DOE/RG-0067

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New England/Hydro-Quebec ±450 kv Transmission Line Interconnection--Phase II

DRAFT
Environmental Impact Statement

U.S. Department of Energy
Economic Regulatory Administration
Office of Fuels Programs

August 1986

DOE/EIS-0129D

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New England/Hydro-Quebec $\pm$450 kv Transmission Line Interconnection-- Phase II

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U.S. Department of Energy
Economic Regulatory Administration
Office of Fuels Programs
Washington, D.C. 20585

August 1986

DOE F 1325.8
(12-84)

United States Government **Department of Energy**

memorandum

DATE: July 16, 1986

REPLY TO
ATTN OF: EH-23

SUBJECT: Approval of the Draft Environmental Impact Statement (EIS) for the New England/Hydro-Quebec Transmission Line Interconnection Phase II

TO:

Marshall A. Staunton, RG-1
Acting Administrator
Economic Regulatory Administration

As requested, we have reviewed the subject draft EIS. During this final review, the draft has been further revised in response to comments from the Office of Environmental Guidance and the Office of General Counsel which were given to RG-22 on June 24.

Based on our review, and after consultation with the Office of General Counsel, we have determined that this draft EIS, incorporating the additional changes noted, is adequate for publication. The document is assigned number DOE/EIS 0129D.

The Office of Environmental Guidance will continue to assist your office in filing the statement with the Environmental Protection Agency and other distribution matters.

Mary L. Walker
Assistant Secretary
Environment, Safety and Health

COVER SHEET
DRAFT ENVIRONMENTAL IMPACT STATEMENT
NEW ENGLAND/HYDRO-QUEBEC TRANSMISSION LINE INTERCONNECTION-PHASE II

a) Lead Agency: U.S. Department of Energy, Economic Regulatory Administration

b) Proposed Action: Amendment of Presidential Permit PP-76 issued to Vermont Electric Power Company

c) For additional copies or further information on this statement, please contact:

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For general information on the DOE's Environmental Impact Statement process, contact:

Dr. Robert J. Stern, Director
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Washington, D.C. 20585 (202) 252-4600

d) Designation: Draft EIS (DEIS)

e) Abstract: This draft Environmental Impact Statement (EIS) was prepared by the Economic Regulatory Administration. The proposed action is the issuance of an amendment to Presidential Permit PP-76 to the Vermont Electric Transmission Company to operate the international interconnection therein authorized at power levels above those stipulated in PP-76, and to construct new transmission facilities to distribute this power. The proposed new facilities, referred to as Phase II, consist of the extension of the Phase I ±450-kV DC transmission line (predominantly along existing transmission rights-of-way) between the town of Monroe, New Hampshire (the terminus of Phase I) and the town of Groton, Massachusetts; the construction of an 1800-MW DC/AC converter terminal at the terminus of the proposed DC line; and the construction of two new 345-kV AC transmission lines along existing transmission rights-of-way and terminating at an existing substation at West Medway, Massachusetts. These new transmission lines are needed to reinforce the existing New England 345-kV AC transmission system and thereby allow the NEPOOL system to operate reliably at the higher levels of import. The principal environmental impacts of the construction and operation of the transmission facilities will be the conversion of a small amount of primarily forested land to right-of-way (shrubland/grassland vegetation) or to other project-related uses, and minor (incremental) visual impacts.

FOREWORD

This Draft Environmental Impact Statement (DEIS) is issued by the U.S. Department of Energy (DOE). It assesses the environmental impacts of issuing an amendment to Presidential Permit PP-76 which would result in the construction of certain new electric transmission facilities in New Hampshire and Massachusetts.

The DOE determined that the issuance of the proposed amendment would be a major federal action significantly affecting the quality of the human environment. Therefore, in accordance with the National Environmental Policy Act of 1969 (NEPA), as implemented by the regulations promulgated by the Council on Environmental Quality (CEQ) (40 CFR 1500-1508, November 1978) and DOE's implementing guidelines (45 CFR 20694, March 28, 1980), DOE has prepared this DEIS to provide environmental input to the decision to grant (with conditions and limitations) or deny the amendment. A Notice of Intent to prepare this DEIS was issued May 8, 1985, and a public scoping process was conducted. The public will have an opportunity to comment on this DEIS. After considering all comments, DOE will issue a Final EIS (FEIS). DOE will then issue a Record of Decision not less than 60 days following publication of the notice of availability of the FEIS.

The format of this DEIS follows the suggested format in the CEQ regulations. Section 1 documents the purpose and need for a decision. Section 2 summarizes and compares alternatives and predicted environmental impacts. Section 3 summarizes the affected environments along the proposed transmission line route and at other facilities. Section 4 provides detailed information on analyses of the environmental consequences of the various alternatives. Section 5 presents a glossary, and Section 6 presents the names and professional qualifications of the persons responsible for preparing the statement. More detailed information and analyses are provided in several appendices.

SUMMARY

The proposed action is the issuance of an amendment to Presidential Permit PP-76 to the Vermont Electric Transmission Company (VETCO) to operate the international interconnection therein authorized at power levels above those stipulated in PP-76, and to construct new transmission facilities to distribute this power. This international direct current (DC) interconnection, referred to as Phase I, is currently under construction and was authorized to permit the New England Power Pool (NEPOOL) to transmit surplus hydroelectric energy purchased from Hydro-Quebec, the provincial utility of Canada, to load centers in central New England.

The proposed new facilities, referred to as Phase II, consist of three principal elements. The first is the extension of the Phase I ±450-kV DC transmission line (predominantly along existing transmission rights-of-way) between the town of Monroe, New Hampshire (the terminus of Phase I) and the town of Groton, Massachusetts. The second element is the construction of an 1800-MW DC/AC converter terminal at the terminus of the proposed DC line, on a site adjacent to an existing 345-kV AC substation. The third element is the construction of two new 345-kV AC transmission lines along existing transmission rights-of-way and terminating at an existing substation at West Medway, Massachusetts. These new transmission lines are needed to reinforce the existing New England 345-kV AC transmission system and thereby allow the NEPOOL system to operate reliably at the higher levels of import.

To minimize impacts to the extent practicable, DOE has identified in this Draft Environmental Impact Statement numerous mitigating measures. Should PP-76 be amended, that amendment will include terms and conditions which require the Applicant to implement these mitigating measures. The Applicant has committed to these measures, and they are considered part of the proposed action.

Because of these mitigating measures, and the fact that almost all of the proposed transmission line will be constructed within established transmission line corridors, most of the environmental impacts associated with the proposed action would result from construction activities and would be transitory in nature. These impacts include: clearing and control of vegetation; loss or alteration of wildlife habitat; displacement and/or disturbance of wildlife; disturbance of aquatic resources; release of gaseous pollutants and dust; and disruption of agricultural activities. Impacts from operation and maintenance of the transmission facilities include: collision of birds with structures and electrocution of birds; visual intrusion of an additional line within the transmission corridor; and possible health and safety effects of the electromagnetic environment in close proximity to the proposed line.

A total of about 147 ha (364 acres) will be converted from present uses (mostly forested land) to project-related uses, such as widening of the right-of-way, construction of the converter terminal, and expansion of the ground

electrode site. Of this total, less than 20 ha (50 acres) would be permanently converted to project-related uses that would preclude other uses such as farming or wildlife cover.

Visual impacts of the proposed project would be minor and incremental in nature, i.e., adding to the visual intrusiveness of the existing lines or structures in the transmission corridor.

The operation of the proposed line and associated facilities would not pose any significant hazards associated with electric fields or related effects, or seriously affect other components of human health and welfare in the project region.

Operation of the interconnection would result primarily in supplying imported electrical energy that will be used to reduce oil consumption in the region. The availability of the additional electricity would a beneficial effect on the economy and should enhance continued growth and improvement in the service area.

Three principal alternative DC corridor routes and six alternative converter terminal sites were considered. The alternative routes and sites were identified on the basis of existing rights-of-way or facilities and provided an adequate basis for comparative evaluation. This evaluation found none of the corridors or terminal sites environmentally preferable to the proposed route or site.

If DOE were to deny an amendment to PP-76, the Applicant could implement an alternative action to obtain the necessary capacity or maintain the status quo (no-action). Alternatives to the proposed action that were evaluated by DOE include no action, construction and operation of new conventional or unconventional generating facilities, conservation and load management, decentralized energy sources, fuel conversion, and purchase of power from other utilities. All of these alternatives were deemed less desirable than the proposed action either because they were not deemed to be viable alternatives or they would result in greater adverse environmental impacts than would the proposed action.

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1. PURPOSE AND NEED

1.1 INTRODUCTION

In March 1983, the member utilities of the New England Power Pool (NEPOOL)* entered into a formal agreement with Hydro-Quebec to purchase 33 billion kilowatt hours (kWh) of surplus hydroelectric energy over an 11-year period beginning in 1986. To provide a means of delivering this energy, the construction of certain transmission facilities was proposed. These facilities, referred to as Phase I, included: (1) a ±450-kilovolt (kV) direct current (DC) transmission line extending from the U.S.-Canadian border near the town of Norton, Vermont, to a site adjacent to the existing Comerford generating station in the town of Monroe, New Hampshire, and (2) a converter terminal at the terminus of the DC transmission line. On April 5, 1984, the Economic Regulatory Administration (ERA) issued a Presidential permit in Docket PP-76 to the Vermont Electric Transmission Company (VETCO) authorizing the construction, connection, operation, and maintenance of these facilities. The Secretary of Energy, with concurrence by the Secretary of Defense and the Secretary of State, has the authority to grant or deny such a Presidential permit for the construction of transmission facilities which cross an international border of the United States.

The environmental consequences of the construction and operation of the Phase I facilities have been evaluated in an Environmental Impact Statement (EIS) (U.S. Department of Energy 1984). The Phase I interconnection is currently under construction. The Phase I converter terminal was designed with a capacity of 690 megawatts (MW; 1 megawatt = 1000 kilowatts) to match the capability of the New England alternating current (AC) transmission system to absorb the additional power delivered to Monroe, New Hampshire. The ±450-kV DC line was designed with the capability to transmit additional levels of power should further contracts with Hydro-Quebec be deemed desirable.

Subsequent to the issuance of Presidential Permit PP-76, the members of NEPOOL concluded that additional purchases of hydroelectric energy would be beneficial to the New England region. Accordingly, NEPOOL, on behalf of its member utilities, has signed a firm energy contract with Hydro-Quebec for the purchase of an additional 70 billion kWh of energy over a 10-year period currently scheduled to begin in 1990. For NEPOOL to accept delivery of this additional hydroelectric energy, it will be necessary for the Phase I facilities to operate at power levels above the 690-MW level previously authorized by Presidential Permit PP-76. In addition, it will be necessary to construct certain new facilities to transmit this additional hydroelectric

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*NEPOOL is an operating entity within the Northeast Power Coordinating Council, which is one of nine regional reliability councils in North America. All planning, construction, and operation of generating and transmission facilities are highly coordinated among NEPOOL members. Generating units are centrally controlled and NEPOOL members share in the economies achieved through all pool ventures. A total of 92 individual public and investor-owned utilities constitute the NEPOOL organization. Included among the 92 utilities are 5 small investor-owned utilities, 40 public or municipal utilities, and 9 large investor-owned utilities, which in turn represent 38 subsidiaries or affiliated utility companies.

energy to load centers in central New England. Consequently, on March 4, 1985, VETCO applied to ERA to amend the Presidential permit in Docket PP-76 to authorize an increase in the nominal operating level of the previously permitted facilities and the construction of certain new facilities required to implement the new energy purchase agreement with Hydro-Quebec.

The purpose of this EIS is to provide a sound environmental evaluation as input to DOE's future decision to grant or deny an amendment to PP-76 for the proposed additions to the New England Interconnection. To ensure public input to the planning and preparation of this EIS, public scoping meetings were held in June 1985 in Concord, New Hampshire, and Boston, Massachusetts. During those meetings, DOE received comments from agencies, groups, and individuals. Special attention has been given in this document to the concerns (e.g., electrical effects on cattle and pipelines in close proximity to the right-of-way) and suggestions resulting from the scoping process.

1.2 PROJECT SUMMARY AND PURPOSE

1.2.1 Phase II Facilities

The proposed new facilities, referred to as Phase II, consist of three principal elements (see Figure 1.1). The first is the extension of the ±450-kV DC transmission line (predominantly along existing transmission rights-of-way) between the town of Monroe, New Hampshire, and the town of Groton, Massachusetts, a distance of 214.4 kilometers (km) (133.2 miles [mi]). The second element is the construction of an 1800-MW DC/AC converter terminal at the terminus of the proposed DC line, on a site straddling the town line between Groton and Ayer, Massachusetts, adjacent to an existing 345-kV AC substation. The third element is the construction of two new 345-kV AC transmission lines with a combined length of 83.4 km (51.8 mi) along existing transmission rights-of-way. These new transmission lines are needed to reinforce the existing New England 345-kV AC transmission system and thereby allow the NEPOOL system to operate reliably at the higher levels of import. The Phase II facilities are described in greater detail in Section 2.

The proposed project facilities are necessary to implement the new firm energy contract between NEPOOL and Hydro-Quebec. The benefits that would accrue to the New England region as a result of the Phase II energy contract include (1) the displacement of 12 million barrels of oil per year that would otherwise be used to generate electricity; (2) a reduction in the cost of electric generation with a concomitant reduction in the fuel component of customers' electricity bills; and (3) a reduction of 900 MW in the amount of new, as yet unplanned, generating capacity required to maintain adequate levels of electric reliability in the New England region.

1.2.2 Phase II Energy Contract

The Phase II agreement that has been negotiated between NEPOOL and Hydro-Quebec provides for the guaranteed delivery by Hydro-Quebec of 7 billion kWh of energy per year for the 10-year term of the agreement beginning in 1990. For the years 1990 through 1996, this 7 billion kWh per year will be in addition to the 4 billion kWh per year expected to be delivered under the terms of the Phase I energy contract (see Volume 1, p. 29, of the Applicant's Environmental Report [hereinafter referred to as the "ER"]).

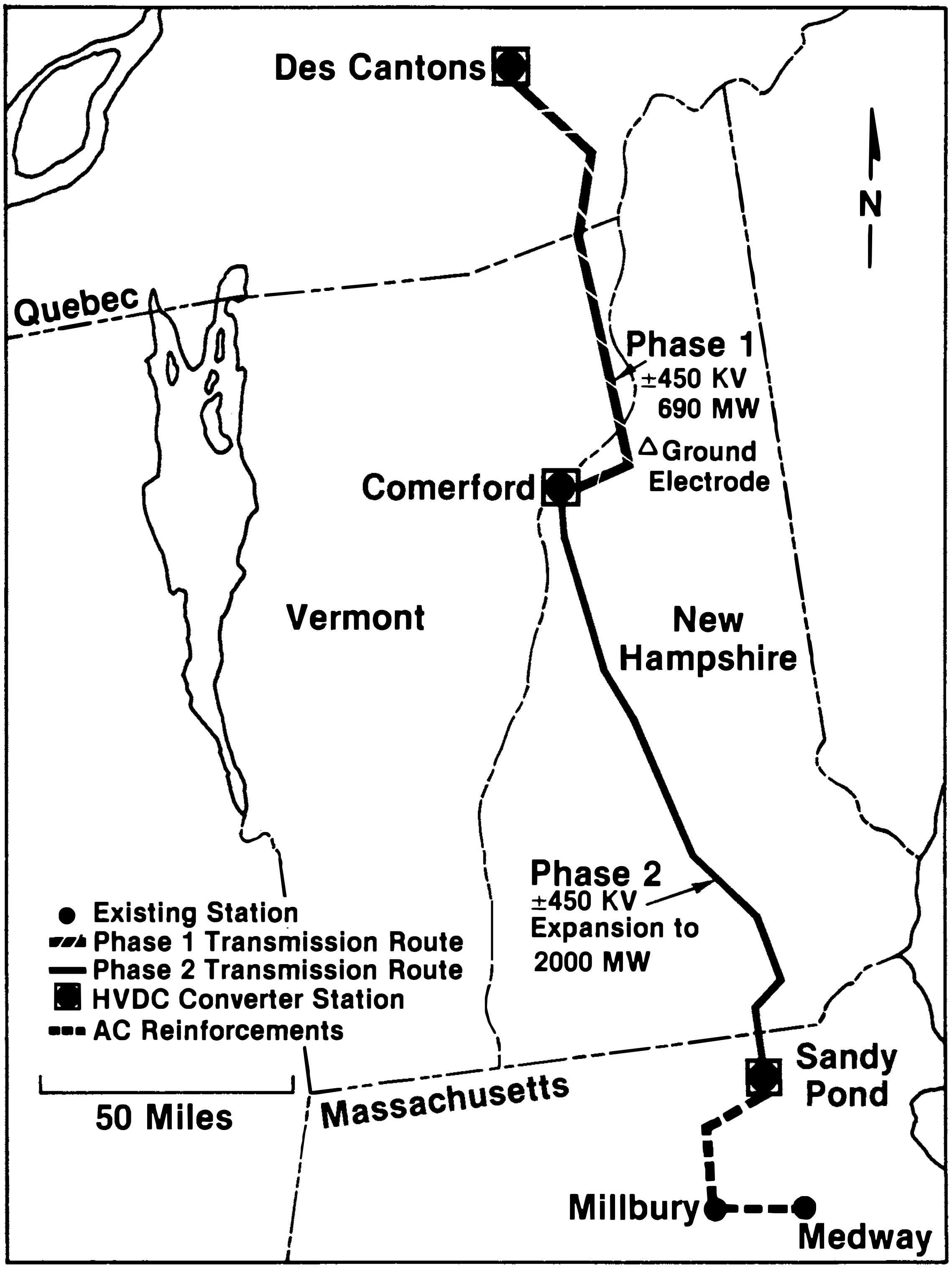

Figure 1.1. Map Showing Locations of Phase I and Proposed Phase II Features of the New England/Hydro-Quebec Transmission Line Interconnect.

The pricing provisions of the Phase II agreement provide that for each of the first 5 years of the contract, the price of the imported energy will be 80% of NEPOOL's average fossil fuel costs (in ¢/kWh) incurred during the previous year. During the second 5 years, the 80% figure would increase to 95%. The average fossil fuel cost reflects the weighted average cost of energy generated from the use of coal, oil, and natural gas.

1.3 COST/BENEFIT OF PROPOSED ACTION

The proposed action should provide economic benefits to the New England region in three ways: (1) reduced fuel costs through a reduction in the amount of oil used to generate electric energy; (2) a reduction of 900 MW in the amount of new generating capacity required to maintain the desired level of reliability on the NEPOOL system during the mid-1990s; and (3) a reduction in the electrical losses incurred when transmitting electric energy to the load centers in southern New England.

1.3.1 Fuel Cost Savings

The Applicant estimates that the cumulative present worth (in 1990 dollars) of the savings in fossil fuel costs over the 10-year period of the Phase II agreement will be $1.37 billion.* In current dollars, savings would range from about $150 million in 1991 to about $500 million in the year 2000.

DOE Staff has reviewed the assumptions and methodology used in this analysis and has determined that both appear to be reasonable. However, because the imported energy will be priced relative to fossil fuel costs and displace oil-fired generation almost exclusively, fuel cost savings will vary directly with fuel prices in general and particularly with the future price of oil. Although some savings in fuel costs will result from any and all fuel price levels (because the imported energy is priced at less than 100% of actual costs), a drastic reduction in the price of fuel could reduce savings to the point that the entire Phase II project was no longer economically viable. In order to evaluate this possibility, DOE Staff performed a sensitivity analysis in which the projected price of fossil fuels was varied ±25% from the base values used in the Applicant's analysis.**

The Applicant has estimated that the cumulative present worth of fuel cost savings (in 1990 dollars) would be $1.3 billion over the 10-year life of the Phase II firm energy contract. By increasing the projected price of fossil fuels 25%, these savings increased to about $1.7 billion. A 25% reduction in the estimated price of fossil fuels reduced estimated gross savings in fuel costs to $1.0 billion.

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*The methodology and the assumptions used in this analysis are described on pages 23 through 54 of Volume 1 of the ER.

**Base fuel prices used in the Applicant's analysis appear on pages 31 and 32 of Vol. 1 of the ER. These projected prices were developed by Data Resources, Inc. in January 1985. Mid-sulfur fuel prices ranged from $29/barrel and $83/ton in 1990 to $78/barrel and $175/ton in the year 2000.

DOE Staff analysis further indicated that the projected price of fossil fuels must drop 60% from the base values before the Phase II project becomes a questionable economic choice. This 60% reduction in projected fuel prices would equate to $11/barrel oil and $33/ton coal prices in 1990 and $28/barrel oil and $65/ton coal prices by the year 2000.

1.3.2 Capacity Benefits

The terms of the Phase II firm energy contract provide for a high degree of control by the Applicant in scheduling or "calling for" the delivery of energy from Hydro-Quebec. The Applicant is not purchasing capacity. However, by performing reliability analyses, the Applicant has determined that the Phase II contract will reduce by 900 MW the amount of new generating capacity required to maintain the desired level of reliability on the NEPOOL system during the mid-1990s.

In determining the economic benefits of this 900-MW reduction in new capacity requirements, the Applicant assumed that the capacity would have come from the installation of gas turbines. The DOE Staff feels that this is a reasonable assumption since gas turbines have a relatively low capital cost; are quickly installed; and are installed, generally, for reliability reasons only.

The economic analysis performed by the Applicant shows that the "capacity benefit" of the proposed action (when coupled with the Phase II firm energy contract) reduces the revenue requirements associated with new capacity additions by $320 million on a cumulative present worth basis (in 1990 dollars).

1.3.3 Reduction in Incremental Energy Losses

The net change in energy losses associated with the proposed action has three components: (1) an increase in losses associated with installation of the Phase II DC facilities, (2) an increase in losses associated with the increased energy flow through the Phase I DC facilities, and (3) a reduction in losses on NEPOOL's existing AC transmission system.

The increased losses associated with the DC system produce a cost increase of approximately $63 million (cumulative present worth) in 1990 dollars. Reduced losses on the existing AC system produce savings of approximately $102 million. The result is a net savings of approximately $39 million (ER, Vol. 1--p. 45-50). Varying the projected price of oil (as discussed in Section 1.3.1) will produce differences in incremental energy loss savings. These differences are noted in Table 1.1.

1.3.4 Gross Savings

Table 1.1 shows the estimated gross savings for the Phase II project under each of the oil price scenarios considered.

Table 1.1 Gross Savings
(millions of 1990 dollars)

Fossil Fuel Prices	Fuel Cost Savings	Capacity Credit	Incremental Loss Savings	Gross Savings
-60%	550	320	16	886
-25%	1,020	320	29	1,369
Base	1,370	320	39	1,729
+25%	1,700	320	49	2,069

1.3.5 Costs

The total capital costs associated with the Phase II facilities are estimated to be $585 million in current dollars. Table 1.2 contains a breakdown of these costs for each component of the project.

The Applicant conducted a revenue requirements analysis over the life of the Phase II firm power agreement. Table 1.3 contains the economic assumptions used in that analysis. The results of the analysis show that a $585 million project cost would produce $897 million of revenue requirements on a cumulative present worth basis (1990 dollars).

The capital costs of the project were determined on the basis of "study grade" estimates that the Applicant feels are accurate to only ±25%. In recognition of this fact, the Applicant performed additional revenue requirement analyses for projected capital costs of $440 million (25% lower than the base estimate) and $730 million (25% higher than the base estimate).

Using the assumptions in Table 1.3, the $440 million capital cost estimate produced revenue requirements of $675 million (cumulative present worth, 1990 dollars). With capital costs of $730 million, revenue requirements would increase to $1,119 million.

1.3.6 Net Benefits

Table 1.4 compares estimated project costs with projected benefits. Costs are represented by the cumulative present worth of revenue requirements generated by the capital costs of the project. Project benefits include the estimated gross savings from fuel costs, capacity credits, and reductions in incremental energy losses.

Table 1.4 shows that the economic effects to the New England region could range from a net cost of $233 million to a net savings of $1.4 billion over the 10-year life of the Phase II firm energy contract. It is significant to note, however, that a net cost of $233 million would result only for the most pessimistic scenario of highest capital cost and lowest cost of fossil fuel.

Table 1.2. Capital Construction Cost Estimate for Proposed Facilities

Item	Capital Construction Cost Estimate[a] (millions of dollars)
133.2 miles of ±450-kV DC transmission line	182.0
One 1800-MW converter terminal connected to Sandy Pond substation	252.0
36.0 miles of 345-kV AC transmission line connecting Sandy Pond and Millbury No. 3 substations	40.5
16.1 miles of 345-kV AC transmission line connecting Millbury No. 3 and West Medway substations	17.7
345-kV AC circuit breakers and miscellaneous equipment at Sandy Pond, Millbury No. 3, and West Medway substations	18.3
Remove and rebuild two sections of two 115-kV AC transmission lines and remove and rebuild portions of two 69-kV AC transmission lines and support structures on the Sandy Pond to Millbury right-of-way; install 115-kV AC circuit breakers and miscellaneous substation equipment	46.5
Other miscellaneous facilities	28.0
TOTAL	$585.0

[a] Capital construction cost estimate represents the sum of current-year construction, escalation, and allowance for funds used during construction (AFUDC) cost estimates.

Table 1.3. Assumptions Used in Revenue Requirements Analysis

Cost of Money:	DC facilities:	60% Debt @	11.0%
		40% Equity @	14.0%
		Weighted Total	12.2%
	AC lines:	45% Debt @	11.0%
		10% Preferred Stock @	10.0%
		45% Equity @	14.0%
		Weighted Total	12.25%
Present Worth Rate:			10.4%
Property Taxes:	Converter:	1.0% of project capital cost	
	AC and DC lines:	2.5% of project capital cost	
	Escalation Rate:	2.5% per year	
O&M Costs:	Converter:	1.9% of project capital cost	
	DC line:	0.6% of project capital cost	
	AC lines:	0.7% of project capital cost	
	Escalation Rate:	5.0% per year	
	Land/Right-of-way lease charges:	2.3% of project capital cost	
Life of Facilities:	Tax:	15 years for personal property 18 years for real property	
	Book:	10 years for DC line and converter 30 years for AC lines	
	Normalized:	10 years for DC line and converter 30 years for AC lines	
Tax Rates:	Federal Income:	46.0%	
	Massachusetts Income:	6.5% (70% subject to income tax)	
	New Hampshire Income:	9.03% (30% subject to income tax)	
	Investment Tax Credit:	10.0% deferred and amortized over book life	
Depreciation:	Book:	Straight line	
	Tax:	Rate set by Accelerated Cost Recovery System tax laws	
In-Service Date:		December 1990	

Source: ER, Vol. 1--pp. 40-41.

Table 1.4. Net Benefits of the Proposed Project
(millions of 1990 dollars)

Fossil Fuel Prices	Gross Savings	Project Costs: Capital Costs	Project Costs: C.P.W. Rev. Req.[a]	Net Benefits
-60%	886	+25%	1,119	-233
		Base	897	-11
		-25%	675	211
-25%	1,369	+25%	1,119	250
		Base	897	472
		-25%	675	694
Base	1,729	+25%	1,119	610
		Base	897	832
		-25%	675	1,054
+25%	2,069	+25%	1,119	950
		Base	897	1,172
		-25%	675	1,394

[a] C.P.W. Rev. Req. = Cumulative present worth revenue requirements.

In addition to the economic benefits identified above, the construction of the Phase II facilities could provide other benefits not yet quantified. These potential benefits include:

- The opportunity for increased energy banking whereby NEPOOL members could transmit relatively inexpensive energy north to Quebec during off-peak periods and receive equal amounts of energy during on-peak periods when generation costs in New England are much higher. The basic Energy Banking Agreement was established under Phase I but the amount of energy banking was limited to power levels of 690 MW by the capacity of the Phase I facilities. Construction of the Phase II facilities would raise the potential level of energy banking to almost 2000 MW.

- Additional opportunities for energy interchange, whereby if Hydro-Quebec has additional surpluses of energy, it could sell the surpluses to New England at a fraction of New England's avoided fuel cost.

- Increased ability to make emergency transfers of power to either side of the border for mutual reliability purposes.

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 1.5, the NEPOOL region is heavily dependent upon oil (mostly foreign) for the production of electric energy. In 1984, 37% of all

Table 1.5. NEPOOL Generating Mix

	Installed Generating Capacity (winter)			
	1985 Actual[a]		1994 Projected[a]	
Source of Energy	MW	%	MW	%
Oil	11,031	51	9,711	38
Natural Gas	21	-	22	-
Coal	2,627	11	3,412	13
Nuclear	4,322	21	6,622	26
Hydro	2,970	13	2,988	11
Other[b]	921	4	2,963	12
TOTAL	21,892	100	25,718	100

	Electrical Energy Generated			
	1984 Actual[c]		1994 Projected[c,d]	
Source of Energy	Million MWh	%	Million MWh	%
Oil	34.1	37	17.7 (24.7)	15 (21)
Natural Gas	3.4	3	0	0
Coal	14.7	16	22.2	19
Nuclear	23.8	26	40.7	36
Hydro[e]	4.5	5	4.2	4
Other[f]	1.1	1	10.2	9
Net Purchases	11.5	12	19.6 (12.6)	17 (11)
TOTAL	93.1	100	114.6	100

[a] Source: New England Power Pool (1985).

[b] Values for 1985 include 53 MW of wood-burning capacity, 181 MW of cogeneration, and 687 MW of net purchases and sales. Values for 1994 include 53 MW of wood-burning capacity, 1158 MW of cogeneration, 1745 MW of net purchases and sales, and 7 MW miscellaneous.

[c] Source: North American Electric Reliability Council (1985).

[d] These values represent projected generation for each fuel type if the proposed project is installed. The values in parentheses represent projected generation if the proposed project is not installed.

[e] Values shown are net of pumped hydro pumping losses.

[f] Includes cogeneration of 0.9 million MWh in 1984 and 9.7 million MWh in 1994. The remaining energy is made up of generation from wood and refuse.

electricity generated in the New England area was produced by burning oil. However, future supply plans developed by NEPOOL (New England Power Pool 1985)* could reduce the region's dependence on imported oil for the production of electric energy to about 15% of total electric generation by 1994. These plans call for the installation of 2300 MW of nuclear capacity, the conversion of approximately 1100 MW of oil-fired capacity to coal-fired operation, the development of approximately 1000 MW of cogeneration in the region, and the importation of hydroelectric energy through the terms of the New England/Hydro-Quebec Phase I and Phase II agreements.

Table 1.5 also shows that with the construction of the Phase II facilities and the implementation of the Phase II firm energy contract, oil-fired generation in New England in 1994 is projected to reach 17.7 million MWh (15% of total generation). This will require the burning of approximately 29 million barrels of oil.

If the energy from the Phase II agreement were not available, oil-fired generation in 1994 would rise to 24.7 million MWh (21% of total generation). This would require the burning of approximately 41 million barrels of oil--12 million barrels more than with the energy from the Phase II firm energy contract. Oil-fired generation is operated in New England for almost all hours of the day. Any imported energy would displace almost 100% oil no matter what time of the day it was received. A heat rate of 10,000 Btu/kWh and a heating value of oil of 6 million Btu/barrel were used in converting oil-fired energy to barrels of oil displaced.

An additional impact of the Phase II interconnection and the Phase II firm energy contract is to reduce the amount of generating capacity required to maintain adequate levels of reliability. In order to determine the "capacity benefit" of the interconnection, the Applicant performed a loss-of-load analysis. This analysis considers the variability of system load and the random outages of generating units in determining the probability that the amount of generating capacity available at any time would not be sufficient to supply all of the customer demand for electricity. Based on this analysis, the Applicant has determined that the "capacity benefit" of Phase II is equivalent to 900 MW.

Another measure of system reliability is the capacity reserve margin. Reserve margins are defined as the difference between planned resources and peak demand, expressed as a percentage of peak demand. The resource plan submitted by the Applicant shows that NEPOOL will have reserve margins ranging from a low of 17.5% to a high of 43.2% during the 10-year period of the Phase II agreement. Without the 900 MW "capacity benefit" associated with Phase II, the range of NEPOOL reserve margins would drop to between 13.4% and 38.3%. Details of the NEPOOL reserve margins for the 10-year period of the Phase II agreement appear in Table 1.6.

It is typical for utilities to plan for reserve margins between 15% and 25%. However, various utility system characteristics, such as average

*Throughout this document, complete citations for references cited in a chapter are listed at the end of that chapter.

Table 1.6. NEPOOL Load and Generating Capacity Projections

Year	Total NEPOOL Load (MW)	Total NEPOOL Capacity[a] (MW)	NEPOOL Reserve Margins[a] (MW)	%
1991	18,400	26,356 (25,456)	7,956 (7,056)	43.2 (38.3)
1992	18,873	25,904 (25,004)	7,031 (6,131)	37.3 (32.5)
1993	19,303	25,820 (24,920)	6,517 (5,617)	33.8 (29.1)
1994	19,586	25,719 (24,819)	6,133 (5,233)	31.3 (26.7)
1995	20,040	25,468 (24,568)	5,428 (4,528)	27.1 (22.6)
1996	20,441	25,098 (24,198)	4,657 (3,757)	22.8 (18.4)
1997	20,791	25,075 (24,175)	4,284 (3,384)	20.6 (16.3)
1998	21,106	25,077 (24,177)	3,971 (3,071)	18.8 (14.6)
1999	21,388	25,416 (24,516)	4,028 (3,128)	18.8 (14.6)
2000	21,809	25,634 (24,734)	3,825 (2,925)	17.5 (13.4)

[a] These values represent NEPOOL's total generating resources and capacity reserve margins assuming a 900-MW capacity benefit of the Phase II facilities and firm energy contract. The values in parentheses represent the NEPOOL resources and reserve margins that would result if the Phase II facilities were not installed and the Phase II firm energy contract were not in place.

generating unit size, number and type of units, unit availabilities, and other factors can cause the level of reserves required for adequate reliability to vary considerably from system to system. Consequently, the projected range of capacity reserve margins (with and without Phase II) for the NEPOOL system cannot be construed as either inadequate or excessive without further detailed studies.

1.5 REFERENCES FOR SECTION 1

New England Power Pool. 1985. NEPOOL Forecast Report of Capacity, Energy, Loads and Transmission, 1985-2000. New England Power Pool.

North American Electric Reliability Council. 1985. Electric Power Supply and Demand, 1985-1994. North American Electric Reliability Council.

U.S. Department of Energy. 1984. Environmental Impact Statement, New England/Hydro-Quebec ±450-kV Direct Current Transmission Line Interconnection. DOE/EIS-0103. U.S. Department of Energy, Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness, Washington, DC.

2. PROPOSED ACTION AND ITS ALTERNATIVES

2.1 PROPOSED ACTION

The proposed action is to amend Presidential Permit PP-76, granted to the Vermont Electric Transmission Company (the Applicant), to allow member utilities of the New England Power Pool (NEPOOL) to purchase additional quantities of energy from Hydro-Quebec, the provincial utility of Quebec, Canada, and to construct several new facilities in order to utilize the additional power purchased under the proposed amendment. The new facilities (see Figure 1.1 in Chapter 1) include (1) an extension of the ±450-kilovolt (kV) direct current (DC) line authorized in the original Presidential permit by about 214 km (133 mi) southward from the Comerford converter terminal in Monroe, New Hampshire, to a location between Groton and Ayer, Massachusetts; (2) a new 1800-megawatt (MW) converter terminal (referred to as Sandy Pond) at the terminus of the new DC transmission line; (3) two new 345-kV alternating current (AC) transmission lines extending a total of 84 km (52 mi) from an existing substation adjacent to the proposed converter terminal to an existing substation in Millbury and thence to an existing substation in Medway, Massachusetts; and (4) an expansion of the Phase I ground electrode system in Lisbon, New Hampshire. The construction of these facilities is herein referred to as Phase II of the New England/Hydro-Quebec Interconnection.

One of the data sources used for the description of the proposed Phase II project is the Applicant's Environmental Report, submitted to the U.S. Department of Energy (DOE) as part of Docket PP-76A from May to September 1985; hereinafter this report is referred to as the "ER". Along the proposed route, data are compiled primarily by town, which is a geographical and governing unit somewhat analogous to townships in other regions. Several towns make up a county, and a town may include several villages or population concentrations. For the purposes of this report, the term "town" has been used to indicate the larger geographical and governing unit.

2.1.1 Study Area Selection and Description

The term "study area" as used in this document refers to those areas investigated in order to characterize the environs and evaluate the potential impacts of the proposed project. For a given resource, the study area was chosen so as to (1) provide sufficient data in a context broad enough to allow description of the existing condition of that resource, and (2) encompass the area within which impacts could be reasonably expected to occur. Thus, the extent of a specific study area depended on the environmental resource being considered. For instance, the socioeconomic study areas were based primarily on town, or in some cases county, boundaries along the proposed route; while climatic considerations were based on a broader area (central Massachusetts and interior New Hampshire). In a similar manner, consideration of expected level of impact to soils and vegetation was confined mainly to the actual work areas; while evaluation of visual impacts involved considering an extended area away from the immediate project site. Descriptions for the study area considered for each resource (or affected environmental parameter) are provided in Section 3.

2.1.2 Corridor and Route Selection

Based on its review of the general purposes of the proposed action, route selection and facility siting procedures, and other issues involved (ER, Vol. 4), the DOE Staff concurs with the Applicant that because of economic, environmental, and service reliability considerations the proposed route (and alternatives) should meet the following criteria:

(1) The northern terminus should be located at the Comerford converter terminal site (built during Phase I) in order to avoid the requirements of building a new DC line from the Canadian border;

(2) The southern terminus should be located based on system reliability and economic considerations of AC transmission system reinforcements that would be required in association with the new converter terminal; and

(3) Both the DC and AC transmission lines should be located, where practical, within existing utility corridors.

Use of existing corridors is consistent with federal routing guidelines. Additionally, any routing outside of existing, dedicated, and already utilized corridors would lead to far greater economic and adverse environmental impacts. Locations where new transmission lines could be sited on or adjacent to existing transmission line rights-of-way were initially identified by the Applicant. In total, nine transmission-line plans were evaluated based on six potential locations for the Phase II converter terminal. These alternatives allowed comparisons of AC vs. DC lines (converter located at Comerford, New Hampshire), a compromise between AC and the planned DC extension (converter located at Londonberry, New Hampshire), and alternative locations for the converter terminal with the proposed DC extension (converter terminal located at Ludlow, Millbury, Tewksbury, or Sandy Pond, Massachusetts). The proposed route was then determined based on additional factors suggested by local authorities, local planning and zoning regulations, cost and engineering criteria, and environmental and land-use factors. (A map showing the proposed route and the three alternative routes is provided in Figure 2.1.) Public opinion on the proposed route was next solicited and considered through procedures required by the states of New Hampshire and Massachusetts and through a public scoping meeting conducted on June 4 and 5, 1985, by the U.S. Department of Energy. That meeting was designed to solicit concerns and suggestions from property owners, local residents, government agencies, and public interest groups. The Staff concurs with this approach.

2.1.3 Description of the Proposed Route

The proposed route (Figures 2.2 through 2.4) would begin at the Phase I converter terminal site in the town of Monroe, New Hampshire. The first portion of the route would be for the new ±450-kV DC transmission line that would extend 214 km (133 mi) to the Groton/Ayer town line in Massachusetts. Except for the first 1.3 km (0.8 mi), which would be on existing utility property, the DC line would be located entirely within occupied transmission line rights-of-way. For the first 181 km (112.5 mi) from Monroe to Sandy Pond Junction (in Hudson, New Hampshire) the DC line would be located between two

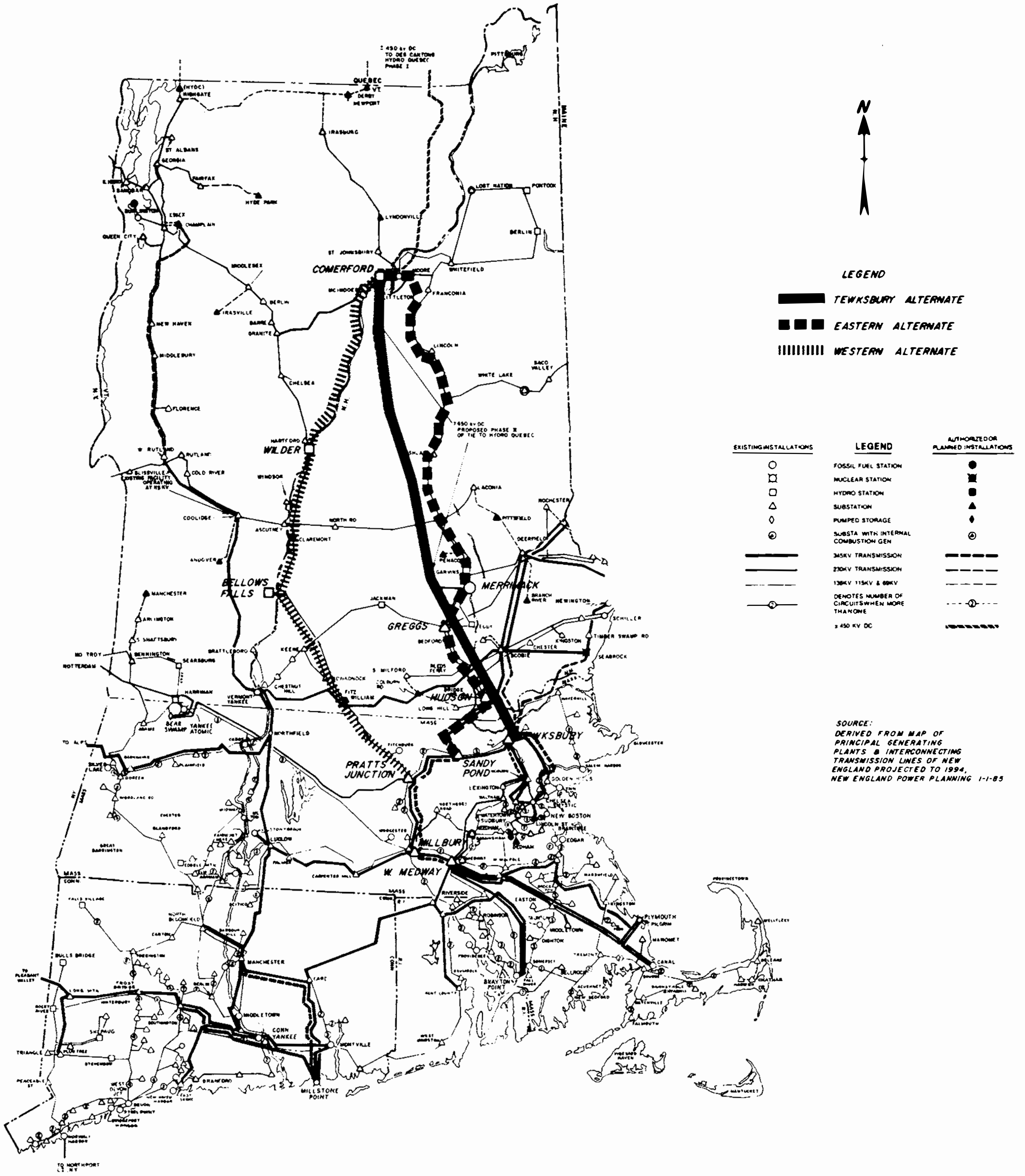

Figure 2.1. Locations of Proposed and Alternative Routes for Phase II. (The proposed and Tewksbury alternative DC line routes follow the same corridor from Comerford to the Hudson substation. From there, the proposed route turns southwest to Sandy Pond, while the Tewksbury alternative continues southeast to the Tewksbury alternative converter terminal site.) (From ER, Vol. 4--Fig. III-1)

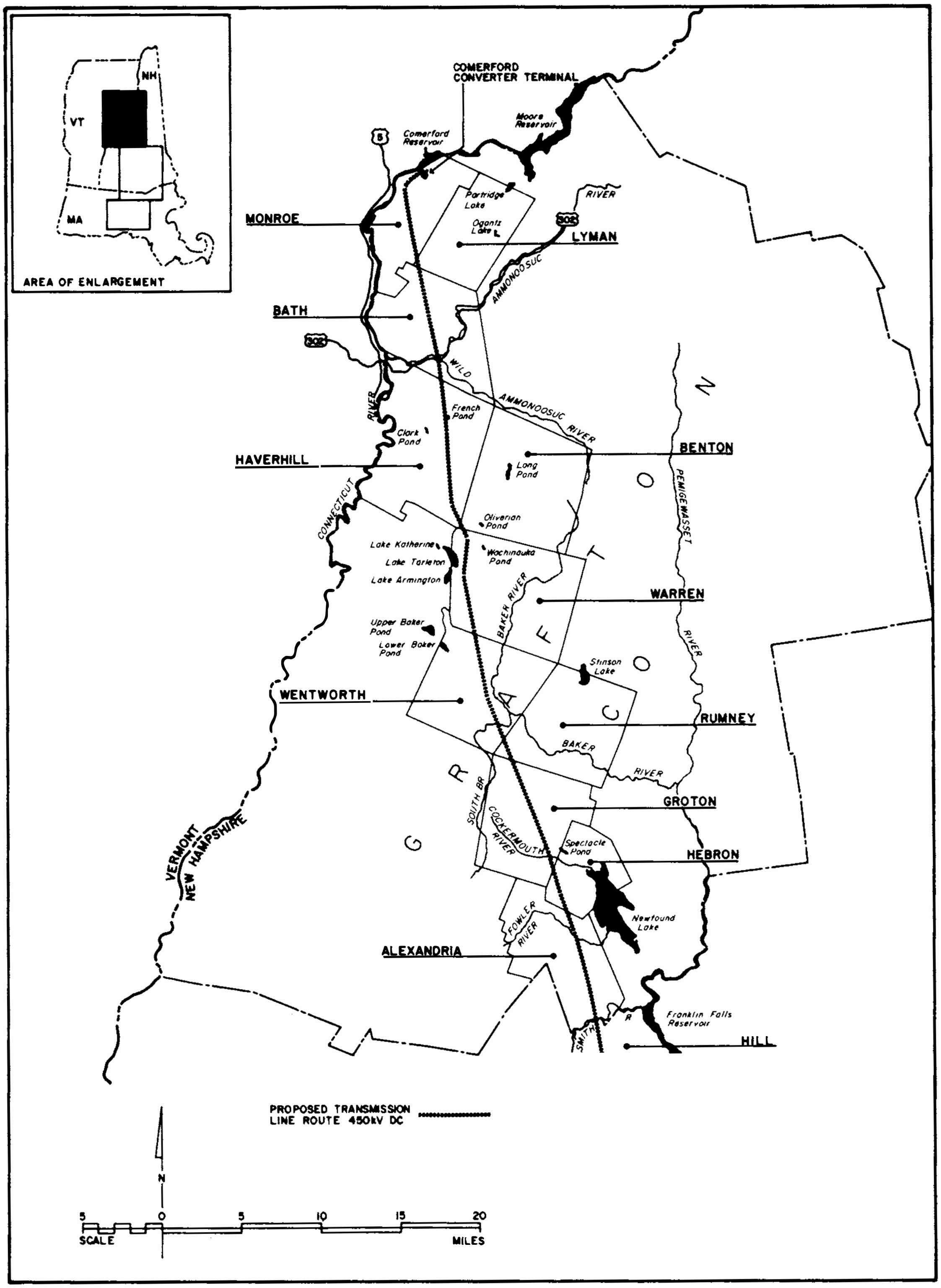

Figure 2.2. Northern Segment of Proposed Route.
(Map provided by the Applicant.)

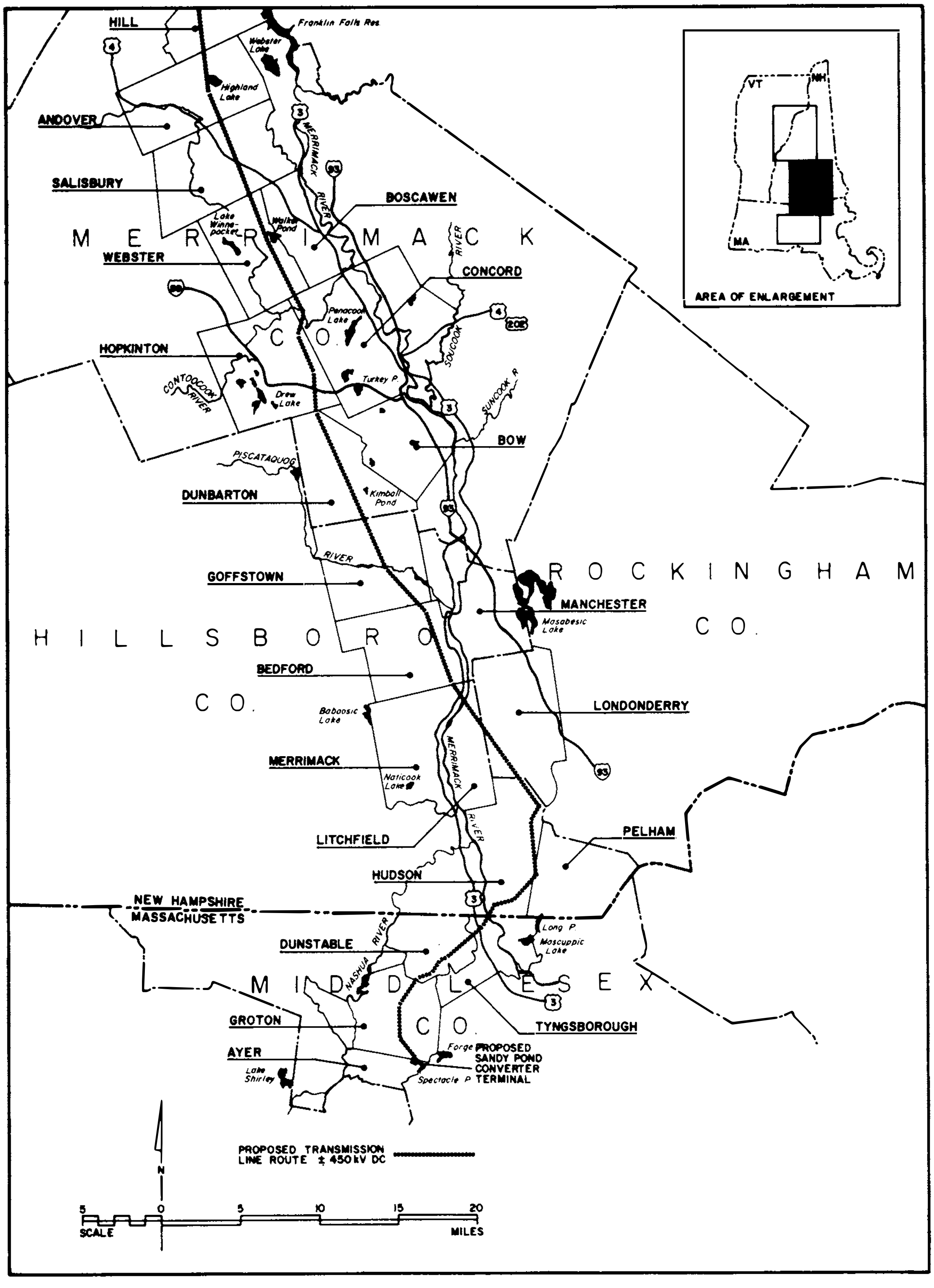

Figure 2.3. Central Segment of Proposed Route.
(Map provided by the Applicant.)

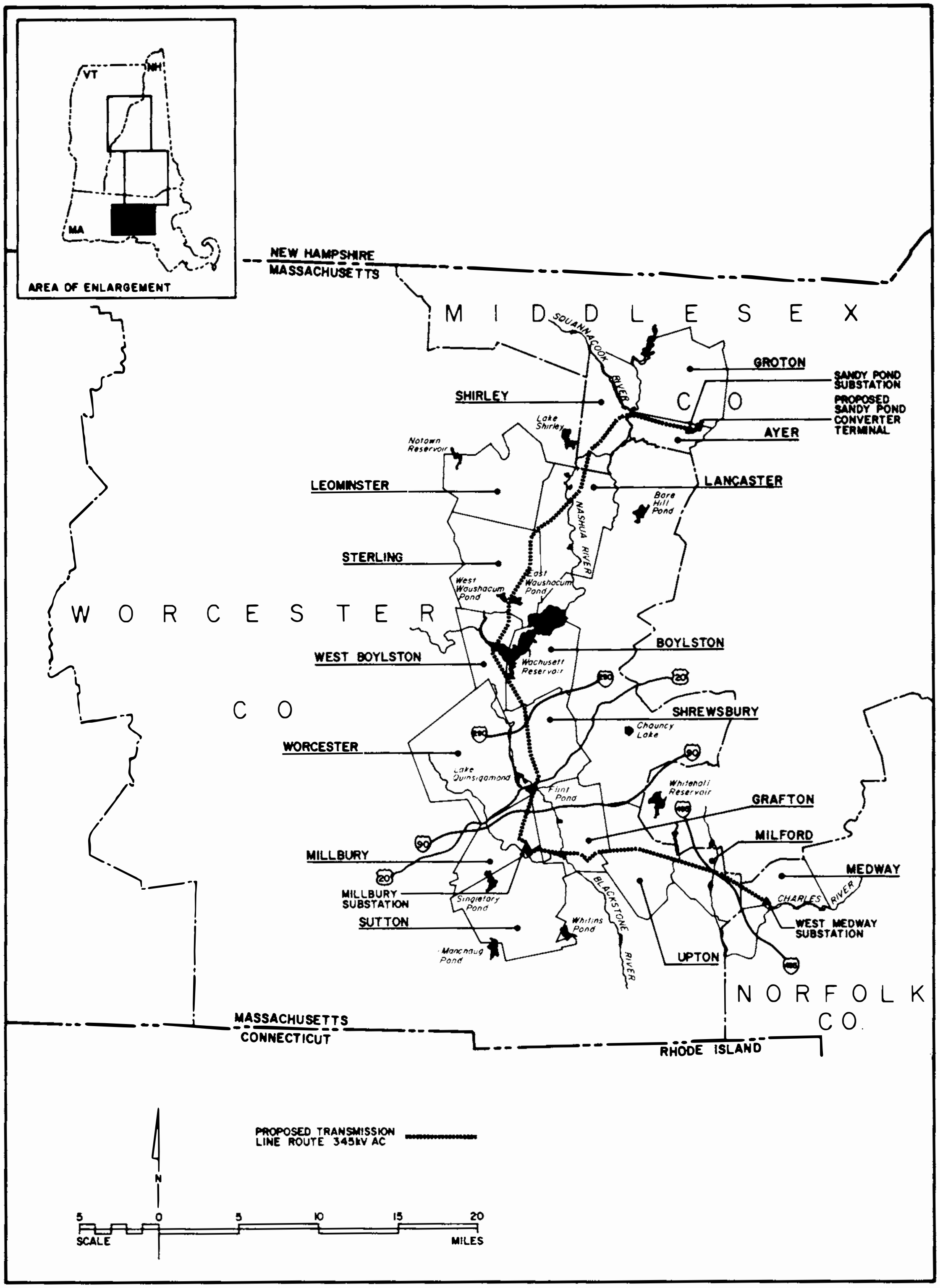

Figure 2.4. Southern Segment of Proposed Route.
(Map provided by the Applicant.)

single-circuit, 230-kV AC transmission lines, extending in a south-southeasterly direction. The proposed DC line would then depart from the 230-kV AC transmission line right-of-way in a south-southwesterly direction and would be in an existing 345-kV AC transmission line right-of-way between Sandy Pond Junction and Groton/Ayer Massachusetts, a distance of 33 km (20.5 mi). The terminus of the proposed DC line would be at the proposed 1800-MW converter terminal at a site straddling the town line between Groton and Ayer, Massachusetts. The converter terminal would be constructed adjacent to an existing 345-kV AC substation known as Sandy Pond substation.

