Gilmore

DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

MASTER

**FEASIBILITY OF
DETERMINATION OF LOW-HEAD HYDROELECTRIC
POWER DEVELOPMENT AT EXISTING SITES**

PRDA ET-78-D-07-1706

NORTH HARTLAND DAM PROJECT

FEASIBILITY REPORT

SUBMITTED BY:

VERMONT ELECTRIC COOPERATIVE, INCORPORATED
NON-ACADEMIC NONPROFIT CORPORATION

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PRDA ET-78-D-07-1706
COOPERATIVE AGREEMENT
NO. EW-78-F-07-1790

NORTH HARTLAND DAM PROJECT

FEASIBILITY REPORT

MARCH 1979

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DEPARTMENT OF ENERGY
VERMONT ELECTRIC COOPERATIVE INC.

NORTH HARTLAND DAM PROJECT

FEASIBILITY REPORT

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NORTH HARTLAND DAM
OTTAUQUECHEE RIVER
WINDSOR COUNTY, VERMONT

1 - INTRODUCTION

The North Hartland Dam Project feasibility study has been undertaken by Acres American Incorporated under the terms of a contract with Vermont Electric Cooperative Inc. (VEC) dated August 7, 1978. The study has been jointly funded by the Department of Energy (DOE) and VEC under Cooperative Agreement No. ET-78-D-07-1706. The North Hartland Dam and Reservoir is a federally owned, flood control facility operated and maintained by the Corps of Engineers. The objective of the study is to establish the technical and economic feasibility of developing the hydroelectric power potential at the dam.

A preliminary permit (No. P2816), was granted to VEC for the project, by the Federal Energy Regulatory Commission (FERC) on February 19, 1979. This report presents the results of the feasibility study for the proposed 6 MW hydroelectric installation and deals with the conceptual design alternatives, construction cost estimates and schedules, preliminary environmental and safety assessments and power marketing studies for the project.

The existing North Hartland Dam is located on the Ottauquechee River, about 1.5 miles above the Ottauquechee/Connecticut River confluence, in Windsor County, Vermont. The reservoir controls a 220 square mile drainage area, and has a capacity of 71,400 acre-feet. The proposed generating plant will be located near the toe of the dam and will develop a gross head of 65 feet between the current permanent pool elevation of 425 feet and the estimated tailwater elevation, 360 feet.

A summary of the investigation and findings is presented in Section 2 of this report. Section 3 contains a description of the existing facilities and basic data and assumptions used in the study. Sections 4 and 5 deal with the alternatives considered in developing conceptual designs for the project and selecting the recommended installations. A description of the selected design is presented in Section 6 and cost estimates and schedules for engineering, licensing and construction of the project in Sections 7 and 8.

Preliminary environmental and safety assessments are described in Sections 10 and 11. Project marketing studies are presented in Section 12 and recommendations in Section 13. Plates, background data and other related information are attached in Appendixes A through F.

The VEC Project Manager for this study was Mr. Walter N. Cook and subsequently Mr. William J. Gallagher. The Principal Investigator for Acres was Mr. John D. Lawrence, P.E., assisted by Mr. Richard E. Mayer, P.E. The assistance of the Corps of Engineers, New England Division, in the preparation of this report, is gratefully acknowledged, as is the guidance provided by the various other state and federal environmental agencies contacted.

SECTION 2

SUMMARY

2 - SUMMARY

The North Hartland Dam Hydroelectric Project has been found to be a technically feasible concept. The proposed project will have a recommended 6000 KW nominally rated capacity at a 52 feet turbine design head and 1680 cfs demand flow. The gross generation expected from the project is 11,980,000 KWh per year. It is estimated that the project will cost \$8,997,000 at 1978 price levels, with no allowance for funds during construction.

The project will provide peaking power at a levelized cost of about 41 mills per KWh at 1979 price levels, based on 7 percent cost of money, a 1985 commissioning date, and allowing for funds during construction and cost escalation over a 30 year period. The benefit-cost ratio compared with an equivalent oil-based generation source over a similar period is estimated as 1.06.

2.1 - Conceptual Design of Hydroelectric Installations

(a) Description of Proposed Facilities

The proposed hydroelectric development will be located downstream of the existing North Hartland Dam, as shown in Plate 1, Appendix A, and will make use of the existing dam outlet facilities as an intake and penstock. The conduit will be steel lined and extended approximately 680 feet downstream. A separate bypass will be installed with a flow control gate discharging into a concrete-lined channel. The proposed powerhouse will be constructed at the downstream end of the existing outlet channel. The tailrace of approximately 250 feet length will be excavated in the existing Ottauquechee River bed.

Power from the project will be transmitted via a new 46 KV transmission line approximately six miles to an existing Vermont Electric Power Company transmission line of similar voltage.

The North Hartland reservoir is presently being operated for flood control purposes as a unit of the comprehensive plan of flood protection for the Connecticut River Basin. All existing structures are operated, maintained and monitored by the Corps of Engineers and are in excellent condition. The spillway crest structure and overflow channel show minor signs of frost damage to concrete, which can be repaired at minimal cost. This structure has never, in fact, been used. There is also evidence of minor leakage in the intake tower gate chamber, which is not considered serious.

(b) Alternatives Considered

Two alternative powerhouse locations were considered together with the associated dam and spillway modifications, and a range of sizes and numbers of units. In order to develop a gross head of 65 feet at the upstream powerhouse location, it will be necessary to raise the reservoir permanent pool elevation by 25 feet. In such a case, major modifications to the existing dam or spillway will be required. On the other hand, extension of the penstock to a downstream powerhouse location will allow development of

a similar 65 feet of gross head without raising the present permanent pool level or requiring modifications to the dam or spillway. Adoption of the downstream powerhouse location, with two tube-type turbine-generator units, was found to be the most acceptable and cost effective alternative. No specific facilities exist in the North Hartland Dam and outlet conduit for passage of fish. Consequently, no provision has been made in the proposed development for such facilities other than in the installation of appropriately sized trash racks at the intake and tailrace to prevent passage of fish through the power plant.

(c) Plant and Unit Size Selection

The plant and unit sizes have been selected on the basis of the availability and condition of the existing facilities, reservoir water levels, the hydraulic characteristics of the existing and modified intake, conduit and outlet channel, the availability and variation of reservoir outflows, and comparative power values. The selected 6 MW installation at the downstream location is considered to provide optimum usage of the available hydroelectric potential at the site. Initial plant size optimization and comparison of alternatives was based on preliminary power values published by the FERC for an alternative combustion turbine source in New England. The selection of plant size and configuration will not be significantly influenced by any likely differences in power values. Nevertheless, further scrutiny of optimized plant size may be warranted in later phases of project evaluation when power values are more specifically defined. The plant capacity is limited to a significant extent by the dimensional constraints and hydraulic characteristics of the proposed intake and penstock structures.

Full consideration has been given to the number and type of units for the power facility. Alternatives evaluated comprised one-, two- and three-unit installations, utilizing double- and single-regulated Kaplan and fixed-blade propeller turbines in both horizontal (tube, bulb or Straflo) and vertical configurations, and installed capacities ranging from 4500 to 6800 KW. Although smaller installations providing mid-range power may result in lower net costs per KWh of generation, the project would not be considered an economic alternative to other mid-range generating sources already available to VEC. In the case of the single-regulated Kaplan (or tube) turbines, plant sizes were limited to standard manufactured units with 2000, 2250 and 2500 mm runner diameters. Three-unit alternatives were found to provide no significant economic benefit in terms of increased generation and were therefore rejected in favor of the one- or two-unit installations.

Project cost evaluations for one- and two-unit alternatives are summarized in Table 2.1. On the basis of the costs provided by manufacturers for this study, the tube unit alternative appears to provide a significant potential for cost reduction of approximately \$1,761,000, relative to its nearest competitor. This alternative was therefore selected for more detailed cost determinations at the upstream and downstream sites.

2.2 - Development Construction Cost Estimates and Schedules

(a) General

Detailed construction cost and schedule data were developed for two principal alternative hydro developments under consideration for the North Hartland Dam Project. The data is presented to a degree of detail such that further detailed economic evaluations as well as finance and schedule planning may proceed with an acceptable level of confidence.

(b) Cost Estimates

Summary cost estimates for six alternative project design concepts considered are presented in Table 2.1. Detailed cost estimates were prepared for the proposed installations with two standardized 3000 KW tube turbines, at each of the upstream and downstream powerplant locations considered. As indicated for Alternatives 1 and 6 in Table 2.1, the 2-tube unit installation at the downstream location, at a total estimated cost of \$8,997,000, is \$1,388,000 less in construction cost than the upstream location.

Cost estimates for each alternative were based on equivalent plant facilities at each location, relative to access, provision of powerhouse maintenance and dewatering services and automatic operation. Estimated construction costs were based on current (1978-79) cost levels applicable to the type of work involved and local conditions in the Vermont and effective through the third quarter of 1979. Additionally, unit costs for the major civil construction activities were estimated to allow for the environmentally sensitive location of the project and associated construction restrictions pertaining to noise, dust, preservation of water quality and limitations due to the flood control requirements of the existing structures.

(c) Schedules

The project schedules are shown in their two principal phases on Plate 12 Engineering Schedule, and Plates 13 and 14, Construction Schedule, for the upstream and downstream locations. The Engineering Schedule has essentially been based on concurrent licensing and engineering design and equipment procurement activities to result in the shortest construction lead time. Consecutive licensing and engineering activities would lengthen the schedule by at least 90 weeks.

The FERC licensing phase of the schedule will include a 15 week preparation period in parallel with initial engineering design activities. The initial design activities will include finalizing the project arrangement and preparing turbine/generator procurement documents. The earliest date scheduled for receipt of the FERC License will be week 95, shortly after which time the civil construction contract document will be ready for bidding. This License lead time of 80 weeks is somewhat longer than the processing time required for the recently issued Lawrence Hydro Project (FERC No. 2800) on the Merrimack River in Massachusetts. To avoid schedule delays, the latest date for receipt of License will be week 108.

The critical portion of the Construction Schedule will be the closure of the outlet conduit through the dam to allow penstock and bypass installation and power plant construction to take place. This has been optimistically scheduled to take place during the relatively dry four month period of July through October, weeks 132 through 150 of the schedule. The reservoir will be kept drawn down during this period by means of pumps. Timely delivery of penstocks, bypass control gate, turbines and generators and associated equipment (as well as spillway gates if the upstream powerhouse alternative were to be constructed) will all be crucial to realization of the schedules shown. Procurement of these items has therefore been scheduled during the licensing period and sufficiently in advance of the civil construction contract to allow appropriate manufacturing lead times in each case. Licensing and contract award by week 108 will be essential.

Several potentially adverse circumstances will present themselves if construction were to start at other times of the year or if high flows were to occur during the summer season. Potential problems will include loss of partially completed tunnel and power plant installation, winter concreting operations, overtime and extra shift operations, and many other possibilities for which contingency planning will be required. The construction schedule for plant commissioning at the upstream site on Plate 13 will require 54 weeks from week 108 and a similar period for the downstream site. Each schedule has been based on separate Electrical and Mechanical Installation Contracts awarded 8 weeks after the Civil Construction Contract.

(d) Project Cash Flow

With a conservative assumption of consecutive licensing and engineering activities, a commercial service date of January, 1985 is reasonably attainable. Assuming 6 percent annual escalation of estimated 1978 costs, the cash flow requirement for the recommended downstream site only, by quarter (13 week period), is presented in Table 2.2. The calculated allowance for funds during construction (AFDC) has been estimated assuming a 7.0 percent annual cost of money and end of period payment. The total project cost, including AFDC, escalated to the commercial service date, is thus \$13,931,000.

2.3 - Preliminary Environmental and Safety Assessments

(a) Existing Conditions

The proposed hydroelectric facilities at North Hartland lie within and on federally owned lands. The development will be integrated with the existing North Hartland Reservoir which is currently being operated for flood control purposes as a unit of the comprehensive plan of flood protection for the Connecticut River Basin. The existing reservoir and adjacent areas are scenically attractive, provide significant wildlife habitats and are used for recreational activities on a relatively small scale.

(b) Preliminary Environmental Assessment

The proposed development of hydroelectric potential will have negligible impact on the present terrestrial and aquatic systems both during construction and operation of the facilities.

Current evaluations of alternatives for hydroelectric installations have identified essentially three principal development concepts. Two of these involve raising the existing reservoir conservation pool level by 25 feet and construction of a power plant immediately downstream of the dam. The third alternative will make use of the present reservoir operating level in conjunction with a powerplant located about 700 feet downstream from the dam. To assist in the selection of the most favorable alternative, preliminary environmental and safety assessments have been conducted. These assessments identified the major impacts anticipated from construction and operation of the proposed hydroelectric facilities.

Detailed environmental/safety assessments will be required as part of the licensing process. The current study on the other hand, has been brief and preliminary and has been adapted to the level of feasibility assessment appropriate at this time. The study consisted of a preliminary review of pertinent environmental reports, a site reconnaissance and contacts with individuals from state and federal agencies having expertise on the terrestrial and aquatic ecosystems found within the project area.

A summary of the environmental impact assessment is presented in Table 2.3.

(c) Preliminary Safety Assessment

Construction of the proposed hydroelectric facilities will potentially impact the safety of the public as well as construction workers in the immediate vicinity of the powerplant. Appropriate precautions will be necessary to minimize these risks. Design and operating procedures will be formulated to insure that no significant change in risks to public safety will arise during operation of the hydroelectric installations.

The results of the preliminary safety assessment are summarized in Table 2.4.

2.4 - Marketing Studies

Current VEC plans for future peaking generation requirements are based on purchases of gas turbine capacity until 1989. Alternatives available to VEC beyond that date are confined to further purchases or investment in oil-based generation sources. Commissioning of North Hartland in 1985 is a reasonably attainable objective which would result in displacement of 5700 KW of gas turbine capacity and a total of 11,980,000 KWh of generation per year, of which at least 5,133,000 KWh are oil-based.

Consideration of the future scarcity and more rapid escalation in costs of fuel-dependent sources, indicates hydroelectric peaking generation to be more

economic on a present worth basis over a 30 year period. VEC could derive maximum hydro potential from a hydro site of the particular capacity envisaged. The proposed project will closely conform to and coordinate with the utility power requirement of the Cooperative. Additional generation capacity presently available to VEC may be used to backup the North Hartland plant during periods of seasonally low flows. Reserve requirements for the proposed project also presently available to VEC will additionally allow full use of the hydro potential for firm power requirements rather than so-called "dump power" sales for energy not carefully fitted to the system's daily and monthly load curves.

2.5 Recommendation

Based on the findings of this report it is recommended that a FERC license application be filed for the project at an early date.

TABLE 2.1

NORTH HARTLAND DAM PROJECT
PRELIMINARY PROJECT COST COMPARISONS (THOUSANDS \$)
TOTAL INSTALLED CAPACITY - 6.0 MW

		A L T E R N A T I V E S					
		1	2	3	4	5	6
<u>Account Item</u>		<u>2-Tube⁽¹⁾</u>	<u>2-Propeller⁽²⁾</u>	<u>2-Bulb⁽³⁾</u>	<u>2-Straflo⁽³⁾</u>	<u>1-Kaplan⁽⁴⁾</u>	<u>2-Tube⁽⁵⁾</u>
330	Land & Land Rights	38	38	38	38	38	38
331	Structures & Improvements	555	542	564	432	713	655
332	Reservoirs, Dams & Waterways	3,897	4,137	4,137	4,137	4,127	2,804
333	Turbines & Generators	2,160	3,970	3,600	3,200	4,370	2,160
334	Accessory Electrical Equipment	160	275	275	275	275	160
335	Misc. Power Plant Equipment	25	30	30	30	118	25
336	Roads & Recreation Facilities	97	97	97	97	97	85
353	Substation Equipment	87	87	87	87	87	87
355/6	Transmission	<u>506</u>	<u>506</u>	<u>506</u>	<u>506</u>	<u>506</u>	<u>506</u>
Sub-Total		7,525	9,682	9,334	8,802	10,331	6,520
Contingencies (15%)		<u>1,129</u>	<u>1,452</u>	<u>1,400</u>	<u>1,320</u>	<u>1,549</u>	<u>978</u>
Direct Cost		8,654	11,134	10,734	10,122	11,880	7,497
Engineering & Administration (20%)		<u>1,731</u>	<u>2,227</u>	<u>2,147</u>	<u>2,024</u>	<u>2,376</u>	<u>1,500</u>
TOTAL PROJECT CAPITAL COST		<u>10,385</u>	<u>13,361</u>	<u>12,881</u>	<u>12,146</u>	<u>14,256</u>	<u>8,997</u>

NOTES: (1) Horizontal, single-regulated units
 (2) Vertical, fixed-blade units
 (3) Horizontal, fixed-blade units
 (4) Vertical, double-regulated unit
 (5) Downstream location (all others upstream)

TABLE 2.2

NORTH HARTLAND DAM PROJECT
ESCALATED CASH FLOW REQUIREMENTS

<u>Year</u> ⁽¹⁾	<u>Period</u>	<u>Payments</u> <u>(\$1000)</u> (2)	<u>Escalation</u> <u>Factor</u> (3)	<u>Escalated</u> <u>Payments</u>	<u>Cumulative</u> <u>Payments</u>	<u>AFDC</u> ⁽⁴⁾ <u>(\$1000)</u>	<u>Cumulative</u> <u>AFDC</u>
1981	OND	70	1.26	88	88	0	0
1982	JFM	70	1.34	94	182	1.5	1.5
	AMJ	70		94	276	3.3	4.8
	JAS	70		94	370	4.9	9.7
	OND	100		142	512	6.6	16.3
1983	JFM	115	1.42	163	675	9.2	25.5
	AMJ	127		180	855	12.3	37.8
	JAS	148		210	1065	15.6	53.4
	OND	266		378	1443	19.4	72.8
1984	JFM	552	1.50	828	2271	26.5	99.3
	AMJ	5000		7500	9771	41.5	140.8
	JAS	2109		3164	12935	173.5	314.3
	OND	300		450	13385	231.9	546.2

- NOTES:
- (1) Based on commercial service date (2 units) Jan. 1, 1985
 - (2) For 6000 KW installation, downstream powerhouse location.
 - (3) Escalation of 1978 costs at 6% per annum
 - (4) Allowance for Funds During Construction (AFDC) at 7 percent annual interest, end of period payments, accumulated through commercial service date.

TABLE 2.3 - SUMMARY OF ENVIRONMENTAL ASSESSMENTS

Factor Considered	Raise Normal Operating Level by 25'	Locate Power Plant Downstream, Reservoir Level Unchanged
Land Use	Minor effect on existing land use. Inundation of 140 additional acres of land all of which currently owned by Federal Government.	No impact.
Hydrology & Water Quality	Increase in evaporation losses. Minor effect on temperature structure. Muddied discharge water downstream during construction. Increased erosion and turbidity downstream during operation.	Downstream effects during construction and operation as for raised level alternative.
Air Quality	Short term effects during construction only.	Short term effects during construction only.
Terrestrial Biology	140 acres will be cleared to accommodate raised level. Minor vegetation loss around reservoir perimeter due to level fluctuation. Displacement of wildlife from lower areas to higher ground. Increased pondage available to waterfowl.	Localized clearing for penstock, power plant access road, and transmission line. Minor vegetation loss due to periodic drawdown. Temporary displacement of wildlife away from site area during construction.
Aquatic Biology	Increased impoundment will benefit future fish propagation. Fish displacement to calmer fringes along downstream sections of river during power generation.	Downstream effects as for raised level alternative. Possible displacement of bass spawning areas close to shore.
Socioeconomics	No impact on populated areas and economic activity in the vicinity. Inundation of some of recreational facilities in vicinity of reservoir will require relocation of facilities. Localized displacement of game and fish will have minor effect.	Negligible effects on populated areas, economic activity, and recreational resources.
Effect on Historic Sites	No Impact.	No Impact.
Energy Conservation	Additional power for public use will be available using a non-depletive energy resource.	As for raised level alternative.

Note: Transmission line impacts are excluded from the above assessments.

TABLE 2.4

NORTH HARTLAND DAM PROJECT
SUMMARY OF CREATED RISK ASSESSMENTS

Factor Considered	Raise Normal Operating Level by 25'	Locate Power Plant Downstream, Reservoir Level Unchanged
Created Risks	<p>Potential risks increased by</p> <ul style="list-style-type: none"> - Larger impoundment volume - Increased internal pressure in discharge piping - New high voltage transmission lines. - Increased downstream discharge. <p>Proposed design, construction and operating procedures will minimize risks.</p>	<p>Increased risk due to larger impoundment volume is eliminated. Other increased risks as for alternative concept.</p> <p>Proposed design, construction and operating procedures will minimize risks.</p>

SECTION 3

PROJECT DATA

3 - PROJECT DATA

North Hartland Dam is located on the Ottauquechee River, 1.5 miles upstream from its confluence with the Connecticut River. The federally-owned dam is operated by the Corps of Engineers, as one unit in a coordinated system of flood control structures in the Connecticut River Basin. The general site plan is shown in Plate 1, Appendix A and a summary of the basic data for the site in Table 3.1.

The project assessment has been greatly facilitated by the availability of drawings of existing structures provided by the Corps of Engineers. This data, together with a site examination have allowed establishment of the technical feasibility of the proposed development with a reasonable degree of confidence. Further optimization of plant size and more accurate estimation of expected generation will be possible with further hydraulic analysis. Such analyses would include additional data and refinement of downstream tailwater conditions and more detailed simulation of flow releases below the dam. More rigorous definition of capacity and energy values would also be necessary for effective optimization studies to be undertaken.

3.1 - Description of Existing Facilities

Photographs of existing facilities are presented at the end of Section 3 of this Report.

(a) Dams and Reservoirs

The dam is a rolled earth and rockfill dam with a 24-foot top width at an elevation of 572 feet msl. The embankment consists primarily of impervious fill with upstream and downstream zones of rockfill. The downstream slope is 2H to 1V downstream; upstream the slopes are 2H to 1V above elevation 480 feet msl and 2.5H to 1V below elevation 480. Inclined gravel drains are provided to intercept seepage water. A dike, 52 feet in height, closes off a saddle south of the dam area.

The reservoir is long and narrow and has a surface area of about 215 acres at the current permanent pool elevation of 425 feet msl and 1110 acres at the crest of the overflow spillway.

(b) Outlet Works

The outlet works consist of concrete-lined an inlet and outlet channels, a tower type intake located upstream of the dam and a 14'-3" circular concrete conduit through the dam.

The intake structure has three hydraulic, cylinder-operated slide gates for controlling discharges through the outlet works. Three sets of stoplog guides with wooden stoplogs are provided upstream of the gates to permit gate and gate guide inspection and maintenance. A 1000 psig hydraulic pumping unit for the gates is located in the gate control room at the top of the intake, above maximum flood level. The air vent intakes for the gates are located in the floor below the gate control room. Air vents consist of three large ducts extending from near the top of the tower to the downstream side of the gates. Only the gate control room and the floor below it are heated. Access to the intake is via a service bridge extending from the top of the dam to the gate control room at the top of

the intake tower. Stairs are provided for access to the gate area about 160 feet below. A service road leads to the intake at elevation 450 for installation and removal of stoplogs, and if necessary, removal of gate equipment through a watertight hatch located at that level.

The outlet conduit extends from a transition immediately downstream of the gates to the downstream toe of the dam. Water from the conduit discharges through a 100-foot long concrete-lined channel with 20 feet high walls, into a 25 feet wide, vertical-sided channel in rock. This channel discharges into the lower river channel about 700 feet downstream.

(c) Spillway

The spillway is an L-shaped side-channel inlet type, with a concrete overflow weir, designed to discharge extreme flood flows. The partly concrete-lined, partly unlined side-channel discharges about 1000 feet downstream of the spillway crest.

3.2 - Site Inspection

The site was inspected by the project team September 25 and 26, 1978. A report on this inspection is attached to this report as Appendix B.

In general all structures are well maintained and in excellent condition. However, there is some minor evidence of cracking and deterioration of concrete surfaces in the spillway, probably due to frost action. The spillway has never been operated; nevertheless, some remedial repair work of the spillway is probably called for.

There is also evidence of minor leakage through construction joints in the intake tower which reportedly occurred during major floods in 1969 and 1972. These leaks are currently of no significance but may require remedial work if the permanent reservoir pool elevation is raised.

The proposed structures downstream of the dam will entail substantial excavations in existing river bed materials and rock. No major difficulties are anticipated provided existing ground slopes in overburden are not undercut and the usual construction precautionary and dewatering measures are taken. Excavated slopes in overburden materials are not anticipated to be unusually large. Excavation slopes in the existing rock, which is predominantly a fine-grained well-jointed slate, are expected to be stable with a minimum of rock support.

3.3 - Hydraulic Data

All data used in the investigation are based on information contained in project maps, drawings and reports provided by the New England Division, Corps of Engineers and historical river data from the U.S. Geological Survey.

(a) Streamflows

The drainage area of the Ottawauechee River at North Hartland Dam is 221 square miles. Hydroelectric potential at the dam has been assessed on the basis of average monthly river flows derived from records at the USGS gage (No. 01151500) located 1800 feet downstream from the dam. The period of record is from 1936 to 1977; adjustments have been made to allow for reservoir storage after the dam became operational in 1961.

Average monthly river flow data are presented in Table 3.2. Minimum releases during operation of the reservoir for possible power generation purposes are also indicated in Table 3.2. These releases follow recommendations made by the Corps of Engineers, New England Division, Waltham, Massachusetts.

(b) Flood Flows

The reservoir is typically operated to provide storage of flood waters, followed by controlled releases to alleviate flood damage downstream. The reservoir is generally maintained at a low level to provide this storage capacity. During large floods, the low level outlet is kept closed until the reservoir level reaches a predetermined limit.

Extreme floods are discharged over the emergency spillway and through the low level outlet. The standard project flood (SPF) and routing for the Ottawauechee River at the North Hartland Reservoir, as developed by the Corps of Engineers, are shown in Figure 3.1. The derived hydrograph has a peak inflow of 71,000 cfs. Routing of the SPF through the reservoir results in a maximum water surface elevation of 549.1 feet and a maximum outflow of 8500 cfs.

The hydrograph and routing for the spillway design flood (SDF) are shown in Figure 3.2. Peak inflow for this flood is 199,000 cfs and maximum outflow 171,000 cfs, which includes 159,900 cfs over the spillway plus 10,100 cfs through the outlet works. For an initial reservoir level of 545.5 feet, the crest of the emergency spillway, the maximum reservoir level is 567 feet. Data provided by the USGS for "one day high values" for the period of record indicates a 100-year recurrence flow of approximately 11,600 cfs at the North Hartland gaging station. The gage height for this flow is 11.5 feet. A similar depth has been assumed for the river channel immediately downstream of the dam in estimating the maximum tailwater design elevations for the power plant.

(c) Reservoir Area and Capacity

Reservoir area and capacity data are presented in Table 3.3. The reservoir was formerly maintained at elevation 410 feet in winter months and 425 feet in summer months. It is understood that the level is currently being maintained at 425 feet year-round when flow conditions permit.

Alternatives considered for development of hydroelectric potential include the possibility of raising the reservoir permanent pool elevation to 450 feet. Normal daily reservoir drawdown from this elevation will be limited to approximately 1.2 feet in summer months and 2.3 feet for the remainder of the year. Alternatives based on the current permanent pool elevation of 425 feet will entail daily drawdown of up to approximately 1.8 feet in summer and 3.5 feet in other periods.

(d) Hydraulic Design Data

In general, turbines have been rated for average reservoir and tailwater conditions during the wettest month of April.

The following hydraulic design data have been established for the preliminary conceptual design of power facilities at upstream and downstream locations:

	<u>Upstream</u>	<u>Downstream</u>
Reservoir elevation (feet msl):		
- maximum:	450.0	425.0
- normal:	449.5	423.9
- minimum:	447.8	421.5
Tailwater elevation (feet msl):		
- maximum:	393.0	369.0
- normal:	384.8	360.5
- minimum:	383.0	359.5
Normal gross head (feet):	64.7	63.4
Normal net head (feet):	55.9	51.6
Design (rated) flow (cfs):	1550	1680
Minimum flow (cfs):	310	336

The selected "normal" or rated design conditions relate to average reservoir and tailwater levels during daily operation of the generating plant. Head losses through the intakes, penstocks and power plant have generally been estimated on the basis of Corps of Engineer and USBR standard design practices.

