The Energy Contract will provide the overwhelming majority of the economic benefits that could accrue to the applicant through the execution of the above agreements and construction of the proposed line.

1.3 COST-BENEFIT OF PROPOSED ACTION

The key factor determining the economic benefits of the proposed line is the amount of surplus hydro energy that will be available for import from the HQ system. As indicated in Section 1.2, HQ has targeted an average of 3 million MWh per year for an 11-year period for potential sales to NEPOOL. The actual amount available in any year will be almost completely dependent upon the load growth rate, the annual level of precipitation, and the new facility construction program on the HQ system.

With this uncertainty in mind, the applicant has evaluated the economic benefits of the proposed facilities for various levels of energy imports. In the most optimistic case, 4.6 million MWh of surplus energy is imported from HQ. This results in a 12-year, levelized annual savings of $167.7 million in 1986 dollars. However, this analysis was performed prior to the signing of the Energy Contract. In this analysis, the price of the HQ energy was placed at 80% of the NEPOOL decremental (avoided) costs. Under the terms of the newly signed Energy Contract, 2/3 of the energy imported by NEPOOL will be priced at 80% of the NEPOOL weighted-average fossil fuel cost and the remaining 1/3 at 80% of the decremental costs. This new pricing schedule produces levelized fuel cost savings of approximately $233 million per year (1986 dollars) for the average 3 million MWh of imported energy targeted in the new Energy Contract. This new pricing schedule would produce approximately 40% greater fuel cost savings ($233 million vs. $167 million) at only 2/3 of the import level assumed in the most optimistic case studied by the applicant.

In a worst-case analysis, the applicant assumed that no surplus energy would be available from HQ for the duration of the agreement (11 years). Under these circumstances, economic benefits would be achieved primarily through the Energy Banking agreement. This case produces fuel cost savings of $32.6 million per year on a levelized basis (1986 dollars). DOE staff has reviewed the NEPOOL on-peak/off-peak fuel cost differentials. The anticipated fuel cost savings derived from energy banking appear to be consistent with the available data.

The latest cost estimate for the subject transmission facilities appears in the ER as $151 million (1986 dollars). Table 1.1 (supplementary data submitted by the applicant) shows the assumptions used by the applicant in performing the economic analysis. DOE staff has reviewed these and feels that they reasonably represent the cost function associated with the installation of the proposed facilities.

The one exception is in the area of fossil fuel price escalation. The applicant has chosen to use 11% per year through 1990, and 9% thereafter. Although it is extremely difficult to project the cost of foreign oil and other fossil fuels, the current market conditions tend to make these estimates appear high.

However, with the levelized annual cost of the project being $23.8 million (ER, Vol. 1--p. 12) and the targeted figure of 3 million MWh as an assumed import level, oil prices for the NEPOOL system would have to fall well below $20 per barrel before the economic benefits of the new line would become marginal. Current NEPOOL oil prices are approximately $30/barrel.

From the above analysis, it appears as though the proposed action will prove to be a sound economic venture. In actuality, the benefits could be considerably higher than stated by the applicant because in the "best" case of 4.6 million MWh (and in the updated 3.0 million MWh case) it was assumed that no energy banking would take place concurrently with the purchase of surplus hydro energy. In all likelihood in a typical year, there would be some level of attractively priced surplus energy supplied by HQ coupled with some amount of energy banking.

In the opinion of DOE staff, the assumptions made by the applicant in support of the economic analysis are conservative enough for the proposed action to achieve the desired economic benefits over a wide range of variation in study parameters.

1.4 RESOURCE PLAN AND SUPPLY REQUIREMENTS

The applicant is a member of NEPOOL and as such it is relevant to consider the supply and demand situation on a NEPOOL basis.

As shown in Table 1.2, the NEPOOL region is heavily dependent upon oil (mostly foreign) for the production of electric energy. In 1981, 50% of all electricity generated in the New England area was produced by burning oil. However, by 1990, this value will be reduced to 29% of all generation. This will be accomplished by (1) the planned installation of almost 3500 MW of nuclear capacity, (2) the conversion of approximately 2400 MW of oil-fired generation to coal-fired operation, and (3) the installation of a 568-MW coal-fired generating unit.

The projected level of 1990 oil-fired generation cited above (29% of total generation) represents approximately 50 million barrels* (ER, Vol. 1--p. 24) of oil required to produce electric energy. This quantity of oil at

*This value has been reviewed by DOE staff and appears reasonable.

Table 1.1. Assumptions Used in the Economic Analysis for the NEPOOL/Hydro-Quebec Interconnection

Capital Costs			Millions of 1986 $	
Vermont line (incl. AFUDC)			50.1	
New Hampshire costs (incl. line, converter, AFUDC, and AC reinforcements)			151.1	
TOTAL			151.1	
Financing	Ratio		Interest	
Debt	90%	at	12%	= 10.8%
Equity	10%	at	16%	= 1.6%
Return				12.4%
Present Worth Rate	12.4%			
Depreciation				
Book life	30 years			
Tax life	15 years			
Federal Income Tax Rate	46%			
State Tax Rates	Income Tax - 7.5%			
	Business Profits - 0			
Property Tax Rate	Based on local rates			
O&M				
Line	0.5% of gross plant			
Substation	4.0% of gross plant			
Escalation				
O&M	9% per year			
Property tax	2.7% per year			
Fossil fuel	11% per year through 1990; 9% thereafter			
Construction	9% per year			

Table 1.2. NEPOOL Generating Mix

	Installed Generating Capacity (Winter)			
	1981 Actual†1		1990 Projected†1	
	MW	%	MW	%
Oil	13,023	61	10,646	42
Coal	1,129	5	3,998	16
Nuclear	4,314	20	7,769	30
Hydro	2,932	14	2,985	12
Other	-	-	70	-
TOTAL	21,398	100	25,468	100

	Electrical Energy Generation			
	1981 Actual†1		1990 Projected†2	
	Millions MWh	%	Millions MWh	%
Oil†3	42.1	50	32.0 (28.0)	29 (25)
Coal	4.5	5	24.0	21
Nuclear	25.8	31	50.0	44
Hydro†4	4.4	5	4.0	4
Purchases and other	7.4	9	2.0 (6.0)	2 (6)
TOTAL	84.2	100	112.0	100

†1 Source: Electric Power Supply and Demand: 1982-1991 (N. Am. Elec. Reliabil. Counc. 1982).

†2 Source: ER (Vol. 1--Exhibit 1-2). These values represent projected generation for each fuel type if the proposed interconnection is not installed; the values in parentheses represent projected generation if the proposed interconnection is installed.

†3 Includes small amounts of gas burned as secondary fuels in non-steaming units.

†4 Values shown are net of pumped hydro pumping losses.

today's price would cost over $1.5 billion. The proposed interconnection is expected to reduce the 29% value to 25% of total generation, thereby effecting a 14% reduction (7 million barrels in 1990) in total New England oil consumption in the electric utility sector.

DOE staff feels that this level of reduction could be achieved* through the importation of the 3 million MWh of surplus hydro energy targeted by HQ (see Section 1.2.1, Energy Contract) and an additional 1.5 million MWh of oil-fired generation displaced through energy banking.

In addition to reducing the NEPOOL oil dependence, the above capacity addition plans will create reserve margins ranging from 35% to 50% during the winter peak seasons from 1983 to 1990 (N. Am. Elec. Reliab. Counc. 1982). (Reserve margins are defined as the difference between planned resources and peak demand, expressed as a percentage of peak demand.) A typical range for desired reserve margins is 15% to 25%. However, various utility system characteristics such as average generating unit size, number of units, unit availabilities, and other factors cause the levels of reserve required for adequate reliability to vary considerably from system to system. The projected range of capacity reserve margins for the NEPOOL system cannot be construed as either adequate or excessive without further detailed studies.

One of the major factors affecting oil consumption in the New England region will be the rate of load growth. The applicant predicts a 2.6% annual compound growth rate in peak demand and a 2.7% growth rate in energy requirements for the period 1982-1996. This compares favorably with the 2.3% energy growth rates projected for the New England region by Data Resources, Inc., in the spring of 1982.

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*Oil-fired generation is operated in New England for most if not all hours of the day. Any imported power would displace almost 100% oil no matter what time of the day it was received. The conversion rate is based on average generating unit heat rates of 10,000 BTU/kWh and heating value of oil averaging 6 million Btu/barrel.

REFERENCES (Section 1)

North American Electric Reliability Council. 1982. Electric Power Supply and Demand: 1982-1991. August 1982.

Data Resources, Inc. 1982. New England energy demands (Table A-59). Energy Review 6(1):173.

2. PROPOSED ACTION AND ITS ALTERNATIVES

2.1 PROPOSED ACTION

The proposed action is the issuance of a Presidential Permit for the construction of an international interconnection for the purpose of exchanging electric power. The transmission line will be a bipolar, direct-current (DC) line designed to operate at ±450 kV. The line will extend from the U.S.-Canadian border in the town of Norton, Vermont, to a station in the town of Monroe in northern New Hampshire--a distance of about 95 km (59.5 mi), with right-of-way encompassing about 560 ha (1400 acres). The transmission line will terminate at each end in a converter terminal. The purpose of these terminals is to convert alternating-current (AC) power to direct-current (DC) power--and vice versa--so that the high-voltage, direct-current (HVDC) transmission line can be connected to existing AC power systems.

The primary data source for the description of the proposed project is the Applicant's Environmental Report, submitted to DOE as part of Dockets PP-76 and PP-77 from May to June 1982; hereafter this report shall be referenced as the ER. Copies of the ER are available for public review in the public reading rooms of libraries in St. Johnsbury, Vermont; Littleton, New Hampshire; and Washington, DC.

Along the route of the proposed interconnection, data are compiled primarily by town, which is a geographical and governing unit. Several of these towns make up a county. A town may include several villages or population concentrations. For example, the town of Concord includes the villages of Concord, East Concord, North Concord, and Miles Pond. Towns are somewhat analogous to townships in other regions. To avoid confusion and for the purposes of this report, the term "town" will be used to indicate the larger geographical and governing unit, as distinct from the population concentrations, which will be referred to as "villages" or "communities".

2.1.1 Preferred Corridor

2.1.1.1 Corridor Route Selection

Selection of a route for the Preferred Corridor was carried out on the basis of a regional overview (ER, Vol. 2 and 3). The regional study area consisted of the three northeast counties of Vermont, known as the Northeast Kingdom, and a small portion of Grafton County, New Hampshire (Figure 2.1). The overview was designed to assess the feasibility of the proposed transmission interconnection and to find a preferred study corridor and alternatives for further consideration. Due to the need to avoid mountainous areas, existing developments, areas with future development potential, and unique and fragile environmental areas, a straight-line route is not feasible. The purpose of the overview study was to select a route in which all these factors were taken into consideration.

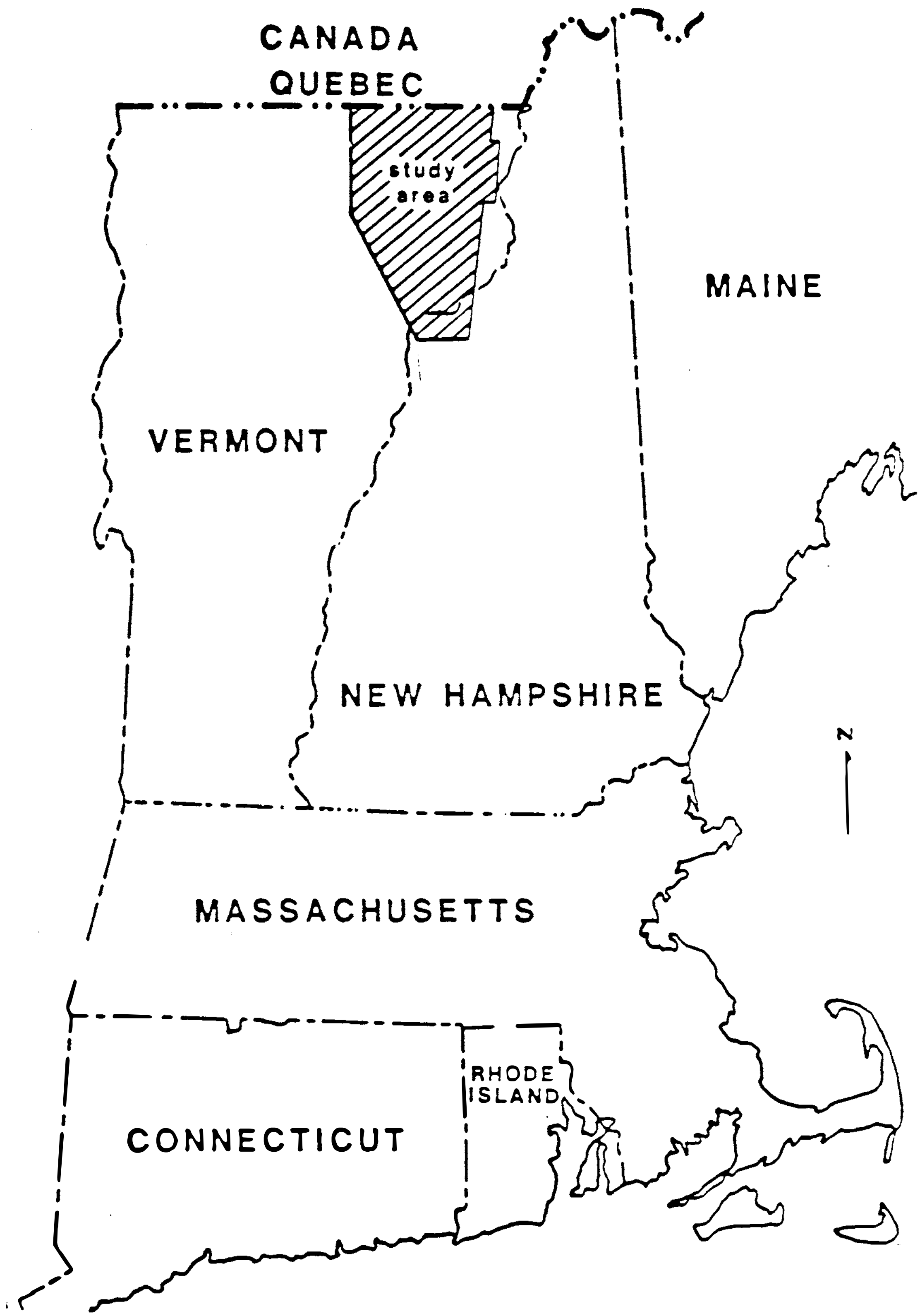

Figure 2.1. Location of the VETCO Study Area.
Source: ER (Vol. 3--Exhibit 3-1).

Environmental and land-use factors in the study area were evaluated with regard to their impacts on a transmission corridor and, conversely, the impacts that a transmission corridor would have on the natural and the man-made environment. After identifying opportunities and limitations for a corridor location, additional factors suggested by local municipal authorities, local planning and zoning regulations, and cost and engineering criteria were incorporated into the evaluation process. In addition, public opinion was considered through procedures required by the states of Vermont and New Hampshire and through a public scoping meeting conducted on March 10, 1982, by the U.S. Department of Energy that was designed to solicit concerns and suggestions from property owners, local residents, government agencies, and public interest groups. It was determined that the Preferred Corridor should meet following criteria:

1. The corridor should avoid unique cultural and biological resources.

2. The corridor should avoid primary recreation areas and public-owned lands.

3. The terminal point should occur near the Comerford Station where interconnection to NEPOOL is possible.

4. The point of entry should be located in the eastern portion of the town of Norton in order to connect to the Hydro-Quebec portion of the interconnection.

5. Highway crossings should provide adequate visual screening.

6. The corridor should avoid prime agricultural lands.

7. The corridor should take advantage of existing logging roads serving otherwise inaccessible areas.

8. The corridor should avoid elevations above 760 m (2500 ft).

9. The corridor should avoid slopes in excess of 25%.

Routing was subject to further scrutiny with regard to: (1) scenic and visual classification in the corridor area, (2) floodplains, (3) lakes, (4) floodway considerations, (5) wetlands, (6) wildlife habitats, and (7) deeryard areas.

Final screening criteria in the corridor selection process included: (1) minimum impact as a result of property severance, (2) avoidance of current development and developing areas, (3) minimum disturbance on existing right-of-way, (4) selection of areas of potential acquisition without acquisition of buildings, and (5) consideration of project costs (structures, right-of-way, and access roads).

The final Preferred Corridor was selected on the basis of information derived from literature searches, field investigations, and local opinions presented at public hearings. Upon evaluation, a corridor in the eastern part of the study area was determined to follow the route most compatible with the criteria set forth and, as a result, was selected as the Preferred Corridor (Figures 2.2 and 2.3).

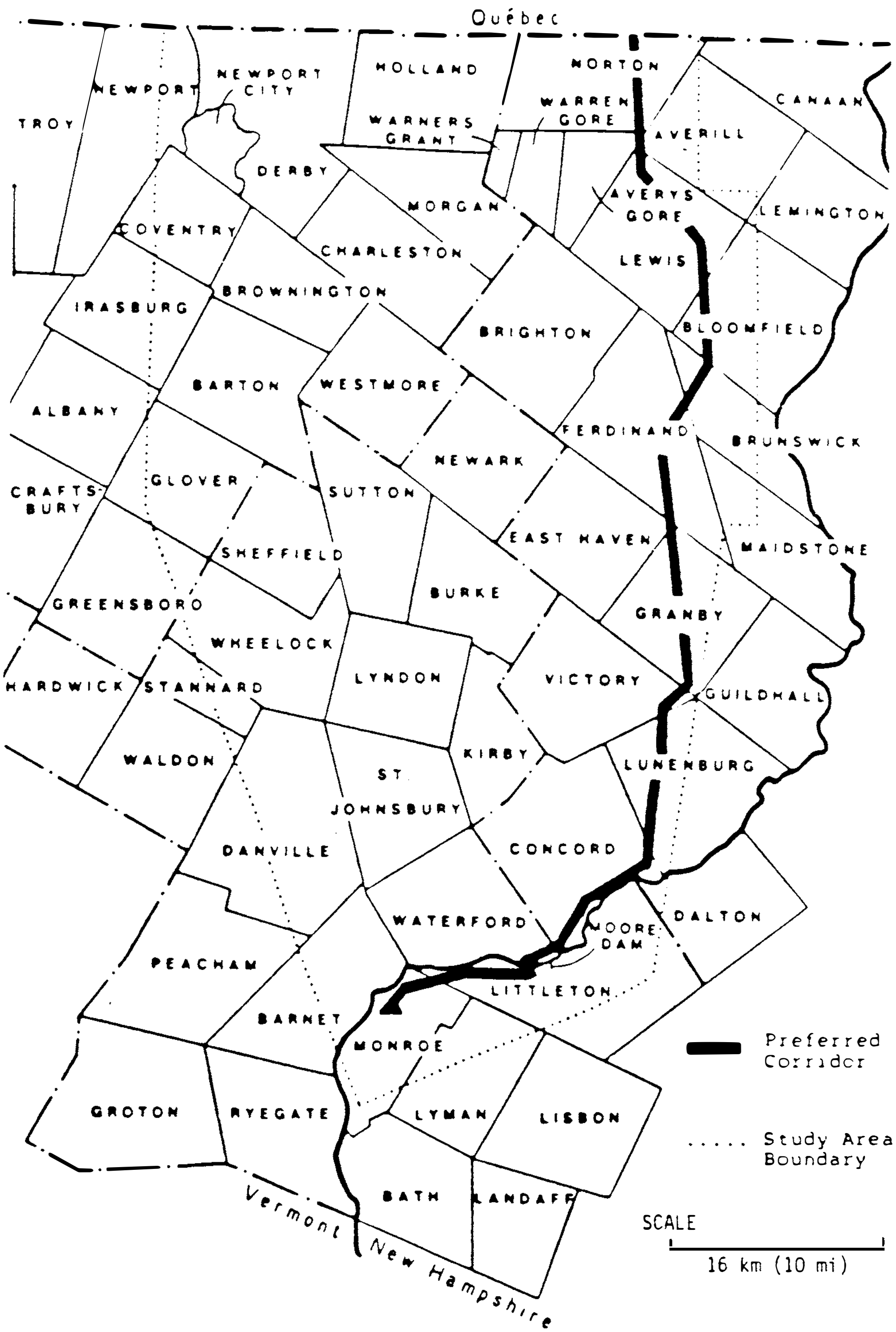

Figure 2.2. Location of the Preferred Corridor.
Source: ER (Vol. 3--Exhibit 3-4).

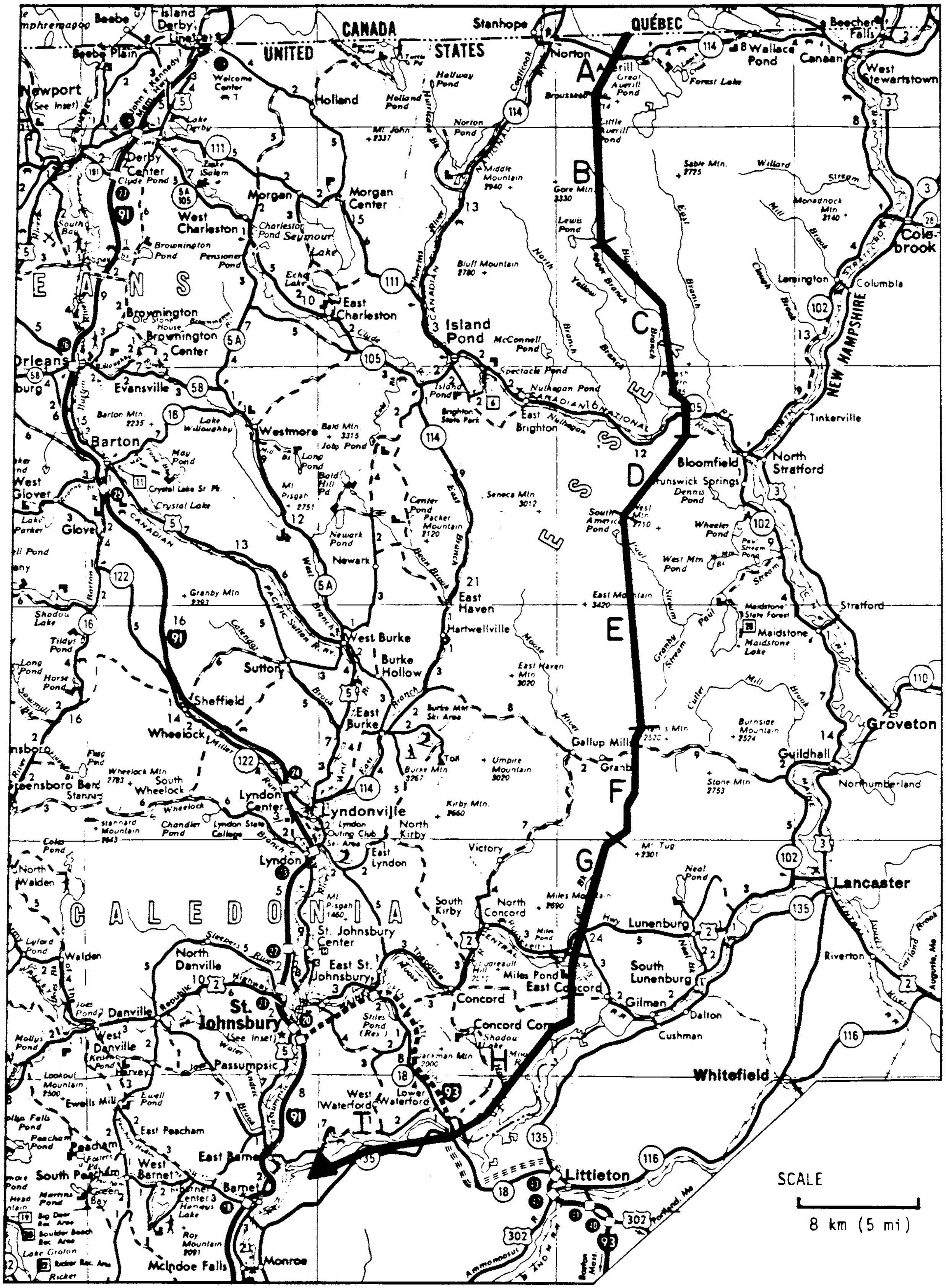

Figure 2.3. Transportation Routes and Communities Along the Preferred Corridor. Lettered segments are discussed in Section 3.6.2.

2.1.1.2 Description of the Preferred Corridor

The Preferred Corridor will begin at the U.S.-Canadian border in the eastern portion of the town of Norton (Figure 2.2). (Detailed maps of the Preferred Corridor route are presented in Appendix A.) The route will then extend south across Route 114 (Figure 2.3), passing through a low point east of Trophy Mountain and west of Black Mountain. The corridor will then angle southeast to avoid Yellow Bog and the Nulhegan Deeryard. It will extend southwest of the Potash Mountains and cross the Nulhegan River and Route 105, just east and north of French Mountain. The corridor will continue southwest past North Notch Mountain, Notch Mountain, and Notch Pond--avoiding the Wenlock Wildlife Management Area. The corridor will then angle to the south just east of South America Pond, and extend across the Paul Stream Basin into the town of Granby--west of Unknown Pond and avoiding Ferdinand Bog.

The Preferred Corridor will continue south through Granby, east of Mud Pond and Granby Village (Figure 2.3). It will avoid Victory Bog and Victory State Forest by staying west of Temple Mountain and east of Miles Mountain. The line will cross U.S. Route 2 east of Miles Pond, then extend south through Carr Brook Basin and Roaring Brook Basin. It will reach the Connecticut River west of the community of East Concord and parallel an existing right-of-way toward Moore Dam in Waterford. There, the Preferred Corridor will cross the Connecticut River and enter the town of Littleton, New Hampshire, where it will join and parallel an existing 230-kV transmission line in a southwesterly direction. The Preferred Corridor will extend into the town of Monroe, Grafton County, and continue parallel to existing right-of-way, concluding by crossing over the 230-kV lines and extending to its southern terminus at the site of the proposed converter terminal.

2.1.2 <u>Design Description</u>

2.1.2.1 Design Specifications

Basic design parameters for the proposed transmission line are listed in Table 2.1. Initial design studies indicate that the pole conductor will be a three-bundle, aluminum and steel conductor with subconductors of approximately 48- to 50-mm (1.9- to 2.0-in.) diameter. The subconductor spacing will probably be between 460 to 760 mm (18 to 30 in.). The bundle will be installed in the inverted triangle formation (i.e., apex down).

Spacing of electric poles (center to center of the positive and negative poles or conductors) will depend upon the type of support structure, type of insulation, and selected level of electric effects at ground level. For the proposed wood-support, H-frame structures, the electric pole spacing could be as wide as 16 m (52 ft) (Figure 2.4).

The transmission line will be designed to meet the National Electric Safety Code (NESC) specifications for heavy ice loading conditions (ice buildup of 12.7-mm [0.5-in.] thickness) and extreme wind conditions (wind pressure of 90 kPa [13 $lb/in.^2$]). In addition to the NESC loading conditions, the transmission line will be designed to withstand heavy icing (determined from a review of meteorological data) and imbalancing due to ice buildup.

Table 2.1. Proposed Transmission Line Data for the New England/Hydro-Quebec Interconnection

Length of line	95 km (59.5 mi)
Voltage	±450 kV DC
Configuration	Bipolar, horizontal pole spacing
Capacity	2000 MW
Conductor type	Aluminum/steel
Conductor size	To be determined, but will be about 50 mm (2 in.) in diameter
Minimum clearance: conductor to ground at mid-span	Not less than 11 m (36 ft)
Lightning protection	Single or twin extra high-strength galvanized steel groundwires providing a shielding angle to conductors of not less than 25°
Tangent structures	H-Frame
Heights of tangent structures	29-34 m (95-110 ft)
Average span length	210 m (700 ft)
Right-of-way width	61 m (200 ft)

Source: ER (Vol. 3).

The conductors will be protected from lightning strikes by installation of a buried counterpoise wire and two aerial groundwires, one above each conductor bundle.

2.1.2.2 Support Structures

Support structures will be of two types: tangent and angle. Conductors that extend in straight lines or shallow curves will be supported by tangent structures. Where sharper turns in the line occur, angle structures will be used to support the conductors.

VETCO currently proposes to use a wood H-frame, tangent tower structure or a similar tubular steel H-frame structure fabricated from natural weathering steel (CORTEN or similar) (Figure 2.4). The type of tower selected will depend upon economics, aesthetics, and ground clearance required to provide the selected level of electric effects at ground level below the conductor and at the edge of the right-of-way. Strength limitations associated with the height of wood pole structures may exclude their use, depending on the structure height required to provide the selected levels of electric field at the ground surface.

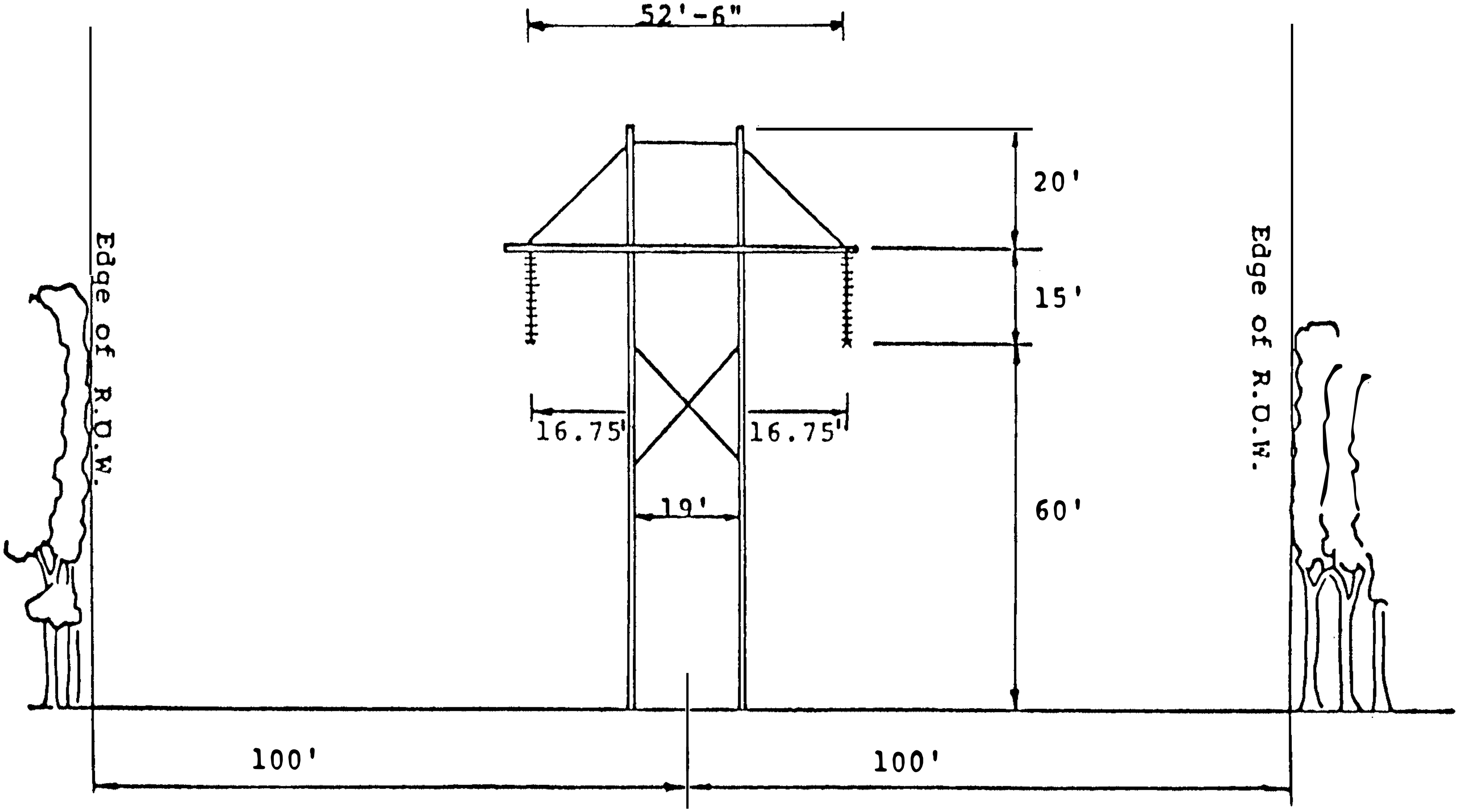

Figure 2.4. Proposed H-Frame Tangent Structure for the ±450-kV DC New England/Hydro-Quebec Interconnection. Source: Vermont Electric Power Company (1981--Exhibit 5).

Angle structure types will depend upon the types of tangent structure finally selected. If the tangent structures are wood H-frame or tubular steel poles, the angle structure will most likely be two tubular steel poles with each pole carrying a bundle of conductors (electric pole) (Figure 2.5).

2.1.2.3 Converter Terminal

At the converter terminal in Monroe, New Hampshire, a building will be erected on a 9-ha (23-acre) terminal site for the purpose of housing HVDC converter equipment (ER, Vol. 1). This building is expected to measure approximately 110 m (350 ft) in length, 46 m (150 ft) in width, and 20 m (65 ft) in height. It will be a metal building, with the color chosen to be visually inconspicuous. Normally, the building will be unattended.

Also to be located on the terminal site--surrounding the building--will be a switchyard containing electric power equipment and associated structures. The highest structures in this switchyard will be for transmission line terminations. These structures will be about 23-m (75-ft) tall. Electric conductor and converter work in the switchyard will be of the modern, open-construction type. All power equipment will be painted a visually inconspicuous color.

Communication to and from the terminal will be via a microwave system, with the transmitter/receiver and antenna equipment adjacent to the terminal building. The antenna tower will not exceed the proposed 23-m (75-ft) electric termination structures in the terminal yard. The microwave system will connect to the existing NEPCO system and be extended via intermediate sites to Canada. This will require the construction of a new repeater station at the summit of Sheffield Heights, Sheffield, VT (Figure 2.3), which will affect an area of less than 1 ha (2.5 acres). A smaller, passive reflector will be placed in an open field southeast of Route 135 near the converter terminal. Other components of the microwave system will use existing facilities.

The terminal will be connected to NEPOOL's existing AC power system at the Comerford 230-kV switchyard located about 600 m (2000 ft) northwest of the terminal site. The AC transmission line running from the terminal to this switchyard will be placed on new right-of-way up to 61 m (200 ft) in width.

In addition, a remote ground electrode will be installed in order to provide a path to correct for current imbalances between the positive and negative halves of the HVDC interconnection (ER, Vol. 1 - February 1983 Supplement). The electrode will be located at least 8 km (5 mi) from the terminal in order to avoid interference with high-voltage AC equipment. Studies are currently ongoing to determine the location of the ground electrode. The converter terminal will be connected to the electrode via a single distribution conductor. Where possible, the conductor will be strung between the poles of the interconnection. Additionally, existing road or transmission line right-of-way will be used as much as possible for routing the connecting conductor. The ground electrode is expected to be used 10-15 times per year and operate for a maximum of 15 minutes.

At present, the most likely candidate site for situating the ground electrode is in Lisbon, New Hampshire, about 18 km (11 mi) from the converter terminal. Approximately 10 km (6 mi) of new, 9-m (30-ft) wide right-of-way will be needed if this site is selected. Final selection of a site will occur in time to have an analysis of impacts available for the Final EIS.

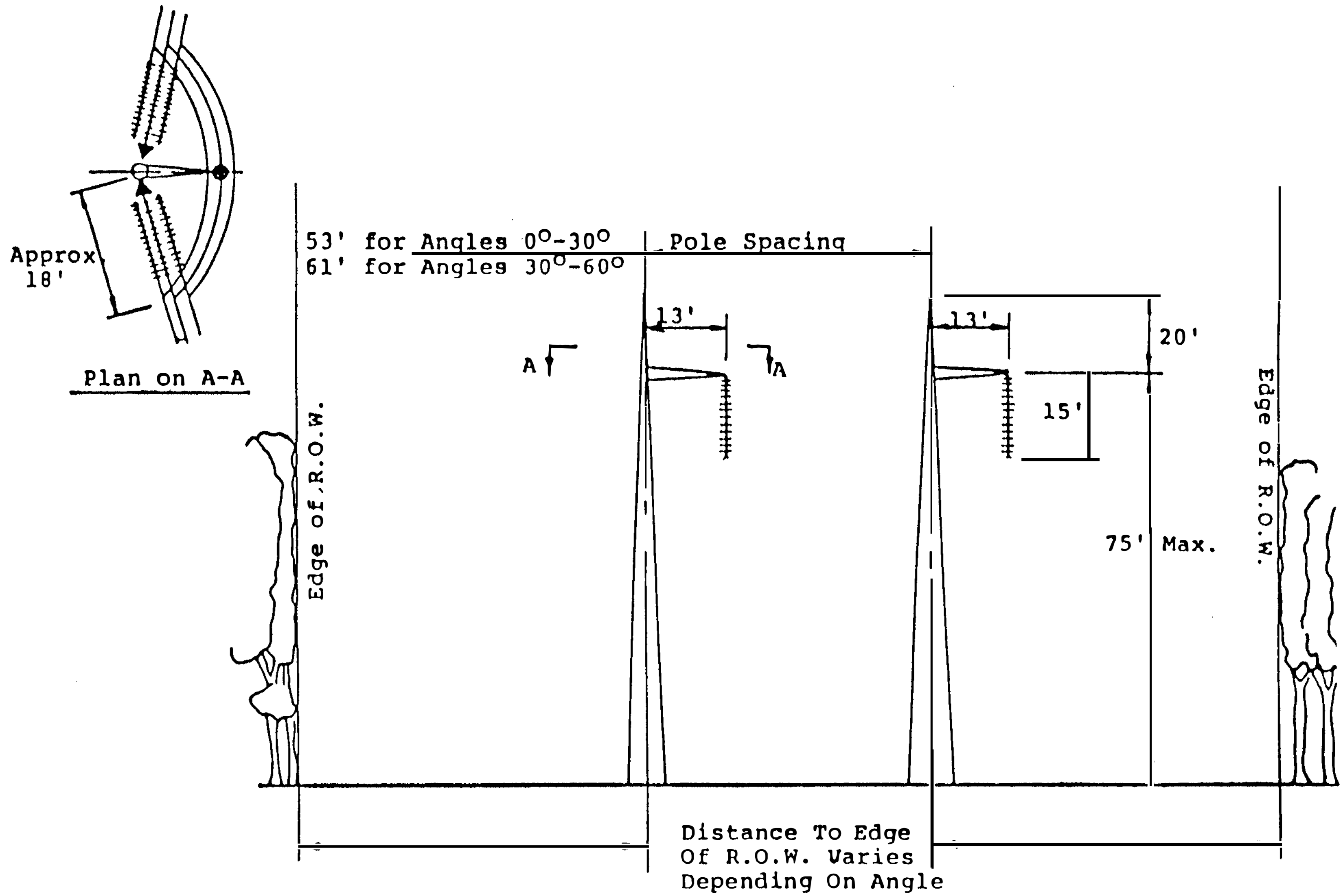

Figure 2.5. Proposed Angle Structure for the ±450-kV DC New England/Hydro-Quebec Interconnection. Source: Vermont Electric Power Company (1981--Exhibit 6).

NEET does not yet have a detailed diagram of its terminal but expects the configuration to be approximately the same as that of Minnesota Power and Light's Arrowhead Terminal (Figure 2.6), although dimensions will differ.

2.1.3 Construction Activities

2.1.3.1 Surveying Activities

Initial surveying activities for the transmisson line will locate the centerline and edges of the right-of-way in relation to the boundaries of properties to be crossed. After the final line route is selected and engineered, the route centerline will be staked out. In addition to route location, physical features and property data will be mapped at this time, allowing refinements in tower location or profile, if necessary. Prior to construction, final tower locations and other work areas will be determined. During construction, survey crews will monitor tower locations and transmission line alignment.

2.1.3.2 Right-of-Way Clearing and Maintenance Practices

Transmission line right-of-way will be cleared of trees and shrubs to facilitate (a) staking, access, assembly, and erection of structures; (b) installation of conductors; and (c) maintenance. This will also provide adequate electric clearances for energized lines. Where the line does not parallel existing lines, a 61-m (200-ft) wide cleared right-of-way will be required. Where existing lines are paralleled, new right-of-way of only 46 m (150 ft) in width will be needed. Up to 13% of the 95-km (59.5-mi) route will parallel existing right-of-way. Approximately 517 ha (1280 acres) in Vermont and 46 ha (114 acres) in New Hampshire will be within new right-of-way. About 85% of this area will require clearing.

Other than those areas chosen for selective clearing and other special landscaping techniques, the right-of-way will be cleared according to the Applicant's standard procedures (ER, Vol. 3--App. A; Vt. Elec. Power Co. 1982). The right-of-way will be maintained in order to ensure the safety and integrity of the transmission line. Salient points of the Applicant's program include:

- Use of best available technology
- Use of an environmentally sound approach
- Compliance with state and federal laws and regulations
- Application of herbicides only when there is no danger of wind drift off the right-of-way or into areas of rare plants
- No application of herbicides within 15 m (50 ft) of streams or in areas used for agriculture

Some sections will have already been cleared by the current land owner prior to construction. All remaining areas will be cleared under contract. The contracts will provide that cut wood be sold unless other disposition has been agreed upon by the owner. VETCO will dispose of the material onsite if they determine that removing the product will cause environmental damage.

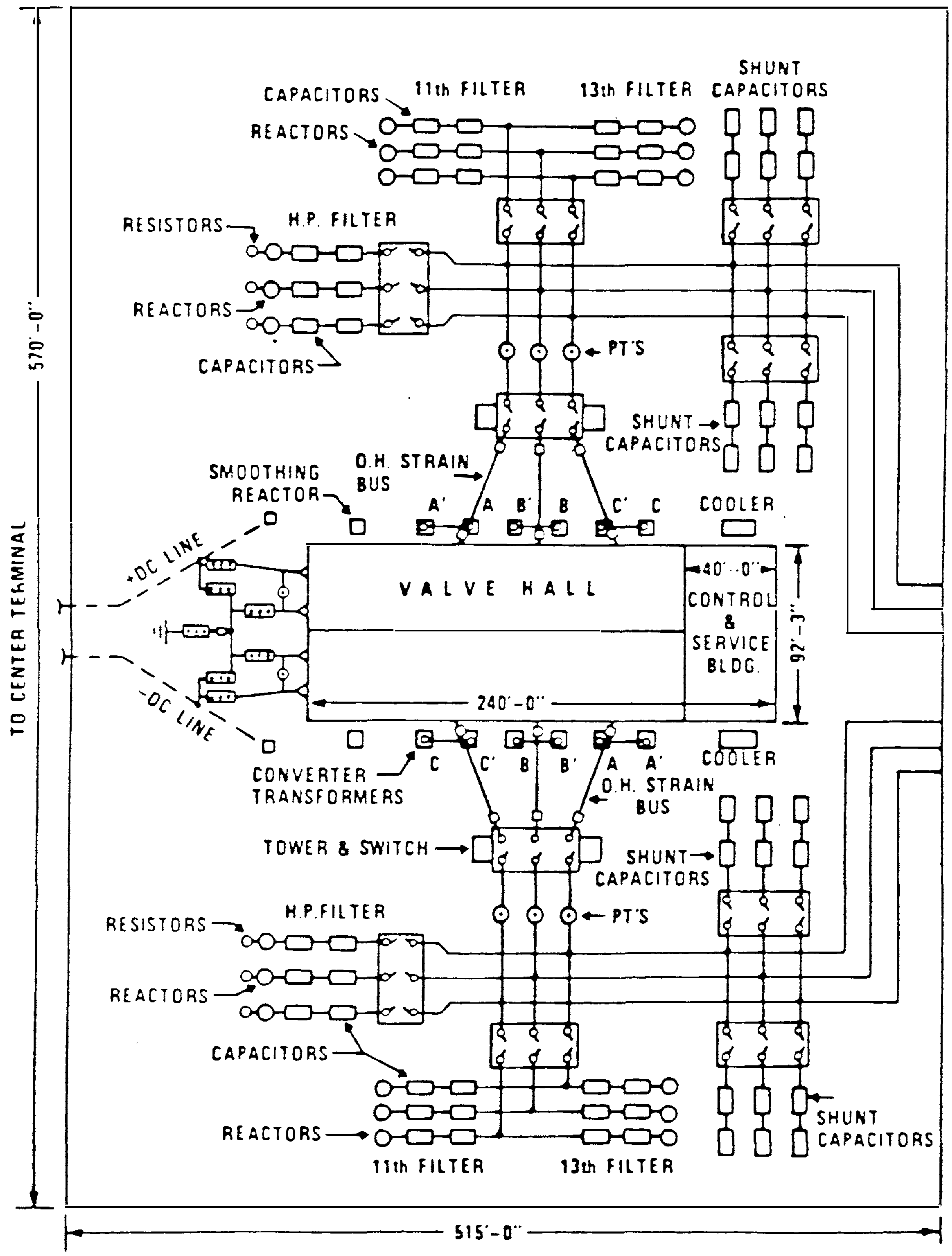

Figure 2.6. Arrowhead DC Terminal Yard Layout.
Source: ER (Vol. 1--Exhibit 1-23).

2.1.3.3 Access Road Construction

Existing roads will be used to the extent possible, although it is anticipated that some of these roads will need upgrading--e.g., alignment improvement, grading, widening, and reinforcing of structures. Some new access roads will be required both within the right-of-way and from existing roads to the right-of-way. The number and location of these new roads has not been determined.

Construction staging areas along the route will be selected, to the extent possible, at existing cleared areas. To control erosion at these areas, state-of-the-art construction techniques will be used in grading.

2.1.3.4 Support Tower Installation

The installation of tower foundations will vary with the local surface geology (ER, Vol. 3). For areas overlain with soil and glacial deposits, excavation may be accomplished with earth augers or backhoes. Areas with very dense glacial till and bedrock will most likely be excavated by means of drilling and blasting. Less than 10% of the route is expected to require the latter excavation (Klunder Assoc. 1981). For direct-burial type of structures, a support pole will be placed in the excavation hole and backfilled with excavated material or crushed stone that is tamped in place. For structures requiring concrete foundations, such as angle structures, reinforcing bars and anchor bolts will be set and concrete then placed into the hole and allowed to cure. Once curing is complete, the hole will be backfilled as needed and the support pole mounted on the foundation.

For each tangent structure, it is anticipated that two holes 0.6 to 1.0 m (2 to 3 ft) in diameter will be excavated to a depth of 3.0 to 3.6 m (10 to 12 ft). The average spacing of structures will be approximately 210 m (700 ft). Tubular-steel angle structures will require two excavations per structure for concrete foundations that will be approximately 2 m (6 ft) in diameter and 4.5 to 6.0 m (15 to 20 ft) deep, depending on soil conditions. It is anticipated that less than 15% of the structures will be of the angle type.

2.1.3.5 Framing and Stringing

Framing (assembly) operations will be carried out at the same time as structure installation. The crossarms will be hoisted into position, complete with the insulator strings, by means of ropes pulled by a vehicle and attached to the structural poles by land. The crossbraces will also be raised in the same manner.

Conductors will be strung for the line using either slack-stringing or tension-stringing methods (ER, Vol. 3). Generally, crews will operate over a distance of about 8 km (5 mi) at a time. Insulators and stringing blocks will be either hung from the structures while they are being erected or installed separately just prior to the stringing operation.

2.1.3.6 Converter Terminal

Construction will involve the following activities: (1) site preparation, (2) foundation work, (3) erection of building and structures, (4) installation of power equipment, and (5) testing and commissioning.

Site preparation will include surveying, clearing, and grading the terminal site. The site will then be covered with crushed rock to prevent refoliation, and fenced. Existing trees will be left standing on three sides of the site for natural screening. Additional landscaping will be conducted--if appropriate--on the fourth side of the site, which abuts the private (paved) access road of the New England Power Company. In total, the terminal will occupy a graded and fenced area not to exceed 300 × 300 m (1000 × 1000 ft) (approximately 9.2 ha or 23 acres). In addition, approximately 4 ha (9 acres) of new right-of-way will be used to connect the converter terminal to the Comerford Station, and up to 9 ha (22 acres) of new right-of-way will be used to connect with the ground electrode. The ground electrode itself will require disturbance of about 200 m^2 (2200 ft^2) of ground surface.

Foundation work will include forming and pouring foundations for the terminal's building and switchyard structures. These activities will require concrete and other building materials to be trucked in from offsite.

2.1.3.7 Schedule

The preliminary project schedule is presented in Figure 2.7.

2.2 ALTERNATIVE ROUTES FOR THE INTERCONNECTION

The following four alternative routes were evaluated in the current analysis. An environmental comparison of the routes is presented in Section 4.2.

2.2.1 Vermont Options

Alternative Corridors were selected on the basis of the regional overview conducted by the Applicant (ER, Vol. 3), which is summarized in Section 2.1.1. Based on these considerations, the Applicant's analysis initially identified three study-corridor concepts. Each corridor concept contained a series of about 1.6-km (1.0-mi) wide segments (numbered from 1 to 28 in Figure 2.8). These corridor concepts were then evaluated against more detailed standards and criteria for transmission corridor locations and tested against technical and engineering criteria.

The three primary corridor options studied included: (I) the Central Spine Corridor, (II) the Interface Corridor, and (III) the Essex Mountains Corridor (see Figure 2.8 and Table 2.2). Although these three corridors each contain several routing possibilities, each is sufficiently different from the others in location and character to have its own identity. A variant of the Essex Mountains Corridor was determined to follow the optimal route and is considered to be the Preferred Corridor (Section 2.1.1).

The Central Spine Corridor would generally follow the route of U.S. Interstate 91 (Figure 2.3). The route would begin at the Canadian border in the middle of the town of Derby (Figure 2.8). The corridor would extend generally southward through the towns of Brownington and Barton in Orleans County. After extending into the town of Sheffield, Caledonia County, the corridor would extend southeastward through the town of Sutton into Lyndon. Northeast of Lyndonville (Figure 2.3), the corridor would again extend southward into the town of St. Johnsbury, crossing the route of U.S. Interstate 93, now under

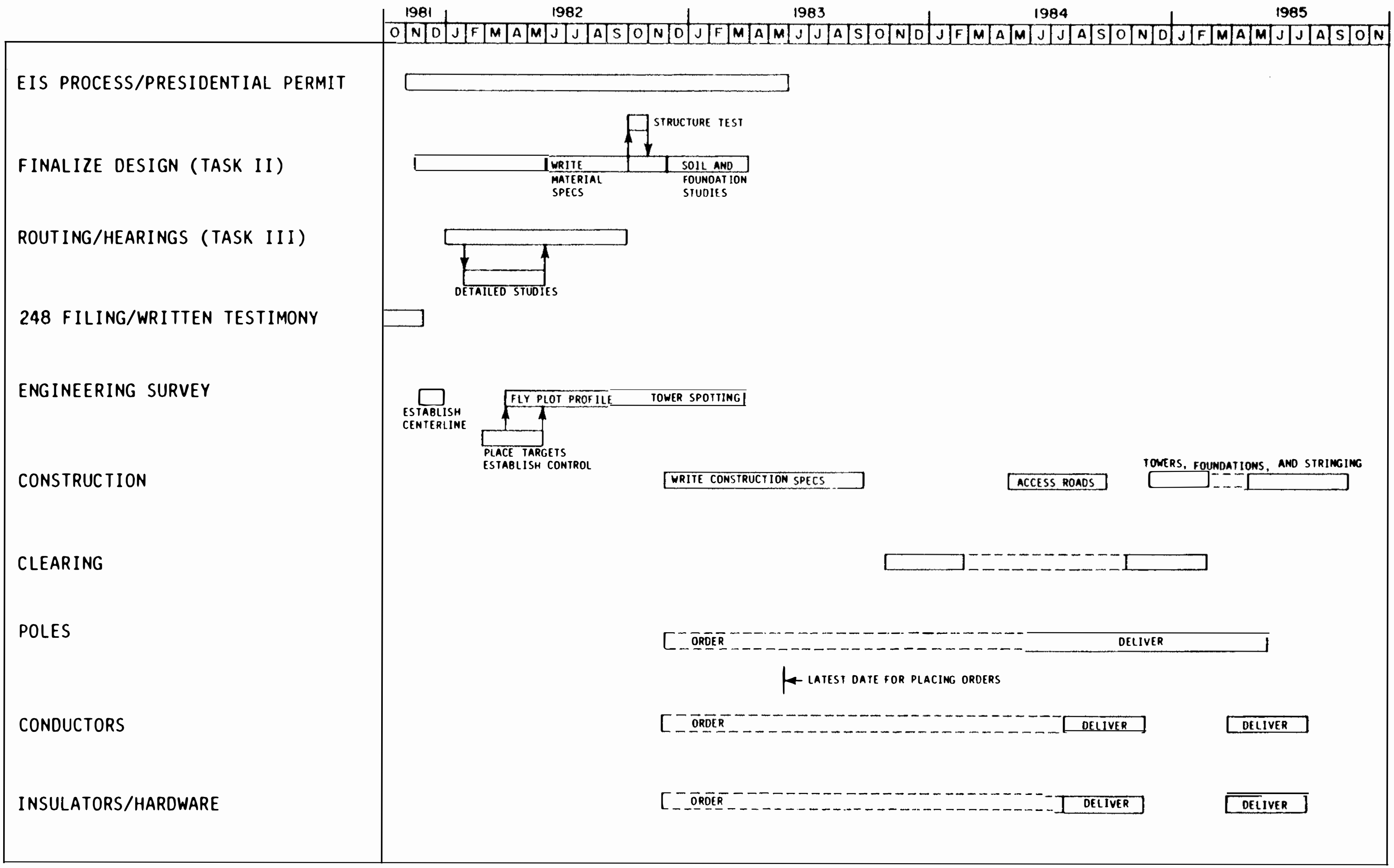

Figure 2.7. Preliminary Project Schedule for the New England/Hydro-Quebec Transmission Interconnection. Redrawn from the ER (Vol. 3--Exhibit 3-6).