A new 345-kV AC transmission line is proposed to be built on an existing right-of-way between the Sandy Pond substation in Ayer, Massachusetts, and the existing Millbury No. 3 345-kV AC substation in Millbury, Massachusetts. From the Sandy Point substation, this line would extend in a south-southwesterly direction to the town of West Boylston, from where it would turn south to the Millbury No. 3 substation. The line would traverse a distance of about 58 km (36 mi) and would be located on an existing right-of-way between an existing 345-kV AC transmission line and two existing 115-kV AC transmission lines. For the majority of this right-of-way, the existing single-circuit, 115-kV AC steel-lattice structures would be removed and replaced with double-circuit, single-shaft, steel-pole structures (ER, Vol. 2--Figs. II-7, II-10, II-11, and II-12). Where the proposed 345-kV AC line would cross the Wachusett Reservoir, the existing 69-kV AC structures would be removed and replaced by steel-pole H-frame crossing structures (ER, Vol. 2--Fig. II-9).

A second new 345-kV AC transmission line would extend from the Millbury No. 3 substation to the West Medway substation in Medway, Massachusetts. This line would run in an east-southeasterly direction for approximately 26 km (16 mi). The transmission line would be located on an existing right-of-way and would parallel an existing 345-kV AC line and two existing 115-kV AC lines.

2.1.4 Proposed Design and Construction Activities

2.1.4.1 Design Description

Line Specifications

Basic design parameters for the proposed DC transmission line are listed in Table 2.1. Each of the two current-carrying pole conductors would consist of three-bundle aluminum and steel (ACSR) subconductors. The subconductors would be installed in an inverted triangular formation (i.e., apex down). There would also be a single, dedicated metallic return conductor extending the length of the DC line. It would connect the new converter terminal to the ground electrode via the Phase I converter terminal-ground electrode connection.

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

Basic design parameters for the two proposed AC transmission lines are listed in Table 2.2. The three current-carrying pole conductors would each consist of two-bundle ACSR subconductors. The subconductors would be spaced

Table 2.1. Design Parameters for Proposed DC Transmission Line for Phase II of the New England/Hydro-Quebec Interconnection

Length of line	214.4 km (133.2 mi)
Voltage	±450 kV DC
Configuration	Bipolar, horizontal pole spacing
Capacity	1800 MW
Conductor type	Aluminum/steel
Conductor size	50 mm (2 in) nominal diameter
Minimum clearance: conductor to ground at mid-span	12.2 m (40 ft)
Lightning protection	Two aerial shield wires and a buried longitudinal counterpoise wire attached to each structure.
Tangent structures	Lattice steel H-frame (first 181 km [112.5 mi]), single-shaft steel-pole (last 33.3 km [20.7 mi])
Height of tangent structures	22.9-35.1 m (75-115 ft); 27.4 m (90 ft)
Average span length	183 m (600 ft)
Right-of-way width	61 m (200 ft) for first 1.3 km (0.8 mi); within 107-m (350-ft) ROW[a] for next 173.5 km (107.8 mi); within 172.7-m (566.5-ft) ROW for next 6.3 km (3.9 mi); within 82-m (270-ft) ROW for next 13.7 km (8.5 mi); within 76-m (250-ft) ROW for next 10.3 km (6.4 mi); within 102-m (335-ft) ROW for next 6.6 km (4.1 mi); and within 76-m (250-ft) ROW for last 2.7 km (1.7 mi)

[a] ROW = Right-of-way.

Source: ER, Vols. 1-3.

Table 2.2. Design Parameters for Proposed AC Transmission Lines for Phase II of the New England/Hydro-Quebec Interconnection

Length of lines	58 km (36 mi) and 26 km (16.1 mi)
Voltage	345 kV AC
Conductor type	Aluminum/steel
Minimum clearance: conductor to ground at mid-span	7.6 m (25 ft)
Lightning protection	Two aerial shield wires and a buried longitudinal counterpoise wire attached to each structure
Tangent structures	Wood- or steel-pole H-frame and single-shaft steel-pole
Height of tangent structures	Generally 19-30 m (61-97 ft) with average of 23 m (75 ft) for H-frames and 26-37 m (85-120 ft) with an average of 29 m (95 ft) for single-shafts
Average span length	183 m (600 ft) from Sandy Pond to Millbury and 152 m (500 ft) from Millbury to West Medway
Right-of-way width	Various widths ranging from a minimum of 58.8 m (193 ft) to a maximum of 123 m (405 ft)

Source: ER, Vol. 2.

in a horizontal plane. Spacing of electric conductors would vary with type of support structure. Where standard 345-kV H-frame structures were used there would be 7.9-m (26-ft) phase spacing, and where narrower 345-kV H-frame structures were used there would be 6.1-m (20-ft) phase spacing. The conductors would be protected from lightning strikes by installation of a buried counterpoise wire and two aerial groundwires (shield wires).

Both AC and DC transmission lines would be designed to meet the National Electric Safety Code specifications for heavy ice loading conditions (ice buildup of 12.7 mm [0.5 in] thickness and 0.2 kPa [4 lb/ft^2] of wind pressure) and extreme wind conditions (wind pressure of 0.2 kPa [4 lb/ft^2]). In addition, the transmission structures would be designed to withstand heavy icing (determined from a review of meteorological data) and imbalancing due to ice buildup.

Support Structures

Lattice-steel, H-frame support structures are proposed for use on the DC line from the Comerford converter terminal to Sandy Pond Junction in the town of Hudson, New Hampshire. Single-shaft steel poles would then be used for the remainder of the DC line (ER, Vol. 4). The AC line would generally use wood- or steel-pole, H-frame support structures, except for a few locations along the Sandy Pond to Millbury right-of-way, where single-shaft, steel-pole structures would be used (ER, Vol. 2). Coloration for the steel poles would be provided by use of natural-weathering steel (CORTEN or similar).

Converter Terminal

At the town line between Groton and Ayer, Massachusetts, a building would be erected on a cleared, 12-ha (30-acre) site to house high-voltage, direct current (HVDC) converter equipment for the proposed converter terminal (ER, Vol. 1). The converter terminal yard would occupy 300 m (1000 ft) on a side and would cover an area of 9.3 ha (23 acres). The building would be 76 m (250 ft) long, 30 m (100 ft) wide, and 18 m (60 ft) high. It would be a metal building constructed on a concrete foundation. The color would be selected to be visually inconspicuous. Normally the building would be unattended. An auxiliary building measuring 18 m (60 ft) by 12 m (40 ft) by 7.5 m (25 ft) high would be located near the converter terminal building to house spare parts for the electronic conversion equipment (ER, Vol. 1).

The terminal building would be surrounded by a switchyard containing electric power equipment and associated structures. The highest structures would be for the transmission line terminations. They would be about 24 m (80 ft) tall for the DC line and 23 m (75 ft) tall for the AC lines. Electric conductor and bus work in the switchyard would be of the modern, open-construction type. All power equipment would be painted a visually inconspicuous color.

Communication to and from the converter terminal would be via a microwave system connected to the existing New England system at an existing station on the Shared Microwave System at the Sandy Pond substation (ER, Vol. 1).

The converter terminal would be connected to NEPOOL's existing AC power system at the Sandy Pond 345-kV AC substation southwest of the terminal site. Two 345-kV AC connector lines, each about 0.5 km (0.3 mi) long, would extend from the converter terminal to the Sandy Pond substation. The connector lines would be supported by single-circuit wood or steel H-frame structures varying from 18 m (60 ft) to 32 m (105 ft) high. Each structure would carry two bundled ACSR conductors per phase (six conductors) and two 1.0-cm (3/8-in) diameter, seven-strand, utility-grade galvanized steel aerial groundwires. Also, one 1.0-cm (3/8-in) diameter, common-grade galvanized steel or #4 Copperweld counterpoise wire would be buried for each connector line.

Ground Electrode

The Phase I ground electrode system would be expanded as part of the proposed Phase II project. The ground electrode would correct for current imbalance between the positive and negative halves of the HVDC interconnection and accommodate abnormal operating conditions. The expansion would entail construction of a second series of metallic rods connected by cable and buried in eight vertical holes 0.3 m (1 ft) in diameter and 40 to 70 m (130 to 230 ft) deep. This second array of holes and rods would be physically separated from the Phase I array but would be electrically connected so that they would function as a single ground electrode.

During normal operation of the proposed DC line, approximately 20 amperes of electricity at less than 500 volts would flow over the electrode feeder and through the ground electrode. In cases of abnormal operating conditions, the maximum voltage to ground would not exceed 15 kV at a current of 2450 amperes. The ground electrode is designed to operate at this level for 15 minutes (ER, Vol. 8). It is also designed such that when operating at full capacity, the ground current would not be perceptible to humans or animals. The ground electrode is expected to be used for abnormal operating conditions 20 to 30 times per year.

The ground electrode expansion would be located on a 120-ha (300-acre) parcel of land off Oregon Road in Lisbon, New Hampshire, about 18 km (11 mi) southeast of the Phase I converter terminal. The site is heavily wooded. About 1.2 to 1.6 ha (3 to 4 acres) would have to be cleared for the electrode array, and a short, 15-m (50-ft) wide corridor would have to be cleared for the feeder line. The proposed converter terminal would be electrically connected to the expanded ground electrode by a dedicated metallic return conductor installed on the proposed DC transmission structures from the proposed converter terminal to the Phase I converter terminal. At the Comerford terminal, the conductor would be connected to the Phase I ground electrode feeder line.

2.1.4.2 Construction Activities

Schedule

Design and construction of the proposed Phase II transmission lines, coupled with required relocations of the 115- and 69-kV AC transmission lines, would take place over a 5-year period. The proposed converter terminal would be constructed over a 3-year period.

Design of the proposed DC line began in March 1985 and will continue through 1986; design of the proposed AC lines will continue through the first quarter of 1989 (ER, Vol. 2). Material would be ordered for the transmission lines from August 1986 through August 1989. Construction of the proposed DC line would start in September 1987 and be completed in January 1990. Relocations of the 115- and 69-kV lines would occur between August 1987 and July 1989. The proposed 345-kV AC lines would be constructed between September 1988 and April 1990.

Site preparation for the proposed converter terminal would begin in July 1987 and be completed by January 1988. Site foundation work would be completed by October 1988. The building and switchyard structures are expected to be completed by July 1989, with the electrical power equipment to be installed by March 1990. Final facility testing would be completed by July 1990.

Right-of-Way Clearing Practices

As necessary, transmission line rights-of-way would be cleared of trees (with shrubs retained where possible) to facilitate (1) staking, access, assembly, and erection of structures; (2) installation of conductors; and (3) maintenance. This would also provide adequate clearance for energized lines. The clearing program would be planned and implemented to encourage growth of desirable, low-growing plants. This would help stabilize the rights-of-way against erosion and provide for natural vegetation control. Areas requiring clearing are discussed in Section 4.1.4.1.

Generally, tall-growing trees would be cut near ground level, leaving the stumps and roots in place. Stumps would be removed in areas where access roads and structures are to be located. Sawlogs, pulpwood, and cordwood resulting from clearing would be sold or stacked and left at the edge of the right-of-way. Slash would be chipped and removed or spread over designated areas of the right-of-way. In areas inaccessible to logging machinery, felled timber would be left. These practices comply with applicable state regulations (ER, Vols. 2 and 3).

Access and Maintenance Roads

To the extent possible, existing roads would be used to gain access to project sites, although it is anticipated that some of the roads would need upgrading, such as alignment improvement, grading, and widening. Some new access roads would be required both within the rights-of-way and from existing roads to the rights-of-way. Off-road access may be pursued in special cases, e.g., steep slopes, wetlands, and agricultural areas (ER, Vols. 2 and 3). The number and location of the new access roads have not been determined, but the need for new roads would be limited because most of the proposed transmission lines would be constructed within existing rights-of-way. To the extent possible, construction staging areas would be located at existing cleared areas along the proposed route.

Methods to mitigate erosion related to construction of access roads and staging areas are listed in Sections 2.1.5.2 and 2.1.5.3.

Support Structure Installation, Framing, and Stringing

In upland areas, construction of support structures would include excavation, setting the structure, and backfilling the excavation. The 345-kV AC H-frame structures would be directly embedded with either locally excavated material or selected clean backfill. The H-frame structures for the ±450-kV DC line would employ concrete cylindrical caisson, spread-footing, or steel grillage foundations. The single-shaft DC structures; single-steel-pole, 345-kV AC structures; and double-circuit, 115-kV AC, single-steel-pole structures would be directly embedded or set in concrete cylindrical caisson foundations. Most steel pole angle structures would require concrete cylindrical caisson foundations.

Directly embedded structures would require excavations ranging from 3 to 7.5 m (10 to 25 ft) deep and 1 to 3.7 m (3 to 12 ft) in diameter. The concrete cylindrical caisson foundations would require excavations 4.6 to 11 m (15 to 35 ft) deep with a 1.8- to 3.7-m (6- to 12-ft) diameter opening. A spread-footing foundation would require an excavation of 4.6 to 9.1 m (15 to 30 ft) in width and length and about 3 to 4.6 m (10 to 15 ft) in depth. The steel grillage foundation would require an excavation 3 to 6 m (10 to 20 ft) by 6 to 9 m (20 to 30 ft) and a depth of 3 to 4.6 m (10 to 15 ft). Grillage of heavy steel members would then be built up from the bottom of the excavation to the original grade. The excavation would be backfilled and legs of the H-frame structure bolted to the exposed members of the grillage (ER, Vols. 2 and 3).

Three methods of structure placement would be used in wetlands. The first is direct embedment within an excavation 1 to 2 m (3 to 7 ft) in diameter and 3 to 9 m (10 to 30 ft) deep. The second method is to drive piles into underlying firm ground and attach the structures to the piles. The third method is to install a concrete foundation and set the structure on the foundation. Site-specific evaluations based on structure types, soil strength, structural loads, environmental impact, and economics would need to be made by the Applicant in determining which structure placement method to use (ER, Vols. 2 and 3).

After support structures were in place, insulators would be installed and aerial groundwires and conductors would be strung. Conductors would be pulled through the stringing blocks by tensioning equipment.

Converter Terminal

Construction of the proposed converter terminal would include (1) site preparation, (2) foundation work, (3) erection of buildings and structures, (4) installation of power equipment, and (5) testing and commissioning. Site preparation would include surveying, clearing, and grading of the terminal site. Where feasible, a buffer zone of uncut vegetation would be left around the site to act as a screen. The cleared site would be covered with a layer of crushed rock to prevent regrowth of vegetation and then would be fenced. Foundation work would include forming and pouring foundations for the buildings and switchyard structures. Concrete and other building materials would be trucked in from offsite. Erection of the buildings and switchyard structures and installation of the electrical power equipment would require cranes, utility trucks, and other construction equipment.

Expansion of the Ground Electrode

Expansion of the Phase I ground electrode system would necessitate improvements to an existing logging road to allow access for construction equipment to the site for the Phase II array. Additionally, a short, 15-m (50-ft) wide corridor would be cleared for the proposed ground electrode feeder connector. The ground electrode array would require eight electrode holes, each 0.3 m (1 ft) in diameter and 40 to 70 m (130 to 230 ft) deep. Coke breeze, a graphitic material that is a good conductor of electricity, would be shipped to the site for use as borehole backfill (ER, Vol. 8).

2.1.5 Mitigative Measures Committed to by the Applicant

The following subsections summarize the measures committed to by the Applicant to mitigate impacts from construction, operation, and maintenance of proposed project facilities. The environmental consequences of the project, evaluated in Section 4, are based on the assumption that these mitigative measures will be carried out. If DOE determines that an amendment to the Phase I permit is in the public interest, a condition will be placed in that amendment requiring the Applicant to implement the mitigative measures identified in this section.

2.1.5.1 Air Quality

Practices that the Applicant would implement to mitigate impacts to land and water resources (see below) generally also would help mitigate impacts on air quality. These include the following:

- *Except where transmission lines and an access road enter and leave the proposed converter terminal site, natural vegetation would be left intact between the proposed converter terminal and areas where the public has access.* [While this mitigative measure would primarily minimize ecological and visual impacts, it also would mitigate noise impacts to nearby residents.]

- *The transmission line systems have been designed so that air-quality changes resulting from their operation would be minimal and generally confined to the right-of-way.*

- *Construction work would occur primarily during daylight, which would minimize off-hour noise impacts to nearby residents. Power equipment at the converter terminal site would be designed and located so that the noise at the nearest residence would not be objectionable relative to existing ambient noise levels.*

2.1.5.2 Land Features and Use

Land Features

Impacts related to unstable slopes would be mitigated through the use of careful siting of structures and use of thoroughly supervised construction practices. Judicious siting of project facilities would be employed to minimize the impacts associated with geological instability, such as landslides, slumping, mass wasting, and earthquakes. The following criteria represent specific mitigative measures committed to by the Applicant:

- *To reduce the potential for erosion and mass soil movement, areas that are known to be susceptible to erosion or slope instability would be evaluated during final design. Transmission structures would be located to avoid large areas of steep or unstable slopes wherever practical, and other construction work would, when possible, be conducted in a manner that minimizes changes in natural topography and disturbances of unstable areas. In areas where this is not possible, excess excavated materials not used as backfill would be removed to a suitable disposal site.*

- *Landscape alterations for transmission structure foundations and access roads would be minimized to reduce erosion losses. The converter terminal switchyard would be surfaced with crushed rock. In general, grading and leveling would be avoided at potentially unstable areas.*

- *Typically, excavation for structures would be limited to transmission structure foundation holes and the converter terminal site.* [This is not expected to create other than minor problems of instability.]

- *Existing access roads, bridges, and cleared areas would be used to the extent possible during construction. Construction of new roads would be* *held to a minimum to ensure the least disturbance to soil, vegetation, and water.*

- *New access roads would follow, wherever practical, the natural contour of land so that excessive cutting and filling would be avoided.*

- *Access roads would be maintained to minimize erosion due to construction traffic, and traffic would be confined to the right-of-way and designated roads.*

- *Overland travel would be minimized where the right-of-way crosses riverbanks or passes close to lakes, wetlands, or other surface waterbodies to minimize potential soil erosion and sediment transport.*

- *In areas subject to erosion, roads used for construction which will not be used for maintenance access would be restored to the original natural contour of the land and revegetated, after construction. Where construction roads will be used for maintenance access, drainage and erosion control devices would be left in place and side slopes would be graded and stabilized to blend with the terrain.*

Land Use

Criteria adopted for routing the proposed transmission lines would tend to limit land-use impacts. For example, the proposed route is direct, thus minimizing the overall length of the lines. Furthermore, the proposed lines would be constructed almost entirely within established rights-of-way, thus essentially maintaining compatibility with existing land-use patterns and minimizing additional impacts to adjacent land uses. Furthermore, the following mitigative measures would be instituted:

- *Wherever possible, placement of transmission structures in agricultural areas would be avoided. Where feasible, the heights of structures would be increased in order to span croplands.*

- *Reasonable attempts would be made to place proposed transmission structures directly opposite to, or in line with, existing structures, thus concentrating structures in one portion of the agricultural area and minimizing inconvenience to operators of farm machinery.*

- *Typically, structures would be self-supporting and no guy wires would be used, thus minimizing the amount of cropland unavailable for production.*

- *After construction, access roads in cropland areas where the soil has been compacted would be loosened through tillage and seeded or left fallow, depending on the land owner's wishes.*

- *Fences and stone walls would be repaired upon completion of construction.*

- *Clearing operations would be supervised by experienced foresters and construction supervisors.*

- *Slash and small trees would be chipped and the material would be either spread over designated areas on the right-of-way or hauled offsite for disposal. At the converter terminal site, grubbed stumps would be hauled offsite and buried. Where practicable, merchantable timber would be cut to length, skidded offsite, and sold.*

- *Wherever possible, construction and maintenance access roads would be located so as to minimize disturbance of residential and commercial areas.*

- *Construction activities would be intermittent and would be spread along the entire length of the proposed lines, thereby reducing the potential for local traffic congestion due to the proposed project.*

- *During line-stringing operations, guard structures would be placed at all highway, railroad, and existing utility line crossings to ensure public safety and minimize disruption of traffic flow patterns.*

- *Construction of the proposed lines would be closely coordinated with affected railroads in order to minimize interference with scheduled rail traffic.*

- *The Federal Aviation Administration would be notified relative to the proximity of proposed lines to airports, and measures required by the FAA would be implemented.*

- *Crossings of the proposed lines over existing transmission lines would be coordinated with owner utilities.*

- *All conductor clearances of the proposed lines over highways, railroads, and existing transmission lines would be in accord with the National Electric Safety Code and appropriate state codes.*

- *Following project construction, the construction laydown and staging areas that had been established at various locations along the proposed transmission line routes would be restored to conditions similar to what existed prior to project construction.*

2.1.5.3 Hydrology, Water Quality, and Water Use

Construction of the transmission line system and use of related access roads could increase soil erosion and stream channel siltation due to alteration of near-surface materials. However, careful location, construction, and maintenance of the transmission facilities and access roads could minimize these adverse impacts. Specific mitigative measures would include the following:

- *Proposed facilities would be designed and constructed so as not to interfere with local drainage patterns.*

- *In general, streambank grading for construction sites and access routes would be avoided; machine clearing would be prohibited within steep-slope areas adjacent to streams; and river fording would be held to a minimum. Streams would be forded only where streambanks and bottom* *materials were sufficiently stable. Fording by heavy equipment and vehicles would be minimized or avoided where practicable.*

- *Gravel would not be removed from stream bottoms, although it might be moved to enable culvert placement.*

- *As a general practice, transmission line structures and foundations would not be placed in rivers or lakes; structures would be set back as far as practical from riverbanks and streambanks to reduce the potential for erosion and sedimentation; and transmission line facilities would span existing water supply reservoirs.*

- *Where feasible, stream and river crossings would be at or near right angles to the water course. Access roads would be located to avoid streams and wetlands to the extent feasible.*

- *Where practicable, vegetation buffers (native ground cover, brush, and low-growing trees) would be left along streams to stabilize the soil, trap sediments, and thus minimize surface runoff erosion and other adverse impacts to water quality.*

- *Construction sites and access routes would be located to avoid areas of unstable soils, steeply sloped riverbanks, streams, and wetlands wherever feasible.*

- *Excavated soils from structure foundations would not be disposed of in waterbodies.*

- *Construction sites would be prepared in a manner that minimizes erosion and probability of stream or wetland sedimentation.*

- *In the vicinity of streams, existing roads and bridges would be used as much as practical for transporting materials and equipment during construction. Any damage to permanent access roads, bridges, ditches, and culverts caused by transportation of construction equipment or supplies would be repaired.*

- *Culverts, ditches, and waterbars would be installed, as needed, at stream crossings to control surface runoff, maintain existing drainage patterns, and minimize erosion.*

- *Unless they are to be used for transmission-line or right-of-way maintenance, temporary bridges, culverts, and other such facilities would be carefully removed, and the disturbed area restored after project completion.*

2.1.5.4 Ecology

Since herbicide use has the potential to affect both aquatic and terrestrial resources, the Applicant has committed to the following mitigative measures that relate to herbicide use in general and to use near waterbodies:

- *The Applicant would only use herbicides that are registered with the U.S. Environmental Protection Agency and approved for use in right-of-way management by the states in which they are to be applied.*

- *Herbicides would only be applied by means of selective spray application by workers using hand-held application tools, and there would be no broadcast application. Only state-licensed or certified operators would supervise herbicide applications.*

- *No herbicides would be applied to surface waters, and state and company guidelines would be followed which establish buffer zones around sensitive areas (such as public water supplies, wells, and residences). These guidelines specify for each type of sensitive area whether no herbicides would be used, only certain herbicides would be used, or only certain herbicide application methods would be used (see Table B.1 in Appendix B for the current guidelines).*

Terrestrial Vegetation

- *All construction and vehicular activities not involved in right-of-way clearing, transmission line structure construction, or wire stringing would be restricted to designated work areas or access roads.*

- *The growth of herbaceous species, most shrubs, and some low-growing trees that are considered desirable ground cover for the right-of-way would be encouraged.*

- *No equipment containing polychlorinated biphenyls (PCBs) would be located at the converter terminal.*

- *Power transformer equipment containing insulating oil would be placed over pits capable of containing the entire volume of oil.*

Terrestrial Wildlife

The primary means by which impacts to wildlife would be mitigated are by careful routing and design of the transmission lines, including the following considerations:

- *The transmission lines have been designed to minimize corona effects (and hence, minimize air ion production, audible noise, radio and T.V. interference, and ozone production), and the large distances between the conductors and grounded structure parts minimize the likelihood of bird electrocution.*

Aquatic (Including Wetlands)

The mitigative measures discussed in Section 2.1.5.3 to minimize impacts on water quality also would minimize impacts on aquatic ecosystems, including wetlands. Additional details on mitigation of impacts to floodplains and wetlands are provided in Appendix B.

Threatened and Endangered Species

- *Final structure locations and construction schedules would be designed to avoid jeopardizing the continued existence of any endangered or threatened species found along the corridor.*

2.1.5.5 Socioeconomics

In general, socioeconomic impacts are projected to be minor and short term, and no significant mitigative measures have been developed, with the following exception:

- *The Applicant would reduce potential adverse effects to local traffic flows during construction through judicious choice of access roads and prior notification to communities.*

2.1.5.6 Visual Resources

The Applicant has conducted a visual resource characterization study of the natural and man-made features along the rights-of-way involved in this phase of the project (ER, Vols. 7 and 8). These mitigative measures are based, in part, on the results of that study. Mitigation proposed by the Applicant for visual resource impacts consists of measures in four general categories: design and location of structures, right-of-way treatments, measures involving the converter terminal site, and construction laydown and staging areas. Measures related to the design aspects of line structures include the following:

- *Tangent structures would be similar to adjacent existing structures in form and color; line angle steel pole structures would be self-supporting structures to avoid the visual impact of guy wires (lattice steel H-frame structures may require guy wires at line angles and dead ends).*

- *Structure heights would be minimized at points where significant reductions in line visibility could be achieved, consistent with other environmental objectives, such as spanning wetlands, croplands, or cultural resource areas.*

- *Two existing 115-kV lines would be rebuilt as a double-circuit line to minimize the number of structures within the Sandy Pond-Millbury right-of-way and eliminate the need for right-of-way expansion.*

Mitigative measures involving locations of line structures include the following:

- *Where feasible, placement of structures in visually sensitive areas would be avoided. In addition, when feasible, structures would be set back at least 15 m (50 ft) from public roadways.*

- *Where feasible, new structures would generally be located opposite or in line with existing structures to avoid a staggered appearance of structures and promote symmetry within the right-of-way.*

Considerations of right-of-way treatments would include the following:

- *Clearing would be minimized to permit preservation of a tree buffer along the edges of rights-of-way where practicable.*

- *When feasible, indigenous low-growing species would be preserved across rights-of-way at road crossings to provide visual screening. Where feasible, new plantings would be established in selected areas along or across rights-of-way and at the converter terminal at locations where screening would appreciably reduce visual impacts.*

- *Those converter terminal facilities with suitable finish would be painted colors compatible with the surrounding environment.*

- *Following use during construction, the small construction and staging areas located along the proposed routes would be reclaimed. Disturbed surfaces would be covered with stockpiled topsoil, if needed, and the overall appearances of the areas would be restored to conditions similar to those existing prior to project construction.*

2.1.5.7 Cultural Resources

The Applicant has conducted a literature/file search for previously recorded cultural resource sites along the proposed route and has conducted field surveys for archeological sites and historic structures (New England Power 1986). (The methodology and results of the surveys are described in Section 3.7 and Appendix C.) Proposed structure locations have been moved in those cases where archeological sites would lie within the estimated 9.3-m^2 (100-ft^2) construction-impact area. All federal and state regulations pertaining to cultural resources will be adhered to during construction. Additional mitigative measures include the following:

- *The Applicant would conduct further archeological testing, prior to construction, as appropriate should any proposed structure locations be moved to an archeologically sensitive area that has not previously been tested.*

- *Identified surficial cultural features on the right-of-way would be flagged to facilitate avoidance during the construction phase.*

- *The Applicant would assess potential impacts and the need for mitigation measures for adversely affected historic structures in proximity to the proposed rights-of-way in consultation with the New Hampshire and Massachusetts Historic Preservation Officers and, if necessary, the Advisory Council on Historic Preservation (New England Power 1986--p. 11).*

2.1.5.8 Health and Safety

- *Standard work practices and regulations would be followed to ensure the health and safety of workers to the fullest extent possible.*

- *All vegetation clearing, construction, and maintenance activities near public drinking water supplies would be done so as to avoid or minimize changes to water quality or quantity.*

- *Standard utility company practices would be followed where it is necessary to ground stationary objects such as fences, large metal roofs, fuel containers, and antennas that are located under the transmission lines.*

- *The ground electrode would be designed so that the ground current would not be perceptible to humans and animals with the system operating at full capacity.*

- *Special maintenance practices would be used near public and private wells and near public water supply reservoirs (hand-cutting of vegetation, use of specific herbicides, or specific herbicide application methods).*

- *Limitations on herbicide use established by the states of New Hampshire and Massachusetts would be followed (see Table B.1 in Appendix B for the current limitations).*

2.1.5.9 Radio and Television Interference

Radio and television interference from operation of the proposed AC and DC transmission lines could be mitigated by one or more measures. Mitigation typically involves reorientation, relocation, and/or replacement of receiver antennas. Television interference resulting from the physical presence of transmission facilities is usually also remedied by changes of antenna systems. Interference due to gap sparking is mitigated by routine maintenance of the transmission line facilities.

- *As a matter of policy, any television interference problems that can be attributed to the operation of the project facilities would be corrected by the Applicant.*

2.1.6 Related Consultation and Permitting Requirements

Consultation with certain federal and state agencies is required by statute. In addition, many federal and state agencies have some degree of responsibility for certain geographical or topical areas addressed in the environmental impact statement (EIS) (U.S. Department of Energy 1984). DOE requested consultation with each of the agencies identified in Table 2.3, and each was invited to contribute information and views to be considered by DOE staff while preparing the EIS. The U.S. Army Corps of Engineers was granted the role of cooperating agency in these proceedings. Table 2.4 presents a list of the federal licenses and/or approvals expected to be sought in connection with the Phase II facilities.

2.2 DESCRIPTION OF ALTERNATIVES TO THE INTERCONNECTION

The decision under consideration by DOE is to grant or deny an amendment to Presidential Permit PP-76 which would authorize an extension of a previously authorized international interconnection to be used for electric power exchanges between NEPOOL and Hydro-Quebec. Therefore, a no-action decision on the part of DOE is equivalent to denial of the permit amendment. Upon denial of the permit amendment, the Applicant could choose one of two basic courses of action: (1) maintaining the status quo by also taking no

Table 2.3. Consultations

Subject Area	Legislation	Agency
Endangered Species	Endangered Species Act of 1973, as amended; state laws	U.S. Fish and Wildlife Service; state agencies
Historic Preservation	Archeological and Historic Preservation Act of 1974; Archeological Resources Protection Act of 1979	State Historic Preservation Offices; Advisory Council on Historic Preservation
Work in Navigable Water	Section 404 of Federal Water Pollution Control Act	Corps of Engineers
Prime and Unique Farmlands	CEQ Memo of August 30, 1976	Soil Conservation Service
Floodplains	Executive Order 11988	Corps of Engineers; state agencies
Wetlands	Executive Order 11990	Corps of Engineers; state agencies
Water Pollution, Air Pollution	Various water pollution and air emissions acts (Federal Water Pollution Control Act, Clean Air, Clean Water Emissions Standards)	U.S. Environmental Protection Agency; state agencies
Land Use	Federal Land Policy and Management Act of 1976	Soil Conservation Service; state agencies
Water Use and Availability	Water Resources Planning Act of 1965; Safe Drinking Water Act; others	Office of Water Policy; state agencies
Soils	Soil and Water Resources Conservation Act of 1977	Soil Conservation Service
Noise	Noise Pollution and Abatement Act of 1970; Noise Control Act of 1972	U.S. Environmental Protection Agency; state agencies
Siting, Planning	State siting acts; county zoning commission regulations	State and county agencies
Solid Wastes	State laws	State agencies
Herbicide Use	State laws	State agencies

Table 2.4. Federal Licenses and Approvals

License/Approval	Agency
Amendment of Presidential Permit for Transmission of Energy at International Boundaries	Department of Energy, Economic Regulatory Administration
Amendment of Energy Export License	Department of Energy, Economic Regulatory Administration
Possible Amendment of Water Power Project License	Federal Energy Regulatory Commission
Rate Schedules and Financing[a]	Federal Energy Regulatory Commission
Dredge or Fill	Army Corps of Engineers
Cross Navigable Waters	Army Corps of Engineers
Possible National Pollutant Discharge Elimination System Permit	Environmental Protection Agency and Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control
Notice of Construction Affecting Navigable Airspace	Federal Aviation Administration
Microwave Facilities	Federal Communications Commission
Financing and Transactions Between Affiliates[a]	Securities and Exchange Commission

[a] These licenses/approvals are related to financing and corporate matters as distinguished from construction-type licenses or approvals.

action and (2) pursuing alternatives which could provide benefits similar to those of the proposed transmission project.

2.2.1 No-Action Alternative -- Maintain Status Quo

As discussed in Section 1, the benefits associated with the proposed action include a reduction in oil used to generate electricity, a reduction in the cost of electricity in New England, and a reduction in the requirements for future generating capacity additions. If a "no-action" alternative were chosen by DOE and the Applicant chose to maintain the status quo by not pursuing an alternative action, the oil consumption, electricity cost, and capacity requirement savings associated with the proposed action would not occur. This would mean the New England region would continue to rely on the use of oil for the production of approximately 21% of its electric energy requirements. This would increase oil consumption by approximately 12 million barrels per year over that which would be required if the Phase II interconnection were in service. Without the Phase II interconnection, New England oil consumption for electric generation is projected to be approximately 42 million barrels in 1994 (North American Reliability Council 1985).

In addition, the unrealized savings in fuel costs and incremental energy losses, and the loss of 900 MW of capacity benefits would combine to increase the cost of producing electricity in New England by approximately $832 million (cumulative present worth; 1990 dollars) over the 10-year period of the Phase II contract.

2.2.2 Construction and Operation of a New, Conventional Central Station Generating Facility

Instead of maintaining the status quo by taking no action, the Applicant could pursue other means of achieving the benefits associated with the proposed action. One of these alternatives is the construction of a new central-station, non-oil-fired generating plant. Candidate plant types would be limited to nuclear and coal since there are no remaining sites in New England that would support a large hydroelectric installation. Nonconventional energy sources -- such as biomass, solar, wind, etc. -- are discussed in Section 2.2.3.

While construction of a non-oil-fired generating plant could achieve the same level of reduction in oil consumption as the proposed action, the time required to license and construct such a plant (either nuclear or coal-fired) would not permit placing these alternatives in service before the mid to late-1990s. However, since the proposed action is not being considered primarily for reliability reasons (see Section 1), the timeliness of the non-oil-fired generating plant option, in itself, should not preclude consideration of this alternative.

A comparison of the life-cycle costs of energy from new non-oil-fired generating plants and the proposed transmission project favor the proposed action. An analysis conducted by DOE Staff concluded that the levelized cost (including capital costs, O&M, and fuel costs) of the energy to be imported over the proposed interconnection is estimated to be 9.06 ¢/kWh in 1990 dollars. Further analysis by DOE Staff suggests that the projected cost of energy from nuclear and coal-fired plants in 1990 could be 14.6 ¢/kWh and 12.4 ¢/kWh, respectively.

Construction and operation of a new, centralized generating facility (coal or nuclear) would result in generally different environmental impacts from those associated with the proposed interconnection extension. Because these impacts would be highly site- and design-specific, they cannot be quantified for detailed discussion here. Furthermore, it should be noted that during the construction of nuclear or coal-fired generating plant, certain mitigative measures would be employed in order to bring any potential impacts to within the limits established by the Environmental Protection Agency.

Features of a coal-fired powerplant that have the greatest potential for adverse environmental impacts include mining, cleaning, and storage of coal, emission of particulate and gaseous combustion products, disposal of fly ash and flue-gas desulfurization sludge, and release of thermal effluents to aquatic systems (Dvorak et al. 1978). Mining, cleaning, and storage of coal result in land disturbance, noise, and releases 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 to adversely affect 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 suspected 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. Visual impacts would also result from the powerplant and its associated structures, as well as visible emissions from smokestacks and cooling towers (if any). The effects of construction of new transmission lines associated with the new powerplant would be qualitatively similar to those discussed for the proposed interconnection extension.

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 extension would probably be combustion emissions. Localized deterioration of air quality in terms of sulfur dioxide and particulates would likely result from operation of a plant of that capacity (Dvorak et al. 1978). Although the level of combustion emissions would be brought to within prescribed limits by the use of appropriate emission control strategies, the net emissions would be greater than for the proposed action, which does not require the combustion of fossil fuel.

Air-quality impacts from an operating nuclear plant are negligible, but land disturbance for plant and transmission facilities would be similar to that for a coal-fired plant, as would the potential thermal effects to aquatic systems. Currently, no new nuclear plants are under construction-license consideration by the U.S. Nuclear Regulatory Commission.

2.2.3 Construction and Operation of Nonconventional Generating Facilities

Solar-, wind-, and biomass-powered facilities of a size required to meet the energy supply level of the proposed interconnection cannot be considered as alternatives to the proposed action. 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 proposed project. Furthermore, because New England will continue to rely on oil for at least 15% of its electric energy needs even with the proposed project in service, these technologies can be considered as additional oil-saving measures rather than alternatives to the proposed action. Notwithstanding, these fuels are now available and will be used increasingly at small, dispersed sites throughout New England (U.S. Department of Energy 1981). Dispersed use of these technologies is discussed in Section 2.2.5.

2.2.4 Conservation and Load Management

Implementation of conservation measures (e.g., insulation, weatherization, energy-efficient appliances or machinery, and more efficient lighting and heating) in any of the customer classes (residential, industrial, or commercial) results in less energy use, which may be translated into less demand for energy produced by oil-fired generating capacity.

Load management is a method to increase the base load by reducing peak power demands while filling in low demand periods of the load cycle. This more effective use of utility generating capacity is accomplished by attempting to alter customer use patterns (ER, Vol. 6). While load management initiatives have reduced, and will continue to reduce, energy demands, expected growth rates for electricity consumption are still projected to be high enough to require significant new sources of non-oil-fired generation.

Electric energy demand projections for the NEPOOL service area (see Section 1) include the assumption that by the year 2000 the effects of conservation by NEPOOL customers and utility load management and conservation programs will reduce the demand for electricity by 1000 MW from what customer demand otherwise would be without these programs in place. Therefore, the benefits of the proposed interconnection are in addition to any benefits derived from conservation and load management, and the proposed project does not preclude further pursuance of these programs.

2.2.5 Decentralized Energy Sources

Dispersed applications of various small scale energy technologies -- e.g., (1) solar, primarily for single-residence or business applications of solar water or space heating, and photovoltaic power generation; (2) wind-electric generation; (3) low-head hydroelectric installations; (4) coal-fired industrial cogeneration; and (5) wood stoves for home and business space heating -- also could decrease electric energy demand and reduce the need for oil-based electric energy.

The member companies of NEPOOL are actively pursuing the development of alternative generation sources, and projected contributions from these sources have been included in the planning studies. For example, New England Electric began purchasing power (about 15 MW) from the Lawrence hydroelectric project in September 1981. Several other small hydroelectric projects are also in the development/construction stages, but these will produce less than 50 MW of capacity (ER, Vol. 6).

A study by the New England River Basins Commission (1981) concluded that the entire New England region had the potential for developing only 144 MW of new hydroelectric facilities at 130 sites throughout the region. (See Section 2.2.5 for discussion of small, decentralized energy sources). Therefore, DOE does not believe that a hydroelectric facility is a viable candidate plant type for consideration as an alternative.

New England Electric also was involved in the construction of the U.S. Windpower Windfarm at Crotched Mountain, New Hampshire, where 20 wind machines had a total installed capacity of 1 MW. While this development did not meet expectations, new windfarms near Canaan, New Hampshire, and Florida, Massachusetts, are in developmental stages (ER, Vol. 6). New England Electric 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. Other NEPOOL companies have similar programs. Data Resources, Inc. (1985--Table A-62) estimates that solar energy and other decentralized sources will contribute less than 300 MW to New England sources of electricity supply through the year 2000. Therefore, the alternatives discussed above cannot be considered alternatives to the proposed project, but simply additional ways to meet the overall objective of reduction in oil-fired generation.

2.2.6 Fuel Conversion

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 the use of oil and natural gas to the use of coal (U.S. Department of Energy 1981, 1982). It was concluded that as many as 27 powerplants could qualify for the voluntary conversion provisions of the Omnibus Budget Reconciliation Act of 1981 (U.S. Department of Energy 1982). A number of the plants identified were in the NEPOOL region. However, to date only 12 of these 27 powerplants have been converted. The utilities in New England are not actively pursuing conversion of the remaining plants because of scheduled retirements, site limitations, or economic considerations. Therefore, the approval or denial of a Presidential Permit amendment for the proposed transmission project would neither preclude nor promote additional coal conversion activities. Furthermore, future conversions could be considered complementary rather than alternatives to the proposed action since coal conversions would reduce the average cost of fossil-fired electric generation in New England and thereby reduce the cost of energy purchased under the terms of the Phase II agreement.

2.2.7 Purchase of Power From Other Utilities

Presently, several NEPOOL members purchase power from the New York Power Authority (NYPA), Hydro-Quebec, the New Brunswick Electric Power Commission (NBEPC), and, to a limited extent, Ontario Hydro. The search for alternative sources of purchased power can be broken down into two areas: contiguous utility systems and systems which are far removed from NEPOOL. However, in order to be considered a viable alternative, a potential source must be able to provide NEPOOL with a comparable quantity of firm (guaranteed) energy at prices which are competitive with those of the Phase II agreement.

One of the contiguous utility systems which is a potential source of purchased power is the New York Power Pool (NYPP). NYPP is comprised of the major electric utilities in New York State. NYPP is heavily dependent upon oil for the production of electric energy and is presently a competitor of NEPOOL for the surplus hydroelectric energy available in Canada and the coal-fired surpluses in the midwestern United States.

Several NEPOOL members currently purchase power from the Point Lepreau Unit #1 nuclear generating unit which is owned and operated by the NBEPC. Provincial officials in New Brunswick have indicated an interest in constructing a second unit at Point Lepreau if U.S. utilities would be willing to purchase a sufficiently large portion of the output of the unit. NEPOOL has determined that the total cost of energy from this second unit would be about 80% more expensive than the energy from the Phase II agreement. In addition, the delivery of energy from this unit to the load center in Massachusetts likely would require the construction of a 345-kV AC transmission line through the state of Maine. The DOE Staff has reviewed this assessment and has determined that, while the magnitude of the cost differential between Phase II energy and Point Lepreau #2 energy appears to be somewhat overstated (when one considers the projected cost of energy from U.S. nuclear plants), the relative economics do appear to favor the Phase II energy. Furthermore, the 345-kV transmission line required to implement this alternative would be approximately 290 km (180 mi) long, possibly not along existing rights-of-way, and would likely result in greater environmental impact.

The Midwest is considered another potential source of purchased power because of its present surplus of non-oil-fired capacity. The Midwest generally is considered to include the utilities within the East Central Area Reliability Council (ECAR). ECAR is another of the nine regional reliability councils of the North American Electric Reliability Council. This council includes electric utilities in Michigan, Indiana, Ohio, Kentucky, West Virginia, and parts of Virginia and Pennsylvania. There are several factors which preclude consideration of Midwest energy as a viable alternative to the proposed action:

(1) Load and capacity projections indicate that the present capacity surpluses enjoyed by the ECAR utilities would not last long enough to sustain a firm energy sale to NEPOOL through the 1990s.

(2) Any available surpluses are likely to be purchased by utilities in the Pennsylvania-New Jersey-Maryland region (PJM) which have existing direct transmission connections to ECAR utilities.

(3) Any power purchased from ECAR must follow through the central New York State and PJM systems. The transmission systems in these areas are already heavily utilized and could not withstand the additional load imposed by wheeling Midwest energy to New England.

(4) The construction of additional transmission through New York and/or the states of the PJM systems could meet with various regulatory,

legal, and environmental obstacles which could prevent or delay implementation and raise the final cost of the energy.

However, an analysis performed by the applicant indicates that, notwithstanding the above logistical impediments to the purchase of Midwest power, the total cost of energy delivered to New England would be almost double that of the Phase II agreement. The DOE Staff has reviewed this analysis and is in agreement with this conclusion.

2.2.8 Description of Alternative Converter Terminal Sites, Routes, and Designs

Potential alternative routes were identified by the Applicant on the basis of existing rights-of-way, as discussed in Section 2.1.2. Based on these considerations, the Applicant's analyses initially identified six potential converter terminal sites and three potential DC corridor routes (ER, Vol. 4). These alternatives were then evaluated based on a number of environmental and economic considerations. The DOE Staff has reviewed the methodology and rationale employed by the Applicant in evaluating alternatives, and based on that review concludes that the alternatives identified by the Applicant are viable and provide an adequate basis for comparative evaluation with the proposed route and proposed converter terminal site.

2.2.8.1 Converter Terminal Options

Options for converter terminal locations were initially determined on the basis of system reliability (ER, Vol. 4). This criterion was then used in conjunction with economic considerations and the occurrence of existing transmission corridors to rank terminal locations. No feasible alternative to the northern terminus for the proposed Phase II project exists. Siting of the northern terminus at any location other than at the proposed Comerford terminal site at Monroe, New Hampshire, would necessitate construction of a new DC line from the Canadian border. Also, full capacity utilization of the Phase I DC transmission line could be achieved only with the northern terminus for the Phase II project located at the Comerford terminal site (ER, Vol. 4).

Six potential sites were identified for the Phase II converter terminal: Monroe and Londonberry, New Hampshire; Ludlow, Millbury, Tewksbury, and Groton/Ayer, Massachusetts. These sites were chosen because they provided a wide geographic range in identifying an economically optimal network or because they were located near the site of an AC substation. Based on these considerations, only the proposed Sandy Pond site at Groton/Ayer and the alternative at Tewksbury were deemed feasible. This decision was based primarily on economic considerations (ER, Vol. 4). The economic considerations also translate into environmental, social, land use, and other considerations, because the extra costs are primarily associated with forest clearing, wetland modification, land condemnation, and similar activities.

The alternative Tewksbury converter terminal site would be located near the existing Tewksbury 345-kV AC substation. This site is about 32 km (20 mi) east of the proposed converter terminal site. Land area, equipment, grounding system, communication system, and other facilities that would be required for the Tewksbury converter terminal are the same as, or similar to, those needed for the proposed Sandy Pond converter terminal (see Section 2.1). The major differences between the two terminals relates to development of the facilities. The Tewksbury terminal would require construction in a wetland and floodplain. Also, because the Tewksbury site is located in an area of numerous existing overhead transmission lines, ground-surface-installed sulfur hexafluoride bus ducts would have to be used for the two 345-kV AC circuit connections with the Tewksbury 345-kV AC substation (ER, Vol. 1). The connector circuits would each be about 0.6 km (0.4 mi) long.

2.2.8.2 AC Reinforcements

Essentially the same two AC transmission system reinforcements as proposed would be required whether the converter terminal were located at Sandy Pond or at Tewksbury. The proposed AC system is described in Section 2.1.4.1.

2.2.8.3 DC Route Alternatives

On the basis of the criteria discussed in Section 2.1.2, three alternative routes for the DC line have been identified: (1) the Tewksbury alternative (Figures 2.5 and 2.6), (2) the eastern alternative (Figures 2.7 and 2.8), and (3) the western alternative (Figures 2.9 and 2.10). The Tewksbury alternative would involve use of the alternative Tewksbury converter site and provide as direct as possible routing of the DC line from Comerford to Tewksbury. The eastern alternative would utilize the nearest north-south right-of-way east of the proposed DC route, and would terminate at the proposed Sandy Pond terminal. Similarly, the western alternative would utilize the nearest existing north-south right-of-way west of the proposed DC line.

The first 181 km (112.5 mi) of the Tewksbury line (to the town of Hudson, New Hampshire) would be the same as the proposed DC route (see Section 2.1.3). The remaining 23.5 km (14.6 mi) would follow an existing right-of-way southeast to the alternative Tewksbury terminal site. This stretch would run between two 230-kV AC transmission lines. A 115-kV AC line presently located between the 230-kV lines would have to be relocated for a 15.1-km (9.4-mi) stretch between Hudson, New Hampshire, and Dracut, Massachusetts. Additionally, a 7.2-km (4.5-mi) stretch from Dracut to Tewksbury would require relocation of the 115-kV line and relocation of an existing 230-kV AC line and a planned 345-kV AC line onto double-circuit, single-pole structures.

The eastern alternative would extend for 248 km (154 mi) from the Comerford terminal to the proposed Sandy Pond terminal site. Most of the route would be along existing rights-of-way. However, in many cases these rights-of-way are too narrow to accommodate the new DC line, and thus significant right-of-way acquisition and clearing would be required (ER, Vol. 4--p. 55). From the Comerford terminal, the eastern alternative would follow existing rights-of-way east and south for about 163 km (101 mi) to the vicinity of the Merrimack station in Bow, New Hampshire. These rights-of-way are occupied primarily by 115-kV AC lines and intermittently by a 60-kV AC line. The eastern alternative would then follow existing right-of-way southwest for about 53 km (33 mi), crossing the proposed route near the Greggs

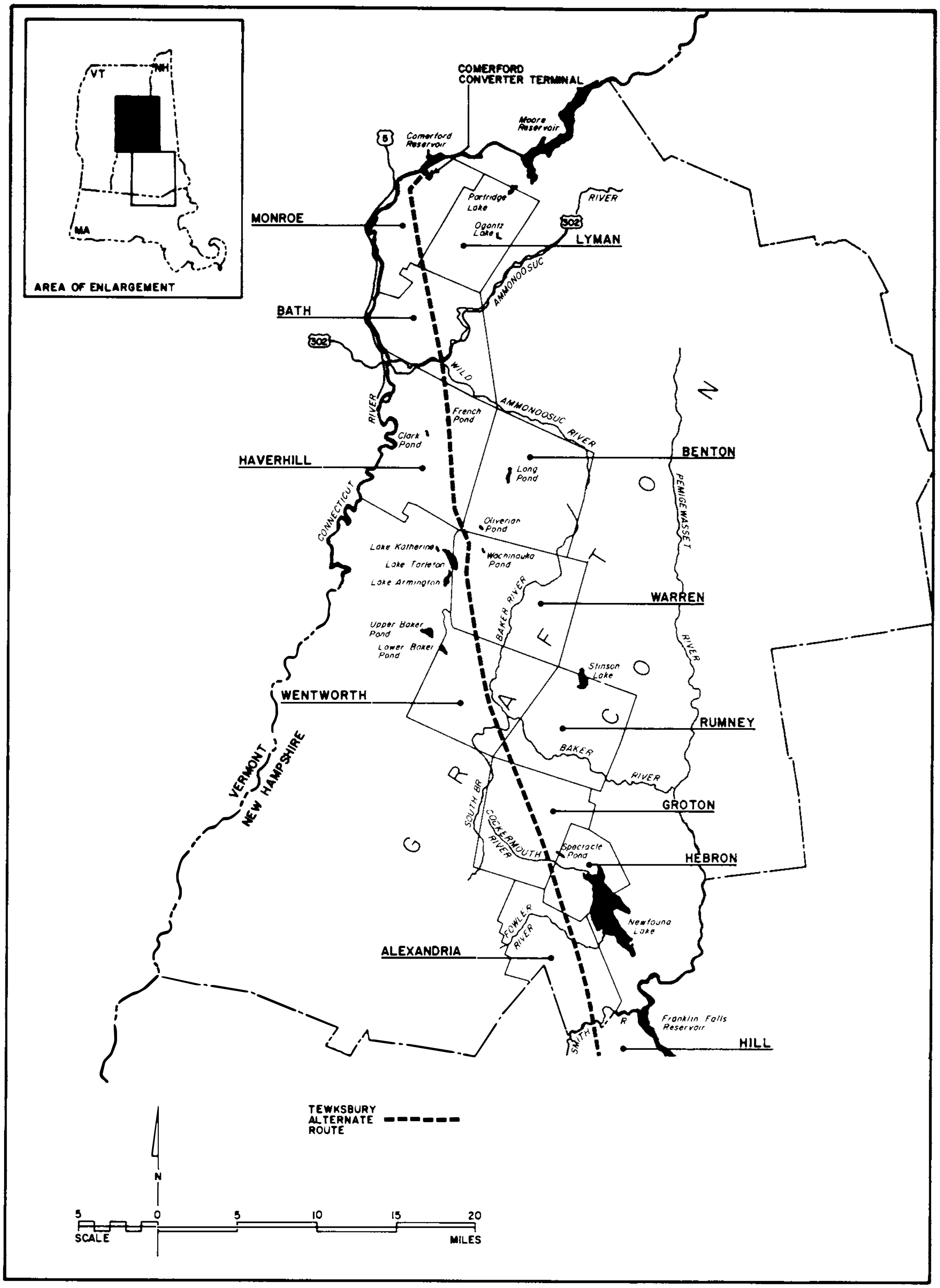

Figure 2.5. Northern Segment of the Tewksbury Alternative Route. (Map provided by the Applicant.)