Tailwater rating curves were developed for the assumed tailrace channel geometries (shown on Plate 2). These rating curves are shown in Figure 3.3.

3.4 - Power Values

The proposed North Hartland Dam project will be utilized essentially as a peaking plant with an annual capacity factor of about 20 percent. The alternatives available to VEC for meeting future increases in peaking power demand are the purchase of, or direct investment in gas turbines or hydro installations.

Detailed marketing studies for the proposed hydroelectric development are discussed in Section 12 of this report. Precise values for power and energy generation for the proposed project cannot be assigned until appropriate negotiations are undertaken with the New England Power Pool, (NEPOOL), of which VEC is a member. Such negotiations will be part of the project licensing process. The FERC publication entitled "Final Draft Hydroelectric Power Evaluation" (August 1978), identifies preliminary capacity and energy values for gas turbines in New England with private financing as \$30.50 per KW per year and 30.5 mills per KWh (20 percent capacity factor) respectively. These values were considered adequate for use in the evaluation of installed capacity and selection of alternative project arrangements.

3.5 - Site Photographs

Photographs of the following project features were taken September 25, 1978:

- Reservoir and Inlet Tower
- Spillway
- Outlet Channel and Downstream Area
- Conduit Outlet

Copies of these photographs are presented on the following pages.

RESERVOIR & INLET TOWER

SPILLWAY

OUTLET CHANNEL & DOWNSTREAM AREA

CONDUIT OUTLET

TABLE 3.1
NORTH HARTLAND DAM PROJECT
SITE DESCRIPTION

<u>LOCATION</u>	Ottauquechee River North Hartland, Vermont
<u>DRAINAGE AREA</u> (sq. mi.).....	220
<u>STORAGE CAPACITY ALLOCATIONS</u>	
(Acre ft)	
Winter/Spring - Elev. 410	71,400 (6.1")
Summer/Fall - Elev. 425	68,750 (5.8")
<u>DAM</u>	
Top Elevation (ft, msl)	572
Maximum Height (ft)	185
Length (ft)	1,520
Type	Earthfill with rockfill protection
<u>SPILLWAY</u>	
Type	L-shaped side-channel spillway/Ogee weir
Length (ft)	450
Elevation (ft, msl)	546.5
Area at Crest (acres)	1,175
<u>OUTLET WORKS</u>	
Type of Conduit	Circular
Diameter (ft)	14.25
Length (ft)	743
Gates	6' x 10.5' (3)
Invert Elevation (ft, msl)	390
<u>MAXIMUM RELEASE RATE</u>	
(cfs)	6,000
<u>SPILLWAY DESIGN FLOOD</u>	
Design Inflow (cfs)	199,000
Design Spillway Discharge (cfs)	159,900
Design Surcharge (ft)	20.3
Freeboard (ft)	5.2
<u>STANDARD PROJECT FLOOD</u>	
Design Inflow (cfs)	71,000
Design Spillway Discharge (cfs)	8,500
Design Surcharge (ft)	2.6
<u>BECAME OPERATIONAL</u>	1961
<u>MAXIMUM POOL LEVEL</u>	Apr. 1969 - 128.2 ft.
Percent Flood Storage Utilized	63

TABLE 3.2
NORTH HARTLAND DAM PROJECT
AVERAGE MONTHLY RIVERFLOWS (CFS)

<u>Month</u>	<u>Riverflow</u>	<u>Minimum Release</u>
January	267	40
February	210	40
March	616	40
April	1372	40
May	680	40
June	275	40
July	163	10
August	118	10
September	131	10
October	182	10
November	319	40
December	329	40

TABLE 3.3
NORTH HARTLAND RESERVOIR AREA AND CAPACITY
 (DA = 220 square miles)

<u>Elevation</u> (msl)	<u>Stage</u> (ft)	<u>Area</u> (acres)	<u>Capacity</u> (ac/ft)
390	0	Gate Invert Elevation	
410	20	80	700
Minimum Pool Elevation = 410			
410	20	80	0
415	25	130	625
420	30	170	1,250
425	35	215	2,350
Permanent Pool Elevation = 425			
425	35	215	2,350
430	40	255	2,400
435	45	280	4,825
440	50	305	6,225
445	55	330	7,875
450	60	355	9,525
455	65	380	11,450
460	70	410	13,350
465	75	430	15,500
470	80	450	17,650
475	85	470	20,000
480	90	495	22,350
485	95	505	24,950
490	100	540	27,525
495	105	515	30,325
500	110	595	33,100
505	115	620	36,250
510	120	650	39,400
515	125	685	42,825
520	130	715	46,200
525	135	815	50,300
530	140	915	54,375
535	145	975	59,250
540	150	1,030	64,100
545	155	1,085	69,500
546.5	156.5	1,100	71,100
Spillway Crest Elevation = 546.5			
550	160	1,140	74,900
555	165	1,235	81,100
560	170	1,330	87,300
570	180	1,480	101,400

1-inch runoff = 11,725 acre-feet

SUMMER STANDARD PROJECT FLOOD HYDROGRAPH

FIGURE 3.1

SPILLWAY DESIGN FLOOD HYDROGRAPH

FIGURE 3.2

TAILWATER RATING CURVES

SECTION 4
ALTERNATIVE
FACILITY DESIGNS

4 - ALTERNATIVE FACILITY DESIGNS

4.1 - Approach to Analysis

The power output of a hydroelectric plant is essentially a function of the available head and flow at any given time and the characteristics of the turbine/generator installation in terms of unit flow capacity, speed and efficiency. At the given head and selected unit speed, the turbine/generator may be operated in a number of settings requiring different discharges and consequently power outputs. The turbine efficiency and, in turn, the output will also vary with head, setting and consequently, flow. Turbines may or may not be equipped with inlet control wicket gates and/or variable pitch propeller blades which may be used to control the flow.

For the purposes of this study, the turbine "rated" output was assumed to be that at the selected design net head and maximum flow. For preliminary design purposes, all units were assumed to have wicket gates which will be fully open at the "full-gate" or maximum flow condition, or alternatively, variable pitch propeller runners for load variation. Maximum efficiency was assumed to occur at the "best gate" condition, say 90 percent of full gate, for which the flow will be correspondingly less than the maximum for the particular head. The efficiency at full gate, and for all other heads and gate settings will be less than maximum by varying amounts. Typical curves of efficiency versus flow and output assumed in the study are illustrated in Appendix F.

In the operation of a hydroelectric power plant both head and flow can vary hourly, daily, monthly, seasonally and yearly. The objective of an analysis to determine the available power potential at a given site is to attempt to simulate as closely as possible the actual operation of a given installation at the site. In detailed optimization studies for a selected plant size and dam height, this simulation would normally be undertaken for an actual or synthesized representative sequence of river flows for time intervals as short as one hour over a period of one or up to several years. In performing this simulation, certain rules of operation are generally observed such as:

- (a) Reservoir operating rules for maximum and minimum water levels, spillway and minimum streamflow releases.
- (b) Maximum and minimum periods of plant operation, weekdays and weekends.
- (c) Preferred gate settings and minimum operating flows for unit operation.

It is generally not economically practicable to undertake such simulations in a feasibility study such as that currently being made. A simpler approach is necessary which will approximate reasonably closely a more detailed simulation and allow rapid consideration of numerous alternative selections of rated head and flow and numbers and types of unit. The approach used in the current study was based on average flow data for each month of the year utilizing daily flow records (provided by the USGS). Descriptions of the Acres American computer model and input data used to undertake these analyses are presented in Appendix F. Studies made to evaluate plant design alternatives are described in Sections 4.2 through 4.8 and 5.

4.2 - Plant Operation

The generating facilities at North Hartland will be designed to provide power during daily peak periods in the VEC system using the available head and reservoir outflow. The existing reservoir will be operated on a daily cycling basis to insure that the level is restored to the permanent pool elevation every 24 hours while still maintaining at least the minimum downstream release requirement. Thus the available flow for power generation is dependent upon river inflow, storage capacity, required outflow and the period of operation. The daily sequence of operation proposed for North Hartland will be selected to provide essentially optimum power and energy output within these constraints. The generation period will vary from month to month according to the river inflow and minimum release requirements listed in Table 3.2.

The use of the existing intake and conduit structures for power generation purposes necessitates the installation of trashracks at the intake, steel lining of the existing conduit to withstand greater internal pressures and provision of a separate downstream bypass and control gate. These facilities are discussed further in Section 6 of this report.

During normal operation of the powerhouse and outlet works, the existing slide gates within the inlet tower will be kept fully open and the conduit will be operated with downstream control. Depending on the river flow, the powerhouse will be operated as follows:

- River Flow Less Than Plant Flow - While the units are operating, the downstream control gates will be closed, with all flow passing through the turbines. When the units are shut down for reservoir recovery, the downstream control gate will be opened sufficiently to pass the required release flow.
- River Flow Greater Than Plant Flow - It will be possible, within limits, to discharge through both the turbine and control gates simultaneously should river inflow exceed plant flow. However, as discharges through the gate increase, the head loss in the conduit will also increase, decreasing the net head at the turbines. Operation of the units will at some point become impractical. In such cases, operation of the turbines will be curtailed for periods while appropriate reservoir level drawdown is made. During these periods of high discharge, when the units are not operating, the downstream control gate will be fully opened and flow will be controlled by the three intake slide gates.

4.3 - Turbine Alternatives

With the available flows at North Hartland, a gross head of between 60 and 66 feet or a net head of 45 to 55 feet, the station capacity will be between 2,000 and 8,000 KW. The following types of turbines may therefore be applicable to the North Hartland development:

- fixed blade propeller
- Kaplan (adjustable blade propeller)
- Francis
- cross flow.

For the propeller and Kaplan units, several alternative power plant configurations are also available.

(a) Type of Unit

- (i) Fixed Blade Propeller - The fixed blade propeller turbine would normally be the least expensive installation from a capital cost standpoint. The units, however, have poor part load efficiency resulting in a loss in energy output at low flows unless several units are installed. The units could be provided for two modes of operation:

- single-regulated, with wicket gates
- unregulated, without wicket gates.

The units with wicket gates and governors can be used for operation at part load. If the wicket gates and governors are eliminated, a cost reduction for the turbine of about 20 percent can generally be expected. The units, however, would have to operate at a fixed point, with no part load capability. The unit would be brought "on-line" by opening the intake valve and connecting the unit to the electrical system as soon as synchronous speed is reached. Unit speed would be maintained by system frequency and the unit output would be a function of the head on the unit.

- (ii) Kaplan - The Kaplan unit is hydraulically the same as the fixed blade propeller except that the runner blades are adjustable, providing improved part load efficiencies. As a "rule of thumb", Kaplan units are about 15 percent more costly than propeller turbines.

With the Kaplan unit, two modes of operation can be provided:

- double-regulated, with wicket gates
- single-regulated, without wicket gates.

With a double-regulated unit, the unit speed (and load) is controlled by operation of the wicket gates. The runner blades are adjusted to maintain optimum efficiency, providing very good part load efficiency.

For a single-regulated unit, without wicket gates, the governor operates the adjustable runner blade to regulate speed and load. The resulting efficiency curve is somewhat of a compromise between the double-regulated Kaplan and the propeller. With a single-regulated Kaplan, the unit must be brought "on-line" by opening the inlet valve (or gate) in a similar manner to an unregulated propeller unit. The single-regulated Kaplan unit has a somewhat improved part gate efficiency over a regulated propeller unit at about the same cost. The regulated propeller, however, has two lines of defense for shutting down the unit; the wicket gates and the inlet valve. On the other hand, the single-regulated Kaplan only has one, the inlet valve. For small units of the type being considered for North Hartland, the single line of protection should be satisfactory.

- (iii) Francis - Francis units are normally applicable to higher heads, generally above 100 feet. In the early part of the century when small units were developed, the Francis was used almost exclusively because

of lack of development of the fixed blade propeller and Kaplan units. The Francis unit was also more suited to varying head than fixed blade propeller turbines. Francis units have somewhat better part load efficiency than fixed blade propellers, though less than Kaplan. Furthermore, Francis units do not require as deep a setting, which is an advantage at installations with high rock levels.

Francis units do not appear to be the economically suitable for the North Hartland installation for the following reasons:

- The runner diameter is generally larger than the fixed blade propeller or Kaplan runner, resulting in increased turbine costs and powerhouse dimensions.
- Unit speed is slower, resulting in higher generator costs.

It is believed that the increased equipment and powerhouse costs would more than offset the deeper excavation required for a propeller or Kaplan unit. Unless a low cost "standard" design unit becomes available, there is no advantage in considering a Francis unit at North Hartland.

- (iv) Cross Flow - The cross flow turbine is a radial impulse type turbine manufactured by Ossberger of Germany and distributed in North America by Stapenhorst, Inc. of Point Clare, Quebec. The peak efficiency for these units is lower than for other types. Nevertheless, the units have good part load efficiency, and because the turbine is basically an impulse type, it can be set relatively high above minimum tailwater level, reducing powerhouse excavation costs.

To date, the largest cross flow unit in operation can accommodate only 247 cfs. A relatively large number of units would therefore be required at North Hartland. A recent DOE study entitled "Report on Turbogenerating Equipment for Low Head Hydroelectric Developments" indicates that equipment costs for cross flow units are higher than for other types of turbines. Power plant costs are thus likely to be much higher for this type of unit than for the other types of turbines.

(b) Unit Configuration

For fixed blade propeller or Kaplan types of unit, the following configurations could be adopted:

- vertical, with spiral case
- horizontal tube
- horizontal bulb
- horizontal Straflo.

Although inclined configurations could also be provided for the tube, bulb or Straflo units, for ease of installation horizontal units are preferred. For the North Hartland installation, a Francis unit would probably be of the vertical type with a spiral case.

- (i) Vertical with Spiral Case - This is the more conventional type with a vertical runner and shaft and an elbow draft tube. The requirement for a spiral case and elbow draft tube will probably increase the powerhouse dimensions (and costs) over other arrangements. Traditionally the equipment costs for the vertical units are lower than the other types. This may not be the case at North Hartland for the small physical size of units being considered.
- (ii) Horizontal Tube - These units are manufactured by Allis Chalmers in North America and by some European manufacturers (AB Bofors, KMW). Although the powerhouse width will be reduced relative to the vertical units, the powerhouse depth is usually not significantly less, since the draft tube must be located below the generator. The units can be provided with speed increasers to reduce generator costs.
- (iii) Horizontal Bulb - From the point of view of the powerhouse arrangement, horizontal bulb (and similarly Straflo) units are the least complex. Bulb units have essentially "straight-through" horizontal waterpassages with the generator located in a steel bulb in the middle of the waterpassage upstream of the turbine. These units are designed and manufactured in Europe and Japan. Powerhouse width is about the same as for tube units. Relatively high speeds compared to tube or vertical types are usually selected to reduce the size of the direct connected generator. In spite of the straight horizontal waterpassage, a deeper unit setting is generally required for the bulb and the powerhouse depth is therefore not reduced significantly. Equipment costs for bulb units are generally higher than for vertical or tube units.
- (iv) Straflo - Straflo units are a rather unique design with the generator incorporated at the outer rim of the turbine runner. These units are manufactured by Escher Wyss. Powerhouse width and depth are similar to those of a bulb, but the length is generally less. Powerhouse structure costs would probably be lowest with the Straflo arrangement. With the generator at the outer rim of the turbine runner, the increased unit inertia over the bulb unit increases the regulation characteristics of the unit. A critical design feature of the Straflo unit is the seals at the periphery of the turbine runner to prevent egress of water into the generator area.

The main drawback of the Straflo unit is lack of experience. None has yet been installed in North America. In Europe, no installations have been recently built, although several units are now under construction and a large number of small units were installed before 1952. In addition, equipment costs are generally being quoted at relatively high levels for Straflo units.

(c) Standard Designs

To make hydraulic turbine generating equipment more economically attractive, several manufacturers are now offering "standard" designs. The intent of this approach is to spread the engineering cost for such a

turbine over a number of units, thereby reducing the cost compared to a "custom built" unit. The net head of about 50 feet at North Hartland is near the upper limit of structural design for standard units. For example:

- Allis Chalmers offers "standard" tube units up to 50 feet head and 5000 KW. Discussions with the manufacturer indicate that these units may also be suitable for a marginally increased head.
- AB Bofors are offering similar standard tube units up to 100 feet head and 5000 KW.
- Fuji Electric are offering standard bulb units up to 55 feet head and 3400 KW.
- Escher Wyss are offering standard Straflo units up to 50 feet head and 22,000 KW.

Other manufacturers such as Barber Hydraulic Turbine and Vevey also offer standard units, but these appear to be too small for the North Hartland application. The decision on selection of a fixed blade propeller unit, single-regulated Kaplan or double-regulated Kaplan may be influenced somewhat by the availability of "standard" designs.

A review of standard Francis unit designs offered by various manufacturers has indicated that units of the capacity being considered for North Hartland, up to about 8000 HP, are not available. Francis units have therefore been eliminated from further consideration.

(d) Regulation

As noted above, the units can be provided with wicket gates or adjustable runner blades to enable partial load operation at low flows. With a relatively long penstock, the gate operating time must be set sufficiently low to prevent excessive water hammer in the conduit. The slow gate operating time will not permit satisfactory speed regulation of the units. Unit speed must be maintained by the frequency of the electrical system to which the units are connected. Consequently, a speed sensing governor will not be needed, and a slightly more economical gate control unit can be provided.

4.4 - Generator Alternatives

The two types of generators for installation in low head, small capacity hydro plants are:

- synchronous generators, and
- induction generators.

For relatively small capacities, induction generators would preclude the use of much of the station control and protective relaying equipment usually provided with synchronous generators. This is often technically possible and economical in a large electric system on which the plant has little impact.

Enquiries made to manufacturers have indicated that with small machines a significant saving in generator cost may in fact be realized by the use of induction generators. Data furnished by the Ideal Electric Company indicates the economic break-even point for synchronous and induction generators occurs at about 5000 KW machine size.

For most ratings, a higher unit speed (900, 1200, or 1800 rpm) results in a lower weight and a consequent reduction in cost of the generator. For most ratings of horizontal tube turbines, the turbine speeds are less than 400 rpm. This necessitates the use of a speed increaser between the turbine and the generator. For generators with ratings of up to 2250 KW and a speed of 900 rpm or greater, induction generators requiring no excitation system are believed to offer a significant advantage in terms of smaller unit overall dimension and reduced weight, compared to synchronous generators.

Unless restricted by system and/or operational requirements such as power factor improvement, isolated plant operation, black start, etc., for low head hydro plants with generating units of up to 2250 KW, the application of induction generators instead of synchronous generators could therefore result in significant reduction in electrical cost of the plant.

Use of induction generators at North Hartland may be complicated by the machine VAR requirements which would have to be available either from the VELCO transmission system, six miles distant, or by capacitance connected to the generators. Use of capacitance and possibly additional switching for protection against overvoltage and over- and underfrequency conditions in case of separation from the system, may prove to be a significant cost item.

The main U.S. supplier of standard tube units, Allis Chalmers, does not currently offer induction generators at lower cost than synchronous machines. This may therefore discourage their use at North Hartland. Nevertheless, further consideration of this equipment should be undertaken during later phases of project development.

In the application of synchronous generators, some cost saving could also be achieved through the use of brushless synchronous units instead of synchronous machines with a separate static excitation system. The operating cost would be reduced appreciably for an automated, unmanned plant with supervisory controls for remote operation.

4.5 - Site Potential

(a) Available Options

The essential objective of the current study is to develop a technically and economically feasible design for the North Hartland plant. Numerous alternatives are available for obtaining an optimum installation, involving variation of the following design-related parameters:

- (i) Reservoir operating procedures and associated dam and spillway crest elevations;
- (ii) Powerhouse/outlet location and arrangement;
- (iii) Plant capacity and mode of operation;
- (iv) Unit type and number.

The generation potential of the project has been estimated on a monthly basis for various arrangements selected to be representative of the above alternatives. The specific alternatives initially investigated were:

- (i) Permanent pool elevations of 450 feet and 425 feet msl;
- (ii) Two power plant locations;
- (iii) Design generation flows of 1100, 1500, 1600, 1700 and 2000 cfs;
- (iv) Vertical Kaplan and fixed blade propeller; and horizontal tube, Straflo and bulb-type turbines;
- (v) One-, two- and three-unit installations.

Tailwater elevations were selected to develop maximum available head in each case.

Initial studies of pool elevation and plant location were based on a two-unit installation. Consideration of plant installed capacity and type of unit were also based on a two-unit powerhouse at the upstream location. Consideration of the number of units was also based on the upstream location. Studies of the downstream powerhouse location were based on the two-unit installation, essentially as selected for the upstream case.

The selection of pool elevation is discussed in Sections 4.6 and 4.7, and of plant location in Section 4.8. The examination of plant and unit type and size is the subject of Section 5 of this report.

(b) Design Constraints

The maximum allowable head under DOE guidelines for small hydro is 66 feet (20 meters). The current reservoir operating levels, 420 to 425 would provide only 35 to 40 feet of head for a plant located immediately downstream from the dam. To achieve the desired head, the operating pool would have to be raised to 450 msl or the plant located far enough downstream to gain an additional 25 feet of head. Raising the reservoir operating pool will require that the current reservoir operation be modified or the spillway and dam crest elevations also be raised.

The primary consideration in developing proposed hydroelectric plant designs for the site was the latitude likely to be permitted in using the reservoir and outlet works of the dam. Liaison has been maintained during the study between Acres and the New England District, Corps of Engineers. The Corps have provided the following guidelines on the use of the existing facilities:

- (i) No significant reduction in the flood control effectiveness of the project can be permitted.
- (ii) Sudden variations of the reservoir outlet and/or plant discharge cannot be permitted.
- (iii) No increase in the spillway discharge for the design flood conditions can be permitted.
- (iv) Flow curtailment for extended periods, during construction of the power facilities or subsequently, cannot be permitted.

- (v) If the existing conduit is used to supply water to the turbines, it is necessary to provide a bypass at the outlet for maintenance of flow during periods of plant shut-down.
- (vi) Small reductions in the outlet works discharge capacity are acceptable.

Implementation of the guidelines, which relate to flood control, storage, and spillway and outlet discharges, has been given full consideration in the study. Guidelines which are oriented to safety are discussed in Sections 10 and 11.

4.6 - Spillway Modification

Raising of the reservoir permanent pool elevation may be accomplished by modifying the existing spillway to limit overflow discharge levels.

(a) Approach

Designs for spillway modification options were made within existing constraints for the discharge and maximum reservoir level during the passage of the SDF and SPF as shown on Figures 3.1 and 3.2. The Corps computer program 23-J2-L2-32 (Hydrograph Combining and Routing Program) was used to route the design flood hydrographs.

Raising the normal pool to an elevation of 450 feet compared to the original 410 feet, will reduce the flood storage by 9500 acre feet; if a flood occurs with the pool at elevation 450, the spillway discharge will increase above acceptable limits. To mitigate for this lost storage, a section of the spillway crest may be lowered to release, earlier in the outflow hydrograph period, some of the water that would normally be stored. Gates will be required within the crest slot, to throttle the outflow, to within the maximum allowable limits, as shown on Plate 4.

With these modifications to the spillway, the peak discharge for the SPF will not be increased but the duration of the peak will be longer than the current period (see Figure 3.1). The effect of the modified peak on flood control benefits calculated originally by the Corps downstream in the Connecticut River will require further analysis. It is believed that a modified spillway design, which will satisfy the Corps requirements, could if necessary be achieved.

(b) Alternatives Evaluated

To allow early passage of flood flows, the crest in one portion of the spillway will be lowered to form a slot. Slot widths of 50, 100 and 200 feet wide were investigated with both bascule and radial gate control. The results of this analysis are summarized in Table 4.1.

Two arrangements were selected for costing:

- installation of a bascule (pelican gate), 100 feet wide by 11.5 feet high;
- installation of two radial gates, each 24 feet wide by 28 feet high.

(i) Bascule Gate

The bascule gate will consist of a long overflow gate pivoted at the bottom. For the purposes of this study it was assumed that the gates will be operated by a hydraulic cylinder located below the gate in the spillway face. Gate operation will be automatic by water level float controls.

(ii) Radial Gates

Each radial gate will be square in shape, operated by a wire rope hoist mounted above the maximum reservoir level and supported on concrete piers. Normally the water will pass under the gate; however, during passage of the maximum flood, water will flow over the gates in the closed position. Gate operation will be automatic.

The arrangements for both gates are shown in Plates 4 and 5.

Cost estimates were prepared for these two arrangements including:

- breaking out concrete;
- new concrete;
- excavation of an approach channel;
- equipment costs including installation.

Although the bascule gate arrangement will require less modification to the spillway structure, equipment costs are higher. The radial gate alternative was found to be about \$500,000 lower in cost; this alternative was therefore selected for use in the study for comparison with other project arrangements.

(c) Intake Structure Modifications

The generation flow would be drawn from the reservoir through the existing intake structure and outlet conduit. The raised reservoir level will consequently necessitate modifications to the intake, including:

- increasing the height of the stoplog checks about three feet (the top of the checks are presently at elevation 450, the proposed reservoir level);
- increasing the elevation of the intake tower access road (which is presently at elevation 450);
- providing a curb around the intake equipment hatch;
- providing trash racks at the upstream side of the intake structure to prevent large debris from passing through the turbines.

Use of the intake for reservoir releases will in certain circumstances lead to high velocities through the trash racks. With extreme maximum head, these high velocities will tend to create rack bar vibration leading to fatigue failure. Possible solutions to this problem are:

- (i) Design the rack for the worst possible discharge.
- (ii) Provide a mechanical device for lifting the racks when the structure is being used for high discharges.
- (iii) Move the rack some distance upstream of the intake and substantially increase the rack area.
- (iv) Design the racks for reasonably high velocity with the knowledge that they may fail due to vibration under extreme high discharges.

The first three alternatives may be very costly. Considering the very rare occurrence of extreme reservoir levels, it has been assumed that the fourth alternative will be preferred. Should the racks actually fail, then they would pass through the outlet works without causing damage to the turbines. It should be noted that the mode of failure would be due to vibration and may not actually occur with the high discharge.

4.7 - Spillway and Dam Raising

Raising the dam and spillway structures may also be undertaken to mitigate the loss of flood storage due to an increased normal pool level. The storage between the original design winter-spring pool level of 410 feet and elevation 450 feet is 9500 acre feet. Raising of the spillway crest by 7.5 feet will be required to compensate for this loss of storage. The crest will be raised by placing concrete on top and forward of the existing crest as shown on Plate 3. The spillway design flood was routed assuming the starting water surface at the new crest, elevation 554.00. The top of dam elevation was estimated by adding the original freeboard, 5.2 feet, to the maximum water surface during passage of the spillway design flood. On this basis, raising of the crest of the dam by 6 feet to elevation 578, will be required.

The embankment height will be increased by excavating the crest and downstream slope areas of the embankment to remove the surficial material, scarifying the surface of the impervious material, extending the rockfill and impervious material on the upstream side to the desired elevation, and placing and compacting rockfill over the downstream slope.

Since the increase in embankment height will not alter the phreatic line, the downstream slope will tend to become more stable due to the added weight of the material. Although the stability of the upstream slope will be somewhat reduced, especially under rapid drawdown conditions, the reduction in safety factor will not fall below the acceptable minimum for rapid drawdown conditions. A detailed stability analysis of the embankment will be necessary before selection of the final design of this alternative can be made.

Modifications will also be required for this alternative to the top of the intake tower, including raising the gate control room, air vent inlets and the access bridge by about 6 feet to prevent flooding at the maximum water levels.

Implementation of this alternative will be somewhat complicated because of real estate requirements, and the necessity to raise the adjacent saddle dike. The Corps currently own in fee land to elevation 505 feet and have flowage easements on land below elevation 550 feet. The guide taking elevations would increase together with land rights costs. In addition, relocations of graves in a cemetery, houses, and roads in the area will be necessary. The main road into the site crosses the saddle dike and this road will also require raising.

Raising the spillway and dam is estimated at a cost of \$2.3 million more than the modified spillway scheme; this alternative has therefore not been considered further.

4.8 - Powerhouse Location

(a) Alternatives Considered

Two plant location were examined. The first, upstream alternative was assumed to be located approximately 260 feet downstream of the dam adjacent to the existing outlet channel. A new bypass control gate and concrete-lined outlet will be located in the existing channel south of the powerhouse, as shown on Plate 2. The second downstream alternative was assumed to be located approximately 680 feet downstream of the dam at the the end of the existing outlet channel. The new bypass for this alternative will be located alongside and to the east of the powerhouse.