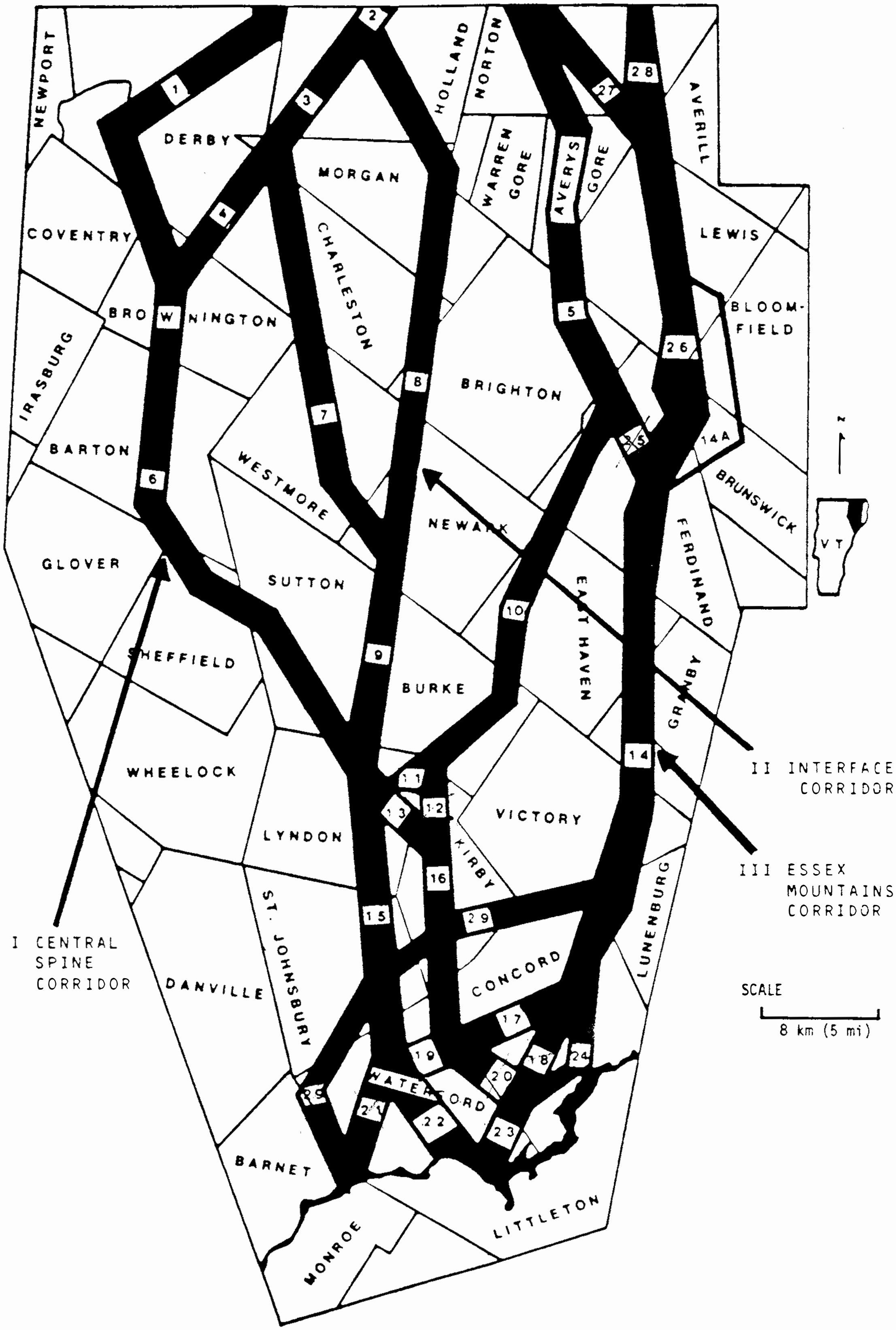

Figure 2.8. Alternative Corridors in Vermont.
Source: ER (Vol. 3, Exhibit 3-3).

Table 2.2. Approximate Length of Vermont Corridor Options, Canadian Border to Converter Terminal

Corridor Option	Segments†[1] in Vermont	Approximate Length
Central Spine Corridor	1,6,15,22	99 km (62 mi)
Interface Corridor	2,8,9,13,16,19,22	94 km (59 mi)
Essex Mountains Corridor	28,26,14,24,23	95 km (60 mi)

†[1] See Figure 2.8.

Source: ER (Vol. 3).

construction. East of the community of St. Johnsbury, the corridor would shift to the southeast and extend through the town of Waterford to Moore Dam where it would join the New Hampshire segment of the Preferred Corridor.

The Interface Corridor would begin in the eastern portion of the town of Holland (Figure 2.8). Thence, it would extend in a generally southernly direction, passing east of the community of Island Pond (Figure 2.3). The corridor would extend through the towns of Warners Grant, Morgan, Charleston, Brighton, Westmore, Newark, Burke, and Lyndon. Northeast of Lyndonville (Figure 2.3), the corridor would shift eastward away from a junction with the Central Spine Corridor and extend southward through the towns of Kirby and Concord. The route would join the Central Spine Corridor in the town of St. Johnsbury, east of the community of St. Johnsbury.

2.2.2 New Hampshire Option

A fourth alternative corridor for the proposed interconnection would pass through the westernmost towns in New Hampshire, from Pittsburg to Monroe, and cross into Canada in the vicinity of Tabor Notch (Figure 2.9). This route was originally under consideration as a separate application by NEET for a Presidential Permit (ER, Vol. 2). That application has since been withdrawn.

The New Hampshire alternative route (Figure 2.9) would enter the United States at a location 2.0 km (1.25 mi) northwest of Tabor Notch, New Hampshire. It would extend along new right-of-way in a southeasterly direction through the towns of Pittsburg, Clarksville, Stewartstown, Colebrook, Columbia, Odell, and Stratford in Coos County. The route would then extend to the southeast on new right-of-way and parallel existing 115-kV transmission line right-of-way through the town of Stark, Coos County. The route would diverge from existing right-of-way and traverse a portion of the town of Northumberland in a southwesterly direction. It would rejoin an existing 115-kV transmission line and extend south through Northumberland, Lancaster, and Whitefield. At a point east of Wee Pond, the route would diverge from existing right-of-way and traverse Whitefield and Dalton on new right-of-way extending southwesterly. After crossing the Johns River in Dalton, this alternative route would parallel another existing 115-kV transmission line over Dalton Mountain to the Connecticut River. The route would cross over the 115-kV line at the river

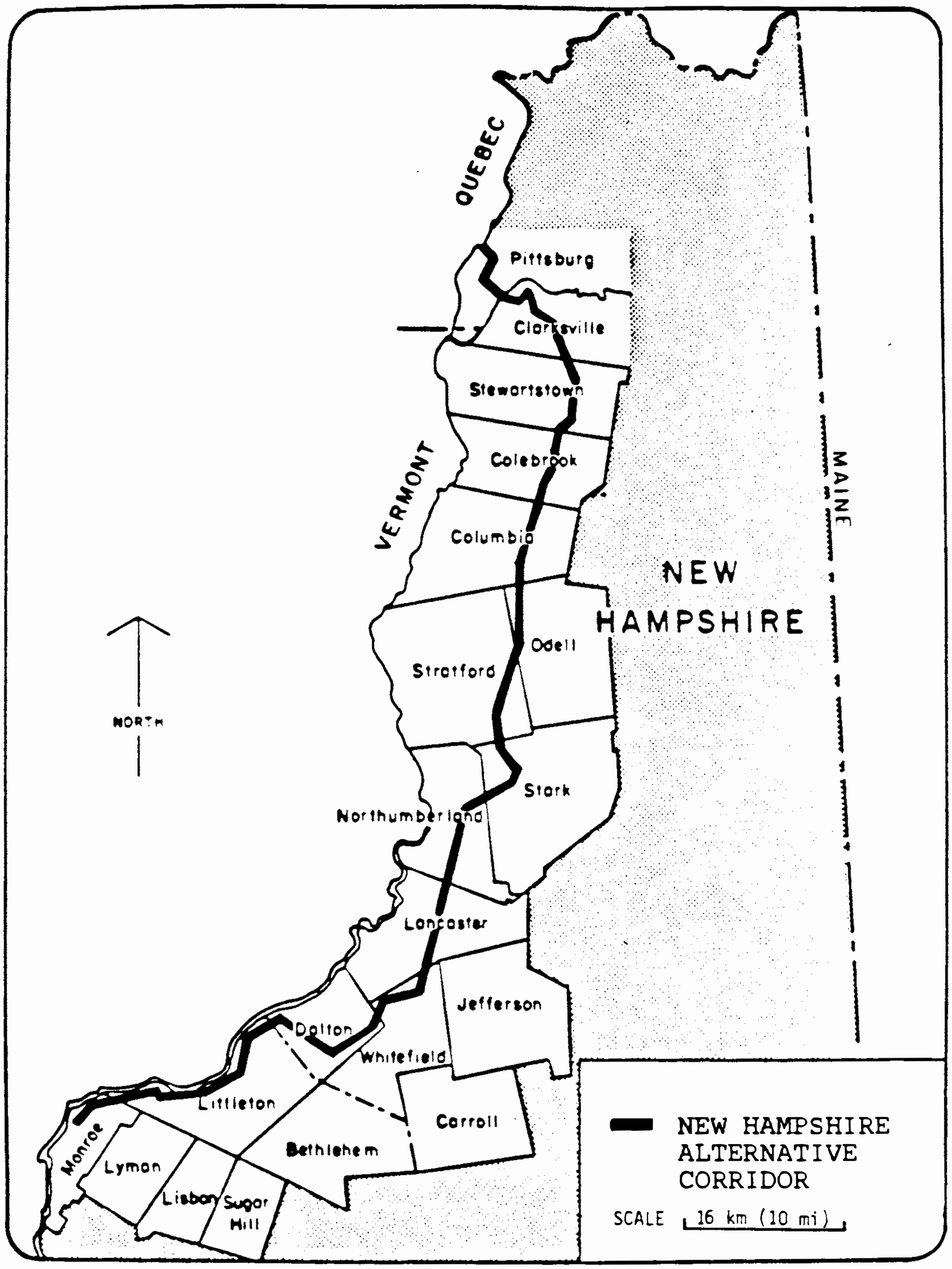

Figure 2.9. New Hampshire Alternative Corridor. Source: Modified from ER (Vol. 2--Exhibit 2-9).

and then traverse Dalton on new right-of-way in a southwesterly direction. Paralleling the Connecticut River, the route would cross the town of Littleton, Grafton County, on new right-of-way. At the end of this segment, it would span two portions of Moore Reservoir. This alternative route would parallel existing 115-kV line near the Littleton Substation and then turn northwesterly to proceed on new right-of-way, meeting the final 11 km (6.8 mi) of the Preferred Corridor near Moore Dam.

2.2.3 Comparison of Preferred Corridor and Alternative Routes

2.3 NO-ACTION ALTERNATIVES--ALTERNATIVES TO THE INTERCONNECTION

The decision under consideration by DOE is, in this case, to grant or deny a Presidential Permit to the Applicant for an international interconnection for power exchange between NEPOOL and Hydro-Quebec. Therefore, a no-action decision on the part of DOE is equivalent to denial of the Permit. If the Applicant chose a course of maintaining the status quo, NEPOOL would be dependent upon oil as fuel for approximately 43% of its projected capacity by 1990 (Table 1.1). Alternatively, the Applicant may choose other sources of non-oil-fueled generating capacity to decrease dependence upon oil fuels by the equivalent amount projected for the proposed interconnection. These alternatives for generating capacity are discussed below.

2.3.1 Construction and Operation of a New, Conventional Generating Facility

Construction of a new, non-oil-fired generating plant could replace oil-fired capacity that was obsolete or for which early retirement could be justified on the basis of fuel savings. Candidate plant types would be nuclear, coal, or hydropower. Nonconventional fuel candidates--such as biomass, solar, or wind--are discussed in Section 2.3.2.

If a coal-fired generating plant were under construction now, it would come on-line about 1990, which would be about 4 years later than the proposed interconnection. A nuclear plant beginning construction in 1984 would not become operational before 1994, which would be beyond the time currently thought to be critical. The capital cost of either a coal or nuclear facility would be several times that estimated for the proposed DC/AC converter terminal and transmission line. Neither of these options, coal or nuclear, would be as viable an option as the proposed interconnection, where timely oil backout or economics are prime considerations.

Construction and operation of a new, centralized generating facility (coal or nuclear) would result in environmental impacts that would generally differ from those associated with the proposed interconnection. Because these impacts would be highly site- and design-specific, they cannot be quantified for discussion here; however, a generic description of these potential impacts can be presented.

Features of a coal-fired power plant that have the greatest potential for adverse environmental impacts include coal mining, coal cleaning and storage, particulate and gaseous combustion emissions, disposal of fly ash and flue-gas desulfurization sludge, and release of thermal effluents to aquatic systems (Dvorak et al. 1978). Coal mining, clearning, and storage result in land disturbance, noise, and release of toxic liquid effluents (often termed acid drainage) into surface waters. Disposal of combustion products (ash and desulfurization sludge) requires sizable land areas and has the potential for adverse effects on groundwater, soils, and aquatic systems. The toxic effects of air pollutants from combustion emissions (sulfur dioxide, nitrogen oxides, and particulates) on plants and animals can be significant. Acid precipitation, a secondary effect of combustion emissions, is known to cause direct and indirect impacts on terrestrial and aquatic ecosystems. Release of heated condenser cooling water to aquatic systems has the potential to be detrimental to fish, shellfish, and other aquatic organisms. The effects of construction of new transmission lines associated with the powerplant would be qualitatively similar to those discussed for the proposed interconnection.

The most significant environmental concern associated with a coal-fired generating facility of a size that would produce power equal to that supplied by the proposed interconnection would probably be combustion emissions; localized deterioriation of air quality in terms of sulfur dioxide and particulates would likely result from operation of a 700-MW coal-fired plant (Dvorak et al. 1978).

Air quality impacts from an operating nuclear plant are negligible, but land disturbance for plant and transmission facilities would be similar to a coal-fired plant, as would the potential thermal effects to aquatic systems. Nuclear facilities have the added problems of radioactive waste disposal and generally adverse public opnion regarding the safety of nuclear power facilities. Currently, no new nuclear plants are under construction-license consideration by the U.S. Nuclear Regulatory Commission.

There is no known potential in New England for further large-scale, hydropower-based generation capacity sufficient to replace the Hydro-Quebec interconnection (see Section 2.3.3 for discussion of small, decentralized energy sources). Therefore, this alternative is not believed by DOE to be a viable alternative to the proposed interconnection.

2.3.2 Construction and Operation of Nonconventional Generating Facilities

Solar-, wind-, and biomass-fueled facilities of a size required to meet power needs of 690 MW cannot be considered as alternatives to the Hydro-Quebec interconnection. The optimum technologies for the exploitation of these fuels will not be available in time to allow oil backout in the same quantity or time frame as the interconnection. However, these fuels are now and will increasingly be used in small, dispersed sites throughout New England (U.S. Dep. Energy 1981). Dispersed use of these technologies is discussed in Section 2.3.3.

2.3.3 Conservation, Fuel Conversion, and Decentralized Energy Sources

Implementation of conservation measures (e.g., insulation, weatherization, energy-efficient appliances or machinery, and more efficient lighting or heating) in any of the customer classes (residential, industrial, or commercial) results in less energy use, which may be translated into less demand for oil-fired generating capacity. Likewise, implementation of small-scale, dispersed applications of various energy technologies--e.g., (a) solar, primarily for single-residence or business applications of solar water or space heating and photovoltaic power generation; (b) wind electric generation;

(c) low-head hydroelectric installations; (d) coal-fired industrial cogeneration; and (e) wood stoves for home and business space heating--could also decrease electric energy demand and reduce the need for oil-fired generating capacity.

DOE's determination of demand for the NEPOOL service area (see Section 1.4) involved consideration of the effects of conservation by NEPOOL customers and utility load management and conservation programs. Thus, the benefits of the proposed interconnection are in addition to any benefits from conservation, and the proposed interconnection is not a substitute for conservation or alternative energy sources.

In addition, the member companies of NEPOOL are actively pursuing the development of alternative generation sources, and contributions from these sources have been included in the planning studies. For example, New England Electric began purchasing power from the Lawrence Hydroelectric project in September 1981 (about 15 MW) and has been involved in the construction of the U.S. Windpower Windfarm at Crotched Mountain, New Hampshire, where 20 wind machines have a total installed capacity of 1 MW. It also has a power swap/cogeneration arrangement with United Shoe Machinery, is cooperating in a photovoltaics project at the Beverly High School, is planning a woodburning facility, and recently signed a special cogeneration agreement with Brown University in Rhode Island. New England Electric has signed contracts to purchase power from a number of planned alternative energy projects, including three resource recovery facilities and a number of small hydroelectric installations. Other NEPOOL companies have similar programs. Many of these alternative energy projects are similar to the pool-to-pool transfers over the proposed interconnection because they provide energy and displace oil, but they provide little or no capacity. Data Resources, Inc., (1982) estimates that solar energy and other decentralized sources will contribute less than 0.1 MW to New England sources of electricity supply through year 2000.

However, estimates by DOE suggest that a combination of solar, wind generation, low-head hydro, wood-burning stoves, and coal-fired cogeneration could potentially contribute up to 2700 MW of capacity to NEPOOL by 1990 (U.S. Dep. Energy 1981). These estimates assume that appropriate economic incentives will exist and that institutional, legislative, and unknown technical matters will not hinder implementation. The above analysis may also be overly optimistic in that it would require a concerted and coordinated effort involving the public, commercial/industrial interests, and a number of individual utilities. At any rate, even if all of the above capacity were implemented, NEPOOL would continue to be substantially dependent on oil-fired generation. Thus, the alternatives discussed above cannot be considered alternatives to the proposed interconnection but simply additional ways to meet the overall objective of reduction in oil-fired generation.

Pursuant to implementation of the Powerplant and Industrial Fuel Use Act of 1978 (FUA--Public Law 95-620), DOE evaluated the benefits and environmental effects of converting up to 42 powerplants in the northeastern United States from use of oil and natural gas to use of coal (U.S. Dep. Energy 1981, 1982). A number of the plants examined were in the NEPOOL region. It was concluded that as many as 27 powerplants would be voluntarily converted to coal use, resulting in a substantial reduction in use of oil (U.S. Dep. Energy 1982). However, this reduction in oil-fired generation would occur irrespective of the approval by DOE of the Presidential Permit for the proposed interconnection with Hydro-Quebec. Thus, the fuel conversion program described above is not an alternative to the interconnection but a complementary means of meeting the objective of reduction in use of oil-fired generating capacity.

2.3.4 Purchase of Power from Other Utilities

Various members of NEPOOL currently purchase power from Ontario Hydro, the Power Authority of the State of New York, New Brunswick (Coleson Cove), and, to a limited extent, Hydro-Quebec (ER, Vol. 1--p. 20). These purchases amount to a maximum of 265 MW (to help cover winter peak demand). All but 148 MW of this power is under contracts that will expire by 1985. The Applicant's efforts to determine whether contracts will be renewed, and for how much, have led to the conclusion that the potential for increasing such purchases up to 690 MW (the quantity involved with the proposed interconnection) is low, especially for non-oil capacity at a price lower than NEPOOL's generating cost. Thus, purchase of power from non-NEPOOL utilities is not considered to be a viable alternative to the proposed interconnection in the current evaluation.

2.3.5 Comparison of Alternatives and the Proposed Project

The discussion of potential alternatives in preceeding subsections concluded that conservation, decentralized energy production, fuel conversion, and power purchases were not viable alternatives to the proposed interconnection for one or more of the following reasons: (1) potential capacity was too low, (2) the alternative would be implemented irrespective of the DOE decision on the proposed action, (3) alternative capacity was already figured in demand projections, and/or (4) the alternative was complementary to the proposed interconnection in that both could be implemented and would contribute toward meeting the objective of reduction in use of oil-fired generating capacity within NEPOOL.

Only alternatives involving new large-capacity, centralized generating facilities were not ruled out for the reasons stated above. Such facilities would include coal- or nuclear-fueled steam-electric plants and large-scale hydroelectric installations. Large-scale hydro was ruled out because there are no remaining sites within New England where an installation with a capacity of 600-700 MW could be located. Thus, of the alternatives examined, only coal- or nuclear-fueled generating plants are considered feasible alternatives to the proposed interconnection.

As previously stated, the nuclear option is not as economically viable as coal due primarily to the longer period required for design, licensing, and construction as well as greater costs. If a decision to construct a nuclear plant were made in 1983, the plant would likely not begin commercial operation before 1994; a coal plant could possibly be put on-line by about 1990. The long lead time for either type of facility would minimize or even preclude attainment of significant economic benefits associated with reduced use of oil-fired generating capacity. The proposed interconnection could begin contributing to oil back-out as early as 1986. It is also important to emphasize that construction and operation of either the coal or nuclear option would cost several times more than the proposed interconnection. Maintenance costs for the interconnection would be minimal compared to those of the powerplants, particularly when plant fuel costs are added. Environmental impacts would also be greater with the powerplant option. Even though the types of impacts differ and a quantitative comparison cannot be made, it is clear that the number of impacts and, in general, the magnitude of impacts would be significantly greater with the powerplant alternative.

Impacts associated with the interconnection would essentially be limited to the three-year construction period; the current evaluation by DOE identified no significant adverse impacts related to operation of the proposed transmission line and only short-term~~, relatively mino~~r impacts related to construction of the interconnection. Powerplant impacts would be of a similar magnitude (or possible greater) during the construction period (although the construction period would be much longer), but operational impacts (previously discussed) would exist for the 30-year life of the plant. ~~Although operational impacts could be largely mitigated or minimized, there would undoubtedly be some minor environmental degradation in the vicinity of the plant, e.g., local effects on air quality due to combustion emissions and possible thermal or chemical impacts to aquatic systems due to plant effluents. Additionally, other minor impacts would result from mining, processing, transportation, and storage of fuel and from disposal of combustion wastes or spent nuclear fuel.~~

~~It is the opinion of the DOE staff that the powerplant alternative is substantially less desirable because of the significantly greater adverse environmental impacts, the much greater capital and maintenance costs, and the long delay that would exist before accrual of economic benefits. Additionally, because no other alternative to the interconnection was found to be viable (for reasons stated at the beginning of this section), DOE considers the proposed action to be the preferred alternative. Alternative routes for the interconnection are described in Section 2.2 and compared in Section 4.2.~~

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3. AFFECTED ENVIRONMENT

3.1 CLIMATE, METEOROLOGY, AND AIR QUALITY

The climatic characteristics of northeastern Vermont and northwestern New Hampshire are generally: changeable weather, large day-to-day and annual temperature variations, evenly distributed monthly precipitation, great differences between the same season of different years, and considerable anomalies in localized climate (Lautzenheiser 1959a, 1959b). The nearest first-order weather station to the proposed transmission line corridor is Burlington, Vermont, where climatic averages are: (1) a mean monthly temperature of 7°C (45°F), ranging from -8°C (18°F) in January to 21°C (70°F) in July, and (2) an annual precipitation of 833 mm (33 in.) and an annual snowfall of 2000 mm (79 in.) (Natl. Oceanic Atmos. Admin. 1980).

The changeability of the weather is attributable to the large number of storm tracks and the frequent migration of air masses through the region. The predominant wind direction is west, with deviations to the southwest in the summer and to the northwest during winter. The winds within the valleys tend to parallel the terrain. The average monthly wind speed is about 4 m/s (9 mph) and remains fairly constant during the year. The fastest mile (i.e., the fastest record passage of one mile of air) at Burlington is 32 m/s (72 mph) (Natl. Oceanic Atmos. Admin. 1980).

Precipitation is fairly uniform throughout the year and is mainly associated with frontal passages. Sunshine averages about 50% of possible on a year-round basis. Although the frequency of frontal passages decreases during the summer months, increasing thunderstorm activity in the summer more than compensates for the precipitation difference. Snow cover is usually continuous through the winter (Baldwin 1974). A monthly summary of foul weather as recorded at Burlington is found in Table 3.1.

Hurricanes occasionally affect northern Vermont, but the area is far enough inland that the destructive nature of the winds is considerably lessened. Thunderstorm days have a frequency of 20 to 30 per year; however, severe thunderstorms with attendant hail or tornadoes are rare (Baldwin 1974). Glaze and freezing rainstorms in winter make travel hazardous. At least one ice storm each winter season can be expected (Lautzenheiser 1959a). Structural design of steel towers will include the possible ice load and magnified wind stress caused by the increased area exposed to the wind.

The few air quality monitors that exist in the region are usually sited near major stationary sources of pollution and, therefore, do not represent the rural setting found along the proposed transmission line corridor. Ambient air quality data for 1979 (U.S. Environ. Prot. Agency 1980) indicate that the pollutant levels of suspended particulates, sulfur dioxide, and nitrogen dioxide are well below standards in the urban areas of Vermont and are

Table 3.1. Summary of Foul Weather Recorded at Burlington, Vt

Month	Percent of Possible Sunshine	Mean Sky Cover†[1]	Number of Days: Sunrise to Sunset: Clear	Partly Cloudy	Cloudy	Precipitation (≧ 0.01 in.)	Snow, Ice Pellets (≧ 1.0 in.)	Thunderstorms	Heavy Fog (visibility ≦ 0.25 mi)
Jan	41	7.6	4	7	20	14	5	*†[2]	1
Feb	48	7.3	4	7	17	12	5	0	1
Mar	51	7.2	6	6	19	13	4	*	1
Apr	50	7.1	5	8	17	12	1	1	1
May	56	7.0	5	9	17	13	*	2	1
Jun	59	6.7	5	10	15	12	0	6	1
Jul	65	6.4	5	13	13	12	0	7	1
Aug	61	6.4	6	12	13	12	0	6	1
Sep	54	6.5	6	10	14	12	0	2	3
Oct	49	6.8	6	8	17	11	*	1	2
Nov	31	8.3	3	5	22	14	2	*	1
Dec	33	8.1	3	6	22	15	5	*	1
Yearly	50	7.1	58	101	206	153	22	25	16

†[1] Sunrise to sunset.

†[2] * = Less than one-half.

Source: National Oceanic and Atmospheric Administration (1980).

undoubtedly even lower in the rural areas. Carbon monoxide and hydrocarbon levels are probably well below standards in the rural areas also. However, ozone is known to occur at high levels even in rural areas. Elevated levels of ozone are not infrequent in the urban areas of New England (U.S. Environ. Prot. Agency 1980), and it should be assumed that these high levels may occur in the rural areas along the proposed transmission line.

3.2 LAND FEATURES AND USE

3.2.1 Topography, Geology, and Soils

The study area is located within the White Mountains section of the New England Physiographic Province (Fenneman 1928). Underlying the proposed corridor, the bedrock consists of metamorphosed sedimentary and volcanic rocks that have been intruded by granitic rocks. In general, the intrusive rocks weather and erode more slowly than the metamorphosed sedimentary rock and have given rise to a complex topography (U.S. Dep. Energy 1978). Many features of topography, hydrology, soils, and vegetation can be related to the action of Pleistocene glaciation and nonglacial fluvial erosion. Frost action is considered to be the major erosive force at higher elevations.

New England soils are comparatively young, having formed some 11,000 to 15,000 years ago after the recession of the last glacier. In many areas, especially the mountains, glacial scouring removed all surface material. Because of the length of time required to weather bedrock into soil, the soils in such areas are very thin and poorly developed. Soils that have developed on glacial till are somewhat deeper and silty but are also stoney and continue to heave up boulders during the seasonal freeze-thaw cycles. Soils forming in the stream valleys may be sandy or silty and may contain areas of peat or muck.

Because of the rugged topography and heavily wooded nature of the terrain, detailed soil investigations near the transmission corridor have been restricted to more open river valleys and road cuts. Nonetheless, the section can be described as having ice-contact stratified drift and outwash underlain by till in the valleys, thin layers of till and occasionally a kame terrace on the valley slopes, and exposed bedrock on the hilltops (Borns and Calkin 1977). The proposed converter terminal will be located on relatively flat terrain with well-drained soils developed on glacial till.

3.2.2 Agriculture

Since the late 1800s, the number of operating farms and farmland acreage in the study area has been steadily declining. The most productive agricultural soils are found along the Connecticut, Coaticook, Moose, Nulhegan, and Ammonoosuc river valleys and the valley area around Island Pond (ER, Vol. 2--p. 31 and Vol. 3--p. 101). Prime agricultural soils identified by the U.S. Soil Conservation Service are mostly located in the southern and western portions of the study area (U.S. Dep. Agric. 1974a, 1974b; Pilgrim and Peterson 1979). In 1978, farmland accounted for 31.3% of the total land area in Caledonia County, Vermont; 6.0% of Essex County, Vermont; and 8.0% of Grafton County, New Hampshire (U.S. Bur. Census 1977, 1978). The major agricultural commodities for all three counties are dairy products and livestock (U.S. Dep. Agric. 1980, 1981).

Near the Preferred Corridor, the town of Norton has the most extensive amount of agricultural land. Eight active farms are located east and southwest of the village along State Route 114 and the Coaticook River (see Figure 2.3), where the soils are suited for multicrop capability as well as pastureland (ER, Vol. 3--p. 101; Town of Norton Plan. Comm., undated). The average farm is 60 ha (150 acres) in size with a dairy herd of 50 to 150 in number. Active farms are also located near the proposed transmission line corridor along Shore Road near the village of Granby and in the town of Waterford near Moore Reservoir (ER, Vol. 3--Appendices, Land Use Map L-1/1-8). The New Hampshire towns of Littleton and Monroe are largely forested with scattered parcels of agricultural land (ER, Vol. 2--p. 33). Approximately 15% of the 9-ha (23-acre) terminal site location in Monroe, New Hampshire, is currently under crop cultivation.

3.2.3 Forestry

Within the study area, most of the Preferred Corridor traverses Essex County, the most extensively forested county in the state of Vermont. The forest types found in the study area are described in Appendix C. Based on the latest comprehensive surveys (Kingsley 1976, 1977), about 75% of Caledonia County and 94% of Essex County are classified as forestland and virtually all of the forested area qualifies as commercial timberland. About 90% of Grafton County is classified as forestland, and about 80% is designated as commercial timberland. Collectively, the maple/beech/birch and spruce/fir forest types occur on 76% of the commercial timberlands, and comprise 73% of the net growing stock and 74% of the net volume of sawtimber in Essex County. Comparable percentages for Caledonia County are 73, 70, and 78%, respectively. In Grafton County, the white and red pine, spruce/fir, and maple/beech/birch forest types occupy 80% of the commercial forestland, and comprise 84% of the net volume of growing stock and 85% of the net volume of sawtimber.

The more striking attributes of Vermont and New Hampshire forest resources are that most commercial timberlands are underutilized and undermanaged. Considerable valuable growing space is occupied by rough and defective trees. Economic constraints and losses due to pest infestations are among the more significant factors affecting the management and utilization of forest resources (Appendix C). During the period 1977 to 2030, the area of commercial timberland in Vermont is expected to remain relatively stable, whereas that in New Hampshire is expected to decrease about 23% (Wall 1981).

3.2.4 Mining

Essentially, all of the bedrock formations within the study area are composed of metamorphic and igneous rock. Mineral resources in these igneous and metamorphic terrains are in the category of nonmetallic industrial rock and mineral products. Bedrock minerals in the study area are generally uneconomical to mine and only of local importance because they are usually of low grade and found only in small deposits. To date, mineral extraction has never taken place on a large scale and provides a living for only a few persons (ER, Vols. 2 & 3).

Various types of glacially derived sediments cover bedrock formations in thicknesses ranging from 1 to 60 m (a few to several hundred feet) in the major river valleys in the study area. Sand and gravel are extracted from deposits adjacent to the walls of the glacially formed valleys. These deposits are not extensive and are used only for local construction materials (ER, Vol. 2 & 3).

3.2.5 Recreation

Tourism is currently the second most important industry in Vermont, exceeded only by the economic benefits derived from the manufacturing sector (DeLorme Publ. Co. 1981a). Outdoor recreation is a major component of New Hampshire's economy and mode of life (Forest Resour. Comm. 1980). The Green Mountains National Forest to the west of the study area and the White Mountains National Forest to the east of the study area afford opportunities for a wide range of dispersed recreational activities. Natural resources and developed recreation facilities in the national forests contribute substantially to meeting recreational demands by out-of-state visitors as well as residents.

Much of the participation in outdoor recreation stems from individuals engaged in various types of dispersed recreation such as auto touring, river touring, snowmobiling, cross-country skiing, bicycling, hiking, hunting, and fishing. A high portion of land in the study area is privately owned and posting of private properties has become commonplace. Thus, there is no reliable way for estimating the amount of private land available for hunting, fishing, and other dispersed recreation on an informal basis.

The only federally administered recreation site within the study area is the McIndoes Dam fishing and picnic area in Caledonia County (Vt. Agency Environ. Conserv. 1978). Within Essex and Caledonia counties, the state of Vermont's recreational holdings vary in size from small roadside picnic areas and water access developments to a 6,000-ha (15,000-acre) portion of the Groton State Park/State Forest complex in extreme southwestern Caledonia County (towns of Groton and Peacham). Other major Vermont state holdings in the study area are the Steam Mill Brook Wildlife Management Area (WMA), four parcels of Darling State Park, and Willoughby State Forest in Caledonia County; and Victory Bog WMA, Victory State Forest, and Hurricane Brook WMA in Essex County. State-owned recreation sites within or adjacent to the New Hampshire portion of the study area include Forest Lake State Park, Strawberry Hill State Forest, and the Lake Partridge public access.

Many of the municipal and private holdings in the study area are urban-type facilities such as playgrounds, swimming pools, and city parks. The more intensively developed areas in Caledonia County are at or near the villages of St. Johnsbury and Lyndonville. In Essex County, the greatest concentration of developed recreational facilities is at and around Island Pond in the town of Brighton. Near the New Hampshire segment of the Preferred Corridor, such facilities are concentrated around the village of Littelton. Municipal forests are used for a variety of recreational activities, and some are of appreciable size, i.e., roughly 405 ha (1000 acres) of land area--including the St. Johnsbury Municipal Forest (town of Waterford) and Hardwick Village Municipal Forest (town of Hardwick) in Caledonia County, and the Brighton Waterboard Municipal Forest (town of Brighton) in Essex County. The quasi-public/private sector provides a wide variety of recreation developments in rural settings including ski resorts, hunting and/or fishing lodges, developed campgrounds, and riding stables.

Notable private holdings along the Preferred Corridor include Comerford Reservoir, Moore Reservoir, and adjacent land areas owned by the New England Power Company. The reservoirs are accessible to the public at several points and include developed boat launchings. Opportunities for fishing, boating, and other water-based recreational activities are available in areas other than those restricted for public safety.

Auto touring is a principal type of dispersed recreation activity on a year-round basis. Pull-outs, picnic tables, and trash cans are common facilities along the more scenic routes. Major transportation routes are in the study area are identified in Figure 2.3. However, numerous secondary roads and trails are utilized for sightseeing, particularly during fall color changes in tree foliage. Bicycling is the second most popular recreational activity in the area during the summer season, and the trend indicates a further increase in popularity (Vt. Agency Environ. Conserv. 1980). Four bike touring routes traverse portions of Essex and Caledonia counties, as well as northern Grafton County in New Hampshire (DeLorme Publ. Co. 1981a, 1981b). Segments of the bike touring routes that traverse the right-of-way of the proposed New England/ Hydro-Quebec interconnect include: State Route 50 extending between Pond Island and Bloomfield, Essex County; State Route 135 extending between Lancaster and Littleton, New Hampshire; and State Route 18 extending northwesterly from Littleton to a junction with U.S. Route 2 east of St. Johnsbury, Vermont.

There are no major cross-country hiking or backpacking trails within the study area; thus, extended hiking is primarily limited to the larger public ownerships outside the area.

Numerous lakes, ponds, rivers, and streams in the study area are potential fishing areas (Section 3.4.2). Most lakes and ponds are used as "natural" sites for swimming, which is identified as the most popular summer recreational activity in Vermont (Vt. Agency Environ. Conserv. 1978). A number of waterways are identified as white-water routes for canoeing or kayaking: the Clyde River between Pensioner Pond and Island Pond; the Moose River between Gallup Mills and North Concord; short segments of the lower Nulhegan River; a short segment of the Passumpsic River below Lyndonville; a short segment of the Lamoille River in extreme western Hardwick; and the lower segment of the Wells River. Additionally, portions of the Connecticut River provide opportunities for either day or overnight canoe trips; these rivers are ranked Class II and III waters (i.e., easy and intermediate degrees of difficulty, respectively) according to the International River Classification System (DeLorme Publ. Co. 1981a).

Cross-country skiing and hunting are the two most popular winter sports in the area (Vt. Agency Environ. Conserv. 1980). Two well-known ski touring centers in the study area are located near East Burke and another is at Peacham (DeLorme Publ. Co. 1981a). Also, downhill skiing is available at East Burke and Lyndonville. Most cross-country skiing occurs informally on both private and public lands. In parallel with skiing activities, participation in snowmobiling has increased in recent years and is ranked as the seventh most popular winter recreational activity in Vermont (Vt. Agency Environ. Conserv. 1978). The level of snowmobiling is also high in New Hampshire (Quinn 1982); the Bureau of Off Highway Vehicles sponsors and maintains trails in numerous areas throughout the state (DeLorme Publ. Co. 1981b).

3.2.6 Residential, Commercial, and Industrial

Development is basically concentrated in the southern portion of the study area in the Vermont towns of Granby, Concord, Waterford, and St. Johnsbury and the New Hampshire towns of Littleton and Monroe (Figure 2.2). Vermont has traditionally defined an urban area as a town or city having a population of 5000 persons or greater (Vt. Agency Environ. Conserv. 1978). Currently, the only towns within the study area with a population of more than 5000 are St. Johnsbury and Littleton (Figure 2.3); the only additional town in Vermont that is predicted to have a population greater than 5000 by the year 2000 is Lyndon. Littleton is the largest community in the southern portion of the study area. There is considerable residential and commercial development in the center of the Littleton area and along the major roadways near the area (ER, Vol. 2--p. 44). Residential growth has occurred east of Littleton into Bethlehem and south to Lisbon. There is also scattered residential development northwest of the community. Moore and Comerford Reservoirs, owned by New England Power Company, form a large power generation and transmission complex within the towns of Littleton and Monroe.

There are a number of second or vacation homes scattered throughout the study area. Most of these homes are located along lake shorelines and rivers or in ski areas and exceptionally scenic or picturesque villages. In 1973, Essex County had approximately 1200 second homes, and Caledonia County had approximately 1400 second homes (Vt. Agency Environ. Conserv. 1978). Grafton County contains 1500 to 2000 second homes.

The majority of the study area is part of the Northeastern Vermont Development Association Regional Planning Area, which also includes Orleans County. This region is often referred to as the Northeast Kingdom and is characterized by an overall low population density and rural environment that is heavily forested. Such rural areas, which comprise about 77% of Vermont's land area, are specifically noted for sparse settlement patterns and large land ownerships. These villages and small communities (population below 2500) generally focus development pressure inward, except along lakeshores and major transportation routes. Five paper companies control approximately 80% of the land along the Preferred Corridor. The four largest private landowners in the Northeast Kingdom are the St. Regis Company, James River Company, Diamond International Company, and International Paper Company. About 90% of these large forest landholdings are located in Essex County (ER, Vol. 3--p. 46). Smaller forest management companies in the area include Washburn, Georgia Pacific, and Boise Cascade.

Of those towns traversed by the Preferred Corridor, only Norton, Brunswick, Concord, Waterford, Littleton, and Monroe have either a municipal development/land-use plan, subdivision regulations, or zoning laws. In general, the designated uses or districts include rural/residential, lakeshore and streambank, agricultural and forest, and industrial-commercial. Land-use plans for the study area indicate that the pattern of future development will be similar to that of the past. Current developed areas may expand slightly, but much of the land will remain forested. According to realtors in St. Johnsbury, forestland in Essex County sells for about \$250 to \$300 per acre (ER, Vol. 3--p. 49). In 1980, the average price of residences in the towns in Essex County that would be traversed or in close proximity to the transmission line corridor ranged from \$7,000 to \$34,500 (ER, Vol. 3--Exhibit 3-25).

The southern end of the Preferred Corridor and the proposed terminal site are located in the town of Monroe, New Hampshire. All the land that would be occupied by the terminal station is owned by the New England Power Company. Under the Monroe Zoning Ordinance of 1979, the area is designated as a rural zone (ER, Vol. 1--p. 34). Land adjacent to the site is dominated by electric generation and transmission facilities (e.g., Comerford Dam Substation transmission lines). The closest residences are located along State Route 135, approximately 100 m (2000 ft) from the proposed site, and a total of six residences are located within approximately 1 km (0.5 mi) of the site (ER, Vol. 1--pp. 34 and 42).

3.2.7 Natural Areas

None of the Primary Natural Areas identified by the Vermont Natural Areas Project (VNAP) are located in the vicinity of the proposed New England/Hydro-Quebec transmission line right-of-way (Vt. Agency Environ. Conserv. 1978). Moose Bog, a 133-ha (330-acre) site located in Essex County, west of the Preferred Corridor, is included in the Vermont Fragile Areas Registry and the Unique Wildlife Ecosystem Program administered by the U.S. Fish and Wildlife Service (1979).

Moose Bog is a peat bog and a habitat for bird, mammal, and plant species of very restricted distribution in the state of Vermont (Vt. Agency Environ. Conserv. 1982). The bog is currently owned by the Vermont Fish and Game Department. Vermont natural areas in the vicinity of the proposed transmission line right-of-way have been identified by the Applicant (Table 3.2).

The nearest significant natural area near the New Hampshire portion of the study area, as selected by the advisory committee of the Society for the Protection of New Hampshire Forests, is Franconia Notch, a registered Natural Landmark located in Grafton County 35 km (22 mi) southeast of the Preferred Corridor (N.H. Dep. Resour. Econ. Dev. 1977). The New Hampshire Office of State Planning recognizes 8 privately owned and 78 publically owned natural areas in Coos and Grafton counties (Forest Resour. Comm. 1980). Only one area is near the New Hampshire portion of the study area: Airport Marsh, a state wildlife management area located in the town of Whitefield, about 30 km (19 mi) northeast of the Preferred Corridor. Other local natural areas are the Rocks and Bretzfelder sites, conservation education areas in the town of Bethlehem; and the Greason and Bradley properties (town of Dalton), and the Forbes/Martin property (town of Sugar Hill), which are conservation easement areas. Recognized unusual plant communities occur in the Littleton Wildflower Preserve, town of Littleton, and Spaulding Swamp, town of Whitefield. Additionally, the New Hampshire Office of Comprehensive Planning classifies wetlands, steep slopes, and floodplains as future conservation lands where development should be limited because of natural resource features and other environmental considerations (ER, Vol 2).

3.2.8 Airports, Navigation Routes, and Training Areas

Within the Vermont portion of the study area, airports are located near St. Johnsbury and Island Pond, and a small private landing strip is located near the village of Norton (ER, Vol. 3--p. 125). An airfield is also located in Littleton, New Hampshire (DeLorme Publ. Co. 1981b). A military training

Table 3.2. Natural Areas of Vermont in the Vicinity of the Proposed New England/Hydro-Quebec Transmission Line Right-of-Way

Natural Area	Inventory Number†[1]	Significance Level	Area		Location (Towns)
			Hectares	Acres	
Ferdinand Bog	V0009	Local/State	332	820	Ferdinand
Brousseau Mt. Lodus Slopes	V0262	Local/State	150	370	Norton, Averill
Little Averill Lake Beach	V0280	Local/State	2	4	Averill
Mud Pond	V0266	Local/State	32	80	Grandby
Victory Bog	V0841	Local/State/Regional	405	1000	Victory
Averill Lake	V0368	Local/State	518	1280	Averill, Norton
Concord Sugar Maple-Beech Forest	V0395	Local/State/Regional	57	140	Concord
Gore-Sable-Monadnock Wilderness	V0952	Local/State/Regional	4045+	10000+	Averys Gore, Averill, Lewis, Ferdinand Bloomfied, Remington, Brunswick
East-West Mts. Wilderness	V0953	Local/State/Regional	4045+	10000+	Ferdinand, Brunswick, Maidstone, Grandby, East Haven, Newark
Umpire-Temple Mts. Wilderness	V0054	Local/State	4045+	10000+	Victory, Lunenburg, Concord
Notch Pond Brook Deeryard	V0740	Local	162	400	Ferdinand, Brunswick
Paul Stream Deeryard	V0741	Local	283	700	Ferdinand, Maidstone
Rogers Brook Deeryard	V0742	Local	202	500	Victory, Grandby
Lee's Hill Deeryard	V0743	Local	162	400	Victory
Bog Brook Deeryard	V0744	Local	690	1700	Victory
Nulhegan Deeryard	V0745	Local/State	4045+	10000+	Lewis, Brighton, Ferdinand, Brunswick, Bloomfield

†[1] Numbers from the Vermont Natural Areas Inventory.

Source: ER (Vol. 3).

route (IR-800) crosses over the Preferred Corridor north of Granby. A low-altitude federal airway (V-104) crosses over the proposed line near Miles Pond. A Military Operations Area (Yankee One, MOA) is located in the southern portion of the study area (U.S. Dep. Commer. 1982).

3.2.9 FERC-Licensed Lands

Where the Preferred Corridor crosses the Connecticut River, the lands are owned by New England Power Company under a license from the Federal Energy Regulatory Commission (FERC). The proposed line would parallel existing transmission lines for a distance of approximately 4.0 km (2.6 mi) on FERC-licensed lands. In addition to the transmission lines, nearby FERC-licensed lands contain power generation facilities associated with the Comerford and Moore reservoirs. The FERC lands that have not been devoted to reservoir facilities are predominately hardwood woodland.

3.3 HYDROLOGY, WATER QUALITY, AND WATER USE

3.3.1 Surface Water

From the northern border of Quebec and Vermont at Norton to its southern terminus at the converter terminal, the preferred transmission line corridor successively traverses the following watersheds: the eastern uplands of the Connecticut River; the Nulhegan River watershed, between its East and Black Branches, crossing the main stem of the river in the vicinity of the Route 105 bridge in the town of Bloomfield; the upper reaches of a portion of the Connecticut River watershed, drained by Notch Pond Brook; minor upland brooks flowing into Paul Stream; and the extreme eastern portion of the Connecticut River watershed in the towns of Lunenburg, Concord, and Waterford (Figure 2.3). The Preferred Corridor successively crosses the streams and rivers listed in Table 3.3. Smith Brook, a permanent stream, winds through the vicinity of the proposed converter terminal from a small permanent pond 0.8 km (0.5 mi) southwest of the site.

Lakes or ponds near the corridor include Notch Pond and South America Pond in Ferdinand, Mud Pond in Granby, Miles Pond in Concord, Moore Reservoir in Concord and Waterford, and Comerford Reservoir in Monroe and Littleton. The principal great wetland systems (complexes of swamps, marshes, bogs, open water, and wet woods) near the Preferred Corridor include the Yellow Bog in the town of Lewis and adjacent towns and Victory Bog in the town of Victory. The proposed corridor skirts Ferdinand Bog in Ferdinand and Moose Bog in Ferdinand and Brunswick (ER, Vol. 3).

In March 1978, the Vermont Water Quality Standards were adopted by the Water Resources Board. These standards are in the process of being reviewed and revised, as are the federal regulations governing water quality standards. Within the Vermont portion of the study area, segments of the Clyde and Barton rivers, the lower half of the Moose River, the Water Andric, and the Passumpsic River and its East Branch have been classified under the 1978 standards as either Class B or Class C waters.* In northeastern Vermont, the major type of water pollution is attributable to nonpoint source pollution resulting from silviculture activities. Timber harvesting increases the rate of soil erosion and increases the levels of turbidity and siltation of local waterways. Not all streams within the study area have been segmented, classified, or monitored and chemical analysis of the unclassified streams is extremely limited. These streams are assumed to be meeting all applicable water quality standards because they are not receiving point source pollution discharges and nonpoint problems are believed to be limited. Thus, they would probably be Class A or Class B waters (Vt. Agency Environ. Conserv. 1982).

Except for the Connecticut River, the lower half of the Ammonoosuc River, and the final reaches of the Israel and Johns rivers--which are classified as Class C waters--all rivers within the New Hampshire portion of the study area are currently meeting the goal of fishable/swimmable water quality (Class A or Class B) as well as state water quality standards (N.H. Water Supply Pollut. Control Comm. 1980). The major cause for river systems not meeting state water quality standards is the discharge of inadequately treated municipal and paper-mill wastes as well as suspected degradation caused by urban agricultural and silvicultural stormwater runoff. The New Hampshire Water Supply and Pollution Control Commission is responsible for planning and implementation of water quality protection in New Hampshire.

Floods may occur in any month of the year although they occur most frequently in the spring as the result of heavy precipitation with snowmelt. Flooding occurs fairly often during springmelt in smaller streams and tributaries, and is usually worsened by the formation of ice jams. Flooding on main streams occurs less frequently because of natural and man-made regulation from lakes or reservoirs. Localized storms occur rarely but can cause destructive flooding in brooks and small streams.

3.3.2 Groundwater

Within the study area, Paleozoic crystalline igneous and metamorphic rocks form the major consolidated rock aquifers. Reported yields of several bedrock wells range from 0.06 to 6 L/s (1 to 100 gal/min); median yields are from 0.2 to 1 L/s (3 to 16 gal/min) (Hodges and Butterfield 1967). Unconsolidated sand and gravel aquifers occur in major stream valleys such as the Nulhegan-Clyde Valley. In the Nulhegan Valley, groundwater flow is rapid in

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* Class A - Waters are of the highest quality and are potentially acceptable for water supply uses after disinfection.

Class B - Waters are considered suitable for swimming and other recreational uses, for irrigation and cattle watering, for good fish habitat, and for use as public water supply with proper treatment.

Class C - Waters are suitable for recreational boating, irrigation of crops not used for consumption without cooking, habitat for wildlife and for common food and game fishes indigenous to the region, and such industrial uses as are consistent with other class uses.

the gravel aquifer, and wells may yield over 6 L/s (100 gal/min). Yields of less than 0.06 L/s (1-2 gal/min) are common for private wells drilled into the till soil adjacent to the Preferred Corridor (ER, Vol. 3).

In New Hampshire, water quality criteria for surface water applies to groundwater. The converter terminal will obtain necessary water supplies from the Littleton Water and Light Company, which receives its water from the Gale River and a groundwater well in the Connecticut River basin. In general, groundwater in the Connecticut River basin is of good to excellent quality; has a low bacterial count, low concentrations of dissolved solids, and no suspended matter; and is generally soft (0 to 60 mg/L of hardness) or moderately hard (61 to 120 mg/L) (N.H. Water Supply Pollut. Control Comm. 1979).

3.4 ECOLOGY

3.4.1 Terrestrial

3.4.1.1 Vegetation

The local forest types of Vermont are grouped into seven major forest types because of common ecological relationships, considerable intermingling of species in transition areas between types, limited distribution of some local types, etc. Of the seven major forest types, six are represented in Essex and Caledonia counties, Vermont. Two additional forest types are found in Grafton County, New Hampshire (Kingsley 1976). These forest types are described in Appendix C. The maple/beech/birch forest type is the most extensive of the major forest types occurring in Essex, Caledonia, and Grafton counties--about 50, 42 and 44%, respectively, of the total commercial timberland in the three counties. The spruce/fir forest type comprises about 30, 25, and 22% of commercial timberlands of Caledonia, Essex, and Grafton counties. The relative extent of the white and red pine forest type within commercial timberlands of Caledonia, Essex, and Grafton counties is about 13, 12, and 14% respectively.

Aside from the commercial timberlands, additional forested areas of Caledonia, Essex, and Grafton counties are classed as noncommercial forestlands--about 1.0, 0.2, and 9.0% of the three counties, respectively. The noncommercial category includes productive forestlands, withdrawn from the forest resource base for special use, and nonproductive forest; the latter typically occurs on rocky ridges and in wetland environments. Most of the other vegetation types occurring in Caledonia, Essex, and Grafton counties are relatively nondescript in character. For example, 13% of Caledonia County is classified as cropland (U.S. Bur. Census 1977). The percentage of cropland in Essex and Grafton counties is about 3% each. Vegetation types associated with industrial, commercial, and residential land uses are also of nondescript character.

3.4.1.2 Wildlife

The Preferred Corridor traverses wildlife habitat ranging from remote forests in the north to forest interspersed with active and inactive farmland in the vicinity of the corridor's southern segments (ER, Vols. 2 & 3). The route is characterized by wildlife associated with boreal forest to the north and east and by wildlife of the northern hardwoods to the south and west (U.S. Dep. Energy 1978).

Among species more prevalent in the northern portions of the route are furbearers such as black bear (Ursus americanus), marten (Martes americana), Canada lynx (Lynx canadensis), bobcat (Lynx rufus), and snowshoe hare (Lepus americanus). Game species occurring in the north include moose (Alces alces) and several species of waterfowl (U.S. Dep. Energy 1978). Spruce grouse (Canachites canadensis) may also be found in appropriate habitat in the northern portions of the route.

In the southern portions of the route, such furbearers as long-tailed weasel (Mustela frenata) and mink (Mustela vison) are more prevalent (U.S. Dep. Energy 1978). Wood duck (Aix sponsa) and white-tailed deer (Dama virginiana) are game species that become more prevalent in the southern portions of the route.