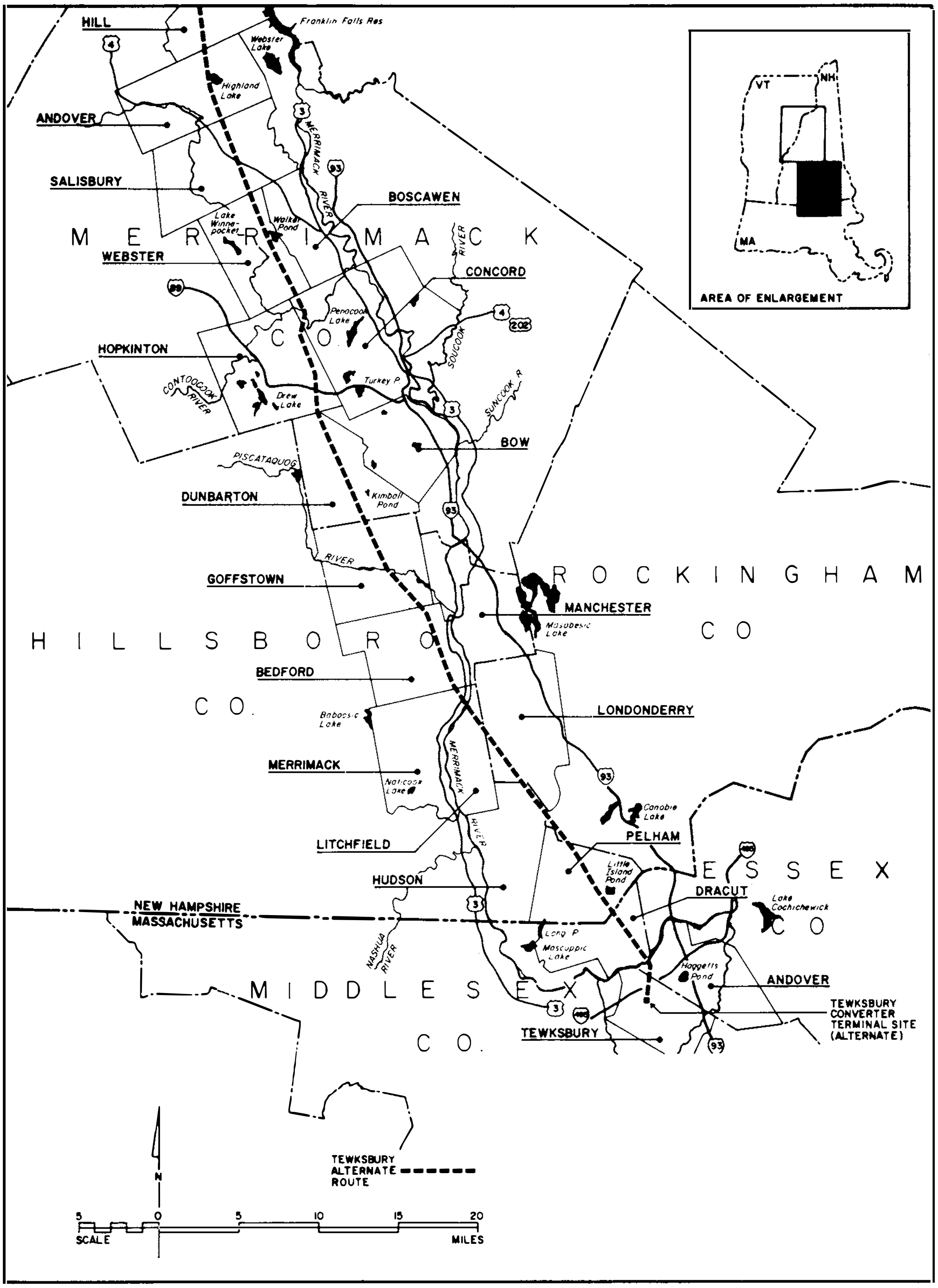

Figure 2.6. Southern Segment of the Tewksbury Alternative Route. (Map provided by the Applicant.)

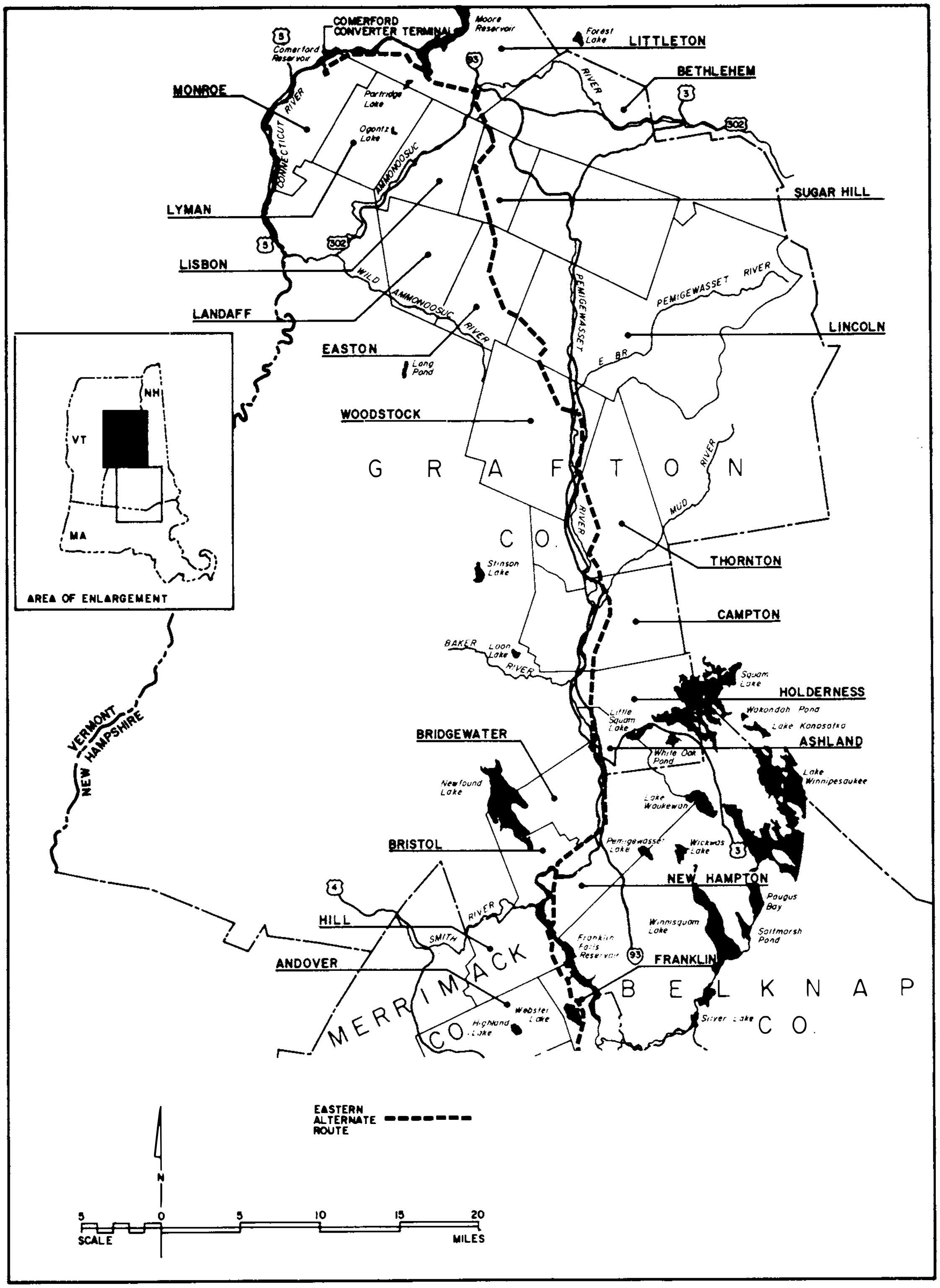

Figure 2.7. Northern Segment of the Eastern Alternative Route.
(Map provided by the Applicant.)

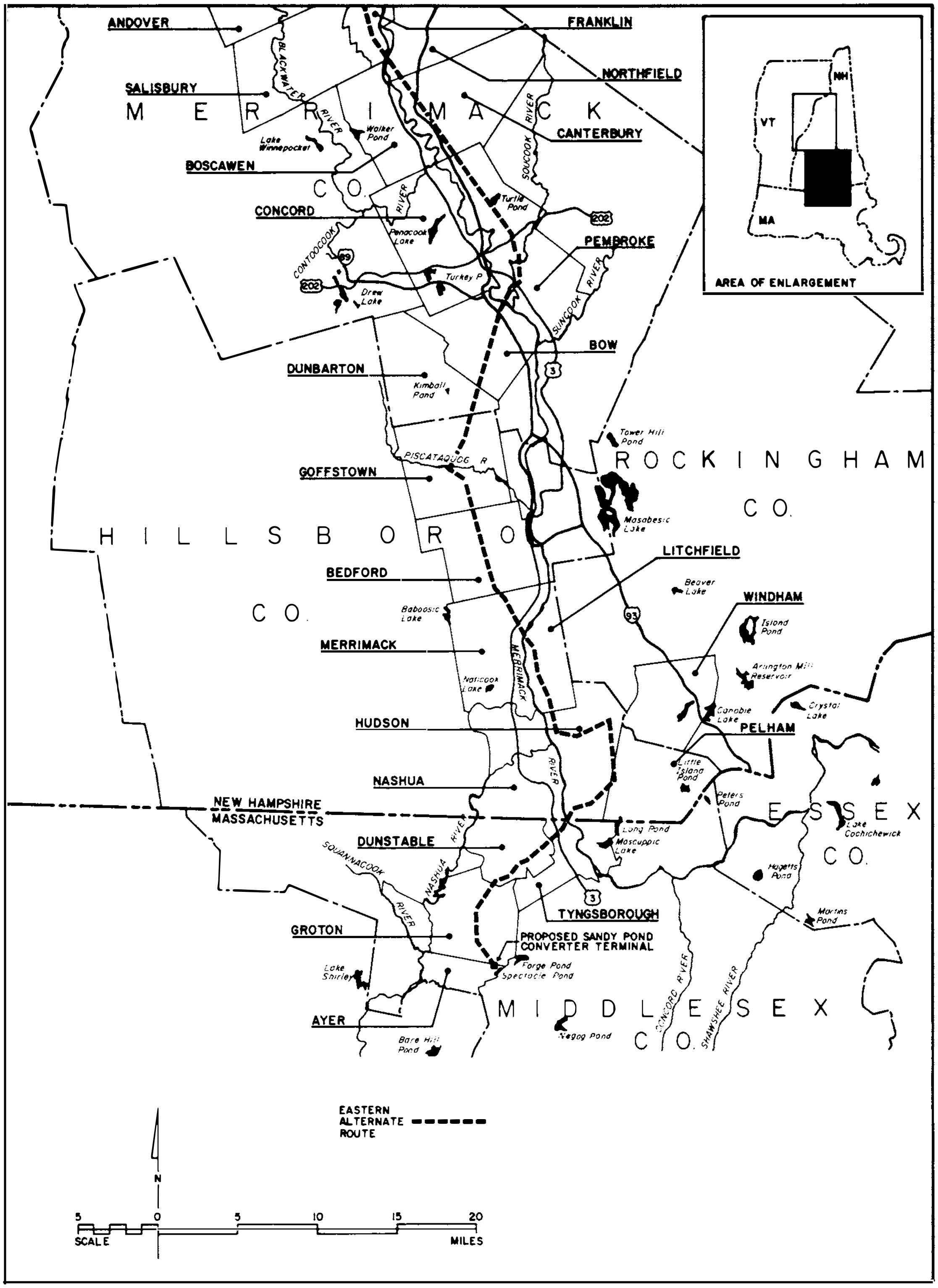

Figure 2.8. Southern Segment of the Eastern Alternative Route.
(Map provided by the Applicant.)

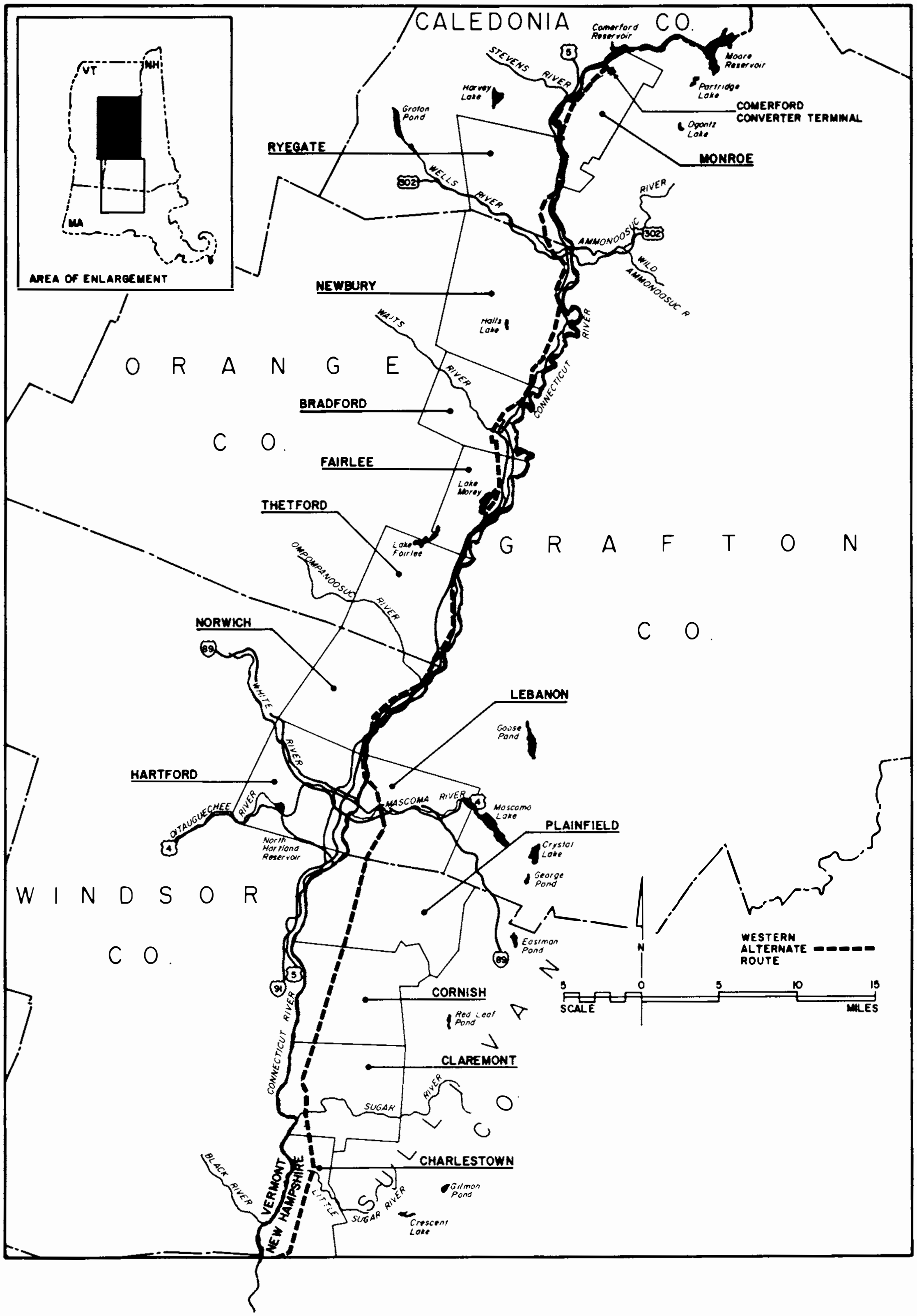

Figure 2.9. Northern Segment of the Western Alternative Route. (Map provided by the Applicant.)

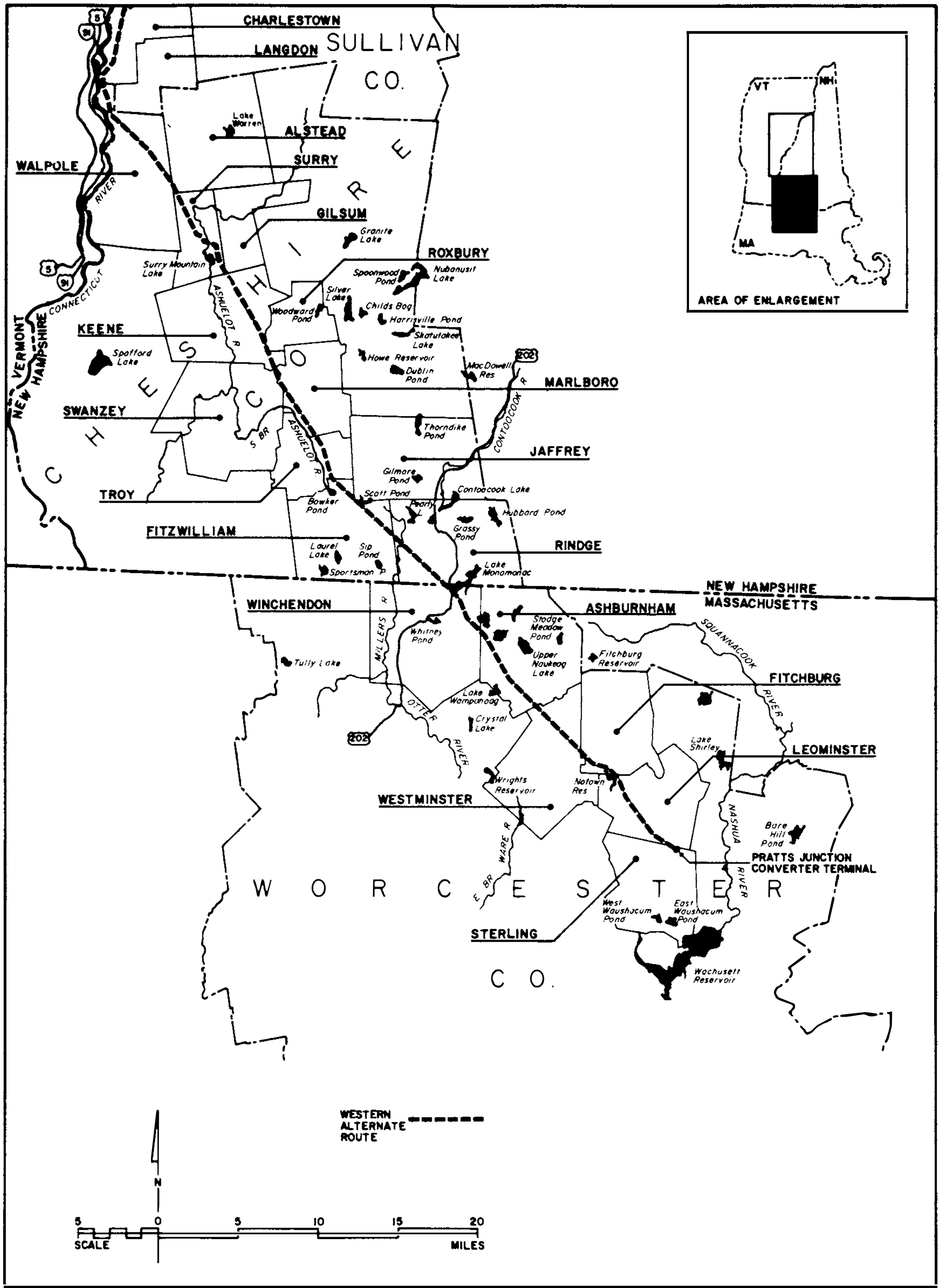

Figure 2.10. Southern Segment of the Western Alternative Route. (Map provided by the Applicant.)

substation in Goffstown, New Hampshire, and then would proceed southeast until it joined the right-of-way of the proposed DC line in Hudson, New Hampshire. This stretch is occupied primarily by 115-kV AC lines and intermittently by low-voltage lines. The remaining 32 km (20 mi) of the eastern alternative would be identical to the proposed route (see Section 2.1.3).

The western alternative would extend for 246 km (153 mi) from the Comerford terminal to the Phase II converter terminal site. Similar to the case for the eastern alternative, the need to widen the existing rights-of-way to accommodate the new DC line would necessitate significant right-of-way acquisition and clearing along the western alternative route. From Comerford, the route would extend about 87 km (54 mi) southwest along existing right-of-way to the Wilder hydroelectric generating station in Hartford, Vermont. The existing right-of-way is occupied primarily by 34.5- to 46-kV AC lines. This right-of-way follows the Connecticut River Valley in Vermont for about 76 km (47 mi). For the next 64 km (40 mi), the western alternative would extend south within an existing right-of-way paralleling the Connecticut River Valley on the New Hampshire side to Walpole, New Hampshire. A 115-kV AC line currently occupies this right-of-way. The western alternative would follow a double-circuit, 115-kV AC line for about 95 km (59 mi) to the Pratts Junction 69/115/230-kV AC substation in Sterling, Massachusetts. Various segments of the 115-kV line would require relocation. Rather than running the Western alternative back north about 24 km (15 mi) to the proposed Sandy Pond converter terminal site, the Applicant would construct a converter terminal adjacent to the Pratts Junction substation. A new 345-kV AC substation at Pratts Junction would also have to be constructed to connect the converter terminal to the 345-kV AC transmission system (ER, Vol. 4).

2.2.8.4 Design Alternatives

Several alternative structure designs were considered for the DC line: steel-pole H-frame, steel-pole single-shaft, and lattice steel H-frame (ER, Vol. 4). These alternatives would only be practical for the northern 181 km (113 mi) of the DC line, but were not chosen due to economic and environmental considerations (ER, Vol. 4). The proposed single-shaft steel pole is the only structure type that could be used on the remainder of the DC line that would not require acquisition of additional right-of-way.

2.2.8.5 Underground Transmission System

Installing the transmission lines underground is a technically feasible alternative to construction of the proposed overhead transmission lines. However, environmental impacts and construction costs would be greater and system reliability would be lower for an underground system than for overhead systems (see Section 2.3 and ER, Vol. 4).

An underground DC line would require one bipole circuit (two cables) and one spare cable. Self-contained, oil-filled cables would be installed in a continuous trench. The trench would be at least 1.2 m (4 ft) wide and 1.5 m (5 ft) deep, with the cables placed at least 1.1 m (3.5 ft) below ground level. Thermal sand and clean backfill would be used to refill the trench. Buried splices would be required every 0.5 km (0.3 mi), underground oil pressure stations every 2.4 km (1.5 mi), and a control cable the length of the line. The land over and in the vicinity of the line would have to be maintained free of trees and shrubs. Improved access would also be required for the length of the line (ER, Vol. 4).

An underground 345-kV AC transmission line would require three parallel, high-pressure, oil-filled, pipe-type cables. They would be installed in a continuous trench similar to the trench for an underground DC line. Backfilling would also be similar to that for a DC line. Cable splices would be required every 0.8 km (0.5 mi) and above-ground oil pumping stations every 8 to 16 km (5 to 10 mi). One or more above-ground reactive compensation stations would also be needed. Access and ground maintenance requirements would be similar to those for an underground DC line (ER, Vol. 4).

For either line (DC or AC) to be constructed underground, a continuous work area generally about 12 m (40 ft) wide would be required. Additionally, new right-of-way acquisition would be required where the lines would have to deviate from existing rights-of-way (e.g., at archeological sites, lakes, wetlands, steep slopes, and areas of high erosion) (ER, Vol. 4). Transition stations would be required to go from underground to overhead and vice versa. These stations generally require an area of about 19 m^2 (200 ft^2). Bus work, termination structures, and a control equipment building would be located at each site. Maximum structure height would be 24 m (80 ft) (ER, Vol. 4).

2.3 COMPARISON OF ALTERNATIVES

2.3.1 Comparison of the Proposed Action and Alternative Actions

In the discussion in the preceding subsections, it was concluded that the potential alternatives of no action, conservation, load management, decentralized energy production, fuel conversion, and domestic power purchases were not viable alternatives to the proposed project for one or more of the following reasons: (1) potential capacity was too low, (2) reasonable expectations of the alternative capacity and energy savings were already figured in demand and resource projections, and/or (3) the alternatives were complementary to the proposed action in that their contributions would reduce somewhat the demand for oil-fired generation of electricity in New England.

Therefore, only alternatives involving new large-capacity, centralized, non-oil-fired generating facilities could be considered viable alternatives. 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 sufficiently large generating capacity could be located. Thus, of the action alternatives examined, only coal- or nuclear-fired generating plants are considered feasible alternatives to the proposed project.

As previously stated, neither the coal nor nuclear option is as economically viable as the proposed transmission project due primarily to the higher capital requirements of these alternatives. In addition, the long period required for design, licensing, and construction of these plants would preclude either type of plant from being placed in service until the mid- to late-1990s. By comparison, the proposed transmission project could be placed in service by the last quarter of 1989.

Environmental impacts also would be greater for the powerplant option. Even though impacts would be brought within established limits by the adoption of various mandatory mitigative measures, the net adverse impacts would still be greater for the powerplant alternative.

Most of the impacts associated with the proposed project would occur during the construction period; the current evaluation by DOE identified no significant adverse impacts related to the operation of the proposed transmission line and only short-term impacts related to construction of the project. Powerplant impacts would be equal to or greater during the construction period (although the construction period would be much longer and localized to the powerplant site vicinity), but certain adverse operational impacts (previously discussed) would exist for the life of the plant -- 30 years or more.

The "no action" alternative would not produce the impacts associated with the construction of the proposed project; however, it would cause the burning of an additional 12 million barrels of oil per year in New England with a resulting increase in airborne emissions. Furthermore, the "no action" alternative would not produce the economic benefits projected for the proposed project.

Only alternative routes and designs are concluded to be feasible alternatives to the proposed action. However, consideration of the environmental consequences of the alternative designs and routes (see Sections 2.3.2 and 4.2) indicates that the magnitude of impacts (especially economic) would be significantly greater than for the proposed project.

2.3.2 Comparison of Proposed and Alternative Converter Terminal Sites, Routes, and Designs

Extensive descriptions and comparisons of the proposed and alternative routes were provided in the Applicant's ER (Vol. 4). The more pertinent comparisons are outlined in Table 2.5 and briefly discussed in the following subsections. Above- and below-ground alternatives also are discussed below.

2.3.2.1 Air Quality

The air-quality conditions at the locations for the proposed and alternative routes and converter terminal sites are very similar. These conditions are discussed in Section 3.1. The alternative routes and terminal sites are close to the sites of the equivalent components of the proposed route. Thus, greater variations in air quality would occur between the northern and southern extremes of a particular route than at equivalent sections among routes.

Changes in air-quality conditions related to construction and operation would be similar for all overhead alternative routes. Increased construction activities associated with the underground alternative would have a greater impact on air quality. Impacts (potential or real) would result from increased fugitive dust, engine emissions, and audible noise associated with the increased construction activities. The underground alternative would have less potential impacts on air quality during operation due to reduction or elimination of ozone, air ions, audible noise, and magnetic and electric field effects associated with overhead transmission systems.

Table 2.5. Summary Comparison of Proposed and Alternative Routes[a,b,c]

Characteristics	Proposed Route	Tewksbury Route	Eastern Route	Western Route
Length (km)	214.4	204.5	248.0	246.2
Centerline slopes >20% (km)	9.3	9.3	21.1	22.2
Rights-of-way acquisition required (ha)	0	0	641.4	440.3
Potential home/business relocations (number)	0	0	40-60	35
Clearing required (ha)	86.2	13.7	693.3	716.3
Selected land use types crossed (km)				
Forest	24.0	N/A[d]	204.4	165.9
Wetland	15.0	15.0	10.3	6.1
Agriculture	16.4	14.8	15.0	36.5
Residential	0.8	0.3	10.8	9.5
Business/commercial	3.1	3.5	N/A	N/A
Number of crossings				
Roads	137	121	N/A	N/A
Streams/rivers	209	191	N/A	N/A
Lakes/ponds	12	10	N/A	N/A
State/national forests	2	2	N/A	N/A
State parks	0	0	N/A	N/A
Wildlife management areas	2	2	N/A	N/A
Recreational areas	21	23	N/A	N/A
Trails	2	2	N/A	N/A
Capital construction costs ($ million)	585	608	662	649

[a] Source: ER, Vol. 4--Tables IV-2, IV-4, and IV-6.

[b] Data do not include the proposed 345-kV AC transmission lines that would be common to the proposed and alternative routes.

[c] Conversions: 1 km = 0.62 mile; 1 ha = 2.47 acres.

[d] N/A = not available.

2.3.2.2 Land Features and Use

Geology and Soils

The geologic and soil impacts associated with the overhead design options of the ±450-kV DC transmission line, 345-kV AC line, and double-circuit 115-kV AC line would be similar because major design, construction, and operational features of the lines are similar. Slope stability and resulting landslides might be a problem on sloping areas such as stream crossings. The geologic impacts of the proposed overhead transmission facilities would likely be less than those associated with an underground transmission line. Construction of an underground line would require more extensive excavation, grading, or backfilling than an overhead line, and therefore would create potential landslide or mass-wasting problems. In addition, the underground cable installation would require areas for permanent access to the splicing manholes and for temporary site storage for thermal sand and spoil material. The longer construction time for the underground line would increase the potential for erosion of exposed materials and soil.

There would be no significant differences in geologic and soils impacts between the Tewksbury alternative DC transmission line and the proposed route. However, geology and soil impacts associated with the eastern and western alternative routes would be greater than those associated with the proposed route, primarily because of the substantially greater right-of-way clearing that would be required (ER, Vol. 4--Table IV-4, Table IV-6).

The proposed Sandy Pond converter terminal would be located on a graded 12-ha (30-acre) site adjacent to the existing Sandy Pond 345-kV AC substation. Most of the site is an existing upland oak woodland with low to moderate topographic relief. The 11-ha (26-acre) Tewksbury alternative terminal site would be located in a wooded wetland, the Great Swamp, and partially on land occupied by an existing 345-kV AC substation. The geologic and soil impacts are expected to be similar at the proposed and alternative converter terminal sites. However, development of the Tewksbury alternative site would require creation of compensatory offsite flood storage (ER Vol. 4--p. 44). Thus, impacts on soil resources would likely exceed those associated with development of the proposed site.

Land Use

Design alternatives identified by the Applicant include types of transmission structures as well as DC and AC underground transmission systems. Compared with the proposed steel lattice H-frame and other alternative designs, the steel-pole, single-shaft structures would require the least space and therefore would result in the least amount of land area dedicated to electric energy transmission.

Land-use conflicts during construction of either the DC or AC underground transmission system would be far greater than those associated with construction of the proposed overhead transmission line. Long-term considerations of land use would favor development of the underground systems. However, building an underground system within the established transmission corridor would not alleviate land-use constraints associated with the two currently existing transmission lines within the corridor.

The western and eastern alternative transmission line routes are each longer than the proposed route. Furthermore, the intensity of land-use impacts associated with the two alternative routes would also be greater than for the proposed route. The Tewksbury alternative and the proposed route correspond with established transmission line corridors and traverse relatively similar terrain; therefore, land-use impacts related to those two routes would be relatively similar. The Tewksbury alternative is about 4.6% shorter than the proposed route (ER, Vol. 4--p. 42). Thus, land-use impacts would not be a significant issue for choosing between the two routes.

Land-use opportunities at both the proposed and alternative Tewksbury converter terminal sites are relatively limited. Although consisting of marginal forest land, the proposed terminal site has some potential for production of commercial wood products and for dispersed recreational use. Thus, development of the proposed site would result in somewhat greater land-use impacts than would development of the Tewksbury alternative.

2.3.2.3 Hydrology, Water Quality, and Water Use

Surface Water

Potential surface-water impacts related to erosion, water quality, drainage patterns, surface runoff, and damage to streambanks would be similar for all overhead transmission facilities. The adverse impacts associated with construction of an underground transmission system are expected to be greater than those associated with the proposed overhead facility, mainly because of increased volume of excavated material for trenches and manholes and increased length of construction time for an underground system. Surface-water impacts could increase, particularly when the underground line passed under surface waterbodies.

The proposed DC and the Tewksbury alternative transmission lines would have comparable surface-water impacts. The substantially greater right-of-way clearing and soil disturbance associated with developing the eastern or western alternative routes would increase erosion potential and sediment deposition in surface waterbodies to a greater extent than would be the case for the proposed route.

The proposed Sandy Pond converter terminal site contains no surface waterbodies, whereas the Tewksbury alternative converter terminal site contains 3 ha (8 acres) of 100-year floodplain, of which 2.4 ha (6 acres) are vegetated wetlands. The western alternative converter terminal would be adjacent to a small wetland and a tributary stream to the North Nashua River (ER, Vol. 4); therefore, surface-water impacts for the proposed terminal site would be less than for the alternative converter terminal site.

Groundwater

Some adverse impacts on groundwater conditions, including aquifer contamination and disruption of shallow groundwater flow patterns, would be similar for all overhead design options. The groundwater impacts of the underground transmission line are expected to be greater than those of the overhead transmission option since the underground line would involve excavating a continuous trench for the entire length of the proposed interconnection. Routing detours to bypass areas that would hinder or preclude trenching operations would substantially increase the volume of materials to be excavated. Backfilled trenches would tend to serve as subsurface collector drains for groundwater at shallow depths.

There would be no significant differences in groundwater impacts among proposed and alternative converter terminal sites, although there would be slight changes in groundwater conditions for the Tewksbury alternative converter terminal site because of the filling of the 3-ha (8-acre) floodplain.

2.3.2.4 Ecology

The ecological characteristics of the alternative routes and converter terminal site are similar to those of the proposed routes and of the site for the proposed converter terminal facilities (see Section 3.4). Differences are primarily in the extent of various habitat types within each route or at each site. Of major concern are the amounts of forested habitat that would require clearing and the extent of disturbance to wetlands. Differences in numbers of flowing or standing waterbodies to be crossed are of minimal concern, as these waterbodies would be spanned in almost all cases. The differing amounts of open (non-forested) upland habitat are not of major concern because such habitats would only be minimally impacted by structure placement, laydown area development, and access road improvements. Additionally, such habitats can be more readily restored than can forested or wetland habitats.

Briefly, the principal differences of the overhead route alternatives as compared with the proposed route are as follows:

- Tewksbury Alternative--less forest clearing (including forested wetlands) (9.3 ha [22.9 acres] for the Tewksbury route vs. 74.1 ha [183 acres] for the proposed route), and greater wetland and floodplain displacement (due to location of the converter terminal partially in a floodplain/wetland area) (4.6 ha [11.3 acres] of wetland displacement for the Tewksbury route vs. 4.1 ha [10.2 acres] for the proposed route, and 4.2 acre-feet of floodplain displacement for the Tewksbury route vs. 3.2 acre-feet for the proposed route) (ER, Vol. 4).

- Eastern Alternative--greater forest clearing (693 ha [1,713 acres] for the eastern alternative vs. 86.2 ha [213 acres] for the proposed route), less wetlands traversed (10.3 km [6.4 mi] of wetlands to be traversed for the eastern alternative vs. 15.0 km [9.3 mi] for the proposed route), and greater erosion potential (21.1 km [13.1 mi] of terrain with centerline slopes greater than 20% for the eastern alternative vs. 9.3 km [5.8 mi] for the proposed route) (ER, Vol. 4).

- Western Alternative--greater forest clearing (716 ha [1,770 acres] for the western alternative vs. 86.2 ha [213 acres] for the proposed route), less wetlands traversed (6.1 km [3.8 mi] for the western alternative vs. 15 km [9.3 mi] for the proposed route), and greater erosion potential (22.2 km [13.8 mi] of terrain with centerline slopes greater than 20% for the western alternative vs. 9.3 km [5.8 mi] for the proposed route) (ER, Vol. 4).

Differences among these alternatives are discussed more fully in Section 4.2.2.4.

The only other alternative of concern is that involving placement of the transmission lines underground. The underground line would follow the same route as the proposed overhead system. However, because of construction and maintenance differences, there would be differing effects on ecological resources. Compared with the overhead line, the underground alternative generally would require increased clearing of vegetation, significantly more disturbance of streams and wetlands, increased potential for erosion (due to more excavated material), and increased disturbance to wildlife and vegetation (due to requirements to maintain the right-of-way of the underground system in a grassy condition). These differences are discussed in more detail in Section 4.2.1.4.

2.3.2.5 Socioeconomics

Socioeconomic impacts caused by implementation of alternative designs would be the same as those of the proposed project, except in the case of development of an underground transmission line. The underground option could create greater disturbance (temporary and long-term) to communities along the right-of-way as a result of increased traffic, noise, and dust levels.

The Tewksbury alternative overhead route and converter terminal site would have effects similar to those of the proposed project; however, the eastern and western alternatives would have greater impacts because of the need for right-of-way expansion. For these alternatives, the acquisition of an additional 400 to 600 ha (1,000 to 1,500 acres) would necessitate relocation of 35 to 60 homes or businesses, and heavier access road demands would have potential disturbance effects on local communities.

2.3.2.6 Visual Resources

Visual impacts are minimized when structures of multiple transmission lines within a common corridor are symmetrical in terms of structural design and placement. Thus, the Applicant's selection of steel lattice H-frame structures for the proposed DC transmission line between the Comerford converter terminal and Sandy Pond Junction in New Hampshire would cause less incremental visual impact than any of the three alternative structure types considered. Overhead supports for the proposed DC transmission line between Sandy Pond Junction and the proposed converter terminal site at Sandy Pond in Massachusetts would be single-shaft, steel-pole structures (ER, Vol. 2--p. 48, Vol. 3--p. 34). The level of visual intrusiveness associated with these structures is generally considered relatively low compared with that of other structure designs of similar stature. However, this advantage would be offset to some extent since the form and line attributes of the proposed single-shaft structures would contrast with those of H-frame structures of an existing transmission line within the common right-of-way.

During construction, development of the proposed overhead DC transmission line would result in far less visual impact than would construction of the alternative underground transmission system. However, following reclamation of sites disturbed during construction, the situation would be reversed in that the incremental visual impacts of overhead transmission lines would exceed those of underground systems. Nonetheless, the appearance of the rights-of-way for underground systems would intrude on numerous landscapes since the rights-of-way must remain cleared of trees and shrubs (ER, Vol. 4--p. 80). The effect would be most noticeable in forested landscapes, particularly in areas where construction constraints would necessitate routing of the underground system outside the established rights-of-way (ER, Vol. 4--p. 86).

The potential for visual impacts for both the eastern and western alternative routes would be greater than that for the proposed route. The alternative routes are appreciably longer, encroach on substantially greater residential area, and would require considerably more right-of-way clearing than would be the case for the proposed route (ER, Vol. 4--Sec. III.C, Sec. III.D). The alternative Tewksbury route corresponds with the proposed route for about 174 km (108 mi). The remainder of the two routes would traverse relatively similar terrain and cultural developments. However, visual impacts would be greater for the Tewksbury alternative, primarily because the alternative route traverses a 7.2-km (4.5-mi) segment of an established transmission corridor in which paralleling transmission lines would entail support structures of six differing structural designs.

Both the proposed and alternative Tewksbury converter terminal sites are characterized by low-quality landscape views. Furthermore, both sites are relatively well screened from views by the general public. Thus, visual resources are not meaningful issues for choosing between the two converter terminal sites.

2.3.2.7 Cultural Resources

Alternative structure types (single pole and waisted) could have greater visual impact on historical sites near the right-of-way, although specific impacts have yet to be identified. Burial of the transmission line would have much higher potential for both surface and subsurface damage to archeological sites.

Among the alternative overhead routes considered, the western alternative probably has the highest potential for impacts to archeological and historic sites because its northern segment would traverse the Connecticut River Valley. Cultural resource surveys would be needed in order to effectively assess the adverse impacts, as in the case of the proposed route.

2.3.2.8 Health and Safety

Health and safety concerns generally would be similar among all overhead transmission system alternatives. As discussed in Section 4.1.8, the levels of air ions, ozone, audible noise, electric fields, and magnetic fields associated with ±450-kV DC and 345-kV AC transmission lines are within levels that have been shown to have little or (more often) no biomedical or behavioral effects on animals and humans. Therefore, no impacts would be expected from any of the overhead alternatives. Nevertheless, perceived impacts would probably be greater for both the eastern and western alternatives compared with the proposed route and the Tewksbury alternative. This difference would be due to the greater number of residential and business developments adjacent to the eastern and western alternative routes.

Worker safety issues would be similar for all overhead transmission line alternatives. Relative safety would be less for the eastern and western alternatives because those routes would be longer and because greater amounts of forest would require clearing.

The underground alternative would not have the perceived impacts associated with electric and magnetic field effects and other operational air-quality concerns. However, worker safety issues would increase because of the greater amount of construction activities required for an underground system. Also, health and safety issues would be greater because of the increased maintenance (effort and frequency) required for an underground system.

2.3.2.9 Radio and Television Interference

In contrast with electrical fields surrounding conductors of overhead transmission lines, there is essentially no electrical field surrounding cables of underground transmission systems (Bonneville Power Administration 1982). Thus, receivers adjacent to buried transmission cables are not subject to radio and television interference.

The eastern and western alternative routes would traverse more residential and commercial development than would the proposed route (ER, Vol. 4--Sec. IV.C-D). Thus, the potential for occurrences of radio and television interference would be greater along the eastern and western alternative routes. The extent of residential and commercial developments traversed by the proposed route and the alternative Tewksbury route would be relatively similar; therefore, the potential for the incidence of radio and television interference would likewise be similar.

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3. AFFECTED ENVIRONMENT

3.1 AIR RESOURCES

The principal climatic characteristics of central Massachusetts and interior New Hampshire include 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 (National Oceanic and Atmospheric Administration [NOAA] 1980).

Average annual temperatures are about 9.4°C (49°F) in the Massachusetts portion of the study area and from 7.8°C (46°F) in the south to 5.0°C (41°F) in the north in the New Hampshire portion (NOAA 1980).

Precipitation is fairly uniform throughout the year and is mainly associated with frontal passages. 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). In Massachusetts, annual precipitation is about 114 cm (45 in), and in New Hampshire ranges from 104 cm (41 in) in the south to 94 cm (37 in) in the north. Annual snowfall is just under 178 cm (70 in) in Massachusetts, and in New Hampshire ranges from 152 cm (60 in) in the south to 229 cm (90 in) in the north (ER, Vols. 1-3).

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. Over the general area that would be traversed by the transmission line, the wind speeds range from monthly average highs of 8 to 15 km/h (5 to 9 mph) in the summer to 13 to 19 km/h (8 to 12 mph) in the winter (ER, Vols. 1-3).

Hurricanes and tropical storms occasionally affect the area, 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 can be expected each winter (NOAA 1980).

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 1983 (U.S. Environmental Protection Agency 1984) indicate that the pollutant levels of suspended particulates, sulfur dioxide, and nitrogen dioxide are well below standards in the urban areas of Massachusetts and New Hampshire, and are undoubtedly even lower in the rural areas. Carbon monoxide and hydrocarbon levels are probably well below standards in the rural areas also. However, elevated levels of ozone are frequent in the urban areas of New England (U.S. Environmental Protection Agency 1984). High levels may also occur in the rural areas along the proposed transmission line during summer due to pollutant transport into the region coupled with climatic conditions that promote ozone production (ER, Vols. 2 and 3).

3.2 LAND FEATURES AND USE

3.2.1 Geology and Topography

The proposed route lies within the New England physiographic province, a northward continuation of the Piedmont, Blue Ridge, and Valley provinces. This area is differentiated from the more southerly portion of the Appalachian range (ER, Vols. 2 and 3), in major part due to the pronounced effects of glaciation.

The geomorphology of the area is partially influenced by the underlying crystalline bedrock. The granites and metamorphic rocks form a plateaulike surface. In general, these rocks have been compressed to some degree, uplifted, and eroded to their present character (Fenneman 1938). The geomorphology also has been influenced by intense glaciation; dominating much of the surface geology are such glacial features as moraines, drumlins, kames, and eskers (ER, Vols. 2 and 3).

The New England physiographic province is divided into five distinct sections (Hunt 1967). Three of these are included within the study area--the White Mountain section in the northern portion of the study area, the New England Upland section in the central portion of the study area, and the Seaboard Lowland section in the southern portion of the study area (ER, Vol. 2--p. 73).

In general, topographic relief and land elevations decrease from north to south. Dominant land forms of the northern part of the study area are an upland plateau and the adjoining White Mountains; the latter is an extensive mountain mass with average elevations of about 580 m (1,900 ft) above mean sea level (MSL). Several lower mountain ranges extend north-south across the plateau. Central and southern portions of the study area are located within an upraised and eroded peneplain. Residual hills and low mountains (monadnocks) are relatively abundant in the upland or northern portion of the peneplain and occur with decreasing frequency in a southerly direction. The uplands of the peneplain are strongly dissected, typically by steep-sided, narrow valleys. Compared with topographic relief of the upland peneplain, land forms of the southernmost part of the study area are lower and smoother. Surface elevations typically range from 75 m (250 ft) to 150 m (500 ft) MSL.

The area along the proposed route and the proposed substation sites are within Seismic Zone 2 (Corps of Engineers 1983). This designation means that the region has light to moderate earthquake potential (ER, Vol. 2--p. 74). No structural damage would be expected from an earthquake in a Seismic Zone 2.

3.2.2 Soils

The soil conditions of New England reflect the strong influence of recent glacial events. Some of the origins of the soils are glacial till, glaciofluvial deposits, and glaciolacustrine deposits (Soil Conservation Service 1965). Soil resources relevant to the proposed project are those within a study area defined as a 16-km (10-mi) wide corridor centered on the proposed transmission line (Figure 2.1). Soil resources within this study area range in thickness from nonexistent (exposed bedrock) to very deep alluvial deposits in river valleys. In some cases, stream terraces can be seen in the river valleys.

The slopes of the soil surfaces range from flat to more than 25% in limited areas. Because of the existing vegetation cover along and within the established right-of-way, the amount of soil erosion is relatively minor. However, sand and gravel extraction activities have resulted in accelerated erosion rates in several spots along the route.

The proposed DC and AC transmission line routes would traverse a total of about 27 km (17 mi) of prime and important (statewide basis) farmland in Massachusetts (ER, Vol. 2--Table III-28). This distance represents about 26% of the total 103 km (64 mi) of proposed transmission line route in the state. In New Hampshire, the proposed 195-km (121-mi) DC transmission line route would traverse a total of about 8 km (5 mi) of prime and important farmlands, about 4% of the New Hampshire route (ER, Vol. 3--Table III-30). Thus a cumulative total of 35 km (22 mi) of prime and important farmlands would be traversed by the proposed routes within the two states.

Some soils of the 9-ha (23-acre) converter terminal site also have been identified as prime farmlands, but the site is characterized by rock outcrops and large boulders and thus may not be well suited for farming (ER, Vol. 1, Sec. IV.C.1.b).

3.2.3 Agriculture

Land use for agricultural purposes in Massachusetts and New Hampshire has decreased markedly during the last few decades. For example, in Massachusetts the proportion of land categorized as "land in farms" decreased from 33.0% in 1950, to 17.9% in 1964, and to 12.2% in 1982 (Bureau of the Census 1984a); in New Hampshire the corresponding percentage decreases were 29.7%, 15.7%, and 8.2%, respectively (Bureau of Census 1984b).

As shown in Table A.1 of Appendix A, the proportion of land in farms in the counties traversed by the proposed transmission line is relatively low, ranging from 13.8% for Worcester County to 5.2% for Norfolk County. However, data presented by the Applicant (ER, Vol. 2--Table III-19, Vol. 3--Table III-18) indicate that agriculture ranks second only to forestry as a major land use in the project study area. The proportions of land in farms in these counties in 1982 were essentially unchanged from comparable 1978 data. The percentages of land in farms for 1982 decreased from those for 1978, with the exception of Worcester and Grafton counties, but all changes were less than 1% of the land in the respective counties. On the other hand, the average size of farms in all counties decreased during 1978-1982, and in some cases changes were substantial. For the most part, the effects of decreased farm size were essentially offset by corresponding increases in the number of farms. (Bureau of the Census 1984a, 1984b).

Among the Massachusetts counties along the proposed route, sales from livestock production and dairy operations were major sources of agricultural income in Worcester County in 1982, while sales from crop production, especially nursery and greenhouse products, were principal sources of income for farms in Middlesex and Norfolk counties. For the New Hampshire counties along the proposed route, sales from dairy operations constituted the predominant agricultural income in Grafton and Merrimack counties; dairy products, fruits, nuts, and berries were the principal sources of income from Hillsborough County farms; and sales of agricultural products from Rockingham County farms derived primarily from dairy and poultry operations, (Table A.1).

3.2.4 Forestry

As of 1977, about 59% [1.2 million ha (3 million acres)] of the land area in Massachusetts consisted of forest land. Of this, about 95% (1.1 million ha [2.8 million acres]) was classified as commercial timberland (Forest Service 1978). In New Hampshire, about 87% of the land in the state, or 2 million ha (5 million acres), consisted of forest land, and about 94% of the total forested area was classified as commercial timber land.

The predominance of forest land use in counties traversed by the proposed transmission line is illustrated in Table A.2 of Appendix A. Forest land use in New Hampshire counties substantially exceeds that for most Massachusetts counties. The proportion of total forest area for New Hampshire counties ranges from about 75% in Rockingham County to about 90% in Grafton County. For Massachusetts counties, the proportion of forest lands ranges from about 44% in Middlesex County to about 69% in Worcester County (Table A.2). For the most part, the lower percentages of forest land in Middlesex County are attributable to the intensive residential, commercial, and industrial land use in the Boston area. This is supported by forest land data presented by the Applicant (ER, Vol. 2--Table III-19) that are based on a project study area composed of only those towns within a given county that are traversed by the proposed line.

The data presented in Table A.2 reveal that about 90% or more of the forest land in each county traversed by the proposed route consists of commercial timberland and that most forest lands are in private ownerships.

The distribution of forest types within counties traversed by the proposed transmission line is presented in Table A.3 of Appendix A. In general, the trends in occurrence of the forest types correspond with ecosystems as delineated by the U.S. Fish and Wildlife Service (1979); i.e., forest stands of New Hampshire counties correspond with the Northern Hardwoods-Spruce forest, while forest types in Massachusetts counties represent transition to the Appalachian Oak forest.

3.2.5 Mining

Cumulative data from long-term inventories indicate that only minor quantities of the major metals (gold, silver, lead, zinc, and iron) have been extracted in Massachusetts and New Hampshire (Geological Survey 1970). The major materials extracted in the two states are essentially nonmetallic and are of relative minor economic significance. The 1984 production of minerals in New Hampshire derived primarily from sand and gravel materials, followed by more limited extraction of stone products (F.E. Compton Co. 1984). As observed during Staff reconnaissance of the New Hampshire project area (Figure 2.1), sand and gravel materials are generally poorly sorted, extraction is not extensive, and use appears oriented to local needs.

Exploitation of mineral resources in the project area occurs only as scattered sand and gravel pits and granite quarries (ER, Vol. 3--p. 61).

The value of mineral production in Massachusetts is more substantial than in New Hampshire (F.E. Compton Co. 1984). Mineral resources of economic value within Massachusetts counties wholly or partially traversed by the proposed transmission lines (Figures 2.2 through 2.4) occupy a total of about 4,828 ha (11,930 acres). About 97% of this total area consists of sand and gravel deposits (ER, Vol. 2--Table III-3). Of the total surface area of economic mineral deposits (1,695 ha [4,190 acres]) in Middlesex County, only 7% occurs within towns traversed by the proposed transmission line and involves only sand and gravel deposits. About 395 ha (980 acres) of sand and gravel deposits and 15 ha (35 acres) of other mineral deposits occur in towns of Worcester County traversed by the proposed line. Only 48 ha (120 acres) of economic sand and gravel deposits occur in the town of Medway in Norfolk County (ER, Vol. 2--p. 79).

3.2.6 Natural and Recreational Areas

3.2.6.1 New Hampshire

The study area for the inventory of natural and recreational sites in New Hampshire consisted of a 6.4-km (4-mi) wide corridor centered on the proposed transmission line route. Designated natural areas include the White Mountain National Forest, which is traversed by the proposed route for about 15 km (9 mi) in the towns of Benton, Warren, and Wentworth (Figure 2.2). An additional 35 natural areas are located partially or wholly within the study area corridor, of which 19 areas are state (16), town (2), and private (1) forests ranging in size from 10 ha (25 acres) to 400 ha (1,000 acres) (Freeman 1981). Amont the larger designated natural areas adjacent to the proposed route are the Hopkinton-Everett and Blackwater reservoirs in the town of Hopkinton and Webster, respectively (Figure 2.3). Other designated areas featuring aquatic attractions include Musquash Swamp, Merrimack Fish Rearing Station, Smith Pond Bog, Contoocook River, and the Parker Natural Area (Freeman 1981; New Hampshire Office of State Planning 1983a). Other notable areas are the 440-ha (1,100-acre) Conservation Commission Land and the smaller Contoocook River Park within the towns of Bow and Concord, respectively (Figure 2.3).