The assumed maximum gross head at the upstream site was 65 feet developed between the raised permanent pool elevation of 450 feet and an estimated tailwater elevation of 385 feet. That at the downstream site was 64.5 feet between permanent pool and estimated tailwater elevations of 425 and 360.5 feet respectively. The head at the downstream site will be developed by excavation of up to approximately 10 feet of rock in the existing river bed. Information on river bed and rock levels at this site is scanty at this time and will require augmentation during later stages of development.

For each site, the penstock will be 12'0" diameter, bifurcating into two 10'6" diameter inlets at the powerhouse, as shown on Plates 2 and 3. Each plant will house two 3.0 MW tube-type units as shown on Plate 6. Selection of this installation is discussed further in Section 5.

Design data for the two sites are as follows:

	<u>Upstream</u>	<u>Downstream</u>
Net design head (ft)	56	52
Unit demand flow (cfs)	780	840
Rated unit capacity (KW)	3,000	3,000
Annual generation (GWh)	12.74	11.98

(b) Preliminary Cost Estimates

Total cost summaries for each installation are presented in Table 2.1. These costs are inclusive of diversion works necessary in each case to insure continuation of minimum reservoir releases during construction. Installation of the penstock in the existing conduit will be undertaken during the summer dry period, with the upstream intake gates closed. Provision has been made in each case for a temporary pumping facility in the reservoir to discharge the minimum reservoir releases over the spillway crest structure. In the case of the upstream power plant, costs are inclusive of the radial gate alternative spillway modification, and the necessary modifications to the intake structure as discussed in Section 4.6.

(c) Comparison of Alternatives

From Table 2.1, the downstream powerhouse location will be approximately \$1,388,000 or about 15 percent less expensive than the upstream which must be considered significant. Similarly, a comparison of power plant annual costs and values of generation, as presented in Table 4.2, indicates a significant difference between the projected net benefits at each location, in favor of the downstream alternative. Detailed marketing studies are discussed in Section 12.

The upstream site, requiring raising of the permanent reservoir pool elevation and major spillway modifications is likely to be more difficult to license. The downstream site will also offer some potential for improved economy by additional tailrace excavation to increase the head. An intermediate site between those considered may also lead to economies resulting from a shortened penstock and reduced risks of flooding from spillway discharges. The downstream location with a reservoir permanent pool elevation of 425 feet has therefore been selected as the preferred alternative at this time.

TABLE 4.1

NORTH HARTLAND DAM PROJECT
DAM AND SPILLWAY MODIFICATIONS

Alternative*	Crest El. (ft. msl)		Standard Project Flood			Spillway Design Flood		
			Reservoir Level		Max. Discharge (cfs)	Reservoir Level		Max. Discharge (cfs)
	Dam	Spillway	Initial	Maximum		Initial	Maximum	
1	572	546.5	410	549.1	8,500	546.5	566.7	171,000
2	572	546.5	450	549.9	11,774	546.5	566.7	171,000
3	572	528	450	549.1	8,500	546.5	566.7	171,000
4	572	533.5	450	549.1	8,500	546.5	566.7	171,000
5	572	538	450	549.1	8,500	546.5	566.7	171,000
6	572	535	450	549.1	8,500	546.5	566.7	171,000
7	572	535	450	549.1	8,500	546.5	566.7	171,000
8	578	554	450	556.4	7,151	554	573	154,000

*Description of Alternatives

- 1 - Original design, dam and spillway
- 2 - Original design, dam and spillway
- 3 - Original dam design, modified spillway, 50' slot, 2 radial gates
- 4 - Original dam design, modified spillway, 100' slot, 4 radial gates
- 5 - Original dam design, modified spillway, 200' slot, 8 radial gates
- 6 - Original dam design, modified spillway, 100' slot, 1 bascule gate
- 7 - Original dam design, modified spillway, 200' slot, 2 bascule gates
- 8 - Raised dam, modified spillway, raised crest

TABLE 4.2

NORTH HARTLAND DAM PROJECT
POWERHOUSE LOCATION ALTERNATIVES

	<u>Upstream</u>	<u>Downstream</u>
Installed Capacity (KW)	6,000	6,000
Average January Output (KW) ⁽¹⁾	5,570	5,695
Annual Generation (MWh)	12,736	11,980
Capacity Factor	0.24	0.23
Total Project Cost (\$x1000)	10,385	8,997
<u>Annual Cost (\$ x 1000)</u>		
Fixed ⁽²⁾	1,142	990
O&M ⁽²⁾	82	82
Total	1,224	1,072
Present worth ⁽³⁾	15,189	13,302
Levelized (mills/KWh)	<u>40</u>	<u>37</u>
<u>Annual Value (\$ x 1000)</u>		
Capacity ⁽⁴⁾	170	174
Generation ⁽⁴⁾	388	365
Present worth ⁽³⁾	14,793	14,091
Levelized (mills/KWh)	<u>39</u>	<u>39</u>
Benefit-Cost Ratio	<u>0.97</u>	<u>1.06</u>

NOTES:

- (1) In excess of 3 hours daily.
- (2) Annual fixed charge 11%, O&M \$13.72 per installed KW (1978), per FERC recommendations.
- (3) Present worth, 30 year period, 7% interest rate, energy values only escalated 8% per annum.
- (4) FERC power values for New England (1978), \$30.50 per KW, 30.5 mills per KWh.

SECTION 5

PLANT AND UNIT
SIZE SELECTION

5 - PLANT AND UNIT SIZE SELECTION

5.1 - Installed Capacity

The proposed hydroelectric power installation at North Hartland will take full advantage, within site limitations, of the available head, reservoir releases and power values. The proposed installed capacity of 6000 KW has been selected at this time for the purpose of providing economic peaking power benefits to the VEC system on a life cycle cost basis. A preliminary comparison with a less cost-effective 3000 KW mid-range alternative is presented in Table 5.1.

As a member of NEPOOL, VEC must comply with regulations which stipulate a minimum two-hour firm daily plant output to qualify for capacity credit as a peaking installation. For conceptual design purposes, a minimum daily generation period of three hours was assumed. This minimum period will impact the capacity selection only in the drier summer months. Appreciably longer periods of generation will be possible in winter months, particularly January, the current annual peak month.

(a) Selection of Design Head and Flow

As discussed in Section 4.5, design head at North Hartland is essentially a function of upstream pool elevation variations, tailwater assumptions and head losses through the intake, penstock and generating plant. Examination of installed capacity was initially based on the proposed upstream powerhouse location with a permanent power pool elevation of 450 feet and a derived tailrace rating curve as shown in Figure 3.3 (It is considered that similar evaluations for the downstream location will produce generally similar results.). Head losses, based on standard Corps of Engineers and USBR design practice, are a function of the design flow and the geometry of the water passages as shown on Plates 2 and 3. The penstock diameter of 12'-0" is essentially the largest practical size which may be installed in the existing 14'-3" diameter conduit. At this diameter, penstock velocities of as much as 17.7 fps will occur at a generation flow of 2000 cfs, the maximum considered, with consequent high friction and related head losses.

Initial evaluations were made assuming a two-unit horizontal tube installation, with single-regulated Kaplan turbines. Within the limitations of available reservoir releases, the unit and plant design flows were essentially governed by the available runner sizes for standard tube units manufactured by Allis Chalmers. In the applicable net head range of 50 to 60 feet and unit flows of 500 to 1000 cfs, only three runner diameters are available, 2000, 2250, and 2500 mm (see Figure 5.1). Unit design flows of 550, 750, 800 and 1000 cfs were consequently selected for evaluation as being representative of the range of installed capacity appropriate to the installation. The 550 cfs flow was considered appropriate to the 2000 mm runner size, the 750 and 800 cfs flows to the 2250 mm size and the 1000 cfs flow to the 2500 mm size.

(b) Annual Generation

Monthly average periods of generation, power outputs and generation, were determined using the methods described in Sections 4.1 and 4.2. A summary of results is presented in Table 5.2.

For purposes of comparison, potential power and generation revenues were estimated for each month on the basis of FERC recommended power values for 1978, for an alternative combustion turbine installation. The average output in the VEC peak demand month of January was used to determine the annual power value.

Although January capacity values continue to increase for each larger installation considered, annual energy falls. In net annual value terms, a plateau is reached between 5867 and 6055 KW of rated plant capacity (Table 5.2, alternatives 2 and 3). Consideration of future trends in power values and the available alternatives to VEC for meeting peak power demand will not significantly alter this result, which was confirmed during consideration of power marketing (Section 12). A plant installed capacity of 6000 KW was therefore selected. The appropriate tube units for such an installation will each be rated at 3000 KW with a runner diameter of 2250 mm or 88.6 inches.

The design characteristics and output data for this installation are presented in Table 5.3.

5.2 - Type of Unit

As stated in Section 5.1, initial assessment of installed capacity was based on a two-unit, tube configuration. The powerhouse arrangement is shown on Plate 6 and described in more detail in Section 6. For purposes of comparison, two-unit, vertical, fixed blade propeller, and bulb and Straflo installations were also evaluated.

(a) Vertical Fixed Blade Propeller Units

Evaluation of these units for the upstream site was undertaken essentially in parallel with tube units, for unit flows of 550, 750, 850 and 1000 cfs. Results of this evaluation are presented in Table 5.4. Although a 6000 KW probable optimum installation is again indicated, power and generation values are generally about 1 percent less. The arrangement for the two 3000 KW fixed blade propeller turbines and directly connected vertical synchronous generators is shown on Plate 7. Each turbine will have a steel spiral case with a butterfly-type intake valve upstream of the spiral case.

A structural steel powerhouse superstructure will be provided over the units to enclose the generator and associated miscellaneous electrical and mechanical equipment. Hatches will be provided in the superstructure roof for installation of the turbine and generator equipment, using a mobile crane. The heaviest lift during erection will be about 30,000 pounds. The arrangement for the ancillary electrical equipment and the miscellaneous mechanical equipment will be essentially the same as for the two-unit tube alternative.

Cost comparisons in Table 2.1 indicate a substantial increase of almost \$3 million or 30 percent for the fixed blade alternative relative to the tubes. This cost difference may be less in an actual bid situation. These estimates are based on regulated units with wicket gates and governors. Although some reduction in cost may be realized by elimination of wicket gates, there would be corresponding decrease in generation for the

unregulated units. Further cost reductions of about \$130,000 may be possible by provision of a high speed generator drive through a speed increaser. The benefits of this reduction have to be viewed in light of efficiency reduction and potential increased maintenance costs for speed increasers. Such an approach is not recommended for this size of vertical unit.

On the basis of current cost estimates, vertical fixed blade propeller units cannot be recommended. Nevertheless the possibility of economies to be gained from using these units should not be overlooked during later phases of project evaluation.

(b) Horizontal Bulb Units

Although a detailed analysis has not been made, the installation of two 3000 KW horizontal bulb units has been briefly considered. A typical horizontal bulb unit installation is illustrated on Plate 8. The selected units are based on package bulb units essentially as manufactured by Fuji Electric. These units are fixed blade propellers with wicket gates; power and generation data may therefore be assumed similar to the fixed blade propeller alternative (Table 5.4). The additional generation obtained by use of adjustable blades is probably similar to that for the tube, approximately 1 percent, and is therefore not considered cost-effective.

Costs for this alternative are also presented in Table 2.1, indicating a prohibitively large increase relative to tube units of \$2.5 million, or 25 percent.

(c) Horizontal Straflo Units

The installation of two 3000 KW Straflo units has also been considered, as illustrated on Plate 9. The selected units are based on standard designs currently being marketed by Escher Wyss. These units will also be fixed blade with adjustable wicket gates for which power generation will be essentially as indicated for fixed-blade units in Table 5.4.

Estimated costs (Table 2.1) are \$1.8 million, or 17 percent greater than for tube units.

5.3 - Number of Units

The basis for selection of number of units, within the constraints of available machinery and head, was essentially the value of annual generation. In general, due to scale economies, for a given installed capacity, fewer, larger units of any particular type are less expensive than a larger number of smaller units. On the other hand, to a limited extent, a larger number of units allows greater flexibility of operation and lesser impact of unit outages. Fewer units with adjustable blades will also allow flexibility of operation but usually at increased machinery cost.

The potential for improved generation with a 6000 KW installation at North Hartland was investigated for the following power plant alternatives at the upstream site:

- 3 - single-regulated Kaplan (tube) units
- 3 - fixed blade propeller units
- 1 - double-regulated vertical Kaplan unit

The results of this evaluation are presented in Table 5.5. Each of the three-unit alternatives will increase annual generation by about 1.3 percent, or an equivalent \$5200 per annum at 1978 levels. By inspection, the additional cost of a three-unit power plant will not be justified.

The arrangement for a single, vertical 6000 KW Kaplan unit installation is shown on Plate 10. The turbine/generator arrangement will be the same as for the fixed blade propeller units, with steel spiral case, vertical direct connected synchronous generator and butterfly-type turbine intake valve.

Because of the weight of the generator (heaviest lift about 80,000 pounds) it has been assumed that a 45-ton powerhouse crane will be provided above the unit. The arrangement for the ancillary electrical equipment and miscellaneous mechanical equipment will be essentially the same as for other alternatives.

The single unit Kaplan installation will increase annual generation relative to the two-unit tube alternative by 0.3 percent or an equivalent \$1100 per annum. From Table 2.1 the additional cost of this alternative is not justified.

5.4 - Equipment Selection

Data was obtained from several U.S. and foreign manufacturers for turbine, generating and associated equipment. Prior to selection of unit capacity, it was necessary to make preliminary estimates of design requirements. Data was subsequently adjusted to take account of design changes on the basis of engineering judgment and experience.

The initially selected preliminary design requirements for each alternative considered are presented in Appendix C of this transmittal, together with a list of manufacturers from whom design data was received. The unit efficiency characteristics did not weigh heavily in consideration of unit selection except for some reduction in output due to lower efficiencies of the standard tube turbines; best gate efficiency and overall efficiency of the other alternatives were reasonably consistent. The peak efficiencies of all units except the standard tube are within approximately 1 percent. The fixed blade units have steeper efficiency curves and for this reason were considered for multiple unit installations. The multi-unit schemes have a potential advantage over single-unit installations during outage and repair since the plant can still generate with the remaining units.

On the basis of preliminary benefit-cost evaluations, the 6000 KW, two-unit, single-regulated, Kaplan or tube installation was selected. A detailed description of this plant configuration is presented in Section 6 of this report. Detailed cost evaluations for this alternative, at both upstream and downstream powerhouse locations, are presented in Section 7.

TABLE 5.1

NORTH HARTLAND DAM PROJECT
PLANT CAPACITY ALTERNATIVES

	<u>Alt. 1⁽¹⁾</u>	<u>Alt. 2</u>
Installed Capacity (KW)	6,000	3,000
Average January Output (KW)	5,695	2,850
Annual Generation (MWh)	11,980	11,700
Capacity Factor	0.23	0.45
Total Project Cost (\$x1000)	8,997	7,105
<u>Annual Cost (\$ x 1000)</u>		
Fixed	990	782
O&M	82	58 ⁽²⁾
Total	1,072	840
Present worth	13,302	10,424
Levelized (mills/KWh)	<u>37</u>	<u>30</u>
<u>Annual Value (\$ x 1000)</u>		
Capacity ⁽³⁾	174	87
Generation ⁽³⁾	365	293
Present worth	14,091	10,642
Levelized (mills/KWh)	<u>39</u>	<u>30</u>
Benefit-Cost Ratio	<u>1.06</u>	<u>1.02</u>

NOTES:

- (1) See Table 4.2
 (2) O&M \$19.21 per installed KW (1978), per FERC recommendations.
 (3) Power values for combustion turbine and available mid-range alternatives, \$30.50 per KW, 25 to 30.5 mills per KWh.

TABLE 5.2

NORTH HARTLAND DAM PROJECT
SINGLE-REGULATED KAPLAN (TUBE) UNITS (2)
ANNUAL GENERATION (UPSTREAM SITE)

	<u>A L T E R N A T I V E</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Unit Full Gate				
Flow (cfs)	550	750	800	1,000
Unit Best Gate				
Flow (cfs)	484	660	704	880
Rated Head (ft)	60.4	56.5	55.2	49.2
Unit Full Gate				
Power (KW)	2,302	2,934	3,056	3,403
Unit Best Gate Power				
(KW)	2,073	2,642	2,752	3,064
January Power (KW)	4,209	5,437	5,712	6,610
Jan. Daily Generation				
Time (Hrs.)	6.1	4.4	4.1	3.0
January Generation				
(KWh)	781,037	731,397	718,963	661,701
Annual Generation				
(KWh)	13,134,965	12,845,121	12,626,609	11,809,392
Capacity Factor	0.33	0.25	0.24	0.20
Capacity Value (\$) ⁽¹⁾	128,388	165,832	174,220	201,601
Generation Value (\$) ⁽²⁾	400,616	391,776	385,112	360,186
Annual Value (\$)	<u>529,004</u>	<u>557,608</u>	<u>559,332</u>	<u>561,787</u>

NOTES:

(1) Based on FERC recommended \$30.50 per KW yr. (combustion turbine)

(2) Based on FERC recommended 30.5 mills/KWh (20% capacity factor)

TABLE 5.3

NORTH HARTLAND DAM PROJECT
PRELIMINARY TURBINE AND GENERATOR DATA
(UPSTREAM POWERHOUSE LOCATION)

STATION CAPACITY ----- 6000 KW

NUMBER OF UNITS ----- 2

UNIT CAPACITY ----- 3000 KW

TURBINE:

- type ----- single-regulated Kaplan

- configuration ----- tube

- net head (full gate) ----- 56 ft.

- full gate horsepower ----- 4230 hp

- full gate efficiency ----- 86%

- best gate efficiency ----- 88%

- full gate flow ----- 775 cfs

- runner diameter ----- 88.6 in.

GENERATOR:

- type ----- synchronous

- configuration ----- horizontal drive through
speed increases

- output ----- 3700 KVA⁽¹⁾

- power factor ----- 0.9

- power ----- 3300 KW⁽¹⁾

- speed ----- 900 RPM

- efficiency (including speed increaser) --- 95%

NOTE:

(1) Generator rating based on single unit operation with lower tailrace level and increased net head.

TABLE 5.4

NORTH HARTLAND DAM PROJECT
FIXED BLADE PROPELLER UNITS (2)
ANNUAL GENERATION (UPSTREAM SITE)

	<u>A L T E R N A T I V E</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Unit Full Gate Flow (cfs)	550	750	850	1,000
Unit Best Gate Flow (cfs)	484	660	748	880
Rated Head (ft)	60.4	56.5	53.7	49.2
Unit Full Gate Power (KW)	2,275	2,899	3,122	3,364
Unit Best Gate Power (KW)	2,073	2,642	2,845	3,064
January Power (KW)	4,209	5,437	5,960	6,610
Jan. Daily Generation Time (Hrs.)	6.1	4.4	3.9	3.0
January Generation (KWh)	781,044	731,397	704,817	661,701
Annual Generation (KWh)	13,025,004	12,741,165	12,101,232	11,597,839
Capacity Factor	0.33	0.25	0.22	0.20
Capacity Value (\$) ⁽¹⁾	128,389	165,831	181,778	201,601
Generation Value (\$) ⁽²⁾	<u>397,263</u>	<u>388,606</u>	<u>369,088</u>	<u>353,734</u>
Annual Value (\$)	<u>525,652</u>	<u>555,437</u>	<u>550,866</u>	<u>555,335</u>

NOTES:

- (1) Based on FERC recommended \$30.50 per KW yr. (combustion turbine)
 (2) Based on FERC recommended 30.5 mills//KWh (20% capacity factor)

TABLE 5.5

NORTH HARTLAND DAM PROJECT
3-UNIT AND 1-UNIT INSTALLATIONS
ANNUAL GENERATION (UPSTREAM SITE)

	<u>A L T E R N A T I V E</u>		
	<u>1</u>	<u>2</u>	<u>3</u>
Type of Unit	Horiz. Tube	Vert. Prop.	Vert. Kaplan
No. of Units	3	3	1
Unit Full Gate Flow (cfs)	500	500	1,500
Unit Best Gate Flow (cfs)	440	440	1,320
Rated Head (ft)	56.5	56.5	56.5
Unit Full Gate Power (KW)	1,956	1,933	5,867
Unit Best Gate Power (KW)	1,761	1,761	5,283
January Power (KW)	5,437	5,437	5,437
Jan. Daily Generation Time (Hrs.)	4.4	4.4	4.4
January Generation (KWh)	731,397	731,397	731,397
Annual Generation (KWh)	13,017,062	12,906,844	13,052,090
Capacity Factor	0.25	0.25	0.25
Capacity Value (\$) ⁽¹⁾	165,831	165,831	165,831
Generation Value (\$) ⁽²⁾	<u>397,020</u>	<u>393,659</u>	<u>398,089</u>
Annual Value (\$)	<u><u>562,851</u></u>	<u><u>559,490</u></u>	<u><u>563,920</u></u>

NOTES:

(1) Based on FERC recommended \$30.50 per KW yr. (combustion turbine)

(2) Based on FERC recommended 30.5 mills/KWh (20% capacity factor)

**ALLIS-CHALMERS
STANDARD TUBE UNITS SIZING CHART**

FIGURE 5.1

SECTION 6

CONCEPTUAL
FACILITY DESIGN

6 - CONCEPTUAL FACILITY DESIGN

The project arrangement and conceptual layouts of the proposed development recommended at the downstream powerhouse location are shown on Plates 2, 3, and 6 of Appendix A.

6.1 - Intake and Penstock

The reservoir will generally be maintained at a permanent pool elevation of 425 feet msl for power generation purposes. The existing intake structure and outlet works will be used in a dual function as the intake and penstock for the power development as well as the reservoir outlet. The only modification to the intake will be the installation of trash racks appropriately sized to prevent passage of fish and debris and the addition of water level monitoring and automatic gate control equipment.

(a) Penstock Design

The existing conduit was originally designed to withstand earth fill loading plus hydrostatic head which varied from zero at the outlet up to 175 feet at the inlet during the passage of the spillway design flood. The wall thickness of the conduit and the steel reinforcing were reduced according to the reduction in pressure.

For the proposed installations, the conduit will operate with downstream control and the pressure will normally be relatively constant. Thus, in the downstream sections of the conduit the head could potentially increase from zero up to 175 feet. This could result in bursting or increased exfiltration from the existing concrete conduit. During powerplant operation, transient pressures resulting from valve closure may also occur.

The stresses in the outlet conduit have been investigated under the combined effects of the existing fill over the conduit and the internal water pressures under operating conditions. The effect of the fill on the conduit was evaluated according to "Conduits, Culverts and Pipes", Corps of Engineers publication EM 1110-2-2902, dated March 1969. Information on the original design conditions and concrete and steel reinforcing specifications for the conduit and outlet works were provided by the New England District, Corps of Engineers.

The conduit was analyzed for a normal operating maximum gross head of 66 feet, increased by 60 percent to account for transient pressures, and for an extreme maximum head of 175 feet which will occur only during the passage of the spillway design flood.

A cross section of the dam taken through the centerline of the conduit is shown in Plate 2. Under the conditions discussed above, the following results were obtained:

- (i) The stresses in the upstream section of the conduit are within the allowable working stress.

- (ii) The stresses in the remaining sections of the conduit were found to exceed the allowable working stresses.

The upstream section of the conduit was also checked for the condition of fill plus external pressure from 175 feet of water with no internal pressure, and was found to be adequate.

A 12'-0" diameter steel lining is proposed for the conduit from immediately downstream of the transition, to take the additional tension created by the internal water pressure. The annulus between the lining and the existing 14'-3" diameter conduit will be filled with concrete and grouted. Seepage from the conduit is not expected to be a problem.

The penstock will extend approximately 640 feet downstream from the toe of the dam to a steel bifurcation to two 10'-6" diameter inlets to the powerhouse. The 12'-0" diameter steel reservoir outlet bypass will branch from the penstock approximately 100 feet upstream of the bifurcation.

(b) Reservoir Outlet Bypass

The 12'-0" diameter steel bypass will discharge through a control gate into a 100-foot long concrete-lined channel east of the powerhouse and from thence into the Ottawaquechee River.

The control gate will normally be kept closed during operation of the powerhouse, as discussed in Section 4.2. At the higher reservoir stages during and after passage of the SDF, flood water will be discharged through the gate and the power plant shut down.

The Corps Reservoir Regulation Manual for North Hartland Dam lists the maximum conduit discharge as 10,000 cfs. Installation of the steel liner will reduce the outlet conduit capacity to about 7500 cfs depending on the roughness coefficient assumed. The difference of 3600 cfs, which is about 2 percent of the total outflow hydrograph peak, will not significantly impact conditions in the reservoir or downstream during passage of the flood, but will lengthen the period required to draw down the reservoir to normal pool elevation by about 20 percent.

It is assumed that the downstream control gate will be a fixed roller vertical lift gate operated by a wire rope hoist. Structurally, the gate will be designed to withstand a maximum reservoir elevation of 567, and the hoist will be sized to raise the gate under such conditions. To prevent the necessity of adding considerable ballast to the gate, it is assumed that the gates will not be required to close under this extreme head. As noted in Section 4, with high outlet works discharges, the gate will be fully open and discharges will be controlled with the intake slide gates. The gate hoist will be located in an enclosed, heated housing. The gate guides and gate leaf will be heated as necessary to ensure satisfactory operation in winter. The supporting structure for the control gate will be designed so that horizontal hydraulic load on the gate will be transferred to the steel bypass conduit.

Alternatives which will warrant further consideration during preliminary project design stages include a hydraulic hoist rather than a wire rope hoist for the gate, and the provision of a radial gate rather than a vertical lift gate.

6.2 - Power Installations

The recommended two, horizontal 3.0 MW tube-unit powerhouse is shown on Plate 6. The structure will be located at the end of the penstock bifurcation, approximately 680 feet downstream from the dam toe, and adjacent to the downstream control gate, as shown on Plate 2.

The tailrace channel will be excavated to a negative slope of one vertical to four horizontal between the invert of the draft tube up to the invert of the outlet channel. The channel will be 50 feet wide at the tailrace inclining to about 150 feet wide at the confluence of the outlet channel and the Ottauquechee River bed. The channel side slopes will be excavated in rock to slopes of one vertical to one-half horizontal.

The powerhouse itself will not have a superstructure; it is proposed that a mobile crane be used for installation and subsequent major maintenance of equipment and for installation and removal of the draft tube gate. The powerhouse is anticipated to require appreciable excavation in rock, for which reason space requirements inside the structure have been minimized. The layout of electrical equipment is based on minimal allowable clearances with the main breaker and transformer located in a switchyard outside the powerhouse.

(a) Selection of Unit Capacity

As discussed in Sections 4 and 5, it has been assumed that the two-unit tube installation will be the most cost effective at the downstream powerhouse location. Unit and plant rated capacity were evaluated by trial and error for appropriately varied heads and flows, based on use of the standard 2250 mm Allis Chalmers runner selected for the upstream location. Table 6.1 presents the results of these evaluations for unit flows of 750, 840 and 850 cfs.

On the basis of estimated power values, a total 6000 KW station capacity was again selected as the near-optimum size for preliminary study purposes. The design characteristics and output data for this installation are shown in Table 6.2.

(b) Mechanical Equipment

A butterfly type turbine intake valve will be provided upstream of each turbine. Since the horizontal tube unit has no wicket gate, the intake valve will be used to start and stop the unit.

The outlet conduit, downstream control gate and the turbine intake valves will be designed for a head equivalent to the maximum reservoir SDF level of 567 feet msl (Figure 3.2). Although it would be possible to subject the turbines to extreme maximum head, it is not considered necessary to design the units (from a structural standpoint) for such conditions. An extreme head could occur on the turbines only if all the following occurred:

- the turbine inlet valve was left open;
- the downstream control gate was left closed or partially closed;
- the upstream slide gates were left open.

To prevent such an occurrence, the forebay controls will automatically close the turbine inlet valve as the reservoir level rises. Should the valves fail to close, the downstream control gate will automatically open as the reservoir level continues to rise. Considering the rare occurrence of such high water levels, this system is considered adequate.