White-tailed deer is the most important game species in the region (Godin 1977; Halls 1980; C.H. Willey 1982). It is of particular importance to this species that overwintering habitat be available in order to survive the harsh winters. During winter, white-tailed deer tend to congregate in deeryards, which provide a source of forage and shelter from cold and snow. Deeryards are characterized by the presence of a dense cover of conifers. The same areas tend to be used as deeryards from year to year, although the intensity of use varies. Within the study area, there are approximately 16,000 ha (40,000 acres) of active and historical deeryards that have been identified by the New England Natural Resources Center and the Vermont Fish and Game Department (Klunder Assoc. 1981). The Preferred Corridor crosses up to 8.6 km (5.4 mi) of known active and historical deeryards (ER, Vol. 3--App. B.D). The corridor crosses the eastern edge of an extensive deeryard associated with Yellow Bogs in the towns of Lewis, Bloomfield, and Brunswick. The corridor crosses the western edge of a smaller deeryard at the base of West Mountain and the eastern edge of a yard south of Granby Village. The corridor traverses two deeryards on the western shore of Moore Reservoir where it parallels an existing right-of-way for a 230-kV transmission line. No deeryards are traversed within the New Hampshire portion of the study area (ER, Vol. 2--Exhibit 2-62).

3.4.2 Aquatic Environment

The 37 streams to be crossed by the proposed transmission line are listed in Table 3.3. Most streams in the area are coldwater trout streams. Generally, good to excellent trout streams have the habitat characteristics given in Table 3.4. Trout streams must also maintain temperatures adequate to meet requirements for survival and reproduction. Temperature requirements for the major trout species in the study area are presented in Table 3.5. Several lakes and ponds also occur near the corridor (Section 3.3.1). These habitats provide coldwater and/or warmwater fisheries. For example, Notch Pond and South America Pond contain eastern brook trout (Salvelinus fontinalis); and Moore Reservoir contains brook trout, brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), brown bullhead (Ictalurus nebulosus), smallmouth bass (Micropterus dolomieui), walleye pike (Stizostedion vitreum), chain pickerel (Esox niger), and yellow perch (Perca flavescens) (Vermont and New Hampshire Fish and Game Departments 1982--personal communication). However, due to oxygen depletion that occurs in Moore Reservoir, the trout species are generally confined to the vicinity of tributary streams to the reservoir.

Table 3.3. Streams to be Crossed in Vermont and New Hampshire by the Preferred Corridor and Their Predominant Game Fish Species

Municipal Division	Streams†[1]	Predominant Game Species†[2]
Norton	Averill Creek (North Branch)	EBT*
	Averill Creek	EBT*, LLS
	Number Six Brook	EBT
Lewis	Tributary to Logger Brook	EBT
	Tributaries to Black Branch of Nulhegan River	EBT
Bloomfield	Nulhegan River	EBT*, BT
	Tributary to Nulhegan River	EBT
	Tributary to Notch Pond Brook	EBT
Brunswick	Notch Pond Brook	EBT*
Ferdinand	East Branch of Paul Stream	EBT*
	Paul Stream	EBT*
	South America Pond Stream	EBT*
	Madison Brook	EBT
Granby	Fitch Brook	EBT
	Stony Brook	EBT
	Tolman Brook	EBT
	North Branch Wilkie Brook	EBT
	South Branch Wilkie Brook	EBT
	Pond Brook	EBT
Victory	Rogers Brook	EBT
	Suitor Brook	EBT
	Stream	EBT
	Hay Hill Brook Tributary	EBT
Lunenberg	Carr Brook	EBT
Concord	Carr Brook	EBT
	Miles Pond Brook	EBT
	Roaring Brook Tributary	EBT, RT
	Roaring Brook	EBT, RT
	Mink Brook	EBT, RT
	Jeep Trail Brook	Insignificant
	Halls Brook	EBT, RT*
Littleton	Connecticut River	EBT**, RT**, BT**, CP, SMB, YP, WP, BB
	Bill Little Brook	EBT
	Tributary of Connecticut River	EBT
	Carter Brook	EBT
Monroe	Scarritt Brook	EBT
	Smith Brook	EBT

†[1] Listed from northern starting point (Vermont) to end of Preferred Corridor (New Hampshire). Source: ER (Vol. 1; Vol. 2--Exhibit 2-84; Vol. 3--Exhibit 3-15).

†[2] EBT = eastern brook trout; LLS = landlocked salmon; RT = rainbow trout (steelhead); BT = brown trout; CP = chain pickerel; SMB = smallmouth bass; YP = yellow perch; WP = walleye pike; BB = brown bullhead; * = stocked (stocking may actually occur in feeder ponds, e.g., Notch Pond, Averill Ponds, South America Pond); ** = occurrence primarily need feeder streams. Sources: DeLorme Publishing Company (1981a, 1981b); Wightman (1982); Ingham (1982).

Table 3.4. Habitat Characteristics of Trout Streams

Factor	Habitat Characteristics Relative to Stream Rating: Good	Excellent
Cover	Moderate undercuts, or brush, stumps	Extensive undercuts, stumps, brush in stream close to bank
Substrate	50% gravel	100% gravel, rubble
Current	Moderately variable	Extremely variable across channel, with numerous "edges"
Pool/riffle ratio	75:25 or 25:75	Near 50:50, with good interspersion
Width/depth ratio	Low	Very low

Source: Galvin (1979).

Eastern brook trout is the predominant game species inhabiting most streams to be crossed by the proposed line, whereas brown trout and rainbow trout (steelhead) are also encountered in several of the streams, e.g., Nulhegan River and Halls Brook, respectively (Table 3.3). Pertinent life history data for these species are given in Table 3.5. Salmonids are annually stocked in some of the streams or ponds feeding into the streams that will be traversed by the proposed transmission line (Table 3.3). Stocking is done to supplement natural reproduction. Generally, heavy trout fishing pressure necessitates constant restocking (Eddy and Underhill 1974).

The principal fisheries near the proposed terminal site are the Comerford Reservoir on the Connecticut River and the Connecticut River downstream of the reservoir. In addition to the previously mentioned species, these habitats could be utilized in the future for the Atlantic Salmon Restoration Program (ER, Vol. 1--p. 44), a joint effort between the New Hampshire Fish and Game Department and the U.S. Fish and Wildlife Service to restore Atlantic salmon to the Connecticut River (ER, Vol. 2--p. 57). Except for landlocked salmon, Atlantic salmon have been essentially extirpated from New England due to pollution of spawning grounds. However, the water quality of many former spawning streams has improved with the initiation of strict water quality discharge limitations, and several of the streams could meet the habitat requirements necessary for successful spawning. To date, Atlantic salmon have not been stocked in the vicinity of Comerford Reservoir. The Nulhegan River and Paul Stream drainage areas are also candidate areas for future Atlantic salmon management because preliminary investigations indicate that these areas contain potential spawning and nursery habitat for the species (Wightman 1982).

Table 3.5. Life History Aspects of the Major Salmonids in the Vicinity of the Preferred Corridor

Parameter	Life History Aspects of Salmonid Species			
	Brook Trout (*Salvelinus fontinalis*)	Brown Trout (*Salmo trutta*)	Rainbow Trout (*Salmo gairdneri*)	Atlantic Salmon (*Salmo salar*)
Spawning season	Late summer to autumn.	Late autumn to early winter.	Usually spring.	Fall.
Spawning temperature	4.4-9.4°C (40-49°F).	6.7-8.9°C (44-48°F).	10.0-15.5°C (50-60°F).	Commences when T° reach 6.1°C (43°F).
Spawning habitat	Gravel beds in shallow [usually <0.3 m (1 ft)] headwater streams or gravelly lake shallows where spring upwelling and moderate current exist.	Primarily shallow, gravelly headwaters.	Smaller tributaries of their river habitat or inlet or outlet streams of their lake habitat. Spawn on fine gravel in riffles above a pool.	Tributary streams of lakes. Usually spawn in gravelly riffles above or below a pool.
Egg development	Hatch in 50 to 100 days (T° dependent) with upper lethal T° limit for developing eggs ∼11.7°C (53°F).	Hatch in 40 to 70 days. Eggs will develop normally at T° up to 10°C (50°F).	Hatch in 18 to >100 days (T° dependent). Upper T° limit ∼15.5°C (59.9°F).	Hatch by April. Eggs develop normally at T° up to 10°C (50°F).
Larval development	Remain in nest until yolk sac absorbed. Become free-swimming when ∼38 mm (1.5 in) long.	Remain in nest until yolk sac absorbed. 7-day TL_{50} for sac fry: 22-23°C (17.6-73.4°F).	Become free-swimming 3-7 days after hatching.	Remain in nest ∼1 month until yolk sac absorbed. Sac fry median lethal T° 22-23°C (71.6-73.4°F).
Thermal preference	14-19°C (57.2-66.2°F).		Optimum below 21°C (69.8°F).	
Thermal requirements for satisfactory growth	≤20°C (68°F).	≤18.3-23.9°C (65-75°F).	≤21°C (75°F).	
Thermal requirements for spawning	≤12.8°C (55°F).		5.5-13°C (41.9-55.4°F) (peak T°).	
Food	Aquatic and terrestrial insects, molluscs, crustaceans, fish, and small mammals.	Aquatic and terrestrial insects, crustaceans, molluscs, amphibians, fish, and rodents.	Zooplankton, larger crustaceans, insects, snails, leeches, fish, and frogs.	Aquatic and terrestrial insects and fish.
Other requirements and comments	Dissolved oxygen minimum of 5 ppm throughout year. Water must be free of heavy silt, noxious gases, and other pollutants. Upper lethal T° range: 21-26.6°C (69.8-79.8°F).	Can withstand less favorable environments of of lower stream reaches. Upper critical T° ∼25°C (77°F). Minimum dissolved oxygen tolerance 4.5 ppm (summer) and 2-3 ppm (winter).	Life history characteristics are highly variable depending on location, type, and habitat. Can tolerate T° range of 0.0-28.3°C (32-83°F).	Parr succumb to T° between 32.9-33.8°C (91.2-92.8°F).

Sources: Scott and Crossman (1973), Carlander (1969), Eddy and Underhill (1974), and Becker (1976).

Other fish species encountered in the study area include slimy sculpin, blacknosed dace, longnose dace, carp, longnosed sucker, white sucker, common sucker, and various species of shiners, darters, and sunfish (MacMartin 1962; ER, Vol. 2--Exhibit 2-44).

Detailed characterizations of the benthic macroinvertebrates of the streams in the project area are not available. Because most of the streams have habitat quality capable of supporting trout, it is likely that the stream maintains a productive benthic community composed of a diverse assemblage of invertebrate species. The benthos is probably dominated by caddisflies (Trichoptera), mayflies (Ephemeroptera), stoneflies (Plecoptera), true flies (Diptera), scuds (Amphipoda), and clams and snails (Mollusca)--with species indicative of good to pristine water quality conditions being prevalent.

3.4.3 Wetlands

Wetlands are systems where the water table is usually at or near the surface or where land is covered by shallow water at least periodically (Cowardin et al. 1979). Within the study area, wetlands are principally marshes (vegetation dominated by grasses, reeds, rushes, sedges, and other nonwoody plants) or swamps (vegetation dominated by bushes and trees). Other wetland types present include bogs, prairies, and ponds. The proposed transmission line corridor crosses or passes near 54 wetlands in Vermont and two wetland areas in New Hampshire. Detailed information on the wetlands is given in Appendix B.

3.4.4 Threatened and Endangered Species

3.4.4.1 Vegetation

Robbins cinquefoil (*Potentilla Robbinsiana*), silverling (*Paronychia argyrocomas* var. *albimontana*), and small whorled pogonia (*Isotria medeoloides*) are the only plant taxa in Vermont and New Hampshire that are currently proposed or listed by the federal government as threatened or endangered (Storks and Crow 1978; U.S. Fish Wildl. Serv. 1980; Nagy and Calef 1980; U.S. Fish Wildl. Serv. 1982a, 1982b). Robbins cinquefoil is restricted to alpine areas and is not found along the proposed transmission corridor (Countryman 1978; Crow 1982). Small whorled pogonia has not been found in any of the towns through which the proposed corridor passes (Countryman 1978; Storks and Crow 1978; Crow 1982). Silverling, found in New Hampshire, occurs on montane ledges and bare slopes--which do not occur near the proposed corridor sections in that state (Storks and Crow 1978; Crow 1982). Of the 23 New England taxa under review for federal listing, only one-sided pond weed (*Potamogeton lateralis*) occurs near the Preferred Corridor (U.S. Fish Wild. Serv. 1980; Crow 1982). This species is found in quiet, open ponds.

The Applicant's consultants found 18 taxa of rare plants during 1981 and 1982 surveys within the Preferred Corridor (Table 3.6). All of the 15 taxa in Vermont are listed as endangered by the Vermont Agency of Environmental Conservation (1975). However none of these taxa are considered as rare in recent listings sponsored by the New England Botanical Club (Countryman 1978; Crow et al. 1981; Crow 1982). The state of New Hampshire does not have a formal list of rare plants although the three taxa are considered rare by local botanists (Storks and Crow 1978; Crow 1982; C.T. Main, Inc. 1982).

Table 3.6. Rare Plants in the Vicinity of the Preferred Corridor Noted in the Applicant's Field Investigations

Vermont	
Braun's holly fern	Polystichum Braunii var. Purshii
Moccasin flower	Cypripedium acaule
Frog orchis	Habenaria viridis var. ophioglossoides
Green woodland orchis	Habenaria clavellata var. ophioglossoides
Northern green orchis	Habenaria hyperborea var. huronensis
Leafy white orchis	Habenaria dilatata
Round-leaved orchis	Habenaria orbiculata
Ragged orchis	Habenaria lacera
Purple fringed orchis	Habenaria psycodes
Bastard hellebore	Epipactis Helleborine
Nodding ladies'-tresses	Spiranthes cernua
Hooded ladies'-tresses	Spiranthes Romanzoffiana
Rattlesnake plantain	Goodyera tesselata
Spotted coralroot	Corallorhiza maculata
Trailing arbutus	Epigaea repens
New Hampshire	
Bullet fern	Crystopteris bulbifera
Sharp-lobed hepatica	Hepatica acutiloba
Grass-of-Parnassus	Parnassia glauca

Source: Vermont Electric Transmission Company (1982); C.T. Main, Inc. (1982); Aquatec Inc. (1983).

3.4.4.2 Wildlife

There are four taxa of wildlife listed by the federal government as threatened or endangered that could possibly occur along portions of the corridor: bald eagle (Haliaeetus leucocephalus), peregrine falcon (Falco peregrinus), Indiana bat (Myotis sodalis), eastern cougar (Felis concolar cougar), and eastern timber wolf (Canis lupus) (U.S. Dep. Energy 1978; U.S. Fish Wildl. Serv. 1982a). In addition, the states of Vermont and New Hampshire recognize nine other species as requiring protection (Table 3.7).

3.5 SOCIOECONOMIC

3.5.1 Institutional Setting

Each organized town in Vermont and New Hampshire is governed by a board of selectmen. Those that are unorganized (Ferdinand, Lewis, Avery's Gore, and Averill) are represented and administered by a supervisor and planner as the Unorganized Towns of Essex County. In the few towns near the Preferred Corridor, community services and utilities are adequate to meet current needs. However, as in the rest of the country, budget problems are occurring.

3.5.2 Population

Most of the Vermont towns traversed by the Preferred Corridor are low-density rural or unpopulated areas, except for the southernmost segment of the corridor which is slightly more settled. In general, larger concentrations of population in the state are found further south or west of the corridor, particularly along Interstates 89 and 91. Past population trends and projections to 2000 in the towns directly along the corridor are shown in Table 3.8. The largest concentration of population within the entire study area is found in the town of Littleton in Grafton County, New Hampshire. Seasonal (vacation or second homes) population for the entire North Country Region in New Hampshire (including Grafton County) is projected at one-third of the resident population. Thus, during the spring, summer, and fall months, the resident population of the Grafton County portion of the proposed route is about 1-1/3 times the figures shown in Table 3.8 (North Country Counc. 1978). In the winter months, the population is lower because many people in the tourist industry leave the area to work in recreation facilities in the south.

Percentage growth between 1970 and 1980 was substantial in the townships of the southern half of the route although, in absolute numbers, the increases were fairly small. Projections were based on these recent growth patterns and thus show similar small increases for the next two decades.

3.5.3 Employment and Economics

The major employment base in Essex County, currently and over the past decade, is manufacturing--which accounted for slightly more than 80% (1066 workers) of total county employment in 1980 (Vt. Dep. Employ. Train. 1981). A slight increase in the wholesale and retail trade sector since 1970 reflects the increased interest in tourism in the area. The employed labor force of Essex County numbered about 1300 in 1980, up about 400 persons from 1970 (Vt. Dep. Employ. Train. 1981; Vt. Dep. Employ. Sec. 1971). The

Table 3.7. Habitat Preferences for Wildlife Species Protected by Federal or State Regulations

Taxon	Preference for Habitat Type†[1]					
	Forest			Clearcut/ Regrowth	Wetland	Agri- culture
	Mixed	Hardwood	Softwood			
Common loon	-	-	-	5	4	5
Bald eagle	1	-	1	-	3	1
Peregrine falcon	-	-	-	3	5	-
Cooper's hawk	4	4	4	2	3	-
Marsh hawk	-	-	-	5	3	-
Red-shouldered hawk	3	3	2	4	5	3
Osprey	1	-	1	-	4	2
Whip-poor-will	4	3	1	5	-	2
Eastern bluebird	-	-	-	4	1	4
Indiana bat	4	4	4	3	5	1
Marten	2	1	5	3	4	1
Timber wolf†[2]	4	2	3	5	4	-
Eastern cougar†[2]	4	2	3	5	4	-
Canada lynx	4	2	3	5	4	-

†[1] 1 = Low preference or correlation; 5 = High preference or correlation; - = Absence.

†[2] Godin (1977) considers these species extirpated in New England.

Source: U.S. Department of Energy (1978).

Table 3.8. Population Trends and Projections Along the Preferred Corridor

Town	1960	1970	1980 Actual	1980 Projected	% Change 1970-1980	1990	2000
Essex County							
Norton	241	207	184	261	-11	350	439
Avery's Gore	-	-	-		-	-	-
Averill	-	8		21	-	38	60
Lewis	-	-	115		-	-	-
Bloomfield	212	196	118	180	-4	185	229
Brighton	-	1365		1548	-	1850	2198
Ferdinand	16	14	12	15	-14	18	22
Brunswick	62	45	82	47	82	53	67
East Haven	164	197	280	437	42	647	939
Maidstone	-	-	77*		-	-	-
Granby	56	52	70	65	35	85	108
Victory	46	42	56	53	33	69	86
Guildhall	-	-	671*		-	-	-
Lunenburg	1237	1061	1138	1468	7	2122	2756
Concord	956	896	1125	1346	26	1988	2684
Caledonia County							
Waterford	460	586	882	945	51	1106	1274
Grafton County							
Littleton	5003	5290	5554	-	5	5780	6025
Monroe	421	385	280	-	-27	313	353
Lyman	201	213	616	-	188	768	958

Sources: Vermont (Essex and Caledonia Counties)

1960, 1970, and 1980 (actual) - U.S. Bureau of the Census (1980--as presented in ER, Volume 3--Exhibit 3-11);

1980 (projected), 1990, and 2000 - Vermont State Planning Office (1978--pp. 55 and 57) (projections based on 1975 population counts and trends);

* - DeLorme Publishing Company (1981a--p. 5).

New Hampshire (Grafton County)

1960, 1970, and 1980 (actual) - North Country Council (1978--pp. 4-5, 8-9);

1990 and 2000 - New Hampshire Office of State Planning (1981--pp. 6, 8).

St. Johnsbury Labor Market Area includes the portion of Caledonia County which is along the proposed corridor (in addition to several other communities). Since 1975, employment has been distributed more evenly across manufacturing (22%, or 2300 workers), trade (about 18%), services, and government (each about 15%) (Vt. Dep. Employ. Train. 1980?). The St. Johnsbury Labor Market Area had about 11,500 workers in 1980, an increase of about 800 from 1970 (Vt. Dep. Employ. Sec., 1970?; Vt. Dep. Employ. Train 1982). Unemployment trends in both Essex County and the St. Johnsbury Labor Market Area has paralleled state trends, but the rate has been consistently higher over the past decade. The 1980 rate was approximately 8%, with 50% of the unemployed from construction and manufacturing industries (Vt. Dep. Employ. Train. 1980?; Vt. Dep. Employ. Sec. 1975?).

The Littleton Labor Market Area in Grafton County, New Hampshire, includes many towns south of the Preferred Corridor as well as Littleton and Monroe. In general, the Littleton Labor Market Area is an economically depressed and stagnant area, relative to the rest of the state of New Hampshire. In April 1981 and April 1982, the Littleton Labor Market Area in New Hampshire had the smallest civilian labor force (about 13,000) of any market area in the state and the second highest unemployment rate (11.3% in April 1981; 13.7% in April 1982, not seasonally adjusted (N.H. Dep. Employ. Sec. 1982). These unemployment rates are considerably higher than those of the state overall, which had 4.9% in April 1981 and 8.4% in April 1982. April is traditionally the month of highest unemployment in New Hampshire, and annual average unemployment figures since 1976 for the area of the Preferred Corridor have ranged from 8.9% in 1976 and 1977, to a low of 5.9% in 1978, to 7.6% in 1981 (Raimondi 1982).

The New Hampshire Travel Council (1980) has estimated that, in 1979, tourism provided "23.2% of state and local revenues" (gathered through taxes, license and entry fees, and so on) and 11% of the state's jobs. An annual payroll of almost $17 million from tourism is estimated for the Littleton Market Area, about 27% of the total payroll (North Country Counc. 1982). Employment opportunities are provided not only by direct employment in tourist facilities and services (dining and lodging), but also by jobs resulting from other needs (e.g., stations) of tourists, of people who wish to be or are part-year residents, and of retirees. Various residents of the area--employed in or owning construction-related businesses, grocery stores, bookstores, and auto repair facilities--have estimated that between 10 and 50% of their business is from nonfull-time residents (Payne 1982).

With two exceptions, the Vermont towns along the proposed corridor rely heavily on property taxes for their revenues, ranging from about 50 to 80% of total revenue. The exceptions, Bloomfield and Brighton, rely on federal and state government revenues (Hanson 1982). This situation is characteristic of most rural community governments, as is the fact that the major expenditure in this kind of community is for schools (Burchell and Listokin 1980; Hanson 1982). New Hampshire has no general state sales or income tax (DeLorme Publ. Co. 1981b), although towns have an annual resident tax of $10 per resident between the ages of 18 and 65 years (N.H. Dep. Rev. 1981). Property taxes make up 80% of revenues for services (including education) for Littleton (Town of Littleton 1981) and about 45% for Monroe (Town of Monroe 1981).

3.5.4 Housing

Housing data in Vermont and New Hampshire are available on a county basis. In 1980, Essex County had 3,704 units and Caledonia 11,611 units (including vacant and seasonal units), up 13 and 21%, respectively, since 1970. In 1970, about 18% of Essex County's housing was vacant or used seasonally as compared to only 8% of Caledonia County's housing. This difference probably reflects Essex County's greater appeal as a vacation area as well as the more strained economic situation in the county. Vacancy rates for rental housing in 1980 were 6.2% for Essex County, 7.4% for Caledonia County, and 11.1% for Grafton County (U.S. Bur. Census 1981).

In 1979, there were 10 temporary lodging establishments (primarily motels, inns, and hotels) with a total of 119 rooms and a capacity of 350 guests in Essex County. In Caledonia County, there were 32 lodging establishments with 544 rooms and a capacity of 1379 persons (Donovan 1982). In Grafton County, there were 14 lodging establishments (White Mountains Region Assoc., undated). Many more lodging establishments are listed in towns just to the south of the study area within easy commuting distance of the proposed route. These figures have remained fairly constant over the past five years. In Vermont, heaviest tourist demand periods are October, July, and August. In the winter months (January to March), demand is lower and some of the establishments are closed (Donovan 1982). Tourist demand in New Hampshire is more consistent year-round, dropping off only in the spring mud and rainy season.

3.5.5 Transportation

Vermont towns along the Preferred Corridor are reached by two north-south routes: State Route 102 along the Connecticut River and State Route 114, which parallels the route of 102 about 24 to 32 km (15 to 20 mi) further west (Figure 2.3). Connecting these routes are State Route 105, between Bloomfield and Island Pond (and on west to Newport); a small road between Granby and Guildhall; U.S. Route 2, between Lunenberg and St. Johnsbury; and the major highway I-93, from the Moore Dam area to St. Johnsbury. In New Hampshire, I-93, a major multilane road, connects the study area with the rest of the state to the south and with Vermont's major north-south interstate route, I-91. Currently, I-93 ends in New Hampshire at Littleton and is connected to Vermont by U.S. Route 18/135. U.S. Route 135 follows the Connecticut River through the study area southeast of Littleton. Construction is underway to extend I-93 across the Connecticut River below Moore Dam (ER, Vol. 2--p. 46). I-93 has an annual average daily traffic volume of about 4000 in the proposed project area (ER, Vol. 2--Exhibit 2-35).

Within the New Hampshire portion of the study area, the most heavily used east-west route is U.S. Highway 302, which in 1980 had annual average daily traffic volumes of about 3200 to 3500 (ER, Vol. 2--Exhibit 2-35). U.S. 302 is a major connector between the White Mountains National Forest, an important recreation attraction, and the states of Vermont, New Hampshire, and Maine (North Country Counc. 1978). The Boston and Maine Railroad crosses the New Hampshire portion of the study area.

The proposed line will cross State Routes 114 and 105, the Granby-Guildhall Road, and U.S. Route 2, all primarily two-lane roads. U.S. Route 2--as a major east-west route across Vermont, New Hampshire, and Maine--is the most heavily travelled of the three, at an average daily volume of about 2500 vehicles. The state routes have 600 to 750 vehicles per day and the road between Granby and Guildhall has only about 40 (ER, Vol. 3--pp. 112-113). All roads in the area carry some truck traffic, primarily related to the timber industry. Timber company roads used for logging operations are found throughout private company forestland. In New Hampshire, the Preferred Corridor crosses I-93 and U.S. Highways 18/135 and 302.

3.5.6 Public Concerns

Citizens have participated in hearings on the proposed line and one organized group (Vermont Public Interest Research Group) has been particularly active in meetings and hearings and in disseminating information on transmission line impacts (see, e.g., N.H. Bulk Power Supply Site Eval. Comm. and Public Util. Comm 1981-1982). Issues of concern have included health effects (both from line operation and herbicide use), reliability of a foreign source of power, need for power, changes in quality of life as a result of perceived greater accessibility and lowered scenic quality, changes in land values, loss of tourist business, tax assessments on the utility, and alternative energy sources (Griffen 1982; Placey 1982; Payne 1982; Edson 1982; Cox, undated; Brunnell 1982; N.H. Bulk Power Supply Site Eval. Comm. and Public Util. Comm. 1981-1982; Gainza 1982). A report of a 1982 "energy analysis" of Brighton, Vermont, was presented in support of the economic benefits of the alternative of conservation as opposed to generating more energy (Greenberg 1980). Responses to the proposed line are mixed, indicated by the resolution of Waterford, Vermont, in which 58 were in favor of construction of the proposed line and 40 were in opposition (Farmer 1982). The selectmen of Waterford qualified this resolution by stating that township support was given only if there were no serious environmental impacts, despite potential tax gains to the township should the line be constructed (B. Willey 1982).

A considerable amount of citizen participation in New Hampshire has also occurred in the context of the proposed project. Attendance has been high at the New Hampshire Bulk Power Supply Public Utilities Commission hearing, DOE public meetings, and meetings presented by the Applicant as the Preferred Route was being developed. Several citizens' groups have been organized in opposition to the route, one of which (Power Line Education Fund) was formally represented by legal counsel at the hearings of the Site Evaluation Committee and Public Utilities Commission regarding the project. Numerous letters to the editor of a local newspaper have appeared expressing views in support of and in opposition to the line (e.g., News and Sentinel 1981). At least one local newspaper carried an editorial expressing disappointment with the response of the New Hampshire Bulk Power Supply Site Evaluation Committee and Public Utilities Commission to speeches of concerned citizens (The Courier 1982). Forty-five physicians signed a statement--which appeared in local papers--asking for a moratorium on the construction of the proposed line until more is known about the health effects of such a line (Physicians' Statement 1982).

3.6 VISUAL RESOURCES

3.6.1 Landscape of the Study Area

The study area is largely a visually attractive rural and natural area. Hilly and mountainous terrain is dissected by a radial network of streams. The valleys, filled with glacial outwash and lacustrine and alluvial material, are level and frequently boggy. In general, summit elevations increase from south to north, with elevations of approximately 260 m (850 ft) along the shores of Moore Reservoir to elevations over 1000 m (3408 ft) at mountain peaks in the north. Except on the valley floors and high hilltops, the central and northern portions of the study area are heavily wooded. Glaciofluvial deposition features are particularly extensive and the forms of many of the bedrock hills in the area are asymmetrically eroded by glacial processes (Newton 1977). The Vermont Scenery Classification and Analysis Report (Vt. State Plan. Off. and Public Serv. Board, undated) has classified the landforms in Vermont into four series: (1) mountains, (2) steep hills, (3) rolling hills, and (4) undulating land. These landscapes are also applicable to the New Hampshire segment of the corridor. The landscape types within the study area include:

(1) Mountains

(a) The Monadnocks Mountains are scattered peaks and related hills in the eastern part of Vermont. In all cases, they strongly contrast their immediate surroundings. Their configuration varies from regular to irregular contouring, and they are obviously dispersed. There are only a few instances of spatial enclosure by the Monadnocks.

(2) Steep Hills

(a) The Northern Steep Hills are in the northeastern part of Vermont and run over into New Hampshire. They are mostly irregular in form, giving a rough sculptured appearance. The hills are almost all connected, but are meandering and so are nonlinear in direction. They tend to have only a medial amount of spatial enclosure.

(b) The Northern Vermont Steep Hills subseries is a small band of hills along the Connecticut River. They are interspersed with water bodies. Most hills are regularly contoured, but are, for the most part, individual and dispersed. Because of their individuality, they create a high amount of spatial enclosure.

(3) Rolling Hills

(a) The New England Rolling Hills subseries consists of a large area in northeast Vermont which is similar to rolling hills in southern New England. Some hills are dispersed with very little direction and less connectedness. Because of the variation in forms, there is a medial amount of spatial enclosure created.

(b) The Eastern Vermont Rolling Hills are in east-central Vermont and are directly associated with the East-Coast Vermont Highlands but have relatively lower elevations. They have a great amount of irregularity and are almost all connected. There is no pattern to their distribution. They provide a medial amount of spatial enclosure.

(4) Undulating Land

(a) The Island Pond Lowlands is a small section of land around Island Pond. It is mostly wetland with some hillocks. The configuration is irregular and dispersed.

3.6.2 Corridor Landscape Description

The following is a brief description of the corridor landscape, its landforms, prominent features, vista points (points where people congregate to enjoy a natural setting), travel roads, and significant viewshed areas (areas of high visibility that would be disturbed by the introduction of major man-made features). Traffic volumes are indicated in Section 3.5.5. Surrounding areas with elevations greater than 750 m (2500 ft) are also discussed due to their special protection from development status given by the Vermont Environmental Control Act (Act 250) of 1970. The following landscape description is adapted from the ER (Vols. 2 & 3) and the Transmission Line Study for the Quebec-New England Intertie (Vt. Dep. Public Serv. 1982). The lettered segments correspond to the areas identified on Figure 2.3. A more detailed mapping of these visual resources can be found in the ER (Vol. 2--Exhibit 2-25; Vol. 3--Appendices, Maps V-1/V-8).

Segment A. Once in the United States, the Preferred Corridor crosses State Route 114 in Norton, which has been designated as a scenic road on the Northeast Development Association tour guide map. The landforms along this segment belong to the New England Rolling Hills subseries which is a varied undulating topography with isolated low hills and lakes. Various pasture and tillage lands are interspersed between forested areas.

Segment B. The Preferred Corridor crosses a section of Northern Vermont Steep Hills which is a remote forest area and passes through a "saddle" between Black and Trophy mountains. This area is characterized by a large massif with some of the highest elevations in the corridor, i.e., 750 to 990 m (2500 to 3300 ft). The hills are regular, dispersed, and offer a high degree of closure. The side slopes of Gore Mountain, especially the northern and southern faces, are used for forestry. The northwest slope of Gore Mountain is visible from State Route 114 and the open areas in Canada. In this area, Gore, Round, Trophy, Black, and Lewis mountains all reach elevations above 750 m (2500 ft). The corridor continues through an area that contains the south slopes of the foothills of Black Mountain.

Segment C. Near the junction of Logger Brook and Black Branch of the Nulhegan River, the corridor enters a wide undulating exposed valley (the Yellow Bog area) that is a large wetland drained by several branches of the Nulhegan River. It is bordered by the steep hills of the Potash Range (1800 to 2000 ft) on the east and by the Island Pond Undulating Lowlands on the west. The uplands within this area are used for forestry, and extensive roadways exist. The corridor then crosses State Route 105 and the Canadian National Railroad line. State Route 105 has has been designated as a scenic road in the Northeast Development Association tour guide map. A number of seasonal residences are located along the highway and just to the north along the Nulhegan River.

Segment D. The corridor extends through the French, West, and Seneca mountain area which divides the Yellow Bog area to the north from the Ferdinand Bog area to the south. A number of the mountain peaks in this area of New England Rolling Hills are above 750 m (2500 ft). There are two significant notches in this area, one at Stevens Brook and the other between Notch Pond Mountain and North Notch Mountain.

Segment E. The corridor traverses the Ferdinand Bog basin near South American Pond and along Paul Stream. This area is relatively flat and vegetated with softwoods and low brushy growth. It is surrounded on three sides by steep mountains and is in the Northern Steep Hills and New England Rolling Hills landform series. The area is used for forestry and is accessible only on paper company roads.

Segment F. The corridor extends to the east of Nurse Mountain and near the village of Granby. This area has patches of cleared land on the sides of scattered steep hills. The Guildhall/Granby road that runs from Gallup Mills and Granby on the west toward State Route 102 and the village of Guildhall on the east has been designated as a scenic roadway in the Northeast Development Association tour guide map. The road runs between the hills and offers panoramas to the Victory Basin and the open pasture area east of the village of Granby. A number of residences exist on Shore Road, southeast of the Guildhall/Granby Road. The corridor then extends through an exposed boggy area (Victory Bog) surrounded by rolling hills. This area can be observed from a few places along the central north-south road, especially at the Moose River Crossing (historic Damon's Crossing located west of the proposed transmission line).

Segment G. As the corridor extends south, it enters the Carr Brook basin and then the Miles Pond area--an area of steep, dispersed hills. In this section the only area greater than 750 m (2500 ft) is Miles Mountain, located to the west of the corridor. The land pattern is forest with a number of mixed seasonal and year-round homes at Miles Pond and along Oregon Road. The corridor crosses the major east-west highway, U.S. Route 2, which is considered a scenic roadway as designated by the tour guide map of the Northeast Development Association.

Segment H. The area from U.S. Route 2 in the town of Concord to the area of land adjacent to Moore Reservoir is characterized by steep hills along the north shore of Moore Lake, with high plateaus cut by streams running southward to the lake. The land pattern is mature, second-growth hardwood with very few clearings. The north shore of Moore Reservoir and parts of the NEPCO transmission corridor are visible from New Hampshire Route 135 across the Connecticut River.

Segment I. Between Moore Reservoir, the substation area at Comerford Reservoir, and the proposed converter terminal location, the topography is rolling to steep. The land is mostly wooded, although there is agricultural land interspersed with woodlots of both hardwood and softwood trees. Besides the two dams and associated facilities of powerhouses, substations, and transmission lines, the area includes local farms, residences, and State Route 18/135 and the nearly completed Interstate 93. The proposed route follows existing 115-kV and 230-kV transmission lines for most of its length between Moore Reservoir and Comerford Station. At the proposed terminal site, approximately 85% of the area is wooded and the balance is under crop cultivation.

3.7 CULTURAL RESOURCES

3.7.1 Prehistoric Sites

Man has lived in Vermont and New Hampshire for at least 10,000 years, since the retreat of the last glacier. Prehistoric peoples preferred to occupy the river valleys and adjacent terraces and uplands and did not intensively occupy mountainous and steep-sloped areas. Although the entire study area has not been comprehensively surveyed for archaeological sites, the most likely site locations within the study area include the Nulhegan, Moose, Ammonoosuc, and Connecticut river valleys and adjacent stream areas.

There are no known archaeological sites within the study area listed in the National Register of Historic Places. The New Hampshire Archeological Society has stated that prehistoric material has been collected in and near Littleton (ER, Vol. 2--p. 51). However, this does not preclude the possibility that undiscovered sites might exist along the proposed transmission route. For example, streams located along the Preferred Corridor route might have been attractive locations for hunting or fishing of prehistoric peoples. Other sites might include quarrying sites, where raw materials for tools were obtained; manufacturing sites, where tools were fabricated and repaired; hunting and butchering sites; and large village sites (Vt. Agency Environ. Conserv. 1978). Such sites could prove important sources of information about the region's prehistoric era. The Vermont State Comprehensive Outdoor Recreation Plan states that if prehistoric sites are not protected, most of Vermont's prehistoric heritage will be gone within 100 years (Vt. Agency Environ. Conserv. 1978).

3.7.2 Historic Sites

The historic resources of Vermont and New Hampshire are diverse (Vt. Agency Environ. Conserv. 1978), including dwellings, villages, covered bridges, public buildings, churches, taverns, schools, and farms (Table 3.9). The study area was not intensively settled by European settlers until after the American Revolution. Settlements were concentrated along the river valleys, and many of the historic structures remaining today are located in the various villages of the study area.

The New Hampshire State Historic Preservation Office has indicated that the towns of Bethlehem, Littleton, and Monroe include structures or districts that would be eligible for the National Register. It has also indicated that the Farm and Forest Museum located near Bethlehem is historically significant (ER, Vol. 2--p. 52).

3.7.3 Paleontological Sites

There are no known paleontologic resources within the vicinity of the Preferred Corridor (ER, Vol. 3--p. 51).

Table 3.9. Vertmont and New Hampshire Study Area Sites Listed in the National and State Registers of Historic Places

Town or Area	Site Name
NATIONAL REGISTER OF HISTORIC PLACES	
Caledonia County	
Danville vicinity	Greenbanks Hollow Covered Bridge
East Burke	Burklyn Hall
Lyndon	Chamberlin Mill Covered Bridge
Lyndon	Old Schoolhouse Bridge
Lyndon vicinity	Bradley Covered Bridge
Lyndon vicinity	Burrington Covered Bridge
Lyndon vicinity	Centre Covered Bridge
Lydonville	Darling Inn
McIndoe Falls	McIndoes Academy
Peacham	Elkins Tavern
Ryegate vicinity	Whitehall House
St. Johnsbury	Fairbanks, Franklin House
St. Johnsbury	Railroad Street Historic District
St. Johnsbury	St. Johnsbury Main St. Historic District
Stannard	Methodist-Episcopal Church
Stannard	Stannard chool House
Essex County	
Lemington	Columbia Covered Bridge
Lunnenburg	Mount Orne Covered Bridge
Island Pond	Island Pond Historic District
Grafton County	
Bethlehem vicinity	Felsengarten
Littleton	Littleton Town Building (Opera House)
VERMONT STATE REGISTER OF HISTORIC PLACES	
Granby	Lee-Lund House
	Carpenter-Hedgdom-Martin Farm
	Granby Central School
	Granby Congregational Church
	Richardson-Noble House
	Matthews-McLean-Grahm House
Norton	Averill Lumber Company - Lakeside Inn
	Nelson Store - Town Clerk's Office
	Nelson House
	Hudlock House

Sources: U.S. Department of the Interior (1979-1982); Vermont Department of Public Service (1982).

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4. ENVIRONMENTAL CONSEQUENCES

4.1 CONSEQUENCES OF THE PROPOSED INTERCONNECT

4.1.1 Air Quality

The greatest impact to air quality will be from fugitive dust generated during clearing and construction activities. Although possibly locally heavy at times, the dust will generally not be bothersome at distances of more than 300 m (1000 ft) from the source due to gravitational settling of the dust particles. At this distance, the concentration will have fallen to less than one-tenth of the initial concentration (Sullivan and Woodcock 1982). Watering has been shown to be an effective and inexpensive method to reduce dust releases by as much as 95% from a haul road if the road was watered twice an hour (Maxwell et al. 1982). Under normal conditions of watering, the major impact should not extend more than 100 m (300 ft) from the dust source. During construction of the line, contractors will be required to provide dust-control measures to avoid undue impact.

Air quality impacts from gaseous pollutants from diesel exhausts, i.e., sulfur dioxide and nitrogen oxides, will be minor and transitory due to the mobile nature of the sources. Because of this, the emission of these gases will not cause or contribute to any air quality violation. The amount of carbon monoxide and hydrocarbons released from diesel engines is also small and will not cause any violation of air quality standards.

The remaining pollutant of concern, ozone, is unique in the case of transmission lines. Ordinarily, ozone is a secondary pollutant formed by the interaction of hydrocarbons, oxides of nitrogen, and ultraviolet radiation within sunlight. In the case of high-voltage transmission loss, ozone is directly produced by the conductor corona of the transmission lines. Under worst-case conditions, ozone levels of about 20 $\mu g/m^3$ (10 ppb) above background have been measured under lines operating at ±400 to ±500 kVDC (Droppo 1979; Krupa and Pratt 1982). Highest production rates of ozone from the line occur during foul weather, which is the time of lowest production rate of ozone as a secondary pollutant from other sources because of the absence of sunlight. A number of field experiments have determined that ground-level ozone concentrations due to the transmission line corona are usually indistinguishable from background concentrations (Sebo et al. 1976; Roach et al. 1978). Measurements of ozone under a line operating under the same conditions as the proposed line resulted in no ozone being detected above background in any weather conditions (Johnson 1982a).

In summary, local ambient air quality will be only slightly and temporarily impacted by fugitive dust emissions if mitigative measures are employed during construction. Release of gaseous pollutants will not result in significant impacts on local air quality.

4.1.2 Land Features and Use

4.1.2.1 Geology and Soils

Geology

The construction and maintenance of the proposed transmission facility will generally have little or no impact on the geologic features of the region. In contrast, many of the geologic features will be of considerable importance in route selection, construction, and operation of the transmission system. For example, system reliability can be affected by unstable areas, landslides, and other natural hazards such as earthquakes. Line construction can be influenced by the bedrock conditions such as steep slopes and shallow and/or wet soils. Special designs and careful siting, therefore, are required to minimize the impacts of these hazards and obstacles on the transmission system.

The natural geologic conditions directly affecting the location of the Preferred Corridor include areas with excessive slopes and unique geologic areas. Within the study area, major areas of excessive slopes (over 25%) are identified for (a) the Bluff-Middle Gore Mountain complex in the towns of Averill and Lewis; (b) the Temple-Miles Mountain complex in the towns of Victory, Lunenburg, and Concord; and (c) the East Haven Range in the town of East Haven Town and much of the town of Waterford. About 10% of the Preferred Corridor extends across areas of excessive slope (Klunder Assoc. 1981). The construction of transmission line structures on steep slopes could require additional supporting structures to ensure minimum ground clearance and could result in potential impacts from increased erosion during and after construction, with subsequent loss of structural support. If the proposed mitigative measures are implemented (see Section 4.3.2.1), impacts due to erosion on steep slopes will be relatively minor.

Several areas within the study area were identified as Unique Geological Areas in the 1972 Vermont Land Capability Maps, but there are no such areas within the Preferred Corridor (Klunder Assoc. 1981). The closest unique geological features to the Preferred Corridor are the cliffs of Black and Brousseau mountains (hundreds of meters [several hundred feet] from the edge of the right-of-way) and the western shores of Lake Averill (1.6 km [1 mi] away). By locating the corridor sufficiently far from mountain cliffs, damage to the facilities during landslides or the induction of slides due to construction activities will be avoided.

Because transmission lines are designed to withstand a considerable amount of bending or twisting, seismic activity of low or medium intensity will have little or no effect on the line. In the event of a major earthquake, however, repairs to the structures may be required. Generally, the historical (1534-1977) seismicity record indicates minor seismic activity within and surrounding the study area (Chiburis 1981).

Sand and gravel resources to be used for foundation, access road, and substation construction purposes will be extracted from a few eskers and kame deposits adjacent to the walls of glacially formed valleys. These resources are of local importance only and will not be unduly strained by construction activities.

Soils

Most soil disturbance will occur during the construction phase of the proposed project. The degree of impact and its duration will depend on construction activities and soil characteristics. Increases in erosion are likely to occur when the soil is exposed or disturbed, e.g., in clearing rights-of-way or constructing roads and substation sites. These impacts will continue until sufficient revegetation has occurred to replace soil-retaining ground cover; this will take about six to twelve months. The potential for erosion is greatest when rainfall is heavy or during spring snowmelt conditions. The subsequent runoff from these events can cause sheet, rill, or gully erosion. Construction of transmission towers on steep slopes can also result in slope and soil instabilities, increased erosion, and sedimentation.

The amount of erosion that will occur along a right-of-way and access roads will be a direct function of the amount of vegetation that must be cleared (Asplundh Environ. Serv. 1977). In open, cleared areas such as fields or logged areas, erosion rates will remain relatively unchanged during right-of-way construction because little further clearing is necessary. Erosion rates will increase up to one-hundred fold in heavily forested areas where much clearing is required and no vegetative cover remains. Where some vegetative cover remains after clearing, erosion losses will be lower--only about ten times above normal, forested soils. Because of the much smaller area involved, erosion due to right-of-way clearing will be negligible in contrast to erosion resulting from timber harvesting activities in the region. Approximately 1000 ha (2500 acres) are harvested per year in Essex County, compared to the one-time clearing of up to 480 ha (1200 acres) for the proposed right-of-way (ER, Vol. 3).

The movement of heavy machinery over the soil during construction and maintenance periods may substantially impact local areas of soil. Such movement may result in compaction of surface soils or removal of upper soil horizons. Mechanical compaction of the soils generally reduces soil productivity by reducing rates of water infiltration and percolation, restricting root penetration, and increasing surface water runoff or ponding. Such impacts, although localized in extent of area disturbed, will be most harmful in areas where rights-of-way cross agricultural lands. Because the Preferred Corridor crosses few areas of farmland or prime agricultural soils (see Section 3.2.1 and 3.2.2), such impacts will be small. Where right-of-way passes through active commercial forest, the impacts due to right-of-way construction will be less than the impacts resulting from timber harvesting activities.

Excavation or backfill activities associated with road and tower construction and substation site preparation may also change soil characteristics by mixing the soil profile, bringing rock fragments or boulders to the surface, interrupting infiltration and drainage, and increasing erosion. With effective mitigative measures (see Section 4.3.2.1), many of the impacts associated with such disturbances will be minor; without mitigation, topsoil fertility may be seriously impaired although such impairment would be very local in extent.

Many of the soils within the Preferred Corridor are potentially poor bases for road construction because of excess wetness, ponding, shallowness, and stoniness. Such limitations, however, can be overcome by proper engineering techniques and suitable roadbed preparation. Such restrictions are less problematical for development of temporary roads to be used by construction vehicles.

Where access roads are constructed through lumber company lands and are used for timber harvesting as well as power line maintenance, the erosion losses from the access road will be attributed to both activities. Joint use of the access roads by the power company and the lumber company will reduce the number of new roads constructed by either company and, as a result, will minimize erosion losses attributable to the transmission line.

After construction of the right-of-way, erosion problems may still persist where areas such as tower sites, access roads, and excavations have not been adequately restored to a tight cover by natural plant succession or artificial seeding. Special attention must be paid to restoration of disturbed areas on rights-of-way, even if this must be done some time after the line has been in use (Asplundh Environ. Serv. 1977).

Of the 95 km (59.5 mi) of the Preferred Corridor, about 9 km (5.5 mi) passes over soils and overburden materials that are less than 1.5-m (5-ft) thick. Because construction of tower foundations in these soils requires the use of rock drilling and blasting techniques that double or triple foundation construction times, these soils have been avoided wherever possible. Where encountered, however, construction activities will accelerate soil erosion rates because these shallow soils are usually located on moderate to steep slopes and may be sparsely vegetated. The potential volume of eroded soil is relatively small because of the thinness of these soils, and the total area to be adversely affected by construction activities in such soils would be limited in extent to about 55 ha (140 acres).

4.1.2.2 Agriculture

The only agricultural lands located near the Vermont portion of the proposed transmission line corridor are along State Route 114 east of the village of Norton, along Shore Road near the village of Granby, and in the town of Waterford near Moore Reservoir. Except for some agricultural land in the town of Norton, none of these agricultural lands are actually located within the Preferred Corridor (see ER, Vol. 3--Appendices, Land Use Map L-1/L-8).

It is estimated that up to 4 ha (10 acres) of agricultural land located within the town of Norton will be crossed by the transmission line right-of-way (Table 4.1). Depending on final alignment, it is anticipated that the transmission lines in Vermont will only skirt, but not cross, lands directly associated with farming activities (ER, Vol. 3--p. 123). In New Hampshire, the transmission line right-of-way will cross 6 ha (16 acres) of agricultural land (Table 4.1).

The transmission line will cross only 0.04% of all agricultural land in Essex County and only 0.001% of all agricultural land in Grafton County. As discussed above, only a small portion of this land under the right-of-way will actually be disturbed by the transmission line towers during construction or operation. In summary, the construction and operation of the proposed transmission line and terminal facility will not significantly impact agricultural resources within the study area.

Table 4.1. Land-Use Categories Identified in the Proposed Right-of-Way Corridor

Land-Use Category†[1]	Cumulative Length of Corridor Occupied		Area Within Right-of-Way†[2]		Percentage of Right-of-Way
	Kilometers	Miles	Hectares	Acres	
VERMONT					
Hardwood	36.8	22.9	225	555	43.5
Mixed Forest	29.6	18.4	180	446	34.9
Softwood	6.6	4.1	40	99	7.7
Wetland	5.6	3.5	34	85	6.6
Clearcut/Regrowth	5.4	3.4	33	82	6.4
Agriculture	0.7	0.4	4	10	0.8
Lake	Negligible		0	0	0
Total†[3]	84.7	52.7	517	1277	100
NEW HAMPSHIRE					
Hardwood	7.4	4.6	29	71	69
Mixed Forest	0	0	0	0	0
Softwood	2.0	1.1	7	17	16
Wetland	Negligible		0	0	0
Clearcut/Regrowth	0	0	0	0	0
Agriculture	1.6	1.0	6	16	15
Lake	Negligible		0	0	0
Total†[3]	11	6.7	43	104	100

†[1] Hardwood = broadleafed, deciduous trees; mixed forest = mix of broadleafed and coniferous trees; softwood = coniferous trees with needle or awl-shaped foliage, evergreen (except for larch); wetlands = primarily nonproductive forest type; clearcut = recently harvested; and regrowth = harvested areas of the recent past wherein regeneration has attained sapling and small pole size.

†[2] Vermont estimates based on a 61-m (200-ft) right-of-way. New Hampshire estimates based on a 39-m (128-ft) right-of-way.

†[3] Totals may not add because of rounding.

Source: ER (Vol. 2--Exhibits 2-12, 2-20, and 2-64; Vol. 3--Appendix B).

The existing agricultural land, including the prime agricultural soils, will be impacted during the construction phase while preparing the right-of-way and structure foundations, installing the towers, and stringing the conductors. This impact is not expected to be significant if the construction activities can take place during the winter season, minimizing the potential for interference with farming activities. During operation, those transmission line towers located on agricultural land will take out of production the amount of land used for the tower itself (approximately 0.2 to 0.3 acres per lattice tower, less if H-frame or single pole construction is used) and various amounts of land not usable by the farmer due to the type of crop planted, machinery used, and where the tower is physically located within the field. The magnitude of the impacts relative to loss of cultivated crop acreage (existing and potential), farm machinery operational difficulties around tower bases, and weed control problems can be reduced by the use of H-frame or single pole structures (rather than lattice towers) and the placement of towers at the edge rather than within an agricultural field.

At the converter terminal site, approximately 15% of the 9.3-ha (23-acre) site is currently under crop cultivation (Table 4.2). This site, completely located on New England Power Company property, will be cleared of vegetation, graded, covered with gravel, and fenced. The construction of the substation, including connector right-of-way over 2 ha (5 acres) of agricultural land (Table 4.2) will impact only 0.004% of all farmland in Grafton County.

4.1.2.3 Forestry

In addition to about 3.2 km (2.0 mi) in Caledonia County, about 81.6 km (50.7 mi) of the proposed line will be located in Essex County, the most heavily forested of the counties in Vermont. For the most part, the actual routing of the proposed line is currently identified only as a corridor, ranging in width between the actual right-of-way requirement (i.e., 61 m [200 ft]) to about eight times the requirement. The width of the corridor allows some flexibility to avoid environmentally sensitive areas in the final alignment of the right-of-way.

Specific information concerning forest resources within the Preferred Corridor is not available. However, the Applicant has provided a series of maps depicting land use within and adjacent to the corridor (ER, Vol. 3--Appendix B). The land-use maps indicate that hardwood forests occupy about 37 km (23 mi) or 44% of the 84.8-km (52.7-mi) corridor in Vermont. For a 61-m (200-ft) right-of-way, the area of hardwood forest will be about 225 ha or 555 acres (Table 4.1). These data are provisional, pending final alignment of the proposed transmission line, but significant differences are considered unlikely.

