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VERMONT MARBLE COMPANY
PROCTOR, VERMONT

MASTER

OTTER CREEK HYDROELECTRIC FEASIBILITY REPORT

HUNTINGTON FALLS DAM · BELDENS DAM · CENTER RUTLAND DAM

FEBRUARY 1979

INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY

DISCLAIMER

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PROCTOR, VERMONT

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EXECUTIVE SUMMARY

Vermont Marble Company (VMCO) owns and operates four hydroelectric projects in a 50-mile reach of Otter Creek in west central Vermont. This study concerns three of the installations — Center Rutland, Beldens, and Huntington Falls. The fourth site is known as Proctor and will be studied separately. All four plants operate as run-of-river stations, and the limited reservoir storage capacity places severe limitations on any other type of operation. VMCO has been aware for some time that the physical condition of the installations is poor and that the concrete has suffered deterioration due to its age, repeated freezing and thawing, and the effects of trash. VMCO also recognizes that rehabilitation, upgrading, and replacement of many of the facilities is now necessary to restore the structures to a satisfactory condition and to maximize energy production at each plant. The plants are presently operating at much lower outputs than can be obtained, because they do not use the available discharge and head.

The results show that, under the assumptions made in this study, Beldens and Huntington Falls can be economically improved. The rehabilitation of the Center Rutland plant did not look economically attractive. However, the improvement of Center Rutland should not be eliminated from further consideration, because it could become economically attractive if the cost of energy starts escalating at a rate of around 10 percent per year.

The study included a brief appraisal of the existing generating facilities and condition of existing concrete structures, a geological reconnaissance of the sites, analysis of the power potential, flood studies, technical and economic investigations and comparative evaluations of the alternatives for developing the streamflow for power generation, selection of the most suitable alternative, financial analysis, preparation of drawings, and preparation of detailed quantity and cost estimates.

The sites and nearby surrounding areas were inspected, and the condition of existing structures and equipment were appraised. The concrete needs repair; and the equipment is old, obsolete, and in need of replacement. The generating units are inefficient and are undersized for economical exploitation of the available hydraulic resources. No geological problems were found during the field inspections that would prohibit construction and the structure sites appear sound. There is some leakage at all sites that can be easily controlled by presently available techniques. In general, the time has arrived when improvements and rehabilitation are, or soon will be, necessary.

The environmental conditions were evaluated and found to be mostly favorable. The few conditions that cannot be classified as favorable require only simple measures to rectify. No environmental impact was found that precludes proceeding with the contemplated improvements.

Three basic philosophies were considered in formulating development alternatives. The first makes maximum use of existing facilities and results in the minimum capital investment; however, it does not fully exploit the available hydraulic resources. The second fully exploits the hydraulic resources, but requires the largest capital expenditure. The third philosophy is intermediate between these two and, consequently, results in intermediate capital investment and energy production. Four alternatives embodying these philosophies were formulated and are shown in Table S-1.

Technical evaluations were made of the components of each alternative to eliminate the least feasible and reduce them to a more manageable number. The evaluations considered the unit size, number of units, total installed capacity, energy produced, topographic and physical conditions of the site, and the upstream and downstream limitations. One large unit would be inoperative for almost half the time and was eliminated from consideration on an energy production basis. The unit size and upstream urbanization resulted in selecting a single development for Center Rutland. Upstream conditions restricted the level of the Beldens reservoir, and the relocated powerhouse was eliminated on a cost basis. Huntington Falls remained as originally conceived. The nine components shown in Table S-2 remained after completion of these evaluations.

TABLE S-1

DEVELOPMENT ALTERNATIVES

ALTERNATIVE I

Upgrade existing facilities, minimum cost and energy.

1. Center Rutland Reservoir El. 507.0
2. Beldens Reservoir El. 284.0
3. Huntington Falls Reservoir El. 218.0

ALTERNATIVE II

Maximum dam raise, maximum costs and energy.

1. Center Rutland Reservoir El. 514.0
2. Beldens Reservoir El. 284.0
3. Huntington Falls Reservoir El. 241.0

ALTERNATIVE III

Intermediate dam raise, intermediate costs and energy - Condition A.

1. Center Rutland Reservoir El. 509.0
2. Beldens Reservoir El. 284.0
3. Huntington Falls Reservoir El. 230.0

ALTERNATIVE IV

Intermediate dam raise, intermediate costs and energy - Condition B.

1. Center Rutland Reservoir El. 514.0
2. Beldens Reservoir El. 284.0; relocate powerhouse one mile downstream.
3. Huntington Falls Reservoir El. 230.0

TABLE S-2

PROJECT SELECTION

ELIGIBLE PROJECTS

CENTER RUTLAND

1. Reservoir El. 509.0; 2-1,200 kW units.
   Identification Symbol CR/2-2.4-509

BELDENS

1. Reservoir El. 284.0; 3-2,100 kW units.
   Identification Symbol BEL/3-6.3-284

2. Reservoir El. 284.0; 2-2,100 kW units.
   Identification Symbol BEL/2-4.2-284

HUNTINGTON FALLS

1. Reservoir El. 241.0; 3-3,700 kW units.
   Identification Symbol HF/3-11.1-241

2. Reservoir El. 241.0; 2-3,700 kW units.
   Identification Symbol HF/2-7.4-241

3. Reservoir El. 230.0; 3-3,100 kW units.
   Identification Symbol HF/3-9.3-230

4. Reservoir El. 230.0; 2-3,100 kW units.
   Identification Symbol HF/2-6.2-230

5. Reservoir El. 218.0; 2-2,300 kW units.
   Identification Symbol HF/3-6.9-218

6. Reservoir El. 218.0; 2-2,300 kW units.
   Identification Symbol HF/2-4.6-218

Quantity and cost estimates were prepared, and the average annual energy production was computed for the nine projects. Table S-3 contains a summary of the data. The cost per kilowatt hour is discussed later.

Economic evaluations were made for the nine eligible projects using the present worth method of analysis. The evaluations used 3, 5, and 7 percent escalation rates; 35-, 40-, and 50-year analysis periods; and discount rates from 6 through 11 percent. A computer was used to analyze a total of 81 cases for which the benefit/cost ratios and internal rates of return were computed. These evaluations were used only to select a recommended development, which was subsequently further analyzed using other methods of analysis.

No analysis was made for zero escalation, because it is considered to be unrealistic; and the three rates selected are indicative of the escalation range to be expected. Escalation was uniformly applied to all costs and benefits for the first half of the analysis period and no further escalation was used for the second half. The minimum analysis period corresponds to the useful life of some major project parts, especially the generating units. The longest represents a usually acceptable standard for hydroelectric economic evaluation. The discount rates are considered to be applicable to this type of development.

Benefits are the value of energy that does not have to be purchased from an outside supplier and, accordingly, are based on the price recently paid. The demand charge, transmission charge, and energy mill rate were combined on a weighted average basis and resulted in 25 mills per kilowatt hour. This rate was escalated after the first year on the same basis as the costs. System energy losses were subtracted from gross generation in computing the total annual benefit, or revenue. The range of the benefit/cost ratios and internal rates of return is shown in Table S-4.

TABLE S-3

SUMMARY OF PROJECT COSTS AND ENERGY

RECOMMENDED DEVELOPMENT

Item	CR/2-2.4-509	BEL/3-6.3-284	BEL/2-4.2-284
Total Capital Investment ($)	4,124,200	6,259,400	4,803,600
Average Annual Energy (kWh)	7,877,000	20,855,000	18,152,000
Installed Capacity (kW)	2,400	6,300	4,200
Cost Per Installed kW ($)	1,718	994	1,144

	HF/3-11.1-241	HF/2-7.4-241	HF/3-9.3-230
Total Capital Investment ($)	14,298,400	11,340,500	11,396,900
Average Annual Energy (kWh)	37,525,000	32,631,000	30,797,000
Installed Capacity (kW)	11,100	7,400	9,300
Cost Per Installed kW ($)	1,288	1,533	1,225

	HF/2-6.2-230	HF/3-6.9-218	HF/2-4.6-218
Total Capital Investment ($)	8,760,800	9,079,700	6,936,000
Average Annual Energy (kWh)	26,740,000	23,275,000	20,225,000
Installed Capacity (kW)	6,200	6,900	4,600
Cost Per Installed kW ($)	1,413	1,316	1,508

TABLE S-4

RANGE OF BENEFIT/COST RATIOS
AND INTERNAL RATES OF RETURN
SELECTION OF RECOMMENDED DEVELOPMENT

3% Escalation	B/C Ratio	IRR
Center Rutland	0.44-0.67	1.38- 1.78
Beldens	0.76-1.31	7.08- 9.21
Huntington Falls	0.54-1.06	4.26- 6.62
5% Escalation	**B/C Ratio**	**IRR**
Center Rutland	0.50-0.77	2.67- 3.10
Beldens	0.86-1.52	8.76-11.12
Huntington Falls	0.66-1.24	5.57- 8.38
7% Escalation	**B/C Ratio**	**IRR**
Center Rutland	0.56-0.89	3.98- 4.47
Beldens	0.79-1.74	10.46-12.56
Huntington Falls	0.74-1.42	7.08-10.18

No benefit/cost ratio greater than 1.00 was obtained for Center Rutland; and consequently, it was eliminated from further consideration in this study. Center Rutland starts to have a benefit/cost ratio greater than 1.00 only if the cost of energy increases at a rate of around 10 percent per year. Relatively low benefit/cost ratios were also obtained for Huntington Falls using three units with reservoir level at El. 241.0. The remaining possibilities considered in this study were Beldens and Huntington Falls with two or three units. A study of the benefit/cost ratios and internal rates of return for these possibilities resulted in selecting two 2,100-kW units at Beldens and two 3,100-kW units at Huntington Falls with reservoir El. 230.0.

Further economic analyses and financial evaluations were made for the two selected projects using 5 percent escalation and a 50-year period. The benefit/cost ratios obtained from these analyses are shown in Table S-5.

TABLE S-5

PROJECT AND RECOMMENDED DEVELOPMENT BENEFIT/COST RATIOS
5% ESCALATION; 50-YEAR ANALYSIS PERIOD

Discount Rate (%)	Benefit/Cost Ratios BEL/2-4.2-284	HF/2-6.2-230	Development
6	1.52	1.24	1.33
7	1.39	1.13	1.22
8	1.28	1.04	1.12
9	1.18	0.95	1.03
10	1.09	0.88	0.95
11	1.01	0.82	0.88

Net present value analyses were made for the Beldens two- and three-unit installations and for the Beldens two-unit installation combined with Huntington Falls two-unit installation, using all three reservoir levels. The internal rate of return is 9.37 percent based on 5 percent escalation and a 50-year analysis period. These analyses confirmed the selection of the recommended development.

An annual cost analysis was made for a 5 percent escalation rate and a 50-year analysis period. This permitted comparing annual costs and benefits more easily than by using the present worth of costs and benefits when escalation is involved. It also permitted computing cost per kilowatt hour for each year of the analysis period. Table S-6 shows the results of this analysis for selected years of the period. The years shown are those when annual costs become equal to annual revenue (years 11 and 12), accumulated costs become equal to accumulated revenue (years 19 and 20), end of the escalation period (years 25 and 26), end of replacement reserve (years 35 and 36), and the end of the period (year 50).

CONCLUSIONS

The proposed improvements are simple and can be provided easily. A total of 43 months is estimated to be the time required before power can be

TABLE S-6

ANNUAL COST AND REVENUE *

RECOMMENDED DEVELOPMENT

	Total Annual Costs ($)			Total Annual Revenue ($)			Mill Rate **	
Year	Beldens	Huntington Falls	Total	Beldens	Huntington Falls	Total	Costs	Revenue
1	555,370	1,003,570	1,558,940	450,000	660,000	1,110,000	35.1	25.0
11	646,370	1,168,570	1,814,940	733,000	1,074,000	1,807,000	40.9	40.7
12	658,370	1,190,570	1,848,940	771,000	1,129,000	1,900,000	41.6	42.8
19	758,370	1,373,570	2,131,940	1,085,000	1,588,000	2,673,000	48.0	60.2
20	775,370	1,404,570	2,179,940	1,139,000	1,668,000	2,807,000	49.1	63.2
25	876,370	1,588,570	2,464,940	1,452,000	2,127,000	3,579,000	55.5	80.6
26	876,370	1,588,570	2,464,940	1,452,000	2,127,000	3,579,000	55.5	80.6
35	876,370	1,588,570	2,464,940	1,452,000	2,127,000	3,579,000	55.5	80.6
36	857,650	1,564,110	2,421,760	1,452,000	2,127,000	3,579,000	54.5	80.6
50	857,650	1,564,110	2,421,760	1,452,000	2,127,000	3,579,000	54.5	80.6

* Based on 5% Escalation; 8% Interest; 50 years.

** Based on net generated energy = 44,404,000 kWh/year.

commercially generated. Eighteen months have been allowed for amending the existing FERC license. Final design and bidding documents would be prepared during 16 months of this same period. Another 4 months are required for bidding, bid evaluation, contract award, and mobilization of the selected construction contractor. The construction contract should be awarded in time for construction to start by April, so that two non-freezing seasons can be used to complete the work as scheduled. The proposed construction schedule envisions award of the construction contract in March 1981, with actual construction starting the following month, and completion during October 1982.

The market for the power and energy generated already exists within the VMCO service area, and electricity that cannot be produced by their hydroelectric plants is presently being purchased from a local utility. Purchases from this source will still be necessary when the proposed improvements are completed; therefore, no question exists regarding the marketability of the output resulting from these improvements.

RECOMMENDATIONS

The recommended development has been found to be technically feasible and economically viable. Therefore, it is recommended that Vermont Marble Company proceed immediately with the measures necessary to implement improvement of Beldens and Huntington Falls. The required measures include the following major items:

- Initiate procedures for amending the existing FERC license.
- Initiate project financing.
- Proceed with final design, drawings, contract documents, and specifications required for construction.
- Obtain the necessary permits and licenses required by local, state, regional, and federal agencies.
- Begin land acquisition activities for any land required that is not presently owned.

It is also recommended that the Central Rutland feasibility study be reactivated if new data forecasts a cost of energy increase at a rate higher than the one assumed in this study.

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OTTER CREEK HYDROELECTRIC FEASIBILITY REPORT

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE

This report presents the results of the technical and economic feasibility investigations of the measures that could be used to improve the capacity and output of three low-head hydroelectric installations on Otter Creek in west central Vermont. The three installations are owned and operated by the Vermont Marble Company (VMCO) and are designated as Center Rutland, Beldens, and Huntington Falls. Another hydroelectric installation, known as Proctor, is also owned and operated by VMCO, but does not constitute part of this investigation. However, it is currently the largest of the four VMCO sites and, consequently, exerts an influence on planning improvements for the other three. Although methods of improving Proctor are to be independently investigated at a later date, its influence is given appropriate consideration in this study.

The three sites included in this investigation are located in a 50-mile reach of Otter Creek, which is located in the St. Lawrence River Basin and is the longest waterway entirely within the State of Vermont. Otter Creek flows generally in a northerly direction and discharges into Lake Champlain.

VMCO operates its hydroelectric projects as a licensed public utility and generates a portion of the energy required for its industrial installations and other demands in its service area. The plant outputs presently are insufficient to fully satisfy demand at all times, and additional energy must be purchased from other sources in the vicinity. The three plants have a combined installed capacity of approximately 3,300 kW and produce about 21 million kilowatt-hours during an average year.

Vermont Marble Company is expanding its mill capacity, which will ultimately reach about four times its pre-expansion capacity. This expansion, together with the normal economic growth in the area, is creating an increased demand for electricity that is projected to continue until the mill capacity reaches its full expansion target. VMCO desires to meet as much of the increased power demand arising from its mill expansion and the other customers in its licensed service area as can be done by improving and using its wholly owned hydroelectric facilities. The projected load forecast is shown in Table 1-1. Evaluations made during the current study indicate that all four of the VMCO hydroelectric plants will not be able to satisfy the projected demand.

TABLE 1-1
LOAD FORECAST

Year	MW	Load Factor %
1982	23	80
1983	26	85
1984	33	60
1985	34	70
1986	35	80
1987	36	80
1988	38	80
1989	40	80

Deterioration of the physical condition of the plants has been evident for a number of years; and rehabilitation, upgrading, or replacement of the facilities is advisable for safety, efficiency, and economy of operation. At the present time, the operating efficiency of the plants is estimated to be less than 70 percent, because of the deterioration and age of the existing facilities.

This investigation has been made to assist VMCO in adopting a future course of action regarding the improvement of the hydroelectric potential of the three sites. It appraises the condition of the existing facilities, analyzes the power potential of each site, evaluates the main development alternatives, and recommends a development plan.

1.2 AUTHORITY

The consulting services were performed under the terms and conditions of a "Consultant Agreement" between VMCO and International Engineering Company, Inc. (IECO), dated September 27, 1978. The Consultant Agreement is based on and entirely consistent with the "Cooperative Agreement No. EW-78-F-07-1793" between the U.S. Department of Energy (DOE) and VMCO entitled "Otter Creek Hydroelectric Feasibility Study".

1.3 SCOPE OF SERVICES

The specific scope of services is contained in Exhibit A to the Consultant Agreement and the Cooperative Agreement, including Appendix A, between DOE and VMCO. The scope conforms to the details contained in the PRDA ET-78-D-07-1706 proposal submitted by VMCO to DOE. In general, the services comprise appraisals and comparative evaluations to determine the best plan for developing each of the three sites and for the combined facilities. In summary, the investigations include hydrology, geology, condition of existing facilities, hydroelectric engineering evaluation, installed capacity, turbine and generator type, energy generated, marketability, project life, capital costs, value of energy, operation and maintenance costs, environmental considerations, economic evaluations, and schedule for activating power and energy generation.