A draft tube gate will be provided to permit turbine dewatering for inspection and maintenance; the gate will be handled by a mobile crane. Unit dewatering will be accomplished with a portable submersible pump lowered through the access hatch into the draft tube. A sump with a small pump will be provided to handle normal station drainage.

Compressed air requirements will be met with a portable compressor. Unit heaters will provide the necessary powerhouse heating, and a halon fire protection system will be provided.

(c) Electrical Equipment

The preliminary evaluations of electrical equipment for the current study have been based on the use of standardized packaged turbine-generators, including individual unit controls and static excitation equipment. The tube units will incorporate a high speed generator drive through a speed increaser. Loading on the unit will be controlled by gate operators and no speed regulation will be provided.

The proposed single-line diagram for the generating facilities is shown on Plate 11. Each generating unit will be connected through an individual generator breaker to a common cable bus, located inside the powerhouse. The common bus will be connected to a 4.16KV/46KV main step-up transformer, connected to a 46KV transmission line through an oil circuit breaker and a disconnect switch. The 46KV transformer, the oil circuit breaker and the disconnect switch will be located in a small outdoor switchyard adjacent to the powerhouse.

The normal supply for the station service will be tapped from the common cable bus by means of a fused disconnect switch. The alternative supply for the station service will be provided from a local feeder.

A 46KV transmission line, approximately six miles long will be constructed for connection of the power plant output to the existing VELCO 46KV line, located west of the site.

The above electrical arrangement has been derived from several alternative arrangements of plant equipment and systems. The selection of electrical layout was based primarily on economic and technical considerations. The electrical arrangement may be optimized further during later phases of project development, on the basis of utility practice, system reliability and mode of operation.

TABLE 6.1

NORTH HARTLAND DAM PROJECT
SINGLE-REGULATED KAPLAN (TUBE) UNITS (2)
ANNUAL GENERATION (DOWNSTREAM SITE)

	<u>A L T E R N A T I V E S</u>		
	<u>1</u>	<u>2</u>	<u>3</u>
Unit Full Gate Flow (cfs)	750	840	850
Unit Best Gate Flow (cfs)	660	739	748
Rated Head (ft)	54.5	51.6	51.2
Unit Full Gate Power (KW)	2,831	2,999	3,014
Unit Best Gate Power (KW)	2,550	2,700	2,714
January Power (KW)	5,262	5,695	5,739
Jan. Daily Generation Time (Hrs.)	4.4	3.9	3.9
January Generation (KWh)	707,810	681,704	678,647
Annual Generation (KWh)	12,393,861	11,980,395	11,925,464
Capacity Factor	0.25	0.23	0.22
Capacity Value (\$) ⁽¹⁾	160,483	173,919	175,258
Generation Value (\$) ⁽²⁾	<u>378,013</u>	<u>365,402</u>	<u>363,727</u>
Annual Value (\$)	<u>538,496</u>	<u>539,321</u>	<u>538,984</u>

NOTES:

- (1) Based on FERC recommended \$30.50 per KW yr. (combustion turbine)
 (2) Based on FERC recommended 30.5 mills/KWh (20% capacity factor)

TABLE 6.2

PRELIMINARY TURBINE AND GENERATOR DATA
(DOWNSTREAM POWERHOUSE LOCATION)

STATION CAPACITY ----- 6000 KW

NUMBER OF UNITS ----- 2

UNIT CAPACITY ----- 3000 KW

TURBINE

- type ----- single-regulated Kaplan

- configuration ----- tube

- net head (full gate) ----- 53 ft.

- full gate horsepower ----- 4240 hp

- full gate efficiency ----- 86%

- best gate efficiency ----- 88%

- full gate flow ----- 815 cfs

- runner diameter ----- 88.6 in.

GENERATOR

- type ----- synchronous

- configuration ----- horizontal drive through
speed increasers- output ----- 3750 KVA⁽¹⁾

- power factor ----- 0.9

- power ----- 3380 KW⁽¹⁾

- speed ----- 900 RPM

- efficiency (including speed increaser) --- 95%

NOTE:

(1) Generator rating based on single unit operation with lower tailrace level and increased net head.

SECTION 7
COST ESTIMATES

7 - COST ESTIMATES

7.1 - Methodology

In developing preliminary costs for a construction project the detail of cost breakdown must be in relation to the key parameters of ultimate cost. Generally, for hydroelectric facilities which fall into the small hydro range and more specifically for the North Hartland Dam Project, the principal cost components include the turbine-generator equipment and the project excavation, rockfill, structural (or "civil") works. The turbine-generator, which in this case is 34 percent of the total project construction cost, must be responsive to the operating needs of the owner, and provide predictable and reliable performance throughout the plant life (i.e., 40 years). This single item, when bid for procurement, can have a major impact on the project civil works and ultimate project cost. The civil works, approximately 54 percent of the construction cost, must be optimized to reflect the requirements of the generating equipment, operating needs and local site conditions. Since these two items total 88 percent of the project construction cost, the principal effort in estimating applicable quantities, unit costs and equipment cost must be applied to them. The remainder of the project items are less site specific and can be estimated more readily from manufacturer price data and published data on installation labor productivity.

7.2 - Construction Cost Estimating

The actual costs of the civil works of a hydroelectric project or other similar construction will depend on such factors as:

- (a) the availability of experienced contractors
- (b) the amount of similar work regionally and locally
- (c) local labor force and labor relations
- (d) contract document and construction drawing accuracy
- (e) site restrictions and construction techniques used
- (f) weather and site conditions during construction

Construction cost can be heavily affected by any one of these factors or the cumulative effect of all since they ultimately determine the productivity of the contractor.

Engineering estimates for conceptual studies are generally developed by breaking down into distinct units, those major work items which make up the project and which will have a significant impact on project cost. The estimates are subsequently made by taking quantities from conceptual project drawings and assigning unit costs appropriate to the difficulty of work involved. A contingency is added to account for minor items not included in the estimate and for reasonable cost variation, outside that projected in the unit costs. At the conceptual design level, 15 percent of the project sub-total is considered an appropriate contingency, for a project of this size and type.

Itemized breakdowns of cost by type of work, for the two powerhouse locations considered, are presented in Appendix D. These summaries are consistent with the FERC system of accounts (FERC Form 6, "Actual Legitimate Original Cost"). Minor items are included in the major categories of work, where they do not provide a significant impact on overall cost.

Estimated unit costs were based on the cost of materials and labor (including delivery, installation, overheads and profit) required to complete construction of the item of work. Particular reference data used to establish appropriate unit costs include various manufacturers data and U.S. Department of Labor statistics. Reference was also made to the following publications:

- Engineering News Record
- Building Costs File Manual, Eastern Edition, McKee-Berger-Mansueto, Construction Publishing Company, Incorporated
- Dodge Guide for Estimating Public Works Construction Costs, McGraw-Hill Information Systems Company
- Building Construction Costs Data, Robert Snow Means, Construction Consultants and Publishers.

The Association of General Contractors, located in Berlin, Vermont was also contacted in establishing current wage-rates and benefits for the various trades that would be involved in the construction of a proposed hydro-power facility. The rates provided by the association were adjusted to include an allowance of 32.5% for premium time and 22% for payroll, taxes and insurance. The premium was based on a 9-hour work day for five days and 8 hours on Saturdays. Unit costs were marked up appropriately to reflect reasonable contractor overhead and profit.

Land costs were based on data provided by the North Hartland town listers office. This data, together with knowledge of the site and the proposed project facilities, formed the basis upon which individual work activities were assessed. Contractor mobilization costs were estimated for individual construction activities and are reflected in the unit costs.

Principal equipment costs are discussed separately in Section 7.3.

Engineering and Administrative costs account for all costs associated with project management, including acquiring permits and licenses, engineering, detailed design, procurement, site construction management, and commissioning the station. For this type of project the Engineering and Administration costs are approximately 20 percent of the project construction cost.

7.3 - Equipment Cost Estimating

Contacts were made with the following U.S. and foreign major equipment manufacturers for the procurement of preliminary costs and data.

Allis Chalmers	General Electric
Dominion Engineering Works	Siemens-Allis
Bofors - Nohab	McNally Valves
Sulzer Bros. (Escher Wyss)	Dominion Bridge
Nissho - Iwai (Fuji Electric)	

Responses were received from Sulzer Brothers Incorporated, Dominion Engineering Works, Allis-Chalmers, Siemens-Allis, General Electric, McNally and Dominion Bridge. The turbine-generator information received is summarized in Tables 7.1 and 7.2 and presented in detail in Appendix C.

The turbine and generator cost data for the various alternatives are not strictly comparable for the following reasons:

- Different unit ratings and speed were selected in each case.
- Different electrical equipment items were included in each case.

The 4800 KW maximum output selected by Allis Chalmers for 2500 mm tube units was based on operation of a single unit at maximum head. Normal operation of two units at the same head will result in an output of 3250 KW. Utilization of speed increasers for the tube-unit alternative requires smaller, lower cost, high speed (900 rpm) generators. Actual manufacturer cost data was not obtained for bulb units at North Hartland. Costs obtained from Fuji Electric for packaged bulb units for other, similarly sized installations, were used to develop estimates for this project. These costs, together with total project costs for six powerplant alternatives, are summarized in Table 2.1.

These estimates are representative of the selected 6000 KW installation, based on the manufacturers' quotations tabulated in Tables 7.1 and 7.2. Comparison of the various types of installation at the upstream powerhouse location (alternatives 1 through 5) indicates a significant cost advantage in favor of the 2-tube unit alternative, primarily due to lower equipment costs. These lower equipment costs are attributed to standardized, packaged design and manufacture and smaller high speed generators. Despite a higher unit setting than any other alternative, the 2-tube installation is no less expensive in terms of civil construction costs. The higher setting could lead to questions of powerhouse stability. Detailed project design will be necessary to check this problem. The possible requirement for additional concrete weight to overcome the problem is not likely to significantly effect the overall economic comparison.

The 2-unit Straflo installation is comparable in civil construction cost to the 2-unit tube alternative, but more than \$1,000,000 more expensive in equipment costs. The 2-unit bulb and fixed blade propeller alternatives would be considered similar in cost but significantly more expensive than the Straflo. Surprisingly, the single-unit Kaplan installation is at least \$1,000,000 more costly than any other alternative.

Generally, lower unit efficiencies are claimed for tube units than for fixed blade, Kaplan or Straflo units. Nevertheless, generation estimates indicated a tube unit installation produces 91 percent more generation than a comparable fixed blade propeller, and 2 percent less than a single Kaplan installation. (See Tables 5.1, 5.3, and 5.4. The latter difference must be attributed partially to the use of speed increasers. The indicated cost reduction as a result will more than compensate for this loss in efficiency.

Based on manufacturers' information, not only are the standard tube turbine units for North Hartland less costly; delivery schedules are also considerably shorter. This significantly shorter delivery schedule leads to greater flexibility in scheduling and a later commitment of construction funds.

It should be noted that the equipment costs and design data are all preliminary, and that all comparisons and recommendations may change when the suppliers are asked to submit firm bids. For this reason the procurement documents should be issued well in advance of the minimum equipment lead time and should provide opportunities to all reputable manufactures to submit bids on preferred types of installation.

Reliability is necessarily an important consideration. All units are expected to provide a reasonably reliable service over the plant life. Based on long term experience with the conventional vertical propeller units, these would be expected to provide the most trouble-free long term service. For this type of unit, the first significant maintenance items may arise with the wicket gate bushings and stator coil windings which would normally be expected to last 30 years before repair is necessary. With the standard Straflo units, the controlling maintenance factor is the wear of the lip seals. These seals, according to Escher Wyss (Sulzer) literature, require overhaul intervals of about 2 to 5 years. Bearing life for this type of unit is not addressed but may be less than on other types of unit. For the bulb unit a shorter coil life might be expected due to the small generator size and circulation restrictions in the housing. The standard tube turbine life expectancy is controlled mainly by the bearings and gear box. According to literature from Bofors-Nohab, life expectancy of both the guide and thrust bearings and speed increasing gear boxes, is about 100,000 hours. For North Hartland, with a capacity factor of about 25 percent, this life expectancy would be in order of about 45 years.

7.4 - Description of FERC Accounts

(a) Account No. 330.00 Land and Land Rights

Description: Cost of land for a 50 feet wide transmission line right of way has been included under this account. All other lands required for construction of power generation facilities lie within the boundaries of federally owned land for the existing North Hartland Dam. It was assumed that no costs will be charged to VEC for use of these lands or any of the existing flood control structures.

(b) Account No. 331.00 Structures and Improvements

Description: The powerhouse excavation, substructure and superstructure were included in this account together with related plant plumbing, heating and lighting and switchyard civil works. Disposal of excavated rock has been assumed over a land distance of two miles or less.

(c) Account No. 332.00 Reservoirs, Dams and Waterways

Description: This account includes all work for reservoir clearing, and construction at the intake structure, penstock, bypass and tailrace channel. Spillway modifications and gate equipment for the upstream powerhouse alternative were also included in this account. Facilities at the intake include the cofferdam, trashracks installation, raising of the base deck for the upstream powerhouse alternative and provision of additional monitoring and control equipment. It has been assumed that the existing gates may be used without modification. A total of 1050 feet of 5/8" thick steel penstock has

been included in the estimates for the power and bypass conduits for the upstream powerhouse location and 1550 feet for the downstream location. Also included were rock and overburden excavation, bedding material, installation rails and supports, fill, concrete backfill, grouting, anchor blocks, and steel bifurcations and expansion/transition sections at the powerhouse.

The penstock was assumed to be shop-fabricated and prepared prior to delivery to site, erection, welding, final painting and testing. Although steel penstocks have been assumed for study purposes, consideration will be given during detailed design to fiberglass or prestressed concrete alternatives which are considered technically feasible. Preliminary studies have indicated no significant difference in cost for these options, but market considerations may dictate significant cost and delivery advantages in favor of one or other alternative during later phases of project development.

At the powerhouse the draft tube bulkhead gates, bypass gate and lining, and concrete-lined outlet channel were also included, together with tailrace excavation and concrete retaining walls.

Facilities have been included for diversion and handling of continuous reservoir releases during construction of the penstocks and powerplant by means of pumping and/or diversion cofferdams. It has been assumed that, weather conditions permitting, some relaxation of normal reservoir operation will be tolerated during the four months, relatively dry, summer period. These relaxations may include short term reductions in reservoir releases, and allowing the reservoir level to rise to predetermined safe limits.

Spillway modifications for the upstream powerhouse alternative include removal of the necessary concrete slot, installation of rock anchors, construction of the required radial gate concrete crest structure, gate and hoist procurement, installation and testing and excavation of the approach channel.

(d) Account No. 333.00 Waterwheels, Turbines and Generators

Description: Costs under this account include procurement, installation and commissioning of turbines (including inlet valves), governors and associated piping, generators, exciters (voltage regulators) and appurtenances. Also included in this account are all control, metering and relay devices, the bus voltage switchgear and the 4.16/46KV transformer which will be part of the turbine generator procurement package.

(e) Account No. 334.00 Accessory Electrical Equipment

Description: Included in this account is the material and installation cost of conduit, cable, station grounding and batteries and miscellaneous hardware.

(f) Account No. 335.00 Miscellaneous Power Plant Equipment

Description: This account includes the procurement and installation of the various power plant systems including compressed air, unwatering facilities, and fire protection.

(g) Account No. 336.00 Roads and Recreation Facilities

Description: This account includes the clearing, grading and surfacing of gravel roads and parking areas for construction, site maintenance and access to the powerhouse and switchyard. Also included is relocation of recreational facilities in the reservoir for the raised reservoir alternative.

(h) Account No. 353.00 Substation Equipment

Description: Included in this account are the installation of the station high voltage breaker, including grounding, foundations, take-off structure and fencing.

(i) Account Nos. 355.00 and 356.00 Transmission

Description: These accounts include procurement and installation of the 6-mile 46KV transmission line, including poles, insulators, conductors, hardware and breakers.

7.5 - Project Cash Flow

Table 7.3 presents the cash flow requirements, for the recommended downstream site only, by quarter (13 week period) beginning at week 0. The allowance for funds used during construction (AFDC) has been estimated assuming a 7.0 percent annual cost of money and end of period payment. The cost basis is for prices ruling at the end of September 1978 and include no allowance for escalation.

Consecutive licensing, engineering and construction of the project will conservatively allow a commercial service date for two 3000 KW units of January 1985. Table 2.2 represents the cash flow requirement for this date assuming a 6 percent annual escalation of costs. Total project cost in 1985 is thus \$13,931,000.

TABLE 7.1

NORTH HARTLAND DAM PROJECT
TURBINE MANUFACTURER DATA

Item	Allis-Chalmers	Dominion Engineering	Dominion Engineering	Escher Wyss
Type of Unit	2 - Horizontal Standard Tube	2 - Vertical Fixed Blade Propeller	1 - Vertical Kaplan	2 - Horizontal Straflo
Best gate efficiency (%)	(1) NA	91.2	91.8	90.5
Full gate efficiency (%)	NA	88.1	88.5	90.2
Speed (rpm)	(2) 900	257.1	180.0	276.9
Runner diameter (inch)	98.4	86.0	126.0	94.5
Runner setting (ft)	El. 382	El. 378	El. 378	El. 375
Unit rated (generator) output (KW)	3,250	3,200	6,400	3,430
Supply & delivery (\$)	2,088,000	2,300,000	2,800,000	3,000,000
(3) Installation (\$)	418,000	575,000	700,000	750,000
(5) Intake Valves (\$)	---	210,000	200,000	210,000
Total	(4) <u>2,506,000</u>	<u>3,085,000</u>	<u>3,700,000</u>	<u>3,960,000</u>

- NOTES: (1) Not available
 (2) Generator speed with increasor, turbine speed not available
 (3) Assumed 20% of equipment cost for tubes, 25% for others (confirmed with manufacturers)
 (4) Complete with valves, speed increasers and all electrical equipment, including generators, switchgear, controls, and HV transformer.
 (5) Prices provided by McNally Pittsburg Manufacturing Co.

TABLE 7.2

NORTH HARTLAND DAM PROJECT
GENERATOR MANUFACTURER DATA (VERTICAL UNITS)

<u>Item</u>	<u>Siemens- Allis</u>	<u>Siemens- Allis</u>	<u>General Electric</u>	<u>General Electric</u>
Unit Rating (KW)	7,000	3,500	7,000	3,500
Speed (rpm)	225	257.1	225	257.1
Power Factor	0.9	0.9	0.9	0.9
Voltage (KV)	4.16	4.16	4.16	4.16
Height (inches)	170	150	NA ⁽¹⁾	NA
Diameter (inches)				
- overall	240	145	NA	NA
- shipped	130	94	NA	NA
Weight of heaviest piece (tons)	40-45	10-15	NA	NA
Supply & delivery (\$) ⁽¹⁾	560,000	350,000	950,000	600,000
Installation (\$) ⁽²⁾	<u>140,000</u>	<u>88,000</u>	<u>238,000</u>	<u>150,000</u>
Total (\$)	<u>700,000</u>	<u>438,000</u>	<u>1,188,000</u>	<u>750,000</u>

- NOTES: (1) Not available
 (2) Per unit including exciter and regulator
 (3) Assumed 20% of equipment cost (confirmed by manufacturers)

TABLE 7.3

NORTH HARTLAND DAM PROJECT
UNESCALATED CASH FLOW REQUIREMENTS

<u>Year</u>	<u>Period</u> ⁽¹⁾	<u>Payments</u> <u>(\$1,000)</u>	<u>Cumulative</u> <u>Payments</u>	⁽²⁾ <u>AFDC</u> <u>(\$1,000)</u>	<u>Cumulative</u> <u>AFDC</u>
1	1	70	70	0	0
	2	70	140	1.2	1.2
	3	70	210	2.5	3.7
	4	70	280	3.7	7.4
2	5	100	380	5.0	12.4
	6	115	495	6.9	19.3
	7	127	622	8.7	28.0
	8	148	770	11.4	39.4
3	9	266	1036	14.1	53.5
	10	552	1588	19.1	72.6
	11	5000	6588	29.1	101.7
	12	2109	8697	117.0	218.7
4	⁽³⁾ 13	300	8997	156.0	374.7

NOTES: (1) Periods are in quarters, i.e., 13 weeks

(2) Allowance for Funds During Construction (AFDC) @ 7.0 percent annual interest, end of period payments, accumulating through in-service date.

(3) Commercial Service Date - Week 162 or sixth Week of Period 13, downstream powerhouse location.

SECTION 8

CONSTRUCTION
SCHEDULES

8 - CONSTRUCTION SCHEDULES

The project is broken up into two portions, the Engineering Schedule on Plate 12 and the Construction Schedules on Plates 13 and 14 for upstream and downstream powerhouse alternatives. Each schedule shows the principal activities during that project phase. The schedules are considered to be fairly tight in that no significant float time has been included between various activities that are in series, although actual activity durations are, for the most part, liberal.

The line of critical scheduling as presented will depend upon the FERC license preparation and processing activity in order that the general civil contract can be issued at week 108. These schedules are predicated on concurrent activities for licensing and engineering the project, such that the award of equipment contracts and the bulk of detailed design activities proceed prior to receipt of the project license. Since there can be no guarantee that a license will be obtained, it may be expedient to defer expenditures on engineering until a license is granted. The overall schedule would in this case be lengthened by at least 90 weeks.

The construction activity will be awarded in two principal contracts, the general construction civil contract at week 108 for all civil and structural work and the electrical and mechanical contract at week 116 for installation of accessory electrical, station, transmission, and miscellaneous power plant systems. It was assumed that the principal procurement contracts for gates and turbine/generators will include installation service.

Penstock design and separate procurement and installation drawings have been scheduled prior to issue of the civil construction contract package. Penstocks will be delivered in appropriate lengths to the civil contractor for installation at site. This procedure is necessary due to the relatively long delivery period anticipated and to prevent delays in commissioning of the plant.

The civil construction contract award is presumed to be in January and the mechanical and electrical installation contract award in March. These dates are essentially predicated on providing the civil contractor adequate time, in perhaps difficult winter and early spring weather conditions, to mobilize and prepare for crucial penstock and powerhouse construction activities during the following summer. Construction of cofferdams, dewatering and pumping installations for maintenance of reservoir releases through the existing spillway are scheduled for the ensuing spring, prior to initiation of powerhouse and penstock excavations. These facilities are also required in the event of flash flooding during the summer period and the necessity to temporarily reopen the intake gates to lower the reservoir. Access to the site, reservoir clearing and relocation of recreational facilities (for the upstream powerhouse alternative only) may all be undertaken in the intervening period.

The majority of concreting will thus be completed before the end of the year. Penstock installation and powerhouse construction are assumed to coincide with the relatively dry 4-month summer period when the intake gates may be closed and minimum 10 cfs reservoir releases maintained by pumping. Construction of the powerhouse in the downstream location will also require construction of cofferdam diversion and dewatering facilities to allow powerhouse excavation and concreting to commence in May.

SECTION 9

DESCRIPTION OF
EXISTING ENVIRONMENT

9 - DESCRIPTION OF EXISTING ENVIRONMENT

9.1 - Regional Setting

(a) General

The general project area is located in the Ottauquechee River basin in South Central Vermont. The basin area of about 220 square miles is primarily in Windsor County with a small portion extending westward into Rutland County. The reservoir is near the New Hampshire border and includes portions of the Townships of Hartland and Hartford, in Windsor County.

The headwaters of the Ottauquechee River originate in the eastern slopes of the Green Mountains above the town of Sherbourne. The river flows south and east for a total of about 36 miles to the Connecticut River, about 4 miles south of White River Junction. The basin area is sparsely populated, predominantly mountainous and scenic, and is currently used mainly for recreational and wildlife preservation purposes, while also supporting relatively small local industries such as tourism, and some agriculture and timber.

(b) Physiography

The topography of the project area consists predominantly of wooded, steep-sided hills and irregular-crested ridges which rise abruptly from relatively narrow valleys. The Ottauquechee River has eroded through a mantle of predominantly glacial material, into underlying bedrock in places. The river valley is thus generally characterized by glacial deposits, terrace remnants, rock outcrops and incised gorges. The Connecticut River, on the other hand, is still in the process of downcutting through pre-glacial valleys.

The maximum variation in ground elevation in the vicinity of the existing dam is about 1000 feet.

(c) Climate

The Ottauquechee River basin has a variable climate characterized by frequent but generally short periods of heavy rainfall in the summer and longer periods of less intense precipitation in the winter months. Thunderstorms may occur over the basin at any time of the year. Winters are moderately severe with subzero temperatures being common; summers are mild with temperatures over 90° Fahrenheit being infrequent. Average annual temperature in the basin area is about 43°F. Precipitation is fairly well distributed throughout the year, average monthly values ranging from a minimum of 2.74 inches in February to a maximum of 3.87 inches in July. The mean annual precipitation is about 38 inches.

Mean annual snowfall is 86.3 inches of which about 50% occurs in January and February. Serious flooding due to a combination of heavy rain and snowmelt is a possibility nearly every year. The length of the growing season is about 4 months, from late May to late September. Prevailing winds are northwesterly in winter and southerly in summer, averaging 6 to 8 mph.

9.2 - Project Environmental Setting

(a) Existing Facilities

The existing North Hartland Dam is a rolled earth and rockfill structure, 1520 feet long, with a maximum height of 185 feet. The dam has a 450 feet long uncontrolled side channel spillway and a gated, 14.25 foot diameter low-level outlet conduit.

The North Hartland Reservoir is normally maintained at elevation 425 feet msl at which the pool area is 215 acres. The reservoir is operated primarily to desynchronize flood flows of the Ottauquechee River from flow in the Connecticut River. The operation of the reservoir is coordinated with other reservoirs in the Connecticut River Basin to obtain the maximum reduction in overall flood damages. During peak flood runoff periods, water is stored in the reservoir and subsequently released as downstream conditions permit.

At the maximum flood level of 566.8 feet msl the reservoir area is approximately 1430 acres. A total of 1405 acres of reservoir area are owned by the Federal Government in fee simple; flowage easements have been obtained on a further approximately 300 acres.

(b) Land Use

The North Hartland reservoir area is mostly forested and includes upland timber, agricultural land, and swamp browse. Of this area approximately 60 percent is woodland, 30 percent cropland and open fields, and 10 percent swamp and impoundment area.

For a distance of approximately half a mile at the upper end of the existing reservoir, the Ottauquechee River flows through a steep rock cut, the Quechee Gorge, up to 165 feet in depth. This and numerous other areas on the shores of the existing reservoir are currently used for tourist recreational purposes.

Approximately 1200 acres of land adjacent to the current permanent (recreational) pool level of 425 feet msl, is subject to inundation to the maximum flood level of 566.8 feet. Such a flood has never occurred in the 18 year life of the existing flood control project, the maximum recorded level being 518.2 feet msl. Much of the pastureland and agricultural areas adjacent to the reservoir has been abandoned.

Although the immediate reservoir vicinity has no industrial development, domestic and mill effluents upstream in the more populated areas of Bridgewater, Quechee and Dewey's Mills contribute a variety of pollutants to the Ottauquechee River.

The shores of the river downstream from the dam and adjacent to the Connecticut River confluence are used primarily for agricultural purposes.

(c) Ecology

The Ottauquechee Reservoir and its environs provide an attractive and aesthetic setting, have a definite attraction for fish and wildlife, and a potential for migrating waterfowl and an improved fishery resource.

(i) Vegetative Habitats

The woodland cover along the steep valley slopes is mainly white birch, yellow birch, white pine, beech, butternut, and hemlock. Some scattered growth of black cherry, sugar maple, and basswood, together with brake fern, steeplesbush, and blackberry undergrowth, can be found on the abandoned pastureland in the area.

(ii) Wildlife

The Ottawaquechee River area provides considerable wildlife resources, and the man-made upstream ponds and pools offer refuge to many migrating waterfowl. The reservoir area, together with surrounding upland, provides excellent deer cover making the area one of the highest producers of deer in the state.

Other upland game found in the site vicinity include ruffed grouse, red foxes, raccoons, ring-necked pheasants, and cottontails. Other fur animal resources present in the site area include muskrats, minks, weasels, beavers and skunks.

A waterfowl management pool has been proposed at elevation 422 to 424 feet in the upper half of the reservoir, but has not been developed to date.

(iii) Aquatic Life

The existing reservoir impoundment offers excellent conditions for the propagation of a fresh water fishery. The downstream waters of the Ottawaquechee River and associated tributaries are well known trout waters attracting many fishermen each year. Since the completion of the North Hartland Reservoir, fish management programs have been carried out to increase the fish populations.