Area requirements for the proposed transmission line from Moore Dam to the converter terminal will entail widening common right-of-way by about 39 m (128 ft) (ER, Vol. 2--Exhibit 2-3). The equivalent area for the increased width of the right-of-way is about 41 ha (102 acres). In accordance with the general distribution of major forest types (ER, Vol. 2--Exhibit 2-12), the additional right-of-way is comprised of about 31 ha (76 acres) of maple/birch/beech and 11 ha (26 acres) of white and red pine forestland. Thus, the development of this right-of-way and the facilities at the converter terminal will result in withdrawal of about 54 ha (134 acres) of land from the forest resource base of Grafton County, New Hampshire.

Table 4.2. Land-Use Categories Identified at the Converter Terminal and Connector Line Sites

Land-Use Category†[1]	Converter Terminal		Connector Line Corridor				
			Length of Corridor Crossed		Area Within Right-of-Way†[2]		Percentage of Total Cover in Corridor
	Hectares	Acres	Meters	Feet	Hectares	Acres	
Hardwood	0	0	0	0	0	0	0
Mixed Forest	8	20	260	850	1.5	4	43
Softwood	0	0	200	650	1	3	33
Wetland	Negligible		Negligible		0	0	0
Clearcut/Regrowth	0	0	0	0	0	0	0
Agriculture	13	3	150	500	1	3	24
Lake	0	0	0	0	0	0	0
Total†[3]	9	23	610	2000	3.5	9.5	100

†[1] Hardwood = broadleafed, deciduous trees; mixed forest = mix of broad-leafed and coniferous trees; softwood = coniferous trees with needle or awl-shaped foliage, evergreen (except for larch); wetlands = primarily nonproductive forest type; clearcut = recently harvested; and regrowth = harvested areas of the recent past wherein regeneration has attained sapling and small pole size.

†[2] Estimates based on a 61-m (200-ft) right-of-way containing land cover in the same proportions found in the corridor as a whole.

†[3] Totals may not add because of rounding.

The converter terminal will occupy an area of about 9.3 ha (23 acres). This area will be cleared of all vegetation, stripped of topsoil, regraded, resurfaced with crushed rock, and fenced (ER, Vol. 1--Sec. III A). About 85% of the converter site is forested; thus about 8 ha (20 acres) of land will be withdrawn from forest production (Table 4.2). The forest vegetation on three sides of the converter site will remain intact for natural screening; open land adjacent to the converter site will be used for construction laydown area, topsoil piling, yarding areas, parking lots, etc. For construction and operation of transmission facilities between the converter and the Comerford switchyard, however, it will be necessary to clear timber species from a 61-m (200-ft) wide right-of-way extending northwest from the converter site for a distance of about 610 m (2000 ft). Thus, the total timberland to be cleared in the vicinity of the converter site is about 10.5 ha (27 acres). The major forest type in the vicinity of the converter is the white and red pine type (cf. Section 3.2.3).

Most of the hardwood stands referred to in Tables 4.1 and 4.2 are very likely representative stands of the maple/birch/beech forest type (see Appendix C). Similarly, most of the softwood stands are very likely representatives of the spruce/fir forest type, and most of the mixed forest represents intermingling of the maple/birch/beech, spruce/fir, and--to a lesser extent--white and red pine forest types.

The total area requirement for the Vermont segment of the proposed transmission line is about 517 ha (1277 acres). This area is not all commercial forestland; however, if it were, the area would represent only 0.03% of the total commercial forestland in Essex and Caledonia counties. In New Hampshire, forest clearing represents about 0.002% of the reported total commercial forestland in Grafton County (Kingsley 1976). If the volume of growing stock removed during right-of-way clearing is calculated relative to existing growing stock, the resulting percentages are equally insignificant. Since the early 1950s, volumes of growing stock (species of commercial value) have been accumulating in Vermont forests in excess of annual timber removals and will continue to do so well into the future (Section 3.2.3).

It is anticipated that a number of landowners, particularly those with large holdings, will choose to clear any right-of-way occurring on their holdings. In a number of instances, harvesting of the right-of-way will likely represent in-lieu-of cuttings on other portions of the same ownership. Thus, it seems reasonable to expect that such clearing will not severely disrupt local forest market conditions. It should also be noted that clearing will not destroy the potential forest resource base. In the absence of maintenance, the right-of-way will be invaded and occupied by forest vegetation.

In view of the foregoing, development and operation of the proposed transmission facilities are expected to have no significant adverse impacts on either forest resources or forest market conditions in Vermont and New Hampshire.

4.1.2.4 Mining

There will be no significant impacts to mining operations during the construction and operation of the proposed transmission line and required access road areas because no known mineral extraction or major sand and gravel operations are located within the proposed transmission line corridor or terminal location.

4.1.2.5 Recreation

One of the principal criteria adopted in early considerations for routing the proposed interconnection entailed avoidance of primary recreation areas and public land ownerships (ER, Vol. 3--Sec. IA). A north-south routing through central Essex County adheres to these guidelines because there is a relative paucity of developed recreation sites and facilities in sparsely populated Essex County, especially in the vicinity of the Preferred Corridor (see Section 3.2.5). Developed recreational resources are considerably greater in Caledonia County than in Essex County.

The Preferred Corridor will not encroach on any known developed outdoor recreation sites, but a few such sites are located within about 1.6 km (1 mi) of the route, i.e., the Norton School playgrounds, the Granby School playgrounds, facilities at Miles Pond, and a boat launching and picnic area adjacent to Moore Reservoir. However, any adverse effects attributable to development of the proposed transmission line will be of a visual nature.

Portions of the Victory Bog and Averill Mountain Wildlife Management areas are within 6 km (4 mi) of the Preferred Corridor; all other large state ownerships are well removed from the route.

Development of the proposed transmission line will have both positive and negative effects on opportunities for dispersed types of recreation in the study area. For example, the proposed line will not disrupt any existing snowmobile routes but it is likely that at least some portions of the route will be integrated with local trail systems. Additionally, the proposed corridor and associated service roads may facilitate access to previously inaccessible hunting and fishing areas. On the other hand, some private landowners may resent intrusions on their holding by the general public. In cases of controversy, provisions for excluding public use may be negotiated as a condition of easements for right-of-way.

Some cross-country skiers, bikers, and hikers will likely view the proposed transmission facilities as detracting from the natural attributes of the local landscape. The proposed transmission line will also be visible to river-touring travelers of several waterways proposed for wild, scenic, or recreational classifications. It will also be visible to participants in water-based recreation activities at Comerford Reservoir, particularly in instances where the line closely parallels the shoreline or spans small embayments of the reservoir. Further discussion of impacts on visual resources in the vicinity of the proposed transmission line is presented in Section 4.1.6.

In summary, direct and indirect adverse effects of the proposed transmission line on recreational resources of the study area will be essentially inconsequential, with the exception of limited visual effects. Effects on dispersed types of recreation will result in both negative and positive consequences. Overall, the impacts on recreational resources are within limits acceptable to the general public.

4.1.2.6 Residential, Commercial, and Industrial

There are no large communities located along the length of the Preferred Corridor in Vermont. Except for the villages of Norton and Granby, and around the Miles Pond and Oregon Road area, there are only scattered permanent and seasonal residences. Approximately 60 permanent residences and 75 seasonal residences and camp areas are located within 1.6 km (1 mi) of the Preferred Corridor (ER, Vol. 3--pp. 113-114). These residences will be subjected to increased noise and dust levels during construction, and possibly inconvenienced due to the movement of construction workers and machinery. Property values and aesthetic considerations may be adversely affected for those residences in close proximity to the proposed line (Sections 4.1.5.4 and 4.1.6).

Although the corridor does not cross any land currently used for residential purposes, segments of land in the towns of Norton, Brunswick, Concord, and Waterford are zoned for residential use. Lands within close view of the transmission line may be less likely to be developed as residential areas due to their close proximity to the line and its potential for visual disharmony with the surrounding rural landscape (Sections 4.1.5.4 and 4.1.6).

The construction and operation of the proposed transmission line will not impact any existing commercial or industrial developments in the study area. Although the transmission line corridor does not cross any land currently used for commercial or industrial purposes (other than timber production, see Section 4.1.2.3), segments of land are zoned for industrial-commercial use in the town of Waterford in Vermont and the town of Littleton in New Hampshire. It is not expected that the transmission line will adversely affect any of this zoned land.

Land adjacent to the converter terminal site is dominated by electric generation and transmission facilities. The closest residences are located along State Route 135, approximately 615 m (2000 ft) from the proposed terminal facilities. A total of six residences are located within about 1 km (0.6 mi) of the site. It is not expected that the additional transmission facilities will have an adverse effect on the surrounding residences.

In summary, the construction and operation of the proposed transmission line and terminal facility are not expected to significantly impact any major residential, commercial, or industrial facilities. However, some scattered permanent and seasonal residences may be impacted (see Sections 4.1.5.4 and 4.1.6).

4.1.2.7 Natural Areas

None of the 64 "Primary Natural Areas" identified in the Vermont Natural Areas Project is located within the Preferred Corridor (Section 3.2.7). Although Moose Bog was not identified as a Primary Natural Area during project screening, the natural uniqueness of the bog has since been acknowledged by the Vermont Agency of Environmental Conservation (1982a), the U.S. Fish and Wildlife Service (1979), and others. The proximity of Moose Bog and other candidate natural areas to the Vermont portion of the proposed corridor is described in Table 4.3.

The natural character of some of the Vermont areas listed in Tables 3.2 and 4.3 clearly will not be appreciably affected by development of transmission facilities within the proposed corridor--due to either distance from the corridor, topographic positions, or both. The Preferred Corridor will not encroach on the prime area of the various deeryards, with the exception of the

Table 4.3. Locations of Candidate Natural Areas of Vermont Local to the Proposed New England/Hydro-Quebec Transmission Line Corridor

Natural Area	Mile-Mark Locations†[1]	Proximity to the Proposed Corridor
Averill Lake	1.0	At closest distance, the Lake is about 3.4 km (2.1 mil) east of the proposed corridor.
Brousseau Mountain Talus Slopes	3.2	At closest distance, the talus slopes are about 1.1 km (0.7 mi) east of the proposed corridor. The corridor is well down on the western flank of the mountain while the talus slopes occupy a southern aspect on the upper slopes.
Little Averill Lake Beach	4.0	At closest distance, the beach is about 2.4 km (1.5 mi) east of the proposed corridor.
Gore-Sable-Monadnock Wilderness Area	5.0 to 16.7	The proposed corridor traverses the wilderness area for a distance of 18.8 km (11.7 mi).
Nulhegan Deeryard	12.6 to 14.7	The eastern boundary of the deeryard includes all or portions of the proposed corridor for a distance of about 3.4 km (2.1 mi).
Moose Bog	17.7	At closest river-mile distance, the bog is about 4.2 km (2.6 mi) upstream (Nulhegan River) from the proposed corridor.
	18.5	At closest straight line distance, the bog is about 2.9 km (1.8 mi) west of the proposed corridor.
East-West Mountains Wilderness Area	20.0 to 31.7	The proposed corridor traverses the wilderness area for a distance of 18.8 km (11.7 mi).
Notch Pond Brook Deeryard	20.4	At closest distance, the deeryard is about 0.8 km (0.5 mi) southeast of the proposed corridor
Ferdinand Bog	24.8 to 28.2	The proposed corridor generally parallels the bog for a distance of 5.8 km (3.4 mi). The west boundary of the northern part of the bog and the eastern edge of the proposed corridor generally coincide for a distance of 2.9 km (1.8 mi) whereas the major part of the bog is about 0.6 km (0.4 mi) or more to the east of the proposed corridor.
Paul Stream Deeryard (2 separate areas)	24.7 to 25.3	The western boundary of the smaller deeryard parallels the proposed corridor for about 1.0 km (0.6 mi) at a closest distance of about 0.25 km (0.15 mi).
	26.6 to 28.3	The western boundary of the main deeryard parallels the proposed corridor for about 2.7 km (1.7 mi) at a closest distance of about 1.3 km (0.8 mi).
Mud Pond	33.3	The pond is relatively close to the proposed corridor but for the most part, the latter is located on the opposite slope of an intervening highland.
Rogers Brook Deeryard	36.1	At closest distance, the deeryard is about 0.4 km (0.25 mi) west of the western edge of the proposed corridor.
Umpire-Temple Mountains Wilderness Area	36.4 to 41.1	The proposed corridor traverses the wilderness area for a distance of 7.6 km (4.7 mi).
Victory Bog	38.9	At closest distance, the bog is about 0.6 km (0.4 mi) west of the western boundary of the proposed corridor.
Lee's Hill Deeryard	39.0	At closest distance, the boundary of the deeryard is about 1.6 km (1 mi) west of the proposed corridor.
Bog Brook Deeryard	39.0	This deeryard is located west of the Victory Bog Natural Area, and at closest distance is about 2.4 km (1.5 mi) from the proposed corridor.
Concord Sugar Maple-Beech Forest	42.5	At closest distance, the forest is about 2.4 km (1.5 mi) west of the proposed corridor.

†[1] The boundary between the United States and Canada is mile mark 0.0, as referenced in maps of the Applicant's ER (Vol. 3--Appendix B).

Sources: ER (Vol. 3--Appendix B); Vermont Agency of Environmental Conservation (1978, 1982a); DeLorme Publishing Company (1981); and U.S. Fish and Wildlife Service (1979).

Nulhegan Deeryard. However, it is unlikely that development in the short segment of the corridor located within the extreme eastern portion of the deeryard (3.4 km [2.1 mi]) will significantly affect the carrying capacity of this vast deeryard comprised of over 4,000 ha (10,000 acres). Development in the proposed corridor adjacent to portions of Ferdinand Bog would jeopardize the local natural setting. Effects can be mitigated by shifting the actual right-of-way to the most distant edge of the proposed corridor.

The Preferred Corridor will traverse portions of three "wilderness areas" for a total distance of about 45 km (28 mi) (Table 4.3). Numerous attributes of wilderness environments are present in these areas--i.e., extensive area, rugged terrain, high elevations, limited human developments, poor accessibility, and suitable habitat for a wide range of wildlife species--and development of transmission facilities would indeed detract from these natural attributes. However, for the most part these areas are privately owned timberlands that have been cut-over in the past and will likely be subject to periodic harvestings in the future. Thus, at given times and places, the effects of timber harvesting will obscure the adverse impacts associated with the proposed transmission facilities. In addition, other types of encroachment into these areas are possible in the future. For example, the current trend whereby urbanites seek rural environments for developing primary or second homes, as well as other recreation facilities, is expected to continue in the foreseeable future.

The Preferred Corridor will not encroach on any of the known conservation areas located in the New Hampshire portion of the study area (Section 3.2.7). The route does not traverse any portion of the towns of Whitefield, Bethlehem, Dalton, and Sugar Hill; thus, the wildlife management area and the other natural and conservation areas in these towns will not be affected by development of the proposed transmission line. The 1-ha (2-acre) Littleton Wildflower Preserve (Flaccus 1972) is located about 1 km (0.6 mi) from the proposed route in the town of Littleton.

In conclusion, the construction and operation of the proposed transmission line are not expected to significantly impact natural areas.

4.1.2.8 Airports, Navigation Routes, and Training Areas

The military flight route (IR-800) in the area of the transmission line operates between 5700 to 8000 ft mean sea level (MSL). The low-altitude federal airway had a 7000-ft MSL minimum operation level, but its current status is listed as either unusable or closed. The Military Operations Area, Yankee One, has operational altitudes between 9,000 to 18,000 ft MSL. The airport closest to the Preferred Corridor is located in Littleton, 8 km (5 mi) east of the proposed route.

No significant impacts to airports, air routes, or military training areas are expected due to the construction and operation of the proposed transmission line and terminal facility.

4.1.2.9 FERC-Licensed Lands

Although the Preferred Corridor traverses 4.2 km (2.6 mi) of lands licensed by FERC, impacts are expected to be minor. The proposed right-of-way will pass on the edge of an 8-ha (20-acre) woodlot that contains a 0.8-ha (2-acre) portion considered to be a natural area (Charles T. Main, Inc. 1982). This area contains a 0.4-km (0.25-mi) hiking trail and is maintained in a natural state by the New England Power Company. Approximately 150 m (500 ft) of right-of-way will cross the large woodlot adjacent to an existing right-of-way. By proper placement of support towers, complete clearing will be limited to about 0.08 ha (0.2 acres) and selective clearing to about 0.24 ha (0.6 acres) for a total affected area of about 4% of the woodlot. The natural area itself will be unaffected by the right-of-way.

The proposed line will also have intrusive visual affects near Comerford and Moore reservoir, thereby affecting some recreational users of these areas (see Section 4.1.6).

4.1.3 Hydrology, Water Quality, and Water Use

4.1.3.1 Surface Water

Right-of-Way Construction

During construction, the rate of surface erosion and siltation of streams will temporarily increase due to removal of trees, brush, ground cover, and other vegetation from new access roads, the transmission line corridor, and staging areas. Depending on the proximity of these activities to waterways, eroded sediments may be washed into stream systems or wetlands causing turbulence and increased siltation. Sedimentation will be most severe during the construction period and will diminish when vegetative cover returns several months later. However, where border vegetation is maintained along stream channels near or crossed by the right-of-way, little sedimentation usually occurs (Asplundh Environ. Serv. 1977). Proposed erosion-control measures will generally limit sedimentation to stream crossings and areas immediately downstream.

The negative impacts associated with increased rates of erosion and stream sedimentation are especially severe within first-order streams (the smallest tributaries in a stream system). Because of their small drainage basins relative to the area disturbed by right-of-way construction, as well as their small drainage channels and low-flow volumes, first-order streams are greatly impacted by slight variations in surface runoff or increases in sediment erosion.

Surface runoff along the transmission right-of-way will be greater due to the loss of vegetation that would have intercepted precipitation and slowed runoff, but the area occupied by the right-of-way (ca. 6 km^2 [2.4 mi^2]) will be small relative to the affected watersheds (except in the smallest first-order stream watersheds) and, thus, the overall impact on surface runoff will be small. The area of the watershed is about 1500 km^2 (600 mi^2). Because the surface runoff conditions will not be greatly affected, alterations in stream-flow and drainage patterns should not occur in most watersheds.

Over 90% of the land surrounding the right-of-way is commercial forest. Harvesting of this timberland will require the construction of numerous access roads and extensive clearcutting of the commercial forests. In Vermont, silviculture activities have been cited as being responsible for many of the nonpoint pollution problems in surface waters (Vt. Agency Environ. Conserv. 1982b). Although the impacts resulting from right-of-way and access road construction should be similar to those occurring as a result of silviculture, the magnitude should be much less due to the smaller total area affected by right-of-way construction, less than 0.03% of the timberland in the project area (see Section 4.1.2.3).

Where undersized culverts and extensive fill are used in constructing stream crossings for access roads, natural stream-flow characteristics can be impeded. Numerous access roads, maintained bridges, and pipe and box culverts constructed by the lumber companies already exist on the privately owned forestlands, and existing access will be used wherever possible in preference to constructing new access or stream crossings.

Where streams are forded without the use of temporary bridges, there may be some gasoline, oil, and grease washed off the wheels and undercarriages of construction vehicles. The impact of such chemicals upon the stream system will be dependent upon stream flow and volume: in large, fast-flowing streams, chemicals will be diluted rapidly; in small, slow-flowing streams, chemical concentrations will remain elevated for longer periods of time. Similar impacts can be expected where farm and logging equipment ford streams. Impacts to stream water quality due to stream crossings for right-of-way construction equipment will be of a more limited duration because this activity will occur only twice during the lifetime of the line.

Impacts to stream systems will also be dependent upon the timing of construction activities and the seasonal flow regime of the stream. During the spring snowmelt, soil losses from disturbed areas will be high due to increased surface runoff. Wet soil conditions and muddy roads in the spring, however, will limit access to the transmission corridor. As a result, few construction activities will be conducted during the period when maximum construction impacts due to erosion and sedimentation would be expected.

Throughout the 95-km (59.5-mi) length of the Preferred Corridor, many watercourses will be spanned--the largest being the Nulhegan River at Route 105 in Bloomfield. Removal of tall trees along streams within the right-of-way will increase the exposure of the stream to sunlight, possibly resulting in locally elevated stream temperatures. Because small trees, shrubs, and herbs will be maintained along right-of-way stream or marsh crossings, little variation in the ambient water temperatures of the stream is expected (Asplundh Environ. Serv. 1977). The greatest impact due to temperature change, however, would be felt along slow-moving, heavily canopied sections of any stream.

Unless properly stored and handled, chemicals, fuels, oils, greases, bituminous materials, solids, waste washings, and concrete used in construction operations may, in the event of a spill, be leached into groundwater or carried into surface waters by runoff. The possible impacts resulting from such spills will depend upon the magnitude of the release, the local hydrology and geology, and the toxicity of the chemical.

Converter Terminal Construction

Smith Brook in New Hampshire will be the only stream to be affected by construction of the proposed converter terminal. Such construction will temporarily increase sediment erosion from the site and increase siltation of the brook for up to several months. Siltation will be reduced by the use of sediment-control measures in adjacent areas. The potential for negative impacts to the stream as a result of construction activities will therefore be small, although not eliminated.

Herbicide Application in Right-of-Way Management

In the maintenance of the rights-of-way, limited and selective application of herbicides will be used to control vegetation. After application, herbicides are usually moved into soils during the first precipitation event. In undisturbed forest soils, herbicide breakdown tends to be slow. However, in disturbed areas such as along utility rights-of-way, where sunlight and soil temperatures are increased as a result of site-clearing activities, most herbicides have been found to degrade within a few weeks to carbon dioxide, water, chlorine, nitrogen, sulfur, and phosphorus (U.S. For. Serv. 1978). Although most herbicide molecules will be adsorbed by fine soil particles, some molecules will be volatized, chemically and biologically degraded, taken up by plants, or perhaps leached to surface water or groundwater.

Under field conditions, most herbicides have been found to be quickly degraded, primarily by microorganisms. Han (1979) showed practical-use levels of Krenite to have a half-life of approximately 1 week in soils of Florida, Illinois, and Delaware. After 3-6 months, all traces of the herbicide and its metabolites disappeared in the soil samples. Greenhouse studies reported by Han (1979) indicate a soil half-life of about 10 days, with ^{14}C-labeled Krenite being 45-75% degraded after 90 days via microbial decomposition. A component of Tordon 101--2,4-D--reportedly has a half-life in grass of 2-3 weeks. Only 5% of a 2 lb/acre treatment dose was recovered from a forest floor 35 days after treatment (U.S. For. Serv. 1978). Picloram, another active ingredient in Tordon 101, is the most persistent of the pesticides proposed for right-of-way management, remaining in soil for 18-24 months (U.S. For. Serv. 1978). These herbicides are currently in use by NEET affiliates in New Hampshire (ER, Vol. 2).

The covering of forest duff remaining in the right-of-way will retard the erosion of any soils contaminated by herbicides. Surface waters may become temporarily contaminated by herbicides only where massive rainfalls occur immediately following an herbicide application on unprotected soils of steep slope a short distance from surface waters. The more persistent and soluble an herbicide is and the more permeable the soil, the more likely that the herbicide will leach down to the groundwater. Garlon 4--which is relatively insoluble--would have little potential to migrate from the soil surface to underground water supplies. Leaching is generally a slow process for Krenite, Garlon 3A, and Tordon 101. The slow movement of water through the upper soil layers allows for microbial degradation. The 2,4-D in Tordon 101 has not been found to leach deeper than 10 cm (4 in.) in forest soil profiles. In the Pacific Northwest, no herbicides used for right-of-way management were found to leach more than 30 cm (12 in.) into the soil. Residues in an Oregon hillside pasture were restricted to the top 15 cm (6 in.) of soil and averaged 60, 20, and 4 ppb after 9, 18, and 27 months, respectively (U.S. For. Serv. 1978). Little or no leaching of Krenite in soil has been noted because it is readily absorbed by soil particles. In general, however, the concentration of herbicide in either surface water or groundwater has been found to decrease rapidly with distance from origin (U.S. For. Serv. 1978).

The specific methods of application, types of herbicides, auxiliary spraying compounds, etc., to be used in the maintenance of right-of-way vegetation have not been specified to date. Practices accepted by the Vermont Pesticide Advisory Council will be followed (see Section 4.3.8.2) for selective application of herbicides (ER, Vol. 3). Thus, many of the potential herbicide-related impacts may be mitigated and substantially reduced.

4.1.3.2 Groundwater

Generally, except for the gravel aquifer in the Nulhegan-Clyde valley, most groundwater of concern in the vicinity of the line is contained in shallow unconfined aquifers within the glacial or alluvial deposits. This groundwater is local in origin, being composed of rainwater slowly percolating down through the surface soils to the underlying till or drift. Careless and excessive application of herbicides in right-of-way maintenance could result in the percolation of herbicides to surface aquifers, potentially affecting local well supplies drilled into the surface aquifer. The low permeability of the surface tills and their correspondingly low pumping rates of about 0.06 L/s (1 gal/min), the distance of the Preferred Corridor to any well, and the discontinuous and selective use of herbicides will help to minimize any contamination should it occur. The low population density in the areas of Vermont to be traversed by the Preferred Corridor will also lessen the potential extent of impacts on potable water supplies. Where transmission line rights-of-way cross major stream valleys or areas of active farming (areas where population densities and hence the number of wells are greatest), the impacts of herbicide spraying may be the greatest. The severity of the impacts, however, would be related to the specific hydrologic characteristics of the area surrounding the transmission line, the permeability of the surface soils, the proximity and rate of pumping of nearby wells, and the biological degradability of the herbicide.

In the Nulhegan valley, water percolation rates are more rapid through the highly permeable gravel deposits and, as a result, recharge water is local in origin. Wells in these materials may yield over 6 L/s (100 gal/min). Due to the rapid rates of percolation, groundwater supplies within this area could be contaminated if water-soluble, persistent herbicides are used in the vicinity of wells. The potential significance of such contamination on local populations and wildlife is discussed in Sections 4.1.4 and 4.1.8.3.

The relatively small size of the right-of-way compared to the size of the aquifer, the small quantities of herbicide that will be used, and the rapid rate of degradation of the herbicides typically used for such control purposes, however, will reduce the potential for significant contamination of the aquifer. If the Vermont Agency of Environmental Conservation (1982b) should classify the Nulhegan-Clyde valley aquifers as Class I groundwaters (groundwaters that recharge community water supplies) or as Aquifer Protection Areas, activities known to contaminate groundwater could be excluded from the area. It is not currently known whether herbicide applications for right-of-way management may be determined as a contaminating activity.

4.1.4 Ecology

4.1.4.1 Terrestrial

Vegetation

Effects on vegetation that would result from right-of-way clearing will closely parallel those typical of logging operations. Since a high proportion of the right-of-way is forested (ca. 85%), most of the adverse effects on vegetation associated with construction of transmission line and converter terminal facilities will be superimposed on impacts resulting from right-of-way clearing.

Although right-of-way clearing and conventional logging are reasonably comparable, objectives differ in several respects. For example, clearing entails not only cutting of large mature trees but also removal of potentially tall-growing trees regardless of size. To the extent practical, damage to shrub and herbaceous species during clearing operations will be minimized. Vegetation immediately beneath the transmission line conductors will be limited to low-growing shrubs and herbaceous species, whereas taller shrubs and certain trees of low height-growth potential will be retained only in the "side strips" or outer portions of the right-of-way (ER, Vol. 3--Appendix A). Certain tall trees (danger trees) outside of the right-of-way that could potentially jeopardize the integrity of the transmission line will also be removed.

The more severe impacts on vegetation resulting from the actual emplacement of transmission line facilities will occur at small construction sites established for erecting the towers or transmission line support structures. On the average, tower construction sites will be located at 210-m to 240-m (700-ft to 800-ft) intervals, but both the height and spacing of the tower supports will vary to avoid environmentally sensitive areas or features. Development of a network of access and service roads for transport of building materials and supplies will also contribute to disruption and/or severe alteration of vegetation. The stringing of shield and conductor cables will result in relatively minor alteration of affected vegetation.

General vegetation types of the 85-km (53-mi) Vermont segment of the proposed right-of-way are presented in Table 4.1. Of the total 517 ha (1277 acres) within the right-of-way, about 440 ha (100 acres) of forestland will be subject to typical right-of-way clearing operations. Assuming a 210-m (700-ft) tower spacing and a 0.09-ha (0.23-acre) construction site for erecting each tower, about 32 ha (79 acres) will be disturbed during clearing operations and further disturbed during tower construction activities. The vegetation of the remaining 73 ha (179 acres) will be less drastically disturbed. For example, some of the wetland vegetation types are sufficiently low in stature as to preclude interference with efficient operation of the proposed line. Agricultural lands and existing clear-cut forestlands will likely entail little if any right-of-way clearing, whereas clearing of forest regrowth areas will likely result in an intermediate degree of disturbance. Access and service road requirements are unresolved at this time.

An estimated 40 ha (100 acres) of forestland between the converter terminal and Moore Dam will be subject to typical right-of-way clearing activities Table 4.1). The effects of constructing transmission facilities will be superimposed on those resulting from previous right-of-way clearing during the widening of an existing transmission line. The collective area affected by construction of tower structures will be about 5 ha (12 acres). Additional but relatively minor impacts will result from construction of access and service roads; however, quantitative estimates of the affected areas are not possible because specific access and service road requirements have not been established. Service roads are typically limited to the right-of-way, and much of the necessary access will likely be via existing roads or trails.

Selective cutting of the right-of-way between the converter terminal and the Comerford Station will be employed to screen the facilities from the view of local residents and travelers on State Route 135 (ER, Vol. 1--Sec. III D). Selective cutting procedures will also be used in the area where the proposed right-of-way traverses Smith Brook. In order to retain as much vegetation as possible and yet maintain the necessary clearance, some trees may be topped rather than felled. The treated area would encompass about 3.7 ha (9.1 acres); the vegetation disturbed by tower construction would be of minor consequence.

The converter terminal in New Hampshire will occupy an area of about 9.3 ha (23 acres) currently supporting forest and cropland vegetation. This area will be cleared of all vegetation, stripped of topsoil, regraded, and resurfaced with crushed rock. The site, therefore, will be unavailable for revegetation. Additional herbaceous vegetation will be disrupted or otherwise altered on an unspecified area to provide space for construction laydown area, topsoil storage, machinery yarding areas, parking lots, etc. If appropriate, landscaping will be initiated to screen the site from public view (ER, Vol. 1--Sec. III A).

The construction impacts on vegetation would be appreciable (85%) in terms of the right-of-way itself, but negligible (<0.03%) in relation to the total vegetation resources of the three counties in which the proposed facilities would be located. In view of the underutilized status of Vermont forest resources (see Section 3.2.3), converted land use of the primarily forested right-of-way is an acceptable trade-off for the benefits derived from energy exchanges involving hydroelectric generation facilities.

Following the initial clearing and subject to easement agreements, vegetation in the right-of-way will be controlled by a combination of mechanical and chemical methods. Only those herbicides and applicable methods approved by the U.S. Environmental Protection Agency and appropriate state agencies will be used. Accordingly, chemicals will be selectively applied at the base or on the foliage of undesirable species.

In an operational mode, the proposed transmission line will create several phenomena that are potentially harmful to biota. Those pertinent to vegetation include the generation of electric fields and the production of air ions, ozone, and oxides of nitrogen. Based on a review of three recent studies (Griffith 1977; Minn. Environ. Qual. Board 1982; Banks et al. 1982), it can be concluded that the electric fields and air ions generated by the proposed transmission line will not appreciably affect local vegetation.

In two other studies (Krupa and Pratt 1982; Droppo 1981), the contributions of HVDC transmission lines to atmospheric concentrations of ozone and oxides of nitrogen were found to be insignificant relative to impacts on vegetation.

In 1981, a test span of transmission line was erected that essentially duplicated design specifications of the proposed New England/Hydro-Quebec interconnect (Johnson 1982a). In supplemental testimony on behalf of the Vermont Department of Public Service, Johnson (1982b) summarized the operational characteristics of the test facility, which included the following statement: "the line does not produce measurable ozone at the edge of the right-of-way."

In conclusion, it is unlikely that operation of the proposed transmission line will cause appreciable adverse impacts on vegetation resources other than those resulting from periodic right-of-way maintenance activities.

Wildlife

Impacts on wildlife from construction of the proposed 95-km (59.5-mi) powerline and converter terminal fall into two categories: (1) loss and alteration of habitat, and (2) disturbance of individuals due to noise generation and human activity.

During construction of the transmission line, forest habitat comprising approximately 85% of the land within the right-of-way will have to be cleared (Tables 4.1 and 4.2). Although data are too limited to make quantitative predictions in regard to construction of the proposed line, qualitative predictions of potential impacts are possible based on other studies (U.S. Environ. Prot. Agency 1971; Dufour 1980; Liddle and Scorgie 1980; Hicks 1979).

Approximately 13 ha (32 acres) of forest will be cleared for the converter terminal and associated right-of-way. Some wildlife associations around the existing right-of-way will be altered slightly, but the habitat that will be affected is not critical or highly preferred by any wildlife species in the area (U.S. Dep. Energy 1978). Because the forest to be cleared represents a minute fraction of that available, impacts to local wildlife populations will not threaten their continued survival.

It is unlikely that construction activities per se will result in a threat to the continued survival of local wildlife species. Most of the activity will occur in a region where clearcutting for timber is a regular operation. Activities will be of relatively short duration, four days per 8-km (5-mi) section of line. Thus, wildlife affected by human activity are likely to be disturbed for only a brief period and are likely to return to normal behavior patterns upon cessation of activities. With the exception of 3 to 4 km of the route in southern Essex and Caledonia counties, the corridor skirts the edges of deeryards. Thus, most deer avoiding construction activities should find ample forage and cover in areas unaffected by human intrusion.

The amount of clearing for the transmission line will result in loss of only a small fraction (<0.03%) of forest habitat of Essex, Caledonia, and Grafton counties. The quality of habitat to be lost, however, is an important consideration in the overall impacts of clearing habitat. General estimates of the quality of habitats (evaluated as to their preferability to wildlife species) affected by the proposed transmission line are presented in Table 4.4. It is estimated that only about 5 to 10% of the line would cross good to high quality habitat for the selected species (U.S. Dep. Energy 1978). The highest valued habitat that could be affected by the construction of the transmission

Table 4.4. Value of Wildlife Habitat Crossed by the Preferred Corridor

Habitat Value	Percent of Total Habitat Within Corridor†[1] Special Species†[2]	Harvested Species†[3]	Deer
1 - Low	0		0
2 ↓	42	51	5
3 ↓	49	44	84
4 ↓	9	0	4
5 - High	0	5	1

†[1] Value based upon habitat preference and number of species found in a given habitat during field studies (U.S. Dep. Energy 1978--Sec. 2.08).

†[2] Officially or unofficially rare, threatened, or endangered species in the region.

†[3] Game and furbearing species.

line are the wetlands (see Sections 4.1.4.3 and 4.1.4.4), which form highly preferred habitat for a large number of harvested species and rare or endangered species.

There have been a number of reports that have examined the impacts of clearcutting and right-of-way management on wildlife (e.g., Arner 1977; Asplundh Environ. Serv. 1977; Carvell and Johnston 1978; Galvin and Cupit 1979). In general, right-of-way maintenance results in the presence of wildlife who prefer open habitat with few large trees. These wildlife species are often those characteristic of early stages of plant community succession, such as are found in abandoned farm fields or post-fire regeneration. Over 50 species of wildlife in the region are frequently found inhabiting early successional stages of vegetation (U.S. Dep. Energy 1978). Maintenance of a clearcut strip in an area of extensive forests offers a more diverse habitat than pure forest stands for supporting a greater diversity of wildlife (Mayer 1976; Johnson et al. 1979; Geibert 1980; Cavanaugh et al. 1981; Kroodsma 1982). The herbaceous and shrubby growth also provide food for a number of wildlife species, especially deer (Krefting and Hansen 1969; Kufeld 1977). Rights-of-way have been assessed as having high value for use by deer, particularly where they cross extensive woodlands (Bramble and Byrnes 1979; Eaton and Gates 1981; Mayer 1976). Rights-of-way through forest in northeastern New York have been shown to provide valuable forage for local white-tailed deer populations (Asplundh Environ. Serv. 1977).

The Preferred Corridor will cross about 82 km (51 mi) of forestland in Vermont and New Hampshire. On the basis of the studies cited above, it is anticipated that the right-of-way through forested land will increase the diversity of wildlife species in the vicinity of the route. In addition, herbaceous and woody shrubs of the right-of-way will provide forage for deer populations in the area.

The Preferred Corridor will pass through about 13 km (8 mi) of known deeryards, which are used for overwintering by white-tailed deer (ER, Vol. 3--Appendix B, Maps D1-D8). The closed canopy over deeryards provides overwintering deer with shelter from the winter conditions of northern New England. The openness of a cleared right-of-way would result in more extreme temperatures, greater winds and convective heat loss, and greater amounts of drifting snow (Herrington and Heisler 1973). Lower temperatures and higher winds impose greater thermoregulatory stresses on individual deer. Deeper snowdrifts increase the metabolic costs of travel and cover potentially important sources of winter browse. Several studies have shown that deer avoid open rights-of-way in the winter in direct proportion to the width of the clearing (Hydro-Quebec 1981; Doucet et al. 1981; Willey 1982). Other studies have found no differences in the winter use of a forest and adjacent right-of-way by deer (Asplundh Environ. Serv. 1977). The different results may be attributable to climatic differences at the study sites. The negative responses of winter use of rights-of-way were obtained in northern Vermont and Quebec.

Where a right-of-way serves as a partial barrier to deer movement within a deeryard, it effectively reduces the amount of yard available to overwintering deer. This could force deer to use suboptimal habitat, leading to debilitating stress. Most of the 13-km (8-mi) right-of-way that passes through potential deeryards will cut across the edge of the yard. Less than 4 km (2.5 mi) will bissect a deeryard where the line parallels Moore Reservoir. Along this section, the route will parallel a current right-of-way that will be widened to about 90 m (300 ft) to accommodate the proposed line. Where the right-of-way crosses through a known deeryard, travel lanes of coniferous trees will be provided that afford deer passage across the clearing.

In addition to selective clearing of woody vegetation, VETCO proposes to use selective applications of herbicides (see Section 4.3.4.1). Most herbicides are known to have toxic effects upon animals (Buffington 1974; Kitchings et al. 1974), and a number of studies have examined the responses of wildlife populations to applications of herbicides. Both Carvell and Johnston (1978) and Asplundh Environmental Services (1977) found that wildlife use of right-of-way habitat and herbicide use appear to be compatible. Other studies have shown that the responses of wildlife to herbicide use are attributable to habitat changes resulting from treatment rather than direct, toxic effects of the applied herbicide on the wildlife (Johnson 1964; Tietjen et al. 1967; Krefting and Hansen 1969; Johnson and Hansen 1969; Beasom and Scifres 1977; Kufeld 1977; Fagerstone et al. 1977; Sullivan and Sullivan 1982).

The available data indicate that proper use of herbicides in right-of-way management does not pose a toxicological threat to wildlife individuals or populations. Although the amounts of herbicides to be used and rates of application have not been determined at this time, the planned use of herbicides in the area of the proposed route should not threaten wildlife. The Applicant is committed to apply herbicides in accordance with state of Vermont and New Hampshire regulations.

Although the primary impacts to wildlife will result from alteration of habitat in the right-of-way, there are several potential impacts from the presence and operation of the transmission line itself: collisions of birds with towers or conductors, electrocution, ozone generation, audible noise generation, spark discharge, electric/magnetic field effects, and air ion generation. Raptors and waterbirds are particularly sensitive to human disturbance (Stalmaster and Newman 1978; Swensen 1979; Erwin 1980; Liddle and Scorgie 1980; Burger 1981).

There are several documented cases of bird mortality from collision with conductors or tower structures (Avery et al. 1978; U.S. Fish and Wildl. Serv. 1978). The majority of the species involved in such incidents are migratory waterfowl. The proposed transmission line will not be tall enough (< 33 m [110 ft]) to pose a threat to any birds in migratory flight. In general, migratory flight occurs at altitudes in excess of 100 m (300 ft) above ground surface (U.S. Fish Wild. Serv. 1978; Lincoln 1979). However, waterfowl landing or taking flight could strike components of a line passing over or immediately adjacent to an open body of water. The Preferred Corridor will pass over less than 1 km (about 0.6 mi) of lakes and cross several drainages that may be used by waterfowl. Because this represents only a minute fraction of the available habitat of this type, it is unlikely that the threat of collisions will affect more than a minor fraction of waterfowl in the locale.

Electrocution can occur when an animal makes contact with two energized conductors or with one energized conductor and a shield wire or grounded part of the support tower. Historically, this has been a problem only with large raptors (such as eagles) and smaller lines. Minimum clearances on the proposed line (> 3 m [10 ft]) will ensure that such a possibility does not exist. Spark discharges to wildlife or livestock under the line are also unlikely because maximum voltage buildup (0.07 kV) in objects beneath the line is not expected to be sufficient for such occurrences (Johnson 1982a). Carpet-like shocks occur at levels of about 10 kV (see Section 4.1.8.2).

The operation of DC lines similar to the proposed line is known to generate ozone when the lines are in corona (Droppo 1979; Bonneville Power Admin., undated; Johnson 1982a; Krupa and Pratt 1982). Maximum, short-term concentrations of ozone at ground level have been measured at about 20 $\mu g/m^3$ (10 ppb) above background levels, which is about 40% of the level of detectability but 10% of the minimum concentration required for toxic effects during short-term exposure of animals (Cleland and Kingsbury 1977; Goldsmith and Friberg 1977; Coffin and Stokinger 1977). Tests for the state of Vermont found that operating a line with the same design parameters as those proposed by the Applicant generated no ozone discernable from background (Johnson 1982a). Therefore, it is unlikely that the transmission line will generate sufficient ozone to be detrimental to wildlife or livestock in the vicinity of the line.

Audible noise levels could reach a 24-hour, day-night weighted average of 44 dB(A) at the edge of the right-of-way. This calculation assumes maximum generation of noise under fair weather conditions throughout a 24-hour period (ER, Vol. 3). Johnson (1982a) measured audible noise directly beneath the positive pole of line constructed and operated according to the specifications of the proposed transmission line. The test line produced no detectable noise under fair weather or fog conditions. Measurements indicated that the noise emission level during snow was about 35 dB(A) immediately below the positive conductor. Rural background noise ranges from 20 to 40 dB(A) depending upon weather conditions (U.S. Environ. Prot. Agency 1974).

There are insufficient data to quantitatively relate audible noise emissions to impacts to wildlife. Deer and elk have been observed using transmission line rights-of-way despite the presence of audible noise (Lee and Griffith 1978). Wildlife use of transmission line rights-of-way under a variety of weather conditions implies that audible noise has a negligible impact upon wildlife activities. The low level of audible noise emitted by the proposed transmission line is unlikely to deter wildlife from using habitat in the vicinity of the right-of-way.

In a number of studies, investigators have attributed animal's behavioral and physiological responses to the presence of air ions (Sheppard 1979; Sulman 1980). In general, responses have been elicited at ion levels on the order of 10^4 to 10^5 positive ions/cm^3 and 10^4 to 10^6 negative ions/cm^3. Increased physiological stress in an animal is attributed to increased levels of positive ions. No similar stress response has been attributed to increased levels of negative ions.

During foul weather, measured ion densities could extend into the lower range of values for which biological effects have been attributed (see Section 4.1.8.2). Because of their great mobility, it is unlikely under normal conditions that wildlife or livestock will remain continuously under a line operating in such conditions. Rapid dispersal of ions to background levels reduces the possible impacts of air ions beyond ~50 m (~150 ft) from the conductors. The data suggest that air ions are unlikely to have impacts on animals temporarily in the vicinity of the right-of-way.

Maximum magnetic fields measured at ground level under ±400 kVDC transmission lines are on the order of one-half the natural, ambient condition (Bracken 1979a, 1979b). Magnetic fields from the proposed line are not expected to influence animals in the vicinity of the Preferred Corridor because field strength dissipates rapidly with distance from the line, and field levels are well below (ca. a factor of 10^{-5}) levels known to elicit even equivocal responses in laboratory animals.

The electric field under DC lines in corona can exceed ± 20 kV/m (Bracken 1979a, 1979b; Stanley Consult. 1980; Bonneville Power Admin., undated; Skarbakka, undated). Operation of the Vermont test line yielded maximum electric fields under the lines in excess of -30 kV/m and +25 kV/m (Section 4.1.8). Electric field strength dropped precipitously to below ±15 kV/m at about 30 m (100 ft) from the centerline (Johnson 1982a), equivalent to the proposed right-of-way edge.

There is little literature on the effects of DC electric fields upon animals (Lee 1979; Sheppard 1979; see Section 4.1.8.2). The magnitude of electric fields under DC lines does extend into the range of values for which behavioral and physiological responses have been reported. These responses have been observed only after several days exposure to a continuous electric field. Because of changing levels of line corona and animal mobility, such conditions are improbable for free-ranging animals using the right-of-way under the proposed line. In addition, maximum field strengths are only found immediately under the conductors and they dissipate exponentially with distance.

Beyond the edge of the right-of-way, field strengths are well below levels known to elicit responses.

4.1.4.2 Aquatic

Construction activities for stream crossings, especially access roads, will result in the principal impacts that can occur to aquatic biota such as: (1) changes in water temperatures resulting from removal of riparian vegetation, (2) habitat destruction or modification resulting from instream construction activities, and (3) downstream increases in turbidity and sedimentation resulting from erosion and stream sediment displacement at the construction site. These impacts can be expected to occur in varying degrees at every stream crossing requiring the construction of an access road. The actual number of access roads and stream crossings involving access roads that will be required is not currently known; this will be determined once the final line alignment within the Preferred Corridor is established and final engineering plans are developed. The severity of impact will depend upon several factors, including: (1) season of construction, (2) stream size (length and width), (3) corridor width, (4) construction procedures, and (5) habitat quality (Dehoney and Mancini 1982). Generally, the smaller streams will have the greatest potential to be impacted because they have less ability to assimilate (dilute) introduced solids and are more affected by removal of riparian vegetation.

Stream temperature alteration is reported to be one of the most significant impacts resulting from vegetation clearing of stream crossings for right-of-way construction (Herrington and Heisler 1973). Although stream temperatures have been reported to increase sufficiently to cause fish mortality in isolated instances--especially to juveniles or embryos (Lantz 1971)--reduced growth, vigor, and resistance to disease are probably the main effects of elevated stream temperatures (Fredricksen 1971-1972). However, considering the short linear extent that would be cleared for the proposed transmission line and/or access road at any stream crossing (e.g., only 200-300 linear feet [60-90 m] of riparian vegetation will need to be removed), it is doubtful that significant thermal increases will occur. In some areas, trout streams may benefit through promotion of low-growing stream vegetation and instream macrophytes (White and Brynildson 1967) as a result of increased sunlight penetration accompanying removal of large trees along the streams.

Habitat disturbance can have an immediate and localized impact on aquatic biota, but turbidity and especially sedimentation can result in greater and more widespread biological impacts. Eggs and larvae of fish and macroinvertebrates would be most adversely effected by increases in siltation and turbidity due to their relative immobility, whereas adult fish would likely vacate the area (Dehoney and Mancini 1982). The mobility of fish allows them to avoid many of the activities associated with stream crossing construction (Busdosh 1982). However, increased siltation could disrupt fish reproduction by covering potential spawning grounds (Karr and Schlosser 1978). The locations where access road stream crossings will most probably be required (e.g., smaller streams), coupled with the physical characteristics often chosen for the crossing areas (e.g., gravelly riffles), essentially coincide with the habitat used by the salmonids for spawning (see Table 3.5). Shelton and Pollock (1966) found that when only 15 to 30% of gravel interstices were filled with sediments, 85% mortality of salmon eggs occurred. Moreover, sediments can act as a physical barrier to fry trying to emerge from nests.

Fish can also be affected by interference (blockage) of pre- or post-spawning migrations due to instream construction activities (Dehoney and Mancini 1982). However, pipeline crossings (which require stream dredging not involved in access road construction, although stream bed grading may be necessary) have been shown to create elevated turbidity levels for only several hours following construction and affect only a short distance of stream, e.g., ≦ 300 m (2,000 ft) (Dehoney and Mancini 1982). Road crossing construction could be expected to have a similar degree of impact. Therefore, disruption of such migration would only be temporary because stream disturbances would not be expected to last more than a few days, whereas fish migration occurs over a period of days to weeks (Geen et al. 1966).

The major water quality impacts currently experienced in the study area are due to nonpoint pollution resulting from silviculture. Impacts include erosion sedimentation and increased stream loading of color-producing and oxygen-demanding organic matter (ER, Vol. 3--Sec. III.B.8). Stream crossing construction will result in similar, but shorter-term (i.e., days to weeks vs. months to years) impacts. A lesser degree of impact will occur at streams where only the line crosses the stream and no access roads are constructed. The streams most sensitive to impact are those that are generally shallow and wide with small sidecharges, little groundwater inflow, and resident populations of coldwater fish species (Galvin 1979). No information was found to determine which streams in the study area would be most sensitive based upon groundwater and sidecharge inflow. However, the majority of the streams are coldwater trout streams (Section 3.4.2). Therefore, it may be conservatively stated that all streams to be crossed by the proposed Vermont transmission line would be sensitive to impacts associated with construction of stream crossings. Fortunately, access roads exist across many streams due to the abundance of maintained logging roads in the area (ER, Vol. 3--Sec. III.B.2). Therefore, not all the streams to be traversed by the proposed transmission line will require an access road to be constructed. As previously stated, the exact number of access roads will be determined once the final routing within the Preferred Corridor is established. The impacts to particular streams will, in principle, be similar.

Benthic invertebrates could be impacted by gill abrasion, smothering, and/or habitat loss through the deposition of suspended solids. Sediment additions significantly increase the number of organisms in the drift (Rosenberg and Weins 1978), at the cost of benthic standing crops in the disturbed area. However, such impacts should be short-term because the benthos are rapidly replenished by various colonization routes (i.e., drift, upstream migration, vertical migration, and aerial colonization [Williams and Hynes 1977]).

The duration of time that an area will remain impacted by stream crossing activities will primarily depend upon the length of time required for introduced silts to be removed from the natural substrates. In turn, this depends upon construction and mitigative procedures. Because only a limited area will be disturbed by construction and adequate mitigative measures will be implemented, stream recovery should be fairly rapid. Stream recovery rates (i.e., return to near original biological and physical conditions that existed prior to construction) are often estimated to occur within a year and as fast as six weeks (Dehoney and Mancini 1982).

Following construction, fish could be impacted as a result of improper design characteristics, e.g., improper culverts. Improper culverts or use of unsuitable (unstable) fill material could lead to complete washout of a stream crossing enbankment. This can result in the most severe erosion stemming from highway development and is responsible for the greatest percentage of fish passage problems (Dryden and Stein 1975). Improper culverts can eliminate fish species from a stream through complete and permanent blockage of migration, particularly upstream spawning runs. Partial blockage, in which case only a particular size range of fish can ascend through a culvert, may allow a species to survive but in greatly reduced numbers. Spawning downstream of the blockage may be hampered by overcrowding--forcing fish to spawn in marginal areas, avoid the system, or not spawn at all (Dryden and Stein 1975). Additionally, improperly stabilized banks and improperly sized culverts may cause long-term erosion. Resultant downstream sedimentation can totally destroy spawning habitat. If areas are not completely silted in, spawning may still be only partially successful due to sediment effects on eggs and larvae. Numerous access roads, maintained bridges, and pipe and box culverts constructed by lumber companies already exist on the privately owned forestlands; existing access will be used wherever possible in preference to constructing new access or stream crossings. Other measures to mitigate the potential impacts are discussed in Section 4.3.3.

Fish may also be physically impaired as a result of stream crossings. The accidental release of toxicants (e.g., gasoline, lubricants, fuel oil, and insecticides) could cause the most serious impacts. Increased suspended solids could reduce dissolved oxygen levels and be abrasive to fish gills. Fish may also be injured when attempting to ascend culverts or other fish passage facilities (Dryden and Stein 1975).

During operation, aquatic systems may be impacted from maintenance activities, primarily vegetation control. However, required vegetation control near stream crossings should be infrequent and of a much lower degree of activity than would occur during construction. For example, in-stream disturbances will not be required and only selected trees may have to be removed or trimmed. Vegetative control near streams may temporarily increase stream bank erosion due to the activity of men and machinery. Impacts would be similar to those discussed for construction.

Secondary impacts to fisheries can occur from increased public access via access roads or transmission line right-of-way. This should have a minor impact, however, because most areas will still be remotely located from major roads. Fishing in the region is primarily for trout (i.e., stream fishing), and ponds and lakes used for fishing would primarily be those developed and routinely stocked for such activity. These water bodies would already have ready access to them and, thus, would not be affected by any increased access that may result from the proposed transmission line. Fisheries could be impacted, however, by increased fishing pressure or by human activity (e.g., off-road vehicles), hindering revegetation and thus prolonging erosion and related perturbations to the stream (Galvin 1979).

Ponds and lakes should not be directly impacted because line routing will either avoid such aquatic systems or span them.

In conclusion, long-term impacts to aquatic ecosystems from the proposed Vermont transmission line will be minimal. Although impacts resulting from construction (e.g., erosion and subsequent increases in turbidity and sedimentation) may occur, they will be localized, short-term, and reversible. The potential for significant adverse impacts will be minimized if proposed (and suggested) mitigative measures are properly implemented. Mitigative measures are listed in Section 4.3.4.2.

4.1.4.3 Wetlands

Although construction activity will avoid wetland areas where possible, it is unlikely that all such areas can be avoided. Therefore, some adverse impacts, although temporary, will occur during construction and stringing operations and following construction. These impacts are discussed in Appendix B. However, these impacts are minor and will be largely reversible. This evaluation is based upon proposed (and suggested) mitigative measures to minimize wetland impacts (see Section 4.3.4.2).