1.4 ACKNOWLEDGEMENTS

Grateful acknowledgement is made of the excellent cooperation and assistance provided by personnel of Vermont Marble Company. Their efforts in obtaining field topography and performing coring operations during extremely adverse climatic conditions were very helpful. Special acknowledgement is given those individuals who actually performed the required field work. Their contribution helped materially in completing this work.

CHAPTER 2

EXISTING FACILITIES

CHAPTER 2

EXISTING FACILITIES

This chapter briefly describes the existing hydroelectric facilities at Center Rutland, Beldens, and Huntington Falls and appraises their present condition. The descriptions and appraisals are based on information obtained in discussions with operating and supervisory personnel and on observations during several site inspections that were made both before and after the inception of the present work. Three major inspections were made during September, November, and December 1978 by all study personnel responsible for performance of the required work. The results of these inspections are contained in this chapter.

2.1 FIELD INSPECTIONS

Field inspections were initiated by the Project Director and Geologist during the last week of September 1978 immediately following receipt of the formal Notice to Proceed with the work. A second major inspection was made between November 6, 1978, and November 10, 1978, by the Project Director, Project Manager, Hydrologist, Mechanical Engineer, and Electrical Engineer. The purposes of this inspection were to familiarize key personnel with field conditions, ascertain the type and condition of existing facilities, initiate field data collection, verify the accuracy of USGS topographic maps, assess the required work, formulate applicable methods and techniques, inspect available records and reports, and affect coordination between VMCO and IECO in work performance. The Project Director and Project Manager met with representatives of the Central Vermont Public Service Corporation (CVPS) and the DOE on December 6, 1978, for coordination of efforts and programmatic review. The three VMCO and two CVPS sites were inspected on that date. The Project Director and Project Manager extended their inspection and data collection until December 8, 1978.

2.2 DATA COLLECTION AND REVIEW

The following is among the data collected and reviewed during these inspections:

- Report by Jackson and Moreland, Engineers; entitled "Report to Vermont Marble Company, Equipment and Operation of the Power Facilities for the Vermont Properties", February 1929.
- Report by Barker and Wheeler, Engineers; entitled "Inventory and Original Cost", June 30, 1940.
- Report prepared by the U.S. Army Corps of Engineers; entitled "Letter From the Secretary of War Transmitting Report from the Chief of Engineers on Otter Creek, Vt., Covering Navigation, Flood Control, Power Development and Irrigation"; U.S. 72nd Congress; 1st Session, House of Representatives, Document No. 144, dated December 10, 1931.
- USGS quadrangle sheets at scale of 1:24,000 for the entire drainage area above Huntington Falls.
- USGS maps of flood-prone areas of Otter Creek basin above Huntington Falls.
- Daily discharge records for East Creek at Rutland, Vermont; Otter Creek at Center Rutland, Vermont; and Otter Creek at Middlebury, Vermont, from USGS Water Supply Paper Series, "Surface Water Supply of the United States" and USGS Open-File Report Series, "Surface Water Records of Massachusetts, New Hampshire, Rhode Island and Vermont".
- Flood frequency data for Otter Creek at Rutland, Vermont, and Otter Creek at Middlebury, Vermont.
- Report entitled "The Resources of New England" - New York Region, Part Two, Chapter XXVII, Lake Champlain Drainage Basin, New York - Vermont, Sections I, III, and VI, New England-New York Interagency Committee, 1954.
- Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105° Meridian, NOAA, 1978.
- Technical Paper No. 29, Rainfall-Intensity Frequency in Northeastern United States, USWB.
- A proposed Streamflow Data Program for Central New England, USGS Open-File Report, 1970.
- Flood Magnitude and Frequency of Vermont Streams, USGS Open-File Report 74-134.
- Hydrometeorological Report No. 33, Seasonal Variation of the Probable Maximum Precipitation, East of the 105° Meridian, United States, USWB, 1956.

- Average Annual Runoff and Precipitation in the New England - New York Area, USGS, Hydrologic Investigation Atlas, HA-7, 1955.
- Hurricane Floods of September 1938, USGS, Water Supply Paper 867.
- The Floods of March 1936, Part I, New England Rivers, USGS, Water Supply Paper 798.
- The New England Flood of November 1927, USGS, Water Supply Paper 636-6.
- General Soil Map; Rutland County, Vermont; SCS, 1972.
- General Soil Map; Addison County, Vermont; SCS, 1970.
- Maps, drawings, computations, records, and related data from the Vermont Marble Company files.

2.3 EXISTING PROJECT FEATURES

A. General

The existing facilities at each of the three sites are generally similar and differ only in details of the major features. The major features comprise a dam with uncontrolled spillway, forebay and intake structure, penstock, power plant, step-up transformers, and transmission line. Principal data for the sites are shown in Table 2-1.

The three sites included in this investigation are located in a 50-mile reach of Otter Creek in west central Vermont. Otter Creek is in the St. Lawrence River Basin and is the longest waterway in the state. It flows generally in a northerly direction and eventually discharges into Lake Champlain. The site locations are shown on Figure 2-1 and are discussed below.

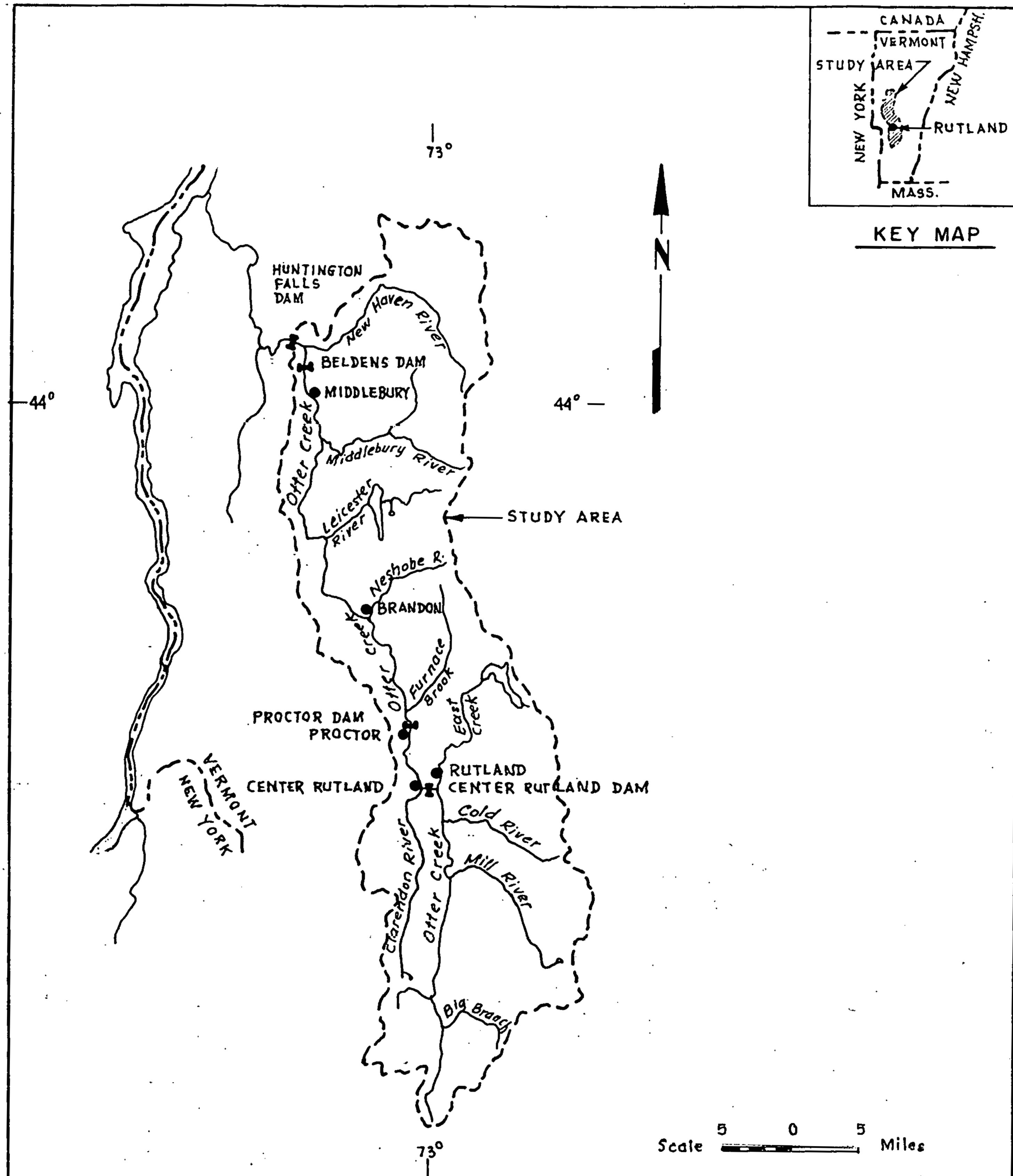
Reliable historical data for the three sites are sketchy, limited, and not readily available. A marble mill and the two dams at Beldens were in existence when the site was purchased by VMCO in 1904. The present generating facilities at that site were constructed in about 1913. Even less historical data is available for Center Rutland, but it is reported to

TABLE 2-1

PROJECT DATA
EXISTING CONDITIONS

	Center Rutland	Beldens	Huntington Falls
Normal Reservoir Elevation[1/]	507.1	283.0	218.1
Dam Crest Length (ft)	190	56 + 57 = 113[2/]	190
Maximum Dam Height (ft)	12	18 & 12	20
Spillway Crest Elevation	504.8	280.5	215.8
Spillway Crest Length (ft)	174	46 + 48 = 94[2/]	175
Flashboard Height (ft)	2.3	2.5	2.3
Installed Capacity (kW)[3/]	275	1,600	1,400
Number Units	1	2	2[5/]
Gross Head (ft)	27	44	44
Generation Voltage (volts)	480	2,300	2,300
Transmission Voltage (kV)	11.0	46.0	46.0
Number Transformers	3	1	3
Transformer Rating, each (kVA)	-	1,500	667
Average Annual Energy (kWh)	1,366,000	9,550,000	10,470,000
Number Intake Gates	1	6	5
Size Intake Gates (width x height-ft)	6.8 x 6.5	5.0 x 18.0	4.8 x 19.0
Penstock Diameter (ft)	6	12 & 10[4/]	2 @ 10
Penstock Length (ft)	75	50 & 30[4/]	2 @ 30

1/ Top of flashboards.
2/ East and West dam.
3/ Nameplate rating.
4/ 12' dia-50'; 2-10' dia-30' each.
5/ 1 @ 800 + 1 @ 600 = 1,400 kW.



LOCATION MAP

PROJECT DAMS
AND POWERHOUSES

predate Beldens. The dam and power station at Huntington Falls were constructed in about 1910 when VMCO purchased the property and are much the same today as they were when constructed. The falls had been dammed prior to 1910 and a grist mill existed near the site of the present powerhouse. All of the facilities have been operating almost continuously since they were acquired. It appears likely that all three sites originated as grist mills or similar installations during the early stages of settling in this area.

B. Center Rutland

1. Structures and Improvements - The Center Rutland site is located about 71 river miles upstream of the creek mouth at Lake Champlain. It is near the center of the town of Center Rutland, Rutland County, Vermont, and is about 350 feet upstream of a bridge across Otter Creek on Vermont Highway 4. The site is about 1.2 miles downstream of the confluence of East Creek with Otter Creek. The creek flows through the City of Rutland and the Town of Rutland upstream of the site. The upstream reach is confined to a reasonably narrow width by the natural configuration of the creek channel and its flood plain. Industrial installations, educational institutions, commercial developments, and other urban structures are located above flood level near each bank. The Otter Creek flood plain widens to about 1,000 feet downstream of the site and continues about 7 miles downstream to the Proctor damsite. Much of the valley between Center Rutland and Proctor is flooded almost yearly during spring runoff. The drainage area is 307 square miles, and the average annual discharge is about 550 cubic feet per second.

Existing structures include the dam, spillway, forebay and intake structure, penstock, power plant, and step-up transformers. There is a commercial lumber installation on the right bank and an abandoned sawmill on the left bank. Both are located essentially in line with the dam axis. A steel-truss railroad bridge crosses Otter Creek at about the midpoint of the dam. The abutments of an abandoned highway bridge are located a short distance downstream of the dam and powerhouse. The immediate area is congested by the existing hydroelectric facilities and other construction.

The dam is about 190 feet long and about 12 feet average height. It is constructed of stone masonry and concrete and is founded on sound rock insofar as can be determined from surface observations. Masonry is exposed on the downstream face of the dam at foundation level. The dam axis bends about 12 degrees near the third point of the length from the right abutment. The dam section is relatively thin and is shown to be about 6 feet thick on old drawings of the structure. The top of the concrete in the spillway crest is at El. 504.8. Flashboards are used on the crest and result in a normal reservoir water surface of El. 507.1. Concrete abutments are provided at both ends of the dam.

The spillway is located on the dam crest and is about 174 feet long. It uses 2.3-foot-high timber flashboards, which are raised to increase the head for normal power generation. The flashboards are hinged to the spillway at their base and are held in the raised position by wire ties secured to the upstream face. The wire ties are broken by the additional pressure created by the flood surcharge, and the flashboards drop to the crest. They cannot be raised until the reservoir level drops below the crest elevation. The spillway discharge efficiency is low, because of the shape of the crest and interference of the flashboards.

The forebay and intake structure are located on the right bank at the north end of the dam. The forebay is very short, but makes an S-bend between the reservoir and the intake. Forebay walls and the intake structure are constructed of concrete and marble masonry. Some portions of these features are exposed rock wherever sound conditions were encountered at the time of construction. Steel trashracks and a timber headgate mounted in a steel frame are provided at the intake structure. The headgate is 6'-9" wide by 6'-6" high and is opened and closed by a manually operated handwheel. The trashrack is about 31 feet wide by 12 feet high. The clear opening between trashrack bars is about 9/16-inch.

The hydraulic efficiency of the intake is lower than normal or necessary. The waterway is not streamlined for hydraulic efficiency and the trashrack bar spacing results in quick accumulation of trash, particularly from leaves and small tree branches. Manual methods presently in use make cleaning difficult. The penstock entrance is square-edged. Ice creates problems at the intake during winter, especially from ice floes and ice break-up. The combination of the layout of this facility, trashrack bar spacing, poor quality concrete, masonry walls, and exposed rock results in a high coefficient of roughness and a correspondingly high head loss.

A 6'-0" wide by 5'-6" high spill gate, or sluice, is adjacent to the intake on the north side. The gate is constructed of timber in a steel frame and is manually operated by a handwheel on an operating deck. There is presently a small leakage through this gate. The original purpose of this gate is unknown and it is not presently used.

There is a second intake in the left abutment that is no longer used. It is connected by a penstock to an abandoned turbine house that at one time was part of the abandoned sawmill.

A 6-foot diameter, welded-steel penstock extends for 75 feet from the square-edged entrance at the intake structure to the turbine inlet in the powerhouse. About 15 feet of the total length is inside the powerhouse. The exterior of the penstock is in good condition; but no internal inspection was made during this investigation, so its overall condition is not known.

The power plant is located on the right bank downstream of the intake structure. It is rectangular in shape and is about 33 feet wide by 38 feet long. The height is about 12 feet from the unit operating floor level to the roof. The substructure is constructed of stone and concrete, and the operating floor is constructed of reinforced concrete. Doors, door frames, and window frames are made of wood.

The roof is constructed of timber covered with tar and gravel and is supported by a structural steel frame. The superstructure walls are constructed of marble blocks and field stone, which vary in thickness from 6 to 30 inches.

2. Generating Equipment - The powerhouse contains one generating unit, which produces about 275 kW. The unit is infrequently used, because of its low capacity and the constant surveillance required during its operation.

The turbine has no nameplate and the following description is based on inspection of the unit, discussions with operating personnel, and available records. It is a steel, cylindrical-case, side-supply unit. The turbine and Lombard governor were manufactured in 1898 by the Holyoke Machine Company and are identified as "swing gate 38 inch horizontal Hercules type 90, right and left hand". A new turbine was installed in 1940 in the original turbine casing. The unit operates at 300 RPM and is reported to produce about 300 horsepower under 27 feet head. The turbine may become inoperative at any time. Based on the external appearance and information provided by operating personnel, it would not be worth repairing if any major expense were involved.

The generator is a horizontal-shaft, open-type, synchronous unit with belt-driven exciter. It is rated at 275 kW, 415 amperes, 480 volts, 60 cycles, 300 RPM, and 0.8 power factor. It is identified as form S, type ATB-24-34M-300. It was manufactured by General Electric Company at an unknown date and was rewound in 1963.

Three 110-kVA, single-phase, 480/11,000-volt transformers are located outside the powerhouse.

3. Auxiliary Equipment - The major piece of auxiliary equipment at Center Rutland is the main switchboard, which consists of three panels. The switchboard contains voltmeters, knife switches, synchroscope, circuit breakers, rheostat controls, ammeters, potential transformer, current transformer, and miscellaneous minor items.