(d) Air and Water Quality

There are no existing air pollution sources in the vicinity of the North Hartland Dam Site.

The Ottawaquechee River has in the past been contaminated during normal flow conditions. As a result, swimming and other similar water oriented recreational uses have been prohibited in the various recreational areas surrounding the reservoir. The state has instituted pollution abatement programs which will eventually improve the water quality to permit swimming.

(e) Socioeconomics, Recreation and Scenic Values

(i) Reservoir Area

The number of persons residing within an hour's drive (40 miles) of the project is of the order of 200,000. Areas in the immediate vicinity of the existing reservoir are however sparsely populated. There are at present no economic activities other than tourist-oriented enterprises and, on the fringes of the reservoir area, some minor agricultural development.

The land and water areas in and around the North Hartland Reservoir provide recreational facilities for boating, hunting, fishing, hiking, camping, snowmobiling, picnicing, and sightseeing. The location is readily accessible by excellent highways and lies only a few hours drive from many of the state's populated areas.

A 215 acre conservation pool is maintained behind the dam at elevation 425 feet msl. From mid-May to mid-October this pool provides for public recreation, fishing enhancement, and is a base for a major water-oriented park at the head of the lake. The reservoir and surrounding area also provide an excellent wildlife habitat and are open for public hunting and fishing.

The Quechee Gorge, located approximately 3.4 miles upstream of the North Hartland Dam, is one of the more popular scenic sites in the state which attracts both in-state and out-of-state sightseers throughout the year. The 165 foot deep gorge with sheer-faced sides, together with the natural aesthetics of the reservoir and surrounding scenery, provide an ideal setting for various recreational activities.

(ii) Downstream Area

In the 1.4 mile stretch of the Ottauquechee River downstream of the dam the primary economic activities are agricultural. Recreational activities are virtually non-existent. One possible exception is a scenic waterfall and covered bridge at the confluence with the Connecticut River which is something of a scenic attraction.

A license has been granted by the FERC to the White Current Corporation for redevelopment of an abandoned mill site at these falls. This license is for a 432 kW capacity installation utilizing a river flow of 270 cfs and a maximum head at the falls of 30 feet.

Although the Connecticut River is currently being developed for salmon fishing, the presence of the two barriers at the falls and North Hartland Dam has precluded passage of salmon up this lower stretch of the Ottauquechee River and into the reservoir.

The lower river is also traversed by one railroad and three road bridges, Routes 5 and 15 and Highway I-91. A water supply well and pumphouse for the Town of Hartland is also located on the south bank of the Ottauquechee River, well above flood levels, downstream of the dam.

(f) Historic Value

The North Hartland Reservoir and surrounding area are of known historic interest. The falls at the junction of the Connecticut and Ottauquechee Rivers, downstream from the dam, and the area in the vicinity of U.S. Route 5 are of significant value marking the retreat of Rodgers Rangers from the attack on the Indian Village of St. Francis, Canada, during the French and Indian War in 1759. The region is alive with similar items of historic lore, dating from the late 1700's when the State of Vermont was essentially independent, until adoption of the Constitution of the United States in 1791.

9.3 - Project Area Photographs

A selection of photographs of existing facilities may be found in Section 3. The following photographs of the North Hartland Reservoir area, were also taken September 25, 1978:

- North Hartland Reservoir: west shore near dam
- North Hartland Reservoir: from west shore, approximately 2 miles above dam
- Ottauquechee River: water supply well, south bank downstream from dam
- Ottauquechee River: Highway 5 bridge and dam from downstream
- Ottauquechee River: covered bridge and falls at confluence with Connecticut River, 1.4 miles downstream from dam.

Copies of these photographs are presented on the following pages.

North Hartland Reservoir:

West shore near dam (note log
boom and boat launching ramp)

North Hartland Reservoir:

from west shore, approximately
2 miles above dam.

Ottauquechee River:

Water supply well, south bank
downstream from dam

Ottauquechee River:

Highway 5 bridge and dam
from downstream.

Ottauquechee River:

Covered Bridge and falls at confluence with
Connecticut River, 1.4 miles downstream from dam.

SECTION 10
PRELIMINARY
ENVIRONMENTAL
ASSESSMENT

10 - PRELIMINARY ENVIRONMENTAL ASSESSMENT

Implementation of the proposed development of hydroelectric potential at North Hartland Dam and Reservoir will require issuance of several federal, state, and local licenses and permits. A prime requisite of these documents is a detailed assessment of the environmental impact of the proposed project. A review has been made of the requirements of the various agencies involved in issuance of these documents.

Several alternatives for development of the hydroelectric potential at the site have been evaluated, as discussed in Sections 4, 5 and 6. The primary objective of the current assessment is essentially to identify by means of site reconnaissance, literature review, and contacts with appropriate agencies, the probable environmental impacts of the proposed project.

10.1 - Federal, State and Local Requirements

(a) FERC Requirements

The Federal Energy Regulatory Commission (FERC) is authorized under the Federal Power Act to issue the necessary license to construct the project. A preliminary permit application for the project (No. 2816) was filed with the FERC by VEC September 16, 1977 and the permit was granted February 9, 1979.

Procedures for obtaining a FERC license are laid down in the Code of Federal Regulations Title 18, Conservation of Power and Water Resources. Regulations for licenses are contained in Part 4 of CFR18, paragraphs 4.40 through 4.42.

The required exhibits to be attached to the application are presented in Table 10.3. Since the North Hartland Dam is a federally owned structure which has been in existence since 1961, it may be possible to obtain waivers of many of the requirements of the formal license application. During the licensing process, the FERC will will solicit the requirements and comments of all other concerned federal, state and local agencies, including:

- Vermont Public Service Board, Montpelier, Vermont 05602
- Vermont Water Resources Board*, Montpelier, Vermont 05602
- Corps of Engineers, New England Division, Waltham, Massachusetts 02154
- Department of the Interior

Other agencies known to be involved directly in negotiations prior to the granting of licenses are:

- Connecticut River Basin Commission
- Individual land owners
- Selectmen of Hartland and/or Windsor, Vermont

Most, if not all, of the above agencies have already been solicited by the FERC in connection with the project preliminary permit application.

*Note that these agencies are part of the parent state agency and also embrace other sub-agencies such as Fish and Wildlife, Recreation, Navigation, etc., all of which will be concurrently involved in granting of licenses.

(b) Corps of Engineers Requirements

Section 211 of the Flood Control Act of 1970 (Title II of Public Law 91-611) authorizes the Secretary of the Army, acting through the Chief of Engineers, to review the operation of Corps of Engineers flood control projects when in the best interest of the public. The Secretary reports directly to Congress recommendations for the modification of any facilities or their operation which will improve the overall project performance in terms of public benefit and environmental quality.

An application for a permit for the proposed North Hartland Dam Hydro-Development project must be filed with the New England Division, Corps of Engineers. Under the provisions of the River and Harbor Act of 1899, the Federal Water Pollution Control Act Amendments of 1972, and the Marine Protection, Research and Sanctuaries Act of 1972, the Division Engineer acting under the authority delegated by the Secretary of the Army, may issue a permit authorizing the work if the work is deemed in the best public interest. Concurrent with the issuance of a permit, the Division Engineer will determine if an Environmental Impact Statement (EIS) is required.

A public notice will be prepared and circulated to Federal, State and local officials and agencies, abutting property owners and other interest groups in the North Hartland Dam geographical area. A copy will also be posted in a local post office and published in a local newspaper. Any controversial proposals will be aired at a public hearing. A review will then be made of all responses and objections to the proposed project. If the District Engineer, having jurisdiction over the project, concludes that granting the permit is justified, but that the proposed project will have a significant environmental impact, an EIS will be required prior to final action on the permit application. The EIS will be prepared by the Corps of Engineers, but the applicant will be required to assist in submitting data and may be assessed the study costs.

(c) State Requirements

An application for a permit to construct the project must be filed with the Public Service Board of the State of Vermont. All applicable environmental conditions and criteria as outlined in Section 6086 of the Land Use and Development Law for the State of Vermont will have to be met.

(d) Environmental Quality Standards

Final approval and licensing of the project will be based on the final assessment of the probable environmental impacts and the public needs. The benefits derived from the proposed project will be weighed against the anticipated adverse effects.

The main environmental impacts to be considered will include those on:

- Land use
- Air and water quality
- Terrestrial and aquatic life values
- Socioeconomics, recreation and scenic value
- Historic value
- Energy conservation

Final approval for construction of the project by the FERC, the New England Division Engineer and the Water Resources Board, State of Vermont, will be based on the applicant's ability to demonstrate that the proposed development will maintain the natural condition of the environment and will not endanger the health, safety, or welfare of the public or of adjoining landowners.

10.2 - Description of Project Alternatives

Basically two feasible alternative for hydroelectric development at the North Hartland Dam have been investigated:

- Raise the normal reservoir operating level by 25 feet and, either modify the existing spillway to allow some of the water normally stored to be discharged, or raise the dam and spillway to maintain the existing flood control capability of the dam. The power generating plant would be installed at the downstream end of the existing outlet conduit.
- Locate the power plant far enough downstream of the dam to gain 20 to 25 feet of generating head while leaving the normal operating level unchanged. Penstock piping would connect the downstream plant with the existing reservoir.

Each alternative will also involve construction of an approximately 6 mile long wood pole, 46 KV transmission line northwest of the site.

Details of the proposed concepts are described in Sections 4, 5 and 6.

10.3 - Impact Assessments

(a) General

The raising of the normal operating level of the North Hartland Reservoir by approximately 25 feet will flood an additional 140 acres of land along the reservoir perimeter. Most of the land to be flooded is wooded. All 140 acres were purchased by the Federal Government for the original reservoir and dam construction. Effects of the proposed hydroelectric development on existing land use will, therefore, be minor.

To maintain the flood control capability of the dam and minimize the potential risks to the downstream areas, the following considerations and criteria will be included in the design and operation procedures for the proposed hydroelectric development:

- The flood control regulation will take priority over power generating operations. Operation of the generating facilities will be carried out only during designated release periods specified by the Corps of Engineers and at the rates of discharge recommended. Coordination of both the flood control and power generating operations will greatly maximize the benefits gained from both uses and minimize risks.
- The investigation of modifications to the existing works has been based on maintaining the same design storm criteria of the existing facility with respect to flood control. The modified facility will handle design

storm inflow while maintaining the maximum allowable downstream outflow. Only the maximum pool elevation is changed and the modified dam and spillway structure will be designed accordingly.

For the favored scheme, during normal operation, the reservoir level will fall a maximum of 3.5 feet over a period of 8 or more hours each day in winter and 1.0 to 1.8 feet over periods of 3 or more hours each day in summer. Downstream daily flows will vary from a minimum of 40 cfs to peaks of 1680 cfs in winter and from 10 cfs to peaks of more than 900 cfs in summer.

The transmission line will impact the land use and terrestrial habitats over the required approximately 50 feet wide right of way. No attempt has been made in the current study to establish a firm route for this line or to make a detailed evaluation of this impact. This assessment will more appropriately be made during the licensing phase of the project.

(b) Data Sources

The data for the current assessment was developed primarily from the Corps of Engineers Design Memorandum No. 9 dated March, 1962 "Master Plan for Reservoir Development" for the North Hartland Dam and Reservoir. Other publications used include "Water Resources Development" in Vermont, 1975, also by the U.S. Army, Corps of Engineers.

These documents describe basic considerations in regard to recreation, water quality and fish and wildlife. There is documentation in the memorandum that the Corps has maintained good liason with Vermont State and local agencies in preparing the master plan for North Hartland. Thus, this document is considered to be representative of environmental thinking relative to the site and a good base from which to evaluate current project proposals. In order to supplement the published data, telephone contacts were also made with the Corps and other agencies in the State of Vermont. The proposed development plans and operating procedures were discussed with each contact to solicit comments in regard to recreation, water quality, fish and wildlife.

(c) Impact on Air and Water Quality

(i) Air Quality

During the construction phase of the proposed project, the air quality will temporarily be affected by construction generated dust and vehicle exhausts. These impacts will be short term and confined to a relatively small area. The prevailing winds will provide adequate dispersion consequently the effect on air quality will be minor.

During operation the project will not have any effect on air quality.

(ii) Water Quality

The increased reservoir normal operating level alternative will increase the reservoir surface area from 215 acres to 355 acres. This additional surface area will result in increased evaporation losses. The larger water impoundment volume and depth will also alter the temperature structure causing minor delays to the spring heating and fall cooling sequence.

Operation during power generation will have minor effects on the water quality in the area. However, some increase in downstream erosion and turbidity may occur due to the more frequent, increased rate of discharge during periods of powerplant operation.

During the earth-moving and dewatering phases of construction, the waters discharging downstream will be muddied and turbidity levels will probably be increased for either alternative. These conditions will be short term and will be minimized by following recommended construction procedures.

Contact with the State of Vermont Water Quality Division indicated that towns upstream of the reservoir are in the process of upgrading sewage treatment facilities. There are no known effluent discharge points located in the river downstream. The State recommends a minimum flow equal to the 1 in 10 year 7-day discharge be maintained at all times downstream, for stream flushing purposes. This flow is estimated to be equivalent to about 22 cfs. The proposed operation of the power plant will be considerably in excess of this on a daily average flow basis.

The water supply well downstream of the dam is well above normal flood water levels and water quality will not be effected by the proposed project.

(d) Impact on Terrestrial and Aquatic Life

(i) Vegetative Habitat

One of the proposed development alternatives will require the raising of the normal permanent reservoir pool level by approximately 25 feet. The increased height will flood an additional 140 acres of land along the upstream reservoir perimeter. During construction, the vegetation growth within this area along the reservoir perimeter will be cleared to accommodate the higher operating pool level. Some localized clearing will also be required for the power plant site, access roadway, and the transmission line route for either concept.

Each development alternative will entail daily fluctuations of reservoir level which will lead to minor changes in vegetation types along the edge of the reservoir.

Effects on vegetation along the downstream sections of the Ottauquechee River will be minimal for either alternative. The increased discharges will have a minor effect on growth within the channel banks and may cause some minor bank erosion and bed scouring.

(ii) Wildlife

The two significant areas of water pondage which provide waterfowl habitat are the North Hartland Reservoir and an upstream conservation pool. The proposed raising of the reservoir level would increase the actual normal pondage area available to waterfowl.

Raising the reservoir level will have little effect on the game and fur animal resources in the area. Most of the animals residing in the lower areas along the reservoir fringes will move to higher ground as the water level rises. The fluctuation of the water level is considerably less than most coastal tidal processes averaging 4 feet over a 24 hour period, and will have little, if any, affect on the animal population.

The generated noise levels and equipment movement during the construction period will disturb some of the wildlife populations in the immediate vicinity of the power plant site. This effect will be relatively localized and result only in the temporary displacement of wildlife away from the construction site area. The termination of activity at the end of construction will result in the return of much of the wildlife to the site area with plant operations having little adverse effects.

(iii) Aquatic Life

The increased impoundment alternative will provide a larger body of water for future fish propagation. Both the intake and outlet structures will be equipped with fish screens to prevent fish movement into the power plant equipment. At present, the existing dam structure is not equipped with a fish ladder or other provision for accommodating the upstream migration of fish. This existing dam has therefore already served as a barrier precluding the movement of anadromous fish species in the area and such provision is assumed to be unnecessary. The increased impoundment size will probably result in noticeable increases in the phytoplankton and aquatic macrophite growth in the reservoir area.

The discharge of up to 1680 cfs during daily power generation for both concepts, compared with the current average downstream base flow of 40 cfs, will have minimal effect on the fish habitat downstream. The downstream channel already periodically handles flows in the order of 6000 cfs during extreme flood releases. The continual daily releases of up to 1680 cfs during power generation will most likely cause fish displacement to the calmer trapped eddy areas in the river. This displacement will be relatively localized and will have less effect in the downstream river reaches characterized by larger channel cross-sectional areas and smaller thalweg slopes.

Contact with the State Fisheries Department indicated that the state is currently engaged in plans to restore atlantic salmon to the Connecticut River and certain tributaries. The Ottauquechee River is not included in these plans. Three barriers exist that preclude migration of fish upstream; a dam at the covered bridge 1.4 miles downstream from the North Hartland Dam, the dam itself and Dewey's Mill Pond. The proposed development will consequently not significantly impact the river between the dam and the covered bridge.

The area of most concern for fishery habitat is in the reservoir itself. At the upper end of the reservoir, there are some shallow pools which provide spawning areas for bass during June and habitat for minnows. Drawdowns of 1 to 2 feet could effect these shallow areas.

Implementation of the originally proposed conservation pool in the upper reaches of the reservoir may be desirable to overcome these problems. Level fluctuations in the pond may also create a safety hazard for ice fishing.

The state have stocked the North Hartland reservoir with tiger muskies and bass. Trout do not do well in the reservoir due to stratification and dissolved oxygen levels falling below acceptable levels at the greater depths.

There is currently no significant tendency for fish to pass through the low level outlet. Construction of power facilities is therefore not likely to cause problems in this regard.

(e) Socioeconomic, Recreation and Scenic Values

The long term effects of the proposed hydroelectric development on existing land use will be minimal. In the short term, a temporary influx of labor and associated economic benefits will result from construction of the project. Although the station is intended to be unmanned, long term employment opportunities for maintenance personnel will be presented.

Raising the pool level will result in the flooding of a boat launch, picnic areas, and camping sites along the reservoir perimeter. Relocation of all these facilities to higher ground is planned during the construction phase of the project. Any hiking and snowmobile trails affected will also be relocated. The costs of all relocations have been included in the estimated project costs for this alternative.

Although the higher pool levels will have a significant backwater effect for a large part of the upstream area, the scenic Quechee Gorge area will not be affected. Effects on the other recreational activities in the reservoir area will be minimal for either concept and include only localized displacement of game and fish.

Contacts made with the Corps of Engineers and the Recreation Division, State of Vermont, indicated that the use of camping facilities in the upper reservoir averages about 50,000 to 75,000 users per year. Use of the boat launching ramp near the dam is limited because of the relatively small surface area of the reservoir. Swimming is not encouraged because of lack of facilities, a beach or bathhouses. Original plans to develop the reservoir for duck hunting by construction of duck blinds have not been implemented, presumably due to lack of interest and funds.

Apart from some relocation of facilities as a result of the proposed development, recreation will not be significantly effected. Water level fluctuation in the pond would create a potential hazard for ice fishermen which will require adequate safety precautions.

The proposed hydroelectric development will also not significantly affect the historic sites or other resources of the area.

(f) Energy Conservation

The existing North Hartland Dam is a very suitable site for the development of hydroelectric power. The existing dam structure, together with the proposed modifications, will provide a potential gross generating head of approximately 66 feet and the Ottawaquechee River offers sufficient flow for peak power generation throughout the year.

This non-depletive energy resource offered by the existing facilities is currently not being utilized. The proposed hydroelectric project will develop this valuable resource, generating power for public use while contributing to the overall objective of reducing the nation's dependency on oil, and other depletive energy resources.

An additional benefit common to all hydroelectric generation facilities is the insignificant impact the development will have on the environment compared with other modes of power generation. This, together with the non-depletive characteristics of hydroelectric power generation make the proposed North Hartland Hydro-Development very attractive from an energy conservation point of view.

10.4 - Conclusions

In general, the change from river flow to reservoir formation at a typical undeveloped hydroelectric site has the most significant effect on the environment and safety of the site area. In the case of the proposed North Hartland Hydroelectric Project, the effects of such a transition have already transpired during the original dam and reservoir construction.

The proposed construction and operation alternatives will have some noticeable effects, however. The raised reservoir operating level will increase evaporation losses, inundate an additional 140 acres of land, and will have minor effects on the temperature structure and biological growth in the reservoir. The periodic drawdown of the level during power generation will have minor effects on erosion and vegetation life along the reservoir perimeter. The increased discharge flow during generation will also effect erosion and biological life along the Ottawaquechee River immediately downstream of the power plant. None of these represent significant or long lasting adverse effects on the environment.

The currently most favored alternative from the point of view of cost is to locate the powerplant further downstream and not alter the current normal power pool elevation. This alternative has a much less significant environmental impact in the reservoir. However, the effects of periodic drawdown and increased downstream discharge during generating periods will be similar to those for the raised reservoir alternative.

Based on this preliminary impact assessment, the overall effects of the North Hartland Dam Project on the existing area conditions will be minimal and will not outweigh the power benefits which will be available to the public.

10.5 - References

The following literature was used in the environmental assessment:

- (1) North Hartland Dam & Reservoir, Design Memorandum No. 9, Master Plan for Reservoir Development, U.S. Army Engineer Division, New England, March 1962.
- (2) Connecticut River Flood Control Master Manual of Reservoir Regulation, North Hartland Dam and Reservoir, Department of the Army, New England Division, Corps of Engineers, May 1969.
- (3) Design Memorandum No. 6, Geology and Materials, North Hartland Dam & Reservoir, Portland, Oregon District, Corps of Engineers, April 1, 1957.
- (4) Water Resources Development in Vermont, U.S. Army Corps of Engineers, New England Division, 1975.
- (5) Cheremisinoff, P.N., Morresi, A.C., Environmental Assessment & Impact Statement Handbook, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1977.
- (6) Vermont's Land Use and Development Law, Reprinted from Title 10, Vermont Statutes Annotated, State Planning Office, Equity Publishing Corporation, Oxford, New Hampshire, June 1974.
- (7) Applications for Department of the Army Permits for Activities in Waterways, Pamphlet No. 1145-2-1, Department of the Army Corps of Engineers, Washington, D.C., October 1974.
- (8) Design Memorandum No. 4 - Real Estate, Connecticut River Flood Control, North Hartland Dam & Reservoir, Corps of Engineers, U.S. Army Office of Division Engineer, New England Division, November 1958.
- (9) An Inventory by County of Vermont Lakes and Ponds, 20 Acres or Larger, State of Vermont, Agency of Environmental Conservation, Department of Water Resources, Planning and Development Division, Montpelier, November 1971.
- (10) Issuance of Permits for Construction or Reconstruction of Dams (pamphlet), State of Vermont, Agency of Environmental Conservation, Water Resources Board, March 1977.
- (11) Environmental Effects of Hydroelectric Power Development, Energy and Environmental Division, Lawrence Berkeley Laboratory, University of California, Berkeley, California, October 1976.

TABLE 10.1FERC LICENSE APPLICATION: EXHIBITS

<u>Exhibit</u>	<u>Description</u>
A	Charter or certificate and article of incorporation of applicant.
B	Certified copy of resolutions of stockholders and/or directors authorizing application.
C	Copies of State laws pertaining to construction of the project.
D	Evidence of applicant's compliance with requirements of State laws pertaining to use of lands and water for the project.
E	Ownership, extent and nature of water rights applicant will use and evidence of applicant's plans for perfecting its rights to use the water for operation of the works.
F	Statement of land ownership affected by project including purchase and construction easement.
G	Evidence of financial of applicant to undertake for preliminary work and project.
H	Statement of proposed operation of project works during low, normal and flood flows.
I	Estimate of dependable capacity and average annual energy output of the proposed project.
J	General map showing project boundaries, features and general location.
K	Detailed map of project area clearly showing project boundaries, survey data, land ownership and location of project features.
L	General design drawings of all principal structures and appurtenant features and other works of the project.
M	General descriptions of mechanical, electrical and transmission equipment and appurtenances.
N	Detailed estimate of cost of developing the project.
O	Detailed engineering and construction schedules.

TABLE 10.1 (Continued)FERC LICENSE APPLICATION: EXHIBITS

<u>Exhibit</u>	<u>Description</u>
P & Q	Not required.
R	Proposed plan for full public utilization of project waters and adjacent lands for recreational purposes.
S	Report on the effect of the project upon the fish and wildlife resources of the project area.
T	Statement of reasons why development of the project by applicant rather than by the Federal Government would be in the best public interest.
U	Statement showing the manner in which the power and energy produced by the project will be utilized.
V	Map, text, photographs and drawings to describe the architectural and landscaping treatment proposed for the project works.
W	Environmental report.

SECTION 11

PRELIMINARY
SAFETY ASSESSMENT

11 - PRELIMINARY SAFETY ASSESSMENT

The primary safety concern with regard to development of hydroelectric power potential at the existing North Hartland Dam is the preservation of unimpaired flood control capability of the reservoir. The preliminary safety assessment performed under the present study is intended to identify the basic issues concerning this and all other safety aspects of the project. The general methods and procedures which will be implemented to insure maintainance of safety requirements have also been examined.

11.1 - Proposed Project Components

The proposed North Hartland Dam Project will involve the following general design and construction requirements:

- modifications to existing intake structure
- steel lining and concrete backfill in the existing conduit
- steel penstock downstream of dam
- bypass control structure, gate and outlet channel
- powerhouse and tailrace structures
- switchyard and transmission line
- spillway modifications (in one considered alternative only).

Details of these items are fully discussed in Sections 4, 5 and 6. The alternative requiring spillway modifications has been demonstrated to be economically unfavorable. This alternative will, therefore, not be discussed further in regard to safety considerations.

The proposed development will utilize the existing North Hartland Dam and spillway facilities, with minor modifications, for flood control purposes. The powerplant will have a 6000 KW rated capacity at an estimated 51.6 feet net head and 1680 cfs demand flow. The selected scheme will include a 12'-0" diameter penstock bifurcating into two 10'-6" diameter inlets at the powerhouse, about 700 feet downstream of the dam. A 12'-0" diameter gated bypass conduit will discharge, together with the powerplant tailrace into the existing Ottauquechee River downstream.

Power output from the station will be stepped up to 46 KV at an outdoor switchyard adjacent to the powerhouse. The power will then be transmitted by overhead line to the nearest VELCO transmission line, 6 miles to the northwest, and thence into the VEC system.

Plates 1 and 2 showing the project location and the selected development scheme are included in Appendix A.

11.2 - Basic Safety Considerations

(a) Risk Potential

Some potentially unsafe conditions will arise as a result of the construction and operation of the project. Specific attention is therefore required to elimination of these conditions, guarding against exposure to them or appropriately warning of their nature. This assessment identifies the principal measures which will be implemented to prevent unsafe conditions or to protect against them.

The design and operation procedures for the proposed hydroelectric development will be such as to maintain the flood control capability of the dam and minimize the potential risks to downstream areas. The flood control regulation will take priority over power generating operations. Operation of the generating facilities will be carried out only during designated release periods specified by the Corps of Engineers and at the rates of discharge recommended. Coordination of both the flood control and power generation operations will greatly maximize the benefits gained from both uses and minimize risks.

In addition to flood control aspects, the possible safety implications of any modifications or additions to the existing facilities will also be checked in detail. Compliance with acceptable design, building, and safety codes will be verified and the acceptability of the project under recent Federal legislation with respect to dam safety will also be checked.

The construction and operation of the proposed project will create additional risks with respect to the following:

- The existing outlet conduit through the dam embankment will be used as a penstock and internal pressures will be increased.
- New high voltage transmission lines will be constructed from the new power plant site to a substation located at an existing transmission line.
- Discharge will be increased from a current average base flow of 40 cfs up to 1680 cfs in the downstream channel during the daily generating period.

(b) Mitigating Measures

The following considerations and criteria will be incorporated into the final design and operational procedures of the various alternative concepts in order to minimize the above potential risks:

- All design work will be performed in accordance with applicable building and design codes and acceptable construction procedures followed. Detailed structural analysis will be carried out to insure the safety and structural integrity of the structures. All design work will be submitted to the Corps of Engineers for approval and a strict quality assurance program will be instituted during the design and construction phases of the project.
- A steel liner will be grouted inside the existing outlet conduit and will be designed to withstand the worst possible pressure conditions.
- The new high voltage transmission lines will be installed and designed according to acceptable procedures and will meet all safety code requirements. Each pole will be equipped with adequate grounding and the most up-to-date safety features, and minimum height clearances will be strictly observed. Warning and danger signs will be clearly posted along the entire transmission line route.

- Warning signs will also be posted along the Ottawaquechee River channel immediately downstream of the dam indicating the possible danger of sudden increase of channel flow.
- All federal, state and local safety codes for construction and operation of the facilities will be strictly followed.

11.3 - Specific Safety Issues

(a) Design

Potentially unsafe conditions will be identified before detailed design efforts commence, to make safety issues an integral part of the design effort. Additionally, applicable federal, state, local and industrial codes and standards must be complied with to insure structural adequacy and personnel safety.