Dedicated recreational areas totally or partially within the study area corridor include two state parks and seven municipal parks. The state parks are the Plummers Ledge Geologic Site in the town of Wentworth and the Wellington Beach State Park in the towns of Bristol and Alexandria. Four of the municipal parks are in the town of Manchester, with one each in the towns of Hudson, Hebron, and Haverhill (Figures 2.2 and 2.3). The most numerous recreational sites adjacent to the proposed route are municipal and school facilities developed for intensive recreation (Freeman 1981). For example, there are more than 40 athletic fields, 5 golf courses, and 2 gymnasiums adjacent to the proposed line in Hillsborough County, primarily in the towns of Goffstown, Manchester, and Bedford (Figure 2.3). Other comparable recreational opportunities or facilities within the study area corridor include water sport activities (16 sites), athletic fields (16 sites), campgrounds (23 sites), winter sport activities (4 sites), a roadside park, as well as public hunting (2) and fishing (4) areas.

The proposed route intersects several designated river and overland recreational routes. Segments of the Baker, South Branch Baker, and Contoocook Rivers intersecting the proposed route are included in the federal inventory of nationwide rivers with recreational potential (National Park Service 1982). The Baker and Contoocook are designated state recreation rivers, and South Branch Baker is a state scenic river route (New Hampshire Office of Comprehensive Planning 1977a). Additionally, intersected segments of the Ammonoosuc and Smith Rivers are state recreation corridors. Several highways intersecting the proposed route include State Route (SR) 135 and U.S. 302/SR 10, which are designated scenic highway/bike routes. Intersected scenic highways include SRs 11, 13, 25, 103, and 112 and U.S. 4; SRs 101, 102, 111, and 114 are designated bike routes (New Hampshire Office of Comprehensive Planning 1977b; ER, Vol. 3--Table III-25). The proposed route intersects the Appalachian Trail in the town of Warren (Figure 2.2).

Additional information concerning recreational resources within the proposed New Hampshire project area is presented in the ER (Vol. 3--Sec. III.C.12).

3.2.6.2 Massachusetts

Sites included in the Massachusetts statewide inventory of recreational resources are classified in four major categories--intensive recreation areas, general recreation areas, natural (conservation) areas, and historical/cultural areas (Massachusetts Office of Planning 1978). The historical/cultural areas located in Massachusetts towns traversed by the proposed transmission line route (the project study area) are discussed in Section 3.7.

The natural and general recreation areas vary considerably in size, but include the larger of the recreation areas in the state. General recreation areas are more highly developed and afford a wider range of recreation opportunities. Of the large recreation areas immediate to the proposed route, the 1,075-ha (2,660-acre) Upton State Forest provides for a variety of dispersed and trail-related recreation activities (Massachusetts Division of Forestry and Parks undated). A small portion of this state forest, as well as a small part of the Wachusett Reservoir, would be traversed by the proposed route (Figure 2.4). Reservoir shorelines provide opportunities for passive recreation activities, and the general area is a major scenic attraction (ER, Vol. 2--Sec. III.C.12).

Located in the town of Worcester (Figure 2.4), the Quinsigamond State Park is outside of the project study area but is located within 2 km (1.2 mi) of the proposed route. The park affords opportunities for swimming, boating, sailing, fishing, tennis, and picnicking (Rand McNally & Company 1985). All or portions of seven additional state parks and forests occur within 8 km (5 mi) of the proposed route.

The conservation areas within the project study area are variable in size and are primarily administered by local town governments. These areas tend to be largely undeveloped with limited opportunities for recreational use. The Applicant has identified seven such sites (ER, Vol. 2--Table III-25)--the Floyd and Bates Conservation Areas, the Whorton Plantation, and the Priest Memorial Area in the town of Groton; the Hollingsworth Conservation Area and a town forest in the town of Ayer; and the Lancaster-Cook Conservation Area in the town of Lancaster.

Intensive recreational areas are sites involving high levels of recreational activity with developed facilities for one or more specific recreational uses, such as athletic fields, tennis courts, swimming pools, and public school playgrounds. Such sites are scattered throughout the project study area, primarily in association with urban areas (ER, Vol. 2--Figures III-6.1 through III-6.12). Other publicly administered recreational sites in the project study area include Sargison and Spectacle Pond beaches, Shalan Park, and Pratt Pond; located in the towns of Groton, Lancaster, Sterling, and Upton, respectively (ER, Vol. 2--Table III-25).

The Applicant has identified several private recreational sites in the project study area (ER, Vol. 2--Table III-15). Seven sites are used by various youth organizations. Other sites include areas used by sportsman clubs (4), a hang glide-ski slope area, and a private beach area.

The proposed route intersects several designated river and overland recreation routes. Intersected segments of the Merrimack and North Nashua Rivers are designated as urban recreation rivers; the intersected segment of the Nashua River is a local scenic river (ER, Vol. 2--Table III-15). A segment of the Nashua River from below Pepperell to the Ayer State Game Farm is included in the Federal Nationwide Rivers Inventory (National Park Service 1982). The federally inventoried segment is immediately downstream from where the proposed route intersects the Nashua River. Overland recreation corridors that intersect the proposed transmission line route include three state routes (SR 113, 119, and 62) that are designated as scenic highways on standard Massachusetts highway maps.

Additional details relative to recreational resources of the Massachusetts project area are available in the ER (Vol. 2--Sec. III C 12).

3.2.7 Residential, Commercial, and Industrial

The New Hampshire study area for land use data presented by the Applicant (ER, Vol. 3--Table III-18) consists of the New Hampshire towns traversed by the proposed route (Figures 2.2 and 2.3). About 5.6% of the study area was reported as "developed" land in 1978. The developed land included areas used for residential, commercial, industrial, recreational, and other minor land use categories. It is expected, however, that the area of developed land has increased since completion of the survey cited by the Applicant. For example, results of a 1980 survey indicate that the number of housing units in New Hampshire counties traversed by the proposed transmission line route increased by percentages ranging from 35.5% to 43.3% during the 1970-1980 period (Bureau of the Census 1983).

Recent estimates of land areas used for residential purposes within towns of the New Hampshire project study area are not readily available. However, the density of housing units (number per unit area) provides some insight into residential land use. Based on 1980 data (ER, Vol. 3--Tables III-14, III-16), the average housing unit density in towns of the study area in Grafton County ranges from less than 1 to 12.4 units/km^2 (2.6 to 32.1/mi^2), thus reflecting the rural character of the county. The greatest concentration of residential land use in the New Hampshire study area is in the town of Concord in Merrimack County, with an average housing unit density of 73 units/km^2 (189/mi^2). Densities for other Merrimack towns are considerably lower. The average housing unit densities for all Hillsborough towns within the project study area are comparatively high, ranging from 32 to 58 units/km^2 (83 to 149/mi^2). In general, residential land use tends to increase with distance from the northern to the southern part of the New Hampshire study area (Figures 2.2 and 2.3).

Employment data provide some insight to the concentrations of commercial and industrial land use in the area (ER, Vol. 3--Table III-17). Accordingly, country-wide employment for industrial and commercial activities indicate that land area used for industrial and commercial purposes is greatest for Hillsborough County and least for Grafton County. Commercial and industrial land use in Merrimack and Rockingham counties is intermediate between that for the aforementioned counties. In general, patterns of commercial and industrial land use tend to correlate with patterns of residential land use.

In Massachusetts, the project study area also consists of towns traversed by the proposed transmission line (Figures 2.3 and 2.4). Based on the Applicant's data (ER, Vol. 2--Table III-19), residential land use represents 9.7% of the total lands in the Massachusetts study area. However, the Applicant's data represent land use before 1971 and do not reflect more recent changes. For example, total housing units in Middlesex, Norfolk, and Worcester counties increased during the 1970-1980 period by 14.3%, 17.5%, and 17.5%, respectively (Bureau of the Census 1983).

Compared with New Hampshire towns, the overall residential land use is substantially greater for Massachusetts towns in the project study area (Figures 2.3 and 2.4). The only comparatively rural town in the Massachusetts study area is Dunstable, with an average housing unit density of 11.0 units/km^2 (28.5/mi^2). The average housing unit densities in Massachusetts towns of Lancaster, Sterling, Boylston, Sutton, and Upton range from 22.5 to 29.4 units/km^2 (58.3 to 76.1/mi^2); while average densities for all other towns of the Massachusetts study area exceed 45 units/km^2 (116/mi^2). The major concentrations of residential land use occur in the towns of Medway, Ayer, Millbury, Shrewsbury, and Milford, with average housing unit densities ranging from 87 to 215 units/km^2 (224.5 to 556.9/mi^2).

Almost half the manufacturing in the Massachusetts study area occurs in the towns of West Boylston, Shrewsbury, Grafton, and Millbury (ER, Vol. 2--p. 128). High levels of both industrial and commercial activities occur in the town of Milford, and high levels of commercial activities in the towns of Ayer and Shirley serve to accommodate demands of the Fort Devens community. Medway is primarily a residential town within commuting distance of the Boston area. Commercial land use is oriented to providing for local needs.

3.2.8 Military

No major military installations occur on or near the proposed route in New Hampshire; however, the northern portions of the proposed route as far south as Hebron, New Hampshire, are within either the Yankee One or Yankee Two Military Operations Areas (National Oceanic and Atmospheric Administration 1985a, 1985b). In northeastern Massachusetts, only Fort Devens is in the project study area. The proposed route is adjacent to Fort Devens in the towns of Ayer and Shirley (ER, Vol. 2--Figure III-6.3).

3.2.9 Transportation, Transmission, and Communication Systems

3.2.9.1 Transportation Systems

Highway and Roads

The northern portion of the proposed transmission corridor (Figure 2.2) traverses predominantly rural area in Grafton County, New Hampshire, and the highway network within the county is generally less developed than in more southerly counties of New Hampshire, where land use is more intensive (DeLorme Publishing Company 1985). The proposed corridor intersects a single federal highway in Grafton County, U.S. 302 in the town of Bath. State routes (SR) in Grafton County that are intersected by the proposed corridor include 135, 25, 25c, 25a, 118, and 104. About 26 local roads (including streets, permanent trails, etc.) within the county also intersect the proposed corridor. In Merrimack County, the proposed corridor intersects U.S. I-89, U.S. 202 (both in the town of Hopkinton), U.S. 4 (in the town of Salisbury), SRs 11 (two places) and 13, and 32 local roads. The highways of Hillsborough County that intersect with the proposed corridor are U.S. 3 and the Everett Turnpike in Merrimack; SRs 114 (two intersects), 101, 3A (two intersects), and 111; and 26 minor roads. In Rockingham County, the proposed corridor intersects SR 102 and three local roads.

The principal highways in Massachusetts that are intersected by the proposed transmission line corridor tend to promote either direct access to downtown Boston or to channel traffic around the immediate Boston area. The principal highways in Middlesex County intersected by the proposed corridor include U.S. 3 and SR 3A in the town of Tyngsborough. Other intersects in Middlesex County include SRs 119/225, 111, and 2A, and about 22 local roads. The highway network in Worcester County is particularly well developed since the county surrounds much of the Boston area. Major highways and towns in which intersections occur are U.S. I-190, SR 117, the Union turnpike, and the Lunenburg turnpike in Lancaster; U.S. I-190 and SR 62 in Sterling; SR 170, SR 110, and SR 140 in West Boylston; U.S. I-290, SR 9, and SR 20 in Shrewsbury; U.S. I-90 in Millbury; SR 122 and SR 140 in Grafton; and U.S. I-495, SR 85, and SR 16 in Milford. The proposed corridor also intersects about 35 local roads in Worcester County. In Norfolk County the proposed corridor extends only into the town of Medway and intersects SR 109 and two local roads.

Railroads

The proposed transmission line route intersects four railroad lines in New Hampshire (DeLorme Publishing Company 1985); all intersections involve freight lines of the Boston and Maine Corporation, a subsidiary of Guilford Transportation Industries, Inc. (National Railway Publication Company 1985). The intersections occur near Bath, Andover, and Goffstown and in Merrimack, New Hampshire. The railway through Andover is scheduled for abandonment (ER, Vol. 3--p. 147).

The Boston and Maine Corporation also operates railroad lines in Massachusetts that intersect the proposed transmission line (National Railway Publication Company 1985); these are freight lines in the towns of Tyngsborough (1), Ayer (2), and Sterling (1) (ER, Vol. 3--Figures III-6.1, III-6.3, and III-6.7). The Boston and Maine/Massachusetts Bay Transit Authority operates a freight/passenger service line that intersects the proposed line near Shirley, Massachusetts. Conrail lines intersecting the proposed transmission line route include one freight line in each of the towns of Sterling and Milford. Also, Conrail/AMTRACK facilities include freight/passenger service intersecting the proposed line in the town of Grafton. Two additional freight lines intersect the proposed line in Grafton, one operated by the Providence and Worcester Railroad Company and the other by the Grafton and Upton Railroad Company.

Airports

Seven airports are located at or within 8 km (5 mi) of the New Hampshire portion of the proposed transmission line route (National Oceanic and Atmospheric Administration 1985a, 1985b). Included are Lee Airport (a private facility near Goffstown) and six public airports: Dean Memorial Airport near Haverhill, Newfound Valley Airport near Bristol, Plymouth Airport near Plymouth, Country Club Airport and Skypark Campground Airport near Goffstown, and Manchester/Grenier Industrial Airport at Manchester. The last mentioned is a comparatively large airport, the only one of the seven with a control tower.

The study area for the inventory of Massachusetts airport facilities adjacent to the proposed transmission line route consisted of a corridor with boundaries at 8 km (5 mi) on either side of the proposed route. The airports nearest the proposed transmission line route include private facilities at the Larson Seaplane Base on the Merrimack River adjacent to the Massachusetts state line, the airport at the Moore Army Air Force Base at Fort Devens (which includes a control tower), and two public airports--the Shirley Airport immediate to Fort Devens, and the Sterling Airport near Oakdale (National Oceanic and Atmospheric Administration 1985b). Additional airports wholly or partially within the study area include private facilities at the Sports Center Airport near Pepperell and the Walters Airport south of Millbury, as well as public facilities, including the Groton Airport southeast of Pepperell, the Fitchfield Airport at Fitchfield, the Hopedale/Draper Airport near Milford, and Norfolk Airport near Medway.

3.2.9.2 Transmission Systems

Major links in the electric power grid of New Hampshire include two 345-kV AC transmission lines that traverse the southern part of the state in general southwest/northeast directions, linking transmission facilities of Maine and southern New Hampshire with facilities in Vermont and Massachusetts (ER, Vol. 3--p. 151). The principal north/south transmission corridor in the New Hampshire portion of the project study area includes two 230-kV AC transmission lines that extend from the Comerford substation near the Comerford Dam to the Sandy Pond Junction in southern New Hampshire, and from there to the Tewksbury substation in Massachusetts. The proposed DC transmission line parallels the existing 230-kV lines in a common corridor from the Comerford substation to the Sandy Pond Junction and then extends southerly and westerly within another established transmission line corridor that intersects the state boundary adjacent to the Merrimack River. The proposed route intersects only a single transmission line in the town of Monroe, but the power grid in southern New Hampshire is relatively well developed, reflecting the more intensive land-use patterns (National Oceanic and Atmospheric Administration 1985a, 1985b). Existing 115-kV lines intersect and/or parallel the proposed route in in the towns of Andover, Dunbarton, Goffstown (4 intersections), Merrimack, Londonderry (2 intersections), and Hudson (3 intersections) (ER, Vol. 3--Figure III-3; National Oceanic and Atmospheric Administration 1985b).

Within the Massachusetts portion of the project area (Figures 2.3 and 2.4), the proposed DC and AC transmission line routes traverse established transmission line corridors for essentially the entire distance from the Massachusetts state line to the project terminus at the West Medway substation. Depending on the location along the route, existing transmission facilities within the corridor segments vary from one to six individual lines operating at voltages ranging from 69 kV to 345 kV (ER, Vol. 2--Figures II-5 through II-15). Electric transmission facilities identified in the towns that are traversed by the proposed DC and AC routes consist of the following: thirty 115-kV lines, ten 345-kV lines, fifteen 69-kV lines, three 230-kV lines, and fifteen existing substations (ER, Vol. 2--p. 152). Land use maps presented by the Applicant reveal parallel transmission lines within corridor segments, as well as existing transmission lines that intersect the proposed DC and AC routes. For example, multiple line intersections occur in the towns of Dunstable, Groton, Ayer, Shirley, West Boylston, and Millbury (ER, Vol. 2--Figures III-6.4 and III-6.7 through III-6.9).

Other transmission systems in the vicinity of the proposed transmission line route include pipelines. A segment of a Tenneco natural gas pipeline in the New Hampshire towns of Londonderry, Windham, and Pelham generally parallels the proposed route (ER, Vol. 3--Figure III-3) at a closest distance of about 1 km (0.6 mi). Pipeline crossings of the proposed route occur in the Massachusetts towns of Lancaster, West Boylston, and Upton in Worcester County, and in the town of Medway in Norfolk County (ER, Vol. 2--Figures III-6.5, III-6.7, III-6.11, and III-6.12).

3.2.9.3 Communication Systems

The study area for identifying air traffic communication facilities adjacent to the proposed transmission line route consisted of a corridor with boundaries at 8 km (5 mi) on either side of the proposed route. Communication facilities within the study area include two VORTAC stations in New Hampshire near Concord and Deery (National Oceanic and Atmospheric Administration 1985a), as well as nondirectional radiobeacons near Deery in New Hampshire, and at Fitchburg and Worcester in Massachusetts. Other nondirectional radiobeacons somewhat more removed from the proposed route include stations in the vicinity of Hooksett and Milford in New Hampshire and a station near Townsend in Massachusetts. Airports near the proposed line that have control towers are the Manchester/Grenier Industrial Airport in New Hampshire and the Moore Army Air Force Base in Massachusetts.

The study area for identifying obstructions to air traffic consisted of an 8-km (5-mi) wide corridor centered on the proposed transmission line route. These obstructions include communication towers for radio, television, and microwave transmissions. Four single and two group obstructions occur within the corridor in New Hampshire; seven single and one group obstructions occur within the corridor in Massachusetts (National Oceanic and Atmospheric Administration 1985a, 1985b). Most of the structures occur near urban areas in southern New Hampshire, and in the Fitchburg, Worcester, and Milford areas in Massachusetts.

3.3 HYDROLOGY, WATER QUALITY, AND WATER USE

3.3.1 Surface Water

The proposed transmission line route successively traverses the watersheds of the Connecticut, Merrimack, Blackstone, and Charles Rivers. The line would cross more than 300 surface waterbodies (ER, Vols. 2 and 3), including the Ammonoosuc, Baker, Cockermouth, Fowler, Smith, Contoocook, Piscataquog, Nashua, and North Nashua Rivers. Runoff in these watersheds varies considerably on a seasonal basis, with the greatest flows in spring and the least flows in summer and fall. Snowmelt and summer thunderstorms can cause dramatic increases in streamflow. Most of the tributary creeks are intermittent in the area of the proposed route. Selected streamflow data for watersheds that would be crossed by the proposed route are given in Table A.4 of Appendix A. Reservoirs that would be crossed by the proposed line range from an isolated pond with a surface area of about 74 m^2 (800 ft^2) to the 16.8-km^2 (6.5-mi^2) Wachusett Reservoir near Worchester, Massachusetts (ER, Vols. 2 and 3).

The quality of surface water can vary considerably in response to such factors as streamflow, time of year, climate, types of material in the stream channel, groundwater inflow, and land- and water-management practices. In general, periods of low streamflow are characterized by poorer water quality than occurs during periods of high flow. Also, influent groundwater providing baseflow adds to the solution loading of the stream.

Most of the surface waters within the Connecticut, Merrimack, Nashua, Blackstone, and Charles River basins crossed by the proposed route are designated as Class B, which is the second highest quality of water, and are used for recreational activities, fish habitat, protection and propagation of other aquatic life and wildlife, and as a water supply following adequate treatment. Exceptions include several streams, lakes, ponds, and reservoirs and their tributaries that are designated as Class A and are used as public water supplies. These are Cross Brook at its two tributaries in the Blackwater River basin, three tributaries of Kimball Pond, a small unnamed pond in the Black Creek watershed, and ten streams within the watershed of Walker Pond, currently used as the public water supply by the town of Boscawen and the city of Concord, New Hampshire.

The Class A surface waters crossed by the proposed transmission line in Massachusetts include the Wachusett Reservoir and 14 other reservoirs and ponds and their tributaries in the Nashua River basin, several streams used for public water supplies in the Blackstone River basin, and the headwaters of the Charles River. A reach of about 14 km (9 mi) of the mainstream Blackstone River, from its source to the outlet of Fisherville Pond, and lower reaches of the Charles River are designated as Class C--the third highest quality of water, and are used for secondary-contact recreation only (ER, Vols. 2 and 3).

Several major surface waters within the counties through which the proposed route would pass (Figures 2.2 through 2.4) are used for public water supplies. In New Hampshire, these include the Wild Ammonoosuc River (serving Woodsville and Bath), Walker Pond (serving Boscawen and a portion of Concord), Bradley Lake (serving Andover), Penacook Lake (serving Concord and Bow), and the Goffstown Reservoir (serving Goffstown). In addition, the Contoocook and Souhegan rivers serve as auxiliary public water supplies for the cities of Concord and Nashua, respectively. In Massachusetts, the Wachusett Reservoir and the Charles River serve as public drinking water supplies for the towns of West Boylston and Milford, respectively. The Wachusett Reservoir is also a source of drinking water for the Boston metropolitan area (ER, Vol. 2--p. 88).

3.3.2 Groundwater

Groundwater in the general project area (Figures 2.2 through 2.4) is available primarily from bedrock aquifers and glacial-drift aquifers of Quaternary age. Glacial-drift aquifers in the area include till, surficial sand and gravel deposits, glacial outwash deposits, and alluvial deposits. The ability of these deposits to yield water depends on the permeability, thickness, and extent of the deposit and the amount of water stored in and recharged to the aquifers.

Water from bedrock of igneous and metamorphic origin is generally available in quantity and quality suitable for single-family domestic supplies. Water in bedrock occurs in secondary pore spaces, such as joints and fractures, which are commonly narrow and represent only a small percentage of total aquifer volume. In the study area, nearly all wells constructed in bedrock intercept some water-bearing fractures; however, bedrock well yields range from a fraction of a liter per second (or a fraction of a gallon per minute) in places where the fractures are small and poorly interconnected, to more than 6.3 L/s (100 gal/min), where they are numerous and well interconnected, as in some fault zones.

Sufficient amounts of water to supply single-family homes are available from the bedrock aquifer nearly everywhere in the Middle Connecticut River and Merrimack River basins. Unconsolidated aquifers of sand or sand and gravel that are relatively thin, narrow, and commonly capable of yielding more than 12.6 L/s (200 gal/min) to properly located and constructed wells are found in major stream valleys. A significant amount of water is stored in thick glacial till, but it is transmitted very slowly through the small intergranular spaces (pores) of the deposits. Accordingly, till is a poor aquifer and normally does not yield enough water for municipal, industrial, or commercial needs (Gay and Delaney 1980; Cotton 1975, 1976a, 1976b, 1977).

Groundwater in the middle Connecticut River and Merrimack River basins near the project area in the state of New Hampshire is generally of good chemical quality. Most of it is clear and colorless, contains no suspended matter and practically no bacteria, and is low in dissolved-solids concentration. Also, it is generally soft (0-60 mg/L) to moderately hard (61-120 mg/L). In general, groundwater from bedrock and glacial-drift aquifers is good throughout the lower Merrimack River basin near the study area in the state of Massachusetts, with dissolved solids less than 300 mg/L, and is suitable for domestic, municipal, irrigation, and livestock supplies. Reported water quality of these aquifers is a calcium bicarbonate type (Gay and Delaney 1980).

Water-supply sources for most communities within the project area consist of groundwater from private suppliers and onsite wells, although larger communities such as Concord, Manchester, and Nashua rely either on surface-water sources or a combination of surface water and groundwater to meet water-supply demands (ER, Vols. 2 and 3).

3.4 ECOLOGY

The counties containing the proposed route are within two ecological provinces (Bailey 1976; Galvin 1979). Most of New Hampshire and the western portion of Massachusetts are within the Northern Hardwood-Spruce Forest section of the Laurentian Mixed Forest province. The remainder of the area is within the Appalachian Oak Forest section of the Eastern Deciduous Forest province. Much of the information provided in the following overview of the predominant habitats and biota occurring within the area traversed by the route is derived from Galvin (1979), U.S. Department of Energy (1984), ER (Vols. 1-3), and references cited therein.

3.4.1 Terrestrial Environment

3.4.1.1 Vegetation

Forest habitat predominates in the study area (consisting in this case of the counties through which the proposed project would be routed). Forest covers about 82% of the counties in the New Hampshire portion of the study area (ER, Vol. 3) and about 59% of the counties in the Massachusetts portion of the study area (Peters and Bowers 1977). These forests can be grouped into eight major types (see Table A.5 of Appendix A). The white and red pine forest is the most common type in the New Hampshire portion of the study area. This type becomes less prevalent in the Massachusetts portion, where oak/hickory forest becomes predominant. This change in forest type occurs within the area of change from the Northern Hardwood-Spruce Forest to the Appalachian Oak Forest section (see Galvin 1979).

The second most common forest type in the New Hampshire study area is the maple/beech/birch forest type, which is commonly known as the northern hardwood forest (Kingsley 1976). The other major forest types in Massachusetts are the white and red pine forest and the elm/ash/maple forest. The latter is the most prevalent forested wetland type in the area (Kingsley 1974).

A variety of species make up the understory and shrub layers in the forest types, and many of them are common along the edge of rights-of-way or become established within them. Such species include huckleberry, blueberry, arrow-wood, flowering dogwood, raspberry, and many others (Jorgenson 1978).

Old field and shrubland also occur throughout the study area and exemplify the habitats found within maintained rights-of-way. These habitats go through a succession from annual herbaceous plants (e.g., crabgrass, ragweed); to perennial herbaceous plants (e.g., little bluestem, goldenrod, milkweed); to small tree and shrub species (e.g., grape, buckthorn, eastern red cedar) (Jorgenson 1978).

Complete lists of the common flora in the study area are given in the ER (Vol. 2--Table III-8, Vol. 3--Table III-9).

3.4.1.2 Wildlife

The wildlife communities in the study-area counties range from those characteristic of heavily forested areas to those characteristic of areas of urban encroachment. A large number of species are found in the study area, as indicated in the ER (Vol. 2--Table III-9, Vol. 3--Table III-10). In the New Hampshire portion there are 244 bird, 39 reptile and amphibian, and 56 mammal species; in Massachusetts the numbers of such species are 208, 26, and 49, respectively. Game species and furbearers in the area include white-tailed deer, black bear, coyote, bobcat, cottontail rabbit, snowshoe hare, opossum, raccoon, red and gray fox, muskrat, mink, striped skunk, weasel, beaver, river otter, and others (Cardoza 1979; ER, Vols. 1-3).

The white-tailed deer is the most important game species in the region (Godin 1977; Halls 1980). Of prime importance to white-tailed deer is the availability of overwintering habitat, or deeryards, which provide a source of forage and shelter. There are six areas with the physical characteristics of deeryards in the New Hampshire portion of the study area. However, these areas apparently have not been surveyed to confirm use by deer.

Gamebirds in the area include wild turkey, ruffed grouse, ring-necked pheasant, northern bobwhite, and more than 20 species of waterfowl. Most waterfowl are migrants or winter residents, but the mallard, wood duck, black duck, and Canada goose nest in the area (Blodget 1983). Waterfowl numbers are not extensive because the study area is within a low-migratory-population corridor for geese and ducks (Bellrose 1976).

3.4.2 Aquatic Environment

About 300 surface waters would be crossed by the proposed transmission line (Section 3.3.1). Of these, at least 53 are known coldwater or warmwater fisheries (ER, Vol. 2--Table III-33, Vol. 3--Table III-35). Generally, most streams in New Hampshire are considered potential trout streams. However, warmer water temperatures in some streams make them unsuitable for year-round use by trout.

Both warmwater and coldwater fish communities occur in the Massachusetts portion of the study area. Existing coldwater fisheries are maintained mostly by annual stocking programs (Massachusetts Division of Fish and Wildlife 1984), but there are a few exceptions. For example, natural trout spawning is reported from Wachusett Reservoir (Halliwell 1981). Ponds and lakes in the study area are considered warmwater fisheries, except for several at higher elevations that are cold enough to support trout year-round. Newfound Lake, the largest lake in the study area, supports a two-story fishery that includes landlocked salmon, lake trout, whitefish, smallmouth bass, pickerel, and yellow perch (ER, Vol. 3). Two tributaries of the lake (Cockermouth and

Fowler Rivers) support spawning runs of landlocked salmon (U.S. Fish and Wildlife Service 1982). Good to excellent trout streams have the general habitat characteristics listed in Table A.6 of Appendix A, as well as temperatures adequate to meet the requirements for trout survival and reproduction (Table A.7).

The principal warmwater game fish in the study area include chain pickerel, white perch, various sunfish, largemouth and smallmouth bass, black crappie, and yellow perch. Eastern brook trout, rainbow trout, and brown trout are the principal coldwater game fish. A number of other game forage and rough fish species occur in the ponds, lakes, and streams throughout the study area (ER, Vol. 2--Table III-9, Vol. 3--Table III-10).

Trout are stocked in some of the streams that would be crossed by the proposed transmission line (ER, Vol. 2--Table III-33, Vol. 3--Table III-35). Stocking is done to supplement natural reproduction or to provide a seasonal coldwater fishery in streams where natural reproduction does not occur. Generally, heavy trout fishing pressure necessitates constant restocking (Eddy and Underhill 1974).

Several of the rivers in the study area are, or soon will be, managed to allow reestablishment of anadromous species, namely the Atlantic salmon, American shad, blueback herring, and alewife. A fishway has been constructed at Lowell Dam and should be operational in 1986. This will allow the latter three species to ascend to the portion of the Merrimack River that is in the study area (ER, Vol. 2). A number of rivers in both the Merrimack and Connecticut River basins are targeted for Atlantic salmon and American shad reestablishment programs (ER, Vol. 3--pp. 94-95).

Detailed characterizations of the benthic macroinvertebrates of the waterbodies in the study area are not available. Since most of the waterbodies are Class A or B waters (ER, Vols. 2 and 3), it is likely that they maintain productive benthic communities composed of a diverse assemblage of invertebrate species indicative of good to pristine water-quality conditions. The few Class C waters to be crossed by the proposed transmission line are probably dominated by invertebrate species tolerant of organic enrichment or other degraded water-quality conditions.

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). Wetlands that would be crossed by the proposed line 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 transmission line corridor would cross 98 wetlands in New Hampshire and 119 wetland areas in Massachusetts. Detailed information on the wetlands is given in Appendix B.

3.4.4 Threatened and Endangered Species

The Endangered Species Act of 1973 requires a determination of the presence of endangered and threatened species and/or their critical habitats within the vicinity of a proposed federal action. The DOE Staff has consulted with, and received information from, the U.S. Fish and Wildlife Service and the New Hampshire Fish and Game Department concerning federally and/or state listed species (see letters in Appendix E from G.E. Beckett, Supervisor, New England Area, Ecological Services, U.S. Fish and Wildlife Service, February 13, 1986; and from H.P. Nevers, Federal Aid and Endangered Species Coordinator, New Hampshire Fish and Game Department, February 14, 1986). Similar correspondence was implemented by the Applicant with the Massachusetts Natural Heritage Program relative to state-listed species. A copy of the correspondence from these agencies is included in Appendix E. The following sections contain information on the endangered, threatened, and rare species that may occur within the area. This information is based upon the above mentioned consultations, coupled with pertinent reference literature.

3.4.4.1 Vegetation

No federally listed endangered or threatened plant species occur within the counties that would be traversed by the proposed transmission line (Beckett 1986).

New Hampshire has not developed an official state list of endangered and threatened plants, but the New Hampshire Natural Heritage Program, through the New Hampshire Natural Heritage Inventory, has developed a list of rare plant species (New Hampshire Office of State Planning 1984). Within 0.4 km (0.25 mi) on either side of the New Hampshire portion of the proposed transmission line, 11 species of rare plants have been reported (Brackley and Hentcy 1985).

Forty-seven plant species listed by the state of Massachusetts as rare and declining occur within the Massachusetts portion of the study area (ER, Vol. 2--Table III-10). Only one of these, the climbing fern, is likely to be present near the proposed transmission line. However, a field survey by the Massachusetts Natural Heritage Program has determined that the climbing fern does not occur in the right-of-way (ER, Vol. 2). The rare plants and their habitats are listed in Table A.8 of Appendix A.

3.4.4.2 Fish and Wildlife

A number of federally listed and state-listed threatened and endangered animal species may occur as transient individuals within the counties containing the proposed route (Beckett 1986). The species, their status, and their general habitats are listed in Table A.9 of Appendix A. In Massachusetts, none of the species listed as endangered or threatened is considered by the Massachusetts Natural Heritage Program to be near the proposed transmission route in that state (ER, Vol. 2). The Massachusetts Natural Heritage Program also has a category listing species considered to be "of special concern". The Program has determined that of the 30 species listed in this category, only the southern bog lemming is likely to be present near the proposed transmission line. It has been recorded from a wetland in Dunstable. Its habitat includes wet sedge meadows, sphagnum bogs, and (less commonly) orchards and open grasslands (ER, Vol. 2).

Of the 19 species list by the state of New Hampshire as threatened or endangered, 11 (all birds) have been observed in the study area. These are the bald eagle, peregrine falcon, Cooper's hawk, osprey, red-shouldered hawk, northern harrier, common loon, upland sandpiper, whip-poor-will, purple martin, and eastern bluebird. No active nests of the first four species are known to occur in the study area, but some individuals of the other seven species may nest in or near some of the counties that would be traversed by the proposed line (ER, Vol. 3).

3.5 SOCIOECONOMICS

3.5.1 Institutional Setting

Local governmental units in both New Hampshire and Massachusetts consist of counties that are further subdivided into towns (which are somewhat equivalent to townships in some parts of the country). Each organized town traversed by or adjacent to the proposed right-of-way (total of 27 in New Hampshire and 17 in Massachusetts) is administrated by a town meeting/board of selectmen type of government. The chief source of local revenue is property taxes (payable directly to cities and towns), followed by revenue-sharing (primarily from the state) (Bureau of the Census 1983).

3.5.2 Population

The population density exhibits marked variation along the proposed corridor, ranging from low-density rural to moderate-density urban (see Table A.10 of Appendix A). The lowest population densities occur in Grafton County, New Hampshire, where several towns (Lyman, Benton, and Groton) contain fewer than 4 persons/km^2 (10/mi^2). (Most towns in the county have total populations of less than 1,000 persons.) The largest population concentrations are in the towns of Shrewsbury and Milford, Massachusetts, where the population density exceeds 385 persons/km^2 (1,000/mi^2), and in Concord City and adjacent towns in New Hampshire.

Growth trends for New Hampshire reflect significant acceleration during the 1970-1980 decade, especially in rural areas. By contrast, growth rates for the same period were much less in Massachusetts, with some towns even reporting modest declines. Moderate growth is projected for the period 1980-1990 in areas in both Massachusetts and New Hampshire traversed by or adjacent to the proposed transmission line route. Past trends and projections are presented in Table A.10.

3.5.3 Employment and Economics

The 1982 labor force in counties traversed by the proposed right-of-way totaled 343,247 for New Hampshire and 1,402,567 for Massachusetts. Unemployment rates for that year ranged between 6% and 7%, except for Worcester County, where it reached 9.4%; by 1984, unemployment had fallen to less than 5.0% (Bureau of the Census 1983; ER, Vol. 2--p. 127, Vol. 3--p. 114).

The primary categories of employment in the area are manufacturing and professional and related services. These two categories respectively account for an average of 27.2% and 23.4% of employment in the area, by county. The other major categories include wholesale and retail trade (18.9%) and government (15.9%) (Bureau of the Census 1983). Manufacturing jobs are chiefly in machinery, electrical products, metals, and lumber and wood products (Bureau of the Census 1985a, 1985b). Tourism is an important industry in several of the counties, especially Grafton.

Median family income was $19,837 for the four New Hampshire counties and $23,322 for the three Massachusetts counties in 1979. Income is lowest in the rural areas; in several Grafton County towns it falls below $14,000 (New Hampshire Office of State Planning 1983b; Bureau of the Census 1983).

3.5.4 Housing

In 1980, there were 249,205 housing units in the New Hampshire counties traversed by the proposed route and 945,628 in the Massachusetts counties. The former represents a significant increase over 1970, ranging between 35.5% and 43.3% by county, while modest increases (14.4% to 17.5%) occurred in the Massachusetts counties. Vacancy rates for rental units in 1980 varied between 4.5% and 6.1% in New Hampshire, except for Grafton, with 11.1%. More moderate rates (2.8% to 4.8%) were reported for Massachusetts (Bureau of the Census 1972a, 1972b, 1982a, 1982b).

In 1982-1983 there were 288 temporary lodging establishments (chiefly hotels and motels) in the New Hampshire counties along the route and 203 in the Massachusetts counties. Figures are highest in areas where tourist demand is strong, especially in Grafton and Rockingham counties, New Hampshire (Bureau of the Census 1985a, 1985b).

3.5.5 Transportation

The transportation network in the proposed project area is described in Section 3.2.9.1. The most heavily traveled roadways in the New Hampshire portion of the proposed route are in the more urban southern regions, traversed by two interstate routes (I-89 NW-SE and I-93 N-S). Average annual daily traffic (AADT) volumes for these roads range as high as 16,000 and 30,000, respectively, for Concord. Other high-volume roads (more than 10,000 AADT for some areas) in the southern towns include U.S. 3 (N-S) and 393 (E-W) and SRs 101 (NE-SW), 101A (NW-SE), 102 (NE-SW), 111 (E-W), 114 (N-SE), and 114A (NW-SE). North of Concord, traffic volumes decline substantially, generally falling below 3,500 AADT. The most heavily used roads (over 2,000 AADT in some areas) include U.S. 302 (N-SW) and SRs 3A (N-S), 10 (N-S), 11 (E-W), and 25 (N-SE) (New Hampshire Department of Public Works and Highways 1984; ER, Vol. 3--pp. 145-146, Table III-20).

Traffic flows are high in the Massachusetts counties, although volume data are not available. The area is traversed by four interstate highways: I-90 (E-W), I-190 (N-S), I-290 (E-W), and I-495 (N-S). Other major roads include U.S. 3 (N-SE) and 20 (E-W) and SRs 2 (E-W), 9 (E-W), 12 (N-S), 117 (E-W), 119 (NE-SW), and 140 (NE-SW) (Massachusetts Department of Public Works 1982-1984; ER, Vol. 2--pp. 148-149, Table III-21).

3.5.6 Public Concerns

Although few public concerns relative to the proposed project were voiced at the DOE scoping meetings held in Concord and Boston on June 4-5, 1985 (U.S. Department of Energy 1985), concerns were expressed at a hearing held in Groton, Massachusetts, on February 5, 1985 (conducted jointly by the

Massachusetts Department of Public Utilities, the Massachusetts Energy Facilities Siting Council, and the Massachusetts Environmental Policy Act Unit of the Executive Office of Environmental Affairs), and in written correspondence to DOE. The primary issue raised was potential adverse health effects (both to humans and livestock); less commonly expressed concerns included visual impacts, potential increases in underground pipeline corrosion, need for power, property value effects, noise, and impacts to wildlife.

3.6 VISUAL RESOURCES

3.6.1 Visual Resources Study Area and Landscape Classifications

A 3.2-km (2-mi) corridor centered on the proposed transmission line route initially was selected for evaluation of visual resources. This selection was based on the assumption that construction of the proposed transmission line within an established right-of-way occupied by one or more existing transmission lines would not significantly degrade viewsheds from the boundary of the study area corridor. However, during field surveys, boundaries of the study corridor were expanded to encompass viewsheds from particularly sensitive areas. In other instances, the boundaries of the study corridor were narrowed in accord with landscape features that would preclude observation of the proposed transmission line.

The Applicant has identified landscapes of the study area in terms of three classes of visual quality--Distinctive, Noteworthy, and Common. Distinctive landscapes are areas of high visual quality, whereas the visual quality of Noteworthy landscapes is less, but nevertheless important. Landscapes characterized by typically inconspicuous features are categorized as Common landscapes. The classification of a given landscape is based on four landscape elements, i.e., landform, water, vegetation, and cultural or man-made modifications. The landscape quality matrix is presented in Table A.11 of Appendix A.

3.6.2 Route Landscape Descriptions in New Hampshire

Vistas along the proposed transmission line route in New Hampshire are predominantly Distinctive and Noteworthy landscape types (see Table A.11), particularly in northern portions of the study area. The following descriptions of landscapes along the proposed New Hampshire route are adapted from the ER (Vol. 8--Sec. III.B.2) and correspond with segments of the route identified by the Applicant--Monroe to Rumney (Segment A), Rumney to Goffstown (Segment B), and Goffstown to the New Hampshire/Massachusetts state line (Segment C). Towns in which the segments begin or terminate are shown in Figures 2.2 and 2.3. Detailed maps delineating the New Hampshire study area established by the Applicant are presented in the ER (Vol. 8--Figures III-2.1 through III-2.8).

Segment A: From the northern terminus of the proposed line in the town of Monroe, this segment extends south for about 60 km (37 mi) to the town of Rumney. The terrain is typical for the White Mountain Section of the New England province, i.e., rolling hills and several low mountain ranges with peak elevations ranging up to 915 m (3,000 ft). Some of the higher peaks include Jeffers, Hogsback, Sugarloaf, and Black mountains in the town of

Benton. Rock outcrops such as Pond Ledge and Owls Head are prominent landscape features in the towns of Haverhill and Benton, respectively. The Connecticut River Valley is the dominant landform of the western portion of the study area in the towns of Monroe and Bath. Vegetation is typically Northern Hardwood-Spruce Forest, with stands of spruce and fir being particularly extensive in northern portions of the segment. However, interspersions of coniferous and deciduous forest stands over large areas create patterns of color that are particularly attractive during the fall. Water elements include scattered lakes and ponds, the relatively large Moore Reservoir, and rapid-flowing drainages such as the Ammonoosuc and Wild Ammonoosuc rivers. Aside from the Connecticut River Valley, cultural developments are characterized by scattered farmsteads and rural residences with small communities and highways located along valley floors. In combination, natural and cultural features comprise a high proportion of Distinctive and Noteworthy landscapes in this segment.

Segment B: From the town of Rumney, this segment extends south about 93 km (58 mi) to the town of Goffstown. The segment is transitory in that topographic relief tends to decrease and cultural development tends to increase in a southerly direction. In general, the terrain consists of scattered hills and remnant mountains, but hills and mountains are more common to the north, while topographic relief is less pronounced in the southern part of the segment. The vegetation is generally similar to that of Segment A, except that the prominence of red and white pine increases while spruce and fir are less important components of forest stands. Water elements of this segment include the relatively large Newfound Lake; numerous scattered small lakes and ponds; and the Merrimack, Contoocook, and Piscataquog rivers. South of the town of Boscawen, the natural landscape has been fragmented by agricultural and residential land use. Other cultural changes remain reasonably compatible with surrounding natural landscapes, but modifications range from residential areas along established roads to small- and medium-sized commercial areas, to the Concord metropolitan area. Compared with Segment A, Distinctive and Noteworthy landscapes are less prominent in this segment of the study area.

Segment C: This landscape segment extends south from the town of Goffstown about 40 km (25 mi) to the New Hampshire state line and is typical of the New England Seaboard Lowland section. Topographic relief generally ranges from 75 to 150 m (250 to 500 ft). Occasional monadnocks such as North and South mountains are the only prominent features of this landscape segment. The dominant white and red pine forest type frequently occurs bordering agricultural areas in relatively flat terrain. Recent development activity has occurred, transforming some rural areas into residential and commercial centers and dramatically modifying the associated landscape. Compared with Segments A and B, lakes and ponds are less common in Segment C and are typically surrounded by moderate development. The proposed transmission line would intersect and generally parallel the Merrimack River throughout this landscape segment. The river corridor has been developed into a major transportation and commercial center that tends to dominate the visual character of the river valley. In summary, this landscape segment includes more elements of Common landscape than other segments of the New Hampshire study area.

3.6.3 Route Landscape Descriptions in Massachusetts

The following descriptions of landscapes within the Massachusetts study area are adapted from the ER (Vol. 7--Sec. 3). The descriptions correspond with the framework of landscape classes discussed in Section 3.6.1 and are in accord with segments of the proposed route identified by the Applicant, i.e., New Hampshire/Massachusetts state line to Ayer (Segment A), Ayer to Millbury (Segment B), and Millbury to West Medway (Segment C). Towns in which segments begin or terminate are shown in Figures 2.3 and 2.4. Detailed maps delineating the Massachusetts study area and formally designated landscape units are presented in the ER (Vol. 7--Figure III). All Distinctive and Noteworthy landscapes in Massachusetts are recorded in the Massachusetts Landscape Inventory identified by name, code designation, and location (ER, Vol. 7--p. 55).

Segment A. The proposed route traverses Common landscape throughout the entire length of this segment. The landform is predominantly gently rolling terrain, only occasionally interrupted by low hills. The Merrimack River is a major drainageway that intersects the study area, but shoreline development significantly detracts from the visual quality of the river landscape. Vegetation patterns are dominated by Appalachian Oak Forest typical of glaciated areas, consisting primarily of the elm/ash/maple and oak/hickory forest types (see Appendix A). The vegetation patterns dominated by forest are interrupted by active and abandoned farms and developed land. Much of the man-made modifications of landscapes include major highways and industrial and residential areas. However, the landscapes in Segment A are primarily rural in character, the exceptions being the considerable development between U.S. 3 and the Merrimack River and in the vicinity of the Sandy Pond substation.

Within Segment A, the Lower Nashua Valley Distinctive Landscape Unit (C1)* encroaches into the outer boundary of the study area and extends close to and parallels the proposed route for a short distance in the town of Groton. The high visual quality of this landscape unit is attributable to picturesque orchards and farms, wooded drumlins, and open high ground that affords vistas of the Wachusett Mountains to the west and monadnock mountain region of New Hampshire to the northwest.

Segment B. Distinctive and Noteworthy landscapes are traversed by, or are adjacent to, the proposed transmission line route at four locations within Segment B (see below). Otherwise, the proposed route traverses Common landscapes for virtually the entire length of the segment, and landform and vegetation elements of Segment B tend to be similar to those of Segment A. However, vegetation patterns tend to be more fragmented in Segment B, primarily due to a generally greater density of residential areas, industrial/commercial complexes, and other man-made modifications. Increased development is particularly notable in towns in the Worcester area. The proposed route intersects the Nashua River, but proximity of the Boston and Maine Railroad, Fort Devens, and a mining area detract from the visual quality of the river landscape. Other water elements include the North Nashua River

*This and subsequent "unit" designations indicate Distinctive and Noteworthy landscapes identified in the Massachusetts Landscape Inventory (ER Vol. 7--p. 55).

and numerous lakes and ponds, many of which are virtually surrounded by residential development.

The four areas of Distinctive and Noteworthy landscapes in Segment B are the Sterling Landscape Unit (C6), the Upper Nashua Valley-Shrewsbury Ridge Landscape Unit (C2), the Nashua Valley Noteworthy Landscape Unit (C1), and the Lunenburg Noteworthy Landscape Unit (C5). The Sterling unit, located in the town of Sterling, is traversed by the proposed route for a short distance, and generally parallels the route for about 3.2 km (2 mi). This unit includes both Distinctive and Noteworthy landscapes; the moderate to high visual quality of the unit derives from extensive apple orchards and open highlands that afford views of distant landscapes. The proposed route also intersects two narrow segments of the Upper Nashua Valley-Shrewsbury Ridge unit in the town of West Boylston. The unit includes both Distinctive and Noteworthy landscapes, primarily consisting of the Wachusett Reservoir and its immediate shorelines. The reservoir is a major scenic attraction. The Nashua Valley Noteworthy unit abuts the proposed route in the town of Ayer, and the Lunenburg Noteworthy unit is adjacent to the proposed route in the town of Shirley.

Segment C. Landscape features traversed by the proposed route virtually throughout the length of this segment are characteristic of Common landscapes, e.g., gently rolling topography and typical regenerating Appalachian Oak forest interspersed with ponds, streams, and wetlands; as well as considerable cleared and developed land. An exception is where the proposed route intersects a 460-m (1500-ft) segment of a southern extension of the Grafton Distinctive/Noteworthy Landscape Unit (C3) in the town of Grafton. This landscape unit widens to the north of the route intersection and generally parallels the proposed route for about 4 km (2.5 mi). Principal features contributing to the comparatively high visual quality include picturesque dairy farms and apple orchards, as well as dispersed highland areas.

Converter Terminal Site. Within rolling topography, the general area of the proposed converter terminal site is characterized by Common landscape dominated by man-made modifications. The site is within a triangle formed by two highway routes and a branch of the Boston and Maine railway system, all within about 520 m (1700 ft) from site boundaries at closest distance (ER, Vol. 1--Figure IV-6). Electric transmission facilities adjacent to the site include an existing substation, a transmission line extending into the area from the north, and an east-west transmission corridor immediately south of the site that is occupied by three transmission lines. Additionally, an industrial complex is adjacent to and south of the site, and a gravel mining area parallels the eastern boundary of the site.

3.7 CULTURAL RESOURCES

3.7.1 Introduction

Cultural resources primarily include archeological sites (both prehistoric and historic) and historic structures, which are protected by or qualify for protection under the National Historic Preservation Act and other federal and state laws. Pursuant to these laws, the Applicant is conducting an inventory and evaluation (in consultation with the New Hampshire and Massachusetts State Historic Preservation Officers [SHPOs]) of sites that could be affected by the proposed action (ER, Vol. 2--p. 152-155; ER, Vol. 3--p. 153-157; Quinn 1985; Talmage 1985; New England Power 1986a, 1986b). Inventory procedures and study area boundaries are described for each site category below. There are no native American religious sites (protected by the American Indian Religious Freedom Act) or paleontological sites impacted by the project.

3.7.2 Regional Prehistory and History

New England prehistory begins with Paleo-Indian settlement, following retreat of the Wisconsin ice sheet after 12,000 years before present (B.P.). Subsequent prehistory is divided into Archaic (preceramic) and Woodland (ceramic) phases. Regional prehistoric overviews are presented by Griffin (1964), Willey (1966), Newman and Salwen (1977), and others. Both New Hampshire (Pillsbury 1927-1928; Squires 1956) and Massachusetts (Hart 1927-1930; Brown 1978) also possess a long and rich historical record, extending back to the 17th century A.D.

3.7.3 Archeological Sites

Archeological sites include surface and subsurface remains from prehistoric and historic periods. A literature/file inventory of previously recorded sites (including the National Register of Historic Places and the appropriate state registers) indicates that the New Hampshire towns traversed by the proposed right-of-way contain 14 archeological sites, and that 4 archeological sites lie partially on or adjacent to the Massachusetts segment (ER, Vol. 2--pp. 152-155; ER, Vol. 3--pp. 153-156).

The Applicant also undertook a field survey for previously unrecorded archeological sites in areas that would be affected by the proposed project. The survey strategy was developed in consultation with the appropriate State Historic Preservation Office (see letters in Appendix E from J.F. Quinn, Deputy New Hampshire State historic Preservation Officer, October 30, 1985; and from V.A. Talmage, Massachusetts State Historic Preservation Officer, September 9, 1985). Survey methods included a 100% pedestrian surface reconnaissance of the right-of-way and proposed converter terminal sites, and subsurface testing of areas on the right-of-way where proposed structure locations coincide with high site potential (Office of Public Archaeology 1985; New England Power 1986a). (See Appendix C for further description of survey methods.) During the course of the survey, new archeological remains (surface and subsurface) were discovered and, where appropriate, subjected to additional testing.

DOE has tentatively concluded on the basis of existing information that no archeological sites which are listed in, or eligible for inclusion in, the National Register would be affected by the proposed action. The determination of the New Hampshire and Massachusetts SHPOs on this matter will not be made until the completion of the cultural resources survey, prior to the issuance of the final EIS (New England Power 1986a, 1986b).

Detailed reports on the inventory and evaluation of archeological sites will not be available until after completion of the draft environmental impact statement (DEIS). However, the Applicant is submitting quarterly progress reports to the DOE (those completed to date are included in Appendix C of this document), which will be made accessible to the public in the same manner as the DEIS. If unexpected developments in the site inventory and evaluation process warrant, the DOE will issue a cultural resources supplement to the DEIS.

3.7.4 Historical Structures

Although prehistoric sites may contain structures and historic sites may lack them, historic structures may be considered separately because the methods employed for inventory and impact assessment differ from those applied to other cultural resources. An initial literature/file search by the Applicant produced a total of 56 historical structures or historic districts containing structures listed on the National Register or the state registers in towns traversed by the proposed route. The structures include houses, covered bridges, churches, schools, and others (ER, Vol. 2--pp. 153-154, Table III-24; ER, Vol. 3--pp. 155-156, Table III-24).

The Applicant also conducted a more intensive project-specific survey during August-November 1985 and April 1986. The survey design (approved, with modification, by the appropriate SHPOs) entailed identification and evaluation of all historic structures located within one-quarter mile of the proposed right-of-way, and also those outside the one-quarter mile boundary but in proximity to it (Office of Public Archaeology 1985--p. 9-12; New England Power 1986a--pp. 10-11). A total of 318 properties were identified in New Hampshire, and 475 in Massachusetts.

A high percentage of the historic structures identified may be categorized as significant. The New Hampshire SHPO has determined that 200 (63%) of the properties in that state are listed in, or eligible for inclusion in, the National Register. The Applicant has disputed some of these eligibility determinations, and is in the process of resolving this issue with the New Hampshire SHPO (New England Power 1986b--p. 3). The Massachusetts SHPO has notified the Applicant that approximately 290 properties (75 individual properties and 5 historic districts) may be eligible (New England Power 1986b--p. 3). Final eligibility determinations are expected to be available in July 1986.

Additional information on the inventory and evaluation process will be made available to the public in the same manner as for other cultural resources (see Section 3.7.3).