C. Beldens

1. Structures and Improvements - The Beldens site is located about 23 river miles upstream of Lake Champlain in an almost unpopulated area at a location identified by the same name on the USGS Middlebury quadrangle sheet. The New Haven River discharges into Otter Creek about 1 mile downstream of Beldens and about midway between it and Huntington Falls. Otter Creek is confined to a relatively narrow valley upstream of Beldens for about 2 miles to the Lower Middlebury Dam, which is owned by the Central Vermont Public Service Corporation. The Otter Creek valley is also relatively narrow downstream of Beldens until it reaches the Huntington Falls damsite 2 miles downstream. The drainage area at the Beldens site is about 632 square miles, and the average discharge is about 982 cubic feet per second assuming it to be the same as at the Middlebury gaging station about 3 river miles upstream where the drainage area is 628 square miles.

Existing facilities at the Beldens site include two dams and spillways, forebay and intake structure, penstock, power plant, and step-up transformers. A picnic area is located on an elevated terrace, well above the right abutment. The left abutment is covered with relatively thick trees and vegetation. No urbanization or commercial installations are in close proximity to this site.

The Otter Creek channel divides at Beldens where an east and west dam are separated by a rock outcrop. The west dam is about 57 feet long and about 12 feet high at its maximum height. It is constructed of concrete; and the abutments are raised, leaving an opening for the spillway. The east dam is similar to the west dam, except that it is about 56 feet long and about 18 feet high at its maximum point. Pedestrian suspension bridges are provided near the axis of both dams. Both of the dams have sound rock foundations, and the falls below each of them appear intact as indicated by surface inspection of the site. There is, however, a solution cavern in the right abutment. The cavern does not appear to be endangering any of the structures at this site, but the resulting loss of discharge could be recovered for power generation. The shape of the dam crest is intermediate between a standard ogee and a broad-crested weir. The crest elevation at both dams is about El. 280.5, and the abutments are at about El. 283. A retaining wall between the right abutment of the east dam and the headgate operating deck of the intake structure rises to about El. 289. Flashboards are used in the weir portion of the dam and provide a normal water surface near El. 283.0.

Spillways are provided in both dams. The spillway length is about 48 feet for the west dam and about 46 feet for the east dam. Timber flashboards, about 2.5 feet high, are provided to increase the head for power generation. Their installation and the problems encountered in their use are the same as at Center Rutland. The spillway discharge flows through two short gorges to the tailrace about 40 feet below the dam crest.

The forebay and intake structure are located on the right bank, southeast of the east dam. There is very little forebay, but flow must make a 90-degree bend between the creek and the headgate structure. The walls and structures are constructed of concrete; however, some portions are exposed rock where sound conditions were encountered at the time of construction. The exposed rock is sound, and the only objection to it is the higher head loss.

Six headgates are provided at the entrance of the intake facility. They are constructed of timber and operate in a structural steel frame. The headgates are 5 feet wide by 18 feet high and are manually operated by handwheels located on a deck at about El. 289. The trashracks are about

56 feet wide by 17 feet high and are installed at an angle of about 60 degrees to the direction of flow. The clear opening between trashrack bars is about 1-1/16 inches. The combination of the inclination of the trashrack with respect to the direction of flow and the close bar spacing results in relatively high head losses. Records show that the penstock entrance is flared slightly, but it is not bell-mouthed. The overall conditions of the intake result in a lower efficiency than necessary or desired. Trash and other conditions affecting hydraulic efficiency are the same as described for Center Rutland.

An 8-foot wide sluice, or spillway, is provided in the north forebay wall immediately upstream of the trashracks. It uses timber stoplogs and apparently was provided for use in sluicing trash from the trashracks.

The penstock is 12 feet in diameter for about 50 feet; then it bifurcates into two 10-foot diameter sections, each about 30 feet long. The 30-foot long sections are connected to the turbine inlets. The penstocks are constructed of riveted steel plate with stiffener angles. The penstock appears to be in good condition, based on exterior inspection; but the interior was not inspected during this investigation, and its condition is unknown.

The power plant is located on the right bank east of the dam and intake structure. It is rectangular in shape and is about 44 feet wide by 40 feet long. The height is about 21 feet from the operating floor level to the roof. The substructure and operating floor slab are constructed of concrete. Wood doors and frames and wood frame windows are provided. The roof is constructed of timber covered with tar and gravel and is supported on timber trusses with bolted connections. The superstructure walls are constructed of marble blocks, which vary in thickness from 15 to 21 inches.

2. <u>Generating Equipment</u> - The powerhouse contains two identical units, which are rated at about 800 kW each. However, the actual output is considerably less than the rated capacity due to age, present condition, and other operating characteristics. The units were originally installed about 1913.

The powerhouse contains two riveted-steel, cylindrical-case, horizontal, end-supply turbines. Each has two distributors and runners discharging through draft tube elbows and a single, vertical, conical draft tube into an open flume beneath the powerhouse. The nameplates indicate that they were fabricated by S. Morgan Smith. The turbines have 33-inch diameter runners and are rated at 1,200 horsepower under 40 feet head at a speed of 300 RPM. The turbine discharge and output is controlled by float level, operating through Lombard horizontal gate shaft governors connected by means of cables, pulleys, gear sectors, and submerged linkages to the wicket gates. The runners are of the Francis type and are mounted on a single horizontal shaft with two underwater bearings and one outboard, oil-lubricated bearing. The shaft is directly coupled to the generator and has a hand-operated brake mounted on it.

The units appear to have been well maintained, with annual inspections including necessary overhaul and periodic runner replacement, according to verbal reports and records. Based on this information and their external appearance, the turbines reasonably can be expected to continue to operate at their present level of performance for some time, provided the present level of maintenance is continued. However, sooner or later major components — such as the shafts, draft tubes, and pressure cases — will fail due to corrosion, erosion, fatigue, wear, or a combination of these. A prolonged shutdown and major expense will be inevitable when this occurs. The design of the turbines is obsolete. No internal inspection was possible.

The two generators are horizontal, open-type units with belt-driven exciters and without voltage regulation features. Both units were fabricated by Westinghouse Electric Corporation. The nameplate rating is 800 kW, 241 amperes, 2,300 volts, 60 cycle, 300 RPM, and 0.8 power factor. The units are not always able to produce rated capacity. Both generators were upgraded and rewound in about 1953 and 1954. Annual inspections have been made, and the units have been well maintained according to reports and records. It is unlikely that generator output can be improved under present operating conditions.

One 1,500-kVA, 3-phase transformer is located in a separate building near the powerhouse. It transforms the voltage from 2,300 volts to 46,000 volts for transmission in the VMCO system.

3. Auxiliary Equipment - The major auxiliary equipment comprises a four-panel switchboard, a motor generator set, and overhead hoisting equipment. The switchboard contains ammeter, voltmeters, rheostat controls, knife switches, bus connections, synchroscope, frequency meter, power factor meter, wattmeter, circuit breakers, and miscellaneous minor electrical appurtenances. The motor generator consists of a 61-horsepower induction motor connected to a 40-kW, 125-volt, 300-ampere, DC generator. The hoisting equipment is a 10-ton, hand-operated overhead crane.

D. Huntington Falls

1. Structures and Improvements - The Huntington Falls site is located about 21 river miles upstream of Lake Champlain and about 1.5 miles upstream of the Weybridge Power Plant, owned and operated by Central Vermont Public Service Corporation. It is about 2 miles downstream of the Beldens site and about 1 mile downstream of the confluence of the New Haven River with Otter Creek.

The creek is confined to a relatively narrow canyon between Huntington Falls and Beldens and for a short distance downstream. The flood plain widens as it nears the Weybridge Power Plant. The drainage area is 749 square miles, including 113 square miles of the New Haven River basin; and the average annual discharge is about 1,170 cubic feet per second based on transposition of the Middlebury discharge to this site on a drainage area basis.

The facilities at this site consist of a concrete-gravity dam with an uncontrolled spillway crest, forebay and intake structure, penstock, powerhouse, and step-up transformers. All of these facilities were constructed in about 1910 and show their age, despite having had good maintenance.

The dam is located at the top of a natural waterfall and is about 20 feet maximum height. The falls below the dam add about another 20 feet to the head available for power generation. The dam is about 190 feet along its crest and most of it serves as the spillway. A road bridge with a 3.5-ton load limit crosses Otter Creek about 300 feet upstream of the dam. There is no urbanization at lower elevations adjacent to the creek, but there are several houses at considerably higher levels. Other than the storage buildings owned by VMCO, the bridge is the only structure that would be affected if the dam is raised.

The dam is constructed of concrete and is founded on sound rock insofar as could be ascertained by surface observations. Old pictures show that the dam faces have been resurfaced with concrete at some time during their life. Unfortunately, the pictures are not sufficiently sharp to show the original construction materials. Since the dam was constructed when rejected marble blocks could have been used as construction materials, a core was obtained to ascertain if masonry blocks were used in the internal portion of the dam. The boring, extending about 20 feet into the foundation of the dam, indicated that it was entirely concrete.

The spillway occupies about 175 feet of the dam crest length and contains 2.3-foot-high flashboards. These are installed and operated similarly to those at Center Rutland and Beldens and experience the same problems. The spillway crest is essentially a broad-crested weir, and the discharge is correspondingly low.

The forebay and intake structures are located on the left bank, south of the left dam abutment. All structures for this portion of the existing facilities are constructed of mass concrete, masonry, or a combination of both. Five headgates about 5 feet wide by 19 feet high are located slightly downstream of an extension of the upstream face of the dam. These gates are constructed of timber, operate in structural steel frames, and are manually opened and closed by handwheels located on a deck at a slightly higher elevation than the top of the dam. A sluice fitted with timber stoplogs is provided on the north side of the headgates in a wall connecting the headgate structure with the dam. This facility is apparently intended to remove trash and ice from in front of the headgates. A forebay channel about 130 feet long extends from the headgates to the intake structure. The forebay channel is initially about 23 feet wide by 17 feet deep, but the width increases to about 41 feet upstream of the intake structure. The top of the right forebay channel wall, adjacent to the creek, is at about El. 219; and consequently, it is overtopped by high reservoir levels. This wall is located at the top of a sharp topographic drop into the creek.

Steel trashracks about 41 feet wide by 19 feet high are provided upstream of the intake structure. The clear opening of the trashrack bars is about 13/16-inch. A small spillway is provided on the right side immediately upstream of the trashracks. This is provided to remove trash and ice from in front of the racks. Difficulties are experienced with the trashracks, which are similar to those at the other two sites except that the flow is directly into the racks.

The intake structure is a mass concrete-gravity headwall and is located at the top of a sharp drop in topography, which corresponds to the waterfall in the creek channel. The top of the headwall is at about El. 220. The downstream face has deteriorated and has recently been resurfaced with reinforced concrete to prevent further deterioration.

Two 10-foot diameter penstocks about 30 feet long extend from the upstream face of the intake headwall to the turbine inlets. The penstocks are constructed of riveted steel and are placed on a steep grade between the intake and the turbine. The penstock entrance is square-edged. The penstocks appear to be in good condition, based on what can be seen externally; but the interior was not inspected during this investigation, and its condition is unknown.

The powerhouse is located at the base of the topographic drop mentioned above. It is about 44 feet wide by 62 feet long and 23 feet high from the operating floor to the roof above the generating units. The units are located in the east, or upstream, end of the structure; and a service area and transformer vault are located at the west, or downstream, end of the structure. The roof is about 32 feet above operating floor level in the west end of the structure. The high-voltage leads from the transformers rise vertically to bus cables near the roof of the transformer vault. The bus cables are connected to the transmission line by means of a take-off structure located on the roof. The substructure is constructed of concrete, although portions of the turbine discharge openings are exposed rock wherever feasible. The operating floor is constructed of reinforced concrete, and the superstructure walls are brick. The superstructure frame is constructed of structural steel and also serves as an overhead crane runway. Steel frame windows and wooden doors are provided. The roof is constructed of timber and is covered with tar and gravel. Timber roof trusses with bolted connections are used to support the roof.

2. Generating Equipment - The powerhouse contains two generating units, which are basically the same as the Beldens units except that the generators were manufactured by General Electric Company instead of Westinghouse Corporation and the units were installed in 1910 instead of 1913. The generators were originally rated at 600 kW.

The generating units have been repaired and new components provided since they were originally installed. One turbine was rebuilt in 1954, both were completely rebuilt in 1957, two new turbine runners were installed in 1968, and one turbine was overhauled in 1975. New coils and punchings were provided for one generator in 1948, and it was otherwise upgraded to produce 800 kW. Similar provisions were made for the second generator in 1952, at which time it was also upgraded to produce 800 kW. One generator was rewound in 1953 and the other in 1954, and one was rewound again in 1968.

Three single-phase, 667-kVA, step-up voltage transformers are provided. They transform the voltage from 2,300 volts to 46,000 volts for transmission in the VMCO system.

3. Auxiliary Equipment - The major auxiliary equipment at Huntington Falls comprises a six-panel switchboard and hoisting equipment. The switchboard contains a synchroscope, ammeters, rheostat controls, bus connections, knife switches, voltmeters, power factor meters, wattmeters, watthour meters, field switch, oil circuit breakers, frequency indicator, and miscellaneous minor electrical appurtenances. The hoisting equipment is a 10-ton, hand-operated overhead crane.

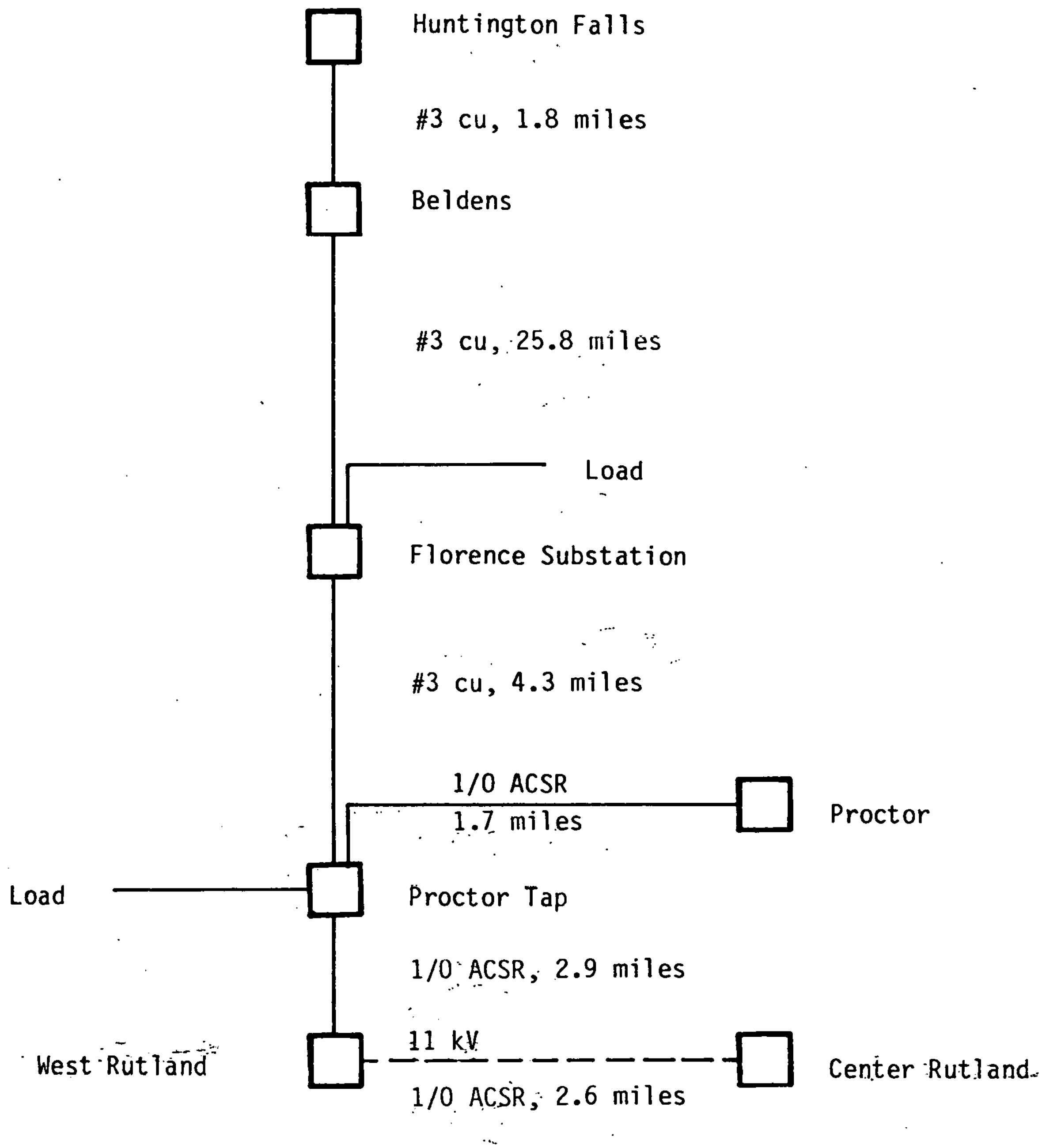
E. Transmission Line

The VMCO transmission system presently comprises about 36.5 miles of 46-kV line between Huntington Falls and West Rutland and about 2.6 miles of 11-kV line between Center Rutland and West Rutland. The conductor sizes and the system line lengths between controlling points are shown schematically in the sketch on the following page. The existing lines are in reasonably good condition; however, an analysis of the conductor size of the line from Beldens to the Florence substation indicates that it is smaller than it should be; and line losses are higher than normally encountered. The analysis assumes that a larger and heavier conductor can be installed on the existing structures. The results of the analysis and the basic data used are shown in Table 2-2.