Important safety issues specific to the project which must be addressed during design include:

- (i) Stability of the project structures under applicable loadings, including hydraulic, seismic, ice and wind loads as well as other dead and live loads.
- (ii) Design flood conditions and interrelationship of the project facilities, the existing flood channel and existing flood control works.
- (iii) Specific construction procedures and restrictions necessary, based on design requirements (e.g. demolition and blasting criteria, care and handling of reservoir releases, cofferdams and excavation restrictions.)
- (iv) Security and protection of potentially dangerous project facilities for which fences, barriers, warning alarms, or other devices are necessary.
- (v) Appropriate clearances, guards, apparatus, special tools, and safety systems to provide personnel with a safe environment in which to perform operating and maintenance functions.
- (vi) Procedures and means by which dewatering and inspection of facilities and removal of major equipment components for servicing can be undertaken later in the plant life.

The recommended method for incorporating safety considerations into the design program involve the careful preparation of a Design Criteria Manual in the early stage of the detail design activity. The manual, covering each engineering discipline and project facility, will define specific design requirements based on the site data and the preliminary engineering plan. The design requirements will incorporate applicable criteria from (or reference to) pertinent design, building and safety codes (including standards and regulations).

Assurance of the effectiveness of the manual in the completed design drawings or documents will be determined by normal design practices of engineering supervision during the work and checking for compliance with the design criteria (including appropriateness and accuracy of design) prior to issue. Before construction documents are released for bidding, a thorough final review by a safety engineer will be undertaken. All engineering personnel will be educated before and during the job on engineering safety and design requirements.

(b) Construction

In addition to normal heavy civil construction safety practices, the construction of the North Hartland facilities will require particular attention to traffic control, blasting procedures, water handling and site security due to the project site conditions and existing structures.

The principal regulatory safety requirement during construction is compliance with standards of the Occupational Safety and Health Act (OSHA). Responsibility for safety is assigned to the construction contractor's site supervisor and requires rectifying action where unsafe conditions exist or unsafe actions occur. The site safety standards include requirements for reporting accidents, periodic site inspections and weekly safety training.

Site activities must also comply with all other federal, state and local regulations which are applicable to health and safety or any special conditions on licenses or permits for construction of the project.

It is recommended that each construction contractor be required to submit an "Accident Prevention Plan" as a part of his proposal which will define his project safety policy, procedures and facilities, to comply with OSHA and other safety and health regulations.

Inspectors representing the owner will be trained in the detection and correction of safety deficiencies and will check the contractor's compliance with his own accident prevention plan.

(c) Operation

Operation and maintenance of the project will have some potential impact on occupational and public safety issues. Occupational safety is principally regulated under OSHA and implemented by the plant owner. Public safety related matters involving project safety and operations will be regulated under specific conditions of the FERC license. Guidelines provided by the APPA will also be followed.

An operating manual providing procedures for start-up, shutdown, cleaning, isolating, tagging, teardown and other aspects of operation and maintenance of the plant facilities and equipment will be prepared to provide a key source for identifying and neutralizing potentially dangerous conditions or actions. This will supplement the basic supervisor/worker instructional safety program required under OSHA and the specific safety requirements instituted by VEC.

Public safety considerations include: (1) proper security of the powerhouse and switchyard from access by the public, and (2) proper warning devices and procedures for normal or abnormal operating flow conditions.

Security and safety of the dam and spillway facilities are currently the responsibility of the Corps of Engineers. These safety and security programs are reliable and effective and will be continued. Programs developed for power facilities will be fully coordinated with these existing procedures. Security of the switchyard and powerhouse by barricade, fencing and warning signs will be in accordance with applicable American National Standards Institute (ANSI) codes. These facilities will be a part of the design responsibilities discussed in Section 10.3(a). Downstream, in the river reach affected by the project, warning signs will be placed to warn of fast rising water levels due to plant operations.

An emergency action plan will be developed for the project to quickly provide the operator, the VEC and Corps supervisors and local regional emergency forces with procedures to follow in case of major structural failure, fire, or accident. The plan must include a procedure in case of a structural failure to comply with normal conditions contained in FERC licenses. All such plans will be updated on a regular basis and periodic training sessions conducted to ensure operating personnel are aware of their emergency tasks.

SECTION 12
MARKETING STUDIES

12 - MARKETING STUDIES

12.1 The VEC System

Vermont Electric Cooperative, Inc., is an electric distribution cooperative serving rural residential areas in Vermont. Recent peak loads varied from 12.3 MW in July (1977) to about 26.5 MW in January (1977). The 1977 annual energy sales were 86,000 MWh.

The total VEC system load, for planning purposes, may be considered as three separate districts, an integrated system comprising the major part of the "Northern" District, and two other minor districts, Halifax and Derby, serviced separately by Hydro Quebec (HQ) and Green Mountain Power (GMP) (see Plate 15).

In a Power Study undertaken by Acres American in June 1976, load projections for annual non-coincident peak load and energy demands for the total VEC system were estimated to be:

	<u>Total System Load</u>	
	<u>Power</u>	<u>Energy</u>
1980/81	32 MW	122,700 MWh
1985/86	39 MW	148,100 MWh
1995/96	60 MW	228,400 MWh

Total system load requirements for VEC were forecast to be such that by 1985/86 from 7 to 9 MW peaking capacity and from 7 to 12 MW of additional base/mid-range capacity will be required. By 1995/96 the additional requirements amount to 11 to 16 MW peaking and 17 to 32 MW base/mid-range.

In addition to its load requirements, VEC must provide an additional 8 MW of peaking capacity as reserves in 1985/86 and 12 MW in 1995/96. VEC can also contractually place capacity additions of about 13 MW in 1985/86 and 20 MW in 1995/96 to replace power currently being purchased from central Vermont Public Service Corporation (CVPSC), HQ and GMP.

In 1977, metered coincidental peak load and energy demands for the Northern District alone, exclusive of districts serviced by HQ and GMP, were as shown in Table 12.1.

Current plans for purchase of additional nuclear and gas turbine peaking capacity and continuation of the block purchase contract with CVPSC are adequate to meet future requirements pending construction of the proposed hydro development. However, there is considerable scope for reduction of system costs in the future by means of optimal planning of utilization of the proposed and other hydro development.

12.2 Power Sources

The power supply situation of VEC is both unique and critical. The cost of electricity and all fuels in Vermont generally, is exceptionally high compared to the nation as a whole, due to a shortage of developed natural resources and long-haul transportation costs. There is currently no Federal Regional Authority, Power Development or Marketing Agency in New England and no major generation construction being undertaken in the State of Vermont.

When current plans take effect, VEC will be receiving wholesale power from a total of 15 different generating sources of supply by contract and ownership, most of which originate out of state. The least cost sources of peaking power available to the cooperative at the present time are through out-of-state contract purchases in gas turbines from Connecticut.

Residential rates for electric power are already excessive and substantially above parity. The VEC service area has the highest unemployment percentage and the lowest annual average wages in the state. Excessive financial burdens and inequities are thus currently being borne by VEC rural consumers.

There is currently no assurance that VEC can continue to purchase peaking or other supplemental power from existing sources beyond the 1980's. There is a clear and present need for VEC to obtain power from alternative, non-fuel-dependent sources such as the North Hartland Dam Project.

(a) Current Purchase Contracts

The capability responsibilities of VEC for base load and intermediate requirements through the early 1990's will be met by means of a combination of the proposed hydro development, nuclear, coal- and oil-fired thermal capacity. Current ownership or unit contract rights in a total of 11.8 MW capacity has recently been expanded by a further 13.8 MW of nuclear capacity which will become operational in the period 1982 through 1991 (see Table 12.2). There is no certainty that the PASNY contract for low cost base hydro power will be renewed in the 1980's. The remaining options currently available to the Cooperative for the required supplemental power are the purchase of oil-fired gas turbine capacity and/or continuation of current flexible bulk purchase contract arrangements with CVPSC. By 1985/86 this requirement is forecast to amount to a minimum of about 11 MW and by 1995/96 about 18 MW, which is approximately 30 percent of the total VEC load. Each of these alternatives is also subject to fuel cost escalations with the result that it could be extremely difficult for the Cooperative to stabilize energy costs to its consumers.

(b) Future System Mixes

The projected system mix developed in the 1976 Power Study report, to meet the forecast total system loads in 1986, is shown in Table 12.3. For assessment of the marketing potential for the North Hartland Project as part of the VEC system, the mix shown in Table 12.4 has been tentatively developed. The North Hartland Project will thus be used to displace gas turbine peaking capacity and surplus hydro energy to displace coal-fired thermal generation.

12.3 Economic Evaluations

Current VEC planning has been based on purchase of gas turbine capacity to meet system peaking and reserve requirements from Northeast Utilities Service Company until 1989. The only alternatives for meeting peaking power requirements currently available from that date, are to negotiate additional purchases of peaking capacity or to invest directly in gas turbine or hydroelectric installations.

The objective of this marketing study was to examine the relative costs of these alternatives.

(a) Investment in Hydro

From Table 2.2, the total project cost for the proposed 6000 KW installation at North Hartland in 1985 will be \$13,931,000, inclusive of AFDC and escalation. Although the life of the project is conservatively estimated as 40 years, a considerably longer period is likely. A summary of annual debt service and operation and maintenance costs of the development for the initial 30 years is presented in Table 12.6. Annual fixed costs and operation and maintenance expenses for 1985 have been assumed from data published in the FERC Final Draft Hydroelectric Power Evaluation Report dated August 1978, as shown in Table 12.5. Operation and maintenance costs for subsequent years were assumed to escalate at 6 percent per annum. Accumulated present worth values for 1985 were based on a 7 percent per annum interest rate and calculated in accordance with an accounting procedure described in a paper by D.O. Stuart and R.D. Meckna entitle "Accounting for Inflation in Present-Worth Studies", published in Power Engineering in February, 1975.

(b) Thermal Generation Alternatives

For purposes of comparison of costs of hydro and thermal generation alternatives, it has been assumed that VEC will continue to purchase Northeast Utilities' gas turbine capacity until 1989 and subsequently invest in gas turbine capacity equivalent to the North Hartland installation. Peaking energy has been based on a 5 percent load factor. Additional mid-range energy requirements to the extent normally available from the proposed North Hartland project, have been assumed to be provided from the Merrimack coal-fired source.

A summary of annual debt service and operation and maintenance costs of the three thermal sources is presented in Table 12.7. Northeast Utilities' source costs were based on actual data for 1978, with an assumed apportionment for operation, maintenance and administration costs. Similarly, transmission costs are actual for 1978 with an assumed O, M and A apportionment. This cost is for transmission from out of state to an equivalent point within the state as will be the case for the North Hartland installation. All O, M and A costs have been assumed to escalate at 6 percent per annum.

Investment costs in gas turbine generation were based on an estimated 1976 cost of \$150 per KW with private financing (assuming that VEC would be a participant in a joint-ownership venture). Escalation to 1989 cost levels

was assumed at 6 percent per annum. Annual O, M and A costs were also based on FERC data for 1976, escalated at 6 percent. Transmission costs were assumed to be as for the Northeast Utilities' source, appropriately escalated.

Gas turbine fuel costs were based on actual Northeast Utilities' costs charged to VEC in 1978. All fuel costs have been escalated at 8 percent per annum. Merrimack energy charges have been based on actual charges to VEC, appropriately escalated.

A summary of debt service and O, M and A costs of the all-thermal alternative to North Hartland, for the 30 year period 1985 through 2014, is presented in Table 12.8. Annual O, M and A costs were again assumed to continue to escalate at 6 percent per annum and all fuel costs at 8 percent. Accumulated present worth values for 1985 were also based on a 7 percent interest rate. Table 12.9 is a similar presentation assuming a 10 percent annual escalation in fuel costs.

12.4 Comparison of Alternatives

The cost inflation rates assumed in Tables 12.6, 12.8 and 12.9 may be considered somewhat subjective at this time. Nevertheless these tabulations serve to demonstrate the appreciable differences in cost between the hydro and fuel-dependent generation alternatives which will arise if fuel costs continue to escalate at a significantly faster rate than others. It is likely that the Merrimack plant will be displaced or up-graded at some point in the period considered with consequent impact on future costs of fuel-based generation. The scenarios examined also take no account of the possibility of future government restrictions on the use of oil for power generation.

Although total projected annual costs for the hydro alternative are initially greater than those for fuel-dependent power sources, by the mid- to late 1990's this situation will probably be reversed. On a present worth basis, the hydro alternative will clearly be more economic over the 30 year period through 2014. Over the 40-year minimum project economic life, the economic benefit of the hydro alternative will be substantial.

The 1979 30-year cumulative present worth cost of the North Hartland hydro alternative, at 7 percent interest, is \$14,718,000 and that for the fuel-dependent alternatives at least \$15,592,000. Corresponding generation costs are 41 and 43 mills per KWh respectively. The cost-benefit ratio for North Hartland on this basis is therefore at least 1.06.

TABLE 12.1
NORTH HARTLAND DAM PROJECT
COINCIDENTAL PEAK - 18 DELIVERY POINTS (1)

1977	Monthly	80%	Net Peaking	Peaking	Hours
Month	Peak	(2)	KW (3)	KWh	Per
	(KW)	(KW)	Required	Required	Day
January	20,335	16,267	4,068	264,195	2.1
February	18,767	15,020	3,747	150,797	1.4
March	16,147	12,925	3,222	134,501	1.4
April	14,965	11,992	2,973	46,887	0.5
May	11,065	8,857	2,208	46,338	0.7
June	10,042	8,035	2,007	95,904	1.6
July	9,257	7,417	1,840	242,104	4.3
August	10,187	8,150	2,037	146,978	2.3
September	11,007	8,812	2,195	113,540	1.7
October	13,372	10,702	2,670	74,376	0.9
November	16,017	12,907	3,110	70,868	0.8
December	20,085	16,067	4,018	153,805	1.2
			TOTAL	1,540,293	

NOTES:

- (1) Excluding HQ and GMP.
- (2) Closest KW amount on the computer readout of 80% of monthly peak.
- (3) From computer readout, energy (KWh) needed to fill the top 20% Peaking KW.

TABLE 12.2

12-6

NORTH HARTLAND DAM PROJECT
PRESENT AND FUTURE POWER SUPPLIES

SOURCE	ARRANGEMENT	KW	YEAR EFFECTIVE
Power Authority, State of New York (H)	Contract with VT PSB.	4,493	Current
Vermont Yankee (N)	S.O.	5,414	Current
Merrimack No. 2 (C)	Life of Unit Purchase Contract	1,909	Current
Central Vermont Public Service Corporation	Block System Power Contract	5,100	Current
Green Mountain Power	Wholesale Tariff	1,877	Current
Hydro-Quebec	Contract	3,600	Current
Northeast Utilities (G)	Unit Purchase Contract	7,500	Current
Seabrook No. 1 (N)	J.O. (M.O. P.S. of N.H.)	4,600	1982
Seabrook No. 2 (N)	J.O. (M.O. P.S. of N.H.)	5,050	1984
Pilgrim No. 2 (N)	J.O. (M.O. Boston Edison)	2,360	1986
Millstone No. 3 (N)	J.O. (M.O. North- east Utilities)	2,300	1982
Charlestown No. 1 (N)	J.O. (M.O. New England Power)	3,450	1986
Charlestown No. 2 (N)	J.O. (M.O. New England Power)	3,450	1988
Montague No. 1 (N)	J.O. (M.O. North- east Utilities)	2,300	1989
Montague No. 2 (N)	J.O. (M.O. North- east Utilities)	2,300	1991

Abbreviations: H - Hydroelectric
N - Nuclear
C - Coal
O - Oil

G - Gas Turbine
J.O. - Joint Ownership
M.O. - Major Owner

TABLE 12.3

NORTH HARTLAND DAM PROJECT
PROJECTED VEC SYSTEM MIX, 1986
(NO HYDRO PEAKING)

Month	Source	Peak Demand (KW)	Energy Demand (MWh)	Load Factor
January	PASNY (H)	4,500	2,510	0.75
	Merrimack (C)	1,900	690	0.49
	Vt. Yankee (N)	5,400	2,610	0.65
	CVPSC (P)	8,950	6,660	1.00
	Supp. Base (N)	5,750	2,780	0.65
	Supp. Peak (G)	7,500	280	0.05
	Reserves (G)	<u>(2,100)</u>	<u>---</u>	<u>--</u>
	Total	34,000 (2,100)	15,530	0.61
July	PASNY (H)	4,500	2,510	0.75
	Merrimack (R)	(1,900)	---	--
	Vt. Yankee (R)	(5,400)	---	--
	CVPSC (P)	3,750	2,790	1.00
	CVPSC (R)	(5,200)	---	--
	Supp. Base (N)	3,450	1,670	0.65
	Supp. Base (R)	(2,300)	---	--
	Supp. Peak (G)	3,300	320	0.13
	Reserves (G)	<u>11,700</u>	<u>---</u>	<u>--</u>
	Total	15,000 (21,100)	7,290	0.65

LEGEND: H - Hydro, base capacity
 C - Coal-fired thermal, mid-range capacity
 N - Nuclear, base capacity
 P - Purchases
 G - Gas turbine, peaking capacity
 R - Reserves

TABLE 12.4

NORTH HARTLAND DAM PROJECT
PROJECTED VEC SYSTEM MIX, 1986
(WITH HYDRO PEAKING)

Month	Source	Peak Demand (KW)	Energy Demand (MWh)	Load Factor
January	PASNY	4,500	2,510	0.75
	Merrimack	1,900	234	0.17
	Vt. Yankee	5,400	2,610	0.65
	CVPSC	8,950	6,660	1.00
	Supp. Base	5,750	2,780	0.65
	N. Hartland	5,700	682	0.16
	Supp. Peak (G)	1,800	54	0.04
	Reserves (G)	(2,100)	---	--
	Total	34,000 (2,100)	15,530	0.61
July	PASNY	4,500	2,510	0.75
	Merrimack (R)	(1,900)	---	--
	Vt. Yankee (E)	(5,400)	---	--
	CVPSC	3,750	2,790	1.00
	CVPSC (R)	(5,200)	---	--
	Supp. Base	3,450	1,670	0.65
	Supp. Base (R)	(2,300)	---	--
	N. Hartland	3,200	291	0.07
	Supp. Peak (G)	100	29	0.39
	Reserves (G)	(9,200)	---	--
	Total	15,000 (21,100)	7,290	0.65

LEGEND: G - Gas turbine, peaking capacity
R - Reserves
E - Exchanged

TABLE 12.5

NORTH HARTLAND DAM PROJECT
ANNUAL COST ASSUMPTIONS: HYDRO

1. Fixed Charges⁽¹⁾

	<u>%</u>
Interest	7.0
Amortization ⁽²⁾	0.5
Insurance	0.1
Interim replacements	0.7
Taxes (local)	1.7
Equity	<u>1.0</u>
Total	<u>11.0</u>

2. Operation & Maintenance (1985)⁽³⁾

Capacity charge	\$12.00/KW-year
Energy charge	0.43 cts/kWh

NOTES:

- (1) Based on FERC values as reported in VEC 1976 Power Study.
 (2) Sinking fund, 40 year life, 7 percent interest.
 (3) Based on reported FERC values for 1975, escalated at 6 percent per annum.

TABLE 12.6

NORTH HARTLAND DAM PROJECT
ANNUAL COSTS: HYDRO

<u>Year</u>	<u>Fixed Costs (\$ x 1000)</u>		<u>O&M (\$ x 1000)</u>		<u>Total (\$ x 1000)</u>	
	<u>Annual</u>	<u>Cum. P.W. ⁽¹⁾</u>	<u>Annual ⁽²⁾</u>	<u>Cum. P.W.</u>	<u>Annual</u>	<u>Cum. P.W.</u>
1985	1532	1432	124	115	1656	1547
1989	1532	6283	156	567	1688	6850
1994	1532	10,763	209	1109	1741	11,872
1999	1532	13,957	279	1629	1811	15,586
2004	1532	16,235	374	2128	1906	18,363
2009	1532	17,858	500	2609	2032	20,467
2014	1532	19,016	669	3073	2201	22,089

NOTES: (1) Present worth in 1985 based on 7% interest rate, accumulated for period commencing 1985.

(2) O&M costs (for 6000 KW installed capacity and 11,980,000 KWh average annual generation) escalated at 6% per annum.

TABLE 12.7

NORTH HARTLAND DAM PROJECT
ANNUAL COST ASSUMPTIONS: OIL/COAL

	<u>Northeast Utilities</u>	<u>New GT</u>	(5) <u>Merrimack</u>
1. <u>Fixed Charges (\$/KW-year)</u>			
		(2)	
Capacity:	11.16	51.08	--
Transmission:	<u>11.30</u>	<u>11.30</u>	
Total	<u>22.46</u>	<u>62.38</u>	
2. <u>O,M&A (\$/KW-year)</u>			
		(3)	
Capacity:	3.16	4.59	--
Transmission:	<u>3.76</u>	<u>4.74</u>	
Total:	<u>7.37</u>	<u>9.33</u>	
3. <u>Energy (cts/KWh)</u>			
		(4)	
O,M&A:	0.45	0.57	--
Fuel:	<u>6.68</u>	<u>9.03</u>	<u>3.14</u>
Total:	<u>7.13</u>	<u>9.60</u>	<u>3.14</u>

- Notes: (1) Projected costs in 1985, based on actual 1978 costs, with O,M&A costs escalated 6% per annum, fuel costs escalated 8% per annum.
- (2) Projected costs in 1989 based on \$150/KW in 1976, 6% escalation and 15.97% annual charge (10% interest, 35 year depreciation, 5% taxes, 0.6% interim replacements and insurance).
- (3) Projected costs in 1989 based on \$2.15/KW-year in 1976 and 6% escalation.
- (4) Energy costs as for Northeast Utilities, escalated to 1989.
- (5) Fuel cost only based on 1.57 cts/KWh in 1976, escalated at 8% per annum.

TABLE 12.8

NORTH HARTLAND DAM PROJECT
ANNUAL COSTS: OIL/COAL (8% ESCALATION)

Year	<u>Fixed Costs (\$ x 1000)</u>		<u>O&M (\$ x 1000)</u>		<u>Fuel (\$ x 1000)</u>				<u>Total (\$ x 1000)</u>	
	(1)		(2)		(3)					
	<u>Annual</u>	<u>Cum. P.W.</u>	<u>Annual</u>	<u>Cum. P.W.</u>	<u>G.T.</u>	<u>Merrimack</u>	<u>Annual</u>	<u>Cum. P.W.</u>	<u>Annual</u>	<u>Cum. P.W.</u>
1985	128	120	65	61	343	215	558	521	751	702
1989	356	687	82	299	466	292	758	2,658	1,196	3,644
1994	356	1,546	110	529	685	430	1,115	5,449	1,581	7,524
1999	356	2,339	147	805	1,007	631	1,638	8,388	2,141	11,532
2004	356	2,904	197	1,070	1,480	928	2,408	11,488	2,961	15,462
2009	356	3,307	264	1,324	2,174	1,363	3,537	14,765	4,157	19,396
2014	356	3,595	354	1,569	3,195	2,003	5,198	18,237	5,908	23,401

- NOTES: (1) Present worth for 1985 (year end) based on 7% interest rate, accumulated for period commencing 1985.
- (2) O&M costs (for 5700 KW installed capacity, equivalent to average January output for North Hartland, and 5,133,000 KWh annual generation) escalated 6% per annum.
- (3) Annual generation, 5,133,000 KWh for GT, 6,847,000 KWh for Merrimack, escalated 8% per annum.

TABLE 12.9

NORTH HARTLAND DAM PROJECT
ANNUAL COSTS: OIL/COAL (10% ESCALATION)

Year	Fixed Costs (\$ x 1000)		O&M (\$ x 1000)		(3) Fuel (\$ x 1000)				Total (\$ x 1000)	
	Annual	Cum. P.W.	Annual	Cum. P.W.	G.T.	Merrimack	Annual	Cum. P.W.	Annual	Cum. P.W.
1985	128	120	65	61	343	215	558	521	751	702
1989	356	687	82	299	502	315	817	2,759	1,255	3,745
1994	356	1,546	110	529	808	507	1,317	5,935	1,781	8,010
1999	356	2,339	147	805	1,302	816	2,118	9,600	2,621	12,744
2004	356	2,904	197	1,070	2,097	1,315	3,412	13,838	3,965	17,812
2009	356	3,307	264	1,324	3,377	2,118	5,495	18,749	6,115	23,380
2014	356	3,595	354	1,569	5,439	3,411	8,850	24,440	9,560	29,604

- NOTES: (1) Present worth for 1985 (year end) based on 7% interest rate, accumulated for period commencing 1985.
- (2) O&M costs (for 5700 KW installed capacity, equivalent to average January output for North Hartland, and 5,133,000 KWh annual generation) escalated 6% per annum
- (3) Annual generation, 5,133,000 KWh for GT, 6,847,000 KWh for Merrimack, escalated 10% per annum.

SECTION 13

RECOMMENDATION

13. RECOMMENDATION

Although the North Hartland dam project may not be economic in the immediate short term, over a 30 year period from the probable earliest commissioning date of 1985, the project will produce lower cost power than any other alternative currently available to VEC. There is potential for some reduction in cost of the project by relocation of the power plant further upstream and deepening of the tailrace channel, with attendant increase in head.

There is evidence that further reductions in equipment costs may also be achieved as a result of marketing efforts by some foreign manufacturers in the United States. Final selection of type of equipment should therefore be based on competitive bids from several manufacturers prior to final design of power facilities.

The environmental impacts of development of power generating facilities at the existing North Hartland Reservoir are relatively minor. It may therefore be anticipated that the obtaining of permits from state and federal agencies for construction of the project will be reasonably straight-forward. It is therefore recommended that a FERC license application be filed for the North Hartland Dam Project at an early date, with a view to commissioning by 1985. As part of the process of preparing this application, consultations should be initiated promptly to determine the specific requirements of the FERC, the Corps of Engineers and relevant state agencies in regard to obtaining the necessary authorization to construct the project. Consideration of the additional cost saving measures discussed above should also be appropriately scheduled during the licensing process.

APPENDIX A

PLATES

NORTH HARTLAND DAM PROJECT

FEASIBILITY STUDY

GENERAL PLAN

PROJECT P4072

PLATE 1

SCALE 0 100 200 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY

PLAN OF FACILITIES

PROJECT P4072

PLATE 2

SECTION AT Q OUTLET WORKS

SCALE 0 50 100 200 FEET

SECTION THROUGH SPILLWAY

SCALE 0 20 40 80 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY
SECTION THROUGH
DAM AND SPILLWAY

PROJECT P4072

PLATE 3

SCALE 0 4 8 16 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY

RADIAL GATE

PROJECT P4072

PLATE 4

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY

BASCULE GATE

PROJECT P4072

PLATE 5

SECTIONAL PLAN ABOVE TURBINE FLOOR

CROSS SECTION AT ϕ UNIT

NOTE: ELEVATIONS ARE FOR UPSTREAM POWERHOUSE LOCATION WITH ELEVATIONS FOR DOWNSTREAM LOCATION IN PARENTHESIS.

SCALE 0 8 16 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY
2-30 MW UNITS
TUBE TURBINE

PROJECT P4072

PLATE 6

SECTIONAL PLAN AT CL DISTRIBUTOR

CROSS SECTION AT CL UNIT

SCALE 0 8 16 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY
2-3.0 MW UNITS
FIXED BLADE TURBINE

PROJECT P4072

PLATE 7

SECTIONAL PLAN AT Q UNITS

CROSS SECTION AT Q UNIT

SCALE 0 8 16 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY
2-3.0 MW UNITS
BULB TURBINE

PROJECT P4072

PLATE 8

[illegible]

AGRE

SECTIONAL PLAN AT DISTRIBUTOR

CROSS SECTION AT UNIT

SCALE 0 8 16 FEET

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY

1-6.0 MW UNIT
KAPLAN TURBINE

PROJECT P 4072

PLATE 10

NORTH HARTLAND DAM PROJECT
FEASIBILITY STUDY

SINGLE LINE DIAGRAM

PROJECT P4072

PLATE II

APPENDIX B

SITE EXAMINATION AND
EVALUATION REPORT

APPENDIX BSITE EXAMINATION AND EVALUATION REPORT
SITE VISIT SEPTEMBER 25 AND 26, 1978

On September 25 and 26, 1978, the project staff visited the North Hartland Dam. A summary of the observations made during that visit are given in the following paragraphs:

DAM

The embankment appears in excellent condition, with no apparent signs of distress resulting from differential settlement or bearing capacity failure of the foundation materials. The embankment slopes, constructed at 2H to 1V have been protected by a layer of loose rocks consisting of angular and flaggy pieces of slate, and do not show any sign of instability. There are no signs of either water erosion on the upstream slope or water seepage from the downstream slope.