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4. ENVIRONMENTAL CONSEQUENCES

4.1 CONSEQUENCES OF THE PROPOSED ACTION

The proposed action includes numerous committed mitigating measures that are identified by category in Section 2.1.5. Each of the following discussions of environmental consequences of the proposed action assumes the adoption and effective implementation of all listed mitigating measures.

4.1.1 Air Quality

The greatest project-related impact to air quality would be from fugitive dust generated during clearing and construction activities. Although locally heavy at times, the dust generally would not be bothersome at distances of more than 300 m (1000 ft) from the clearing and construction activities. At this distance, the concentration of dust would have decreased to less than one-tenth of the initial concentration (Sullivan and Woodcock 1982). During construction of the line, contractors would be required to provide dust-control measures to avoid undue impact. Watering has been shown to be an effective and inexpensive method to reduce dust. For example, one study indicated that dust releases were lowered 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.

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

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 lines, however, 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 kV DC (Droppo 1979; Krupa and Pratt 1982). A number of field experiments have shown that ground-level ozone concentrations resulting from transmission line corona are usually indistinguishable from background concentrations (Sebo et al. 1976; Roach et al. 1978). Johnson and Zaffanella (1982) measured no detectable ozone levels above background beneath a line operating under conditions similar to those proposed for the DC interconnection. Comber et al. (1982b) estimated than an operating 1050-kV AC line may increase ozone by 5 ppb above background. The one-hour EPA standard for ozone is 120 $\mu g/m^3$ (60 ppb). Minimum levels of toxicity are reported to be abut 200 $\mu g/m^3$ (100 ppb). Based on these studies, it is apparent that operation of the proposed transmission system would not result in the production of ozone at toxic levels.

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

4.1.2 Land Features and Use

4.1.2.1 Geology

Construction, operation, and maintenance of the proposed transmission facility would have only minor or negligible impacts on geologic conditions. Terrain changes associated with the construction of the proposed transmission lines would be confined to local landscape alterations caused by construction-vehicle traffic and leveling or grading for transmission line structure sites and access roads. Changes in landform would also occur at the proposed 12-ha (30-acre) converter terminal site, where cut and fill would be used in site preparation prior to construction of terminal facilities.

Placement of transmission structures on sloping areas could produce localized slope failures and resulting landslides. These areas are confined to stream crossings, steeper slopes, and dissected uplands of major river valleys. Examples of such areas include some banks of the Ammonoosuc River near Bath, the Fowler River near Alexandria, and the Merrimack River near Merrimack, all in New Hampshire, and the Wachusett Reservoir in the town of West Boylston, Massachusetts.

A seismic risk map indicates that the study area is in a region expected to sustain minor earthquake damage (Corps of Engineers 1983). The transmission facilities, including structure footings and substations, should be designed with a safety factor to account for earthquake loadings. Seismic activity of low or medium intensity would have little or no effect on the transmission line system. Although the historical record indicates minor seismic activity in the general project area, this does not preclude the occurrence of a major earthquake (intensity of 7 or higher, Richter scale), which would likely cause severe structural damage to the facilities.

Construction of structure foundations, access roads, and substations would result in the consumptive use of sand and gravel resources. These resources might have to be imported from outside the right-of-way, which contains clay-rich till. However, sand and gravel resources are of local importance only and supplies would not be unduly strained by construction needs.

4.1.2.2 Soils

Project-related impacts on soil resources include consideration of important farmlands as identified in the Farmland Protection Policy Act (Public Law 97-98, December 22, 1981). The 298 km [185 mi] of proposed transmission line routes in Massachusetts and New Hampshire would traverse a cumulative total of 35 km (22 mi) of prime and other farmland of statewide importance (Section 3.2.2). At an average structure spacing of 183 m (600 ft), spanning the 35 km (22 mi) of prime and other important farmland would require about 193 structures. Based on published data (Scott 1981), the calculated total cumulative area of important farmland that would be disturbed or inaccessible to operators of farm implements around 193 H-frame structures would range from 1.6 ha (3.9 acres) to 3.2 ha (7.7 acres). The affected area is somewhat overestimated since some important farmlands would be spanned and some single-pole structures would be used in transmission line construction. Some additional important farmlands would be disrupted to facilitate project access, but for the most part, existing access within the established transmission line corridors would be adequate for project development. Because of the limited area involved, project-related impacts on prime and other important farmlands would be of minor consequence.

The major impact on soils would occur during the construction period. Vegetation clearing and construction activities would increase the potential for soil erosion. Much of this erosion would occur in areas with a steep slope and/or highly erodible soil. The grades of many of the slopes along the proposed route equal or exceed 15%. Soils in areas with steeper slopes have more potential for soil erosion.

Potential water erosion at the construction sites for the structures and the proposed terminal site was estimated using the Modified Soil Loss Equation (Warrington 1980). Table 4.1 shows the parameters used and the estimated losses. For the purposes of these calculations, the proposed terminal site was divided into two sections--one of steep relief, which takes up approximately one-quarter of the terminal site, and the other area of low relief. Low canopy cover and low mulch cover percentages were used to simulate a worst-case scenario. If access roads are not properly located, graded, and maintained, concentrated runoff could occur, resulting in gully erosion. After construction and during operation, soil erosion would decrease because of revegetation and leveling of the structure and substation sites.

Table 4.1. Estimated Annual Soil Loss Due to Erosion

	Parameters Used			
Site	Soil Erodibility	Slope Length (m)	Slope (%)	Soil Loss $[kg/(m^2 \cdot yr)]$[a]
Proposed terminal	0.49	305	2	2.3
	0.49	120	12.5	21.7
Route (structures)	0.4	15	5	1.5

[a] 1 $kg/(m^2 \cdot yr)$ = 4.4 tons per acre per year.

Existing soils would be disrupted and/or displaced during the leveling of the 12-ha (30-acre) converter terminal site, grading and excavations at structure construction sites, and construction of access roads. However, the cumulative area of affected soils would be relatively limited since much of the required access has been previously developed during construction of existing transmission lines within the common right-of-way. Furthermore, excavations for structure foundations would entail minimal sacrifice of soil resources, particularly in upland areas. For example, the cumulative area for H-frame structure foundations would generally be less than 0.02 ha (0.04 acre) per 1.6 km (1 mi).

For the most part, excavated spoil materials at the converter terminal and access road construction sites would be used for fill. At transmission line structure construction sites, the excess spoil would be spread over areas adjacent to the structures. However, if the spoil would be unsuitable as a topsoil dressing, the material would be removed from the right-of-way.

4.1.2.3 Land-Use Impacts

Agricultural Resources

Based on analysis of aerial photographs, the centerlines of the proposed transmission lines are estimated to traverse tracts of agricultural lands for a cumulative distance of 13.5 km (8.4 mi) in New Hampshire (ER, Vol. 3--p. 200) and 11.7 km (7.3 mi) in Massachusetts (ER, Vol. 3--p. 188), a combined distance of 25.2 km (15.7 mi). Given an average spacing interval of 183 m (600 ft) between structures, spanning this combined distance would entail construction of about 138 structures. Calculations based on published data (Scott 1981) indicate that the total cumulative area around 138 two-pole (H-frame) structures that would be inaccessible to operators of farm machinery ranges from 1.1 ha (2.8 acres) to 2.2 ha (5.5 acres). The inaccessible area would be even less since single-pole structures would be used along some segments of the proposed line. Furthermore, some tracts of agricultural land would be spanned, and use of pasturelands would be essentially unaffected by structures. Thus, the actual area withdrawn from agricultural production would be of minor consequence. Prime and unique farmland acreage affected by the proposed action is discussed in Section 4.1.2.2.

The proposed project also would entail some short-term impacts on agricultural resource areas. For example, some agricultural land could be temporarily unavailable for use during local construction. Construction activities could be scheduled to minimize damage to annual crops during the growing season; however, perennial crops such as orchards and nursery trees would be subject to damage regardless of the season of construction. Soils along temporary access routes and at construction sites would be subject to varying degrees of compaction, depending on soil properties and compaction loading; thereby causing corresponding reductions in crop yields for several subsequent years (Asplundh Environmental Services 1981). Restoration of productivity would depend on tillage practices and natural factors such as freeze-thaw cycles and soil fauna activity. None of these impacts are regarded as significant.

Forest Resources

Project-related impacts on forest resources would be relatively minor since virtually all of the proposed transmission lines would be located within established corridors in which most of the vegetation is controlled at heights compatible with operation of one or more existing transmission lines. An exception to this is a 1.3-km (0.8-mi) right-of-way that would extend from the Comerford converter terminal to an established transmission corridor in the town of Monroe, New Hampshire. This corridor would be cleared to a width of 61 m (200 ft). The only other forest removal required in New Hampshire would entail clearing a 23-m (75-ft) belt within an established 13.7-km (8.5-mi) transmission corridor from Sandy Pond junction to the state line. From the New Hampshire-Massachusetts boundary to the proposed converter terminal immediate to the Sandy Pond substation, cleared portions of the established transmission corridor would be widened by 23 m (75 ft) for 13 km (8.1 mi) and by 18 m (60 ft) for 6.6 km (4.1 mi). Cleared portions of the established 58-km (36-mi) transmission corridor between the Sandy Pond and Millbury substations would be widened at several locations. However, all such clearings within this corridor would be of limited extent and involve a total of 6 ha (15 acres) of forest vegetation (ER, Vol. 2--Table III-32).

The most extensive right-of-way clearing would occur within the established 25.9-km (16.1-mi) transmission corridor between the Millbury and West Medway substations. Cleared portions of the right-of-way would be increased by widths ranging from 24 m (80 ft) to 30 m (100 ft). Aside from right-of-way clearing, a 15-ha (36-acre) tract would be cleared to accommodate construction of the proposed converter terminal and two alternating current connector lines in Massachusetts, and about 1.2 to 1.6 ha (2 to 4 acres) would be cleared at the ground electrode site in the town of Lisbon, New Hampshire.

In summary, the proposed project would result in withdrawal of about 147 ha (364 acres) from the forest resource base. For perspective, about 60% of the land area in Massachusetts and 86% of the land area in New Hampshire is forested (Kingsley 1976). Additionally, the aforementioned 147 ha (364 acres) withdrawn from the forest resource base represents less than 0.06% of the forest lands in Massachusetts and New Hampshire towns traversed by the proposed transmision lines (ER, Vol. 2, Table III-19; Vol. 3, Table III-18).

Mining Resources

Mining activities represent a very minor land use in the vicinity of the proposed project facilities. For example, the proposed transmission lines would traverse sand and gravel extraction sites for a total cumulative distance of 2.4 km (1.5 mi). Mining activities are not encouraged in the established transmission corridor within which the proposed lines would be constructed (ER, Vol. 2--p. 168); however, where feasible, excavations that would neither interfere with locations of structures nor jeopardize the structural and operational integrity of the proposed lines would be permitted.

Recreational Resources and Natural Areas

The proposed line would be developed within an established transmission corridor, thus all or portions of recreational resources and natural areas within the corridor already are traversed by one or more existing transmission lines. Users of such recreational resources are exposed to views of the lines and experience impacts of a visual nature. The adverse visual effects related to existing lines would be incrementally increased by development of the proposed line (see Section 4.1.6).

Project-related construction would not encroach on any major and intensively developed recreational areas, but some small portions within the established transmission corridor have been developed for recreational use. For example, a segment of the corridor in the town of Bedford, New Hampshire, is part of a golf course, and a boat launch facility and swimming beach are within the corridor in the towns of Shrewsbury-Grafton, Massachusetts (ER, Vol. 2--Table III-40). Other private developments have encroached on the edge of the transmission corridor at several locations; these developments include swimming pools and playground facilities. Users of developed recreational facilities within the corridor could be temporarily inconvenienced by project construction, but the only long-term impact would be visual in nature. Users of portions of the Upton State Forest and Wachusett Reservoir sites would also be exposed to views of the proposed line.

The proposed route intersects eight river segments in New Hampshire (see Section 3.2.6) and four river segments in Massachusetts that are identified as official or potential recreational resources by various agencies or organizations. Project construction likely would not interfere with river recreation, but river travelers would be exposed to views of the proposed line as well as one or more adjacent existing lines at several locations. Eleven scenic highways, six bike routes, and the Appalachian Trail intersect the proposed line (see Section 3.2.6). Project-related construction could temporarily interfere with use of these recreational routes, but the only long-term effect would be visual in nature.

In general, the level of potentially adverse impacts on recreational resources due to the proposed project is relatively low, since the long-term adverse effects on recreational resources would essentially be limited to incremental visual impacts; i.e., the visual intrusiveness of the proposed transmission line would exacerbate the visual intrusiveness of existing lines within the transmission corridor.

Residential, Commercial, and Industrial Areas

With exception of a 1.3-km (0.8-mi) segment located on existing utility property, the proposed transmission line would be developed within established transmission line corridors that have existed for 15 or more years (ER, Vol. 2--p. 194, Vol. 3--p. 206). In some towns, the transmission corridors are incorporated in town zoning district maps and land-use plans. No residential homes or business establishments occur in the transmission corridor; however, the corridor is encroached on at several locations. Two hard-topped parking lots associated with an industrial park extend into the corridor in the town of Bedford, New Hampshire (ER, Vol. 3--p. 208), and a truck-trailer storage facility occupies part of the corridor in the town of Shrewsbury, Massachusetts (ER, Vol. 2--Table III-35). These facilities could be altered during project-related construction. Urban residential areas would be crossed by the proposed transmission lines for a cumulative distance of about 1.9 km (1.2 mi) within nine towns in Massachusetts (ER, Vol. 2--Table III-35). These and other residential areas, as well as commercial and industrial developments adjacent to the transmission corridor, would be subject to increased levels of noise and dust during construction of the proposed project.

Construction impacts related to development of the proposed converter terminal in Massachusetts would primarily affect scattered residential units along roads surrounding the converter terminal site. The proposed route traverses the Fort Devens Military Reservation for about 2,160 m (7,100 ft) and some adjacent residential units could be affected by construction activities. However, since the proposed line would be developed within an establish transmission corridor, the overall effects on residential, commercial, and industrial development would not likely reach unacceptable levels.

Transportation Facilities

Development of the proposed project would involve crossing about 210 major highways and local roads. Some local damage to roadbeds could occur due to movement of heavy vehicles and transport equipment. During line-stringing operations, temporary overhead guard structures would be erected at intersections of the proposed line and transportation routes. Motorists would be subjected to temporary increased levels of noise and fugitive dust at construction sites adjacent to the proposed line, and construction-related vehicles could cause short-term interference with local traffic patterns on routes adjacent to construction sites. However, construction would be scheduled so as to disperse activities along the entire proposed route, thus avoiding concentrations of construction activities (ER, Vol. 2--p. 197). Impacts on railroad facilities would likely be minimal. The Applicant would be committed to coordinate proposed construction activities with appropriate railroad officials to minimize interference with scheduled railway traffic (ER, Vol. 2--p. 201, Vol. 3--p. 214).

Conductor clearances over highways and railways would comply with the current National Electrical Safety Code. The Federal Aviation Administration (FAA) would be notified of the proximity of the proposed line to the Dean Memorial and Newfound Valley airports in New Hampshire, and the Moore Army Airfield and Shirley Airport in Massachusetts. Any issues whereby development of the proposed line would interfere with aeronautical facilities or navigable air space would be resolved though coordination with appropriate authorities.

Transmission Facilities

The proposed transmission line would intersect a total of 33 other electrical transmission lines (ER, Vol. 2--p. 203, Vol. 3--p. 214). The Applicant will coordinate with affected utilities during the design and construction of facilities, and the use of temporary guard structures during construction would avoid or minimize adverse effects associated with transmission line intersections (ER, Vol. 2--p. 203).

Pipelines intersecting the established transmission corridor (see Section 3.2.9.2) been grounded to control electrical effects from existing AC transmission lines, thereby preventing excessive corrosion of the pipelines. The pipeline adjacent to the proposed DC transmission line in the town of Hudson, New Hampshire, would not be affected by operation of the DC line because the ground electrode for the line is located far to the north in the town of Lisbon. The potential for corrosion of underground pipelines in the general area of the ground electrode could be a land-use issue. Studies indicate routine mitigative measures are possible, but further studies and field testing are planned (ER, Vol. 8--p. 153).

Communication Facilities

Project-related impacts on existing communication systems would likely be minimal. Communications for the proposed project involve an existing shared microwave system. Internal equipment at existing stations would be modified, but no additional access routes or station sites would be required (ER, Vol. 1--p. 68).

Other Land-Use Impacts

Development of the proposed project would entail establishing 25 to 35 construction laydown and staging areas at intervals along the proposed route (ER, Supplement, Response No. 7, September 27, 1985). An area of about 0.5 to 1.0 ha (1 to 2 acres) would be required for each laydown and staging site. Because the exact number and location of these sites have not yet been determined, specific potential land-use impacts can not be evaluated. However, following construction of the proposed project, the laydown and staging areas would be reclaimed and restored to conditions similar to those existing prior to construction. Thus, meaningful effects on long-term land-use patterns would be unlikely.

4.1.3 Hydrology, Water Quality, and Water Use

4.1.3.1 Surface Water

Construction and operation of the proposed project would result in some adverse impacts on surface-water conditions. The majority of these impacts would be short-term and limited to the period of construction. Of greatest concern are impacts involving erosion of disturbed construction areas, with subsequent increases in turbidity and sedimentation of rivers, creeks, and wetlands in the area. Removal of trees, brush, and ground cover during construction would expose soils to increased erosion, particularly along shorelines and backshore areas, and movement of construction vehicles and equipment might accelerate the transport of disturbed soils to nearby waterways. The magnitude of potential erosion impact would depend on the steepness of the slope, timing of construction, and amount of ground cover removed (Section 4.1.2.2). At stream and river crossings, construction vehicles and equipment could contribute to siltation by disturbing stream banks and creek bottoms. Siltation increases water turbidity and decreases dissolved oxygen content. The use of erosion control measures described in Section 2.1.5.3 would minimize any potential erosion impacts and the potential of contamination of surface waterbodies.

Water quality could be degraded by release of oils, greases, fuels, and herbicides; improper management of wastes during operation and maintenance of construction equipment; spilling of oil from substations; and release of domestic wastes generated by construction workers. Such contamination could cause a short-term, but potentially severe, reduction in water quality. During periods of high runoff, impacts to surface-water quality could be temporarily severe in affected areas. However, such impacts would be minimized by the proposed mitigative measures (Section 2.1.5.3).

Surface runoff along the transmission line right-of-way would be increased because of removal of vegetation and ground cover. This could result in reduced evapotranspiration and interception, as well as decreased permeability of the ground surface. However, the area within the right-of-way (about 15 km^2 [6 mi^2]) would be small relative to the total area of the affected watersheds. Therefore, the effects of surface runoff from the right-of-way would primarily be reflected by increased flows in the smaller local drainageways. Major drainage patterns and streamflow regimes in the principal drainageways would be essentially unaffected, except for a tributary of Roaring Brook in the town of Monroe, New Hampshire, that would likely be diverted a short distance in order to construct a transmission line angle structure (Walker 1986). In addition, temporary diversions of water might occur along access roads and around construction sites. Local surface drainages might be temporarily or permanently altered by access roads and construction activities. Most of these impacts would be short-term, but even permanent alterations should cause only minor local impacts.

Culverts would generally be used to cross ephemeral streams flowing during construction; however, fording of some streams and passage of construction vehicles and equipment across small wetlands would likely be required. The placement of culverts across streams, the fording of streams, and the construction conducted alongside the stream could result in damage to or collapse of localized portions of streambanks. Mitigative measures would be taken to minimize these potential impacts. Most culverts installed during project construction would be left in place to facilitate access for transmission line and right-of-way maintenance (Walker 1986).

4.1.3.2 Groundwater

Construction activities associated with the proposed project could result in some adverse impacts on groundwater conditions in the study area. Areas of greatest concern are where shallow glacial-drift aquifers occur and where perched water tables exist. In some places, clay-rich till separates the glacial-drift aquifer and a perched groundwater table from deeper aquifers. Excavation for structure foundations might penetrate the impervious clay-rich layer and provide a channel for connection of the groundwater layers. This could cause perched water to drain into lower aquifers or deeper glacial drift aquifers. Penetration of impervious layers might increase recharge of aquifers buried under clayey layers that currently limit recharge. Hydraulic interconnection between aquifers could also result in contamination of glacial-drift and deeper aquifers with pollutants contained in the perched water. Careless and excessive application of herbicides during right-of-way maintenance could result in the percolation of herbicides to shallow glacial-drift aquifers, potentially contaminating water pumped from this aquifer. Although the potential for such impacts exists, the extent and magnitude would be minor if project structures are carefully sited.

Compaction of soils and subsequent disruption of shallow groundwater flow patterns might occur on access roads and around structure sites during construction. Groundwater flow patterns also would be disrupted in areas where dewatering was required during construction due to a high groundwater table.

4.1.4 Ecology

Impacts to biota from Phase II activities would be similar to those discussed for Phase I (U.S. Department of Energy 1984). Therefore, much of the following discussion on ecological impacts is based on analyses from Phase I (and reported herein where applicable), accompanied by site-specific information contained in the Applicant's ER. Where appropriate, additional and/or more updated information has been added to more thoroughly address potential impacts.

4.1.4.1 Terrestrial

Vegetation

Vegetation would be affected by clearing along selected areas of the proposed right-of-way and at the sites for the proposed converter terminal and ground electrode. Clearing would include (1) cutting and disposal of trees and (2) grubbing and disposal of stumps (ER, Vol. 1). The latter would be applicable primarily for the converter site and for areas in the right-of-way where access roads and transmission line structures would be located. Effects on vegetation from clearing operations would be similar to those typical of logging operations (U.S. Department of Energy 1984).

Right-of-way clearing would entail cutting of large mature trees and removal of potentially tall-growing trees. Damage to shrub and herbaceous species would be minimized to the extent possible. Vegetation beneath the transmission line conductors would be limited to low-growing shrubs and herbaceous species, as well as tree species of low-height potential. Removal or selective trimming of some danger trees outside the right-of-way would also be required. The amount of clearing that would be required is discussed in Section 4.1.2.3. Altogether, about 135 ha (330 acres) of right-of-way would be cleared. This area would consist of the general forest types shown in Table 4.2. Relative to total forest resources in the study area, this loss of forested area would be negligible.

Table 4.2. Forest Types and Areas to Be Cleared for the Proposed Right-of-Way

Forest Type	Composition	Area Cleared (ha)[a]
Hardwood	≥ 80% hardwood species	54.5
Hardwood/softwood	51% to 80% hardwood species	38.3
Softwood/hardwood	51% to 80% softwood species	25.7
Softwood	≥ 80% softwood species	13
Plantations	Assorted planted species	3.9
Total		

[a] 1 hectare (ha) = 2.47 acres.

Source: ER, Vol. 2--Table III-32, Vol. 3--Table III-34.

Dust generated by construction traffic and equipment operation could be deposited on adjacent vegetation, affecting photosynthesis and plant growth, as well as making the vegetation less palatable to livestock and wildlife

(Dvorak 1977). However, the relatively minor amount of anticipated disturbance, accompanied by mitigative measures to control dust, would render such impacts negligible.

Following initial clearing, and subject to easement agreements, vegetation in the right-of-way would be controlled by a combination of mechanical and chemical methods. Only herbicides and application methods approved by the U.S. Environmental Protection Agency and approved for right-of-way use by state pesticide boards would be used. Herbicides would be selectively applied at the base or stump (2,4-D, Picloram, Triclopyr, or equivalent) or on the foliage (previously mentioned herbicides plus Fosamine, Glyphosate, or equivalent) of undesirable species. The maintenance program is designed to suppress tree growth while encouraging the growth of shrubs, grasses, ferns, and other mature plants that do not exceed safe heights (ER, Vols. 2 and 3).

Vegetation treatment would involve selective treatment of stump sprouts during the dormant season after the first growing season following clearing. Two years later there would be a second selective application, and subsequent treatments would occur over a three- to five-year cycle (ER, Vols. 2 and 3). This would maintain cleared areas in a vegetative community dominated by shrubs, low-growing trees, and herbaceous plants similar to those occurring on existing portions of the right-of-way. Generally, hardwood species would be more likely to reinvade cleared areas than would coniferous species. This is because some hardwoods have stump sprouts or root suckers, hardwoods generally are faster growing, and conifers are outcompeted by dense stands of bracken fern and blueberry that often invade after clearing (Galvin 1979; Leak et al. 1969). Shrub species occurring in forested areas normally form a significant component of new rights-of-way, as do herbaceous species typical of both forested and open areas (Holewinski 1981).

Although operation of the proposed transmission line would produce electric fields and generate air ions, ozone, and oxides of nitrogen, recent studies (Griffith 1977; Minnesota Environmental Quality Board 1982; Banks et al. 1982a; Droppo 1981; Krupa and Pratt 1982) indicate that such phenomena would have no significant effect on local vegetation. McKee et al. (1978) observed leaf tip damage, with tissue injury and death in the terminal parts and higher parts of the plants, at electric field strengths of 20 to 50 kV/m. However, this affected less than 1% of the plant tissue. No effects were observed at field strengths below 20 kV/m. Maximum field strengths expected for the proposed DC line would be in the 20 to 30 kV/m range and for the proposed AC line would be less than 7 kV/m. Maximum values would occur less than 5% of the time (see Section 4.1.8). Endo et al. (1979) found no effects from high voltage direct current on growth, yield, or chemical composition of wheat after exposure to 70 kV/m. Enhanced plant growth rate has been observed by Krueger et al. (1963) and Wachter and Widmer (1976) from exposure to positive and negative air ions. McKee et al. (1978) emphasized that plant damage due to normal tissue drying typically exceeds that induced from even high-intensity electric fields.

In conclusion, operation of the proposed transmission lines would not be likely to cause appreciable adverse impacts to vegetative resources other than those subject to periodic right-of-way maintenance.

Wildlife

Impacts to wildlife that could result from construction of the proposed Phase II system include (1) loss and alteration of habitat with subsequent loss or alteration of carrying capacities for wildlife populations and (2) disturbance of wildlife by noise and human activity. Habitat loss is a major cause of wildlife population declines (Forsythe and Gard 1980; Fredrickson 1980). Some wildlife associated with the forested areas to be cleared would be affected by the project, but the habitats that would be affected are not critical or highly unique for any wildlife species in the area (U.S. Department of Energy 1978). Since the forested areas to be cleared represent a very small fraction of those types of areas occurring in the counties to be traversed by the proposed line, continued survival of local wildlife populations would not be threatened.

It is unlikely that construction activities would result in any significant impact to local wildlife species. Construction activity would likely disturb wildlife for only a brief period (days) in any given area (except perhaps at the proposed converter terminal, which would be constructed over a period of three years [ER, Vol. 1]). Affected wildlife should return to normal behavior patterns upon cessation of construction activities. This is especially applicable to wildlife currently utilizing the shrub/grassland and wetland habitats on the existing rights-of-way.

Relatively mobile species that inhabit or utilize areas to be affected by construction would be displaced to adjacent areas where, it is assumed, they would find suitable habitat. However, this would depend on the existing carrying capacity of the adjacent areas. This could subject displaced species to greater competition for habitat or food resources. If a given species is at its carrying capacity, then the total number of individuals would likely be reduced (Dvorak et al. 1978). Because the forest habitat to be lost is only a small percentage of that occurring in the study area, it is anticipated that the unaffected forest areas could support displaced individuals. Smaller or less mobile species might be destroyed by construction activities.

Wildlife in adjacent areas (both forested and existing rights-of-way) may also be displaced or disturbed during construction by the level of human activity and noise at the construction sites (ER, Vol. 1). This would apply to animals within auditory or visual range of construction activities. Heavy machinery (the anticipated source of most noise) produces just under 90 dB at 16 m (52 ft), with noise intensity decreasing at the rate of 6 dB per doubling of distance (U.S. Environmental Protection Agency 1974). Values between 50 and 90 dB can cause annoyance (Cheremisinoff and Cheremisinoff 1977). Thus, in theory, animals within 2,000 m (6,500 ft) of construction might be somewhat disturbed by noise from heavy machinery. In actuality, trees and other barriers (e.g., hills) would cause a loss of energy in sound waves, so the effective range of annoyance would be reduced. The consequences of noise (or visual) distractions to animals are not well documented, so it is difficult to predict how much impact these sources would actually have on the local fauna (Soholt and Bynoe 1982), but it is expected to be small. Nevertheless, if reproductive habitat is temporarily abandoned, a localized impact to the following season's wildlife populations might result (U.S. Department of Energy 1978).

Clearing would result in the loss of only a small fraction of the forest habitat in the study area (Section 4.1.2.3). However, the types of habitat lost versus the types of habitat created are important considerations when assessing the overall impact of clearing operations. Also, regardless of the habitat type cleared, some adverse impacts may occur to wildlife populations until vegetation is restored (U.S. Department of Energy 1978).

A number of investigators have examined the impact of clearing and right-of-way management on wildlife (e.g., Arner 1977; Asplundh Environmental Services 1977; Carvell and Johnston 1978; Galvin and Cupit 1979). Generally, right-of-way maintenance results in the presence of wildlife species that prefer open habitat with few large trees. These species are often those characteristic of early stages of plant community succession, such as are found in abandoned farm fields or in areas of postfire regeneration. Over 50 species of wildlife in the region are frequently found inhabiting early successional stages of vegetation (U.S. Department of Energy 1978). Maintenance of a clearcut strip in an area of extensive forest offers a more diverse habitat than pure forest stands and supports a greater diversity of wildlife (Mayer 1976; Johnson et al. 1979; Geibert 1980; Cavanaugh et al. 1976; Kroodsma 1982). Thus, the creation of forest edge should enhance habitat for species typical of open or edge areas, but it would be somewhat detrimental to species that are more restricted to forest habitat. This would result either through competitive interactions with edge-inhabiting species or through habitat reduction.

Following all clearing (selective and nonselective), the corridor would be maintained primarily by selective application of herbicides. It has been shown that wildlife use of rights-of-way and herbicide use are compatible (Carvell and Johnston 1978; Asplundh Environmental Services 1977). 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. The planned use of herbicides along the proposed route would be similar to that in the existing rights-of-way and should not threaten wildlife. The Applicant is committed to apply herbicides in accordance with Massachusetts and New Hampshire regulations.

Although the primary impacts to wildlife would result from alteration of habitat in the right-of-way, there are potential impacts from the presence of the line--collisions of birds with structures or conductors and electrocution of birds. Raptors and waterbirds are particularly sensitive to such problems (Stalmaster and Newman 1978; Swensen 1979; Erwin 1980; Liddle and Scorgie 1980; Burger 1981).

There are documented studies of bird mortality from collision with conductors or structures (Avery et al. 1978; U.S. Fish and Wildlife Service 1978), but the proposed transmission line would not be tall enough to pose a serious threat to birds in migratory flight. In general, migratory flight occurs at altitudes in excess of 100 m (300 ft) above the ground surface (U.S. Fish and Wildlife Service 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. Species such as starlings, red-winged blackbirds, and shorebirds that fly fast at low altitudes and in tight flocks also are vulnerable to collisions (Meyer and Lee 1981). Since structures for the 450-kV DC line would be only 4.6 to 9.1 m (15 to 30 ft) above existing 230- and 345-kV AC line structures, the incremental risks of collision would be minimal.

There is general agreement in most published studies that bird losses to overhead wires are not biologically significant (Beaulaurier et al. 1984; Meyer and Lee 1981; Stout and Cornwell 1976). Nevertheless, some concern for collision potential may be warranted. For transmission line corridors carrying more than one power line, the wires can be a major obstacle. This is especially true for panic-stricken flocks of birds or for birds flying in inclement weather (Jaroslow 1979). The most lethal of four study areas analyzed by Andersen-Harild and Bloch (1973) was one containing 12 wires at eight different levels. An average of nine dead birds per day per 10 km (6.2 mi) of power line was noted. There would be several corridor sections in Massachusetts that would contain over 20 wires positioned at a minimum of five different levels (≥ 12 m [40 ft] height differential from lowest to highest wire) (ER, Vol. 2--Figures II-6 through II-15).

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 structure. Historically, this has been a problem only with large raptors (such as eagles). Minimum clearances between conductors on the proposed line (>3 m [10 ft]) would 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). Spark discharges occur at levels of about 5 to 7 kV (see Section 4.1.8.2).

Other impacts to wildlife stemming from transmission line operation (e.g., air ions, magnetic, and electric field effects) would be similar to effects on human health and safety as discussed in Section 4.1.8.

4.1.4.2 Aquatic

Construction activities (especially construction of access roads) involving stream crossings would be the principal sources of potential impacts to aquatic biota. The potential impacts would include (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, in varying degrees, for every stream crossing affected by construction of an access road or some near-stream vegetation clearing. The severity of impact resulting from such construction would depend upon several factors, such as (1) season of construction, (2) stream size, (3) corridor width to be cleared, (4) construction procedures, and (5) existing habitat quality (Dehoney and Mancini 1982). Generally, the smaller streams would 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. Ephemeral stream channels also may be disturbed, especially in late summer, when they are not easily detected (Irland 1985). Overall, ponds and lakes (including reservoirs) should not be directly impacted because all attempts would be made to route lines to avoid such aquatic systems or to span them. Currently, only Whittier Pond in Hopkinton and an unnamed pond of a tributary of Musquash Brook in Hudson may have structures or foundation pads placed at the edge or, possibly, extending into them.

Stream temperature alteration is reported to be one of the most significant impacts resulting from clearing of riparian vegetation (Herrington and Heisler 1973). For the proposed project, however, only a short linear distance would be cleared for the proposed line and/or access road at any stream crossing, and it is doubtful that significant thermal increases would occur. In addition, results of several studies indicate that low-growing vegetation can effectively shade smaller streams (Brown 1979; Fredricksen 1971-1972). Case histories of rights-of-way in New York have shown that impacts on stream temperatures were negligible (Holewinski 1981).

Disturbance of instream habitat can have an immediate and localized impact on aquatic biota, but turbidity, and especially sedimentation, can result in greater and more widespread biological impacts. Because of their relative immobility, eggs and larvae of fish and macroinvertebrates would be most adversely affected by increases in siltation and turbidity. Adult fish would likely vacate the area and avoid many of the activities associated with stream crossing construction; however, instream construction activities could interfere with spawning migrations (Dehoney and Mancini 1982; Busdosh 1982), and increased siltation could disrupt fish reproduction by covering potential spawning grounds (Karr and Schlosser 1978). The locations where access road stream crossings would most probably be required (e.g., streams less than 3 m [10 ft] wide), 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. Shelton and Pollock (1966) found that when only 15% to 30% of gravel interstices were filled with sediments, 85% mortality of salmon eggs occurred. There are 112 streams less than 3 m (10 ft) wide along the proposed route (ER, Vols. 7 and 8). Since much of the proposed route coincides with existing rights-of-way, access used for construction or maintenance of the existing lines may also be used for the proposed lines. However, it can be assumed that new access roads will be required across some streams and that some existing access will require upgrading. In such situations, streams could be subjected to the above-mentioned impacts.

Following construction, fish could be impacted as a result of improper design characteristics, such as improperly designed culverts. Installation of improper culverts and use of unsuitable (unstable) fill material could lead to complete washout of a stream-crossing embankment. This results in the most severe incidences of erosion stemming from highway development and is responsible for the greatest percentage of fish passage problems (Dryden and Stein 1975). Improperly sized culverts can eliminate fish species from a stream through blockage of migration, particularly upstream spawning runs, and 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.

During operation of the transmission line, 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, instream disturbances would not be required and only selected trees might have to be removed or trimmed. Vegetative control near streams might temporarily increase streambank erosion due to the activity of men and machinery. Impacts would be similar to those discussed for construction. The accidental release of toxicants (e.g., gasoline, lubricants, and herbicides) could cause the most impacts during operation.

Fisheries can be impacted by human activity (e.g., off-road vehicles) that hinders revegetation and thus prolongs erosion and related perturbations to streams (Galvin 1979). However, such potential impacts are not expected to increase as a result of the proposed project because public access via access roads or the transmission line rights-of-way is already well established.

As mentioned, the smaller streams would have the greatest potential to be impacted. The majority of these streams are potential coldwater trout streams (Section 3.4.2). However, only about eight streams less than 3 m (10 ft) wide have been documented as containing spawning trout populations (ER, Vol. 7--Table III-3, Vol. 8--Table III-3). Approximately 25 other small streams are documented to contain trout, but they are mostly stocked. Even some of the streams with spawning trout are supplemented by stocking. Only in a very few instances could spawning populations be affected, and impacts would be offset by subsequent stocking. Additionally, disruption of activities such as 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 likelihood of long-term impacts to aquatic ecosystems from the proposed transmission line facilities would be small. Although impacts resulting from construction (e.g., erosion and subsequent increases in turbidity and sedimentation) may occur, they would be localized, short-term, and reversible. Stream recovery (return to near the original biological and physical conditions that existed prior to construction) is often estimated to occur within a year and as rapidly as six weeks (Dehoney and Mancini 1982). The potential for significant adverse impacts would be minimized if the mitigative measures committed to by the Applicant are properly implemented.

4.1.4.3 Wetlands

In response to Executive Orders 11988 (Protection of Floodplains) and 11990 (Protection of Wetlands), DOE Rules and Regulations (10 CFR 1022) require that a floodplain/wetland assessment be prepared which: describes the project, discusses the effects of the project on floodplains and wetlands, and identifies alternatives including mitigating measures. This assessment is provided in Appendix B, the results of which are briefly summarized below.

Although construction activities would avoid wetland areas where possible, all such areas cannot be avoided. Therefore, some adverse impacts, primarily temporary, would occur during construction, stringing operations, and following construction. These impacts, discussed in more detail in Appendix B, would be minor and largely reversible. Long-term impacts to a minimum amount of wetlands would occur from structure placement and access roads. This has been conservatively estimated to preempt a maximum of 7.7 ha (19.0 acres) out of 214.9 ha (531.0 acres) of wetland habitat within the Phase II rights-of-way (ER, Vols. 7 and 8). The minor amount of floodplain habitat to be affected by structure placement and access roads would have a minimal amount of impact to terrestrial biota, similar to that previously discussed (Section 4.1.4.1). This evaluation is based upon mitigative measures recommended by DOE staff and committed to by the Applicant to minimize wetland/floodplain impacts (see Sections 2.1.5, 4.1.10.4, and Appendix B).

4.1.4.4 Threatened and Endangered Species

Section 3.4.4 identifies consultative and coordinative efforts carried out by DOE and the results of these efforts.

Vegetation

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). Plants considered rare to the study area have been found in the vicinity of the proposed route. However, these species either occur in habitats that would be generally avoided by construction (e.g., wetlands) or have been determined not to occur on the proposed right-of-way.

Fish and Wildlife

A number of state and federally listed threatened and endangered species of fish and wildlife could be affected by the transmission line (see Table A.9 in Appendix A). The major potential for impact is associated with clearing of forest habitat for the right-of-way and, for birds, the potential of collisions with the structures. All of the species listed in Table A.9 are wide ranging, with populations extending throughout at least New England, albeit sparsely. Therefore, loss of a minor fraction of available habitat is unlikely to result in a reduction in numbers of these protected species; in some instances, more preferred habitat would be established. Also, as discussed for birds in general (Section 4.1.4.1), the potential for impact related to wire strikes is negligible.

4.1.5 Socioeconomics

The construction phase of the proposed project would have minor short-term impacts on the local economy, housing, and transportation. The project would create local short-term employment opportunities, but would not have significant impact on the unemployment rate. Construction activities would occur during 1987-1990 and would result in a peak work force of about 550 people. The Applicant estimates that 30% to 40% of the work force would be hired locally (ER, Vol. 2--p. 193, Vol. 3--p. 205). Minor short-term benefits to the local economy would result from project expenditures on equipment, services, and payrolls.

The influx of construction workers would increase short-term demand for temporary lodging; however, since the work force would be distributed in small units (2 to 20 persons) along the proposed route (ER, Vol. 2--pp. 192-193, Vol. 3--p. 204), housing shortages would be unlikely. Residential property values would probably not be affected, given the established presence of multiple transmission lines on the right-of-way.

Movement of heavy equipment and trucks on access roads during construction activities could adversely affect local traffic flows and increase local levels of noise and of fugitive dust. This might be mitigable to some extent through judicious choice of routes and prior notification (ER, Vol. 2--p. 193, Vol. 3--p. 205).

4.1.6 Visual Resources

4.1.6.1 Visual Impacts Analysis Criteria

The methods for establishing the study area and evaluating the visual quality of the existing environment in terms of landscape types are discussed in Section 3.6. The following methodology is oriented toward assessing potential visual impacts related to the proposed project.

The DOE Staff has reviewed the Applicant's methodology for evaluating visual impacts associated with the proposed project, as presented in the ER (Vol. 7--Sec. III.C.2.c, p. 104; Vol. 8--Sec. III.C.2.c, p. 108). In view of the comprehensive nature of the methodology and the generally low level of project-related impacts anticipated, a detailed description of methodology is not presented here. However, some discussion of terminology and analytical procedures is necessary for comprehension of project-related impacts addressed in Section 4.1.6.2.

Initial analytical procedures included establishing vantage points within project study areas from which the proposed transmission facilities could be observed. Vantage points were identified from available data sources and general field surveys and were recorded as "Inventoried Assessment Points" (IAPs). Each IAP was investigated through field reconnaissance and map analysis. In instances where the project-related visual impacts could be ranked as no or minimal impact, the appropriate ranking was recorded and no further analyses were undertaken. In the event that the visual impact at a given IAP exceeded the minimal level, the IAP was designated as a "Visual Assessment Point" (VAP) and the impacts were further evaluated by four types of analyses (ER, Vol. 7--p. 105). Results of evaluations for a given VAP were assigned one of five relative ratings to reflect the degree of impact--i.e., low, low-moderate, moderate, moderate-high, or high. These rankings, as well as the no or minimal impact rankings for IAPs, are used in the following descriptions of project-related visual impacts.

4.1.6.2 Visual Impacts of Corridor Segments and Building Sites Within Project Study Areas

The following discussions of project-related visual impacts correspond with the sequence of segments within project study areas established in Sections 3.6.2 and 3.6.3. In all cases, construction activities and equipment related to the proposed project would result in short-term adverse visual impacts.

New Hampshire

Segment A--IAPs established within this 60-km (37-mi) landscape segment included 102 sites, of which 24 were identified as VAPs. The highest rating of impact assigned was moderate for each of eight VAPs. Given the development plans for the proposed line, the overall visual impact for this segment would be rated as low. The low rating would largely be due to the densely forested, hilly to low mountainous terrain that would screen and obstruct views of the proposed line, as well as limit viewing distances. Furthermore, this segment of the study area is primarily rural in character with limited areas of urban and commercial development; thus, the number of viewers would be comparatively low. The proposed line would parallel two existing transmission lines for all but about 1.3 km (0.8 mi). The visual effects related to the proposed line would be incremental to those of the two existing lines for virtually the entire length of the segment.

Segment B--Analysis of this 93-km (58-mi) segment of the study area resulted in the evaluation of 158 IAPs, of which 21 were identified as VAPs (ER, Vol. 8--p. 132). The highest level of assigned visual impact was rated at moderate-high impact, involving four VAPs; the associated impact areas include highway and bike route crossings (U.S. 202, SRs 9/103 and 11), Whittier and Pillbury ponds, and the village of Groton, including an adjacent road (ER, Vol. 8--Table III-10). The overall impact level for this segment was rated as low-moderate visual impact. Assessment sites in the northern portion of this segment tend to correspond with natural landscapes, recreational areas, and road crossings. To the south, assessment points tend to correspond with residential areas and thus would involve a greater number of viewers. The proposed line would parallel two existing lines; thus, the visual effects related to the proposed line would be incremental to those of the existing lines throughout this segment of the study area.

Segment C--A total of 151 IAPs were established within this 42-km (26-mi) landscape segment, of which 26 were identified as VAPs. The highest project-related level of visual effects is rated at moderate-high impact, and involves four VAPs. The associated impact areas include the Kennedy Hill farm, SR 114 (paralleled and crossed), the Terrell Hill and Back River Road crossings, and areas adjacent to the Back River Road. This landscape segment recently has undergone extensive residential and commercial development. Subdivision and roadside residences constituted 68 of the established IAPs. In view of the visual effects related to existing transmission lines paralleling the proposed route, the scattered distribution of large residential and commercial structures, the fragmented patterns of vegetation, and the low landscape quality of this segment, the incremental increase in visual impact related to development of the proposed line would generally be of minor consequence.

Ground Electrode Site--The ground electrode site is located in a relatively remote area of a property owned by the utility (ER, Vol. 8--p. 139). Forest vegetation would be cleared from about 1.6 ha (4.0 acres) for the proposed ground electrode site and a 15-m (50-ft) wide corridor about 300 m (1000 ft) long. An electrode feeder line would be built within the corridor to connect the proposed terminal with an existing electrode feeder line. Wooden poles supporting the feeder line connector would be well below the height of adjacent vegetation. Therefore, no meaningful visual impact would be expected.

Massachusetts

Segment A--Within this 19.6-km (12.2-mi) segment of the Massachusetts study area, a total of 42 IAPs were established, of which only seven were later designated as VAPs. Given the development of the proposed line, the overall assessment for the segment is a low-moderate visual impact rating (ER, Vol. 7--p. 121). The highest impact rating assigned was moderate-high for the State Route (SR) 119/225 crossing of the proposed route. Two moderate ratings were assigned, also involving highway crossings (U.S. 3 and SR 40). Widening the cleared portion of the existing right-of-way within this segment and development of the proposed transmission line would incrementally increase the visual impacts associated with the existing transmission line presently occupying the right-of-way. However, the vegetation and rolling to hilly terrain would tend to limit viewing distances and otherwise obstruct views of the two lines.

Segment B--Assessment of this 58-km (36-mi) segment entailed establishing 144 IAPs, of which 40 were identified as VAPs. The overall assessment of the segment was rated as low-moderate visual impact (ER, Vol. 7--p. 122). The proposed route would parallel existing transmission lines for all but 0.8 km (0.5 mi) near the Millbury No. 3 substation. Thus, compatibility ratings for the proposed line would tend to be moderate or moderate-high; these rankings are equivalent to relatively low visual impacts. Most visual impact areas in this segment are related to residential developments and highway crossings. About 6% of assessment points in the segment involve ratings of moderate-high visual impacts; the impact areas include the Wachusett Reservoir, a National Historic Monument, three residential-commercial areas, and four highway crossings.

Segment C--A total of 73 IAPs were established along this 26-km (16-mi) segment, of which 17 were identified as VAPs. Only two of these VAPs rated moderate-high impact levels, i.e., the Janock and Carp Road subdivision and the SR 85 crossing. Five moderate impact ratings were assigned, variously involving local streets and/or state and federal highways. Vegetation clearing would create greater potential for viewing the right-of-way in this segment, but the proposed line would parallel existing transmission lines throughout the segment. Thus, the resulting impact would be incremental. The overall assessment for this segment is rated a low-moderate visual impact (ER, Vol. 7--p. 124).

Converter Terminal Site--Site clearing and development of the proposed terminal facilities would drastically alter the character of the site. However, the proposed terminal site is bounded by wooded rolling topography on the northeast, north, and most of the west side of the site. The site is otherwise surrounded by gravel pits, an industrial site, the Boston and Maine freightline and yarding area, and transmission facilities and rights-of-way. Thus, the development of the proposed terminal would be of minor consequence with respect to visual resources.

Construction Laydown and Staging Areas

Small areas of 0.4 to 0.8 ha (1 to 2 acres) would be developed at various intervals along the proposed transmission line segments to serve as construction laydown and staging areas (ER, Supplement, Response No. 9, September 29, 1985). Development of these areas and the related construction activity would degrade the quality of local landscapes. Since locations of staging areas are not normally identified prior to initial construction, the related visual impacts are currently unknown. However, following project construction, the staging areas would be reclaimed and restored to conditions similar to those existing prior to construction (ER, Supplement, Response No. 7, September 27, 1985); thus, no significant long-term visual impacts would be expected.

In summary, the overall visual impacts for both the New Hampshire and Massachusetts portions of the proposed transmission lines are ranked as low-moderate (ER, Vol. 7--p. 125, Vol. 8--p. 135).

4.1.7 Cultural Resources

On the basis of existing information, it does not appear that any significant archeological sites would be adversely affected by the proposed action. However, this issue will not be fully resolved until the appropriate State Historic Preservation Officers (SHPOs) (and, if necessary, the National Park Service and the Advisory Council on Historic Preservation) have reviewed the pertinent data. It should be noted that impacts to archeological sites could occur if design modifications (e.g., altered structure locations) were introduced prior to or during construction.

A large number of significant historic structures are situated in proximity to the proposed right-of-way. Under the Criteria of Adverse Effect (36 CFR 800.3b), it is apparent that many of these structures could be exposed to "visual...elements that are out of character with the property." However, these effects seem unlikely to exceed those of the existing right-of-way; this matter is also under review by the New Hampshire and Massachusetts SHPOs (New England Power 1986a, 1986b).

4.1.8 Health and Safety

Health and safety issues related to the operation and maintenance of the transmission lines would center around potential effects from electric and magnetic fields, air ions, induced current and/or spark discharges, audible noise, ozone production, and use of herbicides. Potential effect on cardiac pacemakers is also an issue of concern. Both DC and AC transmission lines would be constructed in conjunction with the proposed project. Because of differences in the electrical characteristics of the two systems, potential health and safety issues for AC and DC lines are discussed separately. Additionally, since most of the proposed DC line will be routed within existing AC corridors, a discussion of potential combined effects of AC and DC operation is also included.

4.1.8.1 DC Effects

Information presented in the Phase I EIS (U.S. Department of Energy 1984) supports the conclusion that operation of the DC line would generally have negligible effects on health and safety. Information published since that time does not alter the conclusions reached in that document. Much of this newer information is summarized in the ER, Vol. 5a (New England Hydro-Transmission Corp. and New England Hydro-Transmission Electric Co. [NEHTC and NEHTEC] 1985a). A pertinent summary of the potential adverse effects of DC transmission lines is presented in the following subsections.

Electric and Magnetic Environment

The electric field associated with a high-voltage DC transmission line is produced by the electric charges on the separate positive and negative conductors (lines) and by the space charge generated by corona (Bracken 1979a, 1979b; Johnson and Zaffanella 1982). Charges on the transmission line produce a static electric field; the field produced by the space charge is highly variable. 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 as one moves away from the conductor, vertically or horizontally. In the absence of corona, the electric field is composed only of the static electric field; whereas during intense corona, the space charge can be several times that of the static field (ER, Vol. 5a).

Corona (the partial breakdown of air into charged particles) begins to occur when the surface voltage gradient on the conductors exceeds the threshold or onset value of the surrounding air. When the electric field intensity at the HVDC conductor surface exceeds approximately 2500 kV/m, corona can result. Transmission lines are designed to control levels of corona activity, but the onset of corona is influenced by numerous factors, including atmospheric elements, design parameters of the line, and condition of the conductors. Because field intensity at the conductor surface is dependent upon the smoothness of the surface, corona tends to be increased by nicks, scratches, and adhering dust particles, insects, ice, snow, or water droplets. Corona levels for DC systems are highest when surface irregularities occur on the conductor (which may occur during foul weather), although certain effects of corona are probably highest in fair weather (audible noise and radio/television interference) (ER, Vol. 5a). When corona occurs, ion pairs are generated in the air near the conductors, with a net movement of like charges away from each line. At distances away from the conductors the space charge tends to be carried on aerosols rather than small ions. This occurs because the small-ion density decreases from diffusion, recombination, movement to earth, and attachment to aerosols. Because of their charge, ions and aerosols move under the influence of an electric field, as well as the influence of the wind, temperature, humidity, and atmospheric composition (ER, Vol. 5a).

HVDC lines also create a static magnetic field and an AC magnetic field. The static magnetic field is produced by the current flowing through the conductors; whereas the AC magnetic field occurs from AC current and voltage at harmonic frequencies of 60 Hz being introduced onto the DC line by the conversion process from AC to DC (ER, Vol. 5a). At ground level under the proposed line, the static magnetic field produced by the line would be less than the earth's magnetic field and would decrease with distance from the line (Ill. Inst. Technol. Res. Inst. 1976; Hill et al. 1977). The AC field is so small that it can be ignored (Sheppard 1979).

During corona, photons emanating from the conductor surface may strike neutral atoms in the air. These energized atoms may then lose electrons, which when accelerated in the local electric field, may collide with neutral oxygen molecules, causing dissociation and reassociation into ozone molecules (Hill et al. 1977).

Audible noise is created by the breakdown of air molecules during corona. In HVDC systems, electric discharge is greater from the positive electric pole than from the negative pole. Hence, more audible noise is generated by the positive conductor. The negative conductor generally does not produce audible noise. During rain, the large number of raindrops on a conductor can produce corona currents large enough to change the corona mode into a nonaudible type. Peak audible noise levels under HVDC systems, therefore, generally occur during fair weather, snowfall, or early rainfall (Hill et al. 1977; Johnson and Zaffanella 1982).

Potential Hazards from an Operating High-Voltage Direct Current (HVDC) Transmission Line

There is a sizable literature on the health and safety aspects of operating transmission lines (Sheppard and Eisenbud 1977; Phillips et al. 1979; Lee et al. 1982; Algers and Hennichs 1983; Carstensen and Griffin 1983; Hauf 1982; Sheppard 1983a, 1983b; Charry 1984; Reilly 1984; American Institute of Biological Sciences 1985). However, most studies deal with AC systems. These studies have shown that biological systems are affected, sometimes adversely, by exposure to electric and magnetic fields and to air ions, provided that intensities and duration of exposure are of sufficient magnitude. However, the maximum electric and magnetic field strengths of HVDC systems are not of sufficient magnitude to elicit harmful, pathological effects, although nonpathological effects may be elicited (U.S. Department of Energy 1984). Maximum intensities of the electric fields associated with the HVDC environment are reached infrequently (only during periods of maximum corona activity) and decline rapidly with distance from the electrical conductors. Moreover, human and livestock use of the right-of-way is usually periodic and of short duration (minutes to hours). Consequently, exposure to maximum field intensities is expected to be infrequent. The following discusses in more detail the health and safety concerns relevant to the proposed Phase II DC transmission line.