4.1.4.4 Threatened and Endangered Species

<u>Plants</u>

There are no plant species on the federal list of threatened and endangered plants that are likely to occur along the proposed transmission line corridor (see Section 3.4.4.1). For the most part, the corridor is routed around areas of specialized habitats (e.g., rock ledges and wetlands) that could provide habitat for rare plants known to occur in the townships through which the corridor passes. Although rare taxa have been found within the Preferred Corridor (Table 3.6), the centerline has been routed to avoid posing a threat to these populations.

<u>Wildlife</u>

There are nine threatened, endangered, or rare species of wildlife that could be affected by the transmission line (Table 3.7). The major potential for impact is associated with clearing of forest habitat for the right-of-way. All of the species listed in Table 3.7 are wide-ranging, with populations extending throughout New England, albeit sparsely. Therefore, loss of this minor fraction of available habitat is unlikely to result in a reduction in numbers of these protected species. The Applicant's ground surveys found no signs of these protected species within the Preferred Corridor (Aquatec, Inc. 1983).

4.1.5 <u>Socioeconomic Consequences</u>

4.1.5.1 Population

Because of the proximity of the route to some current residential or planned residential areas, there may be a small change in the distribution pattern of future population in the area. However, because population growth is expected to be slight, this impact will be very small.

4.1.5.2 Institutional Setting

Because of the small number of nonlocals on the construction work force, no significant impacts are expected on community services, such as schools, or on utility capacities. Slight temporary increases of demand during the construction period can be handled by existing facilities.

4.1.5.3 Employment and Economics

Approximately 125 to 175 people will be required to build the line (ER, Vol. 3--p. 91). An additional 290 workers will be needed to construct the converter facilities, although probably no more than half that number would be employed at any one time (ER, Vol. 1--p. 55). Because of the special skills and experience needed, a subcontractor and workers from the outside area would make up the majority of the construction work force. A recent survey of transmission line construction workers found that local workers were more likely to be hired for clearing the right-of-way than for other project tasks (Gale 1982). In the case of the proposed line, however, most of the clearing will be done by the private timber companies who own most of the land along the proposed route; thus, few new workers are likely to be hired even for this activity. Even if up to 50 line workers were hired locally, improvement in the local employment situation would be insignificant. According to one forester of International Paper Company, clearing will require crews of about 10 workers per mile. These crews would be taken off other company clearing operations, thus slightly affecting company clearing plans (Sawyer 1982).

Because nonlocal workers will be brought in to construct the converter station and the line, some short-term, small increases will occur in local taxes and in sales of local commercial operations (e.g., lodging facilities, restaurants, food markets, and entertainment). If the incoming, noncommuting workers spent about 40% of their pay locally (Gale 1982), this slight positive impact would likely be felt mostly in St. Johnsbury, the major commercial center in the area.

Counterbalancing these positive aspects of the incoming work force would be the problem of competition with tourists for lodging facilities. The Mountain West study found that for every 100 nonlocal workers on a transmission line construction project, approximately 170 people moved into the area (Gale, 1982). Assuming conservatively that this ratio would be the case for the entire period of the project, then between about 80 to 290 new people (50 to 170 of which would be project workers) would reside temporarily in the area for some part of the five-year construction schedule.

Assuming that 50% of the work force might use local temporary lodging facilities, the number of rooms available for tourists might be reduced by about 25-85 rooms. Since these facilities are nearly filled to capacity in summer, fall, and school vacations, this demand would conflict with tourism in the area. Income to local establishments would remain unchanged, although a reputation for crowding and difficulty in obtaining lodging reservations over the five years of the project could negatively affect the tourist demand temporarily after the project was completed.

Timberland used for the right-of-way will acquire a higher property value. Thus, revenue from property taxes on this land will increase. Using current town tax rates, it is estimated that the total potential increment in taxes paid to all towns along the route will be between $419,000 and $617,000 per year (ER, Vol. 3--Exhibit 3-32). The level of this increment in revenue, however, depends also on other factors: the compatibility between the tax rates of the town and those used by the utility; the depreciation rate used by the utility on its structures; and the assessed value of right-of-way land after the transmission line is in place. These factors are discussed below.

Compatibility between town tax rates and the tax rates the utility is willing to use is now the subject of a court case in New Hampshire (Coos County Democrat 1981; Jennings 1982). The results of this case may clarify whether a utility is subject to the tax rates levied by each town along a transmission line route. If the case is settled in favor of the Public Service Company of New Hampshire, revenue to the New Hampshire towns would be somewhat less for the right-of-way land than has been estimated. Additionally, a utility will depreciate the value of structures, reducing the assessed value of the line every year and, thus, reducing the revenue to the towns.

Finally, landowners whose property is crossed by the line will request easements in the assessed value of their property. A local New Hampshire appraiser for tax assessment has estimated that the value of a residential lot crossed by the line could drop 20% (White, M. [Vol. 4], In N.H. Bulk Power Supply Site Eval. Comm. and Publ. Util. Comm. 1981-1982). The proposed Vermont line will cross some land that is currently residential in Vermont and New Hampshire. Although an estimate of the drop in property tax revenue resulting from easements granted cannot be made, it is clear that some drop would occur. It is unclear if residents whose land is adjacent to the right-of-way would also ask for and be granted lower assessment values or easements. In some towns, these decreases in tax revenues will be compensated by the increase in assessed value of the right-of-way lands.

Some of the land along the proposed route is already or is planned for subdivision and residential development. The presence of the line may slow or stop these plans and thus reduce income. It is possible that investors in development of these sites would be more difficult to find and lot subdivision and access route planning could be more complicated (Bartle, R. [Vol. 5], In N.H. Bulk Power Supply Site Eval. Comm. and Public Util. Comm. 1981-1982). These factors would also lower the projected tax payments from the line. Although towns are probably not budgeting now on the basis of expected revenues from future development, they do take into account the future of their tax base when making long-term plans, such as large capital investments.

The president of a Littleton savings bank stated that his bank had witnessed drops in mortgage value of homes along transmission lines. Construction plans on some lots within the right-of-way or with the proposed line in their viewshed have already been halted. A representative of two organizations of local commercial operations, the White Mountain Region Association and the Littleton Industrial Development Corporation, also expressed concern that the line would reduce the tax base which is so dependent on tourism and retirees moving to the area (N.H. Bulk Power Supply Site Eval. Comm. and Publ. Util. Comm. 1981-1982).

4.1.5.4 Housing

There are nine year-round homes and one seasonal home or camp within 0.4 km (0.25 mi) of the possible transmission line routes; nine year-round and eight seasonal homes between 0.4 and 0.8 km (0.25-0.5 mi) away; and seven year-round and 20 seasonal homes between 0.8 and 1.6 km (0.5-1.0 mi) away (ER, Vol. 3--p. 113-114). There are also an additional 33 year-round homes in the town of Concord between 0.4 and 1.6 km (0.25 and 1 mi) away, and an additional 38 seasonal camps between 300 m (1000 ft) and 1.6 km (1 mi) away (ER, Vol. 3--p. 113-114). Of these residences, three year-round and one seasonal are within 150-300 m (500-1000 ft) and a fourth within 920 m (3000 ft) of the proposed transmission line.

The Preferred Corridor will cross no land that is currently used for residential purposes (ER, Vol. 3--p. 18 and Exhibit 3-7). However, segments in Norton, Concord, and Waterford are zoned for rural residential use (ER, Vol. 3--Exhibit 3-9). The presence of the transmission line may reduce the likelihood that new homes would be built in these segments. A number of homes near the line--particularly in the segments through Concord--would have the proposed line in their viewshed. This situation will detract from the attractiveness of these homes.

Although a few studies indicate that the sale value of houses are unaffected by the proximity of a transmission line, other studies have indicated that housing values would drop because of the proximity and visibility of the line (ER, Vol. 3). These studies showed that a drop in selling prices of between 16% and 29% occurred in properties on the line, with the smallest properties experiencing the greatest drop in selling prices. Decreases in selling prices taper off with larger lot size and with greater distance from the line, regardless of the size of the line (Kellough 1980). Legally, the visual impact of the lines can also be considered in damage payments to landowners (Texas Power and Light Co. vs. Jones, 1927; Ohio Public Service Co. vs. Dehring, 1929; and Hicks vs. United States, 1959 [as cited in Kellough 1980]).

The scenic view from the homes within the study area is an important selling point, as indicated in many of the real estate ads in local papers (see, e.g., The Courier 1982). As a result, a number of residents and realtors of property along the alternative route have expressed fears that housing values would drop with the construction of the line (N.H. Bulk Power Supply Site Eval. Comm. and Public Util. Comm. 1981-1982; McMahon 1982; Winn 1982; Glidden 1982). Others who own property within the study area have postponed their own building plans or withdrawn offers because of the proposed line (Bagley 1982; McMahon 1982). Thus, losses in housing and property values and sale and decreased future residential development may occur if the Preferred Corridor is used.

The small size of the construction work force will have little impact on the year-round housing supply in the area. Some competition with tourists for lodging facilities will occur because of the overlap of the construction schedule with high tourist seasons, but this impact would be temporary (see also Section 4.1.5.3). Construction workers on other transmission lines have been flexible in their housing choices, which have included recreational vehicles, trailers, and motel rooms, as well as single-family houses. They have also tended to reside in larger population centers near line routes with more amenities, even though commuting distances to the construction may be 32 km (20 mi) or more (Gale 1982). Thus, it is expected that most nonlocal workers would reside in the temporary lodging facilities available near the southern part of the proposed route with little impact on local housing.

4.1.5.5 Transportation

Direct transportation impacts will be limited primarily to the period of construction and will be minor. Some slight interference with local and tourist traffic on the routes used by construction-related trucks might occur, along with a slight increase in noise and fugitive dust.

The construction and maintenance activities may also affect the condition of the logging roads. If these roads were used in the spring ("mud season"), considerable deterioration could occur. Mud, however, may also make the roads difficult to use during this season, thus limiting the use of these roads during the construction period.

The indirect impact of views from the roads will be greater than direct impacts. Travellers on some of the routes will be able to view the line and its construction (see Section 4.1.6).

4.1.5.6 Public Concerns

Discussion and controversy about the proposed line has already occurred in public hearings on the project and in local town meetings. A recent survey of residents near such projects found that "... the manner in which right-of-way acquisition negotiations are handled can significantly affect residents' perception of the entire project" (Gale 1982). Depending on techniques used to acquire the right-of-way, local residents may be more resistant to the project and more organized in their opposition.

In the case of a well-publicized transmission line project in Minnesota during the late 1970s, a very active organization of farmers opposed the project at several points, delaying construction of the line. Opposition continued through civil disobedience--resulting in vandalism and creation of obstacles to construction activities (Casper and Wellstone 1981; Gatchel et al. 1981). However, in areas where no protest occurred, vandalism was nonexistent (McConnon 1982). In addition, it has been hypothesized that health symptoms reported by people living along the controversial line may be due to stress from their unsuccessful opposition to and protest of the line's construction (Gatchel et al. 1981) (see also Section 4.1.8). Because of the active opposition to the line in New Hampshire, similar impacts may occur, i.e., vandalism to line structures and health symptoms related to stress in local residents.

4.1.6 <u>Visual Resources</u>

4.1.6.1 Visual Impact Analysis Criteria

One objective in transmission line placement is to plan, design, and construct a line that will be in visual harmony or at least be subordinate to the surrounding landscape (U.S. For. Serv. 1975). Visual analysis is basically a two-step process of examining the visual resources along a proposed corridor and then examining the visual aspects of the actual transmission line alignment and tower placement within that corridor. The assessment in this document relates primarily to the visual resources of the study area in general and the Preferred Corridor rather than the actual right-of-way alignment, which is not currently established. Mitigative measures described in Section 4.3.6 are based upon the optimal placement of the line within the Preferred Corridor area.

Four visual elements compete for dominance in a landscape. These elements are: (1) form, (2) line, (3) color, and (4) texture (U.S. For. Serv. 1973). These four factors exert differing degrees of visual influence, power, and dominance (U.S. For. Serv. 1975). For example, the form of transmission line structures is usually geometric, forceful, and large. Secondly, the transmission line right-of-way generally has a linear impact due to cleared vegetation and straight distance of the line. Third, depending on lighting conditions and the color of the materials that the towers and conductors are constructed of, transmission lines and towers may or may not be highly visible against the natural background. Finally, it must be acknowledged that natural landscape textures can rarely be matched by utility structures.

For an aboveground transmission line, it is important to analyze the surrounding topography, vegetation, and any unique features located within the corridor (U.S. For. Serv. 1975). While evaluating the visual resources along the Preferred Corridor, a number of important factors were considered including: (1) expected image by the viewer, (2) importance of retention of the character of the area, (3) vantage point of viewer, (4) duration of the view, (5) number of viewers, and (6) viewing distance.

4.1.6.2 Visual Impacts Along the Preferred Corridor

The visual impacts along the Preferred Corridor are referenced by lettered segments that correspond to the visual resource segments described in Section 3.6 and in Figure 2.3. A more detailed mapping of these visual resources can be found in the ER (Vol. 2--Exhibit 2-25, Sheet 5; Vol. 3--Appendices, Maps V-1/V-8). The following impacts are analyzed in terms of permanent visual effects due to the construction and operation of the transmission line. Temporary visual impacts during the construction phase will basically consist of an occasional observance of construction personnel and equipment and the actual stringing of conductors across the roadways and river valley areas.

Segment A. The proposed line will cross State Route 114 which has an annual average daily traffic (ADT) of 620 vehicles. This route has been designated as a scenic road on the Northeast Development Association tour guide map. An adverse visual impact will occur where the transmission line is visible to eastbound traffic from distances of 1.6 to 4.8 km (1 to 3 mi) as the line descends from the edge of Averill Mountain towards the highway. However, the line will cross the highway at a right angle and will be screened with adjacent planting and existing ground cover, thereby lessening the visual impact.

Segment B. In the forested areas of Segment B, the line will be visible to occasional recreationists in the Yellow Bog and Lewis Pond areas and to any loggers involved in timber-cutting activities. This area cannot be viewed from any major settlement, developed recreation site, or transportation corridor, thereby minimizing visual impacts. The corridor will traverse the proposed Gore-Sable-Monadnock Wilderness Area (see Section 4.1.2.7).

Segment C. In Segment C, the line will cross State Route 105, which has an average ADT of 740 vehicles. This route has been designated as a scenic road in the Northeast Development Association tour guide map. An adverse visual impact will occur where the transmission line is visible to eastbound vehicles, at Wenlock crossing approximately 5.6 km (3.5 mi) from the proposed line and from subsequent vantage points along the highway looking east towards the Potash Mountain Range. There will also be a long-distance view from State Route 105 from about 16-km (10-mi) away looking towards a viewshed area along the south slopes of the foothills of Black Mountain. A right-angle crossing screened along the highway will minimize the exposure of the line crossing the highway. The Nulhegan River will be crossed in the same vicinity as State Route 105. Visual impact to participants in river touring (e.g., canoeing) will also be minimal because of vegetative screening on both sides of the river bank.

Segments D and E. In Segments D and E, the proposed line will extend through the French, West, and Seneca Mountain region and the Ferdinand Bog area. This area is used for forestry and is only accessible by paper company roads. It cannot be viewed from any major settlement, developed recreation site, or transportation corridor, and visual impacts are expected to be minimal. The corridor will begin to traverse the East-West Mountains Wilderness Area (see Section 4.1.2.7).

Segment F. In Segment F, there will be an adverse visual impact where the transmission line is visible along the road from Gallup Mills to Granby. This road, with an annual ADT of 40 vehicles, has been designated as a scenic route in the Northeast Development Association tour guide map. Eastbound traffic will notice the transmission line corridor on the west slopes of Wilke Mountain and as the line descends from the hills south of Granby to Rogers Brook and Suitor Brook, between 1.6 to 4.8 km (1 to 3 mi). There will also be some long-range views (greater than 5 km) into the viewshed from the Victory Bog basin area. Also in Segment F, the transmission line will cross the Granby-Guildhall Highway (ADT 40 vehicles). However, the line will cross the highway at a right angle, thereby minimizing exposure. In Segment F, the corridor will begin to traverse the Umpire-Temple Wilderness Area (see Section 4.1.2.7).

Segment G. At the beginning of Segment G, the transmission line will be visible only to those in the logging industry and an occasional recreationist. While extending through the Carr Brook Valley area and crossing U.S. Route 2 (ADT 2400 vehicles), the line may be visible by eastbound traffic for 1 to 2.5 km (0.6 to 1.6 mi). This route has been designated as a scenic road on the Northeast Development Association tour guide map. A right angle crossing at U.S. Route 2 in the area of Oregon Road will minimize the impact.

Segment H. In Segment H, the transmission line will be visible in the Carr Brook Basin to people living along Oregon Road facing west. The line will also cross a railroad line that handles only freight and no passenger service. Impact from the line crossing Leonard Hill Road will be minimized by a right-angle crossing and existing vegetation. The proposed line may create visual problems toward the southeast, where the line parallels the existing

115-kV and 46-kV lines, and along the Interstate 93 corridor (currently under construction) for northbound motorists and motorists traveling along New Hampshire Route 135. However, if the lines are placed to the northwest of the viewshed area, they will be concealed from view. The final few miles of the line will be located adjacent to an existing powerline corridor and, therefore, will not add significantly to the existing man-made intrusion in the viewshed along Moore Reservoir.

Segment I. In Segment I, the proposed transmission line will cross the Connecticut River below Moore Dam and extend a short distance (generally parallel to existing 115-kV and 230-kV lines) to the proposed terminal location near Comerford Dam in New Hampshire. An adverse visual impact will occur where the line is visible at the Moore Reservoir crossing, State Route 18/135, Foster Hill Road, and again crossing State Route 135. Structures and conductors will be visible as well as cleared right-of-way. These impacts will be additional to parallel, existing transmission line. At the proposed terminal location, the site will be cleared of vegetation, graded, covered with gravel, and fenced. Structures within the terminal location will include a building and switchyard equipment. Because the terminal is on NEPCO's land and only visible from NEPCO's private access road or from distances greater than 1.6 km (1 mi), visual impacts will be minimal. Because there is an existing substation and transmission lines located at the Comerford Dam, near the proposed terminal facility, any visual impact caused by construction of the terminal will be incremental in nature.

In summary, the construction and operation of the proposed transmission line and terminal facility are expected to adversely impact only four viewing areas along the Preferred Corridor: (1) the area where the line descends from the edge of Averill Mountain towards Vermont State Route 114--Segment A, (2) the area where the line extends through the Potash Mountain Range and can be viewed from Wenloch Crossing and other points along Vermont State Route 105--Segment C, (3) the area where the line descends from the hills south of Granby to Rogers Brook and Suitor Brook--Segment F, and (4) the Moore Reservoir area--Segment I. In these areas, the line will be visible despite measures taken to minimize the impacts (see Section 4.3.6).

4.1.7 Cultural Resources

Construction activities along the Preferred Corridor and required access roads and terminal location will not impact any of the identified prehistoric or historic sites listed in Section 3.7. However, undiscovered sites may be uncovered, damaged, or destroyed during the construction of access roads, right-of-way clearing, installation of the transmission line structures, and construction of terminal facilities. Areas with the highest probability of containing archaeological or historic sites that would be traversed by the transmission line include the Nulhegan, Connecticut, and Ammonoosuc river valleys and adjacent stream areas (Vt. Agency Environ. Conserv. 1978).

Construction impacts to cultural resources can be avoided or reduced by adhering to the mitigative measures discussed in Section 4.3.7. These mitigative measures essentially consist of making a thorough literature search and conducting a field survey by a qualified archaeologist along the transmission line corridor and access road areas that will be disturbed by construction activities and are determined to have a high probability of containing an archaeological or historic site. If artifacts are discovered during construction, the Vermont or New Hampshire State Historical Preservation Officers, as appropriate, should be notified (see Section 4.3.7).

Operation and maintenance of the transmission line and terminal facility will have little or no impact on archaeological or historical resources. This is especially true if an adequate archaeological/historic/paleontological literature search and field survey have been performed along the final corridor route and access road areas, so that maintenance crews can avoid any identified site areas while working on the transmission line.

In summary, the construction and operation of the proposed transmission line and terminal facility are not expected to adversely impact any known cultural resources. Mitigative measures described in Section 4.3.7 should be used to minimize impact to any potential or uncovered archaeological, historic, or paleontological resources.

4.1.8 Health and Safety

4.1.8.1 HVDC Electric and Magnetic Environment

Operating HVDC transmission lines produce a two-component electric field: an electrostatic field and a field of air ions (Bracken 1979a, 1979b). The first component is the electrostatic force field that occurs between the positive and negative conductors (electric poles) and between the electric poles and the earth. This electrostatic field is created by the difference between the surface charges on the electric conductors and the charge on the surface of the earth. The intensity of the electric field--measured in volts (V) or kilovolts (kV) per unit distance--is greatest at the conductor surfaces and decreases rapidly towards the earth.

When the electric-field gradient near the conductor surfaces exceeds approximately 2500 kV/m, the line loses energy and is said to be in corona. Because field gradient at the conductor surface is dependent upon the smoothness of the surface, the corona tends to be increased by nicks, scratches, contamination with dust particles and insects, and adherence of ice, snow, and water droplets. The energy escaping from the conductors during corona causes the release of electrons from gas molecules in the air; these electrons interact with other air molecules and particles in the atmosphere to produce air ions. The charged ions are either attracted to or repelled away from the conductor surfaces. Those attracted to the conductors are neutralized whereas those repelled away flow along electrostatic force field lines to either the opposite conductor or to the earth, creating a minute current flow. The flow of ions and charged particles from the electrical poles form the second component of the HVDC electric field and is known as the space charge.

Stable forms of small air ions created in HVDC environments probably include H_3O^+, CO_4^-, OH^-, H^+, CO_2^+, and O_2^- (Sheppard 1979). Charged aerosols are formed by the transfer of charge from small air ions to condensation nuclei. Beneath HVDC transmission lines, the small air ions tend to remain near the lines. The charged aerosals that are created, however, migrate from the line under the influence of wind. Comber and Humphreys (1979) have determined that there tends to be slightly more negative than positive ions in HVDC environments.

HVDC lines also create a static magnetic field and an AC magnetic field. The DC magnetic field in an HVDC environment is caused by the line and the earth's magnetic field and is relatively small, i.e., within the normal range of the natural background magnetic field (Ill. Inst. Technol. Res. Inst. 1976; Elec. Power Res. Inst. 1977). The AC magnetic field from HVDC transmission lines is so small that it can be ignored (Sheppard 1979).

During corona, photons emanate from the conductor surface and strike neutral atoms in the surrounding air (Elec. Power Res. Inst. 1982). The energized atom may then divide into an electron and a positively charged ion. The electrons are accelerated in the strong electric field around the conductor and may collide with neutral oxygen molecules normally in the atmosphere and cause them to dissociate into two negatively charged oxygen atoms. Ozone is formed when a single negatively charged oxygen atom reacts with a neutral oxygen molecule.

Audible noise is produced by the electric breakdown of air around the poles of HVDC transmission lines when the lines are in corona. The resultant random high-energy discharges produce compressions that travel through air as acoustical energy. In HVDC transmission, the electric discharges at the positive conductor are larger than occur at the negative conductor and hence generate more audible noise. The negative pole generally does not produce audible noise. If corona exceeds a certain level, corona discharges change into nonaudible types. This occurs during rain as large water droplets on the conductors increase corona. The peak noise levels from HVDC lines therefore occur during fair weather.

4.1.8.2 Potential Hazards to Human Health and Welfare

Although the body of research addressing them is relatively small, HVDC electric and magnetic phenomena have been identified as potential sources of hazards to human health and welfare (U.S. Environ. Prot. Agency 1974; Droppo 1979; DOW Assoc. Inc. 1980; Pfanenstiel 1983). Potential hazards include: (1) induction of electric potentials (charges) and currents in persons or objects, creating shock and fuel ignition hazards; (2) adverse physiological and behavioral responses from direct exposure to electric and magnetic fields; (3) sensory irritation and respiratory effects from formation of ozone and other oxidants; and (4) interference with activity or deleterious health effects from exposure to audible noise. These subjects and the health and safety impacts of the proposed transmission lines are discussed below. The following analysis is based upon review of the pertinent scientific literature and on measurements taken beneath a Project UHV-HVDC test line with the same design as the proposed line (see Tables 4.5 and 4.6).

<u>Electric Shock Potential and Field Perception</u>

The ionic currents beneath HVDC transmisson lines operating in corona cause the transfer of energy from the energized lines to receiving objects that are sufficiently insulated from ground. Possible receptors in HVDC transmission line environments include biological organisms (animals, plants, and humans) and inanimate objects such as metallic vehicles, fences, and buildings. Transfer of energy between the line and exposed objects creates a static electric charge on the surface of the receptors. When objects of different static charge come into contact, a transient electric current transfers the excess charge from the higher to lower charge. If the transferred charge is sufficiently larger, a single spark discharge may occur. Carpet shocks experienced in dry rooms are an example of this phenomenon. If the receiving object of lower potential is grounded, an electric current will flow--during contact--from the object with higher change, through the receptor, to the ground. Under certain conditions, spark discharges (shocks) and body currents could conceivably be physiologically harmful, annoying, and stressful; cause involuntary muscular contractions resulting in accidents; and possess sufficient energy to ignite fuels in vehicles operating or stored near HVDC transmission lines (Barthold et al. 1971).

Tests beneath operating HVDC transmission lines of comparable voltages to the proposed line have shown that carpet-like spark discharges can occur in persons accumulating approximately 10 kV of potential and fuel ignition can occur when objects possessing 5-7 kV of potential come into contact (Elec. Power Res. Inst. 1977). For the proposed line, the expected maximum worst-case voltage induced on a person beneath the line is 0.8 kV, well below that level associated with either carpet-like shocks or fuel ignition (Johnson 1982a). In an investigation using a test line with the same design and operating characteristics as the proposed line, the worst-case voltage induced on a large school bus was 0.07 kV, well below the 5-7 kV threshold necessary to cause sparks discharges or to ignite fuel (Johnson 1982a).

The physiological effects of electric currents are a function of the magnitude and duration of the current passing through the person to ground and the body weight of the shocked individual (Dalziel and Lee 1969). Responses of humans to electric shock vary from no sensation below 0.6 milliamperes (mA) of current to death from ventricular fibrillation around 1375 mA (Barthold et al. 1971). The highest induced current on vehicles under the Project UHV-HVDC test line was 0.04 mA, one order of magnitude below the threshold of perception for humans (Barthold et al. 1971; Johnson 1982a). Therefore, the proposed transmission line will not produce electric currents in objects that will be perceived by or harmful to humans coming into contact with them.

Subjective tests with highly insulated volunteers exposed to electric fields created by an operating HVDC test line revealed that the HVDC electric field could be perceived as head and body hair stimulation. A field strength of 22 kV/m was the average threshold of perception; a field of 30-40 kV/m was a "moderate" and "disturbing" nuisance; and a field of 50 kV/m was considered "very disturbing" (Elec. Power Res. Inst. 1977). The highest measured fair-weather electric fields in the right-of-way of the Project UHV-HVDC line ranged up to 14 kV/m (Table 4.5). This is below the average threshold for perception reported in the tests discussed above; only during foul weather are fields in the line right-of-way likely to exceed the threshold of perception for humans (Table 4.5). Because perception is a result of head and body hair stimulation, it is doubtful that people will actually perceive the electric field of the proposed line. During foul weather, an exposed individual is expected to be protected by clothing.

Exposure to Electric Fields

Static electric fields of the magnitude that occur in HVDC transmission line environments have been suspected of causing a variety of biological and behavioral effects in animals and humans. The principal concerns are effects

Table 4.5. Calculated and Measured Electric Fields (kV/m) Under Project UHV's Vermont Test Line Operating at ±450 kV DC†[1]

		Negative Side				Positive Side			
		-30 m†[3]		-12 m†[4]		+9 m†[4]		+30 m†[3]	
Weather	N†[2]	50%	95%	50%	95%	50%	95%	50%	95%
Calculated electrostatic field		-0.6		-12		+12		+0.7	
Fair	14,073	-0.4	-0.8	-11	-15	+8	+11	+0.2	+0.6
Snow	9,003	-8	-4	-12	-23	+10	+16	+4	+10
Rain	290	-10	-11	-29	-33	+18	+27	+10	+14
Fog	411	-3	-5	-13	-26	+12	+24	+6	+10
Frost	1,590	-7	-14	-13	-23	+12	+20	+5	+12
Freezing rain	1,129	-12	-14	-27	-32	+24	+29	+11	+14

†[1] Electric fields were monitored continuously; 50% = median value, and 95% = absolute value below which 95% of the measurements occurred.

†[2] Number of records per weather condition.

†[3] These positions approximate the edge of the proposed 61-m (200-ft) right-of-way.

†[4] The position at which the highest readings were obtained, close to positive or negative pole; these are positions where a probe was actually installed, at 9 m from centerline on the negative side and 12 m on the positive side.

Source: Johnson (1982a).

on the central nervous system. Other areas that have been investigated include metabolism, reproduction, growth and development, blood chemistry, and cardiovascular and respiratory function.

There have been several recent reviews of the literature on the biological effects of electric fields (Bridges 1975; Sheppard 1979; Scott-Walton et al. 1979; DOW Assoc. Inc. 1980). The results of the reviews ranged from findings that no definite evidence exists to associate biological responses to the presence of electric fields, to concluding that many biological responses are attributed to the fields. Because of the limited data and the lack of reproducible findings, it is difficult to predict the specific effects of static electric fields from operation of the proposed line on the health of persons in the right-of-way. Therefore, the assessment in this report takes a conservative approach and assumes that the positive findings from experiments with animals and humans reported in the literature can be expected to occur in the environment of the proposed transmission line at electric fields similar to those nominally used in laboratory studies.

During fair weather, the highest fields measured beneath the Project UHV-HVDC test line were below -11 kV/m 50% of the time and below -15 kV/m 95% of the time (Table 4.5). Fair-weather fields at the edge of the right-of-way, approximately +30 m from the centerline, were below -0.4 kV/m 50% of the time and less than -0.8 kV/m 95% of the time. The highest fields under the Project UHV test line were measured during rain, freezing rain, or snow--with extreme values below -29 kV/m occurring 50% of the time during these conditions and values below -33 kV/m occurring 95% of the time (Table 4.5). During all weather conditions for which data were reported, values decreased sharply with increased distance from the centerline--with the highest 50% value at 30 m from center being -12 kV/m and the highest 95% value at the same location, under similar weather conditions, being ±14 kV/m.

Electric fields within the right-of-way of the proposed line will be within the range of those that have been reported to produce central nervous system, behavioral, reproductive, biochemical, and metabolic effects in experiments with animals and humans. In general, experimental effects occurring below 60 kV/m have been subtle--e.g., improved maze performance in rats (Mayyasi and Terry 1969), increased brain wave activity in anesthetized rats (Lott and McCain 1973), improved performance of human subjects in fine motor skills (Carson 1967), and altered body serotonin levels in mice (Mose and Fischer 1970; Mose et al. 1971; Fisher 1973). If such effects do occur in persons exposed to fields produced by the proposed line, subtle effects would most likely be produced during foul weather when the fields are greatest. Data of the National Oceanic and Atmospheric Administration for Burlington, Vermont (Table 3.1), indicate that foul weather of 0.2 mm (0.01 in.) or greater rainfall occurs on 42% of the days and heavy fog occurs on 4% of the days in a year. On the average, 33% of the foul weather can be expected to occur between 10 p.m. and 6 a.m. when persons will generally be indoors and exposure will be at a minimum. Thus, conditions for potential exposure of individuals to electric fields in excess of levels known to elicit subtle responses may occur about 10 to 30% of the time. Extended exposure to the highest fields is not expected because persons are unlikely to remain in the right-of-way for long periods of time (days) during foul weather.

Subtle behavioral and physiological effects will be transient and difficult to perceive by either the individual or the medical community. Under no conditions will fields reported as capable of affecting blood pressure and heart rates (60 kV/m and above) by Krivova et al. (1973) occur beneath the proposed line. Electric fields below the proposed transmission lines are not expected to cause malfunctioning of cardiac pacemakers or other electromedical devices because the fields will be over 100 times smaller than are necessary to cause reversion to asynchronous operation (Frazier 1980). Beyond the right-of-way, the electric fields will be below levels associated with adverse effects. The line has been sited so that only one permanent residence is within 305 m (1000 ft) of the centerline (ER, Vol. 3). At this distance, all electric fields, pollutants, and noise created by the line will be at ambient background levels.

Exposure to Air Ions

There is a large body of literature addressing the biological effects of air ions. It is hypothesized that air ions may be toxic because of their charge and/or chemical species. The likely pathway into the body is the respiratory tract and the route of absorption into the bloodstream is either through the upper respiratory tract or the alveolar regions of the lungs. As with static electric fields discussed above, the central nervous system is thought to be the primary site of action for the effects elicited by air ions. The serotonin (5-hydroxytryptamine or 5-HT) hypothesis is the most widely acknowledged mechanism of air ion effect and has been supported by the results of others (Krueger 1972). Serotonin is a neural transmitter that plays an important role in sleep regulation, vasoconstriction, and smooth muscle stimulation. According to the hypothesis, air ions alter serotonin levels in the exposed organism which then produces abnormal effects.

Methodological errors are common in a number of the studies addressing the effects of air ions on animals and humans. As with DC electric field research results, assessment of human health impacts from air ion exposure in HVDC transmission line environment is difficult because of inadequate reporting, lack of replicative positive findings, experimental error, and the fact that no widely accepted mechanism for biological damage has been discerned. The general trend of the data, however, indicates that air ions are biologically active, albeit subtly. The pertinent data will be briefly reviewed below.

Exposure of experimental animals and human subjects to ion concentrations has consistently altered brain wave activity, generally interpreted as inducing relaxed states (Assael et al. 1974; Sulman et al. 1978; Lambert et al. 1981). Animals and humans exposed to 10^3-10^6 ions/cm^3 have experienced increased and improved motor activity, improved escape behavior, improved learning, decreased reaction times, and altered moods (Terry et al. 1969; Gilbert 1973; Olivereau 1973; Diamond et al. 1980; Charry and Hawkinshire 1981). Exposures between 10^3-10^5 ions/cm^3 have generally altered serotonin levels in selected organs and fluids of animals and humans (Krueger and Kotaka 1969; Gilbert 1973; Sulman et al. 1974, 1975; Sigel 1979). Ion exposures of 10^3-10^9 ions/cm^3 have produced subtle in-vitro and in-vivo respiratory and circulatory effects in laboratory animals and humans (Bachman et al. 1965; Goldman and Rivolier 1977; Frazier and Preache 1980). Animals challenged with microorganisms experienced altered death rates due to these organisms upon additional exposure to air ions; some were protected whereas others became more susceptible (Krueger et al. 1970, 1971, 1974). Burn victims, weather-sensitive persons, and asthmatics have reportedly experienced alleviation of pain and symptoms after ion exposure (Sulman et al. 1975; Dow Associates, Inc. 1980; Charry and Hawkinshire 1981). In studies of Charry and Hawkinshire (1981) and Sulman et al. (1974), significant minorities of their study populations were determined to be especially sensitive to the effects of air ions.

According to the information summarized in Harrison (1981), Johnson (1982a, 1982b), and the ER (Vol. 3), the proposed transmission line could create worst-case, fair weather concentrations of air ions in the right-of-way of up to 1.4×10^5 ions/cm; maximum foul weather concentrations are predicted to reach 2.2×10^5 ions/cm^3. Air ion concentrations will decrease with distance from the line so that predicted levels at the edge of the right-of-way will generally be 33% of the maximum values in the center of the right-of-way. A spot measurement program conducted by Johnson (1982a, 1982b) revealed that the highest ion concentrations beneath the Project UHV-HVDC test line occurred during fair springtime weather or dry blowing snow, with measured values being 44-69% of the predicted maximum values reported above. Other measured values were generally less than 10^4 ions/cm^3 (see Table 4.6).

The maximum right-of-way air ion concentrations discussed above are within the lower range of values associated with the subtle effects discussed earlier. In attempting to predict the effects of air ion exposure on persons

Table 4.6. Ion Densities Near the Project UHV Test Line Operating Under Conditions and Parameters the Same as for the Proposed Transmission Line

Weather Conditions	Density (10^3 ions/cm^3)†1	
	Positive Ions	Negative Ions
Fair	2.6	3.2
Snow	21.7	11.4
Wet snow	45.0	38.0
Fog	47.2	22.0
Frost	19.8	28.0
Freezing rain	15.1	14.9
Rain	16.7	13.1

†1 Median value measured at point of highest density during operation at ±450 kV and a minimum conductor height of 11 m (37 ft).

Source: Johnson (1982a).

exposed in the right-of-way of the proposed line, it is important to realize that the effects listed above are generally subtle and would be difficult to detect outside of a laboratory setting. These effects would be difficult for the individual to perceive because they would be within the range of physiological and psychological alterations that occur in humans throughout their normal daily activities. Furthermore, periods of the highest ion concentrations will be transient in nature and generally occur during inclement weather when the likelihood of persons traversing the right-of-way is reduced. With these considerations in mind, it is unlikely that the vast majority of persons using the right-of-way will experience any detectable effects from air ions. Under a worst-case scenario, exposed persons could experience slight transient alterations of certain physiological, psychological, and behavioral patterns such as mood change. These effects do not represent a health hazard, they would disappear as soon as exposure ceased (i.e., the person left the right-of-way), and no residual effects would exist. Persons outside of the right-of-way will not experience any adverse health or behavioral effects from exposure to air ions produced by the transmission lines, and no residences located near the proposed line will be exposed to above ambient concentrations of air ions.

Exposure to Ozone and Audible Noise

Experiments with animals and humans indicate a range of effects from ozone exposure at concentrations of 196-1960 $\mu g/m^3$ (100-1000 ppb). Effects include altered pulmonary function, pain upon breathing, morphological changes in pulmonary tissue, biochemical changes, alterations of genetic material, and increased susceptibility to bacterial infections (U.S. Environ. Prot. Agency 1978; Natl. Res. Counc. 1977). The Project UHV-HVDC test line generated no ozone that could be measured above background (Johnson 1982a, 1982b). Therefore, no adverse health effects are expected from ozone produced by the proposed Vermont line.

Recommended standards for noise proposed by the U.S. Environmental Protection Agency (1974) to protect the public against hearing loss and other human health and welfare effects are 70dB(A) and 45dB(A), respectively. The maximum predicted noise level below the positive pole of the proposed line is 42dB(A) (ER, Vol. 1). These levels are generally at background so that no noise distinguishable as originating from the line is expected to occur most of the time. The levels will also decrease with distance from the line. The maximum values predicted are well below the EPA recommended standards for preventing adverse impacts on public health and welfare.

4.1.8.3 Herbicide Use in Right-of-Way Management

Specific data on herbicide use is not available. However, the Applicant (VETCO and NEET) is committed to using selective applications of herbicides in its right-of-way management programs, and it is anticipated that the program will be similar to that currently used by NEES companies in New Hampshire, of which NEET is a member (Table 4.7). This program involves selective application of herbicides by workers carrying hand-held spraying equipment (ER, Vol. 2). Areas near public water supplies, open waters, springs, wells, homes, or roadsides are managed manually. Herbicide application will occur in a prescribed schedule beginning with selective spraying of stumps of all hardwood species during the dormant season after clearing. Two years later, a second selected application occurs, with subsequent applications on a 3-5 year cycle.

Table 4.7. Current Herbicide Usage by NEES Companies

Herbicide	Dilution	Land Application Rate	Purpose
Krenite	1-1.5 gal of herbicide formulation to 98.5-99 gal water (i.e., 0.42-0.63 gal fosamine ammonium)	100 gal of dilution/acre: 0.42 to 0.63 gal active ingredient fosamine ammonium	Selected foliar application
Garlon 3A	1 gal of herbicide formulation to 99 gal water (i.e., 0.44 gal triclopyr)	100 gal of dilution/acre: 0.44 gal active ingredient triclopyr	Selected foliar application
Tordon 101	1 gal of herbicide formulation to 99 gal water (i.e., 0.1 gal picloram and 0.4 gal 2,4-D)	100 gal of dilution/acre: 0.1 gal. active ingredient picloram; 0.4 gal. active ingredient 2,4-D	Selected foliar application
Tordon 101 and Garlon 3A	2 qt each of herbicide formulation 99 gal water (i.e., 0.22 gal triclopyr, 0.05 gal picloram, and 0.20 gal 2,4-D)	100 gal of dilution/acre: 0.05 gal active ingredient picloram; 0.20 gal active ingredient 2,4-D; 0.22 gal active ingredient triclopyr	Selected foliar application
Garlon 4	1 gal of herbicide formulations to 99 gal water (i.e., 0.62 gal triclopyr)	100 gal of dilution/acre: 0.62 gal active ingredient triclopyr	Selective basal or stump application

Sources: ER (Vol. 2); New England Electric Transmission Corporation (1982).

Herbicides are toxic to biological organisms, and many are harmful to humans. The human health hazard or risk from herbicide application depends upon the acute and chronic toxicity of the compound, the pathway of exposure (ingestion, inhalation, or dermal), and the degree of exposure. Adverse human health effects have been recorded to occur from herbicide exposure. Persons at greatest risk are those who have been occupationally exposed either in production or application or by working in agricultural fields tested with herbicides (Barnes 1975; Natl. Acad. Sci. 1975). Others at much lesser risk of effect include consumers ingesting contaminated food, meat, or water, and third parties being accidentally exposed during herbicide application (Barnes 1975). A brief summary of toxicity data for the herbicides most likely to be used is presented in Table 4.8.

In general herbicides used in right-of-way or forest management have not been identified as sources of excess adverse health risks or as sources of excess cancer in the general public (Natl. Acad. Sci. 1975; U.S. Dep. Energy 1982; U.S. For. Serv. 1978). The herbicides most likely to be used in the right-of-way are of low toxicity (Table 4.8). Members of the general public may potentially be exposed to herbicides used in right-of-way vegetation management by (a) inhalation of mists or vapors while the herbicides are dissipating into the atmosphere shortly after application; (b) absorption of freshly applied herbicides through the skin upon contact with treated plants, grasses, and soils; (c) ingestion of contaminated fruits, berries, herbs, or leafy vegetables grown in the right-of-way; (d) ingestion of meat from wild and domestic animals and fish eating the herbicides; and (e) ingestion of contaminated water.

Because of the low volatility of the herbicides and the use of selective, ground-level application techniques, the general public is not expected to be exposed to biologically harmful levels of herbicides via the inhalation pathway. Similarly, direct dermal contact with freshly treated foilage is expected to be an insignificant source of exposure due to low application rates, the small probability of human contact with recently treated foliage and woody stumps, and the low toxicity of herbicides via the skin pathways. The ingestion pathway produces the greatest potential for adverse health effects.

Land used for raising foodstuffs will not be treated with herbicides; therefore, the problem of residues in harvested foods that might grow in the right-of-way generally does not arise.

Available data provide evidence that herbicide application to rights-of-way will not result in biologically significant concentrations in surface waters or groundwaters, especially in view of the proposed selective, ground-level application practices and adherence to rules of pesticide-free zones near surface waters (see Section 4.1.3). The National Primary Drinking Water Standard for 2,4-D (in Tordon 101) to protect community water supplies is 100 ppb. By comparing oral lethal dose (LD_{50}) values in animals and humans for the other herbicides (Table 4.8), it is expected that levels as high or higher than the 2,4-D standard are safe for human consumption.

Herbicide use has been found to be environmentally acceptable as practiced by the U.S Forest Service in the Northeast region. This program involves the treatment of 18,200 ha (45,000 acres) with a variety of herbicides including 2,4-D, Picloram, and Krenite for road and trail management, recreational

Table 4.8. Toxicity Data for Herbicides Used in Right-of-Way Management

Herbicide	Active Constituent	Physical/ Chemical Characteristics†[1]	Toxicity		
			Ingestion	Dermal	Inhalation
Garlon 3A	44% Triclopyr	High solubility in water, low volatility	LD_{50} rat: >2 g/kg; low hazard to humans	LD_{50} rabbit: >4.0 g/kg; low hazard to humans	Low hazard to humans
Garlon 4	62% Triclopyr	BP = 302°F; VP = 36 mm Hg at 20°C; emulsifies in water	LD_{50} rat: >2 g/kg; low hazard to humans	LD_{50} rabbit: >4.0 g/kg; low hazard to humans	Low hazard to humans
Krenite	42% Fosamine Ammonium	VP is negligible; miscible in water	LD_{50} rat: 24.4 g/kg; extremely low hazard to humans	LD_{50} rabbit: >1.68 g/kg	Rats exposed to 56.6 mg/L for 1 hour showed no effects
Tordon 101	10% Picloram, 40% 2,4-D	BP = <180°F; VP = 23 mm HG at 20°C; infinite solubility in water	LD_{50} rat: 3 g/kg	Ld_{50} rabbit: >2 g/kg	Relatively nontoxic

Herbicide	Irritation Potential			Guidelines/ Standards	Other Remarks
	Skin	Eyes	TLV†[2]		
Garlon 3A	Moderate, with superficial burns after prolonged exposure	Moderate, with corneal injury; possible permanent impairment of vision	200 ppm methanol (inhalation)	-	-
Garlon 4	Slight to moderate upon prolonged or repeated contact	None	-	DOW industrial hygiene guide: 10 mg/m^3 kerosene-like solvents (inhalation)	-
Krenite	Mild to moderate	None	-	-	Not associated with cumulative teratogenic, embryotoxic, or mutagenic effects
Tordon 101	Skin irritation with mild to moderate burns upon prolonged or repeated exposure	Moderate, with slight to moderate corneal injury that heals with time	400 ppm isopropanol (inhalation)	-	Repeated or prolonged exposure has caused gastrointestinal disturbances, organ and tissue damage in humans; not teratogenic, carcinogenic, or mutagenic; is fetotoxic

†[1] BP = boiling point; VP = vapor pressure.

†[2] TLV = threshold limit value.

Sources:

Material Safety Data Sheet for Garlon (R) 3A Herbicide, DOW Chemical U.S.A., Midland, MI, August 18, 1981.
Material Safety Data Sheet for Garlon (R) 4 Herbicide, DOW Chemical U.S.A., Midland, MI, June 10, 1980.
Material Safety Data Sheet for Krenite Brand Control Agent, E.I. DuPont De Nemours and Co. Inc., Wilmington, Delaware, December 1980.
Toxicological Inormation on Fosamine Ammonium Salt (Ammonium ethyl carbamoglphosphonate), Haskell Laboratory for Toxicology and Industry Medicine, March 15, 1979.
Material Safety Data Sheet for Tordon (R) 101 Mixture Weed and Brush Killer, Dow Chemical U.S.A., Midand, MI, May 21, 1982.

development, and other uses (U.S. For. Serv. 1978). This conclusion was partially based upon 25 years of herbicide use by the Forest Service with no known health problems in Forest Service personnel, applicators, or local residents.

Several alternatives to vegetative management using herbicides exist including manual, mechanical, and biological methods (U.S. For. Serv. 1978). However, the most readily acceptable techniques are manual or mechanical vegetation control. These methods are much more labor-intensive and expose workers to increased risks of injuries from accidents in tool, equipment, and brush handling. The Bonneville Power Administration in Oregon has recorded injury frequency data resulting from brush cutting activities and found that the 5-year average injury rate is 5 injuries per 200,000-man hours worked. No chemical toxicity injuries were reported among workers over this same time period (U.S. Dep. Energy 1982). Although generally more risky for workers, these methods present little or no risk to the public. Vegetative management using herbicides, on the other hand, substantially reduces health and safety risks for workers while slightly increasing the risks of toxic effects to the public, especially from erosion spill-related events.

In conclusion, although the herbicides proposed for use in the rights-of-way have low degrees of toxicity to animals and humans, their application according to label directions and the mitigative measures in Sections 4.3.3 and 4.3.8.2 will ensure their safe use. It must be remembered that toxicity does not necessarily indicate a hazard. Even for pesticides that are demonstrated to be harmful to humans, extensive experience with them indicates that these potentially dangerous compounds can be used safely (Barnes 1975).

4.1.9 Radio and Television Interference

Radio noise is a general term used in reference to any undesirable disturbance of the radio frequency band, which ranges from 3 kHz to 30,000 MHz. Of interest herein, however, are those frequencies at which corona discharge associated with transmission lines interferes with radio and television reception, i.e., the AM broadcast band (535-1605 kHz) and the lower television broadcast bands (Channels 2-6 at 54-88 MHz). The FM broadcast range from 88 MHz to 108 MHz is unaffected by pulsative-type noise (LaForest 1982).

Subjective evaluations by test individuals have shown that the tolerance level for DC radio interference (RI) corresponds with a broadcast signal-to-noise ratio (SNR) of about 10 to 1. In terms of equivalent dB levels, the RI at the receiving antenna must be 20 dB below the broadcast signal for acceptable reception (Elec. Power Res. Inst. 1977). Bracken (ER, Vol. 3--Appendix C) has reported that a differential of 17 dB results in "entirely satisfactory AM reception." Thus, in an area where a given station broadcast signal is 40 dB, DC RI exceeding 20 dB would likely degrade radio reception of the given signal.

Comber and Nigbor (1982) report that parameters that have the most significant effect on RI levels are the number and diameter of conductors. An increase in either will result in a decrease in RI. Conductor diameters for the proposed interconnect are relatively large compared to those of multiple conductors shown in Table 4.9. Design parameters of the proposed New England/Hydro-Quebec interconnect include provisions for three conductors per pole. Individual conductors will be 4.78 cm (1.88 in.) in diameter.

Table 4.9. Radio Interference Levels in Relation to Voltage Levels and Some Design Parameters of Direct Current Transmission Lines

Conductor Diameter (mm)	Number of Conductors Per Pole	Pole Spacing (m)	Mean Fair Weather Operating Kilovolts†[1]	Radio Interference (dB above 1 μV/m)
61	1	10.5	± 400	53.4
46	2	10.5	± 400	43.2
46	2	18.3	± 500	49.0
46	2	18.3	± 525	49.0
46	2	18.3	± 600	55.9
30.5	4	11.2	± 500	42.9
30.5	4	11.2	± 600	48.9
30.5	4	13.2	± 525	42.8
30.5	4	13.2	± 600	47.3

†[1] Quasi-peak measurements at 834 kHz and 30.5 m radially from the positive conductor.

Source: Electric Power Research Institute (1977).

Measured RI levels associated with design parameters similar to those of the proposed New England/Hydro-Quebec interconnect are not available. However, Bracken (ER, Vol. 3--Appendix C) has estimated that the L_{50} fair weather RI level at 1 MHz at the edge of the right-of-way would be 37 dB; a comparable level for wetted conductor conditions would be 34 dB. Johnson (1982a) has predicted that the RI at 23 m (75 ft) from the centerline on the side of the positive conductors would be less than 40 dB for 80% of the time. Based on a relatively conservative prediction equation (Reiner and Gehrig 1977), Haralampu and Comber (ER, Vol. 2--Sec. V, p. 80) calculated the fair weather RI for three existing DC transmission lines. RI levels at the edge of rights-of-way ranged from 47 dB for voltage levels of ±400 kV to 55 dB for voltages of ±500 kV. Using the same equation, the comparable RI for the proposed New England/Hydro-Quebec interconnect was estimated at 41 dB. In view of the foregoing, it is unlikely that operation of the proposed line would cause complaints concerning radio reception.

The potential for television interference (TVI) causing reception problems appears negligible. Based on investigations at the Dalles test site in Oregon, which involved voltages of up to ±600 kV, the Electric Power Research Institute (1977) concluded that TVI is of little concern at distances greater than 25 m (82 ft) from the centerline of the right-of-way. Other investigations at the Dalles test site involved constructing test facilities simulating design parameters of the Celilo-Sylmar HVDC line. The test facilities were energized to line voltages up to ±600 kV. Test results reported by Chartier et al.

(1979) indicate that no TVI was detectable during fair weather conditions; some interference may have been detected at line voltages of ±500 kV and above during foul weather conditions such as dry snow, but the disturbance was negligible. In view of the foregoing, it is highly unlikely that operation of the proposed international interconnect would cause TVI outside of the right-of-way.

The physical presence of conductors and tower structures may cause scattering, reflecting, or reradiation of primarily television broadcast signals, thus resulting in the phenomenon referred to as "ghosting" (LaForest 1982). However, the Applicant is committed to make modificiations to receiving antenna if it is shown that the proposed line causes interference (ER, Vol. 2--Sec. VI B). TVI as well as RI may result from gap sparking usually caused by faulty or loose fittings; such situations are remedied by routine maintenance.

4.2 CONSEQUENCES OF ALTERNATIVES TO THE PROPOSED INTERCONNECTION

4.2.1 Alternative Interconnection Designs and Routes

4.2.1.1 Alternative Designs

In general, basic impacts from the presence of transmission line right-of-way would not differ from those expected under the proposed action. The right-of-way width could be narrowed perhaps 15 m (50 ft) if the lines were designed for operation at less than 300 kV (Galvin 1979). However, this would reduce the area requiring clearings, but voltages this low would constrain the capacity of the line for delivery of power. Use of lattice-work support structures would require committing more area to tower bases (ca. 150 m^2 vs. 10 m^2) although fewer structures would be necessary per kilometer--3-4/km vs. 4-5/km (Galvin 1979).

A major effect of altered design could be a change in the electric and magnetic fields associated with line operation. Operation at lower voltages would lead to reduced field strengths at the cost of reduced power capacity. Changes in conductor configuration would also alter field parameters. For example, field strengths increase with smaller bundles (2 subconductors per bundle) and decrease with larger bundles (4 subconductors per bundle). The latter could be achieved at higher cost, but the current configuration has substantially reduced the potential for corona below currently operating DC lines.