2.4 APPRAISAL OF EXISTING FACILITIES

A. General

The facilities at all three sites included in this investigation are old; outdated; and understandably reflect their age, despite having had above-average maintenance, periodic replacement, and repair. They have reached



VMCO 46 KV AND 11 KV TRANSMISSION SYSTEM
SCHEMATIC DIAGRAM
EXISTING CONDITIONS

TABLE 2-2

PRELIMINARY ANALYSIS OF 46 KV TRANSMISSION LINE LOSSES
BELDENS TO FLORENCE SUBSTATION
EXISTING CONDITIONS

ASSUMPTIONS

Present energy cost per kWh	= 25 mills
Load factor	= 74 %
Transformer efficiency	= 98.5%
Near-by load	= 45 kW
Line length	= 26 miles
Power factor	= 0.8
Interest rate	= 10 %
Analysis period	= 30 years
Energy cost escalation rate	= 7 %

GENERATION, TRANSMISSION AND LOSS FACTOR

Capacity generated = 800 + 820 + 780 + 660 = 3060 kW

$$\text{kVA transmitted} = \frac{(3060 \times .98.5)}{0.8} - 45 = 3723$$

Loss factor corresponding to 74% load factor = 65%

PRESENT WORTH OF ENERGY LOSSES AND NEW CONDUCTOR COSTS

Item	Conductor Size					
	#3 cu*	3/0 AL	4/0 AL	250 AL	267 AL	300 AL
PW Losses	501,000	312,000	248,000	210,000	173,000	154,000
PW Cost**		95,000	108,000	119,000	124,000	134,000
Total PW	501,000	407,000	356,000	329,000	297,000	288,000

* Existing conductor size
** Installed cost

cu = copper
AL = aluminum

the end of their useful life unless major expenditures are made. They are in need of improvement if they are to play their proper role in relieving the present energy shortage. These facilities use a renewable natural resource and can continue to do so for many more years if properly and adequately upgraded. The condition of the facilities is shown pictorially in Figures 2-2 through 2-5.

B. Dams

All dam concrete is in poor condition as typified by Figure 2-3. Erosion has occurred from the flow of high-velocity water; and damage has been caused by tree trunks, logs, and other heavy debris as shown in Figure 2-4. No preventive measures are used to reduce or eliminate trash and ice damage. The dams show the effects of repeated freezing and thawing and other damage caused by solid ice and the impact of ice floes. Spalling is evident in many places, and progressive deterioration is in progress.

C. Geology

No geologic formation was located nor any geologic condition encountered that would preclude the improvement of the sites. All structures appear to be founded on sound rock, and the waterfalls at the three damsites appear to be intact. They withstood the severity of numerous floods, especially that of November 1927, which is an additional indication of the geological soundness of the sites.

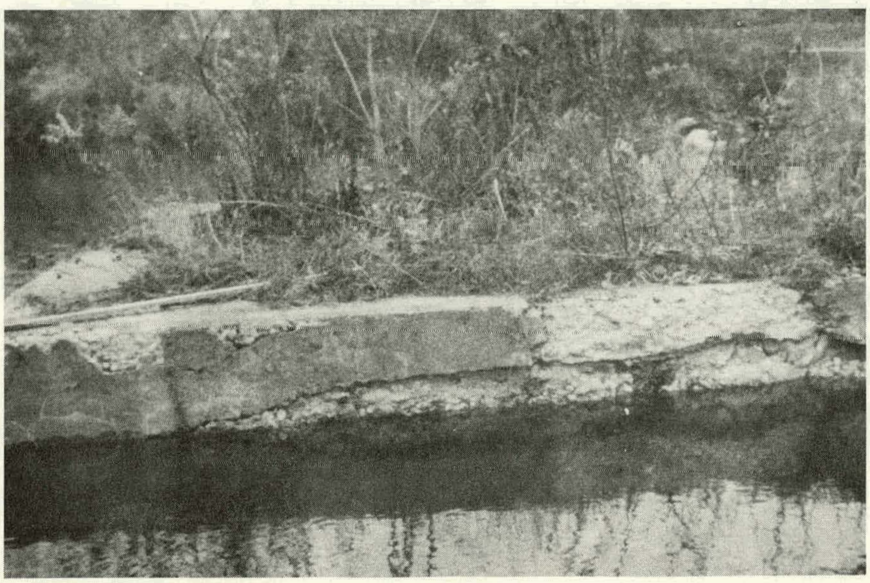
The most serious geological problem encountered was a solution cavern in the right side of the creek upstream of Beldens. It is estimated that as much as 50 cubic feet per second might be flowing through the cavern. This cavern does not appear to be endangering the structures at this site. Further discussions of geology are contained in Appendix D.

FIGURE 2-2

HUNTINGTON FALLS DAMSITE

Huntington Falls Forebay leading to intake structure in upper right corner. Overflow due to surcharged reservoir. Note concrete condition near pole at left of picture.

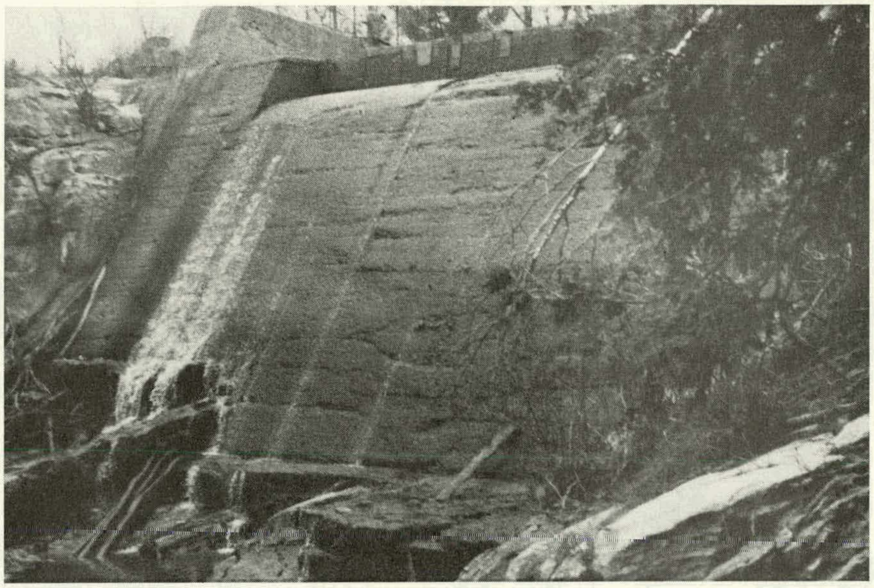
Huntington Falls entrance to Forebay showing concrete condition.



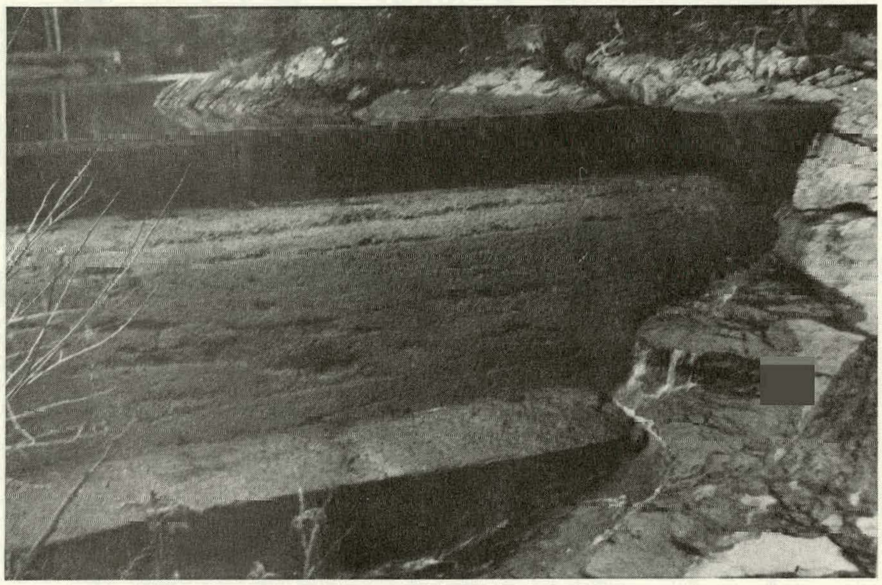
Huntington Falls forebay entrance.

FIGURE 2-3

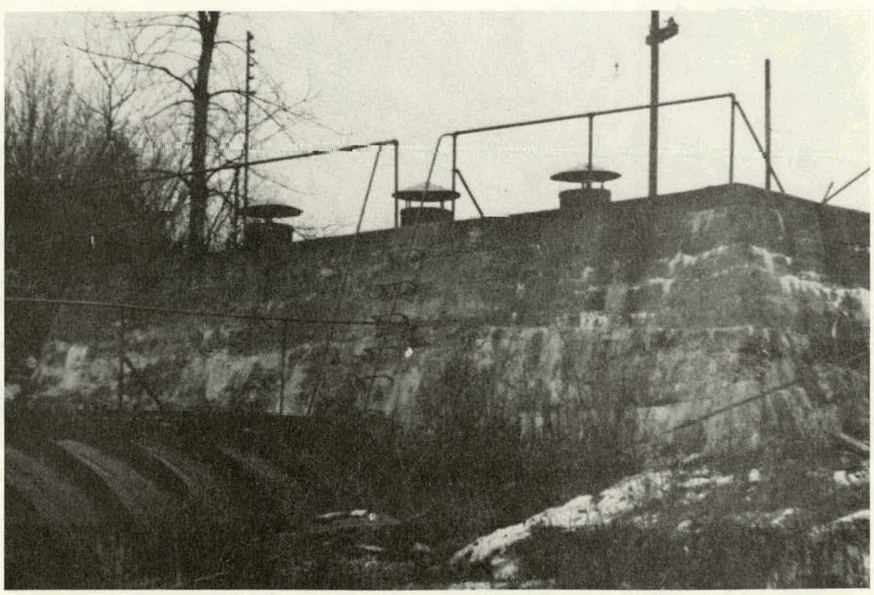
BELDENS DAMSITE



Beldens East Dam showing erosion.



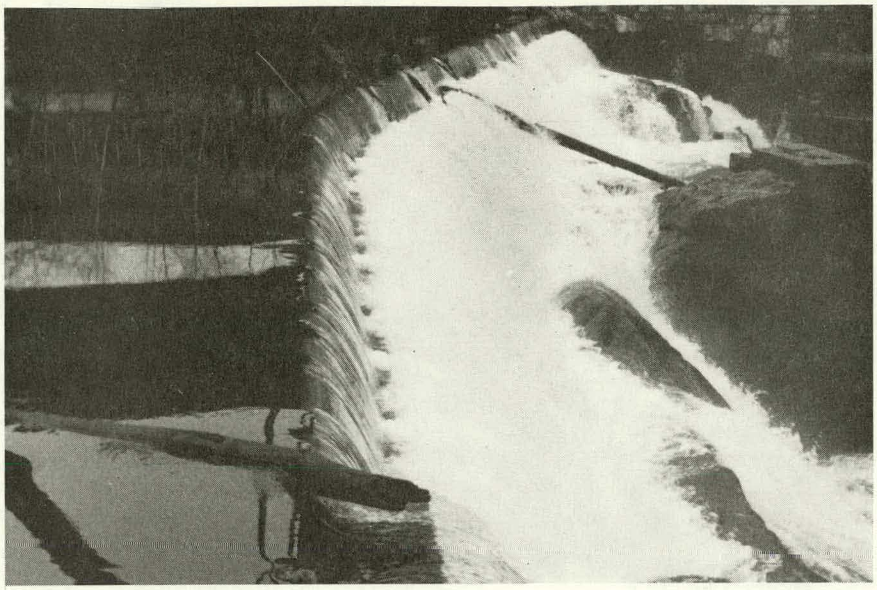
Beldens West Dam showing erosion.



Beldens Intake Structure. Note seepage indications.

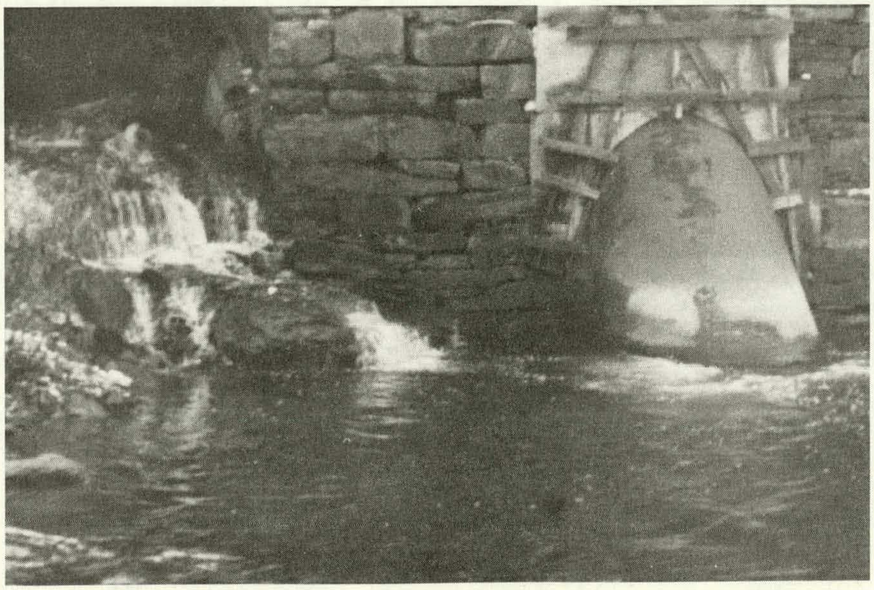
FIGURE 2-4

CENTER RUTLAND DAMSITE

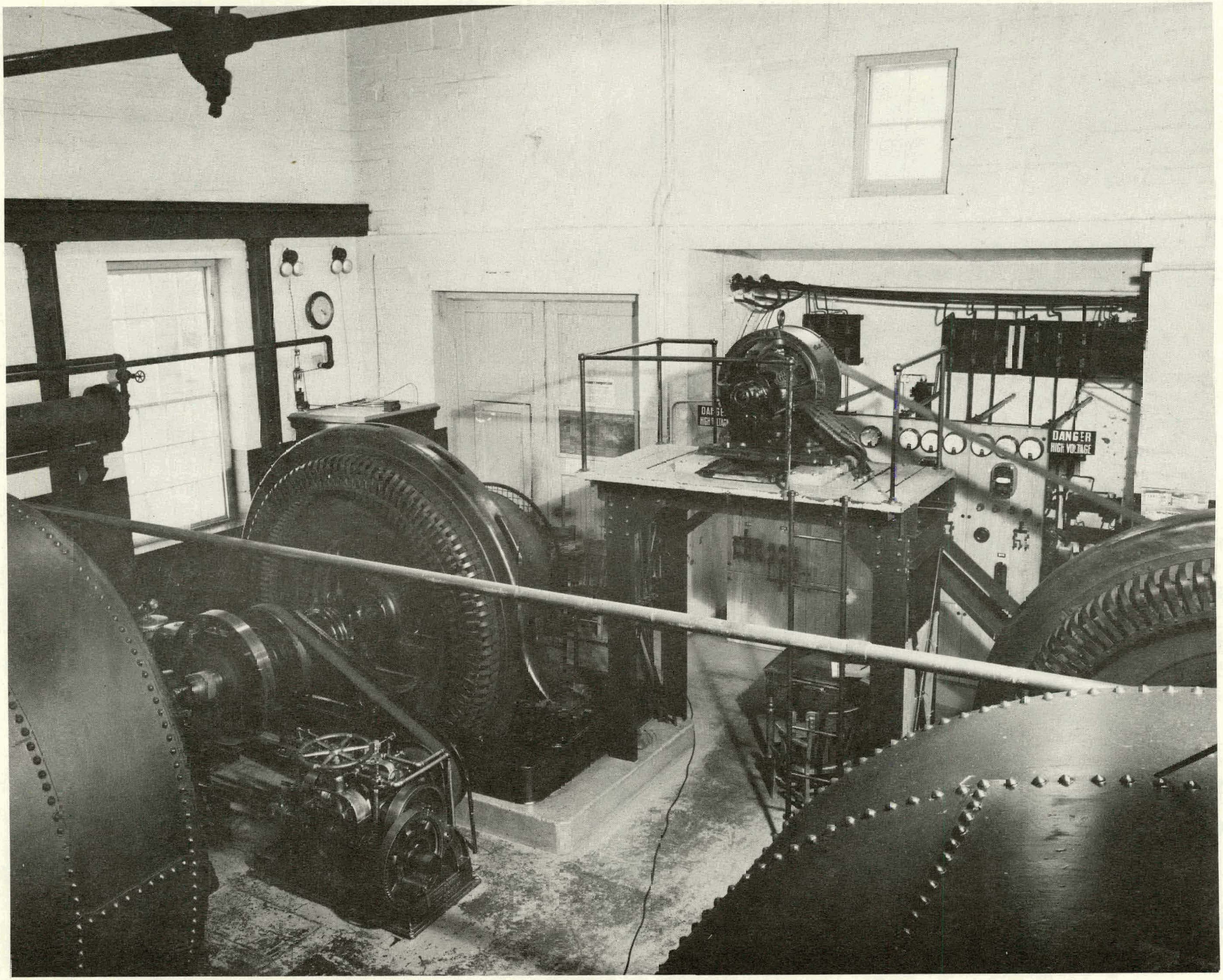


Center Rutland Dam. Note three trunks caught on flashboard.

Center Rutland Powerhouse showing masonry block substructure.



Center Rutland Powerhouse showing draft tube elbow and sluice.