Proximity Effects. Coupling of an electric field with an organism creates the potential for shock hazard (Banks et al. 1982b; Sheppard 1983a, 1983b; U.S. Department of Energy 1984). Electric shock results from the passage of electric current through the body between two points of unequal voltage. Shocks may result from a steady-state flow of current or a transient, spark discharge (e.g., a carpet shock of static electricity). Under an operating transmission line such spark discharges might occur if a grounded human or animal contacted a large, stationary metal object that is well insulated from ground (e.g., a vehicle or watering trough). Hill et al. (1977) measured steady-state currents of up to 175 μA from 61 m (200 ft) of fence (with highly insulated wooden posts) paralleling an operating ±600-kV DC transmission line. This compares with generally accepted levels of 15,000-20,000 μA as providing a margin of safety for operating electrical fences (Dalziel and Burch 1941; Minnesota Environmental Quality Board 1982; Sheppard 1983a). At any rate, utilities metallically ground fences within rights-of-way as a standard practice. On an operating test line similar in structure and operation to the DC portion of the proposed interconnection, Johnson and Zaffanella (1982) estimated the highest current collected on a school bus to be about 40 μA. This is well below the general threshold of perception for DC current of 600 μA (Barthold et al. 1972) and below the National Electric Safety Code limit of 5,000 μA established for contact currents due to electric fields on the largest anticipated truck, vehicle, or equipment under a transmission line.

Tests beneath operating HVDC transmission lines have shown that carpet-like spark discharges can occur for persons accumulating about 10 kV of potential (Sheppard 1983a). The estimated maximum (occurring <5% of the time) accumulated potential is 20 kV, based on an investigation using a test line with design and operating characteristics very similar to the proposed line (Johnson and Zaffanella 1982). These voltage levels would be likely only for well-insulated individuals near the point of maximum conductor sag during summer fair weather. Shocks associated with voltages of this magnitude are considered annoying but not harmful (Sheppard 1983a). Johnson and Zaffanella (1982) reported that occasional shocks occurred while persons were active beneath a ±450-kV DC line similar to that proposed by the Applicant.

Under worst-case conditions for DC systems, shocks might be at levels considered annoying or objectionable. It is anticipated that such conditions would be rare and that most shocks would occur at or below minimally perceivable levels. Even though annoying shocks might occur occasionally, they would not likely result in pathological responses. The predicted levels are well below (3- to 10-fold) levels associated with deleterious effects (Sheppard 1983a, 1983b). Shocks would be no worse than commonly experienced carpet shocks.

Fuel ignition can occur when objects differing in potential by about 5 to 7 kV come in contact (Hill et al. 1977). For a DC test line similar in nature to the proposed DC line, estimated worst-case voltage induced on a large school bus was 7 kV, at the voltage threshold for fuel ignition (Johnson and Zaffanella 1982). Again, these voltage levels were likely less than 5% of the time, in summer fair weather conditions, near the point of maximum conductor sag, and if the vehicle was well insulated from ground. However, it would be prudent to ensure that large vehicles not be refueled beneath operating lines unless the vehicles are well grounded.

Electric Field Effects. Electric fields of the magnitude that occur in HVDC transmission-line environments have been alleged to cause a variety of physiological and behavioral effects in humans and other animals. There have been several reviews of the literature on the biological effects of electric fields, including Banks et al. (1982a), Sheppard (1983a, 1983b), DOW Associates (1980), Minnesota Environmental Quality Board (1982), Michaelson (1981), Scott-Walton et al. (1979), Carstensen and Griffin (1983), American Institute of Biological Sciences (1985), Algers and Hennichs (1983), and Sheppard and Eisenbud (1977). Findings of studies in this area have been diverse, ranging from no evidence of effects to the attribution of many effects due to exposure to electric fields. Because of the diversity of findings and experimental designs, as well as paucity of reproducible results, it is difficult to provide definitive predictions of effects of transmission line electric fields.

Johnson and Zaffanella (1982) measured the electric field under a "Project UHV" test line, which is similar in design and operation to the proposed DC line. Their results indicated that maximum electric field intensities in excess of ±30 kV/m could be expected at mid-span ground level during some weather conditions (Table 4.3). However, these maxima occur

Table 4.3. Electric Fields (kV/m) Under the Project UHV Test Line Operating at ±450 kV DC[a]

		Negative Side						Positive Side					
		-50 m[c]		-25 m[c]		Worst Position[d]		Worst Position[d]		+25 m[c]		+50 m[c]	
Weather	N[b]	50%	95%	50%	95%	50%	95%	50%	95%	50%	95%	50%	95%
Fair (winter)	14,073	-2	-5	-5	-8	-12	-15	+8	+11	+3	+6	+1	+4
Fair (summer)	16,100	-1	-3	-8	-12	-17	-26	+19	+29	+4	+8	+2	+5
Snow	9,003	-3	-7	-5	-12	-12	-23	+10	+17	+4	+10	+2	+5
Fog	411	-1	-2	-4	-8	-13	-26	+12	+24	+6	+11	+3	+5
Frost	1,590	-5	-10	-8	-15	-13	-23	+12	+20	+6	+13	+5	+6
Freezing rain	1,129	-5	-8	-12	-16	-27	-32	+23	+29	+10	+17	+2	+7
Rain	1,581	-1	-4	-11	-15	-30	-34	+29	+32	+14	+6	+2	+7

[a] Electric fields were monitored continuously; measured under point of minimum conductor height of 11 m (37 ft); 50% = median value and 95% = absolute value below which 95% of the measurements occurred.

[b] Number of records per weather condition.

[c] These positions represent distances from centerline between positive and negative conductors; distances approximate the distance to edge of right-of-way above Sandy Pond (50 m) and below Sandy Pond (25 m) from centerline.

[d] Highest absolute values were obtained at about -6 and +9 m from centerline during winter months and about -9 and +12 m in later months.

Source: Based on curves presented in Johnson and Zaffanella (1982).

infrequently (less the 5% of the measurements), with field intensity declining rapidly as one moves from the centerline of the system and as one moves away from the point of maximum conductor sag.

For the proposed Phase II DC line, the median electric field strength at ground level during fair weather under the positive conductor is calculated to be in the range of 8 to 16 kV/m, with calculated fair weather extremes of 20 kV/m under the negative conductor and 24 kV/m under the positive conductor. During foul weather, the median electric field strengths at each conductor would range from 9 to 25 kV/m, with a maximum around 30 kV/m. Maximum foul weather electric field strengths at the right-of-way edge are calculated to be 9 and -3 kV/m, with median intensity calculated at 7.1 and -2.1 kV/m. Median electric field intensity at the right-of-way edge during fair weather may be as low as ±1 kV/m (ER, Vol. 5a). The earth's natural average fair weather electric field strength is about 0.1 to 1.5 kV/m, with an intensity as high as 15 kV/m during thunderstorms (Chalmers 1967).

Electric fields within the right-of-way for the proposed DC transmission line would have intensities within the range of those reported to elicit physiological responses in experimental animals. Effects of exposure to field intensities below 60 kV/m have been subtle--e.g., improved 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). Fischer (1973) observed a 50% increase in spontaneous activity of mice exposed to positive and negative electric fields of 24 kV/m for 10 days, with an accompanying increase in food consumption (10%) and water consumption (13%). An oxygen consumption increase of 14% was noted from an 8-day exposure. From a 15-day exposure to positive and negative electric fields of 5 kV/m, Fischer (1973) found a 1000% increase in spleen plaque production, a 17% increase in spleen weight, a 58% increase in spleen cell count, and a 264% increase in hemagglutination. These responses have been elicited in laboratory situations involving continuous or repeated exposure to constant levels of electric field intensity over periods of days to months.

Several investigations have shown little or no significant effects from electric fields at levels that would be expected from operation of the proposed DC line. Biogenic amines in rat brains exposed to positive and negative electric fields of 3 kV/m for 2, 18, and 66 hours did not exhibit altered neurotransmission (Bailey and Charry 1984). No effects on the course of respiratory disease in rats were observed from an 11-day exposure to positive and negative electric field strengths ranging from 0.1 to 6 kV/m (Krueger et al. 1974). Fam (1981) observed no effect on number, survival, or weight of mice progeny of parents exposed to 340 kV/m for 90 days. The exposed mice also showed no difference in body weight (females) or growth rate. No histologic effects to any organs were noted. There were some mixed effects between males and females for blood counts and chemistry, but observed variations were small. Under no conditions would static fields reported as affecting blood pressure and heart rates (60 kV/m) by Krivova et al. (1973) occur. Subtle behavioral and physiological effects would be transient and difficult to perceive.

It is not expected that humans or livestock would be continuously exposed to electric fields from the proposed DC line during normal circumstances. Electric field intensities under the operating DC line would vary with time and with distance from the centerline (Table 4.3). Highest exposure levels would be restricted to an area in the proximity of either electric conductor near the point of maximum conductor sag. All electric fields would be at or near background levels at a distance less than 150 m (500 ft) from the centerline. Also, it does not appear likely that persons or livestock would remain continuously in the areas of highest exposure for even a number of hours. Thus, biological responses that could potentially be induced would not present a health hazard.

In conclusion, although biological effects have been reported for electric field intensities associated with power transmission, it is improbable that the fields associated with the proposed DC systems would compromise the health and welfare of the local population or farm livestock.

Magnetic Fields. The magnetic field at ground level due only to the proposed DC line is calculated to be 0.34 gauss (G), decreasing to 0.059 G at the edge of the right-of-way (ER, Vol. 5 Suppl.). Magnetic field intensities drop rapidly with distance from the centerline and from the point of maximum sag (Lee et al. 1982). These values are less than the earth's magnetic field of 0.6 G. In general, the literature indicates that the static magnetic fields associated with operating transmission lines do not pose a hazard to human health and welfare (Bracken 1979a, 1979b; Minnesota Environmental Quality Board 1982; Sheppard 1983a). Michaelson (1981) concluded that magnetic field intensities of 3 G would produce no ill effects. Harmful effects have not been documented in laboratory studies at field strengths of 1,000 G (Tenforde 1981) or in studies of people occupationally exposed to magnetic fields (Marsh et al. 1982).

Air Ions. No established exposure limits exist for air ions; therefore, assessment of the impacts from the proposed transmission line must rely on the large body of literature addressing the biological effects of air ions (Sulman 1980; Sheppard 1983a; Charry 1984). It has been suggested that air ions are biologically active because of their charge and chemical form. The most widely acknowledged mechanism for biological effects from air ions has been termed the "serotonin hypothesis". Serotonin is a neural transmitter that is important in sleep regulation, vasoconstriction, and smooth muscle stimulation. It is hypothesized that air ions alter serotonin levels in exposed organisms, producing abnormal effects (Krueger 1972).

Maximum ion densities for both polarities under the proposed DC line and at ground level are expected to be less than 2×10^5 ions/cm^3 during foul weather and less than 1×10^5 ions/cm^3 during fair weather. Under conditions of low corona, clear conductors, and fair weather, ion levels will be on the order of 2×10^3 ions/cm^3 (ER, Vol. 5a). This approaches ambient levels, which are in the range of several hundred to several thousand ions/cm^3. Ion densities for the Project UHV test line, which operates under conditions similar to the proposed DC line, are given in Table 4.4. The values are quite similar to the calculated values for the proposed line. The calculated median ion density at the edge of the proposed DC right-of-way is less than 3×10^3 ions/cm^3 under all weather conditions (ER, Vol. 5a).

Table 4.4. Ion Densities Near the Project UHV Test Line Operating Under Conditions and Parameters the Same as for the Proposed Transmission Line

Weather Conditions	Density[a] (10^3 ions/cm^3) Negative Ions	Positive Ions
Fair (winter)	3	3
Fair (summer)	140	140
Snow	10	20
Wet snow	40	50
Fog	20	50
Frost	30	20
Freezing rain	150	150
Rain	140	220

[a] Median value calculated from electric field and ion current measurements at point of highest density during operation at ±450 kV and a minimum conductor height of 11 m (37 ft). Values are at ground level and under respective conductors.

Source: Johnson and Zaffanella (1982).

Humans and other animals exposed to 10^3 to 10^6 ions/cm^3 have experienced increased and improved motor activity, improved escape behavior, improved learning, decreased reaction times, and altered moods (Sheppard 1983a; Charry 1984). Similar ion concentrations have led to altered serotonin levels in selected organs and fluids of humans and other animals. Subtle respiratory and circulatory effects in laboratory animals and humans have been attributed to exposure to ion concentrations between 10^3 and 10^9 ions/cm^3. Animals challenged with microorganisms have experienced both increased and decreased death rates under additional exposure to air ions (Krueger et al. 1970, 1972, 1974). Burn victims, weather-sensitive persons, and asthmatics have reportedly benefited from exposure to air ions (DOW Associates 1980; Sulman 1980; Charry and Hawkinshire 1981; Sheppard 1983a). Additional findings on biomedical responses of man and animals to air ions are given in Table 4.5.

Maximum ion concentrations below the New England DC interconnection would fall within the the lower range of values associated with subtle effects upon biological systems (compare Tables 4.4 and 4.5). These effects would be difficult to perceive outside the laboratory setting because they are within the range of normal physiological and psychological responses to environmental variation. Furthermore, the periods of highest ion concentrations would be

Table 4.5. Biomedical Responses to Air Ions

Air Ion Dose	Subject	Response	Source
$\pm 9.0 \times 10^3/cm^3$ for 1-day	Humans	No effect on mental performance or physiological response	Albrechtsen et al. (1978)
± 2.0 to $+3.0 \times 10^4/cm^3$ for 1.5 h	Humans	Decreased sociability, increased tension, increased fatigue; no change in anxiety and aggression	Charry and Hawkinshire (1981)
$-2.7 \times 10^3/cm^3$ for 4 to 2 wks, 8 h/day	Humans	Perceived increase in environmental comfort, reduced headaches, reduced nausea and dizziness by some workers	Hawkins (1981)[a]
$-1.5 \times 10^4/cm^3$ for 45 min	Humans	No effects on EEG alpha or reaction time	Hedge and Eleftherakis (1982)
$-1.9 \times 10^5/cm^3$ for 3 h	Humans	Change in heart, rectal temperature, perceived exertion, systolic blood pressure; no change in skin temperature, sweat rate, minute ventilation, diastolic blood pressure	Inbar et al. (1982)[b]
$\pm 8.0 \times 10^3/cm^3$ for 5 h	Humans	No effect on mood	McGurk (1959)
$\pm 1.0 \times 10^5/cm^3$ for 2 h	Humans	No effect on tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, confusion-bewilderment	Sigel (1979)
$\pm 2.0 \times 10^4/cm^3$ for 25 min	Humans	Slight decline in reaction time and flicker-fusion; slight increase in finger-tapping	Slote (1961)
$\pm 5.0 \times 10^5/cm^3$ for 3 min	Rats	Increased heart rate; no effect on respiration	Bachman et al. (1965)
$\pm 8.0 \times 10^4/cm^3$ for 3 wks	Rats	Increased neurophysiological arousal in EEG, slightly lowered CNS arousal (+ ions only), significant decrease in brain (- ion); decreased EEG slow wave activity with slight increase in amplitude (+ ions) or slight decrease in amplitude (- ions)	Lambert et al. (1981)[c] Olivereau et al. (1981)

Table 4.5. Continued

Air Ion Dose	Subject	Response	Source
$5.0 \times 10^5/cm^3$ for 66 h	Rats	No effect on spontaneous motor activity	Bailey and Charry (1984)
$\pm 3.0 \times 10^4/cm^3$ for 15 min	Human	Slight increase in lung function; no histamine threshold	Osterballe et al. (1979)
$-1.0 \times 10^4/cm^3$ for 2 mths, 6 h/day	Human	No effects on blood pressure, respiration, glucose, blood cell count, urinary serotonin, a 50% reduction in blood serotonin	Sulman et al. (1978)[d]
$-1.5 \times 10^4/cm^3$ for 3 to 24 days	Rats	27% reduction in ulceration	Deleanu et al. (1965)
± 3.0 to $4.0 \times 10^5/cm^3$ for 30 days	Mice	25% increase in mortality of animals with respiratory disease	Krueger and Levine (1967)
± 1.0 to $2.0 \times 10^5/cm^3$ for 6 to 10 days	Mice	5% to 23% increase in mortality of animals with respiratory disease	Krueger et al. (1970)
$\pm 5.0 \times 10^3/cm^3$ for 14 to 15 days	Mice	26% increase in mortality rate of animals with respiratory disease	Krueger and Reed (1972)
$\pm 2.0 \times 10^4/cm^3$ for 14 to 16 days	Mice	No change in mortality rate of animals with respiratory disease	Krueger and Reed (1972)
$\pm 5.0 \times 10^5/cm^3$ for 14 to 16 days	Mice	23% lower incidence in mortality of animals with respiratory disease	Krueger and Reed (1972)

[a] Greater impacts resulted from changes in temperature and relative humidity alone.

[b] Greater changes have been observed from ordinary exercise and from psychological variables.

[c] Changes observed are within limits of normal physiological variability.

[d] Serotonin reduction is within normal physiological limits and comparable to ordinary changes induced by dieting.

transient and highest ion concentrations would only occur in localized areas. For example, maximum ion concentrations would occur during such periods as intense rain storms or periods of high dust levels (i.e., when foreign objects would be adhering to the conductors). Furthermore, highest ground-level ion concentrations would occur under the point of maximum conductor sag, and factors such as changes in wind direction can change ion concentrations at any point significantly within a period of seconds (ER, Vol. 5a). Under worst-case exposure scenarios, individuals could experience small transient alterations of physiological and behavioral parameters. These effects would not represent a health hazard and would disappear with the cessation of exposure, leaving no residual effects. Air ions would be sufficiently dispersed that exposure outside the right-of-way would result in effects of even lower magnitude, if at all. Due to the combination of the small area of maximum ion concentrations; natural movements of wildlife, livestock, and humans; and variations in air ion concentrations at any point caused by weather influences (e.g., wind); it would be extremely coincidental for animals (including humans) to be exposed to maximum ion concentrations for more than a very brief period (minutes to hours). Additionally, during conditions that can result in highest ion concentrations (e.g., storms), most animals would avoid open areas such as under transmission lines.

Exposure to Audible Noise and Ozone. Recommended standards for noise proposed by the U.S. Environmental Protection Agency (1974) are 45 dB(A) ($L_{eq(24)}$ or L_{dn}) as an indoor level below which there is no reason to believe that public welfare will be jeopardized, and 55 dB(A) ($L_{eq(24)}$ or L_{dn}) as the corresponding outdoor level, each identified to provide a margin of safety.* Maximum predicted noise levels under the DC line are 42 dB(A) under the positive conductor and 36 dB(A) at the edge of the right-of-way (ER, Vol. 5a). Johnson and Zaffanella (1982) measured noise levels under the Project UHV test line ranging up to 33 dB(A) (below which 95% of the measured values occurred).

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 that would be emitted by the proposed transmission line is unlikely to deter wildlife from using habitat in the vicinity of the right-of-way.

Experiments with animals and humans indicate a range of effects from ozone exposure at 100 to 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. Environmental Protection Agency 1978;

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*A = A-weighting = weighting of the entire audio-frequency spectrum of audible noise by a single number expressing an overall sound-energy level; L_{eq} = equivalent sound level = mathematically time-averaged level of a fluctuating noise; L_{dn} = equivalent day-night sound level = variation of L_{eq} that allows for penalizing noise intrusions at night when people are more sensitive to noise.

National Research Council 1977). The Project UHV test line generated no ozone that could be measured above background (Johnson 1982a, 1982b). Measurements in laboratories and near transmission lines have also shown the level of oxidants produced by DC and AC lines to be near the detection limits (Droppo 1981; Krupa et al. 1980). Levels of ozone produced are less than a few parts per billion, while ambient levels are in the range of 10 to 100 ppb (U.S. Department of Health, Education and Welfare 1970; U.S. Environmental Protection Agency 1973; Coffey and Stasiuk 1975). The National Primary Ambient Air Quality Standards for photochemical oxidants are 120 ppb (maximum 1-hour concentration, not to be exceeded on more than 1 day per year) (U.S. Environmental Protection Agency 1979). Ozone production generally occurs during foul weather, which coincides with the times of lowered background levels of ozone (ER, Vol. 5a). Therefore, no adverse health effects are expected from ozone produced by the proposed transmission line.

Cardiac Pacemakers. DC electric fields are not expected to interfere with the functioning of cardiac pacemakers worn by individuals in the right-of-way. These fields would be 100 times lower than necessary to cause reversion to asynchronous operating mode (Frazier 1980).

4.1.8.2 AC Effects

Potential health and safety effects of AC lines were not addressed in the Phase I EIS (U.S. Department of Energy 1984) because no AC lines were to be constructed in conjunction with that project. A moderate amount of research has been conducted on AC effects, and the results are summarized in the ER, Vol. 5b (New England Hydro-Transmission Corp. and New England Hydro-Transmission Electric Co. [NEHTC and NEHTEC 1985b]). The information in that document supports the conclusion, and DOE Staff concurs, that no health and safety concerns would result from operation of a 345-kV AC line. A pertinent summary of the effects of AC operation is presented in the following subsections.

Electric and Magnetic Environment

Operating, high-voltage, alternating-current (HVAC) lines produce electric and magnetic fields and corona (Bracken 1979a; Lee et al. 1982). Corona from such lines does not produce long-lived air ions. There is little movement of the ions away from the conductor since they are alternately repelled from and attracted to the conductor as the voltage on the conductor alternates polarity. Secondary effects of AC corona include production of audible noise, ozone, and nitrogen oxides (Comber et al. 1982a, 1982b). For a given transmission line configuration, electric field strength depends on line voltage, and magnetic field strength depends on line current. Both vary with distance from the conductors.

Potential Hazards from an Operating High-Voltage Alternating Current (HVAC) Transmission Line

As previously mentioned, most studies on the health and safety aspects of operating transmission lines have dealt with AC systems (or aspects associated with them). Biological systems have been found to be affected when field intensities and duration of exposure are of sufficient magnitude. However, as with HVDC systems, the maximum electric and magnetic field strengths associated with HVAC systems are not of sufficient magnitude to elicit harmful, pathological effects, although nonpathological effects may occur. Maximum intensities of the fields associated with the HVAC environment occur infrequently over the course of a year and decline rapidly with distance from the electrical conductors. Additionally, exposure to maximum field intensities is expected to be infrequent due to periodic and generally short duration use of rights-of-way by humans and livestock. The following discussion details the health and safety concerns relevant to the proposed Phase II AC transmission lines.

Proximity Effects. Risks of pathological shocks under the proposed 345-kV AC line would be extremely low. Maximum transient and steady-state currents would be expected to be about half those shown in Table 4.6 for operating 765-kV AC, lines assuming similar line configurations. No direct physiological hazards have been associated with such shocks (Keesey and Letcher 1970), and there have been no documented cases of human injuries due to electric charges or induced currents from 345-kV AC lines in the United States (ER, Vol. 5b).

Table 4.6. Shock Currents from 765-kV AC Transmission Lines and Currents Affecting Humans[a]

Type of Current	Shock Received by Contact with a Vehicle	Shock Effects
Steady-state (current)	Theoretical: 0.1-7.5 mA[b] Probable: 0.003-0.12 mA	Perceived: >0.5-2 mA Startling: > 1 mA
	Highest Measured Value: 3.5-4 mA	Objectionable: >2 mA Release Currents[c] >5 mA suspected for small child <10.5 mA for average adult female >16 mA for average adult male
Transient (energy released)	Theoretical: 0.02-65 mJ[b] Probable: 0.003-1 mJ	Perceived: >0.1 mJ Annoying: >0.5-1.5 mJ Painful: 250-25,000 mJ

[a] Maximum electric fields of 9 kV/m.

[b] Calculated for worst-case conditions in maximum electric field. Worst-case conditions are: vehicle completely insulated from ground; human completely grounded and having negligible resistance to electric current.

[c] Current above which contact cannot be voluntarily broken.

Source: Scott-Walton et al. (1979).

Electric Field Effects. In New England, typical maximum electric field strengths at ground level under 345-kV AC transmission lines are 7 kV/m. For the proposed 345-kV AC lines, the maximum electric field strength at ground level is calculated to be 6.6 kV/m in the right-of-way and 1.8 kV/m at the edge of the right-of-way (ER, Vol. 5b). Electric fields of these intensities are at levels for which biological responses have been reported or inferred (Michaelson 1981; Sheppard 1983b; U.S. Department of Energy 1983). As with the DC system, electric field intensities would vary with position, and the maximum ground level intensities would be encountered only in a small portion of the right-of-way (<5%). Recent review of the large body of literature on exposure to AC fields has revealed no evidence of harmful effects from intermittent exposure to field intensities below 10 kV/m (Michaelson 1981; Sheppard 1983b; U.S. Department of Energy 1983).

Field and laboratory studies have generally shown minimal or no impacts from power-frequency electric field strengths of 30 kV/m or less. Exposure to an AC electric field strength up to 20 kV/m did not cause stress or affect health (Hauf 1974; Rupilius 1976). No effects on growth or reproduction of cattle, horses, sheep, and swine pastured under a 765-kV AC transmission line right-of-way with an electric field strength up to 12 kV/m were observed (Amstutz and Miller 1980). Studies on another 765-kV AC line showed no effect on cow milk production (Williams and Beiler 1979). No differences in fertility were noted between cattle pastured near a 400-kV AC line and those pastured in a control area (Hennichs 1982). Rogers et al. (1982) observed no reluctance by cattle to graze under an 1100-kV AC line, although they spent less time under the line when it was energized. This suggests a behavioral effect from the 12-kV/m electric field and/or from the audible noise related to corona activity. Phillips et al. (1981) reported mixed results related to incidence of malformed offspring for swine exposed to 30 kV/m, but no evidence of this for small laboratory animals. Hackman and Graves (1981) concluded that an electric field strength of 30 kV/m was not stressful. Neuroendocrine levels (related to stress) in rats did not significantly change from exposure to 100 kV/m for a few hours to a few days (Quinlen et al. 1985). Quantitative tests for stress were negative for people exposed to 20 kV/m (at 50 Hz) for 5 hours (Hauf 1982; Amon 1977). Beyer et al. (1979) found no change in cortisol content of blood in humans exposed to 10 to 20 kV/m for 1.5 hours.

Continuous exposure to the electric field in the proposed right-of-way is unlikely because it is improbable that humans or other animals would remain in the right-of-way for more than a few hours. Outside the right-of-way, the AC electric field intensities would fall below 2.0 kV/m, and fall below the earth's natural average fair-weather electric field (<1.5 kV/m) within a short distance from the right-of-way. Sheppard (1983b) has identified 1.0 kV/m as a reasonable criterion level for protection of public health for long-term exposure to AC fields.

In conclusion, although biological effects have been reported for levels of electric field intensities associated with AC transmission lines, it is improbable that the fields associated with the proposed AC system would compromise the health and welfare of the local population or livestock.

Magnetic Fields. The proposed 345-kV AC lines would produce maximum ground-level magnetic fields of 0.28 G in the right-of-way and 0.085 G at the edge of the right-of-way (ER, Vol. 5b). These values are less than the AC magnetic field of 1 to 5 G produced near several home appliances (Miller 1974; Gauger 1985). As harmful effects from magnetic fields have not been documented in laboratory studies at field strengths of 1,000 G (Tenforde 1981) or in studies of people occupationally exposed to magnetic fields (Marsh et al. 1982), it can be concluded that magnetic field effects associated with the proposed HVAC transmission lines will be innocuous.

Air Ions. Air ion densities are not of concern for AC transmission lines. As the voltage on the conductor alternates polarity (at the rate of 60 times per second), charged molecules are alternately attracted and repulsed and thus remain near the conductors.

Exposure to Audible Noise and Ozone. Calculated maximum noise levels under the operating 345-kV AC lines would be about 60 dB(A) in heavy rain conditions (ER, Vol. 5b). Generally, the AC lines would generate audible noise during rain or fog. Expected noise levels at the edge of the right-of-way would be ≤ 45 dB (fair weather), 48 dB (when conductors are wet from fog or light rain), and 56 dB (heavy rain) (ER, Vol. 5b). Generally, background levels of audible noise in rural areas are about 35 to 45 dB(A) (U.S. Environmental Protection Agency 1974). Thus, audible noise would be expected to be at or above normal background along the right-of-way. The discernable levels would generally be below those considered annoying because noise levels fall off rapidly as distance from the lines increases.

The lack of anticipated impacts due to ozone production related to the HVDC line also applies to the proposed HVAC transmission lines.

Cardiac Pacemakers. Operation of the 345-kV AC lines could result in maximum AC fields in the range that could induce reversion to asynchrony. Most pacemaker manufacturers have successfully designed them to avoid electromagnetic field problems (ER, Vol. 5b), but some cardiac pacemakers can revert in electric fields of 2 kV/m (Moss and Carstensen 1985; Butrous et al. 1983). Conditions resulting in prolonged reversion are extremely unlikely, but the risks associated with intermittent reversion could cause fainting (Moss and Carstensen 1985). Apparently no accidents have resulted from exposure of a pacemaker patient to an AC transmission line (Scott-Walton et al. 1979; Lee et al. 1982; World Health Organization 1984). Although the combination of circumstances that would lead to an accidental event is extremely rare (ER, Vol. 5b), it is, nonetheless, probably unwise for persons with sensitive pacemakers to work for extended periods in the right-of-way of the AC lines.

4.1.8.3 Combined Effects of DC and AC Transmission Lines

Most of the proposed DC transmission line would share a right-of-way with a 115-, 230-, or 345-kV AC line. The previously presented information has implied that the proposed DC and AC lines would have negligible effects on health and safety. However, some concern may still exist as to whether the combined effects of DC and AC lines operating side by side would have effects greater than expected from either line alone. Information supplied by the Applicant (ER, Vol. 5 Supplement, October 30, 1985), summarized below, strongly implies that combined operations of DC and AC lines would not have adverse health and safety effects.

The highest calculated audible noise level at the edge of the right-of-way would be 55 dB(A) during heavy rain. This is only 1 dB(A) above the calculated audible noise level for the corresponding right-of-way with only the existing AC line.

Shielding of the earth's magnetic field (whose strength is almost twice as high as that of the proposed DC line's magnetic field) is seldom done in experimental studies. Thus, it is reasonable to conclude that studies on the effects of AC magnetic fields--previously concluded to have no health effects at levels expected from the proposed 345-kV AC lines--have in actuality assessed the combined effects of an AC line and the earth's field. Several recent studies (unpublished, but summarized in the ER, Vol. 5 supplement) have indicated that the magnitude and orientation of a DC magnetic field can affect the responsiveness of isolated tissues or animals to superimposed AC electric and magnetic effects. However, these effects are reversible, returning to normal following cessation of exposure (equivalent to moving away from the right-of-way). Additionally, under normal operating conditions for the proposed DC line, the resultant static magnetic field (earth's plus that of the DC line) would be close to or within limits of local variations of the static magnetic field found naturally at the earth's surface. Thus, the combined magnetic effects of AC and DC lines should have no health effects of concern.

There is little movement of small air ions away from an AC conductor. Therefore, an AC line will contribute little to the air ion concentration at ground level. Thus, air ion effects would be similar (negligible) to that previously discussed for the DC line. Additionally, ion concentrations at the the edge of the right-of-way would be less on the AC side (or on either side where the DC line is situated between AC lines) than at the edge of the right-of-way if only the DC line would be present.

There are no data indicating, nor is there reason to believe, that combined effects of DC and AC electric fields would affect health and safety. As stated in the ER (Vol. 5 Supplement), a DC electric field is constant over time and does not capacitively induce currents within objects, but rather causes objects to accumulate charges at their surfaces. This should in effect shield the object from influences of the externally applied DC field.

On the basis of the information above, coupled with the lack of any observed effects from existing shared DC/AC rights-of-way, there is no reason to conclude that any adverse health or safety effects would result from the siting of the proposed DC line within AC rights-of-way.

4.1.8.4 Herbicide Use in Right-of-Way Management

The Phase I EIS (U.S. Department of Energy 1984) concluded that herbicide use would not be a health or safety concern. Vegetation maintenance practices for the proposed Phase II project would be similar to that of Phase I, as well as other New England Electric System (NEES) lines. Therefore, no health and safety effects from Phase II maintenance would be expected. A pertinent summary of herbicide use is presented in the following discussion.

Except for the first 1.3 km (0.8 mi), most of the proposed transmission line would be constructed in existing right-of-way that is currently maintained by NEES. A 2.9-km (1.8-mi) segment between Millbury and West Medway, Massachusetts, is maintained by Boston Edison Company in a manner similar to NEES. Current right-of-way management practices would be maintained along these rights-of-way (ER, Vols. 2 and 3). Selective applications of herbicides would be used to retard the development of tall-growing vegetation that might compromise the integrity and safety of the power transmission system. The Applicant would only use herbicides that are registered with the U.S. Environmental Protection Agency and the states of New Hampshire and Massachusetts and approved for use in right-of-way management. The herbicides currently used by NEES are listed in Table 4.7.

Herbicides would only be applied by means of selective spray application by workers using hand-held application tools; there would be no broadcast application. Areas near public water supplies, open waters, springs, wells, homes, or roadsides would be managed by manual removal of undesirable vegetation. Herbicide applications would follow a prescribed schedule beginning with selective spraying of stumps of all hardwood species during the first dormant season after clearing. Two years later, a second selective application would occur, with subsequent applications on a 3- to 5-year cycle.

Herbicides can be toxic to living organisms and many are considered somewhat toxic to humans (Norris 1981; Gangstad 1982; U.S. Department of Energy 1983, 1984). Human health risk from herbicide application depends upon the acute and chronic toxicity of the compound, duration of exposure, pathway of exposure, and concentration of the compound to which one is exposed. Based on worst-case assessment, the U.S. Department of Energy (1983) has estimated the maximum possible dose to a 50-kg (110-lb) individual exposed to 2,4-D occupationally or via environmental dispersion of the herbicide. Table 4.8 summarizes the results of that assessment scaled to NEES's current application rate of about 2.2 kg/ha (2 lb/acre). Estimated safety margins for use of 2,4-D as proposed by the Applicant range from maximum doses of 100 to 20,000 times less than the threshold level of 20 mg/(kg·day) for chronic effects to the reproductive system. The other herbicides proposed for use by the Applicant are generally less toxic to mammalian systems than 2,4-D (U.S. Department of Energy 1983, 1984).

Herbicide use has been found to be environmentally acceptable as practiced by the Forest Service in the Northeast. 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 development, and other uses (Forest Service 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. These include manual, mechanical, and biological control methods (U.S. Department of Energy 1983). However, the most readily acceptable alternatives are manual or mechanical vegetation control. These methods are

Table 4.7. Current Herbicide Usage by NEES Companies

Herbicide	Active Ingredients	Dilution	Average Application Rate (gallons of active ingredient per acre of ROW)	Type of Application[a]
Krenite	Fosamine	1.5 gallons (gal) herbicide formulation to 98.5 gal water	0.44 gallons active ingredient	High volume foliar[b]
Krenite	Fosamine	14-20 gal herbicide	0.30	Low volume foliar[c]
Garlon 3A	Triclopyr	1 gal herbicide formulation to 99 gal water	0.36	High volume foliar
Garlon 3A	Triclopyr	10 gal herbicide formulation to 90 gal water	0.13	Low volume foliar
Garlon 3A	Triclopyr	50 gal herbicide formulation to 50 gal water	Less than 0.01	Cut stump
Garlon 4	Triclopyr	25 gal herbicide formulation to 75 gal light oil	0.03	Low volume basal and cut stump
Tordon 101	Picloram & 2,4-D	1 gal herbicide formulation to 99 gal water	0.41 (0.08 Picloram and 0.33 2,4-D)	High volume foliar
Tordon 101	Picloram & 2,4-D	14 gal herbicide formulation to P 86 gal water	0.15 (0.03 Picloram 0.12 2,4-d)	Low volume foliar
Tordon 101 & Garlon 3A	Picloram, 2,4-D & Triclopyr	0.5 gal each herbicide formulation to 99 gal water	0.28 (0.03 Picloram, 0.12 2,4-D and 0.13 Triclopyr)	High volume foliar

Table 4.7. Continued

Herbicide	Active Ingredients	Dilution	Average Application Rate (gallons of active ingredient per acre of ROW)	Type of Application[a]
Tordon 101 & Garlon 3A	Picloram, 2,4-D & Triclopyr	7 gal each herbicide formulation to 86 gal water	0.46 (0.07 Picloram, 0.29 2,4-D and 0.10 Triclopyr)	Low volume foliar
Tordon RTU	Picloram & 2,4-D	Undiluted herbicide formulation	Less than 0.02 (0.01 Picloram and 0.01 2,4-D)	Cut stump
Roundup	Glyphosate	1 gal herbicide	0.12	High volume foliar
Roundup	Glyphosate	7 gal herbicide formulation to 93 gal water	0.12	Low volume foliar

[a] Three application methods are used. Foliar treatments are applied to the leaves of the target tree sprouts or seedlings. Basal treatments are applied to the lower 8 to 18 in of a tree's stem. Cut stump treatments are applied to the cut surface of a tree's stump.

These application methods are all selective and are applied only to target plants. They suppress tree growth while encouraging the growth of shrubs, grasses, ferns, and other low-growing plant species.

[b] High volume foliar treatments utilize a relatively low concentration of herbicide mixed with water. They are applied by use of hand-held nozzles extending from hydraulic spray equipment. This method is usually performed in areas of relatively high stem density and areas where access conditions are difficult.

[c] Low volume foliar treatments utilize a relatively high concentration of herbicide mixed with water. They are applied by use of powered backpack equipment. This method is usually performed in areas of relatively low stem density and areas where access conditions are not difficult.

Source: Supplemental response from Vern R. Walker to Anthony Como (DOE, ERA), dated 9 October 1985.

Table 4.8. Maximum Worst-Case Doses [mg/(kg·day)] and Associated Safety Factors for Potential Routes of Exposure to 2,4-D Proposed for Use by the Applicant for Right-of-Way Management

	Handling Herbicides During Application	Drinking 2 L of Water from 10-cm-Deep Stream on Right-of-Way	Consuming 0.5 kg of Fish from 10-cm-Deep Stream on Right-of-Way	Consuming 0.5 kg of Meat from Deer Found on Right-of-Way	Consuming 0.5 kg of Berries Collected on Right-of-Way
Maximum dose[a]	0.050	0.090	0.022	0.0010	0.12
Safety factor[b]	400	222	909	20,000	167

[a] Worst-case estimate of maximum dose to a 50-kg (110-lb) person.

[b] Based on a threshold level of chronic ingestion of 20 mg/(kg·day) of 2,4-D for initiation of effects to reproduction.

Source: Modified from U.S. Department of Energy (1983--Table 7-12).

much more labor-intensive and expose workers to increased risk of injury from accidents in tool, equipment, and brush handling. In Oregon, the Bonneville Power Administration has recorded a 5-year average injury rate of 5 injuries per 200,000 man-hours in brush-cutting activities (U.S. Department of Energy 1983--p. 205). No chemical toxicity injuries were reported among workers over this same time period. Vegetation management using herbicides substantially reduces health and safety risks for workers while slightly increasing the risks of toxic effects to the public, principally via erosion and spill events.

In conclusion, the herbicides proposed for use in the rights-of-way have low degrees of toxicity to humans and other animals, and their application according to label directions and in conjunction with appropriate mitigative measures would ensure their safe use. Extensive experience with toxic herbicides has shown that these potentially hazardous materials can be used safely if appropriate precautions are implemented (Barnes 1975; Buffington 1974; Gangstad 1982; U.S. Department of Energy 1983).

4.1.9 Radio and Television Interference

The term "radio noise" is used in reference to any undesirable disturbance of the radio frequency spectrum, which ranges from 3 kHz to 30,000 MHz. Operational high-voltage transmission facilities contribute to radio noise that can interfere with radio and television reception, particularly the AM broadcast bands (535-1605 kHz) and the lower television broadcast bands (Channels 2-6 at 54-88 MHz) (U.S. Department of Energy 1984). The degraded reception is referred to as radio interference (RI) or television interference (TVI). The FM broadcast range from 88 MHz to 108 MHz is unaffected by pulsative-type noise (General Electric Company 1982).

RI and TVI associated with operational transmission lines result from corona discharge and gap sparking. The latter is generally caused by defective or loose fittings and can be remedied by routine maintenance. Corona (the partial breakdown of air into charged particles) begins to occur when the surface voltage gradient on the conductors exceeds the threshold or onset value of the surrounding air. Transmission lines are designed to control levels of corona activity, but the onset of corona is influenced by numerous factors, including atmospheric elements, design parameters of the line, and condition of the conductors. Corona activity is also influenced by the kind of transmission system. For example, corona activity associated with AC systems increases during foul weather, reaching a maximum during heavy rain. In contrast, corona levels for DC systems are highest when point sources occur on the conductor (which may occur during foul weather), although certain effects (audible noise and RI/TVI) of corona are probably highest in fair weather (ER, Vol. 5a).

Some evidence indicates that DC RI is of a lesser nuisance level than AC RI (Bonneville Power Administration undated). Subjective evaluations by test individuals have shown that the tolerance level for DC RI corresponds with a broadcast signal-to-noise ratio (SNR) of about 10 to 1. In terms of equivalent dB levels (above 1 μV/m, hereinafter implied), the RI at the receiving antenna must be 20 dB below the broadcast signal for acceptable reception. Bracken has reported that a differential of 17 dB results in entirely satisfactory AM reception (U.S. Department of Energy 1984). However, the SNR for acceptable reception involving AC transmission systems is variously reported as 15 to 1, ranging up to 25 to 1. Accordingly, the AC line RI must be 23.5 to 28 dB below the broadcast signal strength for satisfactory reception (Bonneville Power Administration undated). The Applicant proposes that an SNR of about 20 dB for AC transmission lines would result in satisfactory reception quality (ER, Vol. 5--p. II-20), as opposed to the 23.5 to 28 dB noted above.

The preceding attributes of RI and TVI associated with DC transmission systems were included as considerations in evaluating RI and TVI related to Phase I development of the New England/Hydro-Quebec ±450-kV DC transmission line interconnection (U.S. Department of Energy 1984). Based on a relatively conservative prediction equation, it was estimated that the fair weather RI at the edge of the right-of-way would be 41 dB. Since the design parameters of the currently proposed Phase II transmission facilities are similar to those of the Phase I development (ER, Vol. 4--p. 76), it is assumed that the fair weather RI at the edge of the right-of-way for the proposed Phase II DC line would likewise be about 41 dB. Given an SNR equivalent to 17 dB, reception at receiver units located at the edge of the right-of-way would be satisfactory for all broadcast signals exceeding 58 dB. Radio broadcast signals for primary service areas typically exceed 70 dB; thus, RI related to the proposed Phase II DC line would be unlikely to cause complaints relative to radio reception. Complaints of TVI would also be unlikely, as indicated by evaluation of potential TVI related to the Phase I DC line (U.S. Department of Energy 1984).

The Applicant has reported calculated RI levels at the edge of the right-of-way for the proposed AC transmission lines (ER, Vol. 5--p. II-18). For a frequency of 1 MHz, the calculated RI is 68 dB or less during heavy rain, 60 dB or less during wet conductor conditions, and 43 dB or less during fair weather conditions. However, RI levels decrease rapidly with increasing distance from the line. At 30 m (100 ft) from the edge of the right-of-way, the RI level drops to 49 dB or less during heavy rain, 40 dB or less during wet conductor conditions, and 23 dB during fair weather conditions. Given a SNR equivalent of 20 dB for satisfactory radio reception and a 70 dB radio broadcast signal for the primary service area, AM radio reception at the edge of the right-of-way of the proposed AC lines should be satisfactory, except during wet conductor or heavy rain conditions (ER, Vol. 5--p. II-20). At distances exceeding 30 m (100 ft) from the edges of the right-of-way, radio reception within the primary service area should be satisfactory during all weather conditions. The level of interference associated with commercial television frequencies is considerably lower than that associated with the AM radio broadcast band. Thus, the incidence of TVI should be of minor consequence. The physical presence of transmission facilities may cause scattering, reflecting, or reradiation of primary television broadcast signals, thus resulting in the phenomenon referred to as ghosting (General Electric Company 1982). Ghosting can be alleviated by modifications of antennas.

The proposed DC transmission line would be constructed within a common right-of-way in parallel with one or more existing AC transmission lines. Thus, the potential RI and TVI levels at the edges of the common right-of-way would be influenced by any "combined effects" resulting from concurrent operation of the existing AC and the proposed DC transmission lines. The Applicant has calculated RI levels for various segments of the transmission corridor (ER, Vol. 5 Supplement, October 30, 1985). The results indicate that operation of the DC line during heavy rain conditions would alter RI levels at edges of the rights-of-way, ranging from slight increases (generally 3 dB or less) to actual decreases in RI levels in some cases. However, such changes are relatively minor, and the combined effects of AC and DC line operations would not appreciably affect the potential for RI adjacent to the right-of-way. Current evidence indicates that operation of the DC line would be unlikely to cause TVI problems beyond the edges of the right-of-way (ER, Vol. 5 Supplement, October 30, 1985).

4.1.10 Recommended Mitigative Measures

The Applicant has committed to a broad spectrum of mitigative measures that would minimize adverse environmental impacts resulting from the construction, operation, and maintenance of the proposed project. Those measures are outlined in Section 2.1.5. Listed below are additional measures that the DOE Staff recommends be incorporated into the Applicant's mitigative program for the proposed project.

4.1.10.1 Air Quality

Additional measures that should be considered to reduce excess fugitive dust and audible noise include the following:

- *Construction and vehicular activities should be curtailed on dry, windy days in areas prone to excessive dust generation.*
- *Vehicle speed should be controlled on unpaved access roads.*
- *Construction equipment should be properly maintained and properly operated.*

4.1.10.2 Land Features, Hydrology, Water Quality, and Water Use

Additional mitigation measures beyond those committed to by the Applicant that would be warranted under certain conditions include the following:

- *Construction vehicles and equipment should not be operated when unfavorable weather and sensitive site conditions could result in unacceptably excessive wind or water erosion.*
- *Whenever feasible, topsoil materials should be salvaged from construction sites, stockpiled, and used for top dressing of disturbed surfaces following completion of construction.*
- *Refueling of construction vehicles, storage of construction materials, disposal of waste materials, and any other handling of potentially contaminating materials should be prohibited near surface waterbodies. Fuels, chemicals, oils, greases, solid wastes, and other materials needed at construction sites should be stored and handled in a manner designed to prevent spills.*
- *Storage and maintenance yards should not be located near watercourses.*

- *Temporary toilets should be self-contained, and land-stabilization measures should be provided where required to protect the quality of surface water and groundwater.*

4.1.10.3 Land Use

- *Forest vegetation on steep ravines should not be cleared if the height of the spanning conductors is sufficient to preclude jeopardizing the operational integrity of the proposed lines.*

- *As necessary, temporary fences, gates, cattle guards, etc. should be installed to control and minimize disturbance to livestock during project construction and operation.*

- *To the extent practicable, construction activities should be scheduled to minimize damage to standing crops and limit interference with land use operations.*

- *Appropriate federal, state, and local agencies should be consulted as necessary to refine construction procedures in accord with site-specific conditions to further ensure that land-use impacts related to the design, construction, and operation of the proposed transmission facilities would be minimized.*

- *Provisions for screening the proposed transmission facilities should include considerations for minimizing the length of the transmission line segments visible from a given vantage point. This could involve establishing plantations of low-growing trees across or near the edge of the right-of-way in strategic areas. In some places, feather cutting of existing vegetation (i.e., only tall trees removed) within the inner edge of the right-of-way may be effective.*

4.1.10.4 Ecology

Many of the committed and suggested mitigative measures to minimize impacts to land, forest, and hydrological resources would effectively reduce potential impacts to ecological resources as well. The following mitigative measures are designed more specifically to protect fish, wildlife, and their habitats and should be considered for use by the Applicant:

- *No debris resulting from periodic vegetation management should be placed within the high water mark of any waterbody. If tree tops and slash are not disposed of within 8 m (26 ft) of perennial and intermittent streams, the potential for formation of debris dams would be reduced (Lynch et al. 1985).*

- *Erosion gullies and depressions found on the rights-of-way that carry water from heavy rains should be filled with brush from clearing operations (Ulrich 1976). This would trap sediments and eventually stabilize such areas.*

- *Construction and clearing operations in streams (e.g., for access roads) should be restricted during fish nesting and spawning periods.* [For brook and brown trout (major game species of concern) this is during late summer to early fall. Such restrictions could be lifted if it can be satisfactorily demonstrated that natural reproduction does not occur in the stream or that nesting or spawning activities do not occur within the particular section of stream to be crossed.]

- *Prior to the disturbance of gravel stream bottoms, the potential of the area for use as a spawning site should be determined, and if present, be avoided. Local fishery experts should be consulted in this matter.*

- *During the spring thaw period or during periods of unusually heavy rainfall, access roads should be closed to construction vehicles and equipment to minimize unacceptable environmental damage.*

- *In wetlands, construction activities should be conducted, if practicable, when the ground is frozen. However, in intermittent wetlands, construction could also be conducted when the ground is entirely dry.*

4.1.10.5 Socioeconomics and Cultural Resources

- *The Applicant should select construction-phase access routes so as to minimize adverse impact to local traffic flows and other disturbances to communities along the right-of-way. Communities should be given prior notification of impending construction activities on their portion of the corridor.*

- *The Applicant should complete the significance evaluation and impact assessment process in consultation with the New Hampshire and Massachusetts Historic Preservation Officers.*

- *If it is determined that impacts would occur to significant sites (i.e., those eligible for inclusion in the National Register), a mitigation plan should be developed in consultation with the State Historic Preservation Officers and the Advisory Council on Historic Preservation.*

4.1.10.6 Health and Safety

- *Residents adjacent to the transmission lines should be informed of the possibility of induced shock and of the fact that the utilities would ground their equipment upon request. Pacemaker patients should be especially informed.*

4.2 CONSEQUENCES OF ALTERNATIVES TO THE PROPOSED ACTION

4.2.1 Alternative Designs

4.2.1.1 Air Quality

No noticeable differences in air quality would occur due to differences in structure design, conductor spacing, or other overhead design changes. Placement of the line underground would eliminate potential air quality changes that could occur with overhead transmission line operation (e.g., ozone increases). However, air-quality changes related to overhead transmission line operation were not determined to be significant (Section 4.1.1). More intensive construction activities associated with the installation of an underground system could increase fugitive dust and engine emissions over that expected for construction of an overhead system.

4.2.1.2 Land Features and Use

Geology and Soils

Alternative overhead lines with different types of structures, conductor sizes, and configurations (ER, Vols. 2 and 4), including the ±450-kV DC transmission line, the 345-kV AC line, and double-circuit 115-kV AC lines, would have similar geologic and soil impacts. Potential erosion due to soil disturbance during construction and maintenance could initiate geological instability, such as landslides, slumping, and mass wasting near sloping areas, such as at stream crossings.

The geologic impacts of an underground transmission line would be greater than for alternative overhead lines since more extensive terrain excavation, grading, and related cable-laying and backfilling activities would be required. Trenching for the 298-km (185-mi) underground line would require excavation of 0.78 to 1.1×10^6 m^3 (1.0 to 1.4×10^6 yd^3) of material, depending on whether it is a DC or AC facility. The underground line alternative would also necessitate removal of unused excavated material from the site for disposal and transport to the area of about 0.2 to 0.3×10^6 m^3 (0.24 to 0.4×10^6 yd^3) of thermal sand for the trenches. The longer construction time for the underground line would increase the time excavated material would be exposed to the elements, and therefore would increase the potential for erosion. Mitigative measures described in Section 2.1.5 could be taken to minimize potential geologic and soil impacts.

Land Use

Land-use impacts associated with the alternative structure designs would not meaningfully differ from those discussed in Section 4.1.2.3, which includes considerations of the proposed steel lattice H-frame structures. However, structure design does influence land use, depending on the land use involved. For example, structure design is a negligible consideration with respect to use of pastureland, since livestock would graze areas adjacent to and within the base of structures. In the case of agricultural croplands, however, the area within the structure base, as well as additional area around the base, would be unavailable for production due to the area required for maneuvering farm machinery. In general, cropland unavailable for production around four-legged structures is two or more times greater than that for the two-legged H-frame structures (Scott 1981). The use of single-pole structures would entail even less land area. In view of the limited cropland along the proposed route and the fact that cropland would be spanned wherever practical (ER, Vol. 3--p. 204), use of any of the alternative structures would not meaningfully alter project-related land-use impacts.

The construction of either of the alternative DC or AC underground transmission systems would result in extensive land-use conflicts. Excavation of trenches for the underground systems would disrupt land-use patterns along the entire length of the proposed route. For example, some agricultural cropland and pasture would be dissected to the extent that the tracts would not be of feasible size for agricultural management. The excavation, extensive earth moving operations, transport of materials to construction sites, and offsite disposal of excess excavated materials would contribute to relatively intense construction activities. Thus, levels of fugitive dust, construction noise, and construction traffic would impact residential, commercial, and industrial land use to a greater extent than would be the case for construction of an overhead transmission system. Interference with use of local transportation routes would also be relatively severe.

Following construction of either the DC or AC underground transmission system, reclamation of disturbed areas would tend to promote restoration of some preconstruction land-use patterns. However, some land-use constraints would prevail throughout the operation of the underground system. The right-of-way overlying the buried cables would be maintained free of trees and shrubs (ER, Vol. 4--p. 84). Furthermore, permanent roads would be constructed to access facilities, including manholes to cable splicing stations located at 0.5-km (0.3-mi) to 0.8-km (0.5-mi) intervals along the entire length of the underground system. The distance between manholes would depend on the underground system involved (ER, Vol. 4--Sec. VI.B).