SPILLWAY

The reservoir level has not been high enough to overtop the spillway since the dam was constructed. However, the high waters caused by high spring run-off in 1969 and by heavy rainstorm in 1972, was short of spilling by only 25 and 40 feet respectively. A large amount of silt was deposited into the reservoir during both floods.

The concrete weir and the side walls of the spillway appear to be in good condition. However, the concrete floor of the spillway has numerous cracks and there is evidence of deterioration due to frost action.

The near vertical slopes of the spillway channel are excavated in slate which is a fine-grained metamorphic rock of moderate compressive strength. The exposed rock is in excellent condition showing only minor signs of decomposition or mechanical disintegration near the bottom of the slopes. A well developed set of vertical joints exist normal to the slopes. The joints are tight and are occasionally filled with secondary quartz, and are about 2 to 3 feet apart. Scattered rock bolting has been used to protect the slopes.

No major geotechnical or civil problems are anticipated in modifying the spillway or the spillway channel. However, some remedial repairs may be required of the spillway outlet channel apron.

OUTLET WORKS

The intake structure is in excellent condition. Some minor seepage stains were noted at horizontal concrete joints inside the gate house. The conditions of the outlet conduit could not be observed due to a discharge of 50 cfs on the day of the visit.

Operator personnel reported no problem with gate operation. In cold weather, it was noted that operating pressure had to be increased, possibly due to freezing around the gate. No maintenance has been required for the gates since they were put into service. Except for freezes of the level gauge in the intake structure, there has been no problem with low temperatures at the gate area.

A hoist had been provided at the site for installation and removal of stoplogs, however, it was removed because it was never used.

A mobile crane can be brought in if stoplog handling is necessary.

OUTLET AND RIVER CHANNEL

The concrete outlet channel appeared in very good condition.

The slate exposed in the outlet channel is in excellent condition. There is no evidence of chemical or mechanical weathering. The vertical slopes appear to be very stable. Although the channel was not flowing at bank full capacity at the time of inspection, it has in the past sustained greater flows without any significant damage.

A conduit discharge flow of 50 cfs was observed during the site visit, and the water downstream of the outlet conduit at this flow was shallow. A rock channel has been excavated to a slope of 0.4 percent for about 500 feet downstream of the dam. At the end of the channel the river bed then dropped about 15 feet rather abruptly in the area just downstream of the remnant of a breeched small concrete dam. About 200 feet further downstream the river bed dropped about 8 additional feet. If the powerhouse were located in this lower area about 700 to 800 feet downstream of the conduit outlet, an additional head of 20 to 25 feet could be gained.

PROPOSED POWERHOUSE LOCATION

Downstream of the dam the slate present in possible powerhouse locations should be able to develop sufficient bearing capacity to support the proposed powerhouse without causing major geotechnical problems. Due to well developed vertical jointing, minimal use of rock bolts or other rock support may be required. The rock is homogeneous, hard and brittle, therefore no special problems are anticipated in excavating by conventional blasting, should a deeper cavity be required for placing the powerhouse.

APPENDIX C

EQUIPMENT DESIGN AND
MANUFACTURER DATA

APPENDIX CEQUIPMENT DESIGN AND MANUFACTURER DATA

Several manufacturers of hydroelectric power equipment and associated large specialty equipment were approached early in the feasibility study preparation to provide technical data and equipment cost estimates in support of the alternative conceptual designs. Due to other commitments some manufacturers did not respond and the short duration of the study hindered full development and analysis of manufacturers' data.

We would like to acknowledge the following equipment manufacturers for thier input of preliminary data and equipment costs to this report.

1. Turbines-Generators:

The following manufacturers were contacted and correspondence received is included in this appendix.

- Allis-Chalmers
- Dominion Engineering Works
- Sulzer Bros. Inc.
- Bofors-Nohab
- Fuji Electric

Responses were received from:

- Allis-Chalmers
- Dominion Engineering Works
- Sulzer Bros., Inc.

Information received from Bofors-Nohab and Fuji Electric for other similar studies was also used in the North Hartland study.

2. Electrical Equipment:

The following manufacturers were contacted and information was received.

- Siemens-Allis
- General Electric

Correspondence received is attached to this appendix.

3. Bascule and Radial Gates:

Contact was made with Allis-Chalmers for preliminary data and cost of a Pelican type Bascule gate. Dominion Bridge Company Limited was contacted for cost data for the Radial gates. Correspondence received is included in this appendix.

4. Valves:

McNally Pittsburgh Manufacturing Corporation was contacted for cost data and their response is included in this appendix.

BOX 712 • YORK, PENNSYLVANIA 17405 / 717 792-3511

YORK PLANT
HYDRO-TURBINE DIVISION

December 15, 1978

FILE 18

Acres American, Inc.
Consulting Engineers
The Liberty Bank Building, Main at Court
Buffalo, New York 14202

ATTENTION: Mr. J. D. Lawrence
Executive Engineer

SUBJECT: Vermont Electric Cooperative
North Hartland Dam Project
A-C Inquiry 6-33299

Gentlemen:

Reference is made to your letter of November 15, 1978 in which you advise that you are conducting a feasibility study for the Vermont Electric Cooperative for the installation of generating facilities at the existing North Hartland Flood Control Dam in Vermont.

We concur with the selection of using two (2) 2500 mm TUBE turbines, complete with speed increasers, synchronous generators, exciters, speed control and turbine inlet valves. For the turbine inlet valve, we have recognized in the pricing that the valve must be able to withstand the maximum flood condition head of 200'. Accordingly, and as you have advised, we would not contemplate operating the valve nor the TUBE turbine under this extremely high head as the turbine equipment would not be designed to operate under this condition.

It is noted the gross head for the unit is about 60' and the rated net head would be only about 45' at full gate because the units are located at the end of a long relatively high velocity penstock and penstock manifold. Additionally, it is noted that with only one unit operating the net head could be 56' at full load and 58' at a partial load. Therefore, we assume the TUBE turbine would be operated at this maximum head condition and hence the 3250 KW generator would be capable of producing approximately 4750 KW at the maximum head of 58'. Therefore, we would plan on the speed increaser driving a 4800 KW 900 RPM. 3-phase, 60 Hertz, 4160 volt synchronous generator.

For the supply of two (2) Allis-Chalmers standardized horizontal TUBE turbines having a 2500 mm adjustable blade runner, complete with the 3200 mm inlet valve,

Acres American, Inc.

-2-

December 15, 1978

speed increaser, flexible coupling, adjustable blade control, generator complete with control and excitation cubicles including the generator protection and control panel, the outdoor high voltage module, utility metering sections complete with high voltage switch and fuse and 15 KV power station type transformer can be supplied for the present day estimated sum of -

TWO MILLION EIGHTY-EIGHT
THOUSAND DOLLARS\$2,088,000.00

total for two (2), FOB cars York, Pennsylvania.

We enclose Bulletin 54B10241-02 describing the standardized hydroelectric generating units and refer you to Figure 3, Page 5 for the approximate dimensional data required for preliminary powerhouse design.

Please note we market the unit as a complete unit including all of the necessary electrical controls and switch gear. General arrangement drawings will be supplied to the design architects for information only and will not require approval of this standardized package.

If you require any additional information, please advise.

Very truly yours,

R. E. Coates, P.E.
Senior Sales Engineer

/ew
Enclosure

cc: Mr. William Arnold, William R. Arnold, Inc., Jamestown
Mr. George Moynihan, Flow Controls, Inc., Needham
Mr. J. H. Fischer, A-C York
Mr. H. Wirschal/D. Brandl, A-C York

**Dominion
Engineering
Works
Limited**

P.O. Box 220, Montreal, P.Q., Canada H3C 2S5
Telephone: Area 514 634-3411
Cable Address: Domworks Montreal
Telex 05-821673

Head Office and Plant: Lachine, P.Q.
Branch Offices: Toronto and Vancouver

C-4

File: FE-224-339

9 January 1979

Acres American Incorporated
Consulting Engineers
The Liberty Bank Building,
Main at Court
Buffalo, New York 14202
USA

Attention: J.D. Lawrence
Executive Engineer

Subject: North Hartland Dam Project
Feasibility Study

Dear Sir:

We are pleased to submit the turbine data required to complete your feasibility study on the above project.

We hope this information is satisfactory and we will look forward to participating with you on this project.

Yours truly,

DOMINION ENGINEERING WORKS LIMITED

Ian McKay
Sales Engineer
Hydraulic Turbine Section

'mcp

INFORMATION SHEETS
FOR
HYDRAULIC TURBINES AND GENERATORSSUBMITTED BY DOMINION ENGINEERING WORKS, MONTREALPROJECT NORTH HARTLAND DAM DATE NOVEMBER 19, 1978LOCATION NORTH HARTLAND VERMONTOWNER VERMONT ELECTRIC CO-OPERATIVE1. PLANT DATARated Plant Output..... 6,400 kWPlant Design Flow..... 2,000 cfsRated Net Head 45 ftRange of Net Head - maximum 58 ft- minimum 45 ft

Water Levels

Headwater - maximum El. -- normal El. 425 ft.- minimum El. -Tailwater - maximum El. 367 ft.- normal El. 365 ft.- minimum El. 362 ft.Generator - phases/frequency 3/60 Hz- flywheel effect Normal

Other Information _____

2. TURBINES

C-6

2.1 Technical Data

Number of Units..... 2

Type Vertical fixed blade propeller

Rated Power at Full Gate..... 4,500 hp

Turbine Efficiency - full gate..... 88.1 %

- best gate..... 91.2 %

Synchronous Speed..... 257.1 rpm

Runner Diameter..... 86.0 in.

Submergence of Centerline of distributor below min. TWL..... - 5.3 ft

2.2 Prices

Turbines and Governors - Supply & Delivery (2 units) ..\$ 2,300,000.

- Installation (2 units).....\$ 920,000.

* 920,000

Discussed price with Ian McKay,
Jan. 15, 1979. He agreed price
was high. 25% of supply price
is more realistic.

ACRES AMERICAN INC.

C-7

INFORMATION SHEETS FOR HYDRAULIC TURBINES AND GENERATORS

SUBMITTED BY DOMINION ENGINEERING WORKS, MONTREAL

PROJECT NORTH HARTLAND DAM DATE NOVEMBER 19, 1978

LOCATION NORTH HARTLAND VERMONT

OWNER VERMONT ELECTRIC CO-OPERATIVE

1. PLANT DATA

Rated Plant Output..... 6,400 kW

Plant Design Flow..... 2,000 cfs

Rated Net Head 45 ft

Range of Net Head - maximum 58 ft

- minimum 45 ft

Water Levels

Headwater - maximum El. -

- normal El. 425 ft.

- minimum El. -

Tailwater - maximum El. 367 ft.

normal El. 365 ft.

minimum El. 362 ft.

Generator - phases/frequency 3/60 Hz

- flywheel effect Normal

Other Information _____

2. TURBINES

C-8

2.1 Technical Data

Number of Units.....	<u>1</u>	
Type <u>Vertical Kaplan</u>		
Rated Power at Full Gate.....	<u>9,000</u>	hp
Turbine Efficiency - full gate.....	<u>88.5</u>	%
- best gate.....	<u>91.8</u>	%
Synchronous Speed.....	<u>180.0</u>	rpm
Runner Diameter.....	<u>126.0</u>	in.
Submergence of Centerline of distributo. below min. TWL.....	<u>- 5.0</u>	ft

2.2 Prices

Turbines and Governors	- Supply & Delivery (<u>1</u> unit\$)..	<u>\$2,800,000.</u>
	- Installation (<u>1</u> unit\$).....	<u>\$1,130,000</u>

* \$1,130,000

Suggest 25% of supply price

RE: STRAFLO TURBINES

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9 9

REGARDS
SULZER NEW YORK
B.E. MOSER/UK
JANUARY 9, 1979
TELEX 127297

RECORD OF TELEPHONE CALL

JOB NO. P4072.00 FROM (Originator) Allan Short
DATE November 20, 1978 Company Sieman - Allis
FILE NO. North Hartland TO Bob Chadri
Company AAI
SUBJECT Vertical Hydro Generators

The following information on small hydro generators was obtained today:

1. Unit Ratings - 7MW, 0.9 P.F., 225 RPM, 4160V

Est. Price - \$560,000 Including exciter & regulator.

Total Height - 170"

Shipping Dia. - 130"

Overall dia. including air housing - 240"

Wt. of heaviest piece to be lifted by

powerhouse crane - 40T to 45T.

2. Unit Ratings - 3.5MW, 0.9 P.F., 257.1 RPM, 4160V

Est. Price - \$350,000 including exciter and regulator

Total Height - 150"

Shipping Dia. - 94"

Overall dia. including air housing - 145"

Wt. of the heaviest piece to be lifted by

powerhouse crane - 10T to 15T.

CIRCULATE TO:

P. Rodrigue
D. K. Kaushal
D. Mayer
J. D. Lawrence

RECORD OF TELEPHONE CALL

JOB NO. P4072.00 FROM (Originator) Carl Bass
DATE November 15, 1978 Company G.E.
FILE NO. North Hartland TO Bob Chadri
Company AAI

SUBJECT Vertical Hydro Generators

The following is the estimated prices for small hydro generators:

1. Unit Ratings - 7MW, 0.9 P.F., 225 RPM, 4160V

Est, Price - \$950,000 including excitation system.

2. Unit Ratings - 3.5MW, 0.9 P.F., 257-1 RPM, 4160V.

Est, Price - \$600,000 including excitation system.

The information on unit dimensions and weights will be conveyed
at a later date.

CIRCULATE TO:

P. Rodrigue
D. K. Kaushal
D. Mayer
J. D. Lawrence

BOX 712 • YORK, PENNSYLVANIA 17405 / 717 792-3511

YORK PLANT
HYDRO-TURBINE DIVISIONOctober 25, 1978
(Dictated 10/20/78)Acres American, Inc.
The Liberty Bank Building
Buffalo, New York 14202

ATTENTION: Mr. R. E. Mayer

SUBJECT: North Hartland Dam
A-C Inquiry No. 6-35101

Dear Mr. Mayer:

As requested in your letter of October 5, 1978, we have enclosed price information on Bascule gates for the subject project. Our present day preliminary price for one (1) 14' high by 100' long Bascule gate is -

NINE HUNDRED TWENTY
THOUSAND DOLLARS.....\$920,000.00

The above price is F.O.B. York and includes all necessary hardware, including automatic level controls. Installation and concrete would be additional.

To further assist you in your selection of gate size and type, please send us a sketch or drawing of the proposed site along with desired flow and pool elevations.

Gate installation costs are very site specific and are, therefore, difficult to determine on a preliminary basis. However, a very rough estimate would be 20% to 30% of the equipment cost. This installation cost would also include a Field Engineer to supervise the work.

We hope this information is helpful to you. Should you have any questions, please do not hesitate to contact us.

Very truly yours,

M. S. Barandy
Sales Engineer

MSB/db

cc: Mr. W. R. Arnold, William R. Arnold, Inc., Jamestown, New York
Mr. J. R. Brown, Flow Controls, Inc., Needham, Massachusetts

~~INDUSTRIAL PRODUCTS DIVISION~~ ENGINEERED PRODUCTS
P.O. BOX 280, STATION "A" MONTREAL, QUE. H3C 2S7 TEL. (514) 634-3551

JSH/cdi

[illegible]

McNally
McNally Pittsburg Manufacturing Corporation
 Valve Division: 1401 North Pine, P.O. Drawer D, Pittsburg, Kansas 66762
 Telephone: 316-231-3000 Telex: 436405

January 9th, 1979

Acres American Incorporated
 The Liberty Bank Building;
 Main at Court
 Buffalo, New York 14202

Attention: Mr. J. D. Lawrence

Reference: North Hartland Dam Project
 Feasibility Study
 Turbine Intake Valves

Gentlemen:

As requested by your letter of November 17th, 1978, McNally submits the following estimated prices:

- 1) One (1) fifteen foot (15') diameter butterfly valve complete with hydraulic cylinder operator. Valve shall be able to close against 3300 Cfs and operate against 1980 Cfs with a maximum differential head of 26 Psig. The disc to withstand a maximum of 87 Psig.

Price -- \$200,000. each

- 2) Two (2) ten and one half foot (10.5') diameter butterfly valves, complete with hydraulic cylinder operators. Valves shall be able to close against 1650 Cfs and open against 990 Cfs with a maximum differential head of 26 Psig. The disc to withstand a maximum pressure of 87 Psig.

Price -- \$105,000. each

\$210,000. for two (2) valves

If McNally can be of further assistance, please feel free to write or call

Very truly yours,

Jeffrey M. Bowman
 Jeffrey M. Bowman
 Chief Engineer
 Valve Division

JMB:dha

APPENDIX D
COST ESTIMATE SUMMARIES

	<u>Page</u>
Upstream Powerhouse Alternative	D-1
Downstream Powerhouse Alternative	D-10

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-1 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
330.00	SUMMARY OF ESTIMATE LAND & LAND RIGHTS				38,000		
331.00	STRUCTURES & IMPROVEMENTS				555,050		
332.00	RESERVOIRS, DAMS & WATERWAYS				3,896,780		
333.00	WATERWHEELS, TURBINES & GENERATORS				2,160,000		
334.00	ACCESSORY ELECTRICAL EQUIPMENT				160,000		
335.00	MISC. POWER PLANT EQUIPMENT				25,000		
336.00	ROADS & RECREATION FACILITIES				97,200		
353.00	SUBSTATION EQUIPMENT				87,000		
355.00) 356.00)	TRANSMISSION				506,000		
	SUBTOTAL					7,525,030	
	CONTINGENCIES (15%)					1,126,755	
	TOTAL CONSTRUCTION COST					8,653,785	
	ENGINEERING & ADMINISTRATION (20%)					1,730,757	
	TOTAL PROJECT CAPITAL COST					10,384,542

ESTIMATE SUMMARY

CLIENT

PROJECT

Vermont Electric Cooperative

North Hartland, Vermont

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

TYPE OF ESTIMATE

Preliminary

APPROVED BY

JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-2 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST / UNIT	AMOUNT	TOTALS	REMARKS
330.00	Land & Land Rights	19	AC	2,000	38,000	38,000	Transmission right of way

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-3 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Power Plant Structures and Improvements						
.1	Powerhouse						
.11	Cofferdam and Pumping	--	L.S.	--	50,000		Assume one flash flood Including support. Included in Acct. 331.12
.12	Excavation, Rock	4,500	c.y.	22.00	99,000		
.13	Foundation Preparation	--	--	--			
.15	Substructure						
.1510	Concrete	2,300	c.y.	77.00	177,100		
.1511	Forms	10,000	s.f.	4.50	45,000		
.1512	Reinforcing steel	183,000	lb.	0.50	91,500		
.16	Superstructure						
.161	Structrual Steel Frame	16,600	lbs.	0.75	12,450		Included in Acct. 331.15
.162	Walls & Roof	--	--	--			
.163	Roof Hatches	--	L.S.	--	20,000		
.164	Interior Partitions, Floor	--	L.S.	--	1,000		
.165	Doors and Windows	--	L.S.	--	4,000		
.166	Plumbing and Sewage	--	L.S.	--	5,000		
.167	Heating and Ventilating	--	L.S.	--	15,000		
.168	Lighting	--	L.S.	--	5,000		
.169	Miscellaneous	--	L.S.	--	20,000		
.17	Station yard						
.171	Grading, Drainage, Fill	--	L.S.	--	10,000		
	Total Power Plant Structures and Improvements					555,050

ESTIMATE SUMMARY

CLIENT Vermont Electric Cooperative

PROJECT North Hartland, Vermont

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

TYPE OF ESTIMATE Preliminary

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-4 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
332.00	Reservoirs, Dams and Waterways						
.1	Reservoir						
.11	Clearing & Disposal	107	Ac.	1,500	160,500		
.14	Monitoring/Control Equipment	--	L.S.	--	10,000	170,500	
.2	Dams - Concrete						
.21	Pumping	--	L.S.	--	112,000		Summer reservoir releases
.23	Excavation, Rock	13,000	c.y.	20.00	260,000		Approach channel
.24	Foundation Preparation	--	--	--			Included in Acct. 332.23
.25	Concrete	1,500	c.y.	70.00	105,000		Spillway modifications
.251	Forms	7,000	s.f.	7.50	52,500		
.252	Reinforcing Steel	90,000	lbs.	0.50	45,000		Including anchors
.253	Concrete Removal	1,100	c.y.	42.00	46,200	620,700	Existing spillway
.4	Dams - Appurtenances						
.41	Spillway Gates & Hoist	2	Ea.	450,000	900,000		
.42	Outlet Control Gate & Hoist	1	Ea.	210,000	210,000	1,110,000	
.6	Intake Structure						
.61	Trash Racks	--	L.S.	--	48,000		
.69	Structure Modifications	--	L.S.	--	38,600	86,600	Raising base deck etc.
.8	Penstocks						
.81	Rock Excavation	4,000	c.y.	23.00	92,000		
.811	Concrete Removal	140	c.y.	42.00	5,880		Existing outlet
.812	Backfill	2,800	c.y.	5.00	14,000		Selected material
.82	Saddles & Thrust Blocks	120	c.y.	115.00	13,800		Including forms & reinf.
.821	Concrete Backfill	1,070	c.y.	165.00	176,550		Including grouting
.822	Outlet Structure	510	c.y.	150.00	76,500		Including forms & reinf.
.83	Steel Penstocks	1,025,000	lbs.	1.35	1,383,750	1,762,480

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT

Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT

North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-5 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
332.00	Reservoirs, Dams and Waterways (Continued)						
.9	Tailrace						
.91	Excavation, Rock	4,000	c.y.	80.00	20,000		
.92	Riprap	300	c.y.	25.00	7,500		
.93	Draft Tube Gate	--	L.S.	--	29,000		
.94	Concrete	200	c.y.	150.00	30,000	146,500	Misc. retaining walls
	Total Reservoirs, Dams and Waterways					3,896,780

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-6 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
333.00	Water Wheels, Turbines & Generators						
.1	Turbines, Governors, Pumps and Piping						
.101	Supply	--	L.S.	--	1,800,000		2 Units
.102	Install & Commission (20%)	--	L.S.	--	360,000		
.2	Generators, Exciters & Appurtenances						
.201	Supply	--	--	--			Included in 333.101
.202	Install & Commission	--	--	--			Included in 333.102
	Total Water Wheels, Turbines, & Generators					2,160,000

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06
FILE NUMBER P4072.53.41
SHEET D-7 OF 17
BY RL DATE 1-79
CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
334.00	Accessory Electric Equipment						
.12	Cables and Accessories	--	L.S.	--	50,000		4.16 KV cable bus and breaker; control, metering and relays included in Acct. No. 333.101 and 102.
.125	Station Grounding	--	L.S.	--	5,000		
.25	Supervisory Panel	--	L.S.	--	20,000		
.26	Station Service	--	L.S.	--	50,000		
.262	Batteries - D.C. Panels	--	L.S.	--	15,000		
.29	Miscellaneous	--	L.S.	--	20,000		
	Total Accessory Electric Equipment					160,000

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT Vermont Electric Cooperative TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont APPROVED BY JDL

JOB NUMBER P4072.06
FILE NUMBER P4072.53.41
SHEET D-8 OF 17
BY RF DATE 1-79
CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
335.00	Miscellaneous Power Plant Equipment						
.1	Auxiliary Equipment						
.11	Unwatering & Low Level Drainage System	--	L.S.	--	8,000		
.14	Compressed Air System	--	L.S.	--	2,000		
.15	Fire Protection Equipment	--	L.S.	--	8,000		
.18	Protective Coatings	--	L.S.	--	5,000		
.19	Miscellaneous	--	L.S.	--	2,000		
	Total Miscellaneous Power Plant Equipment					25,000	
336.00	Roads and Recreation Facilities						
.11	Clearing & Grubbing	--	L.S.	--	2,000		
.121	Grading, Rock	1,040	c.y.	15.00	15,600		
.122	Fill	9,700	c.y.	3.00	29,100		
.141	Surfacing, Gravel	4,450	s.y.	10.00	44,500		
.29	Relocation of Recreation Facilities	--	L.S.	--	6,000		
	Total Roads and Recreation Facilities					97,200	

Including base

ESTIMATE SUMMARY

Upstream Powerhouse, 2-3.0 MW Horizontal
tube units, w/Radial gates

CLIENT

Vermont Electric Cooperative

TYPE OF ESTIMATE

Preliminary

PROJECT

North Hartland, Vermont

APPROVED BY

JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-9 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
353.00	Substation Equipment						
.11	Structures	--	L.S.	--	60,000		Foundations & fencing
.125	Grounding	--	L.S.	--	2,000		
.21	Transformer 46KV/4.16KV	--	--	--			Included in Acct. Nos.
.22	Circuit Breaker, 46KV	--	L.S.	--	25,000		333.101 and 102
	Total Substation Equipment					87,000	
355.00)							
356.00)	Transmission	--	L.S.	--	506,000	506,000	Including poles, conductors, hardware and terminal switchgear.

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-10 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
330.00	SUMMARY OF ESTIMATE LAND & LAND RIGHTS				38,000		
331.00	STRUCTURES & IMPROVEMENTS				655,050		
332.00	RESERVOIRS, DAMS & WATERWAYS				2,803,850		
333.00	WATERWHEELS, TURBINES & GENERATORS				2,160,000		
334.00	ACCESSORY ELECTRICAL EQUIPMENT				160,000		
335.00	MISC. POWER PLANT EQUIPMENT				25,000		
336.00	ROADS & RECREATION FACILITIES				84,500		
353.00	SUBSTATION EQUIPMENT				87,000		
355.00) 356.00)	TRANSMISSION				506,000		
	SUBTOTAL					6,519,400	
	CONTINGENCIES (15%)					977,910	
	TOTAL CONSTRUCTION COST					7,497,310	
	ENGINEERING & ADMINISTRATION (20%)					1,499,462	
	TOTAL PROJECT CAPITAL COST					8,996,772

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-11 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
330.00	Land & Land Rights	19	AC	2,000	38,000	38,000	Transmission right of way

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06
FILE NUMBER P4072.53.41
SHEET D-12 OF 17
BY RE DATE 1-79
CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
331.00	Power Plant Structures and Improvements						
331.1	Powerhouse						
.11	Cofferdam and Pumping	--	L.S.	--	150,000		Assume one flash flood Including support Included in Acct. 331.12
.12	Excavation, Rock	4,500	c.y.	22.00	99,000		
.13	Foundation Preparation	--	--	--			
.15	Substructure						
.1510	Concrete	2,300	c.y.	77.00	177,100		
.1511	Forms	10,000	s.f.	4.50	45,000		
.1512	Reinforcing steel	183,000	lbs.	0.50	91,500		
.16	Superstructure						
.161	Structural Steel Frame	16,600	lbs.	0.75	12,450		
.162	Walls & Roof	--	--	--			Included in Acct. 331.15
.163	Roof Hatches	--	L.S.	--	20,000		
.164	Interior Partitions, Floor	--	L.S.	--	1,000		
.165	Doors and Windows	--	L.S.	--	4,000		
.166	Plumbing and Sewage	--	L.S.	--	5,000		
.167	Heating and Ventilating	--	L.S.	--	15,000		
.168	Lighting	--	L.S.	--	5,000		
.169	Miscellaneous	--	L.S.	--	20,000		
.17	Station yard						
.171	Grading, Drainage, Fill	--	L.S.	--	10,000		
	Total Power Plant Structures and Improvements					655,050

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-13 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
332.00	Reservoirs, Dams and Waterways						
.1	Reservoir						
.14	Monitoring/Control equipment	--	L.S.	--	10,000	10,000	
.4	Dams - Appurtenances						
.42	Outlet Control Gate & Hoist	1	Ea.	210,000	210,000	210,000	
.6	Intake Structure						
.61	Trash Racks	--	L.S.	--	48,000		
.8	Penstocks						
.81	Rock Excavation	1,300	c.y.	23.00	29,900		
.812	Backfill	400	c.y.	5.00	2,000		
.82	Saddles & Thrust Blocks	220	c.y.	115.00	25,300		
.821	Concrete Backfill	1,070	c.y.	165.00	176,550		
.822	Outlet Structure	510	c.y.	150.00	76,500		
.83	Steel Penstocks	1,516,000	lbs.	1.35	2,046,600	2,356,850	Selected material Including forms & reinf. Including grouting Including forms & reinf. Supplied and installed comp.
.9	Tailrace						
.911	Excavation, Rock	5,000	c.y.	20.00	100,000		
.912	Excavation, Common	1,000	c.y.	5.00	5,000		
.92	Rip Rap	600	c.y.	25.00	15,000		
.93	Draft Tube Gate	--	L.S.	--	29,000		
.94	Concrete	200	c.y.	150.00	30,000	179,000	Misc. retaining walls
	Total Reservoirs, Dams and Waterways					2,803,850

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06
FILE NUMBER P4072.53.41
SHEET D-14 OF 17
BY RL DATE 1-79
CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST / UNIT	AMOUNT	TOTALS	REMARKS
333.00	Water Wheels, Turbines & Generators						
.1	Turbines, Governors, Pumps and Piping						
.101	Supply	--	L.S.	--	1,800,000		
.102	Install & Commission (20%)	--	L.S.	--	360,000		2 Units
.2	Generators, Exciters & Appurtenances						
.201	Supply	--	--	--			Included in 333.101
.202	Install & Commission	--	--	--			Included in 333.102
	Total Water Wheels, Turbines & Generators					2,160,000

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-15 OF 17

BY RL DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
334.00	Accessory Electric Equipment						
.12	Cables and Accessories	--	L.S.	--	50,000		
.125	Station Grounding	--	L.S.	--	5,000		
.25	Supervisory Panel	--	L.S.	--	20,000		
.26	Station Service	--	L.S.	--	50,000		
.262	Batteries - D.C. Panels	--	L.S.	--	15,000		
.29	Miscellaneous	--	L.S.	--	20,000		
	Total Accessory Electric Equipment					150,000	4.16 KV cable bus and breaker; control, metering and relays included in Acct. No. 333.101 and 102.