Beldens Generating Units

Figure 2-5

D. Spillways

The spillways at all three sites are located on the dam crest and have timber flashboards of various heights to increase heads for power generation. Their installation and operation and the difficulties experienced with them are discussed in Section 2.3B and are applicable to all three spillways. The eroded and damaged concrete, the shape of the spillway crests, and the unpredictable operation of the flashboards combine to yield a low discharge efficiency. Flood studies show that spillway discharge capacities must be increased if flood severity and damage are to be ameliorated.

E. Forebays and Intake Structures

The forebays at all sites are relatively short, but are otherwise hydraulically inefficient. The hand-operated headgates eliminate effective control and require considerable time to open or close. The concrete in the walls is badly eroded as shown by Figure 2-2, and the intake walls leak as shown by the lowest picture in Figure 2-3. The exposed rock portion of the forebay channels increases head loss. The trashrack bar spacing also increases the amount of lost head. The narrow trashrack bar spacing permits trash to accumulate quickly, and the manual cleaning operation presently used makes trash difficult to remove. Trashrack rakes, log booms, ice booms, and de-icing facilities are not provided as a precaution against problems that arise from trash and ice. The waterways are not streamlined for hydraulic efficiency, and the square-edged penstock entrance creates head loss. The combination of the foregoing conditions results in an overall hydraulic efficiency that is much lower than desirable.

F. Penstocks

Penstocks are short and in relatively good conditions, based on external inspection. The interiors should be inspected to ascertain their condition; however, it was not deemed necessary to shut the units down for inspection during this investigation, because no leakage was observed. Their continued use and the role they would play in a modernization program is uncertain.

G. Powerhouse Structures

The powerhouse structures are sound and could be used for some purpose other than the installation of new generating units. The manner in which the substructures were originally constructed would be undercut by the excavation required for new units. Even if substructure problems are overcome, the cost of working within the confines of the existing structures would be economically unjustifiable.

H. Generating Equipment

All generating equipment is old, obsolete, and difficult and expensive to operate and maintain. It is of much lower efficiency than new and modern equipment would be, is appreciably undersized for economical exploitation of the available hydraulic resources, and cannot be economically adapted for use at a higher head. The overall plant efficiency is estimated to be less than 70 percent, using the most favorable combination of operating conditions and individual efficiencies. The units are not always able to produce rated capacity. The turbines are set well above tailwater level, and the draft head is only partially recovered because of the types of draft tubes available at the time the units were fabricated. Spare parts are becoming more difficult to obtain and most must be custom-made, thereby steadily increasing maintenance costs. The transformers at Center Rutland and Huntington Falls are old and core losses may be abnormally high. New transformers were installed at Beldens in 1977, and it may be possible to use them elsewhere in the system when this installation is improved.

I. Auxiliary Equipment

Some of the auxiliary electrical equipment appears to have been installed at the time the facilities were originally constructed and, consequently, is in need of modernization. The newer equipment appears to be in satisfactory condition. The hoisting equipment at Beldens and Huntington Falls may be salvaged and used elsewhere.

J. Transmission Line

The transmission line losses are high, as shown by the results previously described and shown in Table 2-2. Other studies presented in Paragraph 3.6D6 show that the present 46-kV transmission voltage is not as economical as 69-kV, provided that the existing transmission line structures can stand the additional weight and do not have to be replaced.

CHAPTER 3

DEVELOPMENT ALTERNATIVES

CHAPTER 3

DEVELOPMENT ALTERNATIVES

This chapter describes the development alternatives investigated and the methods employed in selecting the components of each. The expression "development alternative" is used to signify the development program that is obtained when the improvements of the sites are combined and considered as a unit for specified water levels and other criteria. This chapter also discusses the selection procedure and the reasons for excluding some development possibilities without extensive and lengthy study. Finally, it recommends that Beldens and Huntington Falls with a normal reservoir level of El. 230.0 be improved.

3.1 ALTERNATIVE FORMULATION

A. Basis of Alternative Selection

Three basic philosophies were considered in formulating development alternatives. The first makes maximum use of existing facilities and results in the minimum capital expenditure; however, it does not fully exploit the available hydraulic resources. The second fully exploits the hydraulic resources, but requires the largest capital expenditure. The third is intermediate between these two and, consequently, results in intermediate capital investment and energy production. Four development alternatives embodying these philosophies were studied and are discussed in this chapter.

B. Improvement Options

Each alternative is composed of a combination of available improvement options, which include the following:

- Increase dam height.
- Install new generating equipment.

- Increase discharge through turbines.
- Repair weathered and deteriorated concrete.
- Reduce leakage from all sources.
- Improve hydraulic efficiency of all waterways.
- Provide more efficient trash control.
- Increase flashboard height or provide crest gates.
- Excavate tailraces where gradient is steep.
- Improve transmission line.

These options are discussed in Paragraph 3.3.

3.2 DEVELOPMENT ALTERNATIVES

Four development alternatives, based on the foregoing philosophies, were formulated at the outset of this investigation. The original alternatives underwent refinements and changes as more data became available and more analyses were made. The major change was in the elevations that were obtained during field topographic surveys or from other more reliable sources than had been located previously. Flashboards were replaced by hydraulically operated crest gates as a result of the flood studies. The original and revised development concepts are discussed in the following paragraphs. The four development alternatives investigated during this study are shown in Table 3-1.

A. Alternative I

1. Original Concept - This alternative embodies the minimum capital investment philosophy and uses the applicable upgrading and rehabilitating options listed in Paragraph 3.1B, including increased flashboard heights at Huntington Falls and Center Rutland. The water level at Beldens cannot be increased, because the existing upstream water level backs water up to the toe of an upstream power dam. Improved methods of placing and removing the flashboards will be considered. The dam crests will be retained at

TABLE 3-1

DEVELOPMENT ALTERNATIVE FOR INVESTIGATION

ALTERNATIVE I

1. Upgrade and rehabilitate all sites.
2. Make maximum use of existing facilities, except generating units.
3. Excavate tailraces to lower tailwater.
4. Use wood or metal flashboards or crest gates.
5. Install new generating units.

ALTERNATIVE II

1. Raise Huntington Falls reservoir from El. 218.0 to El. 241.0.
2. Upgrade and rehabilitate Beldens and raise reservoir from El. 283.0 to El. 284.0.
3. Raise Center Rutland reservoir from El. 507.0 to El. 514.0.
4. Excavate tailraces to lower tailwater at Huntington Falls and Center Rutland.

ALTERNATIVE III

1. Raise Huntington Falls reservoir from El. 218.0 to El. 230.0.
2. Upgrade and rehabilitate Beldens and raise reservoir from El. 283.0 to El. 284.0.
3. Raise Center Rutland reservoir from El. 507.0 to El. 509.0.
4. Excavate tailraces to lower tailwater.

ALTERNATIVE IV

1. Raise Huntington Falls reservoir from El. 218.0 to El. 230.0.
2. Relocate Beldens powerhouse to recover head lost at Huntington Falls.
3. Raise Center Rutland reservoir from El. 507.0 to El. 514.0.
4. Excavate tailraces to lower tailwater.

about their present elevation so that flood surcharge does not exceed that which would occur if no changes were made. The crests will be designed to be more hydraulically efficient when the existing concrete is repaired. This improvement will result in either a lower surcharge, if the present crest length is retained, or a shorter crest length, if the same surcharge is adopted. Trash booms will be provided a short distance upstream of all dams to reduce trash problems and the accompanying loss of head at the power intakes. Means for removing trash at the booms will be provided, and trashrack rakes will be used at the intakes to remove the trash that bypasses the booms. New generating units will be provided, because the existing unit outputs are greatly below the available hydraulic potential. However, the old units may be retained and additional new capacity provided that will bring the combined output of the old and new units up to the available potential. Alternative combinations of old and new equipment will be investigated.

At Center Rutland, Vermont Highway 4 is about 300 feet downstream of the dam, and a considerable drop in the water surface occurs between the dam and the highway. This head can be recovered by excavating the tailrace in the deepest part of the river channel. Tailrace excavation can be limited to that required for turbine discharge and need not include the entire waterway width.

2. Revisions to Original Concept - The flashboards were replaced by crest gates to provide improved flood discharge capacity. Crest gates eliminate the problem of raising the flashboards after a flood has subsided and provide a better head condition for energy generation. They also permit sluicing some of the trash and ice that accumulates in the reservoir. It was found possible to raise the Beldens reservoir level from El. 283.0 to El. 284.0 as permitted by upstream conditions. The old generating units were not used because of their age and condition and because of the difficulties and costs associated with providing supplemental capacity compared with those for providing all new equipment.

B. Alternative II

1. Original Concept - This alternative embodies the second philosophy of maximum exploitation of the available hydraulic resources and provides the maximum power and energy production of the four alternatives. It also requires the largest capital investment.

The most important difference between this alternative and Alternative I is the increase in the dam height at Huntington Falls and Center Rutland. The reservoir level selected for Huntington Falls is El. 241.0, which is also the tailwater level at Beldens, the next upstream site. This higher level is to be obtained by either raising the height of the existing dam at its present location or constructing a new dam at about the location of the existing road bridge upstream of the present dam.

Normally, it would be expected that use of the present site would be more economical than a new dam at another site, but this may not be true in this case. The existing dam is about 190 feet long, of which about 175 feet is the overflow spillway length. The bridge span is only about 140 feet, and the crest length difference at the two sites may justify construction of a new dam at or near the bridge site. The existing dam is at the top of a natural waterfall, which may be structurally inadequate to safely withstand the proposed additional head. The falls have successfully withstood the energy of the present flood discharge, but it is not certain that they can withstand the added energy when the head is increased. The energy of the flood for the existing structure is dissipated by the roughness of the falls and the river at the base. These natural energy-dissipating conditions may not be able to serve satisfactorily for the higher head; and a stilling basin, or other type energy dissipator, may be required.

There is a crushed rock zone downstream of the dam on the right bank. This zone does not appear to be endangering the existing structure and probably would not endanger a higher structure; however, its characteristics are not fully known at this time; therefore, its presence in the near vicinity must be considered.

The bridge site offers an attractive alternative location that overcomes some of the uncertainty of the existing site. The dam would be shorter, and the water depths are essentially the same as at the existing site. However, the depth may prove to be greater at the bridge than anticipated because the constriction could have resulted in erosion. The bridge has been in place for a long time, and its abutments appear to be founded on sound rock from surface inspections and nearby rock exposures. The bridge has a 3.5-ton load limit and shows signs of structural distress due to its age. The topography on the right abutment rises sharply above the bridge elevation and has numerous rock outcrops. The left abutment rises gradually to a hill crest well above the proposed increased level of the dam. This abutment also has numerous outcrops that appear to be sound rock. This site offers better and simpler construction diversion potential than the present site, but requires a longer forebay. It is anticipated that a diversion channel will be used that also can subsequently be used for the forebay channel to the intake structure. Consequently, forebay channel velocities will be low as a result of the greater depth and correspondingly increased cross-sectional area of the waterway.

The narrower width of the river at the bridge site will result in a shorter spillway crest length than is available at the existing site and will be considered in flood routing studies. The existing dam will serve as an afterbay dam for the spillway at the bridge site and no further energy dissipation is anticipated.

Raising Huntington Falls dam to El. 241 at either location will require replacing the bridge and relocating about a half-mile of road. The bridge will be placed on top of the dam and the load limit removed, if the bridge site is used. The existing bridge will be raised, if the existing damsite is used; and the load limit will remain.

The facilities at Beldens can be only upgraded and rehabilitated under this alternative, because the Huntington Falls headwater is the tailwater level at this site and the present Beldens headwater is the tailwater at the next upstream site. The generation potential is only partially developed and major improvements can be achieved by using the available upgrading and rehabilitation options. There is considerable leakage at this site that can be reduced or eliminated. Diversion for construction at this site is fairly simple, because the two existing river channels will allow flow to be diverted to one channel while the features on the other are being improved. Final diversion can be routed through the completed channel while the remaining improvements are constructed.

The Center Rutland dam will be raised to obtain an upstream water surface of El. 514.0. Part of the increased height will be obtained by longer flashboards than presently being used, and the remaining additional height will be obtained by raising the dam crest. There are industrial, commercial, educational, and transportation installations on both banks upstream of the dam; and special attention will be required to assure that they are not inundated by the proposed increased dam height.

The existing Center Rutland powerhouse is located on the right bank and uses only a small percentage of the available discharge. This area is congested, and improvement is limited by a nearby industrial lumber installation. The left bank is also congested, but mostly by an abandoned sawmill. There is sufficient space to locate the powerhouse on the left bank without seriously disturbing any other installation. Tailrace excavation similar to that discussed in Alternative I is also applicable to this alternative.

2. <u>Revisions to Original Concept</u> - The flashboards were replaced by crest gates and completely new generating units were provided, as was done in Alternative I. The bridge site was eliminated, because it did not provide sufficient flood discharge capacity without additional protective measures and excessive additional cost. The maintenance responsibility and legal liability arising from the public use of a privately owned facility also influenced the elimination of the bridge site from further consideration. The crushed zone downstream of the existing dam does not appear to endanger the higher dam, and site geology appears to be sound. A powerhouse

on the left bank at Center Rutland was eliminated, because a simple solution for a right bank location was found.

C. Alternative III

1. Original Concept - Alternative III is one of two alternatives that are intermediate between Alternatives I and II. The improvement options are the same as for Alternative II, except for the reservoir levels at Huntington Falls and Center Rutland. A campground is located upstream of Huntington Falls, near the confluence of Otter Creek and the New Haven River. The elevation of this facility is relatively low, and it may be flooded by the higher reservoir water level proposed for Alternative II. A reservoir level of El. 230.0 may not flood the campground. If the campground level is below El. 230, it may be possible to either raise a portion with fill or provide a low dike to prevent inundation. There are also other low areas that may be endangered by this reservoir level, but they appear not to be as critical as the campground. Less land is required for the lower reservoir level than for Alternative II. Raising Huntington Falls at the existing damsite rather than at the bridge will probably be more feasible and economical than it would be for the higher elevation.

About 3 feet of the 11-foot head lost at Huntington Falls with a reservoir water surface at El. 230 can be recovered by excavating the tailrace at Beldens. Tailrace excavation is especially important for this site to regain as much of the lost head as possible.

The Center Rutland dam will be raised to only El. 509.0, because of the urbanization along the banks upstream of the dam. In addition, these upstream installations may entirely eliminate the possibility of raising the dam. Any increased height provided at this site will be obtained by a combination of a small raise of the concrete crest elevation and a moderate increase in the flashboard height. The improvements at Center Rutland comprise the same options proposed for Alternative II, including tailrace excavation, except for the dam height and the manner in which it is obtained.

2. Revisions to Original Concept - The major revisions made to this alternative are the replacement of the flashboards by crest gates and provision of entirely new generating equipment.

D. Alternative IV

1. Original Concept - This alternative is the same as Alternative III, except for the reservoir level at Center Rutland and shifting the Beldens powerhouse to a downstream location to recover the head lost at Huntington Falls. It was included to provide data on an additional intermediate combination.

The 11 feet of head lost by raising Huntington Falls to El. 230 rather than El. 241 can be regained by shifting the Beldens powerhouse about 1 mile downstream. The flow can be conveyed to the downstream site by either excavating a high-level canal on the left bank or using a flume on the flatter part of the hillside until it reaches the proposed downstream powerhouse site. Although this solution regains the head lost by a lower dam at Huntington Falls, it does not generate the same total energy at both sites, because the New Haven River enters Otter Creek downstream of Beldens; and therefore, the Huntington Falls plant will use the New Haven River discharge at a lower head.

2. Revisions to Original Concept - The major revisions made to this alternative are the elimination of the relocated power plant and development of the hydraulic potential at the existing damsite. These revisions were based on technical problems related to the site and the high costs to overcome them. The flashboards were replaced by crest gates, as in the previous alternatives; and completely new generating units were provided.

3.3 DESCRIPTION OF IMPROVEMENT OPTIONS

A. Dam Height and Location

1. Existing Dams and Spillways - The existing water surface levels and spillway crest lengths are shown in Table 3-2. The normal reservoir and spillway crest elevations have been adjusted to those obtained during this investigation and are considered to be accurate. The tailwater levels have been obtained from field surveys, published reports, and other sources.

TABLE 3-2
WATER SURFACE ELEVATIONS AND SPILLWAY CREST LENGTHS
EXISTING CONDITIONS

	Elevations			
	Normal Reservoir Level*	Spillway Crest	Tailwater Level	Spillway Crest Length (feet)
Center Rutland	507.1	504.8	477.0	174.0
Beldens	283.0	280.5	241.1	94.0
Huntington Falls	218.1	215.8	175.3	175.0

* Top of flashboards.

2. Improved Dams and Spillways - The maximum exploitation of the hydraulic resources for power and energy production would develop all of the available head. Consequently, increased dam heights were considered for all sites. The elevations for the normal reservoir water surfaces, tailwater levels, and net heads for the improvements investigated are shown in Table 3-3.

The maximum reservoir level chosen for Center Rutland is El. 514.0 and was selected as being the highest that could be considered without extensive upstream inundation of valuable, developed land and property. The

TABLE 3-3

SUMMARY OF WATER SURFACE ELEVATIONS AND NET HEADS
IMPROVED CONDITIONS

Alternative	Site	Elevation - USGS Datum: Normal Water Surface	Elevation - USGS Datum: Tailwater Level	Net Head (ft)
I	Center Rutland	507.0	476.0	28.0
	Beldens	284.0	238.0	43.0
	Huntington Falls	218.0 - 213.0*	175.0	37.5**
II	Center Rutland	514.0	476.0	35.0
	Beldens	284.0	241.0	40.0
	Huntington Falls	241.0 - 236.0*	175.0	60.5**
III	Center Rutland	509.0	476.0	30.0
	Beldens	284.0	238.0	43.0
	Huntington Falls	230.0 - 225.0*	175.0	49.5**
IV	Center Rutland	514.0	476.0	35.0
	Beldens	284.0	230.0	51.0
	Huntington Falls	230.0 - 225.0*	175.0	49.5**

* Indicates drawdown range

** Based on average normal water surface investigations confirmed that this level could be used for normal conditions, but that excessive flooding was likely to occur during large floods.