DC operation was chosen because of its higher efficiency in transporting power over great distances and because current technology allows for AC/DC conversion that is economically practicable. Operation of the line on AC would reduce production of ion fields substantially to zero, thus reducing total electric field strengths to the nominal levels associated with the presence of a simple electric charge. However, the potential for induced voltage and electric shock is higher in AC fields than in comparable DC fields because of the alternating field's capacity to induce changes in stationary objects (Bracken 1979a, 1979b).

Alternative designs cannot substantially reduce environmental impacts without also reducing the capacity of the line to carry power.

4.2.1.2 Vermont Routing Options

Air Quality

The expected air quality impacts along the Central Spine and Interface corridors would be identical to those expected for the Preferred Corridor.

Geology

Approximately 7 to 14 km (4 to 9 mi) of excessive slopes (>25%) occur along the Central Spine and Interface corridor routes (Klunder Assoc. 1981). This range encompasses the extent of excessive slopes found along the Preferred Corridor (Table 4.10). These areas are considered to have high erosion potential.

Soils

Over 150 ha (380 acres) of prime agricultural soils occur within each of the two Vermont alternative corridors (Klunder Assoc. 1981). This compares to less than 5 ha (12 acres) along the Preferred Corridor. Where these areas cannot be spanned and where clearing must occur, the construction of a transmission line would accelerate erosion. Because of the greater extent of prime soils, this is of considerably greater concern along the alternative corridors.

Agriculture

Within the study area, the majority of agricultural lands are located in the western towns (Klunder Assoc. 1981). Consequently, the more westward routes (i.e., Central Spine and Interface corridors) would traverse six times the amount of agricultural lands traversed by the Preferred Corridor (Table 4.10). Agricultural land is particularly important in alternative segments traversing the towns of Derby, Holland, Barton, and Sutton (Figure 2.8). Much of this land occurs on prime agricultural soils (Klunder Assoc. 1981).

Forestry

Selection of either major alternative route in Vermont would result in less forest clearing than is anticipated for the Preferred Corridor (Table 4.10). Within the Central Spine Corridor, 430 ha (1100 acres) of forest would be affected; within the Interface corridor, 400 ha (1000 acres) would be affected. However, it is not anticipated that removal of forest resources in any of the alternatives would have negative impacts upon the forestry industry. Clearing would amount to less than 0.1% of the regional forestland available for commercial production (Kingsley 1977). In addition, current forest accretion is occurring at a faster rate than commercial harvesting (Section 4.1.2.3). Thus, the reduction in forest clearing (up to 80 ha [200 acres]) achieved by selecting one of the alternatives would not significantly affect the impacts of the proposed line.

Mining

No known mineral extraction or major sand and gravel beds would be located within either Vermont alternative corridor.

Table 4.10. Comparison of Preferred and Alternative Corridor Routing Options

Features†[1]	Preferred	Central Spine	Interface	New Hampshire
Length (km)	95	99	94	130
Right-of-Way area (ha)†[2]	580	600	570	790
Forested land (ha)	480	430	400	760
Agricultural land (ha)	10	60	65	30
Urban land (ha)	0	4	4	0
Prime agricultural soils (ha)	2	190	160	36
Shallow soils (km)	6	20	14	5
Steep slopes (km)	10	14	7	9
Stream crossings	40	90	70	74
Major wetlands (km)	6	1	4	10
Deeryards (km)	13	5	3	8
Road crossings	5	44	47	35
Railroad crossings	2	3	1	6
Pipeline crossings	1	1	1	1
Unique landscape (km)	30	30	25	15
Landscape characteristics	9	18	9	6
Major viewsheds	2	18	6	1
Scenic roads	5	44	47	6
Natural areas	5	4	7	0
Historical sites	0	8	7	0
Structures	5	208	152	99
Average relative ranking†[3]	2.9	1.8	2.5	2.8

†[1] 1 km = 0.62 miles; 1 ha = 2.5 acres.

†[2] Right-of-way is 61-m (200-ft) in width.

†[3] Ranks range from 1 = less preferable to 4 = more preferable for routing a transmission line relative to other alternatives for each of 19 environmental features. Length and area were considered to be equivalent features.

Source: ER (Vol. 2 & 3); Klunder Associates (1981).

Recreation

The study area in Vermont (see Section 3.2.5) offers a variety of opportunities for both centralized and dispersed recreation (DeLorme Publ. Co. 1981). The alternative corridors would traverse the St. Johnsbury Municipal Forest at the juncture of Segments 15, 19, and 22 (Figure 2.8). In the town of Burke, the Interface corridor would pass through Darling State Park and the Burke Mountain Ski Area. Southeast of Lyndonville (Figure 2.3), the Central Spine corridor would cross the Lyndon Outing Club Ski Area; this corridor would cross Crystal Lake State Park in the town of Barton. In addition to passing through these recreation areas, the alternative corridors would pass within 8 km (5 mi) of several other areas including Brighton Municipal Forest, Victory State Forest, Sheffield Municipal Forest, Willoughby State Forest, Mathewson State Forest, and Lyndon State Forest. Many of the lakes near the northern segments of the alternative corridors are used by fishermen (DeLorme Publ. Co. 1981).

The two alternative corridors would directly affect these designated recreation areas. Indirect affects to nearby areas would be primarily due to visual intrusion. On the whole, the alternatives would impact more designated recreation areas than the Preferred Corridor which affects none directly (Section 4.1.2.5). Impacts to dispersed recreation would be on the same order as described for the Preferred Corridor (Section 4.1.2.5).

Residential, Commercial, and Industrial

The two alternative corridors would traverse a more urbanized portion of the study area (Klunder Assoc. 1981). Each corridor would encompass about 4 ha (10 acres) of land classified as urban (Table 4.10). Proposed land-use patterns could result in the residential or industrial development of 75% of the Central Spine Corridor and 55% of the Interface Corridor (Klunder Assoc. 1981). The Preferred Corridor has likely potential development for about 35% of its length, mostly at the southern end. The Central Spine Corridor would contain over 200 structures and the Interface Corridor over 150 in contrast to 5 structures within the Preferred Corridor (Table 4.10).

Use of the Preferred Corridor for the proposed line provides the least potential for competing with residential or industrial uses of land in the study area.

Natural Areas

The Vermont alternatives would encroach on or be near four to seven nature or conservation areas in the study area (Table 4.10). The Central Spine Corridor would pass within 8 km (5 mi) of the Calendar Brook and South Bay wildlife management areas. The Interface Corridor would pass near the Bull Hill and Hurricane Pond wildlife management areas. The Preferred Corridor will affect a similar number of natural areas but none directly (Section 4.1.2.7).

Airports, Navigation Routes, and Training Areas

Impacts on airports, navigation routes, and training areas would be the same as discussed for the Preferred Corridor (Section 4.1.2.9).

FERC-Licensed Lands

The alternative corridors would cross the same FERC-licensed lands crossed by the Preferred Corridor (Section 4.1.2.9).

Surface Water and Groundwater

Impacts of the alternative routings on surface water and groundwater would be similar in nature to those discussed for the Preferred Corridor (Section 4.1.3.1). The alternative routes would cross 30 to 50 more streams than the Preferred Corridor (Table 4.10); hence impacts to surface waters would likely be greater in extent if an alternative routing were chosen.

Terrestrial Vegetation and Wildlife

The nature of impacts to vegetaton and wildlife would be as described in Section 4.1.4.1. Selection of either alternative would result in less (10-15%) area of forest habitat than the Preferred Corridor (Table 4.10). However, this reduction is unlikely to significantly alter impacts because each routing option would encompass less than 0.1% of this resource. The alternative routes would pass through less than half the amount of deeryards traversed by the Preferred Corridor (Table 4.10).

Aquatic Biota

Environmental consequences for aquatic biota along the alternative corridors would be of the same nature as described for the Preferred Corridor (Section 4.1.4.2), but the extent of impacts would be greater because of the greater number of stream crossings (Table 4.10).

Wetlands

Fewer kilometers of wetlands would be crossed by the alternative corridors than by the Preferred Corridor (Table 4.10).

Threatened and Endangered Species

There are no threatened or endangered plant taxa from the federal list or proposed for inclusion on that list that are found along these alternative routes (Countryman 1978; U.S. Fish Wildl. Serv. 1982; Crow 1982). As along the Preferred Corridor, rare taxa of plants might occur but would be unlikely to be impacted (Section 4.1.4.4). Impacts to threatened or endangered wildlife would be equally unlikely.

Socioeconomic Impacts

The socioeconomic consequences associated with selecting one of the alternative Vermont routings would be of the same nature as described for the Preferred Corridor (Section 4.1.5). The work force associated with line construction and operation would not be of sufficient size to substantially alter local demographic patterns or strain local services. The larger population in the locale of the alternative routes should be able to absorb such impacts more readily than along the Preferred Corridor. In addition, nonlocal workers along these routes would contribute an even lower percentage of the local tax income. The more urbanized areas along the alternative routes would also be more able to provide adequate food and lodging services without straining their availability to tourists.

The alternative corridors contain considerably larger amounts of residential land than the Preferred Corridor (Table 4.10). Thus, it is likely that any impacts upon land values would occur more extensively along these alternatives (see Section 4.1.5.4). There is concern that the transmission line could devalue property located adjacent to or within view of the line.

Although the alternative routes would cross more transportation routes than the Preferred Corridor (Table 4.10), impacts would be limited to increased traffic loads during the period of construction. As in the Preferred Corridor, these impacts would be minor (Section 4.1.5.5).

Visual Resources

As with the Preferred Corridor, intrusion into aesthetically pleasing viewsheds would be a principal impact of constructing a transmission line in either of the alternative corridors (Section 4.1.6). In general, the alternative corridors would result in more opportunities for visual impacts to occur than along the Preferred Corridor. Much of the northern ends of both alternative routes would pass through relatively flat lands where concealment would be difficult to achieve (Klunder Assoc. 1981). Both alternatives would pass through more visually sensitive stretches than the Preferred Corridor (Table 4.10). Because of the greater urbanization and population along the alternative corridors, visual intrusion would likely affect a greater number of individuals than along the Preferred Corridor.

Cultural Resources

There are a greater number of historical sites within each alternative corridor than are found in the Preferred Corridor (Table 4.10). Thus, final routing of the right-of-way would have to be more carefully done in order to avoid impacts to these sites. Other impacts would be as described for the Preferred Corridor (Section 4.1.7).

Health and Safety

Health and safety effects would be as described for the Preferred Corridor (Section 4.1.8). Along the alternative corridors, the impacts would affect more individuals because of the larger population and the larger number of structures in these corridors than in the Preferred Corridor.

4.2.1.3 New Hampshire Routing Option

Air Quality

The expected air quality impacts along the New Hampshire option would be identical to those expected for the Preferred Corridor (Section 4.1.1).

Geology

Approximately 9.0 km (5.6 mi) of excessive slopes (> 20%) occur within the New Hampshire option and, along with mountain tops and ridge lines, are considered areas of high erosion potential (Table 4.10). Approximately 2.3 km (1.4 mi) of wooded areas with excessive slopes would be traversed by the corridor in a perpendicular fashion. A total of 5.0 km (3.1 mi) are identified as potential scar areas. The majority of the steeper slopes occur in the northernmost portion of the study area (ER, Vol. 2). The Preferred Corridor has a similar extent of steep slope areas (Table 4.10).

Soils

Approximately 36 ha (90 acres) of prime agricultural soils would be crossed by the New Hampshire option, more than five times the total amount of agricultural land crossed by the Preferred Corridor (Table 4.10). If spanning of these areas is not possible, tower construction within the prime soils would be necessary. Movement of the heavy machinery over these soils during construction might mechanically compact surface soils near the foundation structure, reducing rates of water infiltration and percolation and restricting water penetration. Such effects would be extremely localized in extent of area disturbed.

Agriculture

Agricultural lands occur in a number of places within or in close proximity to the New Hampshire alternative corridor. The majority of these lands are scattered within the northern portion of the study area in the towns of Clarksville (Connecticut River Valley), Stewartstown, Colebrook (Mohawk River Valley), and Columbia; along the Upper Ammonoosuc River east of Groveton; along the Israel River east of Lancaster; east of Beach Hill at the Ammonoosuc River; on the northwest side of Dalton Mountain; at State Route 135 northwest of Littleton; and near the Comerford Dam Terminal.

A total of 30 ha (75 acres) of agricultural land would be located within the right-of-way compared to about 10 ha (25 acres) crossed by the Preferred Corridor (Table 4.10). Approximately 26 ha (64 acres) of agricultural land would be crossed in Coos County and 4 ha (10 acres) in Grafton County. Approximately 60% of this land is in pasture and about 40% is being actively cultivated for crop production (ER, Vol. 2--Exhibit 2-65).

Forestry

The necessary widening of the right-of-way adjacent to existing transmission lines would entail clearing about 190 ha (475 acres) of forestland over a total distance of about 40 km (25 mi) (ER, Vol. 2--Exhibits 2-57, 2-59, 2-61, 2-62). The additional 61-m (200-ft) right-of-way required for the proposed line would traverse about 86 km (54 mi), and include about 530 ha (1300 acres) of forested land. In summary, more than 700 ha (1750 acres) of forestland would be cleared for this alternative as opposed to about 480 ha (1200 acres) for the Preferred Corridor (Table 4.10).

To provide a general perspective as to the significance of right-of-way requirements for the proposed transmission line, several considerations are pertinent. The total right-of-way area requirement is 710 ha (1760 acres). This area is not totally commercial forestland. This area represents less than 0.1% of the total commercial forestland in Coos and Grafton counties; the resulting loss of volume of growing stock would be equally negligible.

The area of commercial forest in New Hampshire is projected to decrease appreciably within the next 50 years (Kingsley 1976). However, forest resources of New Hampshire are currently undermanaged and underutilized as in Vermont. Therefore, although impacts are expected to be larger in New Hampshire, development and operation of this alternative would have no significant adverse impacts on either the forest resources or forest market conditions.

Mining

No known mineral extraction or major sand and gravel operations would be located within this alternative corridor.

Recreation

Only the Coleman, Forest Lake, and Weeks state parks are located in the vicinity of the New Hampshire alternative route. The route would not encroach on any of the above-named state parks, but visitors entering and leaving Coleman State Park would view the transmission line. The line would also be visible from a number of vantage points on western boundaries of the park. However, developed facilities and activity centers are concentrated about Little Diamond Pond where the line would be obscured by intervening topography. Similarly, the proposed line would be visible from certain vantage points in Forest Lake State Park, but activity centers would be screened by intervening topography and forest vegetation. On the other hand, the line would be clearly visible to visitors of Weeks State Park, located on Mt. Prospect, particularly from an onsite observation tower. From this vantage point, the visual impact would be additive since the proposed line would parallel an existing 115-kV transmission line.

Aside from state parks, the proposed transmission line would also be visible from other developed recreation sites The degree of visual intrusion would differ for the various sites, which include: The Mohawk Valley Campground on State Route 26 east of Colebrook, a scenic overlook and a campground site on U.S. Route 2 southeast of Lancaster, a campground at Blood Pond, the Crazy Horse campground located inland from lower Moore Reservoir, and two boat launching sites and a shoreline picnic area on lower Moore Reservoir. Various portions of the structures and segments of the transmission line would be visible to participants in water-based recreation activities at both the Moore and Comerford Reservoirs. Visual intrusion would be greatest where the proposed line crosses over portions of the Moore Reservoir.

As in Vermont (Section 4.1.2.5), development of the New Hampshire route would have both positive and negative effects on opportunities for dispersed types of recreation in New Hampshire. The impacts would be primarily visual.

In general, this alternative would have a greater potential for impacting recreation than in Vermont because of greater recreational opportunities in New Hampshire.

Residential, Commercial, and Industrial

Although no major residential areas would be crossed by the New Hampshire alternative, 99 residences scattered along the length of the route are located within 300 m (1000 ft) of the proposed right-of-way (Table 4.10). Fifty-one of these residences are located along the new right-of-way. These residences would be subjected to increased noise and dust levels during construction, and possibly inconvenienced due to the movement of construction workers and machinery. One homeowner would be significantly impacted and would have to be relocated. Property values and aesthetic considerations could be adversely affected for those residences in close proximity to the proposed line. These impacts would be considerably greater than those anticipated along the Preferred Corridor (Section 4.1.2.6).

About 75% of the alternative route would cross land categorized by the state as rural (ER, Vol. 2--p. 124). By definition, rural land is suitable for low-density residential use. Most local town plans have stated that future development will primarily occur near the existing developed areas. The route should not interfere with most of these plans. However, there is a future residential development planned in the town of Dalton on the northwest side of Dalton Mountain. If this residential development materializes, there would be visual and possibly fiscal impacts to the area residents.

The construction and operation along the alternative route would not impact any existing commercial or industrial developments in the study area. Although the transmission line corridor would not cross any land currently used for commercial or industrial purposes (other than timber production), segments of land in the town of Littleton are zoned for commercial and industrial use.

Natural Areas

The New Hampshire alternative transmission route would not encroach on any known nature or conservation areas in New Hampshire. Hurlburt Swamp and the Pondicherry Wildlife Refuge are closest to the route--4.8 km (3.0 mi) and 5.1 km (3.2 mi), respectively. This alternative would not traverse any portion of the towns of Jefferson, Bethlehem, and Sugar Hill. Thus, the Lovell property, The Rocks, Bretzfelder, and Forbes/Martin property areas would not be affected. Other conservation areas that are relatively isolated from the proposed route by either distance or intervening topography include Patrick Woodlot, Beaver Brook Falls, Lime Pond, and Blood Pond.

Several conservation areas are in the immediate vicinity of the New Hampshire alternative. The two conservation easements (Greason and Bradley properties) would be located about 1 km (0.6 mi) from the route, and are located on Dalton Mountain. For the most part, these two properties are isolated from the route by an intervening portion of the mountain that is of higher elevation. However, views to the southeast of these properties would include portions of the proposed transmission line, where it would parallel an existing 115-kv line. Viewsheds are more critical with respect to the Ben Young Hill, Mudget Mountain, Lovering Mountain, Percy Peaks, and Cape Horn sites. Among other natural attributes, the crests of these mountains are established scenic overlook areas. In all cases, these overlook areas would be about 1.6 km (1 mi) or less from the route; likewise, the proposed route would traverse the base of the respective mountains at lower elevations.

In summary, development of alternative transmission facilities within New Hampshire would not directly affect any natural or conservation areas; however, development would result in adverse, indirect effects of a visual nature to a greater extent than within the Preferred Corridor (Section 4.1.2.7).

Airports, Navigation Routes, and Training Areas

Impacts to airport, air routes, or military training areas associated with the New Hampshire alternative route would be the same as those discussed for the Preferred Corridor (Section 4.1.2.8).

FERC-Licensed Lands

The New Hampshire alternative route would traverse a total of up to about 8 km (5 mi) of lands licensed by the Federal Energy Regulatory Commission (FERC). These FERC-licensed lands are adjacent to Moore Reservoir (ER, Vol. 2--Exhibits 2-59 and 2-62). This amount of land is twice that expected to be crossed by the Preferred Corridor (Section 4.1.2.9).

Surface Water and Groundwater

The environmental impacts of the proposed New Hampshire alternative on surface waters and groundwater would be similar in nature, if not in magnitude, to those discussed for the Preferred Corridor (Section 4.1.3.1). However, surface water impacts would occur to a greater extent since the alternative crosses more streams (Table 4.10).

Terrestrial Vegetation

Certain aspects of construction and operation impacts on vegetation resources discussed in Section 4.1.4.1 are also applicable to this alternative. About 127 km (79 mi) of the alternative right-of-way is forested land. The principal vegetation types in northern portions of the right-of-way are maple/birch/beech and spruce/fir forests (Section 3.2.4.1). White and red pine forest stands are important components of the vegetation in the more southerly portions of the right-of-way. The proportion of the forested land that may have been recently harvested is not known, but it is likely that some degree of land clearing would be necessary on most of the forested right-of-way; this could amount to clearing nearly 1.5 times that amount expected for the Preferred Corridor (Section 4.1.4.1).

Terrestrial Wildlife

Impacts from the construction of the 133 km (82.7 mi) powerline and the converter terminal would be of the same order of magnitude as described for the Vermont Preferred Corridor (Section 4.1.4.1). As with the Vermont option, disturbance of wildlife due to human activity would be of short duration and would be unlikely to threaten the survival of local populations of wildlife. Primary impacts would result from clearing forest habitat; more than 700 ha (1740 acres) of land would require clearing within the 61-m right-of-way, which is about 0.1% of the forest habitat in Coos and Grafton counties. Wildlife associations around the right-of-way would be altered, but no critical or high-value habitat would be affected. Because the forest to be cleared represents a minute fraction of that available, impacts to local wildlife populations would not threaten their continued survival.

Impacts from right-of-way maintenance and line operation along the New Hampshire route would be of the same order as those discussed for the Preferred Corridor (Section 4.1.4.1), although more forest habitat is expected to be cleared.

Aquatic Biota

The potential environmental consequences to aquatic biota from the construction and operation of the New Hampshire option would be similar to those addressed for the Preferred Corridor (Section 4.1.4.2). It is not anticipated that access roads would have to be constructed across every stream crossing. However, until route planning is finalized, the staff must conservatively estimate that all streams would require an access crossing. Therefore, the potential for aquatic impacts is somewhat greater for the New Hampshire alternative because 74 stream crossings would be necessary in comparison to less than 40 for the Preferred Corridor (Table 4.10).

Wetlands

Potential impacts to wetlands within the proposed New Hampshire alternative are similar to those described for the Preferred Corridor (Section 4.1.4.3).

Threatened and Endangered Species

As in Vermont, there are no plant species on the federal list of threatened and endangered plants that are likely to occur along the alternative transmission line route. For the most part, the alternative would be routed around areas of specialized habitats (e.g., rock ledges and wetlands) that could provide habitat for the rare plants known to occur in the towns through which it would pass (ER, Vol. 2; Storks and Crow 1978). Thus, impacts are unlikely.

The major potential for impact to threatened, endangered, or rare species of wildlife is associated with clearing of forest habitat for the right-of-way. Wildlife species are wide-ranging, and populations extend throughout New England, albeit sparsely. Therefore, loss of a minor fraction of available habitat would be unlikely to result in a reduction in numbers of these protected species.

Socioeconomic Impacts

Because of the proximity of the New Hampshire alternative route to some currently residential or planned residential areas, there might be a very slight change in the distribution pattern of future population in the area.

Discussion and controversy about the proposed line has already occurred in public hearings on the project and in local town meetings. Depending on techniques that would be used to acquire the right-of-way (Gale 1982), local residents might be more resistant to the project and more organized in their opposition to a corridor wholly in New Hampshire than has occurred for the Preferred Corridor.

As in Vermont, the number of local workers used for construction of the line would be small relative to the size of the local work force, and the benefits of reducing unemployment would be slight. Incoming workers would also contribute slightly to the local economy by purchasing lodging, goods, and services.

Counterbalancing these positive aspects of the incoming work force would be the problem of competition with tourists for lodging facilities. Tourism is a major source of income and employment in this part of New Hampshire, more so than the area around the Preferred Corridor. Based on estimates from a study of transmission line workers (Gale 1982), between about 80 to 290 new people (50 to 170 of which would be project workers) might reside temporarily in the area for some part of the five-year construction schedule. If one-half of these people used local temporary lodging facilities, this would reduce the number of rooms available for tourists by about 25-85 rooms. Although income to local establishments would be the same whether lodgers were tourists or project workers and their companions and although the supply of housing would not be exceeded, a reputation for crowding and difficulty in obtaining lodging reservations over the five years of the project could affect negatively the tourist demand temporarily after the project was completed.

The most serious, yet unquantifiable, potential impact of a transmission line on the northern New Hampshire area economy would be on the attractiveness of the area to tourists. It is the feeling of local residents and representatives of the business community that the tourist industry is based on the scenic natural, rural and isolated quality of the area. Any intrusion of man-made structures into this scenery, especially along popular tourist routes (e.g., Highways 3 and 26) or in the views of the old inns of the area, would detract and could permanently reduce tourist volume.

Slight negative impacts to farming activities might occur because farm equipment is difficult to operate around the towers. In addition, farmers have had difficulty getting their workers to work under the lines and have claimed that they have received shocks when driving equipment under the lines (Gale 1982).

As discussed earlier with respect to the Preferred Corridor (Section 4.1.4.2), taxes paid by the Applicant on some parcels of land along the route would provide additional revenue for the towns. However, more of the proposed New Hampshire route would traverse or be adjacent to residential development than is the case for the Preferred Corridor. One house would have to be replaced, reducing the current revenue from this site. Property tax income would be affected because easements for the line might result in changing tax assessments and land zoned for future development near the route might not be developed. Change in tax revenues is dependent on at least three factors: compatibility of the township tax rates and the rate the utility would pay, the depreciation rate of the line facilities, and the easements given in land crossed by or adjacent to the right-of-way. The assessed value of residential land would be especially likely to drop because, except for the base area of the towers, agricultural land and forestland could still be productive. Given the heavy dependence of New Hampshire townships on property taxes for revenue, any decrease in present or future assessments would have negative consequences that would lower the increments from taxes paid by the Applicant on the line.

Regardless of assessed value, some residents have bought land for its scenic value and have built or plan to build homes to take advantage of this. Others, who have family homes that have been passed on for generations, feel that the value of the land is not in its salability, but in its attractiveness to their children to keep it in the family (e.g., Placey 1982). Both groups believe that the presence of the line would reduce property value and salability. The alternative route would pass directly over one residence, very near several others, through the viewshed of many, and through several lots where residential development is firmly planned. The one residence in the proposed right-of-way would be relocated (ER, Vol. 2--p. 122) or the house purchased by the Applicant at fair market value (Smith 1982). The owner of this residence also owns a neighboring residence (to be inhabited by his son's family) which is within 76 m (250 ft) of the right-of-way (Harris 1982; Smith 1982). Long-term family land-holding patterns, where members of families live on adjacent properties, are common in rural areas. A recent study (Roper 1981) has shown that these patterns, once disrupted, take many years to reestablish.

Over the period of clearing and construction, temporary increases in traffic congestion, noise, mud, and fugitive dust, and removal of vegetation at construction sites and along access routes would discourage tourism at these particular sites.

Because of the small number of nonlocals on the construction work force, no significant impacts would be expected on community services, such as schools, or on utility capacities. Slight temporary increases of demand during the construction period could be handled by existing facilities.

On the whole, because of the greater population in the vicinity of this alternative and because of greater reliance on tourism, socioeconomic impacts are expected to be greater than anticipated for the Preferred Corridor.

Visual Resources

The construction and operation of the New Hampshire alternative transmission line would adversely impact a number of viewing areas along the route and four sensitive viewing areas in particular. An adverse visual impact would occur where the alternative line would be visible within the proximity of the scenic Harvey Swell farm area near Bear Rock and Colebrook roads. Partial skylining of the alternative line could occur north of and at State Route 26, and the line could be viewed from the Mohawk Valley campground located off of State Route 26.

Another important visual concern would be the line crossing the Appalachian Mountain Club Trail, which ascends the west slope of Percy Peaks near Slide Brook. An adverse visual exposure would occur at the Upper Ammonoosuc River Valley where the terrain is relatively flat and open and used for agricultural purposes.

Where the line crosses the Israel River Valley, an adverse visual impact would occur where the tower structures and conductors would be visible on the open floodplain. Skylining of some towers might also occur. Viewers in this area include local valley residents, motorists using U.S. Route 2, and recreationists using a local campground off the highway.

The alternative line would be visible near Moore Reservoir. The line would be especially visible where it would span two bay areas along the reservoir, using 56-m (185-ft) tower structures. The line would be visible by recreationists using the reservoir, boat ramp, and picnicking facilities and could be viewed from Crazy Horse Campground off Hilltop Road as well as from other panoramic vista points surrounding the reservoir.

The New Hampshire alternative route would result in a greater number of situations in which adverse visual impacts might occur than along the Preferred Corridor.

Cultural Resources

Construction activities along the New Hampshire alternative corridor and required access roads would not impact any of the identified archaeological or historic sites. However, undiscovered archaeological and historic sites could be uncovered, damaged, or destroyed during the construction of access roads, clearing of corridor right-of-way, installation of transmission line structures, and construction of the terminal facilities. Areas with the highest probability of containing archaeological or historic sites that would be traversed by the transmission line include the Connecticut, Mohawk, Upper Ammonoosuc, Israel, Johns, and Ammonoosuc river valleys and adjacent stream areas.

Health and Safety

Construction, operation, and maintenance of an alternative interconnection in New Hampshire would have similar risks to human health and welfare as discussed for use of the Preferred Corridor (Sections 4.1.8 and 4.1.9). However, because of the greater length of a line in New Hampshire and the greater number of people in the area, any impacts due to the line would affect a greater number of people.

4.2.2 Comparison of Alternative Routing Options

A comparison of routing alternatives was made by assigning relative ranks to the value of environmental features of the routes (Table 4.10). Each route was ranked for each feature according to its preferability or compatibility for construction and operation of a transmission line. For example, a shorter length and hence smaller right-of-way area is preferable because disturbance impacts would be smaller. Each route was assigned a rank from 1 (less preferable) to 4 (more preferable), and a composite average rank was calculated (Table 4.10).

The Preferred Corridor ranked as the most environmentally preferrable of the four routing options (Table 4.10). This is principally because the route is one of the two shortest and interferes with human land uses to a considerably less extent than would the other routes.

4.3 MITIGATIVE MEASURES

4.3.1 Air Quality

The only emissions that can be reduced with the application of mitigative procedures is the generation of fugitive dust. Proper dust-control procedures include watering or chemical treatment of unpaved haul roads will be used.

4.3.2 Land Features and Use

4.3.2.1 Geology and Soils

The transmission line will avoid large areas of steep or unstable slopes wherever possible so as to ensure the stability of the transmission towers as well as to lessen erosion losses. Where slopes cannot be avoided, they will be spanned by the power line or the line will follow topographic contours. Likewise, access roads will follow topographical contours where possible and road grades will generally not exceed 10% or 20% for short, steep pitches. All slope problems within the Preferred Corridor will be addressed in this manner so as to lessen or eliminate potential erosion losses.

The following plan for right-of-way development will be used. Vegetation existing along the major portion of the Preferred Corridor will be clearcut. Stumps and root systems--as well as low-growing vegetation, grasses, and shrubs--will be left in place to preserve soil structure and decrease soil losses due to erosion. In areas sensitive to erosion such as streams and river crossings, steep sand banks, or in ravines spanned by the transmission line, tall vegetation will be selectively cleared or trimmed so as not to alter the effectiveness of the root systems in stabilizing soils.

The following practices are planned to minimize erosion due to construction and use of access roads and staging areas. Existing access roads and cleared areas will be used wherever possible for access and construction staging areas. New access roads will be constructed so as to follow the general contour of the land while avoiding localized severe slope conditions, wetlands, and agricultural soils. Access roads will be graded to ensure natural drainage and limit erosion. Culverts and water bars will be installed to control surface runoff and subsequent erosion. To prevent soil damage during wet soil conditions and heavy traffic, the road surface will be stabilized with gravel, stone, or mat, and vehicle traffic may be restricted. In addition, access roads will be routed to avoid close proximity to or paralleling of streams or wetlands.

To lessen soil erosion and to facilitate construction, as much of the construction and clearing operations as possible will be carried out during the winter season to take advantage of frozen ground and stream conditions. Impassible road conditions during the spring melt will limit construction activities during the period when maximum erosion losses due to construction activities could otherwise be expected.

Access roads along croplands where soil has been compacted during construction will be contoured, ripped and plowed, and then seeded and mulched. Where grading operations are required for construction of access roads, cut material will be used as fill material. Excess fill will be graded to conform with local drainage patterns and seeded. After construction, all unnecessary roads and construction areas will be graded, seeded, and planted or mulched to promote revegetation and reduce erosion. In Vermont, mitigative measures outlined in "Guides for Controlling Soil Erosion and Water Pollution on Logging Jobs in Vermont" (Vt. Dep. For. Parks, undated) will be followed. The Applicant is committed to perform all the above practices.

Because federal and state agencies such as the U.S. Soil Conservation Service and the U.S. Fish and Wildlife Service are familiar with existing conditions in the study area, the Applicant should interact with these agencies regarding plans for right-of-way preparation and construction. This will allow refinement of construction procedures to meet site-specific conditions and will further ensure that impacts related to design construction and operation are minimized.

Farmlands will be skirted or spanned so as to minimize the impacts to agricultural soils within the transmission line corridor.

Construction of the right-of-way will result in temporary increases in soil erosion (see Section 4.1.2). Implementing the mitigative measures discussed above, although not capable of preventing soil erosion entirely, should result in limiting erosion to an acceptable level.

4.3.2.2 Agriculture

If a transmission line tower is located on agricultural land, the amount of land removed from crop production can be minimized by using an H-frame or single pole tower. Lattice towers should be avoided. Wherever possible, any tower structures in an agricultural area should be located along the edge of an agricultural field to lessen the probability of operational damage to farm equipment and/or the transmission line tower and to minimize the amount of cropland (existing or potential) removed from production.

4.3.2.3 Forestry

Three types of landscaping will be used during the land clearing and construction phases: (1) selective cutting whereby tree removals will be limited to those that could potentially jeopardize the integrity of the energized transmission facilities and to those obstructing construction or maintenance equipment, (2) feather cutting at the edge of the right-of-way whereby only the taller trees are removed and existing low vegetation is retained, and (3) screen planting in selected areas where residual vegetation is light (ER, Vol. 3--p. 108).

Efforts will be made to salvage sawlogs, pulpwood, firewood, and chips derived from right-of-way clearing, but materials will be disposed onsite if removal will cause environmental damage (ER, Vol. 3--p. 11).

A plan for slash disposal will be prepared and submitted to the Vermont Agency of Environmental Conservation for approval (ER, Vol. 3--p. 108). In readily accessible areas, woody materials are normally disposed by chipping--with the chips spread over the right-of-way. In remote areas, woody vegetation is normally piled at the edge of the right-of-way. Brush piles may not exceed 1.8 m (6.0 ft) in height or 4.9 m (16.0 ft) in greatest horizontal dimension; all brush piles will be separated by at least 1.8 m (6 ft) (ER, Vol. 3--Appendix A).

4.3.2.4 Recreation

Encroachment of the proposed right-of-way on intensive-use or organized recreation sites was avoided by implementing criteria established in the route selection process (ER, Vol. 3--p. 6).

To avoid undue exposure of the sightseeing public to views of the transmission line corridor, the following mitigative measures will be implemented: right-angle crossings at highway-transmission line intersections, maintenance of vegetation screening along highways, and minimizing the lengths of transmission line segments observable from given vantage points (ER, Vol. 3--p. 115.).

4.3.2.5 Natural Areas

To the extent practicable, intrusions of the proposed right-of-way on natural areas were avoided by criteria established in the route selection process (ER, Vol. 3--p. 6).

4.3.3 Hydrology, Water Quality, and Water Use

Construction of the transmission corridor, tower foundations, and necessary access roads will increase soil erosion and stream channel siltation. To minimize these negative impacts, erosion-control measures will be used--including interceptor ditches, rip-rap, water bars, silt dams, pipe culverts, jute mesh, seeding, gravel, crushed stone, or mats. Streamside vegetation buffers will be maintained along all streams to help filter sediments from surface runoff and to stabilize banks. It is recommended that a buffer strip of understory vegetation not less than 30-m (100-ft) wide be left along stream banks to trap sediments in runoff before it reaches the stream. Short, stabilized ditches will be located to disperse runoff. At stream crossings, erosion-control measures may include use of cross drains, water bars, sediment traps, mulching the fill bank, and placing rip-rap on the upstream side. Furthermore, no soil should be pushed into the streams during construction of stream crossings. Using the knowledge developed by the local logging companies, properly designed and installed culverts will be used at stream crossings to ensure natural flow of streams. In Vermont, procedures suggested by the Vermont Department of Forests and Parks (undated) will be used for controlling soil erosion during logging operations. Temporary bridges will be removed upon completion of the project and river banks will be restored.

To reduce the number of stream crossings, existing access roads will be used when practical. Where stream crossings are necessary but unavailable, the type of stream crossing will be determined by local slope conditions. Where streambanks are firm and gradual, streams will be forded. Fill and culvert crossings will be designed and constructed on streams with steep banks to allow for free flow of water through the culvert, especially during the periods of high flow.

In areas of steep slopes and in the vicinity of streams and wetlands, structures will be located to minimize access requirements. In wetlands where upland access is impossible, temporary access for construction operations may require use of culvert and fill roads, wooden swamp mats, helicopters, or all-terrain vehicles. Structures will be placed no closer than 61 m (200 ft) to the stream banks so as to minimize bank erosion and failure. No towers will be placed within wetlands or floodplains, if possible.

Construction of the right-of-way will result in temporary increases in stream siltation and surface runoff. Implementing the mitigative measures mentioned above, although not capable of preventing all adverse impacts to surface waters, should be able to limit the impacts of these disturbances.

Chemicals, fuels, oils, greases, bituminous materials, solids, waste washings, and concrete used in construction operations must be properly stored and handled to prevent accidental spills and contamination of surface waters and groundwaters. Impacts resulting from an accidental release will be site-specific and will be highly dependent upon the quantity and type of contaminant released. To minimize the possibility of an accidental release, the refueling of construction vehicles, storage of construction materials, and the disposal of waste material should be prohibited near streams and wetlands.

4.3.4 Ecology

4.3.4.1 Terrestrial

Vegetation

The growth of herbs, most shrubs, and some low-growing trees that are considered desirable ground cover for the right-of-way will be encouraged (ER, Vol. 3--Appendix A). Selective clearing techniques will be used in wetlands to minimize disturbance of vegetation. Shoreline shrubs and alders will be retained whenever possible. No debris resulting from periodic vegetation management activities should be placed within the high-water mark of any water body. All vegetation control associated with construction clearing and maintenance will follow draft guidelines of VELCO's "Maintenance Program for Vegetation Control on Transmission Right-of-Ways" (ER, Vol. 3).

Wildlife

The primary means by which impacts are to be mitigated are by routing and design of the transmission line. The proposed route was selected to minimize passing through habitats such as deeryards, wetlands, and other areas identified as having high value for wildlife. Line design has minimized electrocution potential as well as corona effects and hence ion currents, audible noise, and ozone production.

Travel corridors will be provided across the right-of-way where it passes through deeryards. The travel corridors are created by allowing trees of a safe height to remain in the right-of-way. These wooded corridors provide protection from the elements and provide a link between two sections of a bisected deeryard. Such travel corridors have been shown to be effective in facilitating deer movement across right-of-ways in New England and Quebec (Willey 1982; Hydro-Quebec 1981).

The right-of-way will be maintained by selective clearing of and selective herbicide application to tree species that may pose a threat to safe line operation. These practices will allow for growth of shrubs and herbaceous plants that provide forage for wildlife.

4.3.4.2 Aquatic (Including Wetlands)

In constructing stream crossings, the stream corridor width will be minimized and care will be taken in selecting the stream crossing angle and site. Where feasible, wildlife trail lanes, streamside vegetation buffer strips, and stream crossings will be co-located. Construction and clearing activities will be restricted during nesting and spawning periods. The spawning season of the principal game species in the streams, brown trout and brook trout, is late summer to early fall. Timing of stream crossing construction activities (especially when access roads have to be built) should be modified so that construction does not occur during the spawning season. Such restrictions on stream crossing construction may be lifted, however, if it can be satisfactorily demonstrated that fish spawning activities do not occur in either (or both) spring or fall in the particular stream under consideration.

During the spring runoff period or during periods of inclement weather, access roads should be closed to construction vehicles and equipment to minimize unacceptable environmental damage. In intermittent wetlands, however, equipment can be used during periods when the ground is entirely dry rather than strictly during winter conditions when the ground is frozen.

Prior to removal of gravel from streams, the potential of the area for use as a spawning site should be determined. Local fishery experts should be consulted in this matter. Furthermore, culverts should be designed so that cross-section velocities are low enough to satisfactorily allow fish passage.

4.3.4.3 Threatened and Endangered Species

The route has been surveyed to ensure that no protected plants or wildlife will be affected. The final routing and construction schedule will be designed to avoid jeopardizing any rare or protected species found along the corridor.

4.3.5 Socioeconomic

To reduce conflicts in demand on local temporary lodging facilities, arrangements for nonlocal workers should be made well in advance of the beginning of construction. Whenever possible, workers from the local labor pool should be trained and hired for construction and operation activities.

Although public opposition to the proposed line has not been as active in Vermont as in New Hampshire, to avoid future problems, certain precautions should be taken. Open interactions should continue to be maintained with local officials, citizens, and landowners along the route. Decisions about final route choices, right of way negotiations, construction practices, locations of temporary roads, scheduling of activities in populated or well-travelled areas, choice of tower structures and others should be made in consultation with the local public (McConnon 1980, 1982; Gale 1982).

Prior to construction, the local towns should be informed of depreciation practices that will be followed and a mutually acceptable arrangement on tax rates should be developed for use in assessing transmission-line lands over the long term.

Clearing plans should be planned for timber company lands in cooperation with the companies so as to avoid problems in availability of subcontractors and crews.

Truck and equipment travel and construction operations should be scheduled so as to conflict as little as possible with existing traffic. Roads through timber company lands should not be constructed or used by trucks or equipment during the spring rainy season.

4.3.6 Visual Resources

In general, where road and stream crossings occur, shrubs and trees will be planted and retained as much as possible to prevent a view into the corridor from along such crossing points. To minimize the time and length of the line seen from the roadway, crossings will be made at right angles to the roadways wherever possible. H-frame and/or single-pole towers should be used to minimize tower dominance. Low-profile tower structures should be used (if feasible) in highly visible areas where standard height of towers could be viewed above the treetops. Poles should be set as far back from roadways and stream banks as feasible. All transmission line structures should be colored to blend in with the natural background vegetation.

Visual impacts can be minimized by selective clearing, leaving as much low growth in the right-of-way as possible, and additional planting. Tapered clearing of the right-of-way--through tree topping, etc.--will soften the edges of the right-of-way, reducing the visual impact. A right-of-way clearing pattern should be developed where feasible to reduce the straight-line corridor effect.

The proposed line will be routed so that it follows and conforms to natural topographic lines as much as possible. In addition, lines should be sited to one edge of a valley or draw and parallel a landform change. Skylining of the line and towers should be minimized. If a hill must be crossed, it should be crossed at an angle (e.g., side or shoulder of the hill rather than the top). If the proposed line traverses a prominent viewing area, the line should be located between the viewing area and a vegetative or topographical screen if feasible.

At the proposed terminal location, existing trees and vegetation should be left standing to the extent possible to screen the terminal facilities. The building and associated terminal facilities should be painted a color that will best blend in with the background vegetation. The height of the transmission line terminating structures should be kept to the minimum safe and practical height.

Specifically, all roads should be crossed at a right angle and the corridor should be screened with appropriate vegetative cover. The proposed line should be placed in the lower portion of the foothills of Black Mountain near the Black Branch of the Nulhegan River, so that Logger Brook will visually conceal the line from viewers in the region. Also, the line should be placed along the lowest elevation possible in the corridor that runs along the west slopes of the Potash Mountains. A slight shift of the transmission line to the east over Cow Mountain in the town of Granby will reduce the amount of exposure in the Victory Basin area. Finally, if the transmission line is placed to the northwest of the viewshed area along Moore Reservoir, it will be concealed from view by recreationists on the reservoir and motorists on Interstate 93.

4.3.7 Cultural Resources

The damage or destruction of cultural resources will be minimized by making a thorough literature search and having a qualified archaeologist conduct a surface reconnaissance of those areas of the transmission right-of-way, terminal site, and access road areas that are determined to have a high probability of containing an archaeological or historic site. Potential sites will be recorded, and uncovered sites should be determined for their potential eligibility and inclusion in the national and/or state historic registers. Local and regional historic preservation groups should be consulted. If artifacts are discovered during construction, the Vermont or New Hampshire State Historic Preservation Officer will be notified. If possible, important sites discovered should be avoided by realigning the transmission line route. If realignment is not feasible, salvage excavations should be undertaken under the supervision of a professional archaeologist with the approval of the Vermont or New Hampshire State Historic Preservation Officer.

4.3.8 Health and Safety

4.3.8.1 Electric and Magnetic Hazards

The transmission line will be constructed and operated in such a manner that the maximum steady-state short-circuit current is limited to 5 mA between the ground and any nonstationary object within the right-of-way (Herrold 1979). This is based on recommendations put forth in the National Electric Safety Code. To prevent secondary accidents from involuntary reactions to shock below the let-go threshold, all fences, stationary objects, or moveable equipment located or regularly operated within the right-of-way will be grounded so that induced currents are less than 1 mA (Herrold 1979). Residents adjacent to the lines will be informed of the possibility of induced shock and of the fact that the utilities will ground their equipment upon request. Additional recommendations include the suggested use of the Rural Electrification Administration (1976) guidelines for grounding objects (such as fences or storage sheds) within rights-of-way and prohibiting school buses from loading and unloading within rights-of-way (Banks et al. 1977).

4.3.8.2 Herbicide Use

In order to ensure the safe use of herbicides for right-of-way management, only those pesticides and herbicides that are approved by the U.S. Environmental Protection Agency, Vermont Pesticide Advisory Council, and New Hampshire Pesticides Control Board will be used. In addition, all federal and state requirements for application of herbicides will be followed. Herbicide applications will be made by certified personnel according to label instructions.

Herbicide drift should be minized by use of thickeners, low-volatile formulations, equipment that produces droplets greater than than 200-μm mass-median diameter, or barriers to inhibit drift (U.S. For. Serv. 1978). Equipment in good condition that minimizes dripping should be used; and used containers and equipment rinse waters should be disposed in a safe manner in an approved disposal site. No wind drift should be allowed into residential areas, cropland, pastureland, or areas of rare plants.

In order to protect water supplies, no herbicide applications will be made within 15 m (50 ft) of open water, water supplies, or homes. This distance should double when making foliar spray applications or when applying to ground with more than a 30% slope (U.S. For. Serv. 1978). Herbicides will not be applied during rain or when rain is likely. Surface water and groundwater should be routinely monitored for pesticide residues, and the public should be notified during times of herbicide application. State-approved vegetation management plans should be prepared and followed, including a plan for remedial action in case of accidental spills as outlined by Dunsmore (1982).

No herbicide applications should take place at a distance less than 15 m (50 ft) from active cropland or pastureland; this distance should be doubled on slopes in excess of 30% (U.S. For. Serv. 1978). A buffer area of the same width should be utilized when applying herbicides near stands of rare plants and near wetlands.

The amount of herbicide application should be reduced by resorting to mechanical means as much as possible and by scheduling applications at sufficient intervals to avoid long-term accumulation of herbicides and residues in soils and biota.

4.3.9 Radio and Television Interference

In the event that radio interference is induced due to operation of the proposed transmission line, the typical mitigative measure will be to improve the effectiveness of the receiving antenna, either by use of a directional antenna or displacement of the antenna to a more remote location. Television interference due to the physical presence of the transmission facilities can also be remedied by suitable design and/or location of the antenna. Television interference associated with direct-current transmission--such as sparking on insulators, current discharge on metal fittings, and charge accumulation on the antenna resulting from ion current--can be mitigated by local remedial methods (ER, Vol. 3--p. 109).

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5. SIGNIFICANT ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED IF PROJECT IS IMPLEMENTED

5.1 AIR QUALITY

No serious air quality impacts are anticipated if the project is implemented.

5.2 LAND USE

Land use within the designated transmission line right-of-way and terminal site will be limited during the lifetime of the line to those activities that are conducive to the continued operation and maintenance of the line.

There will be an unavoidable visual impact as the line extends into the United States from Canada. Eastbound traffic on State Route 114 will notice the transmission line for 1.6 to 4.8 km (1 to 3 mi) as the line descends from the edge of Averill Mountain towards the highway. A visual impact will also occur where the line extends through the Potash Mountain Range area and can be viewed from Wenlock Crossing and other vantage points along State Route 105. On the road coming from Gallup to Granby, eastbound traffic will sight the transmission line corridor where it descends from the hills south of Granby to Rogers Brook and Suitor Brook. Finally, views of the line by local residents, recreationists, and motorists around the Moore Reservoir, Interstate 93, area will be affected.

5.3 GEOLOGY AND HYDROLOGY

Despite the use of mitigative measures to control erosion, temporary increases in the rates of soil erosion and stream siltation will be unavoidable during transmission line construction. Only in first-order (and possibly second-order) streams will these negative impacts be potentially significant. Over the life of the line, however, access roads may contribute significant quantities of eroded soils to nearby streams. The impacts of such sediments on stream biota are addressed in Section 4.3.

Small amounts of herbicides may be washed into surface streams and migrate through the permeable surface soils to unconfined near-surface groundwater. The significance of this migration will depend upon the chemical nature of the herbicide that is ultimately chosen, the local hydrological conditions, and the proximity of domestic wells to the sprayed corridor. The impact of the herbicides on nearby populations and biota are discussed in Sections 4.1.3.1, 4.1.3.2, and 4.1.8.3.

The agricultural soils surrounding the line will not be significantly impacted, except where land is occupied for support structures and access roads.

5.4 FORESTRY AND NATURAL AREAS

About 480 ha (1200 acres) of forestland in the Preferred Corridor will be converted to a shrubland type of vegetation for at least the operational lifetime of the line. About 9.3 ha (23 acres) of the proposed converter terminal site will likely be withdrawn from the forest resource base.

The proposed transmission line will extend through remote terrain for a total distance of 45 km (28 mi), thereby detracting from the natural features of three separate areas that have been suggested as potential wilderness environments.

5.5 ECOLOGY

5.5.1 Terrestrial

Up to 480 ha (1200 acres) of forest habitat along the Preferred Corridor could be lost, but it is not anticipated that this will result in serious effects upon local wildlife populations. Indeed, some species will benefit from the clearing of wooded habitat.

The presence of the approximately 90-m (300-ft) wide right-of-way along the lower 3.5 km (2.3 mi) of the corridor within Vermont could affect the overwintering success of local deer if the area is actively used as a deeryard. The presence of wooded travel lanes across the right-of-way may successfully mitigate this impact.

5.5.2 Aquatic (Including Wetlands)

Disturbances to aquatic and wetland habitats and their associated biota will be an environmental impact of the proposed interconnect and will primarily occur during construction activities. The environmental impacts expected from construction and operation of the transmission line and terminal will be primarily transitory effects on aquatic biota due to construction, provided proper mitigative measures are implemented. Impacts to regional habitats and biota will be minor.

5.6 HEALTH AND SAFETY

A conservative interpretation of the available data leads to the conclusion that electrostatic fields and air ion concentrations in the right-of-way have the potential in very infrequent circumstances of inducing minor and transient physiological and psychological alterations in persons frequenting this area. The physiological and psychological parameters that could be affected would return to normal after exposure ceased. The slight alterations have not been associated with adverse health consequences. During fair weather periods when individuals would be most likely to frequent the right-of-way, electric fields and ion concentrations would be below the threshold reported for biological effects. Likewise, persons frequenting areas outside of the right-of-way would not be affected by the indicated electric phenomena, even during the infrequent extreme occurrences noted.

6. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

6.1 GEOLOGY AND HYDROLOGY

The small areas of soils disturbed by foundation structures, access roads, and general construction activities will be permanently altered by the proposed action. Soil fertility will be decreased by these activities, and losses due to erosion will occur where access roads cross or exist near surface water systems. Sedimentation rates may be increased and may alter the surface water system characteristics, especially in first-order watersheds.

6.2 ECOLOGY

6.2.1 Terrestrial

Although wildlife habitat will be altered for the lifetime of the right-of-way, cover similar to existing habitat could be recovered after decommissioning. Recovery could occur by natural succession or by active, human revegetation. Recovery of forest habitat would take several decades.

6.2.2 Aquatic

Aquatic and wetland habitat commitments (e.g., for access roads or right-of-way clearing) would be relatively minor. In most cases, lost or modified habitat could be returned to original conditions after decommissioning.

6.3 SOCIOECONOMIC

In settled areas where residents have views of undeveloped land that would be crossed by the proposed transmission line, some reduction in the quality of life derived from these views would occur during the life of the line.

Developers of residential land through which the line would pass could lose income from loss of sales and cancellation of building plans by buyers who were attracted primarily by the scenic and undeveloped quality of the area. Sales values of land and residences along the line would decrease.

Tax income would be lost from residential property that was given easements as a result of the line's presence on the property.

Owners of tourist lodging facilities and campgrounds who would have the proposed line on their property or in their viewshed could lose income and business.

7. ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

The alternative of reducing the amount of oil used to generate electricity through the conservation of electricity by ultimate consumers is consistent with project objectives. However, conservation is most appropriately viewed as a complement to, rather than a substitute for, the proposed project.

The New England/Hydro-Quebec interconnect will save more oil and save it sooner than would conservation. This conclusion is based on the following:

- The majority of conservation programs address residential customers and gains derived from improving the thermal characteristics of housing.
- Only about 9% of New England's total electricity sales are to customers with electric space heating. (This 9% figure includes kilowatt-hours for uses other than space heating.)
- Electric-space-heated homes are generally built to higher insulation standards; therefore, the conservation potential is smaller and the options are fewer.
- Finally, much conservation of electricity has already occurred, both among electric-space-heating and nonelectric-heating customers. Growth in sales to residential customers has slowed and the average use per customer is virtually stable, reflecting the impact of lower thermostat settings, more efficient major appliances, wood stoves, and lifestyle changes.

Both the proposed interconnect and conservation methods have the potential for replacing oil-fired generation; therefore, it is unnecessary to choose between conservation and the proposed project in terms of greater benefit or harm. As long as New England is oil-dependent, both the interconnect project and conservation will save oil and dollars. Both are necessary parts of an overall strategy to reduce the dependence of New England public utilities on oil.