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06

FILE NUMBER P4072.53.41

SHEET D-16 OF 17

BY RE DATE 1-79

CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
335.00	Miscellaneous Power Plant Equipment						
.1	Auxiliary Equipment						
.11	Unwatering & Low Level Drainage System	--	L.S.	--	8,000		
.14	Compressed Air System	--	L.S.	--	2,000		
.15	Fire Protection Equipment	--	L.S.	--	8,000		
.18	Protective Coatings	--	L.S.	--	5,000		
.19	Miscellaneous	--	L.S.	--	2,000		
	Total Miscellaneous Power Plant Equipment					25,000	
336.00	Roads						
.11	Clearing & Grubbing	--	L.S.	--	2,000		
.121	Grading, Rock	1,040	c.y.	15.00	15,600		
.122	Fill	9,700	c.y.	3.00	29,100		
.141	Surfacing, Gravel	3,780	s.y.	10.00	37,800		Including base
	Total Roads and Recreation Facilities					84,500

ESTIMATE SUMMARY

Downstream Powerhouse, 2-3.0 MW Horizontal
tube units.

CLIENT Vermont Electric Cooperative

TYPE OF ESTIMATE Preliminary

PROJECT North Hartland, Vermont

APPROVED BY JDL

JOB NUMBER P4072.06
FILE NUMBER P4072.53.41
SHEET D-17 OF 17
BY RL DATE 1-79
CHKD REM DATE

No.	DESCRIPTION	QUANTITY	UNIT	COST/ UNIT	AMOUNT	TOTALS	REMARKS
353.00	Substation Equipment						
.11	Structures	--	L.S.	--	60,000		Foundations & fencing
.125	Grounding	--	L.S.	--	2,000		
.21	Transformer 46KV/4.16KV	--	--	--			Included in Acct. Nos.
.22	Circuit Breaker, 46KV	--	L.S.	--	25,000		333.101 and 102
	Total Substation Equipment					87,000	
355.00)							
356.00)	Transmission	--	L.S.	--	506,000	506,000	Including poles, conductors, hardware and terminal switchgear.

APPENDIX E

PRELIMINARY
PERMIT

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

PRELIMINARY PERMIT

Vermont Electric Cooperative,)
Inc.

Project No. 2816

ORDER ISSUING PRELIMINARY PERMIT
(Issued February 9, 1979)

On September 16, 1977, 1/ Vermont Electric Cooperative, Inc. filed an application for a preliminary permit for the proposed North Hartland Project, FERC No. 2816. The proposed project would utilize the U.S. Army Corps of Engineers' (Corps) North Hartland Flood Control Dam on the Ottauquechee River in Windsor County, Vermont.

Only the Attorney General of the State of Vermont has intervened, but without substantive comments. The Corps, the Department of the Interior (Interior), the Forest Service of the Department of Agriculture, and the Environmental Protection Agency (EPA) commented on the application, but expressed no objections to the issuance of a preliminary permit.

Description of the Proposed Project

The proposed project would involve construction of a powerhouse and appurtenant facilities immediately downstream from the existing North Hartland Dam. Turbine and generator combinations capable of producing between 8,000 and 12,000 kW are being considered for installation in the proposed powerhouse.

Discussion

EPA, Interior, and the Corps, via their respective letters, discussed general problems that might be associated with the installation and operation of hydroelectric generating facilities and suggested that the potential problems be addressed in studies performed during the preliminary permit period. Special Article 7 of this permit requires the permittee to study these and other kinds of potential problems and to utilize the results of its

1/ This proceeding was commenced before the Federal Power Commission (FPC). By regulation of October 1, 1977 (10 CFR 1000.0), it was transferred to the Federal Energy Regulatory Commission (FERC). In this order; the term "Commission" refers to the FPC for actions or statements that occurred before October 1, 1977; otherwise it refers to the FERC. Authority to act on this matter is delegated to the Director, Office of Electric Power Regulation, under section 3.5(g) of the Commission's regulations, 18 CFR 3.5(g) (as amended August 14, 1978)

studies in preparing any application for a license to construct and operate the project.

EPA, Interior, and the Corps also stated that the studies should be coordinated with the Fish and Wildlife Service (FWS), and the Corps.^{2/} Special Articles 10 and 11 require the permittee to consult and coordinate its studies with the Vermont Agency of Environmental Conservation, the Corps, and the FWS.

The North Hartland Project, if constructed, would have an impact upon the recently licensed White Current Project, FERC No. 2787.^{3/} The White Current Project has a licensed capacity of 432 kW and is located approximately one and a half miles downstream of the Corps' North Hartland Dam. Should the North Hartland Project be constructed and operated, the amount of energy available at Project No. 2787 will be diminished due to changes in river flows.^{4/} The studies to be performed in accordance with this preliminary permit will not interfere with the construction or operation of Project No. 2787, and Article 12 of this permit requires the permittee to study the effects of the proposed project on the White Current Project.

Environmental Impacts

A preliminary permit only maintains the right of priority of application for license during the period necessary for feasibility studies, and does not authorize construction of the project. The studies which are required by the permit will be conducted under conditions to assure that no significant adverse environmental impact will result. For these reasons, the issuance of this preliminary permit does not constitute a major Federal action significantly affecting the quality of the human environment.

^{2/} The agencies also recommended consultation with the New England River Basins Commission. That agency, although requested to comment on the application, has not expressed any interest in the proposed project.

^{3/} For a detailed discussion of the impacts, see Order Issuing License, White Current Project, FERC No. 2787 (issued January 15, 1979).

^{4/} Article 26 of the license for Project No. 2787 reserves the right of the Commission to license another hydroelectric project to more completely utilize the water resources of the basin.

It is ordered:

(A) This preliminary permit is issued to the Vermont Electric Cooperative, Inc. for the North Hartland Dam Project No. 2816, located on the Ottauquechee River in the County of Windsor, Vermont, and utilizing waters from the U.S. Army Corps of Engineers' North Hartland Dam and Reservoir, for a period of 36 months, effective the first day of the month in which this permit is issued, subject to the terms and conditions of the Federal Power Act (Act), which is incorporated by reference as part of this permit, and subject to the rules and regulations the Commission issues under the provisions of the Act.

(B) This permit is also subject to the terms and conditions set forth in Form P-1 (Revised October 1975) entitled "Terms and Conditions of Preliminary Permit." Those terms and conditions, designated as Articles 1 through 6, are attached and made a part of this permit, which is also subject to the following special conditions set forth as additional articles:

Article 7. Permittee, in the interest of protecting and developing the natural resources and other environmental values of the project area shall consult with the appropriate federal, state, and local agencies in their fields of responsibility and expertise, shall conduct its project investigations in a manner which protects the environmental integrity of the area, and shall fully explore all feasible alternatives to the project and alternative project designs, taking into account impacts on natural resources and other environmental values. These resources and values include, but are not limited to: forests, land management and treatment, fish and wildlife, recreation and public use, flood regulation, water and air quality (including water supply, ground water studies, waste treatment and disposal), public health and safety, archaeological, historic, and cultural sites; rare, threatened or endangered flora and fauna; and scenic and aesthetic values. The permittee shall initiate and conduct at its expense any studies that may be necessary to determine the impact of construction and operation of the proposed project on these natural resources and values and any measures needed to protect and develop them or to provide for their mitigation or replacement, including alternative designs and operational measures; and shall utilize the results of these studies in the preparation of Exhibits H, R, S, V, and W to accompany any application for a license to construct and operate the project.

Article 8. The permittee shall submit in triplicate at the close of each six-month period from the effective date of this permit, to the Director, Office of Electric Power Regulation, Federal Energy Regulatory Commission, with a copy to the Regional Engineer, Federal Energy Regulatory Commission, New York, N.Y., or

to such other officer as the Commission may designate, and a copy, if requested, to any agency consulted, accurate statements of the progress of all investigations, consultations, and studies accomplished during the period and of work contemplated under this permit for the ensuing period.

Article 9. The permittee shall, for the purpose of assuring the cooperation required by the terms of the permit, designate a liaison officer to act for the permittee in keeping appropriate federal, state, and local agencies specified in this permit currently informed about the progress of investigations throughout the term of the permit; and the liaison officer shall communicate with those agencies within 60 days from the date of issuance of this permit.

Article 10. The permittee, by the end of the first year of this permit, shall: (1) have consulted with the U.S. Fish and Wildlife Service of the Department of the Interior and the Vermont Agency of Environmental Conservation and arranged for the preparation of a study of any effects which the proposed project would have on fish and wildlife resources and of facilities or measures needed to conserve or develop these resources; (2) file with the Commission, and serve copies on the agencies consulted, an outline of the proposed study, including an estimate of its cost; and (3) file with the Commission letters from each of those agencies indicating the extent of consultation. The Commission reserves the right to require modifications of the proposed study. During the remaining two years of the permit, the permittee shall fund or otherwise provide for that study. A copy of the report on the study shall be filed as part of the Exhibit S of any subsequent application for license.

Article 11. The permittee shall coordinate the studies for the proposed project authorized by this permit with the Division Engineer, Corps of Engineers, New England Division.

Article 12. The permittee shall conduct a study, and include its result in any application for a license, of any effects the proposed project may have on the operation of the downstream licensed White Current Project, FERC No. 2787.

(C) This order shall become final 15 days from the date of its issuance unless a petition appealing it to the Commission is filed under Section 1.7(d) of the Commission's regulations, 18 CFR 1.7(d) (as amended, August 14, 1978).

Failure of the Licensee to file such a petition shall constitute acceptance of the order.

(S E A L)

A handwritten signature in cursive script, reading "William W. Lindsay".

William W. Lindsay
Director, Office of Electric
Power Regulation

IN TESTIMONY of its acknowledgment of acceptance of all provisions, terms and conditions of this preliminary permit, Vermont Electric Cooperative, Inc. this ____ day of _____, 197 , has caused its corporate name to be signed hereto by _____, its _____ President, and its corporate seal to be affixed hereto and attested by _____, its _____ Secretary, pursuant to a resolution of its Board of Directors duly adopted on the ____ day of _____, 197 , a certified copy of the record of which is attached hereto.

By _____
President

Attest:

Secretary

(Executed in quadruplicate)

Form P-1
(Revised October, 1975)

FEDERAL POWER COMMISSION

TERMS AND CONDITIONS OF
PRELIMINARY PERMIT

Article 1. The Permittee shall make such engineering and other investigations, secure such data, and perform such acts as are necessary to determine the feasibility of the proposed project and, if said project is found to be feasible, to prepare an application for license for the project that will be in conformance with current rules and regulations of the Commission. In carrying out the requirements of this permit the Permittee shall:

A. Install as soon as practicable, and thereafter maintain, such stream gages and stream-gaging stations as the District Engineer of the United States Geological Survey having charge of stream-gaging operations in the region shall designate as necessary and best adapted for the purpose of determining the stage and flow of the stream or streams affected by the proposed project, and shall provide for the required reading of such gages and for the adequate rating of such stations. The number, design, location, and time of installation of gages and stations, the rating of such stations, and the determination of the flow of the affected stream or streams, shall be made under the supervision of, or in cooperation with, the District Engineer of the United States Geological Survey having charge of stream-gaging in the region of said project; and the Permittee shall advance to said Geological Survey the amount of funds estimated to be necessary for such supervision, or cooperation for such periods as may be mutually agreed upon. The Permittee shall, to the satisfaction of the Commission, keep accurate and sufficient records of the stage and flow of the affected stream or streams, and shall make such records available to the Commission at such times as the Commission may prescribe.

B. Sink such test pits or make such borings or other foundation explorations, and make such detailed geologic studies and tests on foundations and fill materials, as are necessary to support preliminary engineering designs and cost estimates.

C. Begin the required investigations within 60 days after acceptance of the permit, and thereafter prosecute said investigations in such manner and at such rate as in the judgment of the Commission will ensure their completion within the period of the permit.

D. Furnish with any application for license subsequently filed with the Commission copies of engineering and geologic reports, results of tests and analyses, and any other information secured in connection with the investigations, examinations and surveys conducted under this permit.

E. Exercise appropriate measures at all times during field studies to prevent irreparable damage to the environment of the proposed project. All test sites shall be restored as closely as possible to their original condition, and to the satisfaction of the Commission's authorized representative, or, where Federal lands are affected, to the satisfaction of the agency administering such lands.

Article 2. A license will be issued for the proposed project only if in the judgment of the Commission said project will be best adapted to a comprehensive plan for the improvement or development of a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, and for other beneficial public uses, including recreational purposes. In reaching a decision on the desirability of issuing a license, the Commission will consider, among other things:

A. Whether the maps, plans, and specifications are such:

- (1) That full, practicable utilization will be made of the water, storage possibilities, and head at the site to be developed;
- (2) That the structures will be safe and constructed in accordance with good engineering practice; and
- (3) That all unnecessary energy losses, whether in hydraulic works or in mechanical or electrical equipment, will be avoided.

B. Whether in relation to existing or probable future projects upon the same or adjacent streams, the potential for the fullest practicable utilization of the available water, storage possibilities, and head will be maintained.

C. Whether said project will be in general accord with the most beneficial utilization of the water for navigation, water power, irrigation, or other public uses, and for aiding flood control, reclamation, and similar developments.

D. Whether proper provision is made for present or future electrical interconnection with other projects or systems in order to take advantage of diversity of streamflow and of power demands.

E. Whether the use to which the power will be devoted is, in general, in accord with the public interest.

F. Whether the applicant is financially able to carry out the development.

G. Whether the construction, maintenance, and operation of the proposed project works will interfere or be inconsistent with the purpose for which any reservation, as defined in the Federal Power Act, was created or acquired.

Article 3. The priority granted under the permit shall be lost if the Permittee fails to fulfill the requirements of the permit, if the permit is canceled by order of the Commission, or if the Permittee fails, on or before the expiration date of the permit, to file with the Commission or its designated agent an application for license for the proposed project in conformity with the Commission's rules and regulations then in effect.

Article 4. The Permittee shall keep accurate records of all expenditures made for the purposes authorized by the permit, together with all vouchers and other supporting data relating to such expenditures, which records and related materials shall be retained by the Permittee.

Article 5. The permit confers no authority upon the Permittee to undertake construction of the proposed project, or any part thereof, or to occupy or use lands or other property of the United States for the purposes of construction, unless specific permission is given by the Commission for such occupancy or use; and neither the granting of such authority nor the performance of construction work, whether with or without such authority, shall be deemed to have created any equities or to have established any rights with respect to issuance of a license for the proposed project, beyond what would have been created or established had such authority not been given or such work not been performed.

Article 6. The permit is not transferable and may be canceled by order of the Commission upon failure of the Permittee to begin in good faith, or to prosecute diligently, the investigations, examinations, and surveys contemplated under the permit, or to comply with any other conditions therein, or for any other good cause shown after notice and opportunity for hearing.

APPENDIX F

GENERATION MODEL
(BAVMONQ)

EVALUATION OF HYDRO POTENTIAL BASED ON AVERAGE MONTHLY FLOWS
(FLOOD CONTROL DAMS)

CALLING NAME: BAVMONQ

1 - SUMMARY

This program is designed to aid the engineer in the selection of an installed capacity for a proposed hydroelectric plant with peaking power capability. Given a design flow, required generation time, and plant and site specifications, the program will select an installed capacity based on the wettest month of the year and will produce monthly tabulations of generation flow, reservoir fluctuation, net head, duration of generation, power and energy output, revenue, and capacity factor. An optional cost analysis routine will determine if a gas turbine is necessary to meet peaking demands and will calculate installed and operating costs of both the hydro development and the gas turbine.

2 - INPUT DATA

Data is entered interactively when requested by the program. The following values are needed:

2.1 - Flow data

- (a) Average river flows for January through December (cfs)
- (b) Index of the wettest month (e.g. April = 4)

2.2 - Plant type information

- (a) With or without penstock
- (b) Penstock length (ft)
- (c) Penstock velocity (ft/sec)

2.3 - Equipment data

- (a) Number of units
- (b) Type of unit

2.4 - Revenue projections

- (a) Marketable power prices (\$/kW-month)
- (b) Marketable energy prices (mills/kWh)

2.5 - Site specifications

- (a) Pondage per foot (cu.ft/ft)
- (b) Channel invert (ft)
- (c) Rise in tailwater level per cfs of downstream flow (ft/cfs)
- (d) Initial monthly reservoir levels (ft)
- (e) Monthly maintenance flow (cfs)

2.6 - Generation requirements

- (a) Minimum generation time (hrs.)
- (b) Maximum generation flow (cfs)

2.7 - Additional input for calculation of the cost of peaking with a gas turbine

- (a) Maximum peaking power demands for January through December (kW)
- (b) Maximum peaking energy demands for January through December (kWh)
- (c) Monthly interest rate (%)
- (d) Capital cost of the hydro development excluding the power plant (\$)
- (e) Cost of the power plant (\$/kW installed capacity)
- (f) Cost of gas turbine generation (\$/kW - month)
- (g) Cost of energy production by the gas turbine (mills/kWh)

3 - RESTRICTIONS AND ASSUMPTIONS

3.1 - Flow data

Monthly flows should be entered in sequence, beginning with January, and separated by commas. This applies in all cases throughout the program when a series of numbers for twelve months is requested. The index of the wettest month is the integer referring to that month, for example, if March is the wettest month, "3" is the correct entry. A month is assumed to consist of 30.4 days.

3.2 - Plant type information

If no penstock is specified, head losses through the plant are assumed to equal one foot. If a penstock length and velocity are entered, penstock

diameter is calculated based on the input velocity and design flow. For a penstock of length ℓ and diameter d ,

$$h_L = \frac{\ell}{1000} K_s \frac{v^{1.9}}{d^{1.1}}$$

where $K_s = .33$ for a steel penstock

3.3 - Equipment

It is possible to select four types of turbines for this program: Kaplan (double regulated), Kaplan (single regulated), Francis, and fixed blade propeller. There is no restriction on the number of units but they must all be of the same type. No turbine will operate below an arbitrary limit set by the program. These limits expressed as a percentage of full gate flow are as follows:

Kaplan (double regulated).....30%

Kaplan (single regulated).....45%

Francis.....50%

Fixed blade propeller.....70%

The efficiency curves for each turbine are shown in Figure 1. Generator efficiency is assumed to be 95%. The units will operate according to the following restrictions:

- (a) For monthly generation times greater than eight hours, a maximum number of units will run at full gate flow and a single unit will use the remaining water. This unit will not operate, however, if its supply is below the limit shown above.
- (b) For monthly generation times less than eight hours, a maximum number of units will operate at best gate flow and a single unit will use the remaining water.

3.4 - Revenue projections

Marketable power and energy values are needed for each month. The user should note that the demand value is in dollars per kW-month.

3.5 - Site specifications

Pondage per foot represents the increase in reservoir storage in cubic feet obtained with an increase in elevation of one foot.

Channel invert (C_{inv}) and rise in tailwater elevation per cfs of downstream flow (generation flow + flow over the dam, T) should be chosen such that $C_{inv} + (T \cdot Q)$ will equal the tailwater elevation for flow Q .

Initial monthly reservoir levels should reflect any losses in addition to those incurred in the plant. The monthly maintenance flow is the minimum required downstream flow at all times.

3.6 - Generation requirements

The maximum generation flow will be used to determine plant capacity. The program will attempt to maintain this flow or the corresponding 88% flow (best gate, see restriction 3.3) in each month. However, generation time will always remain above the minimum specified duration even at the expense of reduced generation flow.

3.7 - General Notes

There is no required format for any data entry. Internal commas, however, may not be used (for example, 2914.3 not 2,914.3). Any data may be entered in exponential form (for example 2.914E4, where "E" represents the base 10).

4 - METHOD OF SOLUTION

Generation times are first determined as explained in the previous section. Reservoir fluctuations are calculated next. The maximum reservoir level represents the average of initial reservoir levels of the month in question and the month immediately following. The minimum level reflects any draw-down which may occur during the day. Average level is the mean of the maximum and minimum.

Tailwater levels are calculated utilizing the channel invert and foot per cfs rise, as explained in Section 3.5. Net head is equal to the average reservoir level minus tailwater elevation and plant losses.

The plant is rated according to the generation flow and net head in the wettest month. After the plant is rated, power and energy production, capacity factors and revenues are determined for each month.

In the calculation of hydro-gas turbine costs, an installed capacity for the gas turbine based on the maximum monthly demand deficit will be selected. The capital cost of the hydroelectric development per month is the interest charge on the sum of the capital cost of development excluding the power plant and the cost of the installed capacity. The monthly cost of gas turbine generation and gas turbine energy production are calculated based on the input values of capital cost and energy cost and the calculated installed gas turbine capacity and monthly energy demand deficit.

5 - PROGRAM STRUCTURE

The program is divided into input, output, and calculation sections. A subroutine is used to locate flow percentages on the turbine efficiency curves and determine the corresponding efficiencies by linear interpolation.

When a set of calculations is completed, the user has the option of changing the value of one or more parameters. The program will then perform a new set of calculations with all original input intact except that which is specifically changed. If the cost of peaking option is selected, the analysis will be performed on the latest set of power and energy outputs.

6 - SAMPLE RUN

6.1 - Input

```

ENTER 12 FLOW VALUES, JAN.-DEC.
? 244,203,548,1350,602,242,126,116,116,151,263,267
WETTEST MONTH?
? 4
PLANT TYPE? 1=WITH PENSTOCK,2=WITHOUT PENSTOCK
? 1
PENSTOCK LENGTH,FT?
? 750.
VELOCITY,FT/SEC?
? 18.
NUMBER OF UNITS?
? 2
TYPE OF UNIT? 1=KAPLAN,2=KAPLAN WITHOUT WICKET GATES,
3=FRANCIS,4=FIXED BLADE PROPELLER
? 4
MARKETABLE POWER PRICES,$/KW,JAN.-DEC.?
? 2.54,2.54,2.54,2.54,2.54,2.54,2.54,2.54,2.54,2.54,2.54,2.54
MARKETABLE ENERGY PRICES,MILLS/KWH,JAN.-DEC.?
? 33,33,33,33,33,33,33,33,33,33,33,33.
RISE IN RESERVOIR VOLUME/FT RESERVOIR LEVEL?
? 13000000.
CHANNEL INVERT, RISE IN TW/CFS GEN. FLOW?
? 384,.005
MINIMUM GENERATION TIME?
? 3.
INITIAL MONTHLY RESERVOIR LEVELS,JAN.-DEC.,FT?
? 450,450,450,450,450,450,450,450,450,450,450,450.
MONTHLY MAINTENANCE FLOWS,JAN-DEC,CFS?
? 10,10,40,40,40,10,10,10,10,10,10,10.
MAXIMUM GENERATION FLOW,CFS?
? 1500.

```

6.2 - Output

NUMBER OF UNITS=2

FULL GATE FLOW= 750. CFS
 BEST GATE FLOW= 660. CFS
 RATED HEAD= 52.4 FT
 FULL GATE POWER= 2691. KW
 BEST GATE POWER= 2452. KW
 MINIMUM GENERATION TIME= 3.0 HRS
 FIXED BLADE PROPELLER TURBINES
 PENSTOCK LENGTH= 750.0 FT
 PENSTOCK VELOCITY= 18.00 FT/SEC

MONTH	AVG FLOW(CFS)	GEN FLOW(CFS)	INITIAL	RESERVOIR LEVEL (FT)			TW(FT)
				AVERAGE	AV MAX	AV MIN	
JANUARY	244.	1320.	450.0	449.4	450.0	448.7	390.6
FEBRUARY	203.	1320.	450.0	449.5	450.0	448.9	390.6
MARCH	548.	1500.	450.0	448.9	450.0	447.8	391.5
APRIL	1350.	1500.	450.0	449.6	450.0	449.1	391.5
MAY	602.	1500.	450.0	448.9	450.0	447.7	391.5
JUNE	242.	1320.	450.0	449.4	450.0	448.7	390.6
JULY	126.	938.	450.0	449.7	450.0	449.3	388.7
AUGUST	116.	858.	450.0	449.7	450.0	449.4	388.3
SEPTEMBER	116.	858.	450.0	449.7	450.0	449.4	388.3
OCTOBER	151.	1138.	450.0	449.6	450.0	449.2	389.7
NOVEMBER	263.	1320.	450.0	449.3	450.0	448.6	390.6
DECEMBER	267.	1320.	450.0	449.3	450.0	448.6	390.6

MONTH	GEN TIME(HR)	POWER(KW)	ENERGY(KWH)	CAPACITY FACTOR	HEAD(FT)
JANUARY	4.3	5063.	659854.	16.79	54.1
FEBRUARY	3.5	5072.	545161.	13.87	54.2
MARCH	8.4	5315.	1349373.	34.34	51.8
APRIL	21.5	5382.	3523595.	89.68	52.4
MAY	9.2	5310.	1491428.	37.96	51.7
JUNE	4.3	5064.	654266.	16.65	54.1
JULY	3.0	2716.	247682.	6.30	58.1
AUGUST	3.0	2750.	250769.	6.38	58.8
SEPTEMBER	3.0	2750.	250769.	6.38	58.8
OCTOBER	3.0	2626.	239527.	6.10	56.2
NOVEMBER	4.6	5059.	712909.	18.14	54.1
DECEMBER	4.7	5059.	724071.	18.43	54.1

6.2 - Output Continued:

MONTH	POWER VALUE(\$/KW)	POWER REV(\$)	EN. VALUE(MILLS/KWH)	ENERGY REV(\$)
JANUARY	2.54	12860.32	33.00	21775.17
FEBRUARY	2.54	12892.14	33.00	17990.33
MARCH	2.54	13501.12	33.00	44529.29
APRIL	2.54	13671.51	33.00	116278.63
MAY	2.54	13488.63	33.00	49217.12
JUNE	2.54	12861.34	33.00	21590.76
JULY	2.54	6898.16	33.00	8173.51
AUGUST	2.54	6984.14	33.00	8275.38
SEPTEMBER	2.54	6984.14	33.00	8275.38
OCTOBER	2.54	6671.05	33.00	7904.40
NOVEMBER	2.54	12850.90	33.00	23525.99
DECEMBER	2.54	12848.97	33.00	23894.36

TOTAL ENERGY= 10649403. KWH
 TOTAL CAPACITY REVENUE=\$ 132502.
 TOTAL ENERGY REVENUE=\$ 351430.
 TOTAL REVENUE=\$ 483933.
 PLANT CAPACITY FACTOR= 22.59 %