4.2.1.3 Hydrology, Water Quality, and Water Use

Surface Water

All overhead line designs considered would have similar surface-water impacts relative to water erosion, potential reduction in water quality, altered drainage patterns, increased surface runoff, and damage to river-banks. The adverse impacts associated with construction of underground transmission lines would be greater than for any of the overhead transmission line alternatives. This is because there would be more extensive terrain excavation, grading, and backfilling for trenches and splicing manholes, and a longer construction time for underground transmission facilities. In addition, the underground cable would require boring of sleeves at highway and railroad crossings, and river crossings would require cut and fill, jetting, boring, or tunneling (ER, Vol. 4). These construction activities could cause contamination of surface water, particularly during periods of high surface runoff. Surface-water impacts could be minimized by the proposed mitigative measures discussed in Section 2.1.5.3.

Groundwater

Potential adverse impacts on groundwater conditions, including aquifer contamination and disruption of shallow groundwater flow patterns, would be similar for all overhead design options. The groundwater impacts of the underground transmission line would be greater in comparison with overhead transmission lines since the underground line would require more extensive excavation.

4.2.1.4 Ecology

The nature and extent of impacts associated with any overhead design alternatives would be similar to those discussed for the proposed designs (Section 4.1.4). Overall, construction of an underground system would have greater adverse impacts to terrestrial biota. The right-of-way initially would have to be completely cleared of vegetation, and after project completion would have to be maintained in a grassy condition. Large and more mobile wildlife would be affected similarly to what was discussed for an overhead system. However, smaller and less mobile species (e.g., small mammals, reptiles, and amphibians) would be destroyed in greater numbers due to the extensive amount of clearing, trenching, and construction activities that would occur with installation of an underground system. Conversely, potential for bird strikes associated with overhead line designs would be eliminated with an underground system (except in localized areas near transition facilities, converter terminal sites, and AC substations). However, the impact associated with the proposed design relative to bird strikes was concluded to be negligible (Section 4.1.4.1).

An underground system would more adversely affect aquatic systems and wetlands, especially when construction could not be rerouted around such areas. Habitat impairment would occur within the immediate area of construction. Impacts associated with increased suspended solids and sedimentation would occur away from the construction area (e.g., downstream in the instance of stream crossings). Hydrologic impacts could also result from trenching activities within a wetland. Increased potential for erosion due to trenching activities could also impact aquatic systems and wetlands located adjacent to construction areas. With use of proper mitigative measures and construction techniques, adverse impacts to aquatic and wetland systems would mainly be confined to the period of construction plus the time needed for habitat recovery. Recovery rates are usually less than one year, but in selected cases have been estimated to take up to five years or more. Potential maintenance-related impacts would also be greater for an underground system, since retrenching would be required.

During the lifetime of the project, the area covering an underground line would have to be maintained in a grass-like condition. This probably would not greatly affect species with a wide range of habitat requirements or wide-ranging habits, but would limit the diversity of smaller, less mobile species that inhabit forested edge or shrub habitats more commonly associated with overhead transmission line systems.

4.2.1.5 Socioeconomics

Impacts generated by alternative designs would be the same as those projected for the proposed action, except in the case of a buried AC or DC transmission line. Burial of the transmission line would create both temporary and, to a lesser extent, long-term disruption of traffic flows and increased noise and fugitive dust levels. There could also be some short- and long-term loss of agricultural production. However, high construction and maintenance costs might have positive effects on the local economy.

4.2.1.6 Visual Resources

Two existing transmission lines occur within the segment of the proposed DC transmission line route for which alternative structure designs have been identified. Among other factors, compatibility of line and form between features of the landscape is conducive to visual harmony. Thus, the structure designs of the existing transmission lines within the common corridor are relevant to the design of the proposed and alternative structures for the proposed DC transmission line. The two existing transmission lines are supported by lattice-type structures. The proposed steel lattice H-frame is more visually compatible with the structure of the existing transmission lines and therefore would be least intrusive in local landscape settings. At the other extreme, the steel lattice, waist-type structures would be most disruptive with respect to landscape quality.

During the construction period, activities associated either with a DC or AC underground transmission system would result in a greater level of visual impacts than for construction of an overhead transmission system. The visual impacts also would probably be more enduring, since the construction period for the underground system would likely be more extended. Excavations along the entire length of the proposed line, extensive earth-moving operations at construction sites, and a high level of construction activity would severely degrade the quality of affected landscapes. Views from residential and commercial areas would be strongly affected, and users of recreational sites and routes adjacent to construction sites would be subject to visual impacts that would strongly detract from recreational experiences.

Following reclamation of disturbed areas associated with construction of an underground system, the visual impacts would be relatively minor compared with those associated with overhead transmission lines. A principal source of visual impacts associated with underground systems derives from the need to maintain the right-of-way overlying the buried cables free of tree and shrub vegetation (ER, Vol. 4--p. 91). Thus, the right-of-way would cause disruptive visual contrast, particularly in forested landscapes.

4.2.1.7 Cultural Resources

Use of alternative structure types (single pole and waisted) could have long-term visual impacts on some cultural resource sites (specifically, historical sites) above those of the existing right-of-way and transmission lines (Section 4.2.1.6; ER, Vol. 4--p. 77). Other alternative designs would have the same effects on cultural resources as the proposed project, with the exception of transmission line burial, which could cause significant impacts to archeological sites due to surface and subsurface disturbance during construction and maintenance (ER, Vol. 4--p. 91).

4.2.1.8 Health and Safety

Health and safety effects for overhead transmission system alternative designs would be comparable to those described for the proposed route (Section 4.1.8). Potential impacts associated with operation of overhead transmission lines (e.g., electric field, air ions) would be reduced or eliminated with an underground system. However, an increase in herbicide use could be expected as a result of more intensive maintenance requirements for an underground system. Nevertheless, when handled and applied properly, herbicides can be used safely. Construction-related accidents would be potentially greater for an underground system because of increased installation activities.

4.2.1.9 Radio and Television Interference

Given the proposed design parameters, spacing, and heights of pole conductor bundles, neither the proposed nor alternative structures could appreciably influence radio and television interference. This is because interference phenomena essentially derive from corona discharges from surfaces of activated conductors. Faulty or dirty insulators and loose conductor fittings may also contribute to radio and television interference. Neither the alternative DC nor AC underground system would influence radio or television reception, since there is essentially no electrical field around cables of an underground transmission system (Bonneville Power Administration 1982).

4.2.2 Alternative Routes and Converter Terminal Sites

4.2.2.1 Air Quality

Expected air-quality impacts along the Tewksbury, eastern, or western alternative routes would be identical to those expected for the proposed route.

4.2.2.2 Land Features and Use

Geology and Soils

The Tewksbury alternative DC transmission line would traverse about 9.5 km (5.9 mi) of potentially erodible soils compared with about 8.7 km (5.4 mi) crossed by the proposed DC transmission line. About 9.3 km (5.8 mi) of slopes greater than 20% would be crossed by either route (ER, Vol. 4). No significant differences in geologic and soil impacts between these two routes are expected. The eastern and western alternative DC transmission lines would traverse about 21.1 km (13.1 mi) and 22.2 km (13.8 mi) of terrain with center-line slopes of 20% or more, respectively (ER, Vol. 4). In addition, the eastern and western alternative lines would require more access road construction and have more than eight times the clearing area required for the proposed DC lines (ER, Vol. 4). This would result in greater soil erosion potential along the eastern and western alternative routes in comparison with the proposed DC transmission line route.

Land Use

Land-clearing requirements for the proposed DC transmission line route would exceed those for the alternative DC Tewksbury route (ER, Vol. 4--Table IV-2). The differential of about 73 ha (180 acres) would essentially result from widening the cleared portion of an established transmission line corridor within which the proposed DC line would be constructed. The potential impacts on other land-use categories would be relatively similar for the proposed and alternative Tewksbury routes. Thus, the impacts on existing land-use patterns would not be a significant issue in choosing between the two routes.

Adopting either the eastern or western alternative DC routes would result in relatively severe land-use conflicts. Development of the eastern alternative DC route would entail acquiring about 641 ha (1,585 acres) for right-of-way (ER, Vol. 4--Table IV-4). About 441 ha (1,090 acres) of additional right-of-way would have to be acquired for the western alternative DC route (ER, Vol. 4--Table IV-6). In either case, local land-use patterns would be appreciably disrupted. Land clearing for each of the alternative routes would exceed 688 ha (1,700 acres), areas over eight times greater than for the proposed DC route. The principal land-use impacts associated with the two alternative DC routes would result from disruption of established residential and commercial land use. Development of the eastern alternative route would entail relocation of 40 to 60 residential units and business establishments. An estimated 35 home and business sites would be displaced from the right-of-way for the western alternative DC route (ER, Vol. 4--Table IV-6).

The wetland or swamp forest portion of the alternative Tewksbury converter terminal site represents passive land use. The remainder of the site is used for transmission line rights-of-way and related substation facilities (ER, Vol. 1--Sec. V). Some of the utility facilities would be relocated; however, development of the alternative converter terminal would not involve significant issues relative to active land use.

4.2.2.3 Hydrology, Water Quality, and Water Use

Surface Water

The proposed DC transmission line would cross 209 streams and rivers and 12 lakes and ponds, compared with 191 streams and rivers and 10 lakes and ponds for the Tewksbury alternative route (ER, Vol. 4). The two lines would have comparable potential impacts to surface-water resources. There are no surface-water data available for the eastern and western alternative routes; however, based on the areas to be disturbed (Section 4.2.2.2), the adverse surface-water impacts for the proposed route are expected to be less than those for the two alternative routes. The types of surface-water impacts are discussed in Section 4.1.3.1.

Groundwater

Some adverse impacts on groundwater conditions, including aquifer contamination and disruption of shallow groundwater flow patterns, would be similar for the proposed route and the alternative routes. There would be no significant differences in groundwater impacts among the proposed and alternative routes. More detailed discussions on groundwater impacts of the proposed route are given in Section 4.1.3.2.

4.2.2.4 Ecology

Terrestrial

The nature of impacts to vegetation and wildlife along the alternative routes would be as described in Section 4.1.4.1. Selection of the Tewksbury alternative would necessitate clearing of about 73 ha (180 acres) less forest than would selection of the proposed route, but would require more relocations of existing lines, which would increase construction activities and related disturbances. The eastern and western alternatives would require more clearing than the proposed route: 693.3 ha (1,713 acres) and 716.3 ha (1,770 acres), respectively (ER, Vol. 4). However, these differences are unlikely to significantly alter impacts, because any routing alternative would require clearing of only a small percentage of the forest resources in the study area. The potential impacts to terrestrial fauna would be proportionally related to differences in forest areas cleared among the alternative routes, but the significance of the impacts relative to the study area would be minimal.

Aquatic (Including Wetlands)

Environmental consequences for aquatic and wetland biota along the alternative corridors would be of the same nature as described for the proposed route (Section 4.1.4.2 and Appendix B). Impacts to streams would be comparable, as they would be spanned in almost all cases. A greater expanse of wetlands would be crossed by the proposed route (15 km [9.3 mi]) than by the eastern (10.3 km [6.4 mi]) or western (6.1 km [3.8 mi]) alternatives. However, relocations and improved access needs for the alternative routes could affect these differences. Also, both the eastern and western alternatives have about twice the expanse of slopes of over 20% than the proposed route (ER, Vol. 4). This could increase the potential for erosion-related impacts to streams and wetlands.

The Tewksbury alternative would require clearing of 4.8 ha (11.9 acres) of wetlands compared with 3.4 ha (8.3 acres) for the proposed route, with an accompanying wetland displacement of 17.3 acre-feet compared with 10.2 acre-feet and a floodplain displacement of 20.2 acre-feet compared with 3.2 acre-feet. This would result primarily from the floodplain and wetland area occupying the site of the alternate Tewksbury converter terminal site (ER, Vol. 4).

Threatened and Endangered Species

There are no threatened or endangered plant taxa from the federal list or proposed for inclusion on the list that are known to be found along the alternative routes (Crow 1982). As for the proposed route, 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.

4.2.2.5 Socioeconomics

Socioeconomic impacts of the Tewksbury alternative would be similar to those of the proposed project. Both the eastern and western alternative routes would have comparatively high impact because of the acquisition of new right-of-way. The Applicant estimates that the eastern alternative would require an additional 641 ha (1,585 acres) of expanded right-of-way, necessitating relocation of 40 to 60 homes and businesses. It is also anticipated that access road construction would be more substantial for this alternative route, thus creating a potential for increased levels of traffic flow, disruption, noise, and fugitive dust in local communities along the right-of-way (ER, Vol. 4--pp. 60-62).

The western alternative would require 441 ha (1,090 acres) of expanded right-of-way and relocation of about 35 homes and businesses. As in the previous case, higher access road demands would have potential disturbance effects (traffic flow, noise, and dust) on adjacent communities (ER, Vol. 4--pp. 69-71). It is also possible that the significant visual impacts projected for the northern segment (from the Comerford converter terminal and Wilder substation) (see Section 4.2.2.6) could have some impact on property values in the Connecticut River Valley, although the relationship between transmission line construction and property values remains problematic (Kinnard and Stephens 1965; Vredenburgh 1974; U.S. Department of Energy 1983).

4.2.2.6 Visual Resources

The northernmost segments of the proposed DC transmission line and the alternative DC Tewksbury line share a common routing for about 180 km (112 mi), virtually the total distance within an established transmission line corridor. Thus, potential visual impacts associated with these two line segments would be similar. The remainders of the two routes traverse relatively similar terrain and landscapes of relatively similar quality. However, visual impacts related to the proposed DC route would be less severe than those of the Tewksbury DC route, primarily due to the following conditions. To provide adequate right-of-way for the Tewksbury line, existing transmission lines within a 7.2-km (4.5-mi) segment of an established transmission corridor would be altered. An existing 115-kV AC line would be relocated, and an existing 230-kV AC line and a planned 345-kV AC line would be mounted on double-circuit structures. Following these modifications, the paralleling transmission lines within the established transmission corridor would involve support structures of six differing designs. Furthermore, the double-circuit structures would be about 11 m (35 ft) taller than other structures in the corridor (ER, Vol. 4--Table IV-2). The differing designs and heights of structures would be highly intrusive in local landscapes and visible to numerous viewers, including travelers on U.S. I-495.

The potential for visual impacts associated with the eastern and western alternative DC routes would substantially exceed that for the proposed DC route. The comparatively extensive forest clearing requirements for the two alternative routes would be intrusive in numerous local landscapes. Additionally, the two alternative DC routes traverse relatively numerous concentrations of residential and commercial developments. Thus, transmission facilities would be viewed by comparatively large numbers of local residents as well as the traveling public. Levels of visual impacts would be particularly high along the northern segment of the western alternative DC route that generally parallels the Connecticut River Valley.

Much of the alternative Tewksbury converter terminal site is now cleared, and the immediate landscape views are dominated by transmission and substation facilities. Thus, development of the alternative terminal site would not appreciably degrade local landscapes. Vegetation surrounding the site provides a relatively effective screen that limits viewing distance, and the converter terminal would not normally be visible to the general public.

4.2.2.7 Cultural Resources

Adverse effects to cultural resource sites along the Tewksbury alternative route cannot be properly assessed without survey results from the right-of-way (which includes a 23.5-km [14.6-mi] interval of existing right-of-way both in New Hampshire and Massachusetts that is not part of the proposed project) and converter terminal site. No sites are presently listed on the National Register; one archeological site is located on the right-of-way (ER, Vol. 4--p. 51). It is unlikely that this alternative route and substation site would cause significant unmitigable impacts to archeological or historic sites.

The eastern and western alternative routes would require acquisition of substantial new right-of-way areas (641 and 441 ha [1,585 and 1,090 acres], respectively) that have not been surveyed for cultural resources (Office of Public Archeology, 1985--pp. 1-2). Surveys would be necessary in order to assess impacts to significant sites and determine appropriate mitigative measures. Although a high potential for sites exists in the Connecticut River Valley, along the northern segment of the western alternative (Comerford converter terminal to Walpole, New Hampshire), most impacts could probably be mitigated by avoidance, and, if necessary, data recovery.

4.2.2.8 Health and Safety

Construction, operation, and maintenance of any of the alternative routes would entail risks to human health and safety similar to those discussed for the proposed route (Section 4.1.8). The potential for impacts among alternatives would vary with distance of line, amount of structure relocations required, whether an AC substation would be required, and other such considerations.

4.2.2.9 Radio and Television Interference

The potential for the occurrence of radio and television interference is dependent on the proximity of receiver antennae to operational transmission lines. The Tewksbury alternative DC route would closely parallel relatively limited areas of residential and commercial developments. Thus, instances of complaints concerning radio and television interference (if any) would be relatively low. Complaints of interference would be more likely with respect to the eastern and western alternative DC routes, since these routes would parallel areas of substantially greater residential and commercial land use. Operation of the Tewksbury alternative converter terminal would not influence reception quality of receiver units in proximity to operational transmission lines.

4.3. ADVERSE EFFECTS THAT CANNOT BE AVOIDED IF THE PROJECT IS IMPLEMENTED

4.3.1 Air Quality

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

4.3.2 Land Features, Hydrology, Water Quality, and Water Use

Despite the use of mitigative measures to control erosion, some unavoidable increases of soil erosion and sedimentation within creeks and rivers would result from construction activities, particularly during the thunderstorm season. In addition, minor modification of natural topography, drainage patterns, and slopes would be unavoidable. Construction activities would result in temporarily increased suspended solids and turbidity in surface waterbodies of the project area.

4.3.3 Land Use

Land use within the designated transmission line right-of-way would be controlled during the lifetime of the project and limited to those practices and activities that are compatible with the operation and maintenance of the line.

Small areas around structures located in croplands would become unavailable for agricultural use. The cumulative area affected would be of minor consequence.

About 135 ha (334 acres) of forest would be converted to and maintained as shrub and grassland vegetation for the duration of project operation. The additional 12 ha (30 acres) of forest cleared for the converter terminal site would represent a long-term commitment of forest resources, pending eventual dismantling of terminal facilities and reclamation of the site.

Minor deposits of sand and gravel would become unavailable in order to preserve the structural and operational integrity of the proposed line.

Development of the proposed transmission line would not displace or preclude use of any developed public recreational sites or facilities; however, recreational participants in the vicinity of the line could be exposed to views of the transmission facilities that would detract from the quality of the recreational experience.

Despite planning efforts, project-related traffic and construction activities would variously interfere with public use of local transportation routes during the construction phase of the proposed project.

Visual resources would be adversely affected throughout the immediate project area, but some impacts would be limited to the construction phase of the project. Virtually all visual impacts related to the presence of the transmission facilities would be incremental in nature.

4.3.4 Ecology

About 147 ha (364 acres) of forest habitat at the proposed converter station, ground electrode site, and along the proposed route would be cleared, but it is not anticipated that this would result in serious effects upon local wildlife populations. Indeed, some species would benefit from the clearing of the wooded habitat.

Disturbance of aquatic and wetland habitats and their associated biota would be an environmental impact of the proposed project and would primarily occur during construction activities. The environmental impacts expected from construction and operation of the transmission line would consist primarily of transitory effects on aquatic biota due to construction, provided that proper mitigative measures are implemented. Overall, a maximum of 7.7 ha (19 acres) of wetland habitat would be lost for support foundations and access roads. Impacts to regional habitats and biota would be minor.

4.3.5 Socioeconomics and Cultural Resources

No unavoidable adverse effects to socioeconomics and cultural resources currently are identified.

4.3.6 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 insignificant 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 the right-of-way would not be affected by the indicated electric phenomena, even during the infrequent extreme occurrences noted.

4.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

4.4.1 Land Features

Use of sand, gravel, fuel, oil, water, and other materials during construction, maintenance, and operation of the proposed transmission facilities would constitute an irreversible and irretrievable commitment of resources. The sites occupied by transmission structures, the converter terminal, and other structures commit underlying resources, such as agriculturally productive soil, throughout the life of the project.

4.4.2 Ecology

Although wildlife habitat would be altered for the lifetime of the project, cover similar to existing habitat could be recovered after decommissioning. Recovery could occur by natural succession or by revegetation programs. Recovery of forest habitat would take several decades.

Aquatic and wetland habitat commitments would be relatively minor. In most cases, lost or modified habitat could be returned to original conditions after decommissioning.

4.5 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

This section summarizes the relationship between the proposed use of the environment implicit in the construction and operation of the transmission line interconnection and its related facilities and the actions that could be taken to maintain and enhance the long-term productivity of this same land and its resources.

Operation of the interconnection will result primarily in supplying electrical power needed to meet projected demand. The availability of the additional electricity will have a beneficial effect on the economy and should enhance continued growth and improvement in the service area.

A total of about 147 ha (364 acres) will be converted from present uses (mostly forested land) to project-related uses such as widening of the rights-of-way, construction of the converter terminal, and expansion of the ground electrode site. Of this total, less than 20 ha (50 acres) will be permanently converted to project-related uses that would preclude other uses such as farming or wildlife cover.

4.6 CUMULATIVE IMPACTS

Implementation of the proposed Phase II of the interconnection will result in only very small incremental (cumulative) impacts to the NEPOOL system since the new transmission facilities will be constructed almost entirely on existing rights-of-way. Since one of the purposes of the interconnection is to displace oil and other fuels or energy sources, the proposed project will actually postpone or preclude the construction of new fossil-fueled generating facilities in the reasonably foreseeable future in the NEPOOL service area. Other positive incremental impacts include fuel cost savings, the ability to maintain system-wide reliability, opportunities for energy interchange, and an increased ability to make emergency energy transfers to either the United States or Canada for mutual reliability purposes. These effects are discussed in more detail in Section 1.

Since the energy to be purchased from Hydro-Quebec is surplus power, it is likely that the incremental effect on the Canadian generating system of providing the energy will be very small.

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5. GLOSSARY

ALTERNATING CURRENT (AC) - An electric current that reverses its direction at periodically recurring intervals.

ANADROMOUS SPECIES - Species of fish that ascend into rivers from the sea to spawn.

APPLICANT - Vermont Electric Transmission Company, which is applying for the amendment to Presidential Permit PP-76.

AQUIFER - A water-bearing stratum of permeable rock, sand, or gravel.

CARRYING CAPACITY - The maximum number of animals that can be supported by a given area of habitat.

COGENERATION - Production of electrical (or mechanical) energy and thermal energy from the same primary energy source.

COLDWATER FISHERIES - Fish assemblage characterized by trout, char, and/or whitefish. Water temperatures must be low enough to meet the thermal requirements for survival and spawning for natural populations to be maintained. If temperatures are too high, seasonal or annual non-sustaining coldwater fisheries could be maintained through stocking.

CONVERTER TERMINAL - Facility needed to convert DC power to AC power, and vice versa, so that the proposed DC line can be connected to the existing AC power system.

CUMULATIVE PRESENT WORTH - The sum of a series of annual expenditures expressed in terms of a given year's buying power of money.

CUMULATIVE PRESENT WORTH OF REVENUE REQUIREMENTS - Cumulative present worth of the series of annual revenue requirements (see definition below) of a given project.

dB (DECIBEL) - Unit for expressing the relative intensity of sounds on a scale from zero for the average least-perceptible sound to about 130 for the average pain level.

DECLINING SPECIES - A species whose populations are currently undergoing a prolonged, noncyclic decline in the state and, possibly, many other parts of its range, and is either approaching rarity or is already very rare in the state. Such species are likely to become endangered or threatened in the state within the near future.

DIRECT CURRENT (DC) - An electrical current flowing in one direction only and substantially constant in value.

ECOLOGICAL PROVINCE - A broad vegetative region having a uniform regional climate and the same type or types of zonal soils.

ENDANGERED SPECIES - A species classified as being in immediate danger of extinction throughout all or most of its range (federally listed); in danger of extinction in a state as a reproducing species; rare or very local throughout all or much of its range, or having a relatively restricted geographic range (state-listed).

FOSSIL FUEL - Fuel sources ultimately derived from living things. Major fossil fuels are coal, oil, and natural gas.

HARDWOODS - General term for deciduous trees (angiosperms).

HEMAGGLUTINATION - Reaction in which red blood cells suspended in a liquid collect into clumps and which occurs especially as a serologic response to a specific antibody.

HYDROCARBONS - Organic compounds often occurring in petroleum, natural gas, and coal.

HYDROELECTRIC - Of or relating to production of electricity by water power.

KILOWATT-HOUR (kWh) - Unit of work or energy equal to that expended by one kilowatt (1,000 watts) in one hour.

MEGAWATT (MW) - 1,000,000 watts.

PARTICULATES - Particles of material suspended in the atmosphere.

PCBs (POLYCHLORINATED BIPHENYLS) - Highly stable organochlorine compounds used in numerous diverse products such as lubricants, electrical equipment, paints, and plasticizers. These compounds remain persistent in the environment, are bioaccumulated, and can cause detrimental effects at low concentrations.

PHOTOCHEMICAL OXIDANTS - Secondary gaseous pollutants created in the atmosphere from conversions and reactions of primary gaseous pollutants (such as sulfur oxides and nitrogen oxides). They include ozone (O_3) and peroxyacetyl nitrate (PAN).

RARE SPECIES - Populations and/or individuals of a species occurring in very low numbers relative to other similar taxa in the state, although common or regularly occurring throughout much of their range. They may occur in a restricted geographic region or occur sparsely over a wider area. Although rare, populations are apparently stable.

REVENUE REQUIREMENTS - The amount of money that must be recovered or generated in order to pay for the interest, depreciation, taxes, insurance, fuel costs, and all other variable expenses associated with the construction, operation, and maintenance of a project.

SECONDARY CONTACT RECREATION - Recreational endeavors such as fishing or boating that do not generally involve continual direct contact with the water such as swimming.

SOFTWOODS - General term for coniferous trees (gymnosperms).

SPECIAL CONCERN SPECIES - A species whose populations have been shown to be suffering a decline that could threaten the species in the area if allowed to continue unchecked, or a species that occurs in such small numbers or with such a restricted distribution or specialized habitat that it could easily become threatened.

THREATENED SPECIES - A species likely to become endangered in the future throughout all or most of its range (federally listed) or all of its range within the state (state-listed).

WARMWATER SPECIES - Fish assemblage characterized by sunfish and bass (as well as by those species considered trash fish, such as carp, most suckers, and bullheads). Warmwater species generally inhabit waters with temperature ranges within which trout and other coldwater species cannot maintain self-sustaining populations.

6. LIST OF PREPARERS

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APPENDIX A. ENVIRONMENTAL DATA

Table A.1. Summary of 1982 Agricultural Data for Counties Traversed by the Proposed Phase II of the New England/Hydro-Quebec Transmission Line Interconnection

	Massachusetts			New Hampshire			
Categories	Middlesex	Norfolk	Worcester	Grafton	Hillsborough	Merrimack	Rockingham
Total land area (hectares)[a]	21,278	103,532	391,980	445,342	226,970	242,394	18,1072
Farms and land in farms							
Farms (number)	567	205	1,014	397	396	385	427
Average size of farms (hectares)	29	26	53	92	55	67	41
Land in farms (hectares)	16,258	5,422	54,072	36,570	21,828	25,647	17,631
Proportion of counties in farms (percent)	7.6	5.2	13.8	8.2	9.6	10.6	9.7
Use of land in farms							
Total cropland (hectares)	8,005	2,155	23,298	11,766	7,423	8,034	6,652
Harvested cropland	6,269	1,411	17,154	8,811	5,948	6,005	4,929
Cropland, pasture only	1,333	605	4,636	2,695	1,037	1,408	1,266
Other cropland	403	139	1,508	259	439	622	457
Total woodland (hectares)	4,978	2,284	23,663	20,834	12,121	15,015	9,244
Woodland pastured	425	92	4,665	2,818	1,086	1,823	1,335
Woodland unpastured	4,552	2,192	18,998	18,016	11,035	13,192	7,910
Other land (hectares)	3,275	983	7,110	3,970	2,283	2,597	1,735
Pasture other than cropland and pastured woodland	739	231	2,697	2,300	461	1,414	544
House lots, roads, wasteland, etc	2,536	752	4,413	1,670	1,822	1,183	1,191
Market value of agricultural products sold							
Total Sales ($1000)	45,543	9,121	47,319	16,320	15,858	13,714	12,877
Average per farm (dollars)	80,324	44,494	46,666	41,108	40,045	35,621	30,157
Crops, including nursery and greenhouse products ($1000)	24,114	5,941	13,005	1,008	7,175	3,509	4,767
Major commodity groups ($1000)							
Hay, silage and field seeds	889	122	1,373	343	446	715	357
Vegetables, sweet corn, and mellons	3,158	361	2,171	80	1,329	137	NR[b]
Fruits, nuts, and berries	2,054	417	6,465	205	4,049	620	1,840
Nursery and greenhouse products	18,007	5,030	2,845	352	1,319	1,938	1,854
Livestock, poultry and products ($1000)	21,429	3,180	34,314	15,311	8,682	10,205	8,110
Major commodity groups ($1000)							
Poultry and poultry products	2,500	358	9,873	NR[b]	1,710	889	2,457
Dairy products	2,761	705	19,896	12,123	5,629	7,791	3,301
Cattle and calves	NR[b]	NR[b]	2,738	2,137	744	1,180	564
Hogs and pigs	1,133	151	1,215	40	299	121	128

[a] One hectare equals 2.47 acres.

[b] NR indicates not reported.

Sources: Bureau of the Census (1984a, 1984b).

Table A.2. Area by Land Classes and Forest Land Ownership for Counties Traversed by the Proposed Phase II of the New England/Hydro-Quebec Transmission Line Interconnection (thousands of hectares)[a]

			Forested Land			Public Ownership			Private Ownership	
States and Counties	Total Land in Counties	Nonforest Land Use	Total Forest Area	Commercial Timberland[b]	Noncommercial Timberland	Federal	State	County and Municipal	Farmers Owned	Other Private
Massachusetts[c]										
Middlesex	213.7	119.2(55.8)[d]	94.5(44.2)[d]	90.8(96.0)[e]	3.7(3.9)[e]	1.2	3.4	2.3(7.6)[f]	5.5	78.4(92.4)[f]
Norfolk	102.1	51.0(50.0)	51.1(50.0)	44.8(87.7)	6.3(12.3)	0.4	1.1	1.2(6.0)	2.6	39.4(93.7)
Worcester	391.9	123.0(31.4)	268.9(68.6)	259.3(96.4)	9.6(3.6)	0.0	20.0	3.5(9.1)	24.2	211.6(90.9)
Totals	707.7	293.2(41.4)	414.5(58.6)	394.9(95.3)	19.6(4.7)	1.6	24.5	7.0(8.4)	32.3	329.6(91.6)
New Hampshire[g]										
Grafton	448.5	46.5(10.4)	402.0(89.6)	360.3(89.6)	41.7(10.4)	95.9	5.4	1.3(28.5)	24.7	233.0(71.5)
Hillsborough	231.3	46.7(20.2)	184.6(79.8)	178.7(96.9)	5.9(3.2)	0.8	1.8	2.1(2.6)	7.6	166.5(97.4)
Merrimack	240.9	44.6(18.5)	196.4(81.5)	193.6(98.6)	2.8(1.4)	3.5	6.0	1.9(5.9)	8.7	173.5(94.1)
Rockingham	178.9	45.1(25.2)	133.8(74.8)	127.8(95.5)	6.0(4.5)	0.0	2.5	0.9(2.7)	5.8	118.5(97.3)
Totals	1099.6	182.9(16.6)	916.8(83.4)	860.4(93.8)	56.4(6.2)	100.2	15.7	6.2(14.2)	46.8	691.5(85.8)

[a] One hectare equals 2.47 acres.

[b] Forest land producing or capable of producing more than 20 cubic feet of industrial wood per acre per year.

[c] Source: Peters and Bowers (1977).

[d] Numbers in parenthesis indicate percentages of total land areas in respective counties and counties by states.

[e] Numbers in parenthesis indicate percentages of total forested land in respective counties and counties by states.

[f] Numbers in parenthesis indicate total public and total private holding as percentages of the commercial timberland in respective counties and counties by states.

[g] Source: Kingsley (1976).

Table A.3. Area of Commercial Forest Land, by Forest Types, for Counties Traversed by the Proposed Phase II of the New England/Hydro-Quebec Transmission Line Interconnection (hectares)[a]

	Counties in New Hampshire[b]				Counties in Massachusetts[c]		
Forest Types	Grafton	Merrimack	Hillsborough	Rockingham	Middlesex	Worcester	Norfolk
White pine/red pine/hemlock[d]	50,420(13.9)[e]	78,310(40.5)	75,190(42.1)	59,530(46.6)	17,730(19.5)	53,340(20.6)	7,280(16.3)
Spruce/fir[f]	79,770(22.1)	2,790(1.4)	2,830(1.8)	2,310(1.8)	240(0.2)	1,210(0.5)	160(0.4)
Pitch pine[g]	810(0.2)	2,390(1.2)	2,100(1.2)	1,620(1.3)	2,020(2.2)	7,120(2.7)	1,170(2.6)
Oak/pine[h]	3,800(1.1)	4,530(2.3)	3,970(2.2)	2,140(1.7)	7,530(8.3)	28,090(10.8)	3,800(8.5)
Oak/hickory[i]	12,670(3.5)	20,030(10.3)	19,220(10.8)	11,980(9.4)	23,590(26.0)	70,900(27.3)	11,940(26.7)
Elm/ash/red maple[j]	32,420(9.0)	48,080(24.8)	40,150(22.5)	27,400(21.4)	32,050(35.3)	81,020(31.2)	16,230(36.2)
Maple/beech/birch[k]	157,910(43.8)	28,850(14.9)	28,000(15.7)	17,400(13.6)	4,010(4.4)	10,200(3.9)	2,190(4.9)
Aspen/birch[l]	22,540(6.3)	8,580(4.4)	7,200(4.0)	5,420(4.2)	3,640(4.0)	7,450(2.9)	2,020(4.5)
Totals	360,340	193,560	178,660	127,800	90,810	259,330	44,790

[a] One hectare equals 2.47 acres.

[b] Source: Kingsley (1976).

[c] Source: Peters and Bowers (1977).

[d] Eastern white pine, red pine, or hemlock, singly or in combination, constitute a plurality of the stocking. Common associates: aspen, birch, and maple.

[e] Numbers in parenthesis indicate percentages of the totals for the respective columns.

[f] Spruce or balsam fir, singly or in combination, constitute a plurality of the stocking. Cedar swamps are also included in this type. Common associates: white cedar, tamarack, maple, birch, and hemlock.

[g] Pitch pine constitutes a plurality of the stocking. Common associates: oaks (in Massachusetts, a pitch pine/eastern red cedar type).

[h] Hardwoods (usually red or black oaks) constitute a plurality of the stocking, but in which pines constitute 25% to 30% of the stocking.

[i] Oaks or hickory, singly or in combination, constitute a plurality of the stocking unless pines constitute 25% to 50% of the stocking, in which case the type is oak/pine. Hickory is seldom present in New Hampshire. Common associates: elm and maples.

[j] Elm, ash, or red maple, singly or in combination, constitute a plurality of the stocking. Common associates: beech, eastern white pine, basswood and sugar maple.

[k] Sugar maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. Common associates: hemlock, elm, basswood, eastern white pine, white or sweet birch, and red maple.

[l] Aspen, balsam poplar, paper or gray birch, singly or in combination constitute a plurality of the stocking. Common associates: red maple and balsam fir.

Table A.4. Summary of Selected Streamflow Records for Watersheds Along the Proposed Transmission Line Route

River	Location	Record (Years)	Drainage Area (km^2)[a]	Discharge (m^3/s)[a]		
				Average	Maximum	Minimum
Connecticut	Dalton, NH	56	3,920	82.3	1,370	3.26
Ammonoosuc	Bethlehem Junction, NH	44	227	5.9	306	0.5
Smith	Bristol, NH	65	222	4	229	0.08
Contoocook	West Hopkinton, NH	20	1,110	19.8	187	0.43
Piscataquog	East Weare, NH	20	164	2.7	43.3	0.01
Blackwater	Goffs Fall below Webster, NH	58	334	6.0	311	0.22
Merrimack	Manchester, NH	47	8,010	149	2,900	2.78
Nashua	East Pepperell, MA	48	1,120	16.1	592	0.03
North Nashua	Leominster, MA	48	285	5.5	462	0.3
Concord	Lowell, MA	47	1,050	17.8	153	0.11
Charles	Waltham, MA	52	588	8.5	117	<0.01
Charles	Dover, MA	46	477	8.6	91	0.01
Blackstone	Northbridge, MA	38	360	7.5	479	<0.01

[a] $m^3/s \times 35.32 = cfs$; $km^2 \times 0.386 = mi^2$.

Sources: Geological Survey (1984, 1985).

Table A.5. Major Forest Types in the Phase II Study Area

Forest Type	Predominant Species	Associated Species
White and red pine	White pine, hemlock, red pine	Red maple, red oak, quaking aspen, bigtooth aspen, sugar maple, red spruce, yellow birch, white oak, black cherry, balsam fir
Oak/hickory	Oaks (red, chestnut, white, black, scarlet)	Black cherry, sugar maple, red maple, beech, white ash, white pine, black birch, white birch, hickory (shagbark, pignut, mockernut)
Elm/ash/maple	American elm, black ash, red maple	Beech, white pine, sugar maple, basswood
Maple/beech/birch	Sugar maple, beech, yellow birch	Hemlock, American elm, basswood, white pine, white birch, red maple
Spruce/fir	Red spruce, balsam fir, northern white cedar, white spruce, black spruce	Yellow birch, white pine, hemlock, red maple, quaking aspen, paper birch, tamarack
Aspen/birch	Quaking aspen, bigtooth aspen, balsam poplar, paper birch, gray birch	Pin cherry
Oak/pine	Red oak, black oak	White pine, red pine
Pitch pine	Pitch pine	Oaks

Sources: Kingsley (1976, 1977); Jorgensen (1978); U.S. Department of Energy (1984); ER, Vols. 2 and 3.

Table A.6. 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).

Table A.7. Life History Aspects of the Major Salmonids in the Vicinity of the Proposed Route

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°[a] reaches 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 (71.6-73.4°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).

[a] T° = temperature.

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

Table A.8. Rare Plants in the Study Area for the Proposed Phase II Transmission Line

Species	Location	Status[a]	Habitat
Dwarf ragwort (*Senecio pauperculus*)	Monroe, NH	R	Calcareous ledges, gravels
Small drop-seed (*Sporobolus neglectus*)	Monroe, NH	R	Calcareous soils, especially limy ledges and pastures
Sticky false asphodel (*Tofielda glutinosa*)	Monroe, NH	R	Calcareous marshes, damp ledges and shores
Grass-of-parnassus (*Parnassia glauca*)	Monroe, NH	R	Riverbanks, wet calcareous soils
Spurred gentian (*Halenia deflexa*)	Monroe, NH	R	Moist, cool woods
Golden-fruited sedge (*Carex aurea*)	Monroe, NH	R	Meadows, wet banks
Garer's sedge (*Cypripedium reginae*)	Monroe, NH	R	Bogs, swamps, wet meadows, and rich moist woods
Showy lady's slipper (*Cypripedium reginae*)	Monroe, NH	R	Swamps, wet meadows, rich moist woods, calcareous soils
Variegated horsetail (*Equisetum variegatum*)	Monroe, NH	R	Riverbanks, calcareous shores
Wide-leaved lady's tresses (*Spiranthes lucida*)	Monroe, NH	R	Alluvial shores and slopes, rich damp meadows and thickets
Hairy bedstraw (*Galium pilosum*)	Hudson, NH	R	Dry woods
Climbing fern (*Lygodium palmatum*)	Ayer, MA	T	Semi-open edge of woods and streams, damp woods

[a] R = rare; T = threatened.

Sources: Dowhan and Craig (1976); Coddington and Field (1978); Storks and Crow (1978); Brackley and Hentcy (1985); Sorrie (1985); ER, Vols. 2 and 3.

Table A.9. Endangered and Threatened Fish and Wildlife in the Study Area for the Proposed Phase II Transmission Line

Species	Status[a]	Habitat
Fish		
Shortnose sturgeon (*Acipenser brevirostrum*)	E (F, MA, NH)	Lower reach of Merrimack River
American brook lamprey (*Lamptera appendix*)	T (MA)	Tributary to Blackstone River
Birds		
Bald eagle (*Haliaeetus leucocephalus*)	E (F, MA, NH)	Near oceans, rivers, lakes
Peregrine falcon (*Falco peregrinus*)	E (F, MA, NH)	Coasts, mountains, woods
Osprey (*Pandion haliaetus*)	T (NH)	Seacoasts, lakes, rivers
Northern harrier (*Circus cyaneus*)	T (MA, NH)	Grasslands, marshes
Red-shouldered hawk (*Buteo lineatus*)	T (NH)	Fields, wetlands
Cooper's hawk (*Accipiter cooperii*)	T (NH)	Open woodlands, wood margins
Common loon (*Gavia immer*)	T (NH)	Lakes, rivers
Pied-billed grebe (*Podilymbus podiceps*)	T (MA)	Shallow waterbodies
Least bittern (*Ixobrychus exilis*)	T (MA)	Marshes
King rail (*Rallus elegans*)	T (MA)	Marshes
Upland sandpiper (*Bartramia longicauda*)	E (MA), T (NH)	Low, grassy areas
Short-eared owl (*Asio flammeus*)	E (MA)	Open habitats
Whip-poor-will (*Caprimulgus vociferus*)	T (NH)	Woods near fields
Purple martin (*Progne subis*)	T (NH)	Multicelled nesting boxes or gourds in cities and farmyards
Sedge wren (*Cistothorus plantensis*)	E (MA)	Sedge meadows
Golden-winged warbler (*Vermivora chrysoptera*)	T (MA)	Gray birch woods, shrublands
Eastern bluebird (*Sialia sialis*)	T (NH)	Roadsides, farmyards, abandoned orchards

Table A.9. Continued

Species	Status[a]	Habitat
Amphibians and Reptiles		
Marbled salamander (Ambystoma opacum)	T (MA)	Varies from moist, sandy areas to dry hillsides
Eastern spade foot (Scaphiopus holbrookii)	T (MA)	Forests with loose or sandy soil
Blanding's turtle (Emydoidea blandingii)	T (MA)	Marshes, bogs, lakes, small streams
Timber rattlesnake (Crotalus horridus)	E (MA)	Timbered terrain, especially second-growth
Northern copperhead (Agkistrodon contortrix)	E (MA)	Rocky, wooded hillsides and mountainous areas

[a] E = endangered; T = threatened; F = federally listed; MA = Massachusetts-listed; NH = New Hampshire-listed; underlined state is state within study area where species is reported.

Sources: Blodget (1983); Buckley (1984); Cardoza and Mirick (1979); Conant (1975); Massachusetts Natural Heritage Program (1985); Robbins et al. (1983); Smith and Coate (1985).

Table A.10. Population Trends and Projections for Towns in the Study Area

Towns	1960	1970	1980	% Change: 1970-1980	Projected: 1990
New Hampshire					
Grafton County					
Monroe	421	385	619	60.8	768
Lyman	201	213	281	31.9	313
Bath	604	607	761	25.4	839
Haverhill	3,127	3,090	3,445	11.5	3,600
Benton	172	194	333	71.6	402
Warren	548	539	650	20.6	725
Wentworth	300	376	527	40.2	598
Rumney	820	870	1,212	39.3	1,402
Groton	99	120	255	112.5	317
Hebron	153	234	349	49.1	427
Alexandria	370	466	706	51.5	877
Merrimack County					
Hill	396	450	736	63.6	970
Andover	955	1,138	1,587	39.5	2,019
Salisbury	415	589	781	32.6	1,000
Webster	457	680	1,095	61.0	1,424
Boscawen	2,181	3,162	3,435	8.6	3,496
Concord City	28,991	30,022	30,400	1.3	32,170
Hopkinton	2,225	3,007	3,861	28.4	4,713
Bow	1,340	2,479	4,015	62.0	5,246
Dunbarton	632	825	1,174	42.3	1,529
Hillsborough County					
Goffstown	7,230	9,284	11,315	21.9	13,366
Bedford	3,636	5,859	9,481	61.8	11,803
Merrimack	2,989	8,595	15,406	79.2	17,023
Litchfield	721	1,420	4,150	192.3	5,166
Hudson	5,876	10,638	14,022	31.8	17,341
Pelham	2,605	5,408	8,090	49.6	9,230

Table A.10. Continued

	1960	1970	1980	% Change: 1970-1980	Projected: 1990
Rockingham County					
Londonderry	2,457	5,346	13,598	154.4	16,648
Windham	1,317	3,008	5,664	88.3	-[a]
Massachusetts					
Middlesex County					
Tyngsborough	3,302	4,204	5,683	35.2	7,400
Dunstable	824	1,292	1,671	29.3	2,080
Groton	3,904	5,109	6,154	20.5	6,780
Ayer	14,927	8,325	6,993	-16.0	6,840
Shirley	5,202	4,909	5,124	4.4	5,020
Worcester County					
Lancaster	3,958	6,095	6,334	3.9	6,940
Sterling	3,193	4,247	5,440	28.1	6,190
West Boylston	5,526	6,369	6,204	-2.6	6,300
Boylston	2,367	2,734	3,476	26.9	4,030
Shrewsbury	16,622	19,196	22,674	18.1	25,000
Grafton	10,627	11,659	11,238	-3.6	12,210
Millbury	9,623	11,987	11,808	-1.5	12,220
Sutton	3,638	4,590	5,855	27.6	6,700
Upton	3,127	3,484	3,886	11.5	4,160
Milford	15,749	19,352	23,390	20.9	25,230
Norfolk County					
Medway	5,168	7,983	8,447	5.8	9,160

[a] Data missing.

Sources: Bureau of the Census (1962a, 1962b, 1973a, 1973b, 1981a, 1981b).

Table A.11. Landscape Quality Matrix

	Distinctive	Noteworthy	Common
Landform	Drumlins, hills and ridges or other noted geological features providing distant views; high relative relief greater than 200 feet; steep slopes; sharp exposed bedrock outcrops.	Low rounded hills and gently rolling terrain; relative relief 100-200 feet.	Nearly flat to gentle sloping terrain; relative relief less than 100 feet.
Water elements	Major river courses, cascades or falls, large placid lakes or reservoirs; shoreline development absent or sympathetic to water element.	Secondary rivers and meandering streams, moderate-size lakes, ponds, and impoundments; low-density development.	Narrow, slow-moving or intermittent streams and creeks, small farm ponds and similar minor water features; high density shoreline development.
Vegetation	Stands of dense forest, seen as masses of varying color and texture; mosaic of natural and pastoral vegetation; stands of old timber growth greater than 60 feet in height.	Mixed stands of forest and secondary growth seen as interspersed vegetation pattern; some timber greater than 60 feet in height.	Stands of scrubland or unbroken woodland; separated by agricultural or urban land uses; secondary growth common; most timber under 60 feet in height.
Man-made modifications	Designated historic districts, scenic areas or scenic rivers and public park and recreation areas; areas where man's impression is sympathetic to the landscape; farmsteads; little contemporary development.	Moderate-size communities supporting some business, light industry and commercial development occurring in a semi-rural setting; some historic buildings or districts; occasional elements such as quarries, utility lines, junkyards, landfills, and tank farms, but inconspicuous such that visual integrity is not lost.	Large areas of urbanization, industrialization, suburban sprawl or highway strip development dominating the landscape; major "eyesores" that destroy visual integrity.

Source: ER, Vol. 7--Table III-5.

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APPENDIX B. FLOODPLAIN/WETLAND ASSESSMENT FOR THE PROPOSED ROUTE

APPENDIX B. FLOODPLAIN/WETLAND ASSESSMENT FOR THE PROPOSED ROUTE

B.1 PROJECT PURPOSE AND DESCRIPTION

The New England Power Pool (NEPOOL), in cooperation with Hydro-Quebec, proposes to purchase an additional 70 TWh (million MWh) of energy over a 10-year period currently scheduled to begin in 1990. This is in addition to the 33 TWh of surplus hydroelectric energy that NEPOOL member utilities formally agreed to purchase in 1983 from Hydro-Quebec (Phase I). The additional power purchase would necessitate the construction of new facilities to transmit the energy to load centers in central New England.

The proposed project involves extension of the ±450-kV, high-voltage, direct-current (DC) transmission line from the Town of Monroe, New Hampshire (site of the Comerford converter terminal for Phase I) to the town of Groton, Massachusetts. The DC line would terminate at a 1800-MW DC/AC converter terminal to be constructed at the town line of Groton and Ayer, Massachusetts, adjacent to an existing 345-kV AC substation. Additionally, two linearly connected 345-kV AC transmission lines would be constructed adjacent to existing transmission lines in Massachusetts. These lines would originate at the proposed converter terminal and terminate at a 345-kV AC substation at West Medway, Massachusetts. Associated with the proposed project would be an expansion of the ground electrode system in Lisbon, New Hampshire, and AC transmission system relocations between Sandy Pond and Millbury substations in Massachusetts. The proposed route would involve construction of 298 km (185 mi) of transmission lines in New Hampshire and Massachusetts.

B.2 FLOODPLAIN/WETLAND EFFECTS

It is DOE's policy to avoid adverse impacts on floodplains and wetlands to the extent possible (10 CFR 1022). To this end, 10 CFR 1022 provides for compliance with Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands).

The proposed converter terminal would be located in an upland site that is not in a floodplain and does not contain wetland areas (ER, Vol. 1). Therefore, only the transmission lines are of potential concern relative to floodplain/wetland effects. From the Comerford converter terminal to the West Medway substation, the proposed route would traverse the following watershed basins: Connecticut River (New Hampshire), Merrimack River (New Hampshire and Massachusetts), Blackstone River (Massachusetts), and the Charles River (Massachusetts) (see Figures 2.2 through 2.4). Portions of the proposed route consist of forested and unforested wetlands and floodplains (ER, Vol. 7--Figures III-1.1 through III-1.12, Vol. 8--Figures III-1.1 through III-1.22). Locations of wetland along the route were determined from U.S. Fish and Wildlife draft wetland inventory maps (where available), aerial photos, right-of-way maps, and field surveys (ER, Vols. 7 and 8). Floodplains were determined from Flood Insurance Rate Maps or Flood Hazard Boundary Maps (Flood Insurance Agency 1976, 1979; Federal Emergency Management Agency 1982).

B.2.1 Wetlands

The New Hampshire portion of the proposed route would cross (span) 98 wetlands over a total linear distance of about 12.4 km (7.7 mi) (ER, Vol. 8--Table III-1). The Massachusetts portion of the route would cross 119 wetlands over a total linear distance of about 17.8 km (11.1 mi) (ER, Vol. 7--Table III-1).

The wetlands in the vicinity of the proposed route are dominated by emergent vegetation, scrub/shrub vegetation, and forested vegetation. Wetlands dominated by emergent vegetation (e.g., marshes, wet meadows, and ponds) are basically wet grasslands containing plant species adapted to submerged soils (Darnell 1976). These habitats usually contain zoned gradations of plant species as follows (from shallow to deeper water): (1) emergent plants (e.g., reeds, cattails, bulrushes, 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). Based on acreage of wetland types along the proposed route, about 32% of the wetlands contain predominantly emergent vegetation (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

The emergent and pond wetlands contain a diverse and productive fauna, including various species of aquatic and terrestrial invertebrates, fishes, amphibians, and reptiles. The wetlands provide important nesting, brooding, feeding, migratory stopover, and overwintering habitat for waterfowl and shorebirds (Darnell 1976). They also provide habitat for such mammals as muskrat, short-tailed shrew, star-nosed mole, eastern cottontail rabbit, beaver, meadow vole, and red fox (Godin 1977).

Scrub/shrub wetlands or swamps 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 include alder, willow, blueberry, sumac, winterberry, steeplebrush, sweet pepperbush, buttonbush, red osier dogwood, spirea, bog rosemary, bog laurel, leatherleaf, and young trees of such species as red maple and black spruce. Sensitive fern and sedges are predominant herbaceous species (Cowardin et al. 1979; ER, Vols. 7 and 8). About 12% (by area) of the wetlands along the proposed route contain a predominant scrub/shrub vegetation community. About 51% of the wetlands contain a combination of emergent and scrub/shrub wetlands (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

The forested wetlands or swamps are dominated by living or dead trees that are at least 6 m (20 ft) tall. Along the proposed route, forested wetlands are typically dominated by red maple, with black ash and gray birch also present. Coniferous species, which are less common, include larch, black spruce, Atlantic white cedar, and white pine (ER, Vols. 7 and 8). Shrub and herbaceous layers are dominated by the species common in the scrub/shrub wetlands. The presence of forested wetlands dominated by dead trees results from construction of man-made impoundments and beaver ponds, fire, pollution, or insect infestation (e.g., spruce budworm outbreaks) (Cowardin et al. 1979). Only about 5% of the wetlands along the proposed route contain a forested component (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

Animal life in scrub/shrubland and forested wetlands is similar to that for marshy wetlands, but includes a more diverse bird and mammal species assemblage because of the increased habitat and food resources provided by understory and canopy vegetation. Waterfowl and shorebirds found in the marshy wetlands also frequent swampy wetlands; also present are such species as arboreal songbirds, birds of prey, and woodpeckers. Large mammals, such as white-tailed deer, occur in swampy wetlands, as do many smaller mammals such as mice, voles, squirrels, shrews, weasels, otters, lemmings, and bats (Godin 1977).

Wetland habitat can be impacted by clearing of vegetation, construction and improvement of access roads, use of heavy machinery, and installation of structures. The potential effects resulting from these activities include minor 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 adjacent to wetlands (Boelter and Clare 1974). While emplacement of tower bases would result in the loss of some wetland habitat, they might prove to be preferred habitat for nesting waterfowl and calving deer (Thorsell 1976). Because the area of wetlands impacted by the project would be small relative to the total wetland area occurring in the vicinity of the Massachusetts/New Hampshire sites, the overall impacts to wetland habitat would not be of sufficient magnitude to cause localized extinction of any species. Additionally, the habitat that would be affected is not unique to the area. Impacts to wetland habitat would also be minimal because the majority of wetlands would be spanned, and construction activities (e.g., structure placement) would be minimized within these wetland areas.