Electricity's share of the U.S. industrial market for both direct heat and machine-drive uses is estimated to increase in the next 20 years (Data Resour. Inc. 1981-1982). Current industrial equipment is in the process of changing to more energy-efficient machinery that reflects continuing future high prices for oil and gas prices that will be equivalent to oil (on a thermal basis) by the early 1990s. Industrial demand for electricity in New England is projected to increase at about the same or slightly higher rate than the residential and commercial sectors over the next 20 years (Data Resour. Inc. 1982). Price is also projected to increase, but more rapidly, in the industrial sector than in the other sectors over the same period. Industrial consumption of electricity, as a percent of total consumption, will remain the same over the 1982-2000 time period. U.S. consumption of electricity per unit of industrial output will remain relatively flat over the next two decades whereas use of oil and natural gas, on the same basis, will drop rapidly (Data Resour. Inc. 1981-1982). From this information, it can be inferred that although industry will buy electrical equipment of the greatest efficiency possible, the overall use of electricity by industry will increase. Thus, industry will practice conservation, but it will use more electricity where that source of energy is more efficient than oil, gas, or coal.

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APPENDIX A. DETAILED MAPS OF THE PREFERRED CORRIDOR

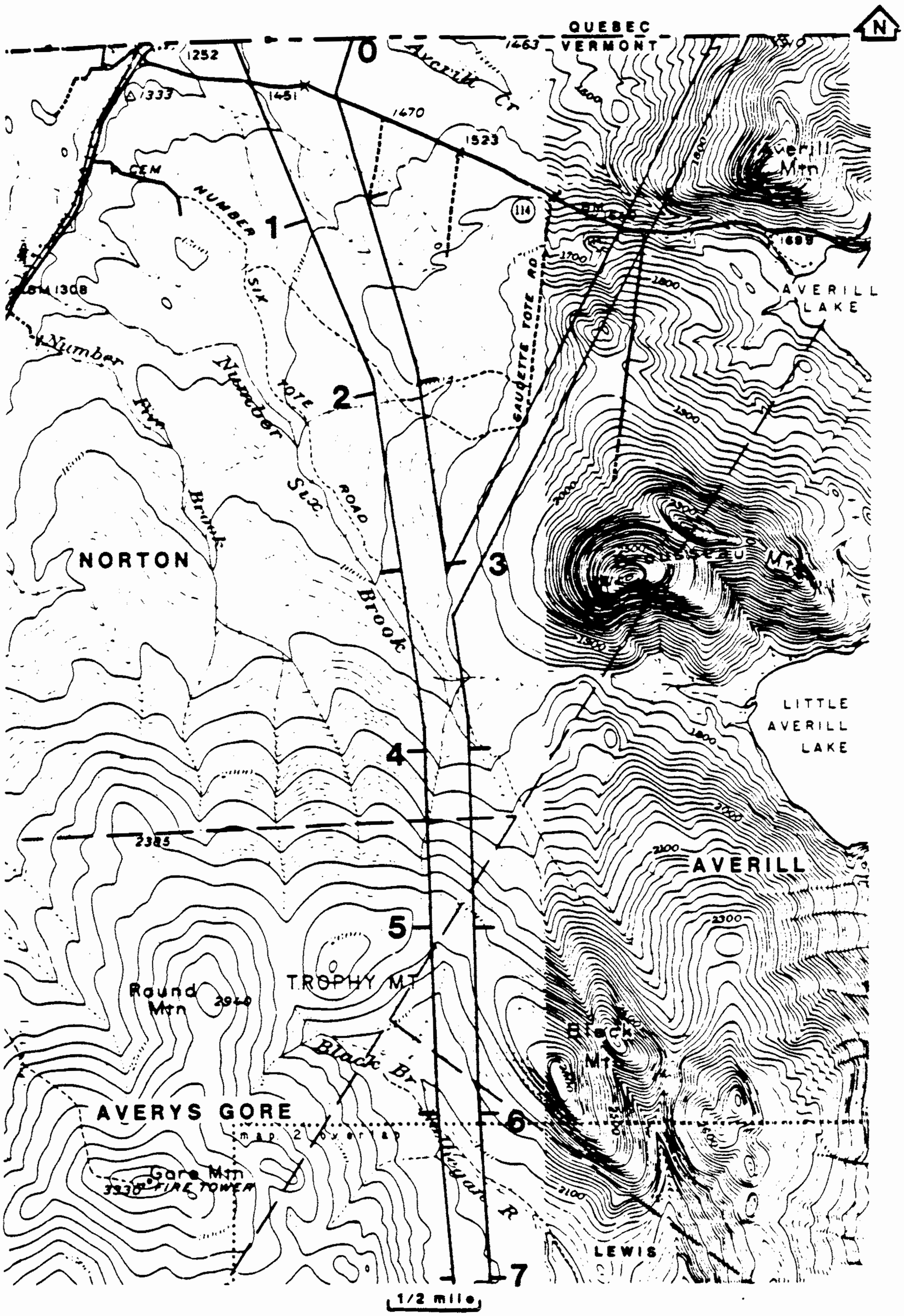

Figure A.1a. Preferred Corridor, Miles 1-7.
Source: ER (Vol. 3--Appendix B).

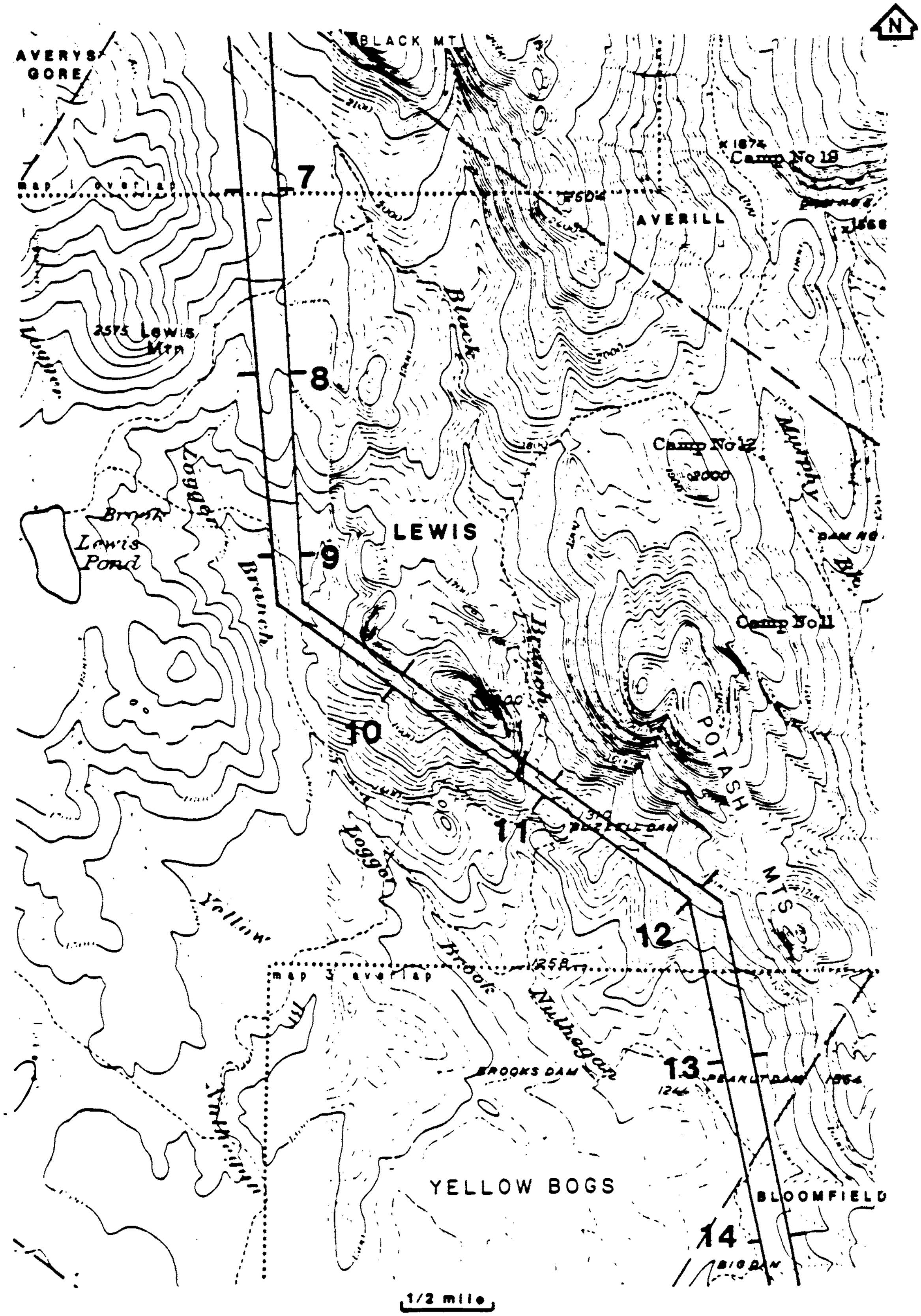

Figure A.1b. Preferred Corridor, Miles 7-14.
Source: ER (Vol. 3--Appendix B).

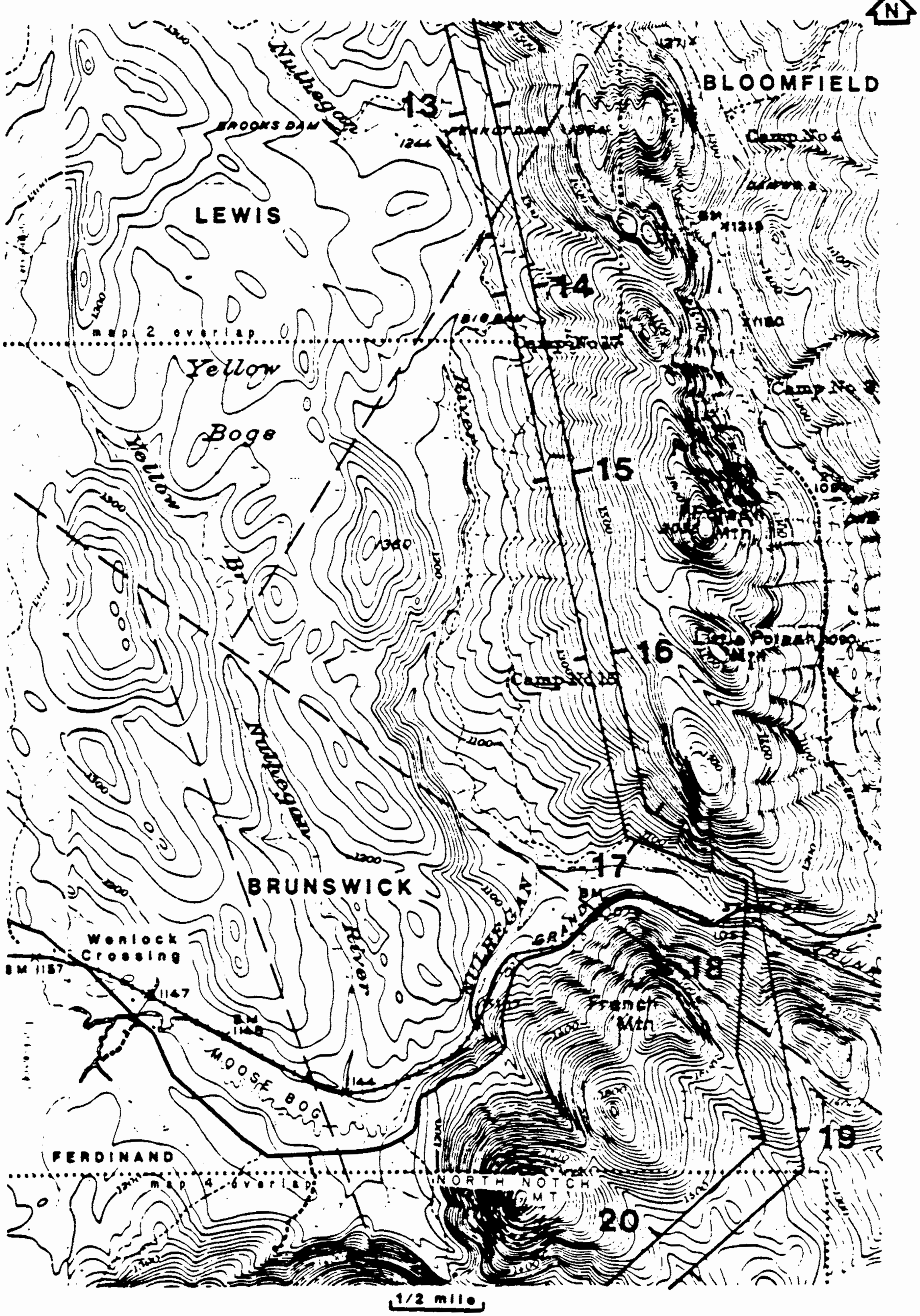

Figure A.1c. Preferred Corridor, Miles 13-20.
Source: ER (Vol. 3--Appendix B).

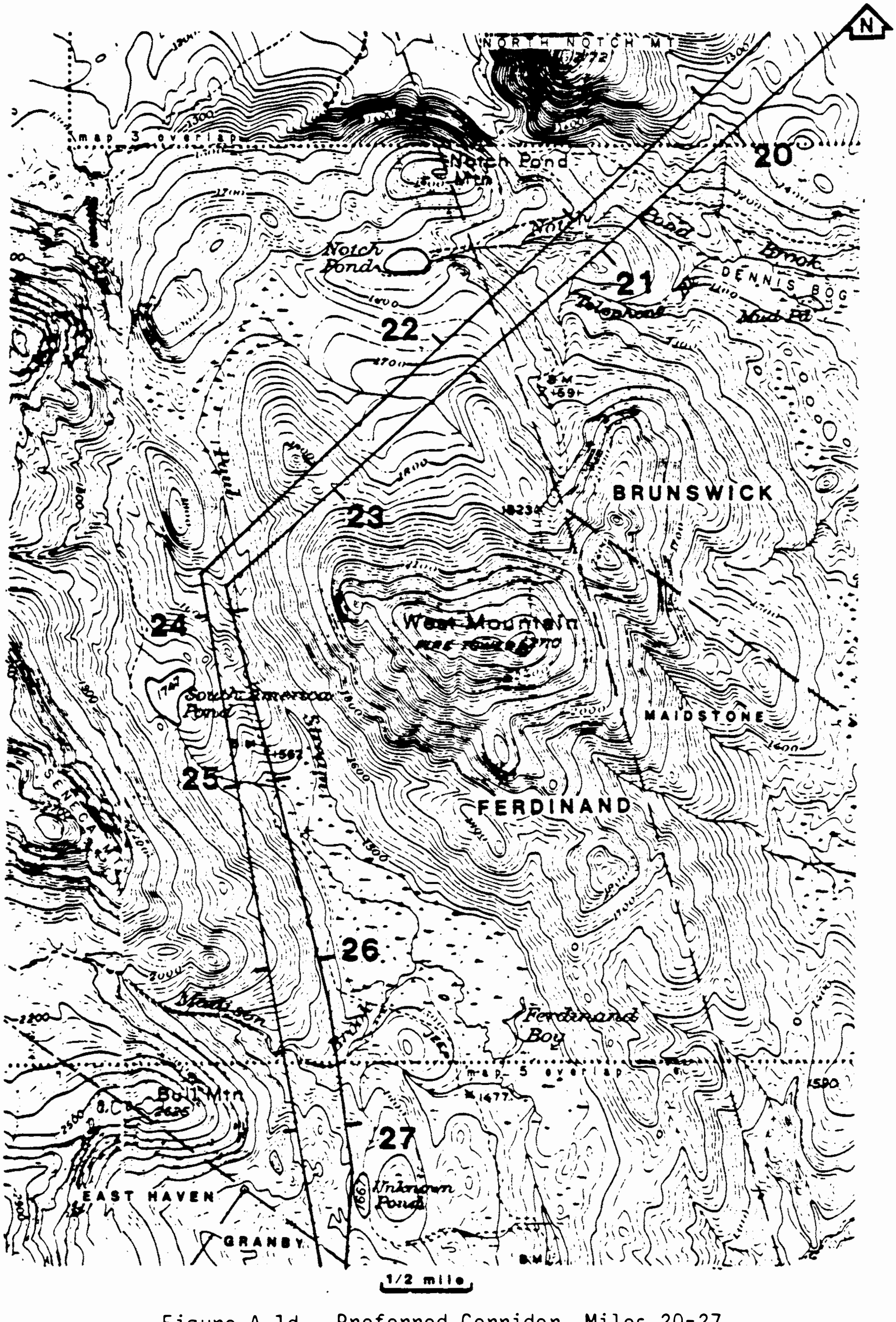

Figure A.1d. Preferred Corridor, Miles 20-27.
Source: ER (Vol. 3--Appendix B).

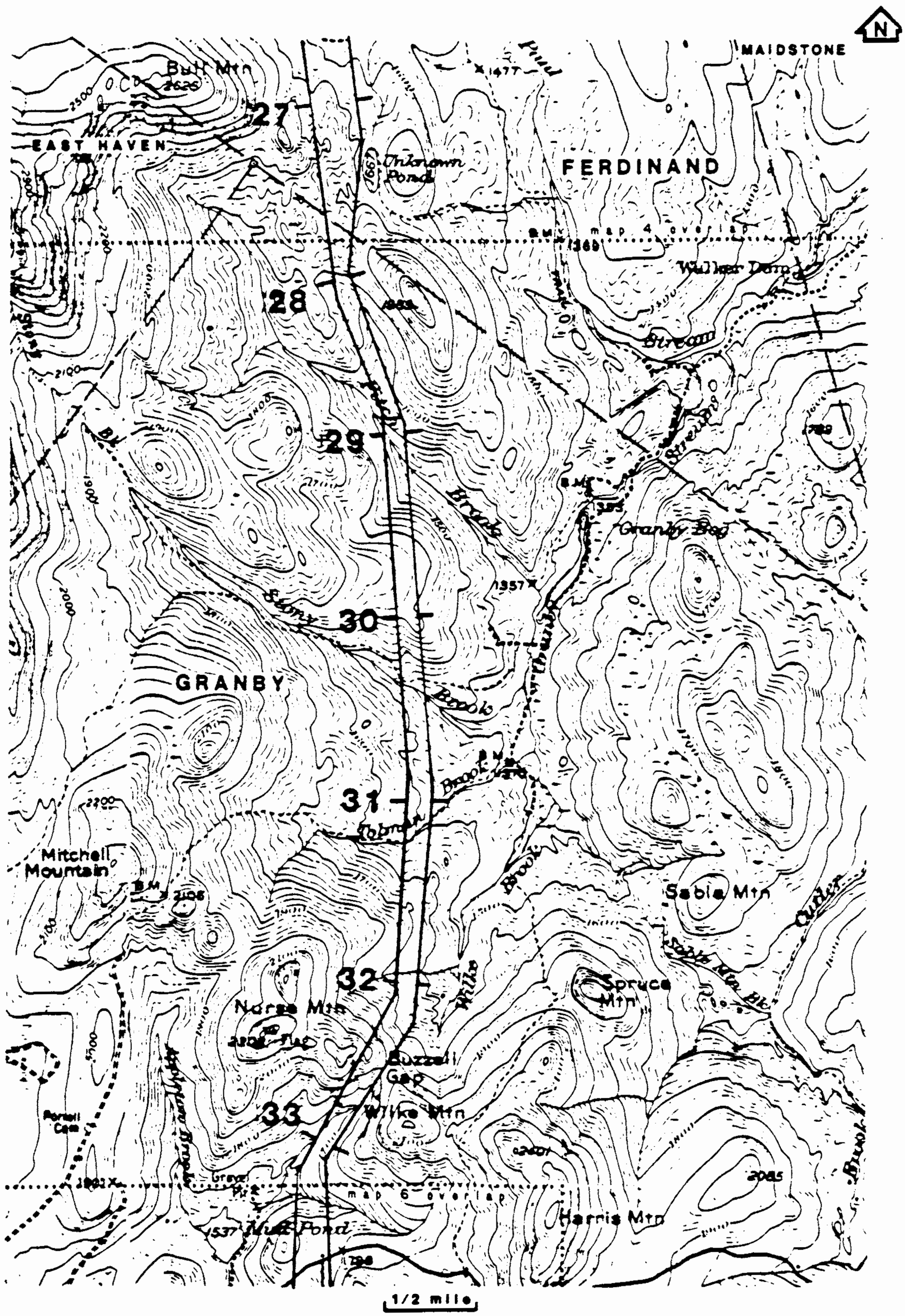

Figure A.1e. Preferred Corridor, Miles 27-33.
Source: ER (Vol. 3--Appendix B).

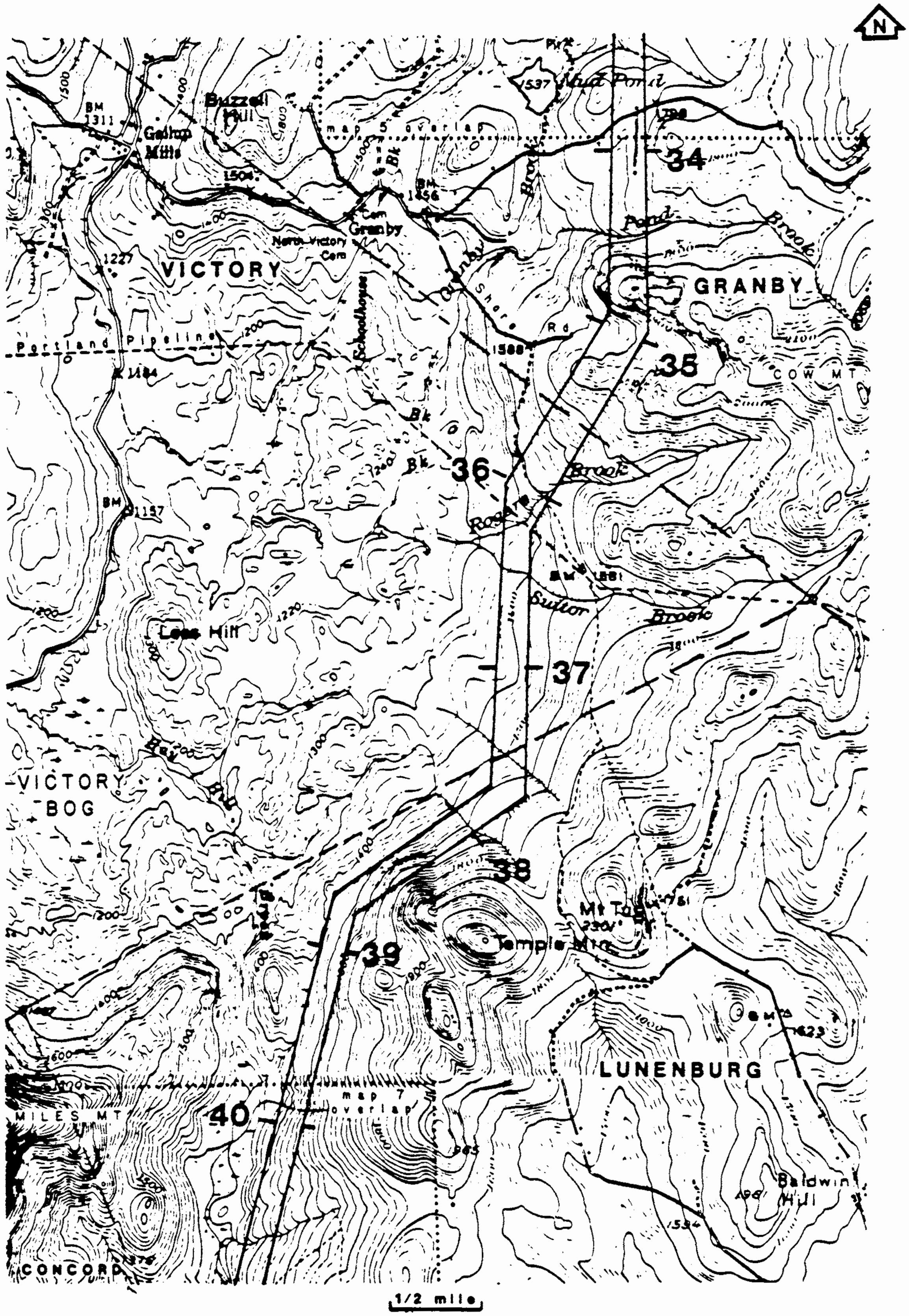

Figure A.1f. Preferred Corridor, Miles 34-40.
Source: ER (Vol. 3--Appendix B).

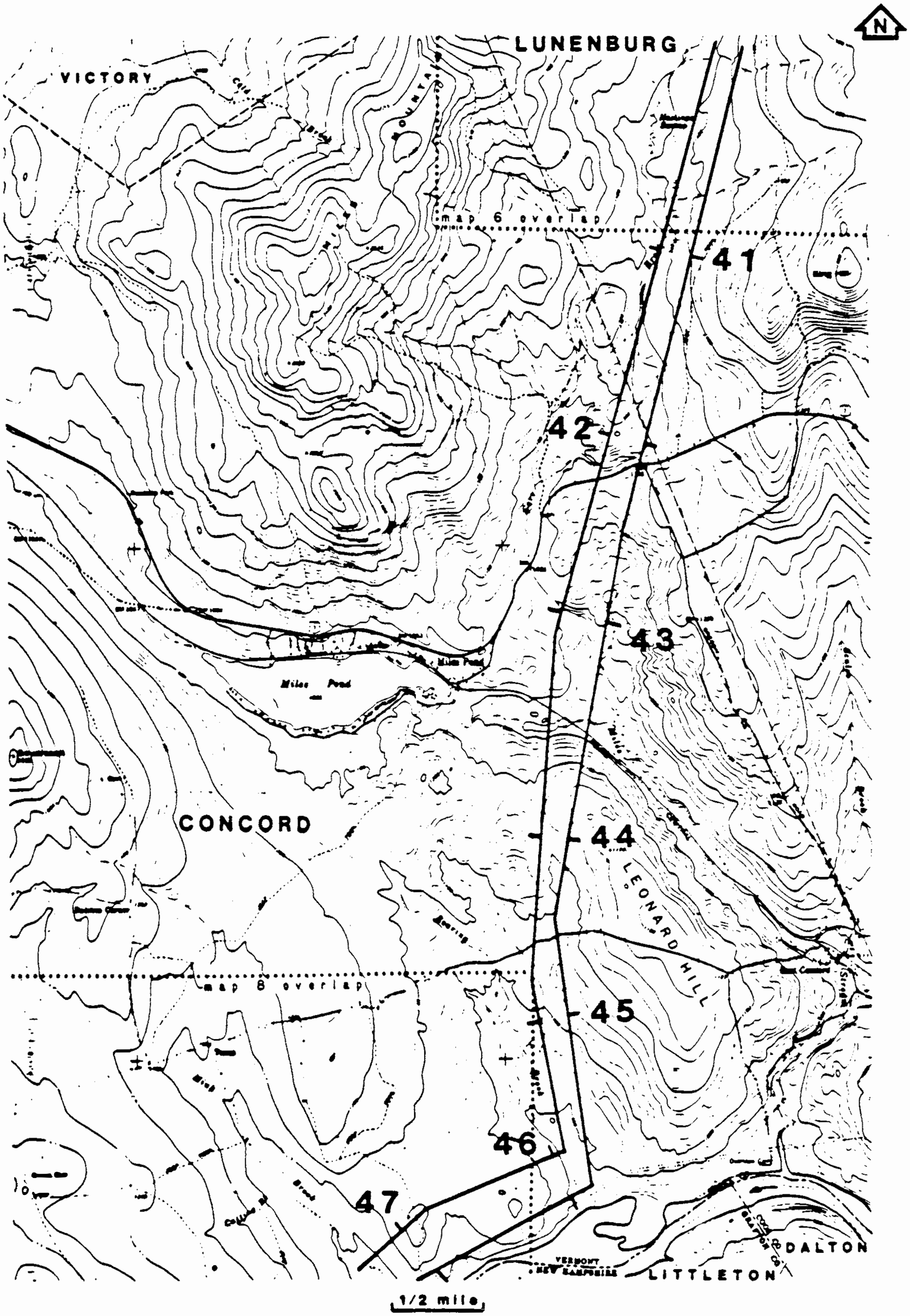

Figure A.1g. Preferred Corridor, Miles 41-47.
Source: ER (Vol. 3--Appendix B).

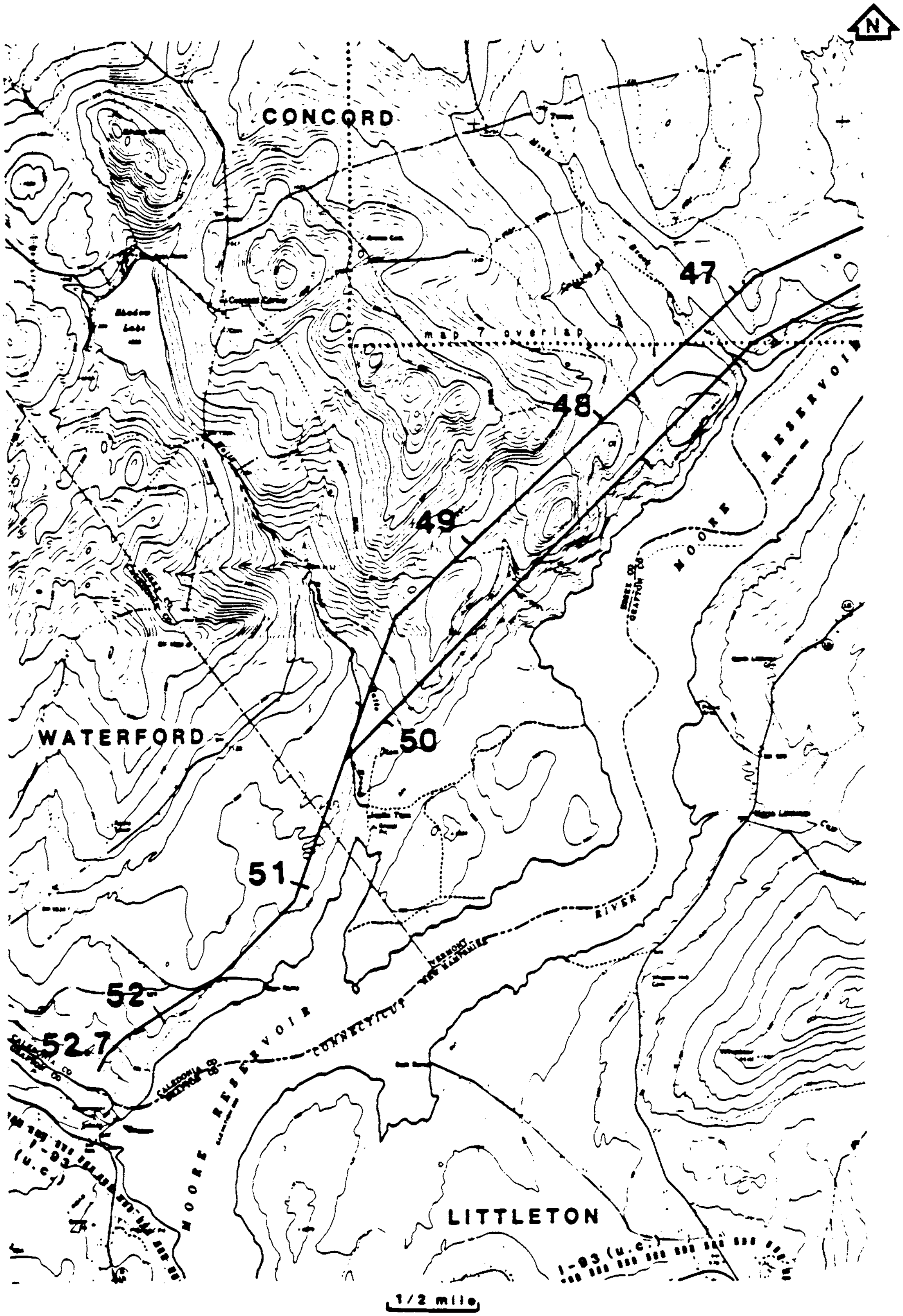

Figure A.1h. Preferred Corridor, Miles 47-53.
Source: ER (Vol. 3--Appendix B).

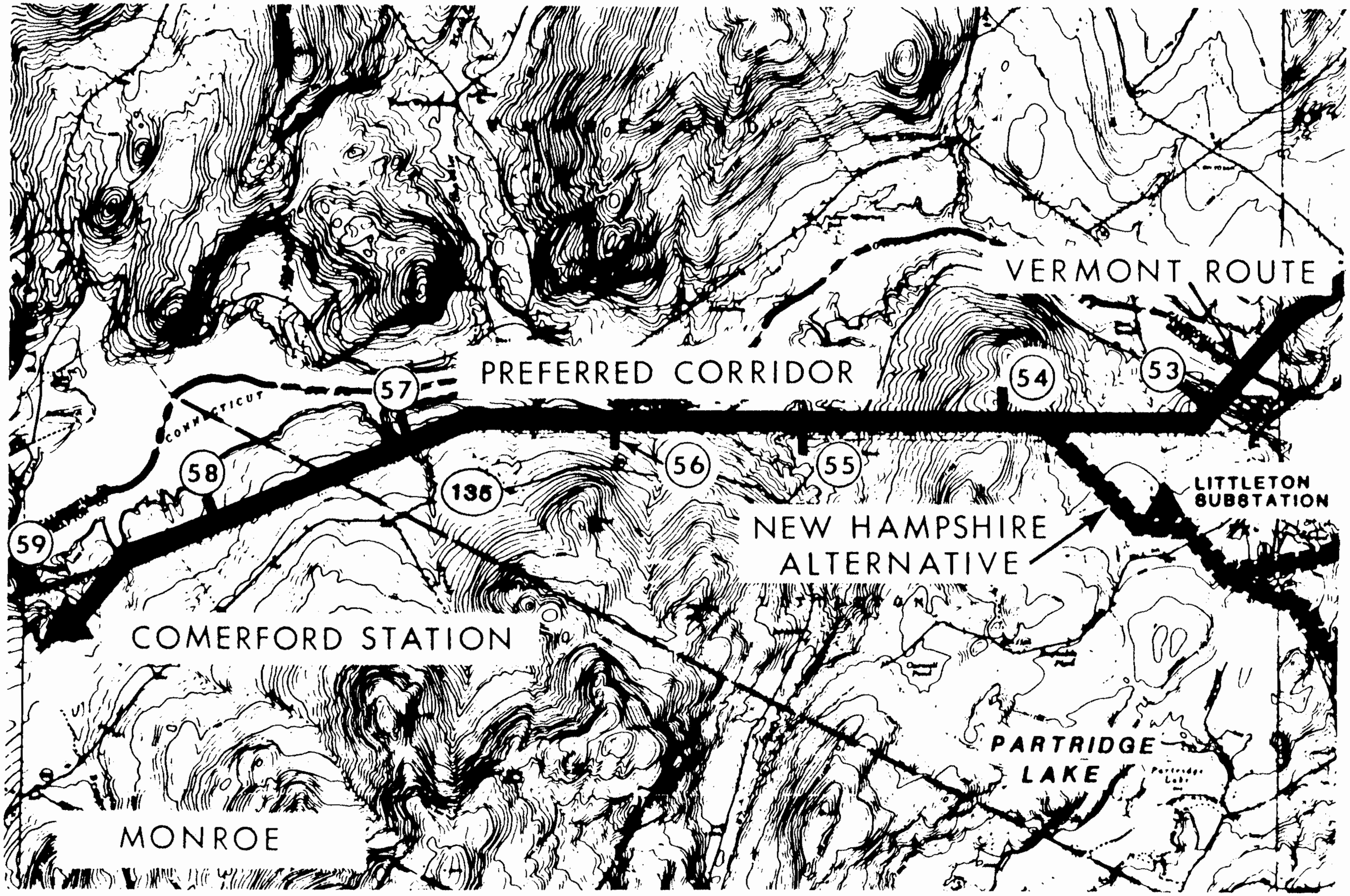

Figure A.1i. Preferred Corridor, Miles 53-59.
Source: ER (Vol. 2--Exhibit 2-63).

APPENDIX B. FLOODPLAIN/WETLAND ASSESSMENT

B.1 PROJECT PURPOSE AND DESCRIPTION

Vermont Electric Power Company, Inc., and New England Electric Transmission Corporation, in cooperation with Hydro-Quebec, propose to construct and operate the New England/Hydro-Quebec Interconnection. This system will be used for the transmission of DC electric power between Sherbrooke, Quebec, and a terminal in Monroe County, New Hampshire. The main purpose in constructing the proposed transmission facility is to allow the New England Power Pool to obtain access to hydroelectric energy located in the Province of Quebec, Canada. The converter facilities will have a loading limit of 690 MW. However, the preferred plan allows for Phase II construction in which the line can accommodate 2000 MW.

The project involves the construction of a ±450 kV high-voltage, direct-current transmission line. The Preferred Corridor will involve construction of 95 km (59.5 mi) of transmission line in Vermont and New Hampshire.

B.2 FLOODPLAIN/WETLAND EFFECTS

From the Quebec/Vermont border to the converter station in the town of Monroe, the proposed route will traverse the following watersheds:

- Eastern uplands of the Coaticook River
- Nulhegan River watershed
- Upper reaches of a portion of the Connecticut River watershed
- Minor upland brooks flowing into Paul Stream
- Extreme eastern portion of the Connecticut River watershed in the towns of Lunenburg, Concord, Waterford, Littleton, and Monroe

Portions of the route consist of forested and unforested wetlands and floodplains. Wetlands within the vicinity of the proposed route are shown in Figure B.1. Incorporated within the Vermont portion of the Preferred Corridor are 162 ha (400 acres) of wetlands and floodplains (ER, Vol. 3--Exhibit 3-7) for a total linear distance of 21.6 km (13.4 mi). The New Hampshire portion will cross 0.12 km (0.08 mi) of wetlands (ER, Vol. 2--Exhibit 2-77). However, with selective routing, most of these habitats will be avoided. Based upon land-use maps (ER, Vol. 3--Appendix B), only about 4.2 km (2.6 mi) of wetlands and floodplains will be completely traversed by the proposed corridor. Assuming a 61-m (200-ft) right-of-way, this equates to only 25.5 ha (63 acres) of wetland habitat within the right-of-way for the course of the proposed route.

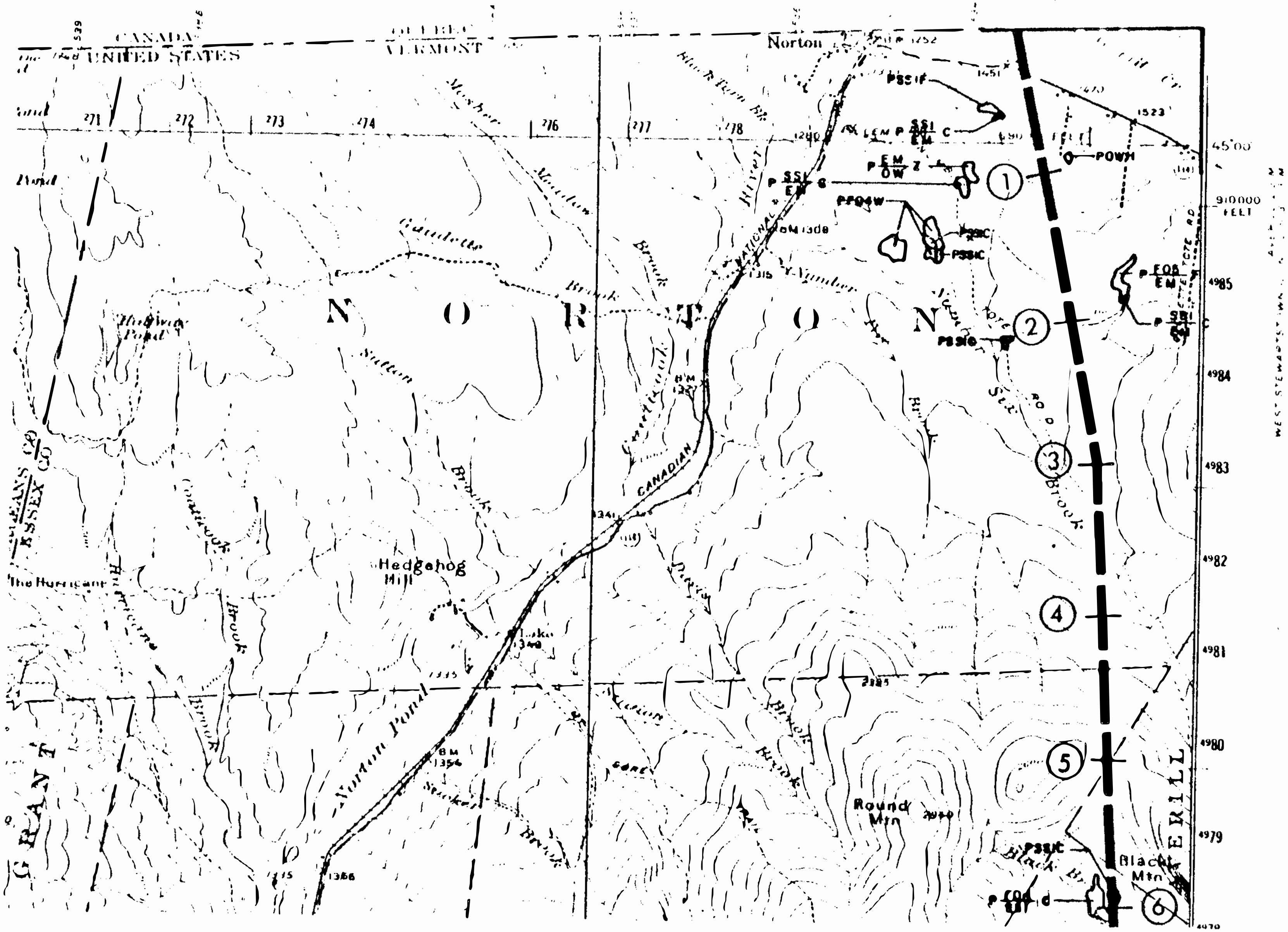

Figure B.1a. Wetlands in the Vicinity of the Preferred Corridor, Segments 1-6, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

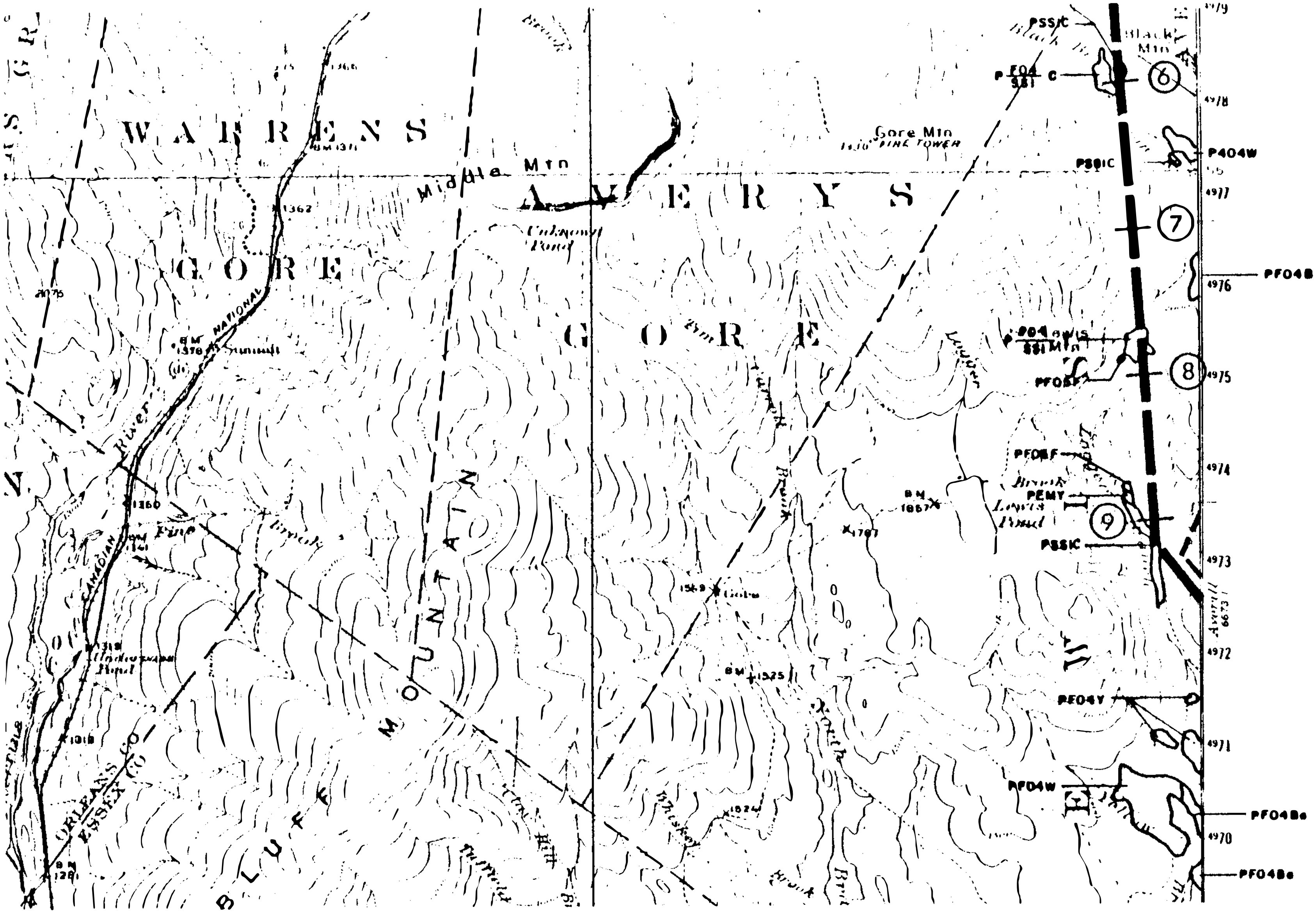

Figure B.1b. Wetlands in the Vicinity of the Preferred Corridor, Segments 6-9, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

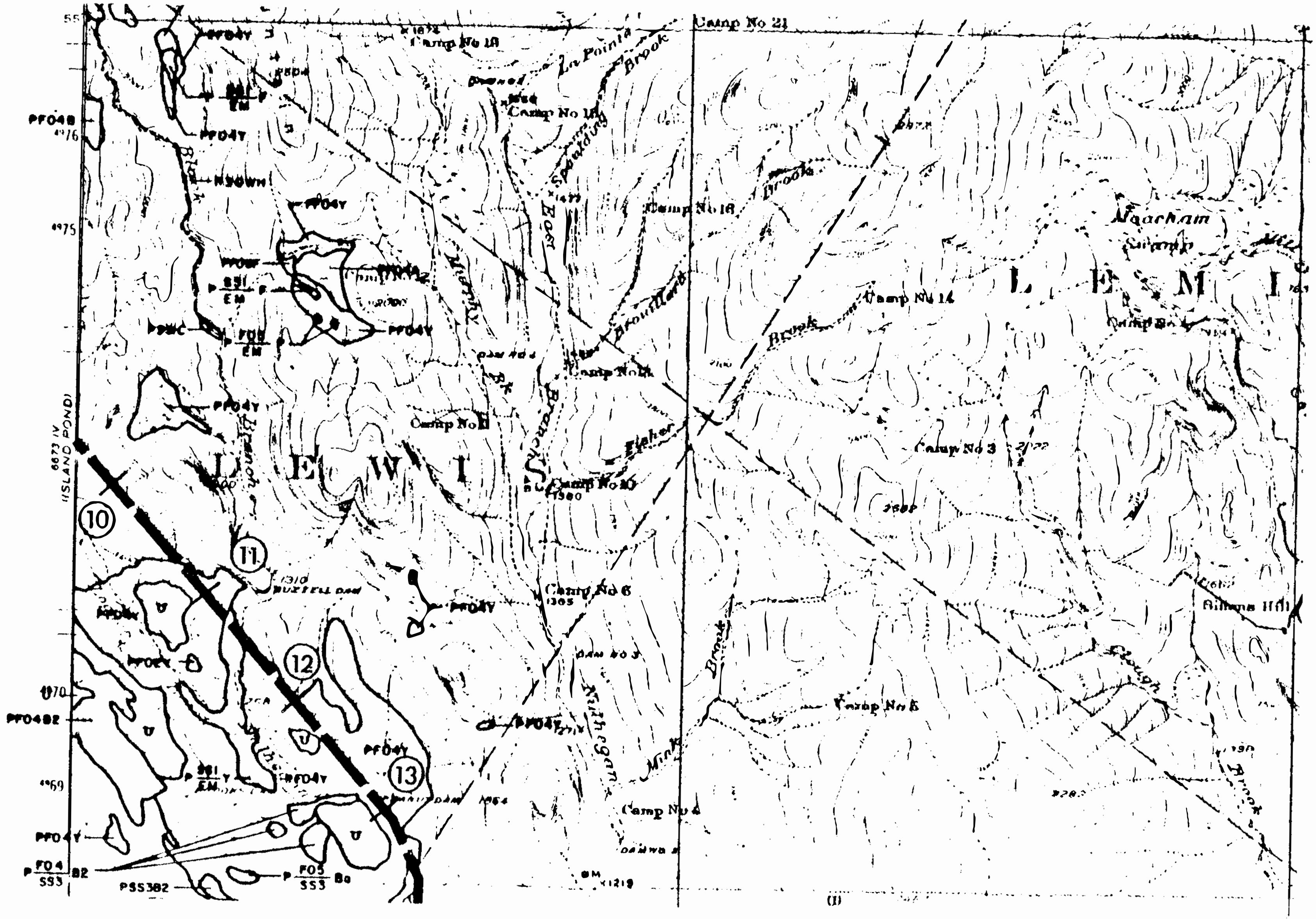

Figure B.1c. Wetlands in the Vicinity of the Preferred Corridor, Segments 10-13, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

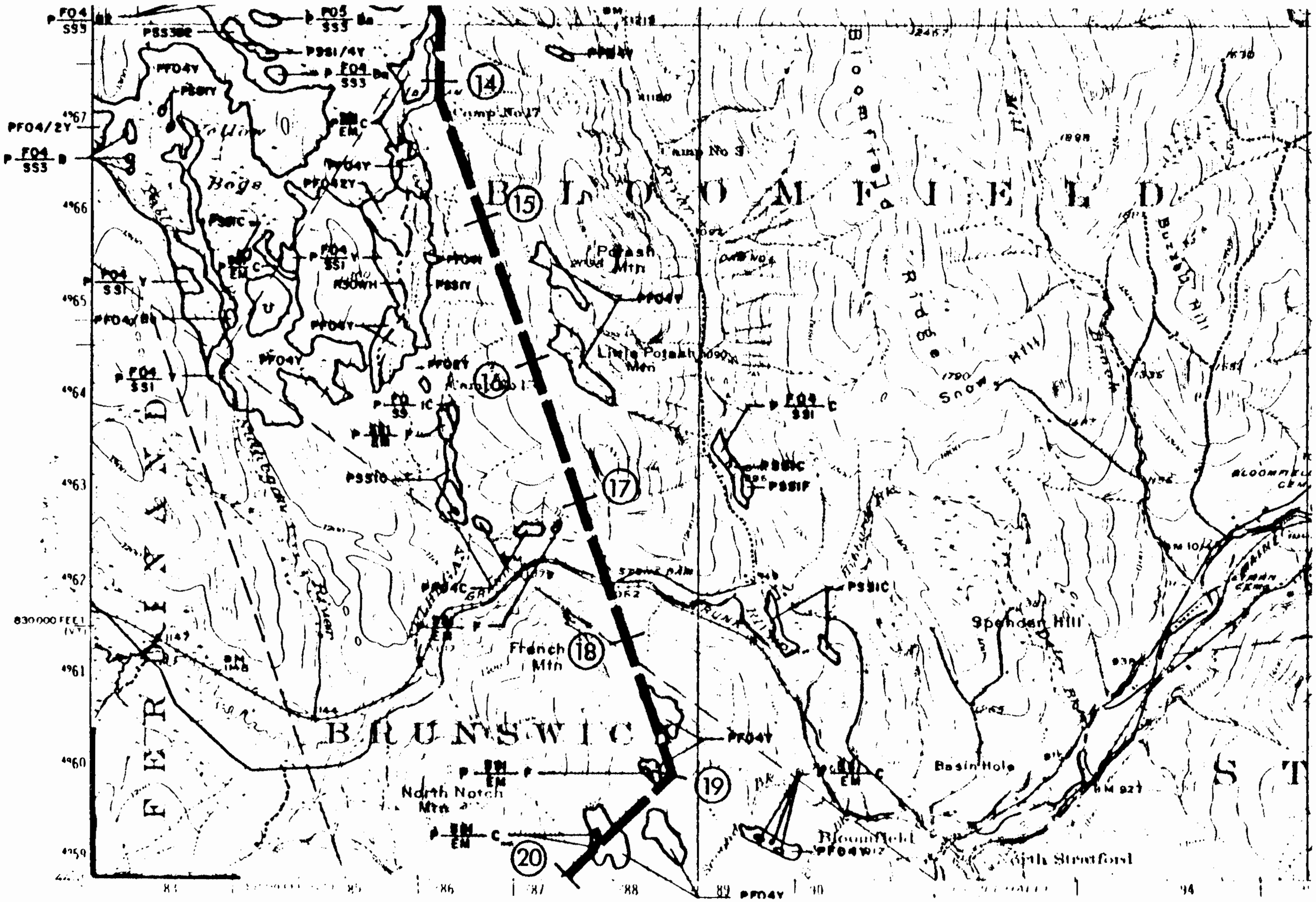

Figure B.1d. Wetlands in the Vicinity of the Preferred Corridor, Segments 14-20, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