Beldens reservoir is presently at El. 283.0 and can be increased by only 1 foot because of the tailwater at the next upstream dam. Consequently, all alternatives used El. 284.0 for the normal reservoir water surface at Beldens.

The highest normal reservoir operating level selected for Huntington Falls is El. 241.0, which would back water up to the tailrace at Beldens. Since that elevation would inundate two parcels of commercial property, reservoir levels at El. 230.0 and El. 218.0 were also considered.

Two sites were considered for the improved Huntington Falls dam with increased height. The first is at the existing site and the second is about 300 feet upstream of the existing site where a low-load-limit bridge is located. The bridge site appeared to be attractive, because it would result in a shorter dam length. However, flood studies showed that as much spillway length as possible should be provided to reduce flood surcharge; and the bridge site was eliminated from further consideration. In addition, the bridge location envisioned that the road would be located on the dam crest, which would introduce maintenance responsibility and public liability risks, making this a less desirable location than the existing dam.

Alternative IV was formulated as a means of recovering the head lost at Huntington Falls if the reservoir is limited to El. 230.0 or El. 218.0. It assumes that Beldens powerhouse would be relocated about 1 mile downstream of its present location and would be at the headwater of Huntington Falls reservoir. Preliminary investigations showed this shift to be impractical because of the head lost in the conveyance facility, the ruggedness of the intervening topography, and the added cost. Therefore, relocating the Beldens powerhouse was eliminated from further consideration.

B. Generating Units

It was recognized that the existing generating units could be overhauled and upgraded. This option was not used, because the present size of equipment is too small to justify this expenditure if the other upgrading options are implemented. Therefore, new units were used at all sites for all development alternatives.

C. Discharge

Optimum exploitation of the available hydraulic resources is not obtained from the existing facilities. This investigation assumed that larger installed capacities would be provided that could use the discharge equalled or exceeded 90 percent of the time.

D. Concrete Structures

The condition of the exposed concrete for all features at all sites precludes leaving it as it is at present. Mass concrete in all dams will be capped, and the added concrete will be anchored to the old structures and the foundation below. Most of the structural concrete in the forebays and intake structures will have to be removed and replaced. This is due not only to the concrete condition, but also to the practicality of capping these structures and the limitations imposed on improving the hydraulic efficiency of these features.

E. Leakage

Most features at all sites leak to some extent. Leakage will be eliminated or reduced by grouting and other seepage control measures. The cavern and leakage at Beldens may require special treatment to make it watertight.

F. Hydraulic Efficiency

Most forebays and all intakes are hydraulically inefficient, and economical improvements can be easily obtained. These improvements will be incorporated with the new structural concrete mentioned above. Trash control will also improve the hydraulic efficiency, and trash booms upstream of the dams will reduce the amount of trash reaching the trashracks.

G. Trash Control

Trashrack rakes will reduce or eliminate head losses due to clogged trashracks. Larger clear spacing than presently exists between trashrack bars can be used with the proposed new generating units. The hydraulically operated crest gates permit sluicing some trash and ice that presently creates problems and head losses.

H. Spillway Gates

Flashboards were considered for upgrading options; however, hydraulically operated crest gates were adopted as a result of the flood and power studies. Trash control improvements were also considered in gate selection. The adopted gates provide a means of obtaining better flood control and improving power generation.

I. Tailrace Excavation

The gradient of the natural river bed downstream of the powerhouses results in the loss of several feet of head in a relatively short distance for normal turbine discharge. This loss can be eliminated by excavating a new tailrace channel, which needs to be only wide enough to accommodate the turbine discharge. Only a minor amount of tailrace excavation is required, but adequate precautions are necessary to ensure that downstream areas are not harmed by this operation.

Flood discharges will continue to flow in the full creek channel. Heads during floods will be about the same as during other periods, because the headwater and tailwater will tend to rise by about the same amount. Unit output can be maintained at its rated capacity during floods by discharging sufficient flow through the turbine to offset any head differential that may occur from unequal rises in headwater and tailwater levels.

J. Transmission Line

The transmission line changes required for increased capacity were considered in formulating development alternatives. The evaluation of the line losses discussed in Paragraph 2.3E shows that larger conductors are justified for the present capacity. Larger capacities than presently produced will be transmitted upon completion of the improvements; and accordingly, transmission line improvements have been incorporated as a part of all development alternatives.

3.4 BASIC INPUT DATA

A. Hydrologic Data and Power Studies

Long-term streamflow records in Otter Creek basin have been compiled by the U.S. Geological Survey for East Creek at Rutland, Otter Creek at Center Rutland, and Otter Creek at Middlebury. These records were available and used for flood and power generation studies. Those studies are presented and discussed in Appendix C.

B. Geotechnical Data

Geotechnical data for all three sites were obtained by field reconnaissance of the sites and from three drill holes at Huntington Falls. The results of the geotechnical reconnaissance and boring logs are contained in Appendix D, and the location of the drill holes are shown on Exhibits A-1 and A-3 in Appendix A.

C. Appraisal of Existing Facilities

The condition of the existing facilities was appraised by field inspections. The results of those appraisals are contained in Chapter 2.

D. Topography

Field topographic surveys were made for Center Rutland and Huntington Falls, including three river cross-sections upstream and three downstream of both dams. The USGS topography was enlarged and used for Beldens.

E. Drawings and Reports

Drawings prepared in 1909, 1929, and 1940 were available and used in performing this investigation and for locating the existing facilities. Two reports, one published in 1929 and the other in 1940, were reviewed; and pertinent data from them were used.

3.5 TECHNICAL CONSIDERATIONS

A. Structure Soundness

The structures are basically sound, despite deterioration of the exposed concrete surfaces, and appear to be in no danger of immediate failure. However, the concrete surfaces have deteriorated to a point where they must be protected from further deterioration. The thinner structural concrete members probably will have to be entirely removed and replaced, but much of the mass concrete in the dams can be used by providing sound concrete capping.

B. Generating Units and Powerhouses

The main factors considered in selecting the generating units and powerhouses are as follows:

- Provide turbine-generator units that are best suited to low-head, run-of-river installations, consistent with economy.
- Use predesigned units to obtain maximum economy.
- Locate and align structures to minimize excavation and the corresponding concrete, consistent with operating requirements and foundation conditions.
- Provide adequate freeboard to prevent overtopping.

Four types of generating units were considered, including the vertical shaft propeller, bulb, tube, and rim generator types. The project layouts contained in Appendix A were prepared for the tube type units.

Three units were adopted initially at all sites, because they would provide maximum flexibility of operation and permit minimum plant outage. The same installed capacity using two units and one unit were also investigated. Finally, installation of two units of the same unit size as the three-unit installation was analyzed to ascertain the effect of a smaller installed capacity. These variations in the size and number of units do not have a direct influence on the formulation of the alternatives, but do exert an influence on the economics and selection of an alternative for implementation.

C. Spillway Gates and Hoists

After consideration of the following factors, hydraulically operated crest gates were selected in lieu of flashboards:

- Flood requirements.
- Ice and trash problems.
- Means of discharging ice floes and trash.

- Positive control for flood discharge.
- Immediate return to full reservoir level as soon as flood danger ceases, so that maximum energy production can be obtained.

D. Inflow Design Flood

1. Selection - The peak inflow selected for spillway design was based on data contained in the U.S. Army Corps of Engineers' publication entitled "Recommended Guidelines for Safety Inspection of Dams". These guidelines are not entirely applicable in this case, because they primarily are based on the downstream property damage and loss of life that would result from a dam failure. Even though dam failure and downstream damage cannot be entirely excluded, the discharge characteristics and channel properties of Otter Creek are more likely to cause upstream flooding and accompanying damage than they are to cause a dam failure. The reservoir volumes are relatively small, and their contribution in reducing flood peak flow would not be significant. However, the Corps of Engineers' guidelines provide a basis for design that is not otherwise available. Accordingly, the range of the inflow spillway design was between the 100-year and one-half probable maximum flood for all sites. The flood with a 500-year recurrence interval was selected for analysis at Center Rutland, Beldens, and Huntington Falls with the reservoir at El. 218.0. One-half the probable maximum flood was selected for the two higher Huntington Falls reservoir levels. The 500-year, at-station discharge of expected probability was computed by the USGS to be 18,782 and 14,711 cubic feet per second at Center Rutland and Beldens (Middlebury gage), respectively. No similar discharge was computed by USGS for Huntington Falls, because they have no gage at that site.

2. Center Rutland and Beldens - The 500-year flood cannot be discharged at Center Rutland and Beldens without almost completely replacing the existing concrete dams with gated structures or permitting the reservoirs to surcharge. Therefore, reasonable and various sized gates were assumed; and the water levels were computed for different discharges up to the 500-year flood level. Spillway crest lengths were either those existing

or those proposed for the improved conditions. A discharge coefficient of 2.62 was used for existing conditions and 3.3 for the improved conditions. The resulting surcharges were lower for the improved conditions than they were for the existing conditions. The results of the analysis are shown in Table 3-4.

TABLE 3-4
CENTER RUTLAND AND BELDENS
COMPARISON OF FLOOD STAGES
IMPROVED AND EXISTING CONDITIONS

		Improved Conditions			Existing Conditions	
Site	Discharge (cfs)	Gate Height (ft)	Head (ft)	Reservoir Elevation	Head (ft)	Surcharged Reservoir Elevation
Center Rutland	4,462	4.0	4.0	509.0	4.6	509.4
Center Rutland	18,782*	4.0	10.4	515.4	11.9	516.7
Beldens	3,468	5.0	5.0	284.0	5.8	286.3
Beldens	14,711*	5.0	13.1	292.1	15.3	295.8

* 500-year flood.

The data for existing conditions were obtained from available records and are shown in Table 3-2. The data for the improved conditions are for the gate sizes and spillway lengths shown on Exhibits A-5, A-6, and A-7.

3. Huntington Falls - This is a larger structure than either Center Rutland or Beldens for normal reservoir water surfaces of El. 241.0 and El. 230.0, and a correspondingly more severe design flood is justifiable. Therefore, the inflow design flood was based on the maximum probable flood, which is estimated to be 174,000 cubic feet per second and is discussed in Appendix C. A spillway design outflow of 70,000 cubic feet per second was adopted for these two higher normal reservoir water surface elevations. The adopted outflow design discharge is about 40 percent of the probable

maximum flood inflow and will generally be adequate for one-half probable maximum inflow, if upstream storage effects are considered.

The adopted spillway design criteria do not require the application of the maximum probable flood conditions to a low dam with normal reservoir water level at El. 218.0, and insufficient flood data were available to prepare a reliable flood frequency analysis. Therefore, it was considered expedient to analyze the surcharge elevations for various spillway discharge capacities rather than to design for one specific capacity. Computations for the existing conditions were made for discharges up to the 70,000 cubic feet per second used for the two higher dams.

The discharge coefficients used for Center Rutland and Beldens were also used for Huntington Falls, and the same general procedures were followed. The data for the existing conditions are the same as shown in Table 3-2. Corresponding data for the improved conditions are for the gate sizes and spillway lengths shown on Exhibits A-1 through A-4, inclusive. The results of these analyses are shown in Table 3-5.

4. Effects on Development Alternatives - The development alternatives were formulated prior to the completion of flood studies; and consequently, they exercised no influence on that aspect of the work. However, it was known at the time the alternatives were selected that floods would play an important role in the alternative that is finally recommended for implementation. The flood studies also influenced the replacement of flashboards by hydraulically operated crest gates.

E. Geotechnical

Geological conditions appear to be favorable at all sites despite the presence of the solution cavern at Beldens and minor leakage at other sites. Most excavation will be in rock, which can be stockpiled for use in the cofferdams. Rock excavation will require blasting.

TABLE 3-5

HUNTINGTON FALLS
COMPARISON OF FLOOD DISCHARGES
IMPROVED AND EXISTING CONDITIONS

Reservoir Water Surface Elevation	Improved Conditions		Existing Conditions		Remarks
	Head (ft)	Discharge (cfs)	Head (ft)	Discharge (cfs)	
		NORMAL RESERVOIR EL. 218.0			
218.0	5.0	8,855	2.2	1,496	
225.0	12.0	32,922	9.2	12,794	Bridge level
232.9	19.9	70,308	17.1	32,421	
		NORMAL RESERVOIR EL. 230.0			
230.0	12.0	34,294	14.2	24,534	
237.3	19.3	69,950	21.5	45,708	Design Q
244.4	26.4	111,907	28.6	70,130	
		NORMAL RESERVOIR EL. 241.0			
241.0	12.0	34,294	25.2	58,002	
248.3	19.3	70,000	32.5	84,950	Design Q
256.5*	27.5	118,974	40.7	119,050	

* Surcharged reservoir level where discharge is approximately the same for existing and improved conditions.

3.6 COMPARISON OF ALTERNATIVES

A. General

A direct comparison of the four development alternatives shown in Table 3-1 was not made because of the many variables used in this analysis. These variables include the size and number of units, total installed capacity, reservoir water surface levels, escalation rates, discount rates, interest rates, and the length of the applicable analysis periods. The analyses were made for individual sites for each of the variables; and the results were compared as a basis for selecting the most favorable combination, even though the components are not the same as listed in any single alternative.

B. Capacity and Energy

The details of the power studies are presented in Appendix C and are summarized below. Table C-6 of Appendix C shows the capacity and energy produced at each of the three sites for the four development alternatives shown in Table 3-1. Table 3-6 shows the results of the power studies for three different heads and four different unit combinations at all sites. In addition, the table shows the percent of time that each component would operate during an average year (% Time Operable), the percentage of the maximum energy output for the three heads and four installed capacities (% Rating @ Fixed Head), and a similar percentage for the site (% of Maximum Output). The capacities shown in the table are theoretical and, therefore, are not the actual capacities that will have to be installed.

The results in Table 3-6 show that one large unit of the same capacity as three small units can operate only about 51 to 53 percent of the time and will produce only about 81 to 82 percent of the energy. Therefore, consideration of one large unit was eliminated without further investigation. The tabulated results also show that two small units of the same unit capacity as the three-unit installations would be able to operate the same amount of time as the three units and generate about 87 to 88 percent of the energy.

TABLE 3-6

SUMMARY OF POWER STUDY RESULTS

IMPROVED CONDITIONS

Plant	Reservoir Water Surface Elevation (ft)	Net Head (ft)	Applicable Alternative	No. of Units	Unit Capacity (kW)	Installed Capacity (kW)	Output* (kWhr/yr)	% Time Operable	% Rating @ Fixed Head	% of Maximum Output
Center Rutland	514	35	II & IV	3	960	2,880	9,453,000	95.6	100.0	100.0
				2	1,440	2,880	9,189,000	85.6	97.2	97.2
				1	2,880	2,880	7,674,000	52.6	81.2	81.2
				2	960	1,920	8,301,000	95.6	87.8	87.8
	509	30	III	3	800	2,400	8,088,000	96.3	100.0	85.5
				2	1,200	2,400	7,877,000	86.7	97.4	83.3
				1	2,400	2,400	6,632,000	54.3	82.0	70.1
				2	800	1,600	7,083,000	96.3	87.6	74.9
	507	28	I	3	770	2,310	7,617,000	95.6	100.0	80.6
				2	1,155	2,310	7,409,000	85.8	97.3	78.4
				1	2,310	2,310	6,206,000	53.1	81.5	65.7
				2	770	1,540	6,685,000	95.6	87.8	70.8
Beldens Site	284	51	IV	3	2,650	7,950	26,349,000	96.9	100.0	100.0
				2	3,975	7,950	25,287,000	83.0	96.0	96.0
				1	7,950	7,950	21,212,000	51.2	80.5	80.5
				2	2,650	5,300	23,220,000	96.9	88.1	88.1
		43	I & III	3	2,250	6,750	22,484,000	96.8	100.0	85.3
				2	3,375	6,750	21,678,000	84.0	96.4	82.2
				1	6,750	6,750	18,134,000	51.0	80.7	68.8
				2	2,250	4,500	19,609,000	96.8	87.2	74.4
		40	II	3	2,067	6,200	20,855,000	96.9	100.0	79.1
				2	3,100	6,200	20,159,000	84.8	96.7	76.5
				1	6,200	6,200	16,915,000	51.8	81.1	64.2
				2	2,067	4,134	18,152,000	96.9	87.0	68.8
Huntington Falls	241	60.5	II	3	3,700	11,100	37,525,000	97.0	100.0	100.0
				2	5,550	11,100	36,230,000	84.6	96.5	96.5
				1	11,100	11,100	30,423,000	51.7	81.1	81.1
				2	3,700	7,400	32,631,000	97.0	87.0	87.0
	238	49.5	III & IV	3	3,050	9,150	30,797,000	96.9	100.0	82.1
				2	4,575	9,150	29,749,000	84.5	96.6	79.3
				1	9,150	9,150	24,932,000	51.4	81.0	66.5
				2	3,050	6,100	26,740,000	96.9	86.8	71.3
	218	37.5	I	3	2,300	6,900	23,275,000	97.0	100.0	62.0
				2	3,450	6,900	22,694,000	87.5	97.5	60.5
				1	6,900	6,900	18,845,000	51.5	81.0	50.2
				2	2,300	4,600	20,225,000	97.0	86.9	53.9

* Gross energy generated at powerhouses.