In a previous project, no vegetative changes related to construction were observed in a cattail marsh in Massachusetts through which a 345-kV transmission line was routed (Thibodeau and Nickerson 1984). Construction was carried out in winter, and equipment was driven across the frozen marsh without any observed alterations to the substrate (e.g., swamp mats). Bog vegetation was found to recover naturally within four growing seasons from the effects of transmission line construction and maintenance (Nickerson and Thibodeau 1984). Thus, relative effects of construction would depend upon the season and/or type of wetland, as well as upon construction methods and mitigative measures employed.

Some minor adverse impacts to wetland wildlife, especially waterfowl, could result from vegetation clearing and management, including herbicide use, within and adjacent to wetlands. Clearing operations could reduce mast used by black duck, wood duck, and green-winged teal; remove some cover for ground-nesting waterfowl; and eliminate mature trees with cavities used for nesting by wood ducks and mergansers. However, some beneficial impacts could result from increased shrub cover and increased nesting cavities in wind-damaged trees (U.S. Department of Energy 1978).

Wetlands would be spanned where possible, with support structures placed outside the wetlands. However, locating some structures within wetlands would be unavoidable. A total of 88 wetlands would be affected by new structure placement, existing structure removal, and/or forest clearing. This includes 33 wetlands in New Hampshire (ER, Vol. 8--Table III-6) and 55 wetlands in Massachusetts (ER, Vol. 7--Table III-6). Construction or improvements to access roads would be needed for placement of new structures. Of the 214.9 ha (531.1 acres) of wetlands within the Phase II rights-of-way, only 10.6 ha (26.1 acres) would require clearing of forest vegetation. Wetlands in these areas would be modified to scrub/shrub or emergent wetlands. These modified wetlands would be maintained, if necessary, by the application of herbicides according to company policy (see Tables B.1 and 4.7). During construction, up to 39.3 ha (97 acres) of wetlands would be disturbed by vehicle traffic and other short-term activities related to structure modification and access road construction. This disturbance would recover within a few growing seasons. New structures and access roads would cause the long-term loss, at most, of 7.7 ha (19 acres) of wetlands--3.2 ha (8 acres) in Massachusetts (ER, Vol. 7--Table III-7) and 4.5 ha (11 acres) in New Hampshire (ER, Vol. 8--Table III-7). It is not expected that placement of new structures or access roads would significantly impound or otherwise alter any of the wetlands.

Following construction, impacts to wetlands could result from maintenance of access roads, increased public access, and periodic maintenance of the line or underlying right-of-way vegetation; however, such impacts would be minimal. Reduction of habitat use by waterfowl directly under transmission lines has been noted in similar situations, but this effect quickly diminishes away from the transmission line (Willdan Associates 1982).

B.2.2 Floodplains

A total of 105 floodplains would be crossed along the proposed route. It is estimated that project-related structures would be placed on 55 of these floodplains, including 38 structures to be placed in 21 floodplains in New Hampshire (ER, Vol. 8--Table III-8) and 79 structures to be placed in 34 floodplains in Massachusetts (ER, Vol. 7--Table III-8). Thirty-three of the structures would be placed within 20 of the wetlands that occur in the 100-year floodplains (ER, Vol. 7--Table III-6, Vol. 8--Table III-6). Concern about floodplain effects primarily relates to displacement of floodplain storage volume by structures, foundation pads, and access roads. Loss of flood storage volume associated with the structures and associated access roads is estimated at 9,900 m^3 (8 acre-ft)--2,500 m^3 (2 acre-ft) in upland areas and 7,400 m^3 (6 acre-ft) in the wetland areas (ER, Vols. 7 and 8).

This is a very insignificant portion of the total floodplain volume considering that the floodplain for a given waterbody could extend up to several hundred meters from the bank and several kilometers beyond the area of the proposed transmission line. No significant impoundment, obstruction, or other modification of flood waters would result. Other impacts to floodplain habitat and biota would be somewhat similar to those discussed for wetlands.

B.3 MITIGATIVE MEASURES

In addition to avoidance of floodplains and wetlands when possible, proper construction and maintenance procedures would be used to minimize potential impacts. Additionally, numerous mitigative measures would be

Table B.1. Limitations on Herbicide Application

Sensitive Site Description	Application Limitation Establishing Protective Buffer (in feet)
New Hampshire	
Wells[a]	
Public--Gravel Packed	400
Other	250
Private	50
Tributaries or Shorelines of Public Reservoirs[b]	
Krenite	50
Other herbicides	100
Streams, Brooks, Ponds, Lakes	
Foliar and basal treatments	10
Cut stump treatments	None
Crops[c]	
Foliar treatment	50
Cut stump and basal treatments	None
Pastures (all treatments)[c]	
In use	25
Not in use	None
Gardens	
Foliar treatment	25
Cut stump and basal treatments	None
Residences	
Foliar treatment	25
Cut stump and basal treatments	None
Water within wetlands	
Within public water supply watershed	
Krenite	50
Other herbicides	400
Not within public water supply watershed	
Foliar and basal treatments	10
Cut stump treatments	None
Massachusetts	
Wells[d]	
Public--Gravel Packed	
Krenite	50
Other herbicides	400
--Tubular	
Krenite	50
Other herbicides	250
Private	
Krenite	50
Other herbicides	100

Table B.1. Continued

Sensitive Site Description	Application Limitation Establishing Protective Buffer (in feet)
Tributary or Shoreline of a Public Reservoir[d]	
Krenite	50
Other herbicides	400
Streams, Brooks, Ponds, Lakes	
Foliar and basal treatments	10
Cut stump treatments	None
Crops	
Foliar treatment[d]	50
Basal and cut stump treatments	None
Pastures (all treatments)	
In use	25
Not in use	None
Gardens	
Foliar treatment[d]	50
Basal and cut stump treatments	None
Residences	
Foliar treatment[d]	50
Basal and cut stump treatments	None
Water within wetlands	
Within public water supply watershed	
Krenite	50
Other herbicides	400
Not within public water supply watershed	
Foliar and basal treatments	10
Cut stump treatment	None

[a] The 250-ft and 400-ft application limitations around public wells are established by the New Hampshire Pesticide Control Board. N.H. Ad. Rules, Pes 502.10. All other application limitations are set by internal company policies.

[b] New Hampshire regulations prohibit herbicide drift or flow into public water supplies. N.H. Ad. Rules, Pes 502.03.

[c] The New Hampshire Pesticide Control Board's regulations require that herbicide applications do not contaminate crops or pasture. N.H. Ad. Rules, Pes 502.04.

[d] As established by the Department of Food and Agriculture's "Interim Guidelines Relative to the Use of Herbicides to Control Woody Vegetation on Railroad Layouts and Rights-of-Way in Massachusetts." All other application limitations are set by internal company policies.

Source: Supplemental response from Vern R. Walker to Anthony Como (DOE, ERA), dated 9 October 1985.

implemented to further reduce the risk of significant adverse environmental consequences. These measures include the following:

- *Prior to construction, each wetland would be reviewed in order to determine location of structures and foundation types to be used and for best method of access.*

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

- *All work in wetlands would be conducted in accordance with conditions of the Corps of Engineers General Permit, as well as those of applicable state and local regulations.*

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

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

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

- *Transmission line structures would not be placed on steep, highly erodible slopes and would be placed to avoid wetlands and floodplains wherever possible.*

- *Erosion- and sedimentation-control procedures would be implemented.*

- *Special equipment or practices would be used in wetland terrain to minimize damage to vegetation and soil.*

- *Excavated material not used for backfill would be moved to upland areas for disposal.*

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

- *Construction adjacent to wetlands would be carried out so as to minimize potential changes to existing water regimes.*

- *Road surfaces would be constructed to promote natural drainage.*

- *Properly sized culverts and breaks would be installed to allow free passage of water and would be routinely inspected and maintained to ensure that surface drainage and water tables remain unaffected.*

- *Only clean fill would be used for structure pads and access roads.*

- *Structure pads and access road height would be limited to approximately 0.3 m (1 ft) above wetland surfaces.*

- *In some areas, fill roads would be breached after construction to minimize changes in preconstruction water levels.*

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

- *Work areas would be cleaned up and restored to ensure revegetation and the maintenance of surface drainage.*

- *An integrated vegetation management system would be utilized. Undesirable vegetation near streams would not be treated by the foliar herbicide application method; however, once manually cut, stumps may be treated with herbicide. Vegetation growing in standing water in wetlands would not be treated with herbicides but, rather, would be manually cut or treated at a later date when the area is dry.*

- *Synthetic filter fabric-based roads could be used in deep wetlands to minimize fill required for access roads.*

- *If construction of permanent gravel access roads is not feasible, optional means of access in place of access roads may be utilized, such as swamp mats or all-terrain vehicles. Off-right-of-way access, if available, may also be utilized to best satisfy environmental objectives. These means could also be utilized for routine inspection and maintenance of structures in the absence of permanent access roads.*

Other specific mitigative measures are listed in Section 4.1.10.

B.4 ALTERNATIVES

Alternatives to the proposed action are essentially limited to those described in Section 2.2 (i.e., alternative routes, an underground transmission system, no action, and alternative generating facilities). For reasons stated in Section 2.2, the only viable alternatives to the proposed project are the alternative routes or underground design. Economic considerations have an important influence on the choice of the proposed project route design (i.e., overhead system) over the alternative routes and design (i.e., underground system).

The economic considerations are largely linked with environmental impacts that would ensue from the alternatives. For example, the increased costs of an underground system are partly related to increased clearing and trenching. Obviously, trenching through all the wetlands within the Phase II rights-of-way (accompanied by increased access road needs) would have a greater impact than that associated with structure placements and access requirements for the proposed design. As stated in Section 4.2.2.4, a greater expanse of wetlands would be crossed by the proposed route than by either the eastern or western alternative route. (See Figures 2.5 through 2.10 for major basins crossed by alternative routes.) However, it is uncertain as to whether this would equate to equivalently less structure and access road requirements in the wetlands. Also, the Staff believes that the much increased environmental costs that would occur from forest clearing (and potential erosion) for the alternative routes (see Section 4.2.2.4) offsets the minor differences in wetland effects among alternatives.

B.5 REFERENCES FOR APPENDIX B

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APPENDIX C. EXCERPTS FROM CULTURAL RESOURCES SURVEY
STATUS REPORTS 1, 2 & 3*

*The following pages are based on the documents "Cultural Resources Survey Status Report No. 1," filed on January 3, 1986; "Cultural Resources Surveys Status Report No. 2," filed on April 1, 1986; and "Cultural Resources Surveys Status Report No. 3," filed July 1, 1986, with the U.S. Department of Energy, Economic Regulatory Administration. All were filed as parts of Docket No. PP-76A by New England Power Company. The contents of this appendix consist of the main text of those reports; attachments have not been included.

CULTURAL RESOURCES SURVEY

STATUS REPORT NO. 1

I. INTRODUCTION

This report is being submitted to the Department of Energy in connection with the pending application for amendment of Presidential Permit PP-76 in Docket No. PP-76A. This report is the first report on the status of the cultural resources surveys which are being conducted in connection with the proposed New England/Hydro-Quebec Phase II Project. (For a detailed description of the proposed transmission facilities, see Volumes 1, 2, and 3 of the Applicant's Environmental Report.) Subsequent status reports will be filed on a quarterly basis.

Two cultural resources surveys are currently in progress in connection with the proposed New England/Hydro-Quebec Phase II Project. The first focuses on archaeological resources; the second focuses on architectural/historical resources.

The purposes of this first status report are threefold. First, this report describes the process by which a Cultural Resources Plan and a Research Design for the cultural resources surveys were developed. Second, this report summarizes the principal elements of those surveys. Third, this report describes the progress of the surveys through the end of 1985. The results reported herein pertain solely to the corridors which would be utilized by the proposed transmission lines and do not include survey results for the Tewksbury alternate route.

II. DEVELOPMENT OF CULTURAL RESOURCES PLAN AND RESEARCH DESIGN

A. Cultural Resources Plan

Early in 1985, New England Power Company (the Company) developed a Cultural Resources Plan (the Plan) to serve as a basis for the required cultural surveys. The Plan was predicated upon compliance with Section 106 of the National Historic Preservation Act (16 U.S.C. Sec. 470 et seq.) and the implementing regulations (36 CFR Part 800).

Section 106 requires, in part, that the head of any Federal agency having authority to license any undertaking shall, prior to the issuance of any license, "take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register [of Historic Places]".

Among other things, 36 CFR Part 800 requires consultation with State Historic Preservation Officers (SHPO's) to:

a. identify National Register of Historic Places' properties or properties that may be eligible for the Register which may be affected by the proposed undertaking; and

b. determine for each Register or eligible property whether the proposed undertaking would have no effect, no adverse effect or an adverse effect on those properties.

The Company determined that for this undertaking (i.e., a transmission line project) archaeological and architectural/ historical surveys would be necessary to satisfy regulatory requirements; other types of surveys (e.g., ethnography) would not be needed. The remainder of this section describes the Company's Cultural Resources Plan and the approval of that plan.

The Plan called for the Company to retain SHPO-approved consultants. The consultants were in turn to perform various activities leading to a final report. These activities included development of a Research Design, the completion of background research, and the completion of a field survey. With respect to archeological resources, the purpose of the field survey was to identify likely locations for cultural materials on the rights-of-way (ROW). With respect to architectural/historical resources, the purpose of the field survey was to identify National Register properties or eligible properties generally within 1/4 mile of the center line of the ROW.

Additional tasks to be performed by the consultants, according to the Plan, included determination of impacts that could affect eligibility on National Register and eligible properties. If necessary, proposed mitigative measures would then be developed. The final activity required of the consultants will be the submittal of a final report to the Company.

The Plan also calls for the Company to submit the final report to the SHPO's including any proposed mitigative measures. The SHPO's, in consultation with the Company, will then determine the effects of the proposed undertaking on National Register and eligible properties based upon the Advisory Council on Historic Preservation (the ACHP) criteria of effect and adverse effect (36 CFR Section 800.3). The final step in the Plan calls for the SHPO's to report their findings to the Department of Energy and, if necessary, the ACHP.

On March 27, 1985, the Company presented the Plan to the Director of the New Hampshire State Historic Preservation Office (NHSHPO) and to the New Hampshire State Archaeologist. On April 1, 1985, a similar presentation was made to the Deputy State Historic Preservation Officer of the Massachusetts Historical Commission (MHC) and to the Massachusetts State Archaeologist. At each of these presentations, recommendations for modifications to the scope of the cultural resources surveys were solicited. The only recommendation made for modification was that if a historic district was near the right-of-way, but outside of the one quarter-mile parameter, possible effects upon the district should be assessed. At each meeting, no other disciplines were recommended for inclusion in the surveys. The Company obtained lists of experienced consultants from the agencies so that the Company's Request for Proposal (RFP) would be issued only to qualified parties.

B. Selection of Consultants

On April 29, 1985, the Company issued its RFP for "a comprehensive cultural resources identification and assessment survey." The RFP was based upon the Plan and was sent to 33 consultants. The RFP stated that proposals would be accepted for either discipline (archaeological or architectural/historical or both) and for either State (New Hampshire or Massachusetts or both).

A total of seven responses to the RFP were received. On May 30, 1985, the Company selected the Office of Public Archaeology (OPA), Boston University, to conduct all of the required surveys. This decision was based upon OPA's archaeological experience in linear surveys, their very high level of expertise in each of the archaeological and architectural/historical disciplines for the regions to be traversed by the proposed project and the quality of their understanding of the project's requirements as shown by their proposal.

C. Research Design

On July 1, 1985, OPA submitted to the Company its Research Design, which explained how OPA would accomplish the required surveys in conformance with the Plan. (See Attachment A). The Company submitted the Research Design to the NHSHPO and the MHC for their determination as to whether the proposed cultural resources surveys would be in compliance with 36 CFR Part 800. Letters of approval without any recommendations for changes or additional areas of study were issued by the MHC on September 9, 1985 and by the NHSHPO on October 30, 1985. (See Attachments B and C.)

III. CULTURAL RESOURCES SURVEYS

A. Archaeology

1. Background Research

The initial phase of the archaeological survey was background research for the development of a prehistoric and historical overview of the study area. This research provided a contextual framework for the evaluation of archaeological sites identified within the project area. Sources for this research included NHSHPO and MHC files, planning commissions, historical societies, other archaeologists, as well as other knowledgeable individuals. This analysis has been completed.

2. Walk-Over Reconnaissance Survey

The initial archaeological field work was a walk-over reconnaissance survey to determine areas of potential archaeological sensitivity for future testing. In accordance with the Plan and the Research Design, OPA conducted a 100% pedestrian survey of the entire proposed corridor from the Phase I Converter Terminal site in Monroe, New Hampshire to Medway, Massachusetts, including the proposed Converter Terminal site in Ayer and Groton, Massachusetts. The pedestrian surveys began in August, 1985 and were completed in September, 1985.

Recommendations for areas to be tested were based upon degree of slope, soil types, relationships to wetlands and water bodies, elevations, surface samples and other topographical features. In New Hampshire, a total of 105 areas (approximately 132,000 linear feet) were proposed for the following testing phase. In Massachusetts, a total of 113 areas (approximately 80,000 linear feet) were recommended for further testing.*

3. Intensive Archaeological Testing

The next phase of the archaeological survey, the so-called "intensive archaeological testing" phase, was designed to test those potentially sensitive areas recommended for further testing as a result of the walk-over reconnaissance survey in order to identify the presence or absence of archaeological sites on the ROW. The initial activity in this phase was determination by Company engineers of the approximate location of transmission structures in the recommended test areas. Structure siting was based upon criteria such as installation of structures opposite or in line with existing structures, avoidance of wetlands, street crossing requirements and analysis of existing lines' profiles, aerial photographs and USGS maps, records of the existing lines and field examinations. Approximately 570 structures were sited within recommended testing areas.

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*Included in the 218 areas recommended for testing were areas of low or minimal archaeological sensitivity. Failure to find cultural materials at these locations helped to verify the validity of the criteria for recommending areas for archaeological testing.

An accuracy range of either ± 50 feet or ± 100 feet was assigned to each structure location based upon the level of confidence that placement within the area would be workable in the final design. For structures with an accuracy range of ± 50 feet, six test pits were dug; for those with a ± 100 feet accuracy range, ten test pits were dug. At many locations, due to terrain features, such as ledge on one side of a proposed structure location, a lesser number of test pits were dug.

The intensive archaeological testing phase started in September 1985 and was completed in December 1985. Approximately 1,900 test pits were dug. For each test pit, a summary form was filled out to provide relevant information. The proposed Sandy Pond Converter Terminal site did not qualify for intensive archaeological testing.

For the vast majority of test pits dug, no cultural materials were recovered. However, at several structure locations cultural materials were recovered in one of the test pits dug. In each such instance, four additional test pits were dug, 25 feet in each direction, to bracket that test pit where the material was located. Nothing was found in any of these bracketing test pits. Therefore, the Company and OPA believe that none of these sites are eligible for the National Register of Historic Places.

Surface remains of former agricultural complexes (e.g., cellar holes, wells, or rock walls) were identified in several areas in each state. These identified features were mapped.

Ten proposed structure locations were moved so that these identified surface remains would not be in the estimated 100' x 100' construction impact area associated with each transmission structure. In the vicinity of these features, as well as in areas not requiring relocation of proposed structures, the Company will flag identified cultural features to avoid impacts during construction.

4. Archaeological Site Examination

The purpose of this phase was to obtain sufficient data on sites discovered during the intensive survey to determine whether or not they are eligible for the National Register. If sufficient cultural materials had been recovered at any location during the intensive archaeological testing phase, subsequent testing, referred to in the Research Design as "archaeological site examination", utilizing two-meter square unit excavations, would have been undertaken to determine data on function, date, integrity and site boundaries. Based upon the results of the intensive archaeological testing, the Company and OPA believe that no locations required such testing.

5. Determination of Effect

Based upon the results to date of the archaeological survey, the Company and OPA believe that the proposed undertaking would not impact archaeological resources of the states of New Hampshire or Massachusetts that are listed in, or potentially eligible for listing in, the National Register of Historic Places.

If, during final design of the proposed transmission facilities, the Company finds it necessary to change the location of any proposed transmission structure in an archaeologically-sensitive area to another location, not previously tested, within that sensitive area, additional testing would be conducted by the Company prior to construction. These test results would be reported to the NHSHPO and the MHC, as appropriate. Also, the Company would cease construction at any site wherein cultural data is uncovered until testing can determine the significance of the data.

B. Architectural/Historical

1. Identification

According to the Research Design, the initial phase of the architectural/historical survey was to survey all cultural properties within one quarter-mile of the proposed corridor's centerline and other cultural properties in proximity to the ROW, but beyond the one quarter-mile limit, which may be impacted. This survey would identify each standing architectural/historical resource either listed in the National Register or potentially eligible for such listing.

The identification survey began in August 1985 and was completed in November 1985. In New Hampshire, 318 cultural properties were identified as in the Register or potentially eligible; in Massachusetts, 675 cultural properties were so identified.

2. Evaluation

In New Hampshire, each identified cultural property was evaluated by OPA in conjunction with the NHSHPO against the National Register criteria (36 CFR Section 60.4) to see if the property was in fact eligible for listing in the Register. Approximately 239 of the identified 318 cultural properties have been determined by OPA and the SHPO to be listed in the National Register or eligible for inclusion. In Massachusetts, evaluation has been completed by OPA for all but the town of Medway. The results have not yet been reviewed with the MHC.

3. Assessment of Impact

According to the Plan and the Research Design, the next phase of the architectural/historical survey will be an assessment of effects upon those cultural properties determined to be listed in or eligible for listing in the National Register. In this process, the SHPOs and OPA will be applying ACHP's criteria of effect and adverse effect. (36 CFR Section 800.3).

Analysis of impacts is currently underway. Results of the impact assessment are expected to be available for inclusion in the next quarterly report.

The Company and OPA will be conducting mitigation analysis, as necessary, based upon the results of the assessment of impact study.

IV. SUMMARY

OPA has completed its field work for the archaeological and the architectural/historical surveys.

For the archaeological surveys, described above, the Company and OPA believe there are no impacts upon significant archaeological resources, i.e., resources listed in or eligible for listing in the National Register, in either state.

For the architectural/historical surveys, described above, the Company and OPA currently are analyzing impacts upon cultural properties in the two states. The Company expects to finalize determinations of eligibility and effects upon such properties during meetings with NHSHPO and MHC staff early in 1986. Any necessary mitigation analysis will commence shortly thereafter.

A Final Report, as described in the Plan and the Research Design, is scheduled to be submitted by OPA to the Company for transmittal to the SHPO's of each state and will be addressed in the FEIS. Final determinations by the SHPO's of the proposed undertaking's effects, if any, upon cultural properties are expected to be completed during the spring of 1986.

CULTURAL RESOURCES SURVEY

STATUS REPORT NO. 2

I. INTRODUCTION

This report is being submitted to the Department of Energy in connection with the pending application for amendment of Presidential Permit PP-76 in Docket No. PP-76A. This report is the second report on the status of the cultural resources surveys which are being conducted in connection with the proposed New England/Hydro-Quebec Phase II Project. (For a detailed description of the proposed transmission facilities, see Volumes 1, 2, and 3 of the Applicant's Environmental Report.) The next status report will be filed on July 1, 1986.

Two cultural resources surveys are currently in progress in connection with the proposed New England/Hydro-Quebec Phase II Project. The first focuses on archaeological resources; the second focuses on architectural/historical resources. The purpose of this status report is to summarize the progress of those surveys since January 3, 1986, the date of Status Report No. 1.

As with Status Report No. 1, the following report relates to the proposed transmission line corridors and does not include survey results for the Tewksbury alternate route.

II. ARCHAEOLOGY

During the first quarter of 1986, the office of Public Archaeology (OPA) of Boston University, the consultant selected to conduct the cultural resources surveys, completed all field work and laboratory analysis for the archaeological surveys. Also during the first quarter, OPA substantially completed preparation of the archaeological portions of the Final Reports which are to be submitted to the State Historic Preservation Officers (SHPO's) of New Hampshire and Massachusetts.

New England Power Company (the Company) and OPA have no reason to change their conclusion (as stated in Status Report No. 1, January 3, 1986) that the proposed undertaking would not impact archaeological resources of the states of New Hampshire or Massachusetts that are listed in, or potentially eligible for listing in, the National Register of Historic Places.

III. ARCHITECTURAL/HISTORICAL

A. Identification

Status Report No. 1 indicated that, in Massachusetts, 675 cultural properties were identified as listed in the National Register of Historic Places or potentially eligible for such listing. This was a typographical error; approximately 475 cultural properties were actually identified in Massachusetts.

B. Evaluation

Early in January the Company and OPA met with the NHSPO in Concord to review aerial and ground photographs of properties previously believed eligible for listing in the Register to determine the effects of the proposed undertaking. For those eligible properties whose eligibility was predicated in part upon their setting, the Company and OPA conducted field reviews to verify that the properties were in fact eligible for listing. Based upon these field reviews, the Company and OPA believe that some properties previously considered eligible are not eligible. A meeting will be held shortly with the NHSHPO to resolve the eligibility of the particular properties in question.

In Massachusetts the results of the Identification Survey were submitted to the Massachusetts Historical Commission (MHC), i.e., Massachusetts SHPO, for their preliminary comments as to which properties might be eligible for listing in the Register. The MHC has informed the Company and OPA that approximately 290 properties (75 individual properties and five historic districts, including a total of about 215 individual properties) may be eligible for listing.

Final eligibility determinations regarding both New Hampshire and Massachusetts will be available in the next Status Report.

C. Assessment of Impact

During the first quarter of 1986, the Company and OPA continued to analyze impacts on potentially eligible or listed properties. This analysis involved additional field surveys in New Hampshire and Massachusetts. Results of the impact assessment, which were expected to be included in this report, are not yet available.

In New Hampshire a meeting will be held shortly with the NHSHPO to present the results of the additional field surveys. In Massachusetts, further field surveys are planned for early April.

The Company and OPA expect to complete their impact assessment during April. Shortly thereafter, Final Reports are to be transmitted to the New Hampshire and Massachusetts SHPO's.

IV. SUMMARY

OPA has been working on the preparation of the archaeology portion of the Final Reports to the SHPO's.

In New Hampshire, a forthcoming meeting with the NHSHPO will resolve outstanding eligibility and effects issues for the architectural/historical survey. In Massachusetts, a forthcoming field survey will consider whether any properties might be adversely impacted by the proposed undertaking. The architectural/historical portion of the Final Reports will be completed after this meeting and field survey.

Final Reports will be transmitted to the SHPO's and final determinations by SHPO's of the proposed undertaking's effect upon cultural properties will be addressed in the FEIS.

CULTURAL RESOURCES SURVEYS

STATUS REPORT NO. 3

I. INTRODUCTION

This report is being submitted to the Department of Energy in connection with the pending application for amendment of Presidential Permit PP-76 in Docket No. PP-76A. This report is the third report on the status of the cultural resources surveys which are being conducted in connection with the proposed New England/Hydro-Quebec Phase II Project. (For a detailed description of the proposed transmission facilities, see Volumes 1, 2, and 3 of the Applicant's Environmental Report.) The next status report will be filed on or about October 1, 1986.

Two cultural resources surveys are currently in progress in connection with the proposed New England Hydro-Quebec Phase II Project. The first focuses on archaeological resources; the second focuses on architectural/historical resources. The purpose of this report is to summarize the progress of those surveys since April 1, 1986, the date of Status Report No. 2.

As with prior status reports, this report relates to the proposed transmission line corridors and does not include survey results for the Tewksbury alternate route.

At the time Status Report No. 2 was prepared, the Applicant had expected Final Reports summarizing the cultural resources surveys to be filed with the New Hampshire State Historic Preservation office (NHSHPO) and the Massachusetts Historical Commission (MHC) in April of 1986. However, because of delays in the preparation and production of those reports, they have not yet been filed. These reports are currently scheduled to be filed in August. Because of the delay in filing these final reports, certain information expected to be included in this status report is not yet available.

II. ARCHAEOLOGY

With the exception of certain maps which are still being prepared, the Archaeology portions of the Final Reports to the NHSHPO and the MHC have been completed. The Applicant and the Office of Public Archaeology (OPA) of Boston University, the consultant selected to complete the cultural resources surveys, continue to believe, as stated in Status Report No. 2, that the proposed undertaking would not impact archaeological resources of the states of New Hampshire or Massachusetts that are listed in, or potentially eligible for listing in, the National Register of Historic Places.

III. ARCHITECTURAL/HISTORICAL

In April, OPA conducted further field surveys in Massachusetts. These surveys were conducted as part of OPA's assessment of impacts on potentially eligible or listed properties. All field work associated with that assessment is now complete. OPA's final assessment of impacts from the proposed undertaking on potentially eligible or listed properties in Massachusetts will be included in the Final Report.

In May, the Applicant and OPA met with the NHSHPO to finalize the list of cultural properties in New Hampshire that are near the proposed undertaking and listed in, or eligible for listing in, the National Register of Historic Places. As a result of that meeting, it was concluded that there are 199 properties eligible for listing and one property that is already listed. Of these 200 properties, 95 are individual properties located in 13 historic districts and 105 are individual properties not located in historic districts. As in Massachusetts, all field work necessary to complete OPA's assessment of impacts on potentially eligible or listed properties in New Hampshire is now complete. OPA's assessment of those impacts will be included in the Final Report.

Preparation of the Architectural/Historical portions of the Final Reports to the NHSHPO and MHC continued during the second quarter of 1986. The Applicant currently expects that the Final Reports will be completed in July and filed with the NHSHPO and MHC in August. These final reports will be addressed in the FEIS. The Applicant and OPA do not believe any of the listed or potentially eligible properties evaluated in Massachusetts or New Hampshire would be adversely affected by the proposed undertaking.

APPENDIX D. U.S. ARMY CORPS OF ENGINEERS REVIEW FOR APPLICABILITY OF SECTION 404(b)(1) GUIDELINES

APPENDIX D. U.S. ARMY CORPS OF ENGINEERS REVIEW FOR APPLICABILITY OF SECTION 404(b)(1) GUIDELINES

Additional power purchase by New England Power Pool would necessitate the construction of new facilities to transmit electricity to load centers in central New England. The proposed route would involve construction of 185 miles of transmission lines in New Hampshire and Massachusetts.

The following is an assessment of anticipated environmental impacts associated with fill activities in the proposed project for applicability of Section 404(b)(1) guidelines.

D.1 IMPACTS ON PHYSICAL/CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

The project would:

(x) change the physical and chemical characteristics of the substance.
(x) change the substrate elevation or contours.
(x) cause erosion, slumping, or lateral displacement of the surrounding substrate.
(x) change water fluctuations.

These changes would affect:

(x) currents, circulation, or drainage patterns.
(x) suspended particulates and turbidity.

These changes would, in turn, affect:

(x) water quality (clarity, odor, color, taste, D.O. levels, nutrient levels, toxins, pathogens, viruses, etc.).
(x) water temperatures.
( ) salinity gradients.
( ) thermal stratification.

Exact locations for transmission structures have not been determined but, where possible, support structures will be placed outside of wetlands. However, placement of fill for some structures within wetlands is unavoidable. It is estimated that a total of 88 wetlands would be affected by new structural placement, existing structure removal, and/or forest clearing. This includes 33 wetlands in New Hampshire (ER, Vol. 8--Table III-6) and 55 wetlands in Massachusetts (ER, Vol. 7--Table III-6). Fill for new structures and access roads would cause, at the most, long-term loss of 19 acres of wetlands; 8 acres in Massachusetts (ER, Vol. 7--Table III-7) and 11 acres in New Hampshire (ER, Vol. 8--Table III-7).

Wetland impacts can be effected by clearing of vegetation, construction and improvement of access roads by filling, use of heavy machinery, and installation of structures. 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 modification (Darnell 1976). Fluctuations in water level might also be detrimental to vegetation located adjacent to wetlands (Boelter and Clare 1974). While emplacement of tower bases would result in the loss of some wetland habitat, they might prove to be preferred habitat for nesting waterfowl and calving deer (Thorsell 1976). Because the area of wetlands impacted by the project would be small relative to the total wetland area occurring in the vicinity of the Massachusetts/New Hampshire sites, the overall impacts to wetland habitat would not be of sufficient magnitude to cause localized extinction of any species. Additionally, the habitat that would be affected is not unique to the area. Impacts to wetland habitat would also be minimal because the majority of wetlands would be spanned, and construction activities (e.g., structure placement) would be minimized within these wetland areas.

Minimal disruption and filling of wetlands will take place and best management practices where filling and construction does occur will be imposed. As part of the best management practices, equipment will be moved over wetland areas during the winter to reduce disruption to the wetland systems.

D.2 IMPACTS ON SPECIAL AQUATIC SITES

The changes presented in Section D.1 would occur in:

- ( ) sanctuaries and/or refuges.
- (x) wetlands.
- ( ) mudflats.
- ( ) vegetated shallows.
- ( ) coral reefs.
- ( ) riffle and pool areas.

The special aquatic site provides benefits including:

- (x) flood control.
- (x) water purification.
- (x) food chain production and nutrient export.
- ( ) storm, wave, and erosion buffers.
- ( ) aquifer recharge.
- (x) habitat for fish and other aquatic organisms.
- (x) wildlife habitat.

The wetlands in New Hampshire (ER, Vol. 8--Table III-1) and Massachusetts (ER, Vol. 7--Table III-1) were delimited using Corps of Engineers' criteria and classified using the U.S. Fish and Wildlife Service classification designation. To further assist in delineation, the U.S. Fish and Wildlife Service wetland inventory maps were screened. In addition, these wetland areas and the surface waters within the right-of-way were field checked.

In all cases the wetlands crossed are palustrine wetlands. The amount of wetland acreage within the right-of-way ranges from 0.1 acre of hardwood forest in Medway, Massachusetts, to 13.5 acres of palustrine scrub-shrub/emergent wetlands in Milford, Massachusetts.

The wetlands in the vicinity of the proposed route are dominated by diverse types of vegetation such as emergent vegetation, scrub/shrub vegetation, and forested vegetation.

Wetlands dominated by emergent vegetation (e.g., wet meadow and ponds) are basically wet grasslands containing plant species adapted to submerged soils (Darnell 1976). These habitats usually contain zoned gradations of plant species as follows (from shallow to deeper water): (1) emergent plants (e.g., reeds, cattails, bulrushes, 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). Based on acreage of wetland types along the proposed route, about 32% of the wetlands contain predominantly emergent vegetation (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

Scrub/shrub wetlands or swamps 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 include alder, willow, blueberry, sumac, winterberry, steeplebrush, sweet pepperbush, buttonbrush, red osier dogwood, spirea, labrador tea, bog rosemary, bog laurel, leatherleaf, and young trees of species such as red maple and black spruce. Sensitive fern and sedges are predominant herbaceous species (Cowardin et al. 1979; ER, Vols. 7 and 8). About 12% by area of the wetlands along the proposed route contains a predominant scrub/shrub vegetation community. About 51% of the wetlands contains a combination of emergent and scrub/shrub wetlands (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

The forested wetlands or swamps are dominated by living or dead trees that are at least 6 m (20 ft) tall. In the study area, forested wetlands are typically dominated by red maple, with black ash and grey birch also present. Coniferous species, which are less common, include larch, black spruce, Atlantic white cedar, and white pine (ER, Vols. 7 and 8). Shrub and herbaceous layers are dominated by the species common in the scrub/shrub wetlands. The presence of forested wetlands dominated by dead trees results from construction of man-made impoundments and beaver ponds, fire pollution, or insect infestation (e.g., spruce budworm outbreaks) (Cowardin et al. 1979). Only about 5% of the wetlands along the proposed route contains a forested component (ER, Vol. 7--Table III-2, Vol. 8--Table III-2).

D.3 IMPACTS ON BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

The changes in Sections D.1 and D.2 would adversely impact:

- ( ) endangered or threatened species, or critical habitat for such.
- (x) fish, mollusks, or other aquatic organisms through:
  - ( ) removal.
  - ( ) temporary displacement.
  - (x) permanent displacement or lowered numbers through changes in overall suitability of habitat in terms of substrate, temperature, water quality, etc.
  - ( ) interfering with spawning migrations.

- (x) other wildlife in terms of:
    - (x) breeding and nesting habitat.
    - (x) escape cover.
    - ( ) travel corridors.
    - (x) food supplies.
    - ( ) competition from nuisance species.
    - ( ) reduced plant species diversity and interspersion of habitat types.

The emergent and pond wetlands contain a diverse and productive fauna, including various species of aquatic and terrestrial invertebrates, fishes, amphibians, and reptiles. The wetlands provide important nesting, brooding, feeding, migratory stopover, and overwintering habitat for waterfowl and shorebirds (Darnell 1976). They also provide habitat for such mammals as muskrat, short-tailed shrew, star nosed mole, eastern cottontail rabbit, beaver, meadow vole, and red fox (Godin 1977).

Animal life in scrub/shrub and forested wetlands is similar to that for marshy wetlands, but includes a more diverse bird and mammal species assemblage because of the increased habitat and food resources provided by understory and canopy vegetation. Waterfowl and shorebirds found in the marshy wetlands also frequent swampy wetlands; also present are such species as arboreal songbirds, birds of prey, and woodpeckers. Large mammals, such as white-tailed deer, occur in swampy wetlands, as do many smaller mammals such as mice, voles, squirrels, shrews, weasels, otters, lemmings, and bats (Godin 1977).

D.4 IMPACTS ON HUMAN USES

The impacts in Sections D.1, D.2, and D.3 would adversely affect human uses of the resources, through degradation of:

- ( ) existing or potential water supplies.
- ( ) recreational or commercial fisheries.
- ( ) other water-related recreational use.
- (x) aesthetics of the aquatic ecosystem.
- ( ) parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves.

Transmission structures and access roads may change the aesthetics of the wetlands that are altered by filling and temporary disruption of native vegetation. Disturbed areas may be revegetated to lessen aesthetic concerns.

D.5 OTHER CONCERNS

The proposal will impact:

- ( ) energy consumption or generation.
- ( ) navigation.
- ( ) air quality.
- ( ) historic resources.
- (x) noise.
- ( ) land use classification.

During construction activities, noise from equipment may displace animals. Following the completion of work, however, habitat use should return to normal.

D.6 EVALUATION AND TESTING OF FILL MATERIAL

(x) The project will use fill from a clean upland source. Therefore, no further evaluation under this section is necessary.

( ) The applicant proposes to discharge dredged material or use fill from other than a clean upland source. The following is an evaluation of the need for testing, testing performed, and evaluation of results.

D.7 REFERENCES FOR APPENDIX D

Boelter, D.H., and G.E. Clare. 1974. Pipelines in forested wetlands. Journal of Forestry 72:561-563.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Biological Services Program. 103 pp.

Darnell, R.M. 1976. Impacts of Construction Activities in Wetlands of the United States. EPA-500/3-76-045. U.S. Environmental Protection Agency, Office of Research and Development. 393 pp.

Godin, A.J. 1977. Wild Mammals of New England. DeLorme Publishing Company, Yarmouth, ME. 207 pp.

Thorsell, R.S. 1976. Environmental concerns in rights-of-way management. An electric utility viewpoint. In: R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-Way Management. Mississippi State University, Mississippi State. pp. 4-6.

APPENDIX E. LETTERS OF CONSULTATION

Massachusetts Natural Heritage Program

RECEIVED
MAIN
MAY 23 1984
Refer to ____________

May 21, 1984

Leo T. Sicuranza
Charles T. Main, Inc.
Planning and Scientific Services
Prudential Center
Boston, MA 02199

Re: N.E. Power Co. transmission lines

Dear Mr. Sicuranza;

Thank you for consulting the Massachusetts Natural Heritage Program about the New England Power Company's proposed transmission line through nineteen Massachusetts towns in Middlesex, Essex, and Worcester Counties. Our staff has reviewed the routes marked on the U.S.G.S. quadrangle map copies, which you provided, for occurrences of rare plant and animal species populations or significant natural communities which should be considered in planning work in these areas.

As we discussed, the MNHP is presently aware of occurrences for three rare animal species and one rare plant species along the routes. These are marked on the enclosed maps, with details given about the species in the following table. Specific locations of current rare species populations should not be publicized to prevent inadvertent damage to their habitats through visiting or collecting. Occurrences since 1978 are considered current.

Quadrangle	Species, date	habitat	rarity, comments
Ayer, MA	Climbing Fern, 1980 and No date (Lygodium palmatum)	Semi-open edges of woods and streams	Threatened in Mass.
Nashua South, N.H. (Tyngsboro)	Southern Bog Lemming, 1976 (Synaptomys cooperi)	Sphagnum bogs, sedge meadows, less commonly in orchards, open grasslands	Endangered in Mass.
Holliston, MA	Blue-Spotted Salamander, 1978 (Ambystoma laterale)	Wooded swampy areas, moist woods. Breeds in ephemeral ponds in spring	Threatened in Mass. Two sites in this area.

Quadrangle	Species, date	habitat	rarity, comments
Holliston, MA (continued)	Spotted Salamander, 1979 (*Ambystoma maculatum*)	Moist woodlands. Breeds in ephemeral ponds in spring.	Uncommon but apparently secure in Mass.

As soon as you become aware of New England Power Co.'s proposed actions in the vicinities of these sites, we would ask that you contact us again for management and protection recommendations, or information on the collection of field data for these species.

I hope this information is useful in your planning, and that you will contact us with any questions. Please note that our inventory expands through ongoing field work and research, so further data on these areas may become available in the future.

Yours sincerely,

Alison Sanders-Fleming

Alison Sanders-Fleming
Environmental Reviewer

ASF/mf
Enc.

Massachusetts
Natural Heritage
Program

29 November 1984

Leo T. Sicuranza
Charles T. Main, Inc.
Planning & Scientific Services
Prudential Center
Boston, MA 02199

Re: New England Power Company
transmission lines

Dear Mr. Sicuranza;

Thank you for consulting the Massachusetts Natural Heritage Program for an update on known rare species sites near the New England Power Company's proposed overhead transmission line through parts of Middlesex, Essex, and Worcester Counties. As we discussed at our recent meeting, I had the rest of our staff review the routes marked on the USGS 7½' quadrangle map copies you provided. Aside from the four rare species occurrences described in the May 21, 1984 letter to you, we are unaware of any additional rare plant or animal populations or significant natural communities which would be adversely affected by the proposed transmission line.

We would like to offer updated information on the four occurrences mentioned above. Their locations were indicated in the May '84 correspondence. As you know, specific locations of rare species sites should not be publicized to prevent damage to their habitats through visiting or collecting.

Climbing Fern, 1984, (*Lygodium palmatum*); Ayer MA quadrangle.

While a location for this State Threatened plant species was confirmed in the 1984 fields season just south of the right-of-way, a field survey of the ROW itself did not reveal any Climbing Fern populations.

Southern Bog Lemming, 1976, (*Synaptomys cooperi*); Nashua South NH/MA quadrangle.

The Bog Lemming reported from this wetland in 1976 represents the most recent known occurrence of this species in Massachusetts, although it is believed that populations of this rare mammal do exist in suitable habitats in the state. The Bog Lemming has recently been reclassified as a Species of Special Concern on the Mass. Division of Fisheries Y Wildlife rare animals list revision presently pending final approval. No fieldwork has been conducted at this site since 1976, and it can be assumed that the species still inhabits the wetland provided that the habitat has not been significantly degraded. Should powerline installation here require disturbance to the wetland through piling relocation or other construction activities, the MNHP should be contacted to discuss possible fieldwork, and potential impacts and mitigation measures.

Blue-spotted Salamander, 1978 (*Ambystoma laterale*), and Spotted Salamander, 1979, (*A. maculatum*); Holliston MA quadrangle.

The Blue-spotted Salamander has been proposed for listing as a Species of Special Concern in Massachusetts. As noted in our May '84 correspondence, the

Division of Fisheries and Wildlife 100 Cambridge Street, Boston, Mass. 02202 (617) 727-3160,-3151

Spotted Salamander is considered to be apparently secure in the state. Due to the recent abundance of data on this species from annual mole salamander surveys, this species has been dropped from the MNHP rare animals list. Its presence, however, especially together with the Blue-spotted Salamander here, is indicative of good quality amphibian habitat. This wetland area is north of the ROW itself, but care should be taken to prevent degradation to the area through runoff or other construction impacts to the wetland system.

I hope this information is useful in your planning, and that you will contact us with any questions. Please note that our inventory expands through ongoing fieldwork and research, so that further data on the area may become available in the future.

Yours sincerely,

Alison Sanders-Fleming

Alison Sanders-Fleming
Environmental Reviewer

ASF/lr

Massachusetts Natural Heritage Program

April 12, 1985

Mr. Leo Sicuranza
Chas. T. Main, Inc.
Prudential Center
Boston, MA 02199

Re: New England Power Company
Transmission Line in Dunstable

Dear Mr. Sicuranza,

As a follow up to the meeting with you and Robert Olsen in our office on March 20, 1985, I would like to restate the Natural Heritage Program's views regarding the impacts of the proposed transmission line in Dunstable on rare and endangered species. As previcus correspondence from our office has indicated (9/29/84 to you, 2/12/85 to MEPA), the Southern Bog Lemming (Synaptomys cooperi) was recorded in 1976 as occurring in a wetland along the transmission line in Dunstable. As you described the details and timing of the construction of the transmission line at this site (no footings will be placed in the wetland, etc.), there appears that the proposed project will have no deleterious impacts to the Bog Lemming or its habitat. Please contact the Heritage Program should you have furthur questions about this or other potential rare species impacts.

Sincerely,

Henry Woolsey

Henry L. Woolsey
Coordinator

HW:yt

Division of Fisheries and Wildlife 100 Cambridge Street, Boston, Mass. 02202 (617) 727-3160,-3151

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

FEB 13 1986

Mr. Anthony J. Como
Coal and Electricity Division
Office of Fuels Program
Economic Regulatory Administration
Department of Energy
Washington, D.C. 20585

Dear Mr. Como:

This responds to your January 23, 1986 request for information on the presence of Federally listed and proposed endangered or threatened species in conjunction with the Department of Energy's Environmental Impact Statement for the New England/Hydro-Quebec Phase II project in New Hampshire and Massachusetts.

Our review shows that except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project area. Therefore, no Biological Assessment or further consultation is required with us under Section 7 of the Endangered Species Act. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our concerns under the Fish and Wildlife Coordination Act. With respect to our comments on the EIS, we have already participated in the scoping process, and will be reviewing the draft and final EIS when those documents are published.

Lists of Federally designated endangered and threatened species in New Hampshire and Massachusetts are enclosed for your information. Thank you for your cooperation and please contact us if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

Enclosure

STATE OF NEW HAMPSHIRE

FISH AND GAME DEPARTMENT

34 Bridge Street
Concord, N.H. 03301
(603) 271-3421

ALLEN F. CRABTREE, III
EXECUTIVE DIRECTOR

February 14, 1986

Anthony J. Como
Department of Energy
Coal & Electricity Division
Office of Fuel Programs
Economic Regulatory Administration
Washington, D.C. 20585

ECONOMIC REGULATORY ADMINISTRATION
DOCKETED
FEB 24 1986
POWER SUPPLY & RELIABILITY

Dear Mr. Como:

I am responding to your letter of 23 January requesting comments on potential impacts of the New England/Hydro-Quebec Phase II on endangered species and other wildlife in New Hampshire.

The only currently listed species which is likely to nest within the transmission corridor is the Whip-poor-will (Caprimulgus vociferus). Birds nesting within the corridor could be adversely affected by construction activities and by corona effects.

Listed species which could nest in woodlands immediately adjacent to the corridor include the Cooper's Hawk (Accipter cooperii) and Red-Shouldered Hawk (Buteo lineatus).

The Peregrine and Bald Eagle, both state and federally listed endangered species, have areas of activity near the corridor. A peregrine release site which is part of the northeastern peregrine restoration effort is located within 1.7 miles of the corridor in Benton, and will probably be operational for the next 2-5 years. The corridor is within hunting range of several other historical and potential peregrine nesting sites. The area of Bald Eagle activity is along the Connecticut River from Monroe to Dalton. Collision with towers or lines would be the most likely source of impact for these species.

As I believe you are aware, the state list of threatened and endangered species is currently under review, and a revised list will be published later this spring.

Other than the specific cases discussed above, our main concerns with the proposed project focus on potential effects on wildlife of electric fields and corona discharge, which are poorly understood at this time, and any construction impacts on wetlands. I would like to review the following publications which are listed in the implementation plan accompanying your letter:

"Biological Effects on High Voltage AC Transmission Lines", "Biological Effects of High Voltage Direct Current Lines", and "The Impact of a Proposed 500 KV Transmission Line on Waterfowl and Other Birds", and would appreciate information on how to obtain them.

Thank you for the opportunity to comment.

Sincerely,
Harold P. Nevers

Harold P. Nevers
Federal Aid & Endangered
Species Coordinator
NH Fish & Game Department

The Commonwealth of Massachusetts

Office of the Secretary of State
Michael Joseph Connolly, Secretary

Massachusetts Historical Commission
Valerie A. Talmage
Executive Director
State Historic Preservation Officer

September 9, 1985

Bradley Spooner
Air & Environmental Resource Programs
New England Power Company
25 Research Drive
Westborough, MA 01581

ATTN: Gordon Marquis

RE: Research Design for Cultural Resources Survey, Hydro-Quebec Project (Phase II)

Dear Mr. Spooner:

Thank you for submitting a copy of the proposed research design for the cultural resources survey of the Hydro-Quebec Phase II project. The purpose of this letter is to confirm the Massachusetts Historical Commission's comments on the research design, as stated in a telephone conversation between Brona Simon (MHC) and Gordon Marquis (New England Power) on July 23, 1985.

The MHC reviewed the research design and believes that it shall provide New England Power with the basic level of documentation required for the identification and evaluation of cultural resources which might be affected by the proposed power line project in compliance with 36 CFR 800, Advisory Council on Historic Preservation Procedures for the Protection of Historic and Cultural Properties. However, MHC recommends that the archaeological field testing program be specfically keyed into project design plans. The focus of the survey is to test areas where there will be project impacts, as specified in the project design.

MHC also recommends that the results of the intensive (identification) survey and the consultant's recommendations for additional investigation, be reviewed by this office.

MHC would like to remind you that a permit from the State Archaeologist must be secured before archaeological field work can proceed (950 CMR 70).

If you have any questions concerning these comments, please contact Brona Simon, State Archaeologist at this office.

Sincerely,

Valerie Talmage

Valerie A. Talmage
Executive Director
State Historic Preservation Officer
Massachusetts Historical Commission

cc: Ricardo Elia, Boston University, Office of Public Archaeology

VAT/dr

STATE OF NEW HAMPSHIRE
DEPARTMENT of RESOURCES and ECONOMIC DEVELOPMENT
OFFICE of the COMMISSIONER

603-271-2411

JOHN T. FLANDERS
Commissioner

105 Loudon Road
Box 856
Concord, N.H.
03301

Date: October 30, 1985
Re: Research Design for the Cultural Resources Assessment Survey of the Hydro-Quebec Hydro Project (Phase II) in NH and MA

Bradley H. Spooner, Manager
Air and Environmental Resource Programs
New England Power Company
25 Research Drive
Westborough, Massachusetts 01581

Dear Mr. Spooner:

I am writing to confirm that the NH State Historic Preservation Office received, reviewed, and approved the "Research Design for the Cultural Resources Assessment Survey of the Hydro-Quebec Project (Phase II) in New Hampshire and Massachusetts," prepared by the Office of Public Archaeology at Boston University. We concur that this is consistent with the cultural resources plan discussed with staff of your office on March 27, 1985, in Concord.

The one reservation expressed by the Historic Preservation Office was the coordination and scheduling of the historical overview to be prepared by the archaeological team (pg. 5) with the identification phase of the architectural component (pg. 9). Ideally, an overview should preceed the initial phase of the architectural survey. After discussions with Lynne Monroe, subconsultant, the staff concern was alleviated, as phased historical research to be conducted by Ms. Monroe will be adequate for the architectural survey.

The Historic Preservation Office has requested the use of New Hampshire's "Minimum Documentation Survey Form" and "State Historical Resources Survey Form" for the identification and evaluative phase, respectively of the architectural component. Lynne Monroe has agreed to this request with minor changes approved by this office.

Sincerely,

Gary W. Hume

for Joseph F. Quinn, Director
Recreation Services
Deputy State Historic Preservation Officer

JFQ:GWH:g
cc: Lynne Monroe, Consultant
Ricardo Elia

APPENDIX F. DISTRIBUTION LIST

Environmental Law Council of NH
2 White St.
Concord, NH 03301

Environmental Quality Div. MDC
20 Somerset St.
Boston, MA 01824

Essex Conservation District
82 Eastern Avenue
Essex, MA 01929

Garden Club Federation of Mass., Inc.
300 Massachusetts Avenue
Boston, MA 01450

New Hampshire Wildlife Federation, Inc.
East Barrington, NH 03825

The Environmental Coalition
Box 757
Concord, NH 03301

Douglas Zook
Learning Center for the Environment
57 Arborough Road
Boston, MA 02130

Stephan K. Rice
Appalachian Mountain Club
Pinkham Notch Camp
Gorham, NH 03581

Beaver Brook Valley Preserve
The Nature Conservancy
69 Depot Road
Foxborough, MA 01719

Frances Brockely
Society for the Protection of NH Forests
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Concord, NH 03301

NH Association of Conservation Commissions
54 Portsmouth Street
Concord, NH 03301

New Hampshire Resource Recovery Assoc.
P.O. Box 721
Concord, NH 03301

Inst. of Natural and Environmental Resources
University of New Hampshire
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Dinah Bear
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Gordon E. Beckett
Supervisor, NE Area
U.S. Dept. of Interior
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Department of HUD (Room 5136)
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Budget Examiner
Office of Management & Budget (NEOB #8222)
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General Counsel
Federal Trade Commission (Room 568)
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U.S. Department of Labor
(Room S-2121)
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Dir., Environmental Affairs
Dept. of Health & Human Services
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Federal Energy Regulatory Commission
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Dr. Donald K. Emig
Director, Environmental Policy
DASD (MRA&L) I
The Pentagon
Washington, DC 20310

Don L. Kilma
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