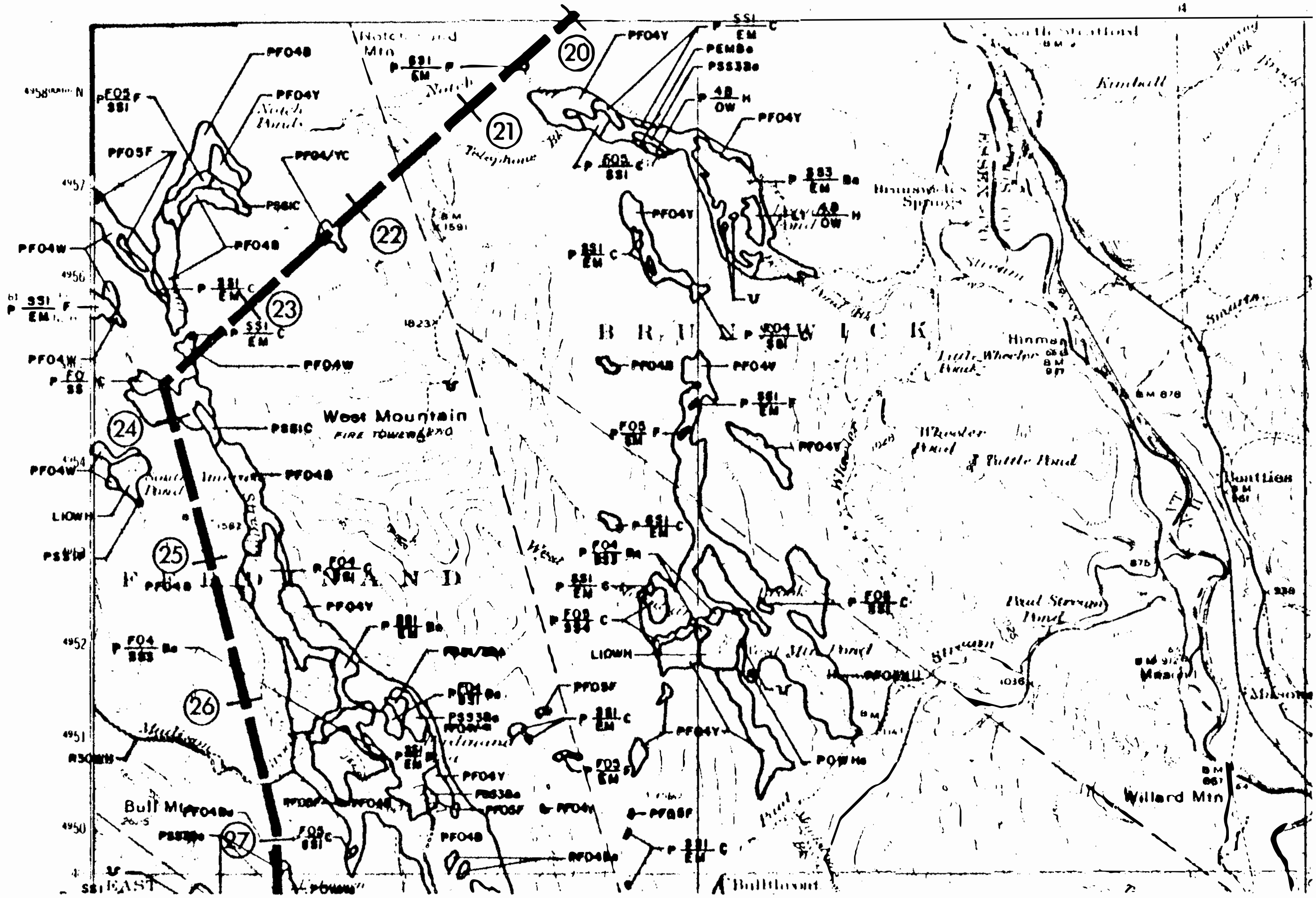

Figure B.1e. Wetlands in the Vicinity of the Preferred Corridor, Segments 20-27, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

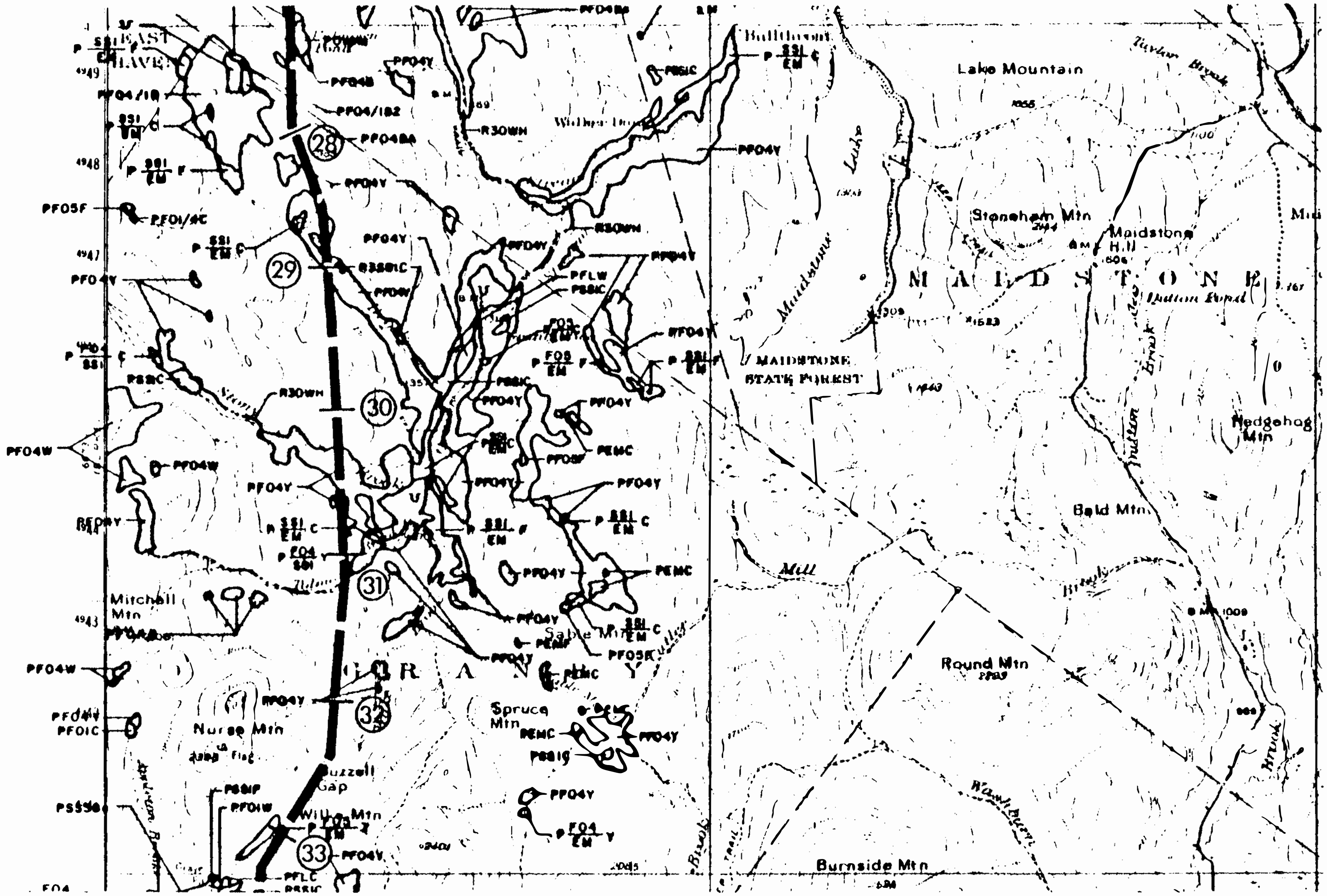

Figure B.1f. Wetlands in the Vicinity of the Preferred Corridor, Segments 28-33, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

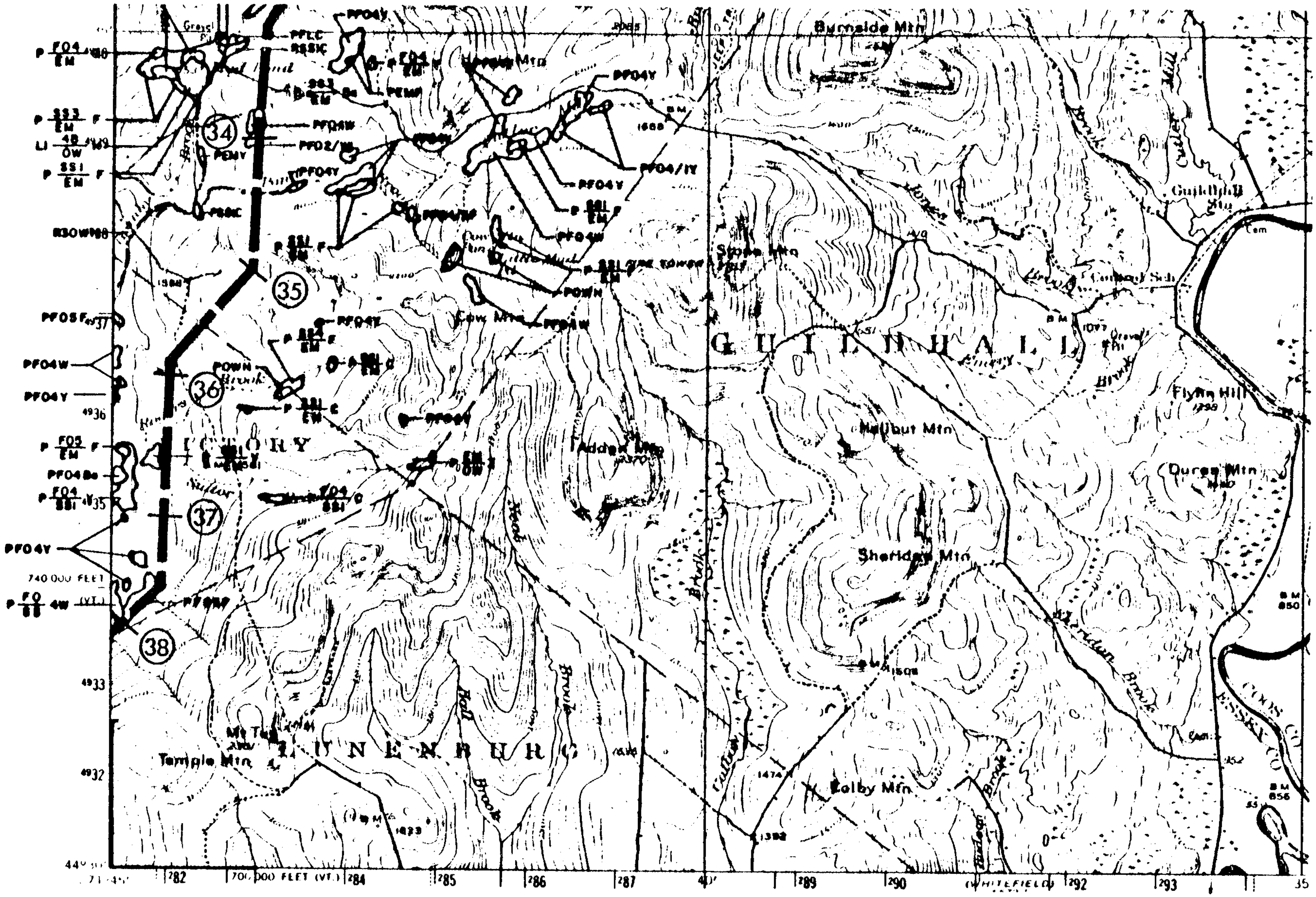

Figure B.1g. Wetlands in the Vicinity of the Preferred Corridor, Segments 34-38, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

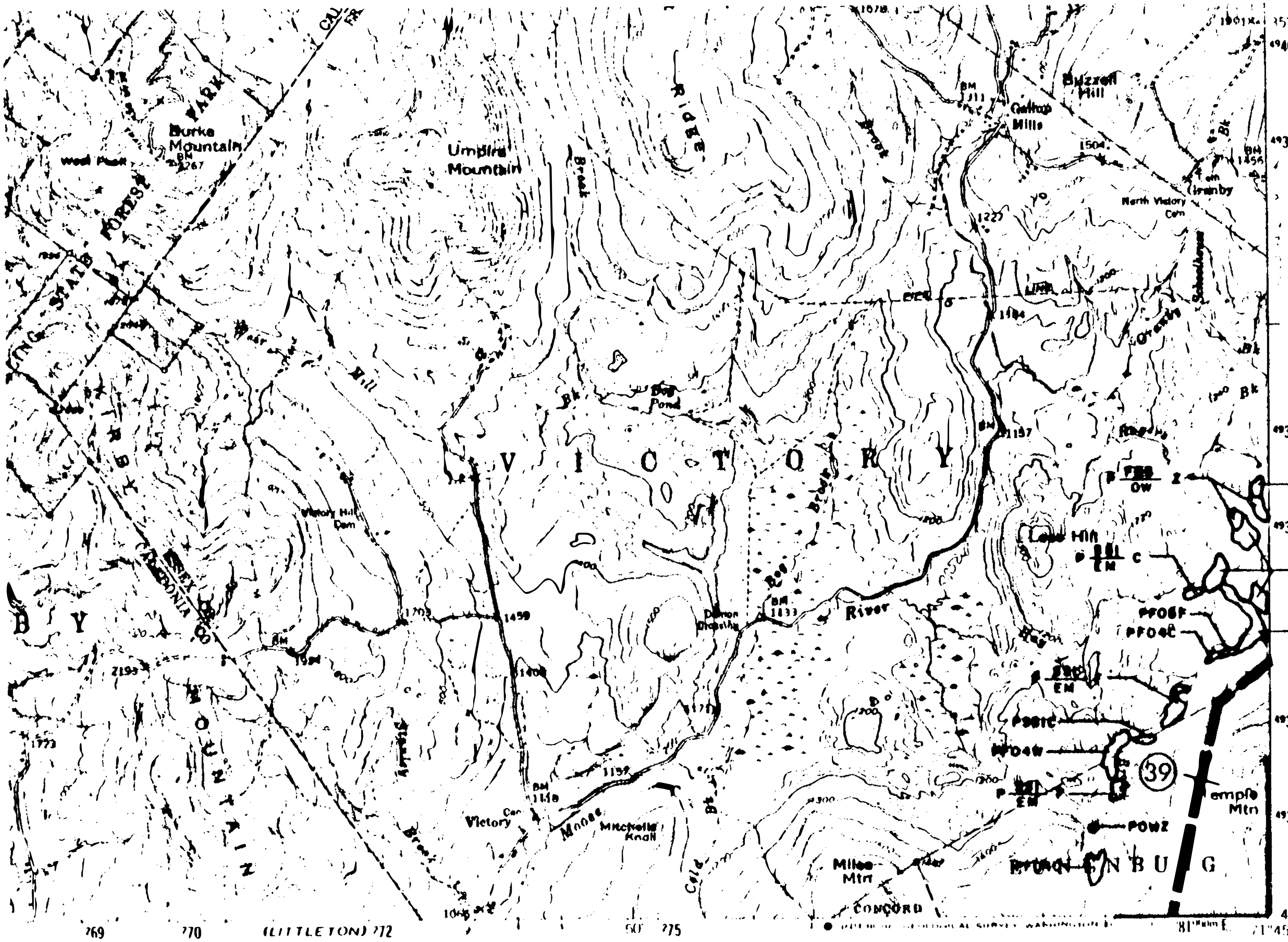

Figure B.1h. Wetlands in the Vicinity of the Preferred Corridor, Segment 39, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 15-min. U.S.G.S. topographic map.

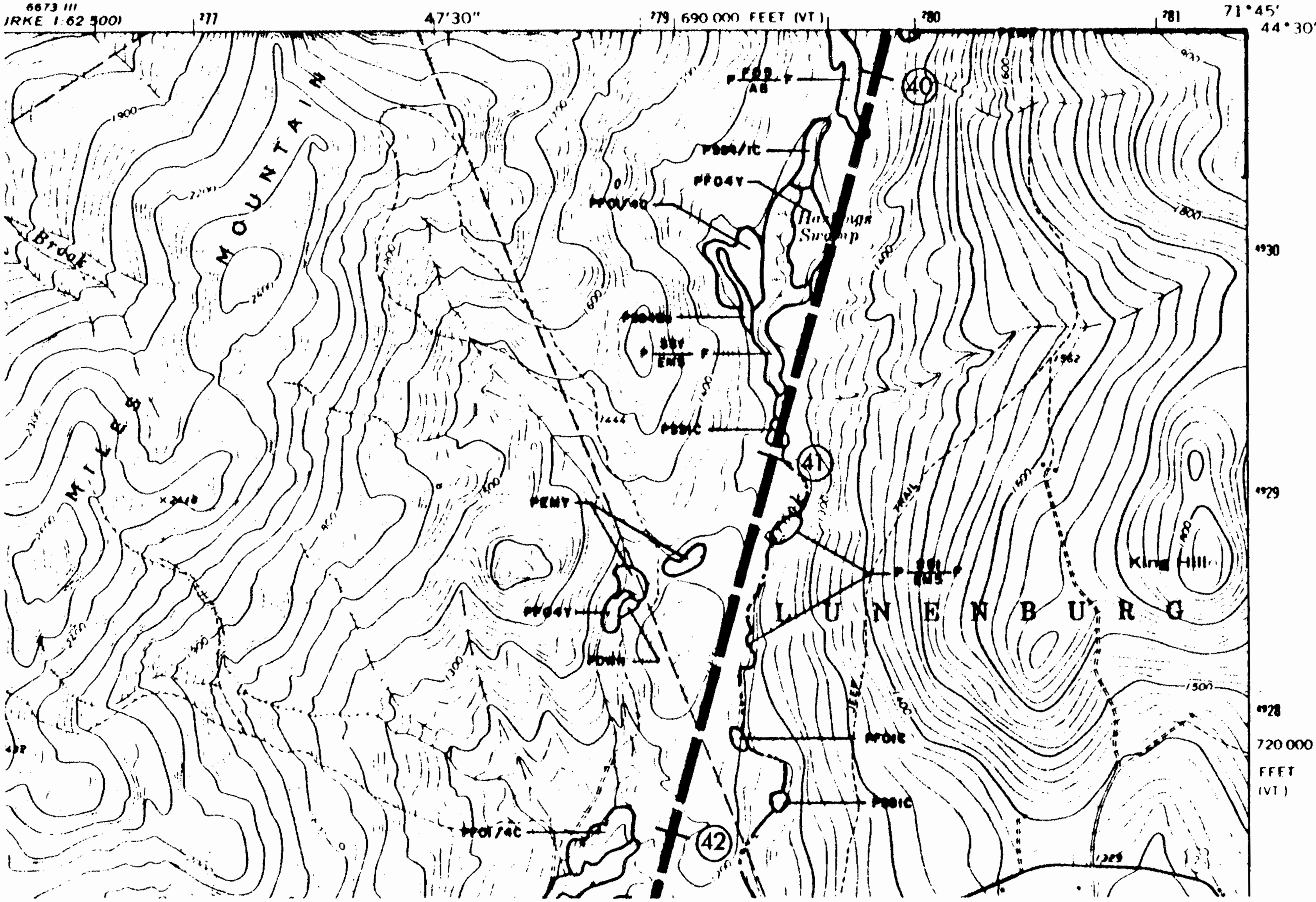

Figure B.1i. Wetlands in the Vicinity of the Preferred Corridor, Segments 40-42, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 7.5-min. U.S.G.S. topographic map.

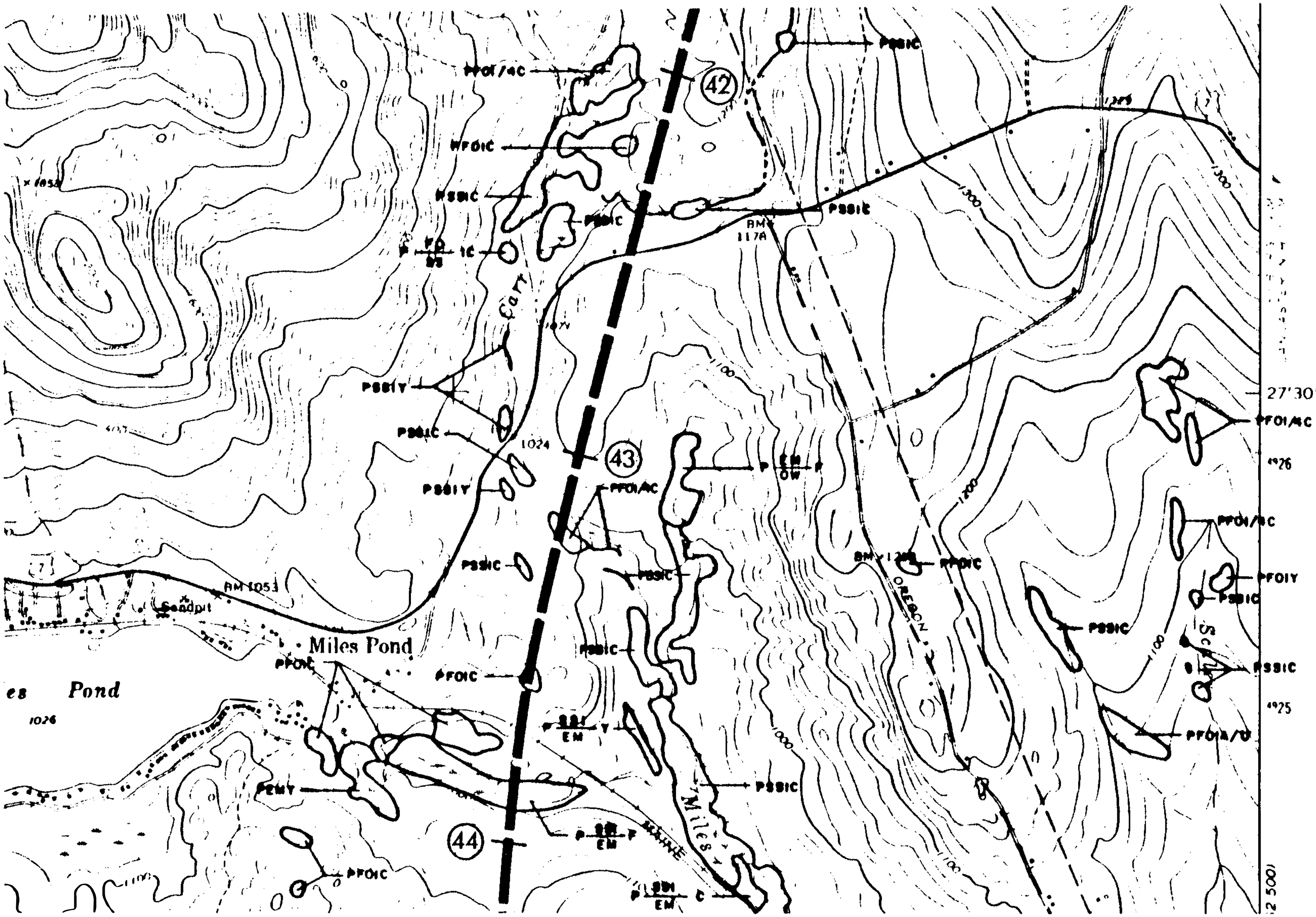

Figure B.1j. Wetlands in the Vicinity of the Preferred Corridor, Segments 42-44, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 7.5-min. U.S.G.S. topographic map.

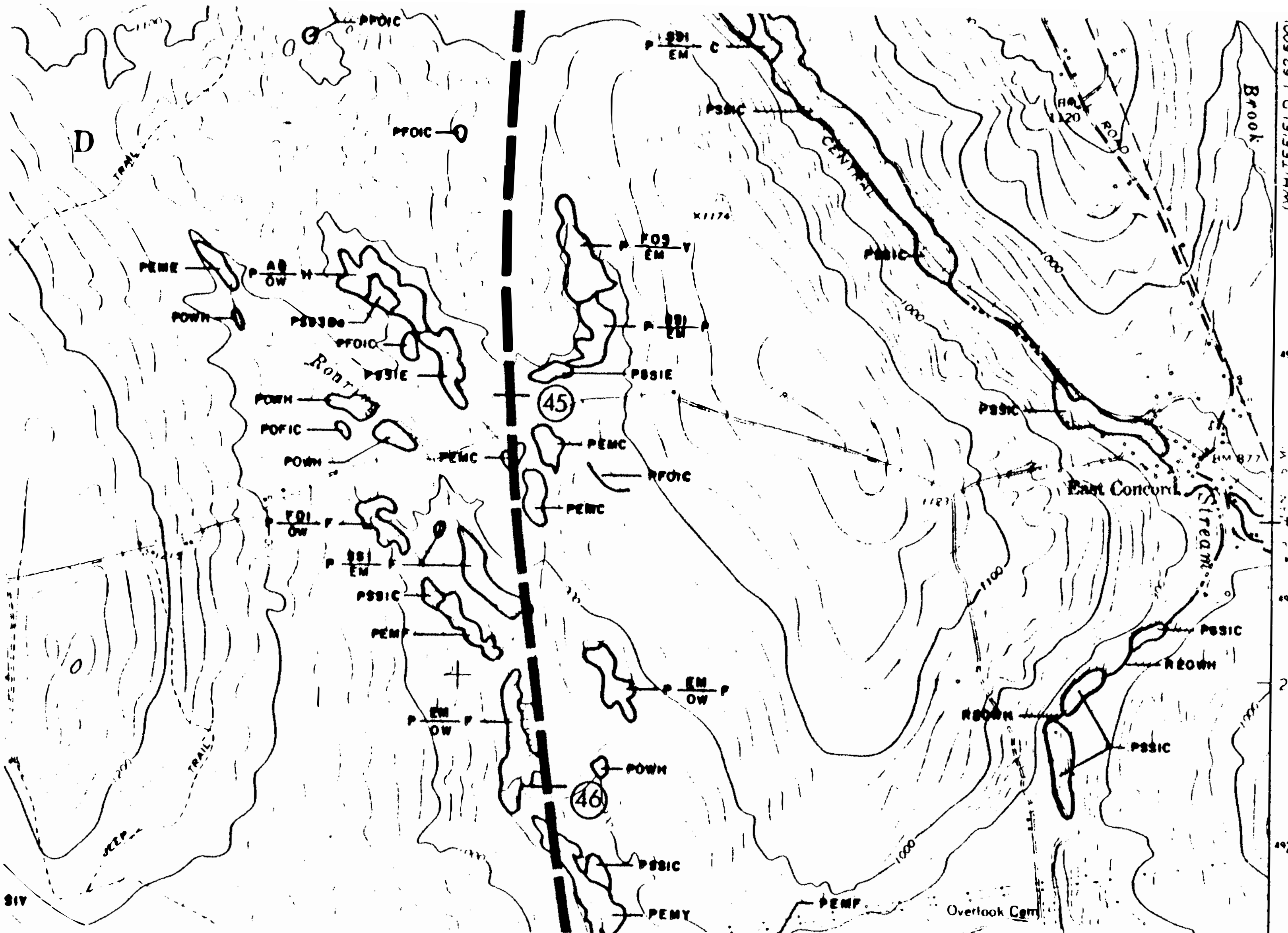

Figure B.1k. Wetlands in the Vicinity of the Preferred Corridor, Segments 45-46, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 7.5-min. U.S.G.S. topographic map.

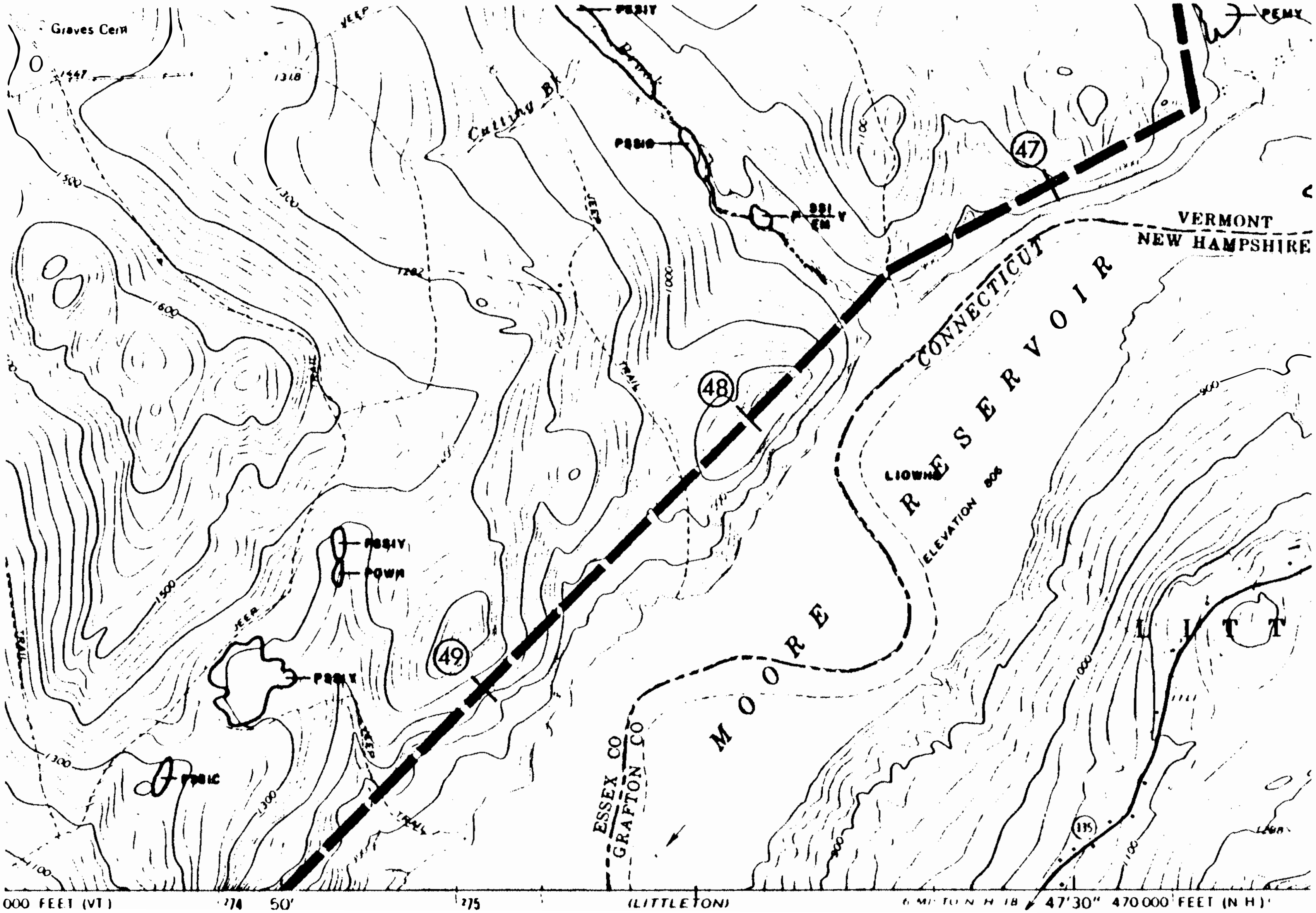

Figure B.11. Wetlands in the Vicinity of the Preferred Corridor, Segments 47-49, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 7.5-min. U.S.G.S. topographic map.

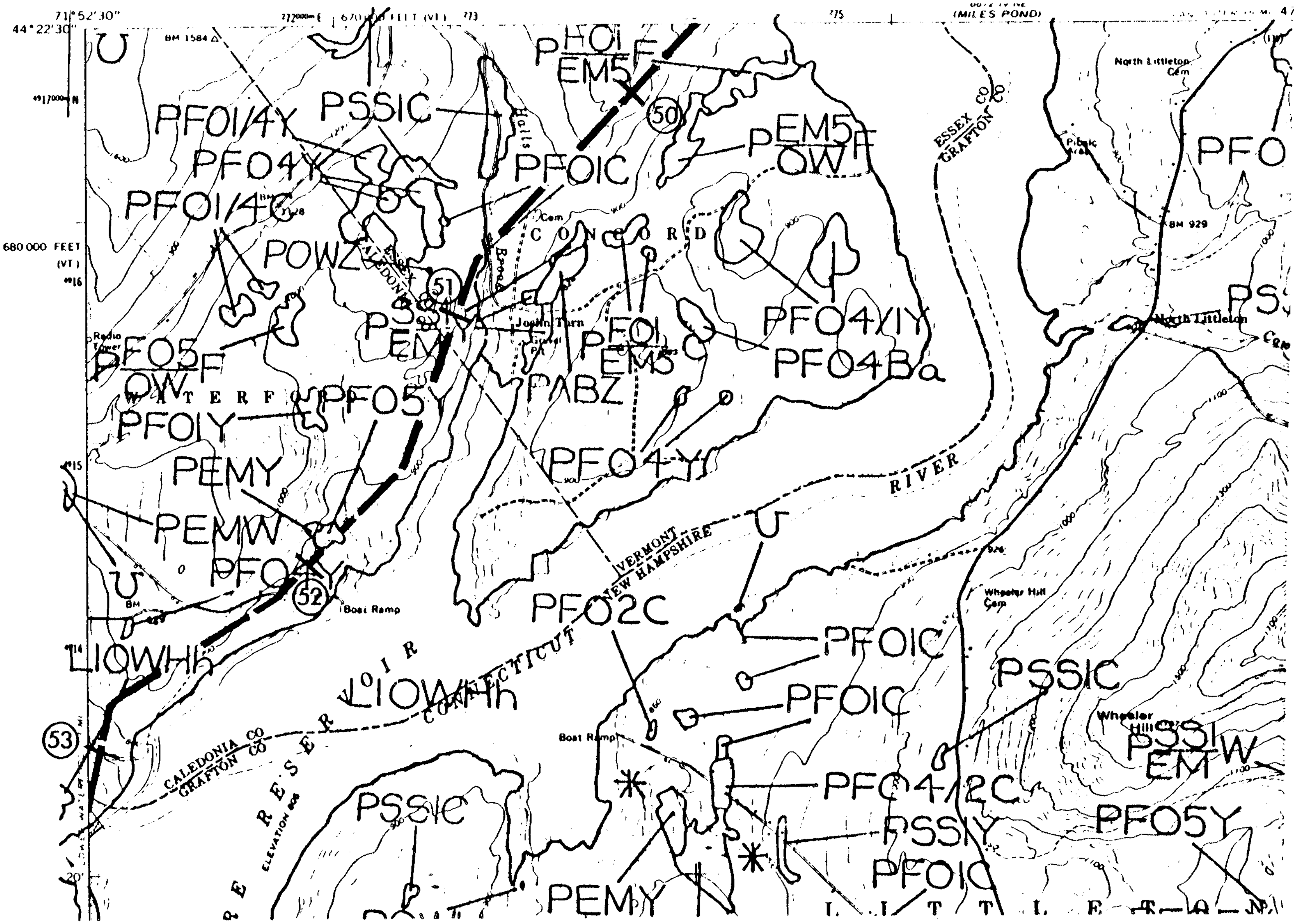

Figure B.1m. Wetlands in the Vicinity of the Preferred Corridor, Segments 50-53, as Identified in the National Wetlands Inventory, U.S. Fish and Wildlife Service. Base map, 7.5-min. U.S.G.S. topographic map (reduced 77%).

Key to Figure B.1

1. From ER (Vol. 3--Appendix B.W). Classification is that of the Applicant based upon the U. S. Fish and Wildlife Service classification (Cowardin et al. 1979), but developed from larger-scaled aerial mappings and ground surveys by the Applicant.

2. Wetland descriptions:

Marsh-like Wetlands

PEMF - palustrine, emergent, semipermanent.
PEMZ - palustrine, emergent, intermittently exposed/permanent.
PEMY - palustrine, emergent, saturated semipermanent/all seasons.
PEMC - palustrine, emergent, seasonal.

Swamp-like Wetlands

PSSIF - palustrine, scrub/shrub, broad-leaved deciduous, semipermanent.
PSSIC - palustrine, scrub/shrub, broad-leaved deciduous, seasonal.
PSSIY - palustrine, scrub/shrub, broad-leaved deciduous, saturated semipermanent/all seasons.
PSS3Ba - palustrine, scrub/shrub, broad-leaved evergreen, saturated, acid.
PSSIE - palustrine, scrub/shrub, broad-leaved deciduous, seasonal/saturated.
PF04 - palustrine, forested, needle-leaved evergreen.
PF04C - palustrine, forested, needle-leaved evergreen, seasonal.
PF04Y - palustrine, forested, needle-leaved evergreen, saturated semipermanent/all seasons.
PF04W - palustrine, forested, needle-leaved evergreen, intermittently flooded/temporary.
PFOSY - palustrine, forested, dead, saturated semi-permanent/all seasons.
PFOSZ - palustrine, forested, dead, intermittently exposed/permanent.
PF02 - palustrine, forested, needle-leaved deciduous.
PFOSF - palustrine, forested, dead, semipermanent.
PFOIC - palustrine, forested, broad-leaved deciduous, seasonal.
PFOI - palustrine, forested, broad-leaved deciduous.

3. Wetlands designations beginning with L or R are impoundments (or lakes) or rivers, respectively.

The wetlands in the vicinity of the proposed Vermont route are dominated by emergent vegetation, scrub/shrub vegetation, or forested vegetation. Wetlands dominated by emergent vegetation (e.g., marshes and ponds) are basically wet grasslands containing plant species adapted to submerged soils (Darnell 1976). These habitats usually contain zoned gradations of plant species (proceeding from shallow to deeper water) as follows: (1) emergent plants (e.g., reeds, cattails, bullrushes, sawgrasses, sedges, and arrowheads), (2) floating leafy plants (e.g., water lilies, pond lilies, smartweeds, spatterdocks, and some pondweeds), and (3) submerged plants (e.g., waterweeds, some pondweeds, muskgrasses, milfoils, coontails, bladderworts, hornworts, and buttercups) (Darnell 1976).

Marsh and pond wetlands contain a diverse and productive fauna including a plethera of aquatic and terrestrial invertebrates, fishes, amphibians, and reptiles. These wetlands provide important nesting, brooding, feeding, migratory stopover, and overwintering habitat for waterfowl and marsh birds (Darnell 1976). They also provide habitat for many mammals such as muskrat (Ondatra zibethicus), short-tailed shrew (Blarina brevicauda), star-nosed mole (Condylura cristata), Eastern cottontail rabbit (Silvilagus transitionalis), meadow vole (Microtus pennsylvanicus), meadow jumping mouse (Zapus hudsonius), and red fox (Vulpes fulva) (Godin 1977).

The scrub/shrub and forested wetlands in the study area can be considered essentially as swamps. Scrub/shrub wetlands are areas dominated by woody vegetation less than 6-m (20-ft) tall, including: true shrubs, young trees, and trees and shrubs that are small or stunted due to environmental conditions (Cowardin et al. 1979). Dominant woody species in these habitats include alder, willow, buttonbush, red osier dogwood, spiraea, dog birch, and young trees of species such as red maple and black spruce (in the broad-leaved deciduous scrub/shrub wetlands) and labrador tea, dog rosemary, bog laurel, and leatherleaf (in the broad-leaved evergreen scrub/shrub wetlands) (Cowardin et al. 1979).

The forested wetlands are dominated by living or dead needle-leaved evergreen, needle-leaved deciduous, or broad-leaved deciduous species (Figure B.1). The dominant woody vegetation in forested wetlands is greater than or equal to 6-m (20-ft) tall. Needle-leaved evergreen wetlands are dominated by black spruce (in nutrient-poor soils) or northern white cedar (in more nutrient-rich soils). Needle-leaved deciduous wetlands are dominated by tamaracks. Broad-leaved deciduous wetlands are dominated by red maple, American elm, and ash. Forested wetlands dominated by dead trees occur due to either construction of man-made impoundments and beaver ponds or fire, pollution, and insect infestation (e.g., spruce budworm outbreaks) (Cowardin et al. 1979).

Animal life contained in scrub/shrub and forested wetlands is similar to that for marshy wetlands, but includes a more diverse bird and mammal species assemblage due to increased habitat and food resources added by understory and canopy vegetation. Waterfowl and shorebirds that are found in the marshy wetlands also frequent swampy wetlands (although potentially in fewer number), but additional species such as arboreal songbirds, birds of prey, and woodpeckers are present. Large mammals--such as white-tailed deer, black bear, and moose--occur in swampy wetlands, as well as many smaller mammals such as mice, voles, squirrels, shrews, weasels, otter, lemmings, and bats (Godin

1977). Several species of birds, for example the Canada jay (Perisoreus canadensis), boreal chickadee (Parus hudsonicus), and northern three-toed woodpecker (Picoides tridactylus) are confined to wetlands, whereas several of the forested wetlands (e.g., within the Gore-Sable-Monadnock Mountains) provide important breeding grounds for black bear (ER, Vol. 3).

Many of the 54 wetlands in the Preferred Corridor are centered within two large wetland systems: Yellow Bog near Lewis, and Victory Bog near Victory (see Figure B.1). Wetlands are also numerous along the Connecticut River Valley and major drainageways. Two small wetlands exist on or near the site of the proposed terminal in New Hampshire (ER, Vol. 1--p. 29).

The predominant floodplains crossed are those associated with the Black Branch of the Nulhegan River, the Nulhegan River, Paul Stream, Fitch Brook, Stony Brook, and the Connecticut River. All of these streams will be crossed by the proposed transmission line.

Although floodplain and wetland habitats will be avoided wherever possible, some construction activities in these areas will be necessary. The habitats can be impacted by vegetation clearing (trees), construction of access roads, use of heavy machinery, and installation of structures and facilities (ER, Vol 3--Sec. III.B.3). The potential effects resulting from these activities include: disruption of drainage patterns, erosion and siltation, habitat destruction, changes in water temperature, increased public access, wildlife displacement, water-level modification, and addition of chemicals. Swampy wetlands would be impacted more by long-term changes in water quality and water level, whereas marshy wetlands could be impacted by short-term modifications (Darnell 1976). Fluctuations in water level might also be detrimental to vegetation located at the margins of wetlands and floodplains (Boelter and Clare 1974). The impacts to wetland habitat would not be of sufficient magnitude to cause localized extinction of any species considering that the extent of impact would be small relative to that occurring in the vicinity of the Vermont/New Hampshire sites. Additionally, the habitat that might be affected is not unique for the area. Impacts to floodplain habitat would also be minimal because major stream crossings will be spanned and construction activities (e.g., tower placement) will not be conducted within close proximity to the streams.

Impacts to wetlands following construction would be minimal. Potential impacts could occur from maintenance of access roads, increased public access, and periodic maintenance required for the line or underlying right-of-way vegetation (ER, Vol 3--Sec. III.B.3).

Proper construction and maintenance procedures will be used to minimize potential impacts as well as numerous mitigative measures to further reduce the risk of significant adverse environmental consequences, including:

- Procedures and recommendations in "Guide for Controlling Soil Erosion and Water Pollution on Logging Jobs in Vermont" will be used and/or agencies such as the U.S. Fish and Wildlife Service and U.S. Soil Conservation Service will be consulted regarding plans for right-of-way preparation and construction.

- Right-of-way preparation and construction will be supervised by experienced foresters and construction supervisors.

- Road widths will be kept to the minimum required to accommodate equipment.

- Cuts will be made only where necessary to reduce road grades to acceptable levels.

- Access roads will be designed to cross streams as nearly perpendicular as possible.

- Towers will not be placed on steep, highly erodible slopes.

- Erosion- and sedimentation-control procedures will be implemented.

- Cut trees will be replaced with low-growing vegetation.

- Towers will be placed to avoid wetlands and floodplains wherever possible.

- Special equipment will be used for wetland terrain to minimize damage to vegetation and soil.

- Use of equipment and construction will be limited to seasons when the ground is frozen or entirely dry, to further minimize the potential for wetland damage.

- Existing roads and cleared areas will be used for access and for construction staging areas wherever possible.

- Construction in wetlands will be carried out so as to minimize potential changes to existing water regimes.

- Existing access will be used where available.

- In some cases, fill roads will be breached after construction to minimize changes in preconstruction water levels.

- In cases where a wetland can be spanned, construction will be limited to adjacent upland areas.

- Herbicides will not be used near stream courses and wetlands.

- The types of foundations and construction techniques used for structure installation in wetlands will be site-specific. If the wetlands have relatively shallow, firm bottoms, a clean gravel pad will be built and holes excavated with a hydraulic clamshell. Excavation will be 0.9 to 1.2 m (3 to 4 ft) in diameter and 3.7 to 4.6 m (12 to 15 ft) deep. Excavations will be backfilled with gravel, and excavated material will be disposed in a spoil area outside of the wetland. In wetlands containing several feet of unsuitable foundation material, piles will probably be used to support the poles. A pile driver will be walked to the site using swamp mats. No excavations will be necessary with this type of foundation.

- Optional means of access in place of access roads may be utilized such as swamp mats, helicopters, or all-terrain vehicles.

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APPENDIX C. FOREST RESOURCES OF THE STUDY AREA

C.1 FOREST COMPOSITION

C.1.1 Maple/Beech/Birch

The maple/beech/birch forest type is the most extensive of the major forest types occurring in Essex, Caledonia, and Grafton counties--about 50, 42 and 44%, respectively, of the total commercial timberland in the three counties. This major forest type includes the local maple/beech/birch type as well as a black cherry type of limited distribution (Kingsley 1977). The maple/beech/birch type typically includes pluralities of sugar maple (Acer saccharum), American beech (Fagus grandifolia), and/or yellow birch (Betula alleghaniensus). Minor associated species are numerous, including: red maple (Acer rubrum), eastern hemlock (Tsuga canadensis), white ash (Fraxinus americana), black cherry (Prunus serotina), northern red oak (Quercus rubra), eastern white pine (Pinus strobus), balsam fir (Abies balsamea), American elm (Ulmus americana), red and white spruce (Picea rubens, P. glauca), and eastern hop-hornbeam (Ostrya virginiana). This forest type is best developed on moist, well-drained, and relatively fertile loamy soils. Sugar maple is the most widespread of the principal species, being least sensitive to site conditions (Erye 1980). However, on the drier sites, beech becomes increasingly prominent. This type tends to attain climax status due to the shade-tolerant nature of the principal species. Stands in which the shade-intolerant black cherry is a principal species are indicative of previous logging or other disturbance.

C.1.2 Spruce/Fir

Commercial timberlands of Caledonia, Essex, and Grafton counties include substantial components of the spruce/fir forest type, about 30, 25, and 22%, respectively. The predominant species include red spruce, balsam fir, northern white cedar (Thuja occidentalis), white spruce, and black spruce (Picea mariana). These species are commonly associated in four or five distinct local forest types. Other commonly associated species of the spruce/fir type include yellow birch, eastern white pine, eastern hemlock, red maple, quaking aspen (Populus tremuloides), paper birch (Betula papyrifera), and tamarack (Larix laricina). The shrub layer of the spruce/fir type is usually poorly developed because of the dense overstory canopy.

Although most major species of the sprüce/fir type tolerate a relatively wide range of site conditions, distribution of northern white cedar is strongly correlated with the moist, slightly alkaline soils derived from limestone. The spruce/fir type occurs in both lowland and higher upland positions. The recent outbreak of spruce budworm will result in altering the character of many spruce/fir stands; however, the long-term effect is not foreseeable at present.

C.1.3 White and Red Pine

The relative extent of the white and red pine forest type within commercial timberlands of Caledonia, Essex, and Grafton counties is about 13, 12, and 14% respectively. The predominant species include eastern white pine, eastern hemlock, and red pine (Pinus resinosa). Red maple, northern red oak, quaking aspen, bigtooth aspen (Populus grandidentata), sugar maple, red spruce, yellow birch, white oak, white ash, black cherry, and balsam fir are common associates in this forest type. Shrub layers of the white and red pine forest type are frequently poorly developed, particularly where eastern hemlock is the principal component of the overstory.

The establishment of red and white pines is strongly correlated with the occurrence of wildfire or other severe disturbance, although forest plantations stocked with these species are not uncommon. Both pines are long-lived species, but white pine tends to displace the shade-intolerant red pine in the absence of disturbance. Some associated species--such as sugar maple, American beech, yellow birch, eastern hemlock, and white oak (Quercus alba)--are more shade-tolerant than white pine; thus the continued presence of white pine is dependent on periodic disturbance. Eastern hemlock is a very shade-tolerant and adaptable species, occurring on rocky acid soils, loams and silty loams of near neutral pH, as well as much and peat substrates (Erye 1980).

C.1.4 Elm/Ash/Red Maple

The proportions of commercial timberlands of Caledonia, Essex, and Grafton counties comprised of the elm/ash/red maple forest type are about 10, 7, and 9%, respectively. Predominant species include American elm, red maple, and black ash (Fraxinus nigra); commonly associated species include American beech, American basswood (Tilia americana), sugar maple, and eastern white pine (Kingsley 1977).

The American elm is, and will likely continue to be, decimated by Dutch elm disease--thus altering the composition in many stands of the forest type. All three species are moderately shade-tolerant, and therefore are not readily displaced by invader species. In instances where soil drainage is improved, the elm/ash/red/maple type tends to be displaced by shade-tolerant species of the maple/beech/birch type. The acreage of this type in New Hampshire forest increased markedly in recent time. Kingsley (1976) attributes at least part of this change in forest type to removals of the more valuable species, leaving residual stockings of red maple to colonize the logged areas.

C.1.5 Aspen/Birch

About 5% of the commercial timberland in Caledonia, Essex, and Grafton counties consists of the aspen/birch type. This type is defined as forests in which quaking aspen, bigtooth aspen, balsam poplar, paper birch, or gray birch (Betula populifolia)--singly or in combination--comprise a plurality of the stocking (Kingsley 1976, 1977). An additional associate of the aspen/birch forest type is pin cherry (Prunus pennsylvanica).

The aspen/birch type occurs on a wide range of sites, the driest sands and wettest swamps excepted. Typical stands of the type almost invariably originate from stump and root sprouts following severe disturbance such as wildfire or logging. Relatively short-lived and shade-intolerant species, aspens and birches are readily displaced by more shade-tolerant species.

C.1.6 Oak/Pine

Less than 1% of the commercial timberlands in Caledonia, Essex, and Grafton counties is comprised of the oak/pine type. This major type is defined as forests in which hardwoods (usually red or black oaks) comprise a plurality of the stocking, but in which pines comprise 25 to 30% of the stocking (Kingsley 1976, 1977).

C.1.7 Oak/Hickory

About 3.5% of the commercial timberland in Grafton County is comprised of the oak/hickory type. This major type consists of forests in which oaks comprise a plurality of the stocking; pines may comprise up to 25% of the stocking (Kingsley 1976). Species commonly associated with the predominant northern red oak include black cherry, sugar maple, red maple, American beech, white ash, and white oak.

C.1.8 Pitch Pine

The pitch pine forest type is of extremely limited distribution in Grafton County. Pitch pine (*Pinus rigida*) comprises a plurality of the stocking, and the chief associates include a variety of oaks.

C.2 FOREST UTILIZATION

About 82% of the commercial timberlands in Vermont and 94% of the commercial timberlands in New Hampshire were fully stocked or overstocked with a wide variety of tree species as of 1973; however, only 25% of these timberlands in Vermont and 46% in New Hampshire were fully stocked or overstocked with merchantable stock trees (Kingsley 1976, 1977). Much of the valuable growing space was occupied by defective trees as well as species of low or no commercial value. For the seven-year period following 1965, there was an increasing imbalance between growing stock accretion and timber removals in Vermont, attributable to a decreased rate of harvest and resulting in a large volume of woody tissue being stored as standing timber. Similarly, in New Hampshire, timber removals during the early 1970s were about half of those that occurred in 1948 when the volume of net annual forest production approximated the volume of annual timber removals (Kingsley 1976).

Projections by Kingsley (1976, 1977) indicated a trend of steadily increasing forest harvest rates following 1973. However, it appears that the anticipated increase in forest product removals following 1973 did not occur. In reporting 1982 forest market conditions in New Hampshire, Engalichev and Sloan (1982) noted that high interest rates constrained borrowing and reduced activity in most forest product markets "to the lowest level in 10 years." Demand for forest products, especially softwood products, declined substantially. Although comparable 1982 market data for Vermont are not available, it seems reasonable to expect that Vermont forest market conditions did not differ substantially from those in New Hampshire. The rate of timber removals will not appreciably increase until economic conditions become more favorable. Largescale use of wood as a substitute energy source for fossil fuels could appreciably alter the forest product markets in both Vermont and New Hampshire; however, significant conversions will likely develop at a slow rate and no significant trend is apparent at present (Forest Resour. Comm. 1980). The extent to which recent market conditions may have further contributed to the large inventory of growing stock in Vermont and New Hampshire forests is not known to be documented. However, the annual recruitment or ingrowth of growing stock is expected to exceed annual harvest volumes in the foreseeable future despite substantially increased rates of future timber removals (Kingsley 1976, 1977).

Insects and diseases are collectively a major cause of forest losses. At least five outbreaks of spruce budworm (*Choristoneura fumiferana*) have occurred in the last 200 years, a given episode usually lasting about 10 years. However, the current outbreak in the Northeast began about 1968 and "shows no signs of abating"; as of 1981, dead and dying trees, attributable to budworm defoliations, occurred on about 19,000 ha (47,000 acres) in Vermont and 9,000 ha (22,000 acres) in New Hampshire (Grimble 1982). The projected area to be defoliated in 1982 is estimated at 39,000 ha (96,000 acres) in Vermont and 17,000 ha (42,000 acres) in New Hampshire and, thus, the total impact of the infestation is not currently resolved. Gypsy moth (*Porthetria dispar*) is also a major forest pest in Vermont and New Hampshire.

In summary, the more striking attributes of Vermont and New Hampshire forest resources are that most commercial timberlands are underutilized and undermanaged. Considerable valuable growing space is occupied by rough and defective trees. Economic constraints and losses due to pest infestations are among the more significant factors affecting the management and utilization of forest resources.

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