These percentages influenced the degree of importance placed on total installed capacity in selecting a development alternative for implementation. The table also shows similar percentages for two larger units of the same total capacity as the three smaller units. The two larger units would operate from about 83 to 88 percent of the time that three smaller units would and would produce from about 96 to 97 percent of the energy.

Three units at Center Rutland resulted in relatively small capacity equipment. Two small units of the same unit capacity as the three small units would produce only about 88 percent of the energy generated by the three units; whereas, two larger units of the same total capacity as the three units would produce more than 97 percent of the energy produced by the three units. Therefore, three small units were eliminated from further consideration.

Further investigations of the land elevations and urbanization upstream of Center Rutland and the results of flood studies disclosed that the reservoir water surface should be no higher than El. 509.0. Therefore, further investigations at this site were reduced to a two-unit installation and one reservoir level. There was not enough sufficiently accurate topographic data available for Beldens to permit making a sound estimate of the head that could be gained by excavating the tailrace or of the volume of excavation that would be required. Therefore, the tailrace water surface was assumed to be at El. 241.0 and resulted in using only one head for further consideration at that site.

C. Development Components for Further Consideration

The elimination procedure discussed in the preceding paragraphs reduced the number of development components to the nine shown in Table 3-7.

D. Capital Costs

1. Quantity Estimates - Quantity estimates were prepared for the nine components listed in Table 3-7. The results of the detailed estimates are

TABLE 3-7

DEVELOPMENT COMPONENTS SELECTION DATA
IMPROVED CONDITIONS

Project Site	Reservoir Water Surface Elevation	Head (ft)	No. of Units	Installed Capacity (kW)	Identification Symbol*
Center Rutland	509.0	30.0	2	2,400	CR/2-2.4-509
Beldens	284.0	40.0	3	6,300	BEL/3-6.3-284
	284.0	40.0	2	4,200	BEL/2-4.2-284
Huntington Falls	241.0	60.5	3	11,100	HF/3-11.1-241
	230.0	49.5	3	9,300	HF/3-9.3-230
	218.0	37.5	3	6,900	HF/3-6.9-218
	241.0	60.5	2	7,400	HF/2-7.4-241
	230.0	49.5	2	6,200	HF/2-6.2-230
	218.0	37.5	2	4,600	HF/2-4.6-218

* Used subsequently for all identification.

shown in Appendix B. Quantity estimates are based on takeoffs from Exhibits A-1 through A-7 contained in Appendix A and are to an accuracy consistent with the present level of investigation. In a few cases, some previously computed quantities for one project possibility were adjusted to obtain corresponding quantities for another, especially at Huntington Falls and, to a lesser extent, Beldens. Some quantities remained constant for the various possibilities being investigated and accordingly were transposed directly from one to another. Land acquisition and land rights were based on reservoir area-capacity curves and the reconnaissance of the areas involved. The quantities estimated for some minor items were subsequently combined into a lump sum amount for the cost estimate. A few quantities were estimated from experience and other standard estimating practices for feasibility investigations.

2. Unit Prices and Unit Costs - The unit prices applied to the quantity estimates are based on recently obtained data for similar construction projects and have been adjusted for the price differential between their location and the study area. Some unit prices were influenced by recent bids for similar construction work. Unit prices are considered to be current prices as of the end of 1978. The effects of escalation are not included in unit prices, but are appropriately considered in other parts of the work.

The costs of turbines, governors, and generators were based on data obtained from equipment suppliers, both for these installations and others. These costs assume the use of pre-engineered package units. The spread between the available cost data was small; and therefore, these costs are believed to be accurate.

The cost of spillway crest gates was primarily based on a recently received bid for similar gates and on a computation of gate weight and the corresponding cost per ton of these type gates. Several assumptions were made in estimating both the gate weights and the unit prices of the gates.

The cost of auxiliary electrical and mechanical equipment was calculated by estimating the costs of the individual auxiliaries required and combining the resulting values into a lump sum amount. This represents a minor cost for these installations, and extreme refinement is considered unnecessary.

The transmission line costs for Huntington Falls and Beldens were estimated together; and a portion of the total was allocated to each site, based on the capacity transmitted and the transmission distance. The amount allocated to Beldens was assumed to be the same for both the three-unit and two-unit improvements considered for that site, and all cost variations were charged against Huntington Falls. Very little change in the transmission line is anticipated for Center Rutland, and only a small lump sum amount was included for this work in the estimate. The results of an analysis of transmission line voltage are contained in Paragraph 3.6D6.

Land acquisition and land right costs are based on prevailing land rates in the area. The cost used for developed land is close to recent selling prices for the type of facility involved. Practically no land acquisition is required for Beldens and Center Rutland; however, small lump sum amounts have been included for both sites.

3. Contingency - A contingency of approximately 15 percent was added to the construction costs shown as "Subtotal" on page 4 of each of the estimates in Appendix B. This contingency is considered sufficient, because the generating equipment costs are considered to be accurate and constitute between 20 and 36 percent of the total capital investment. The crest gates and operators costs are also considered to be accurate and constitute between about 7 and 11 percent of the total capital investment.

4. Engineering and Administration - The cost of engineering and administration was computed as approximately 10 percent of the line shown as TOTAL on page 4 of the quantity and cost estimates in Appendix B. These costs are intended to cover the fees for consulting engineering services, including construction supervision.

5. Interest During Construction - Interest during construction was computed at a rate of 10 percent per annum. The amount of interest shown is based on a straight line drawdown and assumes 24 months to construct Huntington Falls for a normal reservoir water surface at El. 241.0 and 19 months for all other project developments. Interest during construction was computed on the total cost, including engineering and administration, because it was assumed that the money for all costs would have to be borrowed.

6. Transmission Voltage - A present worth analysis was made comparing 46-kV with 69-kV transmission voltage. The following assumptions were used in the analysis and are basically the same as those used for the analysis of the existing transmission line:

Present energy cost per kWh	= 25 mills
Transformer efficiency	= 98.5%
Line length	= 26 miles
Power factor	= 0.8
Interest rate	= 10%
Analysis period	= 30 years
Energy cost escalation rate	= 7%
Conductor material	= Aluminum

The load factors used are those applicable to each installed capacity. The analysis assumed that new conductors would be installed on the existing poles and towers and that no additional right-of-way would be required. This analysis was made prior to final selection of all installed capacities; and consequently, some listed values are not identical to those adopted. The results are shown on Table 3-8.

7. Total Capital Investment - The total capital investment at the time the projects become operational was computed using the criteria described above. The costs are shown in detail in Appendix B and are summarized in Table 3-9.

TABLE 3-8

RESULTS OF TRANSMISSION VOLTAGE ANALYSIS

HUNTINGTON FALLS AND BELDENS TO FLORENCE

IMPROVED CONDITIONS

Installed Capacity (MW)* HF + BEL = Total	Present Worth of Costs ($ x 10^3) 69 KV					46 KV			
	Line Size	Trans-former	Line Loss	Con-ductor	Total	Con-ductor Size	Line Loss	Con-ductor	Total
4.6 + 4.2 = 8.8	556	91	131	203	425	795	228	277	505
6.2 + 4.2 = 10.4	556	103	201	203	507	954	270	321	591
7.4 + 4.2 = 11.6	635	112	221	231	564	1034	312	344	656
6.2 + 5.4 = 11.6	635	112	205	231	548	1034	291	344	635
6.9 + 6.3 = 13.2	556	115	224	203	542	954	301	321	622
9.3 + 6.3 = 15.6	795	125	216	277	619	1034	379	344	723
9.3 + 7.8 = 17.1	795	125	248	277	650	1034	435	344	779
11.1 + 6.3 = 17.4	795	142	221	277	640	1034	423	344	767

* Installed capacities are those investigated and are not entirely identical to those finally adopted.

TABLE 3-8

TABLE 3-9

SUMMARY OF INVESTMENT COSTS AND COSTS PER INSTALLED KILOWATT ($)
IMPROVED CONDITIONS

Cost Item	CR/2-2.4-509	BEL/3-6.3-284	BEL/2-4.2-284
Generating Equipment	1,350,000	2,280,000	1,520,000
Other Construction Cost	1,671,500	2,305,800	1,999,300
Subtotal	3,021,500	4,585,800	3,519,300
Contingency	453,200	687,900	527,900
Total Construction Costs	3,474,700	5,273,700	4,047,200
Engineering and Administration	347,500	527,400	404,700
Interest during Construction	302,000	458,300	351,700
Total Capital Investment	4,124,200	6,259,400	4,803,600
Cost per Installed Kilowatt	1,718	994	1,144

Cost Item	HF/3-11.1-241	HF/3-9.3-230	HF/3-6.9-218
Generating Equipment	3,480,000	3,000,000	2,700,000
Other Construction Costs	6,795,500	5,349,800	3,952,100
Subtotal	10,275,500	8,349,800	6,652,100
Contingency	1,541,300	1,252,500	997,800
Total Construction Costs	11,816,800	9,602,300	7,649,900
Engineering and Administration	1,181,700	960,200	765,000
Interest during Construction	1,299,900	834,400	664,800
Total Capital Investment	14,298,400	11,396,900	9,079,700
Cost per Installed Kilowatt	1,288	1,225	1,316

Cost Item	HF/2-7.4-241	HF/2-6.2-230	HF/2-4.6-218
Generating Equipment	2,326,000	2,006,000	1,800,000
Other Construction Costs	5,823,800	4,412,500	3,281,600
Subtotal	8,149,800	6,418,500	5,081,600
Contingency	1,222,500	962,800	762,200
Total Construction Costs	9,372,300	7,381,300	5,843,800
Engineering and Administration	937,200	738,100	584,400
Interest during Construction	1,031,000	641,400	507,800
Total Capital Investment	11,340,500	8,760,800	6,936,000
Cost per Installed Kilowatt	1,533	1,413	1,508

E. <u>Project Selection</u>

1. General - An economic evaluation of the project possibilities shown in Table 3-7 was made to ascertain the best of the nine. This procedure permitted formulating the plan for an optimum or near optimum development alternative. The evaluation for the selected development was subsequently further refined and is discussed in Chapter 4. The evaluation used a standard computer program that is based on the present worth of costs and benefits and computes the applicable benefit/cost ratio for six discount rates and the internal rate of return for each combination of variables. The basic variables included the project costs, escalation rates, and economic analysis period. These are discussed further in the following paragraphs.

2. Project Costs - The project costs consist of the capital investment, operation and maintenance, and a replacement reserve where required when the analysis period exceeds the useful life of parts of the projects. A residual or salvage value was used where applicable.

3. Escalation - Escalation rates of 3, 5, and 7 percent were applied to all costs and benefits. No case was analyzed for zero escalation because it is considered to be unrealistic. Seven percent maximum escalation was selected to conform to the government's request for such a voluntary limit. All costs and benefits were escalated at the appropriate rates for the first half of the economic analysis period and were then held constant for the second half of the period.

4. Analysis Periods - Analysis periods of 35, 40, and 50 years were investigated. The shorter period was selected because it corresponds to the minimum useful life of some major parts of the projects, primarily the turbines. The maximum period was selected because it represents an acceptable standard for hydroelectric projects. The 40-year period was selected to determine the effects of an intermediate time on project economics.

5. Discount Rates - Six discount rates are a standard feature of the computer program used for this analysis. Discount rates from 6 through 11 percent were used, although the program could have used other rates.

6. Useful Life - The useful life of project features and parts generally follows the depreciation guidelines and rules of the U.S. Treasury Department, Internal Revenue Service. Features or parts of the work having slightly different, but approximately the same, useful life were grouped together and assumed to have the same useful life to simplify calculations.

7. Residual Value - The residual value of all project features or parts was included in the evaluation in conformity with the individual useful life of each and the economic analysis period under investigation. Residual values included the effects of escalation previously discussed. This was done by determining the residual value based on present-day costs and then escalating that amount appropriately. The present worth of the escalated value was determined as the single-payment present worth amount, if it were made at the end of the economic analysis period.

8. Replacement Reserve - A replacement reserve was included by providing a sinking fund for items having a useful life less than the analysis period. This reserve is not required for the 35-year analysis period because all features or parts were assumed to have a useful life of at least that long. Replacement reserve was provided for the 40- and 50-year analysis periods. The costs of the replaceable items were ascertained using present-day values. These values were then escalated for one-half the analysis period and that value was the assumed cost at the time the replacement had to be made. The amount of the annual sinking fund contribution was based on 35 years, at which time replacements would be required.

9. Operation and Maintenance - Annual operation and maintenance costs were computed as 3 percent of the total capital investment for the first year of operation. The first-year costs then were escalated for all subsequent years at the appropriate rates as done for other costs and benefits. The

3 percent value was selected after analyzing several different means of estimating these costs and consists of the following approximate components:

- 1.5 percent for personnel and normal operation and maintenance activities.
- 0.5 percent for administrative and general expenses.
- 1.0 percent for all other costs, including insurance; all local, state, and federal taxes; and miscellaneous and petty expenditures.

10. Benefits - Benefits from the projects accrue because all energy generated does not have to be purchased from an outside source. Therefore, the unit benefit is the rate that an electrical utility would charge for providing the required capacity and energy. The unit rate was selected following an analysis of the cost of energy purchases incurred by VMCO between March and November 1978. The costs consist of an energy charge, demand or capacity charge, and transmission charge. The latter two charges are levied regardless of the amount of energy purchased, even if it is zero. Capacity charges varied between $2.50 and $3.86 per kilowatt; and transmission charges varied between $1.14 and $1.29 per kilowatt, based on a firm commitment of about 1,200 kilowatts out of which about 50 kilowatts were lost in transmission. The energy rate varied from about 15 to 17 mills per kilowatt-hour. The weighted average of all three charges converted to a kilowatt-hour equivalent resulted in adopting 25 mills for the unit cost of the net energy produced during the first year of operation. This rate includes allowances for capacity and transmission charges and was escalated the same as costs.

The gross energy produced by the nine projects under consideration at this stage of the investigation is shown in Table 3-6. Transmission and other losses were subtracted from gross generation in computing benefits. Gross generation, losses, net generation, and the value of the energy delivered to the consumer are shown in Table 3-10.

All energy generated by the proposed improved facilities was assumed to be a benefit arising from the improvements, and no reduction was made for the energy presently generated. This decision was based on the assumption that the existing equipment is well past its useful life, and it may be only a

TABLE 3-10

IMPROVED CONDITIONS
SUMMARY OF ENERGY PRODUCED AND VALUE

Project	Gross Generation (kWhr/yr)	Losses (kWhr/yr)	Net Generation (kWhr/yr)	*Value of Net Generation ($/yr)
CR/2-2.4-509	7,877,000	32,000	7,845,000	196,130
BEL/3-6.3-284	20,855,000	181,000	20,674,000	516,850
BEL/2-4.2-284	18,152,000	134,000	18,018,000	450,450
HF/3-11.1-241	37,525,000	652,000	36,963,000	924,080
HF/3- 9.3-230	30,797,000	379,000	30,418,000	760,450
HF/3- 6.9-218	23,275,000	306,000	22,969,000	574,230
HF/2-7.4-241	32,631,000	494,000	32,137,000	803,430
HF/2-6.2-230	26,740,000	354,000	26,386,000	659,650
HF/2-4.6-218	20,225,000	203,000	20,022,000	500,550

* Value for first year operation; subsequent years escalated.

matter of a relatively short time before the equipment will have to be entirely retired. Operation and maintenance costs also will continue to increase, while output will continue to decrease during the remaining period in which the existing equipment can be kept operable.

F. Project Evaluation for Selection

1. General Considerations - An economic evaluation was made for the nine projects listed in Table 3-7, using the criteria discussed in the preceding paragraphs. A total of 81 variations were analyzed on the computer, and the benefit/cost ratios and internal rates of return were determined. The results of the evaluation are shown in Table 3-11 by groupings under the three escalation rates previously discussed. Major project data for the nine projects are shown in Table 3-12.

The major result of the evaluation is that the improvement of Center Rutland as proposed is not economically feasible for any of the escalation rates. The benefit/cost ratios and internal rates of return are so low for this site that it appears questionable if any improvement concept can be made sufficiently attractive to firmly establish favorable economic feasibility. These adverse results are primarily due to the limited discharge, which results in relatively low energy production at this site.

Beldens is the most economically attractive of the three sites, and benefit/cost ratios in excess of 1.0 and reasonable rates of return were obtained for all escalation rates. The two-unit installation is more economical than the three-unit installation. These results are primarily due to the relatively low investment costs required to improve the site and maximum utilization of the discharge available for increased energy production.

The three-unit installation at Huntington Falls for all three reservoir levels considered is not economically feasible for the 3 percent escalation rate and is only marginally feasible at the two higher escalation rates. The two-unit installation is only marginally feasible for the 3 percent escalation rate,

TABLE 3-11
Sheet 1 of 3

ECONOMIC EVALUATION FOR PROJECT SELECTION

	3% Escalation*						
	Discount Rate (%) and Benefit/Cost Ratio						Internal Rate
Project Data**	6	7	8	9	10	11	of Return (%)
HF/3-11.1-241-50	0.91	0.83	0.77	0.71	0.66	0.61	4.97
HF/3- 9.3-230-50	0.94	0.86	0.79	0.73	0.68	0.63	5.26
HF/3- 6.9-218-50	0.89	0.81	0.75	0.69	0.64	0.60	4.65
HF/3-11.1-241-40	0.88	0.81	0.75	0.69	0.64	0.60	4.58
HF/3- 9.3-230-40	0.91	0.83	0.77	0.71	0.66	0.62	4.87
HF/3- 6.9-218-40	0.86	0.79	0.73	0.67	0.63	0.59	4.26
HF/3-11.1-241-35	0.87	0.80	0.74	0.68	0.64	0.59	4.40
HF/3- 9.3-230-35	0.89	0.82	0.76	0.70	0.66	0.61	4.68
HF/3- 6.9-218-35	0.84	0.78	0.72	0.67	0.62	0.58	4.08
HF/2-7.4-241-50	1.00	0.92	0.84	0.78	0.72	0.67	5.99
HF/2-6.2-230-50	1.06	0.97	0.89	0.82	0.76	0.71	6.62
HF/2-4.6-218-50	1.02	0.93	0.85	0.79	0.73	0.68	6.12
HF/2-7.4-241-40	0.97	0.89	0.82	0.76	0.71	0.66	5.61
HF/2-6.2-230-40	1.03	0.94	0.87	0.80	0.75	0.70	6.25
HF/2-4.6-218-40	0.98	0.90	0.83	0.77	0.72	0.67	5.73
HF/2-7.4-241-35	0.95	0.83	0.81	0.75	0.70	0.65	5.42
HF/2-6.2-230-35	1.01	0.93	0.86	0.79	0.74	0.69	6.05
HF/2-4.6-218-35	0.96	0.89	0.82	0.76	0.71	0.66	5.53
BEL/3-6.3-284-50	1.15	1.06	0.97	0.90	0.87	0.78	7.59
BEL/3-6.3-284-40	1.12	1.03	0.95	0.88	0.82	0.76	7.25
BEL/3-6.3-284-35	1.10	1.01	0.93	0.87	0.81	0.76	7.08
BEL/2-4.2-284-50	1.31	1.20	1.11	1.02	0.95	0.88	9.21
BEL/2-4.2-284-40	1.27	1.17	1.08	1.00	0.93	0.87	8.90
BEL/2-4.2-284-35	1.25	1.15	1.06	1.00	0.92	0.86	8.73
CR/2-2.4-509-50	0.67	0.61	0.56	0.52	0.48	0.45	1.78
CR/2-2.4-509-40	0.65	0.59	0.55	0.51	0.47	0.44	1.51
CR/2-2.4-509-35	0.64	0.59	0.54	0.50	0.47	0.44	1.38

* Escalated at indicated rate for first half of analysis period and retained constant for second half.

** HF/3-11.1-241-50 = Huntington Falls/3 units - installed capacity (11.1 MW) - reservoir water surface elevation (El. 241.0) - analysis period (50 yrs). HF = Huntington Falls; BEL = Beldens; CR = Center Rutland. Typical for all entries.

TABLE 3-11
Sheet 2 of 3

ECONOMIC EVALUATION FOR PROJECT SELECTION

Project Data**	5% Escalation* Discount Rate (%) and Benefit/Cost Ratio 6	7	8	9	10	11	Internal Rate of Return (%)
HF/3-11.1-241-50	1.06	0.97	0.89	0.82	0.76	0.70	6.60
HF/3- 9.3-230-50	1.09	1.00	0.92	0.84	0.78	0.72	6.90
HF/3- 6.9-218-50	1.03	0.94	0.87	0.80	0.74	0.69	6.26
HF/3-11.1-241-40	1.01	0.93	0.86	0.79	0.73	0.68	6.11
HF/3- 9.3-230-40	1.04	0.96	0.88	0.81	0.76	0.70	6.43
HF/3- 6.9-218-40	1.00	0.90	0.83	0.77	0.72	0.67	5.78
HF/3-11.1-241-35	1.00	0.91	0.84	0.78	0.72	0.67	5.89
HF/3- 9.3-230-35	1.02	0.94	0.86	0.80	0.74	0.69	6.20
HF/3- 6.9-218-35	0.97	0.89	0.82	0.76	0.70	0.66	5.57
HF/2-7.4-241-50	1.17	1.07	0.98	0.90	0.83	0.77	7.70
HF/2-6.2-230-50	1.24	1.13	1.04	0.95	0.88	0.82	8.38
HF/2-4.6-218-50	1.18	1.08	1.00	0.91	0.84	0.78	7.84
HF/2-7.4-241-40	1.12	1.02	0.94	0.87	0.80	0.75	7.20
HF/2-6.2-230-40	1.18	1.08	1.00	0.92	0.85	0.79	7.89
HF/2-4.6-218-40	1.13	1.03	0.95	0.88	0.82	0.76	7.35
HF/2-7.4-241-35	1.10	1.00	0.92	0.85	0.79	0.74	6.97
HF/2-6.2-230-35	1.16	1.06	0.98	0.90	0.84	0.78	7.65
HF/2-4.6-218-35	1.11	1.01	0.93	0.86	0.80	0.75	7.11
BEL/3-6.3-284-50	1.33	1.22	1.12	1.04	0.96	0.89	9.41
BEL/3-6.3-284-40	1.28	1.18	1.08	1.00	0.93	0.87	8.97
BEL/3-6.3-284-35	1.26	1.16	1.07	1.00	0.92	0.86	8.76
BEL/2-4.2-284-50	1.52	1.39	1.28	1.18	1.09	1.01	11.12
BEL/2-4.2-284-40	1.46	1.34	1.23	1.14	1.06	1.00	10.71
BEL/2-4.2-284-35	1.43	1.31	1.21	1.12	1.04	0.97	10.50
CR/2-2.4-509-50	0.77	0.71	0.65	0.60	0.56	0.52	3.10
CR/2-2.4-509-40	0.74	0.68	0.63	0.58	0.54	0.50	2.78
CR/2-2.4-509-35	0.73	0.67	0.62	0.57	0.53	0.50	2.67

* Escalated at indicated rate for first half of analysis period and retained constant for second half.

** HF/3-11.1-241-50 = Huntington Falls/3 units - installed capacity (11.1 MW) - reservoir water surface elevation (El. 241.0) - analysis period (50 yrs). HF = Huntington Falls; BEL = Beldens; CR = Center Rutland. Typical for all entries.

TABLE 3-11
Sheet 3 of 3

ECONOMIC EVALUATION FOR PROJECT SELECTION

Project Data**	7% Escalation*						
	Discount Rate (%) and Benefit/Cost Ratio						Internal Rate of Return (%)
	6	7	8	9	10	11	
HF/3-11.1-241-50	1.22	1.12	1.03	0.95	0.87	0.81	8.28
HF/3- 9.3-230-50	1.25	1.15	1.06	0.98	0.90	0.83	8.63
HF/3- 6.9-218-50	1.18	1.08	1.00	0.92	0.85	0.79	7.93
HF/3-11.1-241-40	1.16	1.06	0.98	0.90	0.84	0.78	7.67
HF/3- 9.3-230-40	1.19	1.09	1.01	0.93	0.86	0.80	8.02
HF/3- 6.9-218-40	1.12	1.03	0.95	0.88	0.81	0.76	7.33
HF/3-11.1-241-35	1.14	1.04	0.96	0.88	0.82	0.76	7.41
HF/3- 9.3-230-35	1.17	1.07	0.98	0.91	0.84	0.78	7.75
HF/3- 6.9-218-35	1.10	1.01	0.93	0.86	0.80	0.74	7.08
HF/2-7.4-241-50	1.35	1.23	1.13	1.04	0.96	0.89	9.45
HF/2-6.2-230-50	1.42	1.30	1.20	1.10	1.02	0.94	10.18
HF/2-4.6-218-50	1.35	1.24	1.14	1.06	0.97	0.90	9.61
HF/2-7.4-241-40	1.28	1.17	1.08	1.00	0.92	0.85	8.84
HF/2-6.2-230-40	1.25	1.24	1.14	1.05	0.97	0.90	9.57
HF/2-4.6-218-40	1.29	1.18	1.09	1.00	0.93	0.86	9.00
HF/2-7.4-241-35	1.25	1.15	1.05	0.97	0.90	0.83	8.55
HF/2-6.2-230-35	1.32	1.21	1.11	1.03	0.95	0.88	9.28
HF/2-4.6-218-35	1.26	1.16	1.06	0.98	0.91	0.85	8.71
BEL/3-6.3-284-50	1.52	1.40	1.29	1.20	1.11	1.03	11.28
BEL/3-6.3-284-40	1.46	1.34	1.24	1.14	1.06	1.00	10.72
BEL/3-6.3-284-35	1.43	1.32	1.21	1.12	1.04	0.97	10.46
BEL/2-4.2-284-50	1.74	1.60	1.48	1.36	1.26	1.17	13.07
BEL/2-4.2-284-40	1.66	1.53	1.41	1.30	1.20	1.12	12.56
BEL/2-4.2-284-35	1.63	1.50	1.38	1.27	1.18	1.10	12.29
CR/2-2.4-509-50	0.89	0.82	0.75	0.69	0.64	0.59	4.47
CR/2-2.4-509-40	0.85	0.78	0.72	0.66	0.61	0.57	4.07
CR/2-2.4-509-35	0.83	0.76	0.70	0.65	0.60	0.56	3.98

* Escalated at indicated rate for first half of analysis period and retained constant for second half.

** HF/3-11.1-241-50 = Huntington Falls/3 units - installed capacity (11.1 MW) - reservoir water surface elevation (El. 241.0) - analysis period (50 yrs). HF = Huntington Falls; BEL = Beldens; CR = Center Rutland. Typical for all entries.

TABLE 3-12
Sheet 1 of 3

SUMMARY OF MAJOR PROJECT DATA
IMPROVED CONDITIONS

	Center Rutland	Beldens	
Project Identification Symbol	CR/2 - 2.4 - 509	BEL/3 - 6.3 - 284	BEL/2 - 4.2 - 284
Normal Reservoir Elevation	509.0	284.0	284.0
Dam			
Crest elevation	516.0	287.0	287.0
Crest length including spillway (ft)	195	120	120
Spillway			
Crest elevation	505.0	279.0	279.0
Crest length (ft)	169	94	94
Gate height (ft)	4.0	5.0	5.0
Flood Discharge			
Discharge @ normal reservoir level (cfs)	4,462	3,468	3,468
Maximum discharge (cfs)	18,782	14,711	14,711
Reservoir elevation @ maximum discharge	515.4	292.1	292.1
Design frequency of maximum discharge	500 yr	500 yr	500 yr
Penstock			
Diameter (ft)	8.5	9.5	9.5
Total length (ft)	150	240	160
Number	2	3	2
Powerhouse			
Installed capacity (kW)	2,400	6,300	4,200
Unit capacity (kW)	1,200	2,100	2,100
Number units	2	3	2
Average annual energy (kWh)	7,877,000	20,855,000	18,152,000
Net head (ft)	30.0	40.0	40.0
Normal tailwater elevation	476.0	241.0	241.0
TOTAL - CAPITAL INVESTMENT ($)	4,124,200	6,259,400	4,803,600

TABLE 3-12
Sheet 2 of 3

SUMMARY OF MAJOR PROJECT DATA
IMPROVED CONDITIONS

	Huntington Falls		
Project Identification Symbol	HF/3 - 11.1 - 241	HF/3 - 9.3 - 230	HF/3 - 6.9 - 218
Normal Reservoir Elevation	241.0	230.0	218.0
Dam			
Crest elevation	250.0	239.0	225.0
Crest length including spillway (ft)	350	320	280
Spillway			
Crest elevation	229.0	218.0	213.0
Crest length (ft)	250	250	240
Gate height (ft)	12.0	12.0	5.0
Flood Discharge			
Discharge @ normal reservoir level (cfs)	34,294	34,294	8,855
Maximum discharge (cfs)	70,000	70,000	32,922
Reservoir elevation @ maximum discharge	248.3	237.3	225.0
Design frequency of maximum discharge	1/2 PMF	1/2 PMF	-
Penstock			
Diameter (ft)	11.0	11.0	10.0
Total length (ft)	660	660	660
Number	3	3	3
Powerhouse			
Installed capacity (kW)	11,100	9,300	6,900
Unit capacity (kW)	3,700	3,100	2,300
Number units	3	3	3
Average annual energy (kWh)	37,525,000	30,797,000	23,275,000
Net head (ft)	60.5	49.5	37.5
Normal tailwater elevation	175.0	175.0	175.0
TOTAL - CAPITAL INVESTMENT ($)	14,298,400	11,396,900	9,079,700

TABLE 3-12
Sheet 3 of 3

SUMMARY OF MAJOR PROJECT DATA
IMPROVED CONDITIONS

	Huntington Falls		
Project Identification Symbol	HF/2 - 7.4 - 241	HF/2 - 6.2 - 230	HF/2 - 4.6 - 218
Normal Reservoir Elevation	241.0	230.0	218.0
Dam			
Crest elevation	250.0	239.0	225.0
Crest length including spillway (ft)	350	320	280
Spillway			
Crest elevation	229.0	218.0	213.0
Crest length (ft)	250	250	240
Gate height (ft)	12.0	12.0	5.0
Flood Discharge			
Discharge @ normal reservoir level (cfs)	34,294	34,294	8,855
Maximum discharge (cfs)	70,000	70,000	32,922
Reservoir elevation @ maximum discharge	248.3	237.3	225.0
Design frequency of maximum discharge	1/2 PMF	1/2 PMF	-
Penstock			
Diameter (ft)	11.0	11.0	10.0
Total length (ft)	440	440	440
Number	2	2	2
Powerhouse			
Installed capacity (kW)	7,400	6,200	4,600
Unit capacity (kW)	3,700	3,100	2,300
Number units	2	2	2
Average annual energy (kWh)	32,631,000	26,740,000	20,225,000
Net head (ft)	60.5	49.5	37.5
Normal tailwater elevation	175.0	175.0	175.0
TOTAL - CAPITAL INVESTMENT ($)	11,340,500	8,760,800	6,936,000

but is better at the 5 and 7 percent rates. The benefit/cost ratios and the internal rates of return are consistently larger for normal reservoir El. 230.0 than for either of the other two levels. These results are influenced by the costs of increasing the dam height to El. 241.0 and the generating equipment.

2. Recommended Improvements - Improvements to the Beldens site, using two 2,100-kW units with normal reservoir water surface at El. 284.0, and to the Huntington Falls site, using two 3,100-kW units with normal reservoir water surface at El. 230.0, are recommended. This recommendation is based on the benefit/cost ratios and internal rates of return shown in Table 3-11. Selections based on only these two parameters do not always result in the most economical project or projects and do not give an indication of the value of incremental costs and benefits. Net present value analyses are used for comparing incremental costs and benefits for projects or combinations of projects. Therefore, net present value comparisons were made for some projects for which the benefit/cost ratios were near the same value and that might be affected by this method of evaluation. In all of the cases, the net present value analyses confirmed the selection made by benefit/cost ratios and internal rates of return. The net present value analysis for the recommended development is discussed in Paragraph 4.4.

Improving Center Rutland should not be entirely eliminated from further consideration, despite the low economic feasibility obtained by this study. It should be given additional study to determine if any cost cutting measures are possible by available "tradeoffs". Such means as not providing a trashrack rake, retaining flashboards instead of installing crest gates, not increasing the height of the dam, and similar measures would reduce costs, but would also result in foregoing some of the advantages of the proposed improvements.

CHAPTER 4
RECOMMENDED DEVELOPMENT

RECOMMENDED DEVELOPMENT

This chapter describes the Beldens and Huntington Falls developments that were recommended for construction in Chapter 3. It discusses additional economic and financial analyses made for these two projects, the proposed construction schedule, development costs, assessment of environmental impacts, energy produced, and the market for the energy generated. A summary of the principal project data is shown in Table 4-1.

4.1 DESCRIPTION OF SELECTED PROJECTS

A. Beldens

1. General - The major modifications comprise improving both dams and spillways and providing entirely new power facilities, including the intake structure, penstocks, powerhouse structure, and generating equipment. The reservoir level is raised from the existing El. 283.0 to El. 284.0. The adopted layout is shown on Exhibit A-8.

The feature locations are generally the same as for the existing conditions. The pedestrian suspension bridges near the dam axes are not indicated on the exhibit, but they will be salvaged and used with the improved facilities.

Access to the site is the same as presently exists plus a minor extension to the new powerhouse location.

2. Dam and Spillway Improvements - The condition of the dam concrete is shown on Figure 2-3. The unsound concrete will be removed to a depth of about 1 foot or until sound materials are exposed. About 3 feet of new concrete is provided to form a new dam section of higher hydraulic

TABLE 4-1

SUMMARY OF MAJOR PROJECT DATA
RECOMMENDED DEVELOPMENT

Project Identification Symbol	Beldens BEL/2 - 4.2 - 284	Huntington Falls HF/2 - 6.2 - 230
Normal Reservoir Elevation	284.0	230.0
Dam		
Crest elevation	287.0	239.0
Crest length including spillway (ft)	120	320
Spillway		
Crest elevation	279.0	218.0
Crest length (ft)	94	250
Gate height (ft)	5.0	12.0
Flood Discharge		
Discharge at normal reservoir level (cfs)	3,468	34,294
Maximum discharge (cfs)	14,711	70,000
Reservoir elevation at maximum discharge	292.1	237.3
Design frequency of maximum discharge	500 yr	1/2 PMF
Penstock		
Diameter (ft)	9.5	11.0
Total length (ft)	160	440
Number	2	2
Powerhouse		
Installed capacity (kW)	4,200	6,200
Unit capacity (kW)	2,100	3,100
Number units	2	2
Average annual energy (kWh)	18,152,000	26,740,000
Net head (ft)	40.0	49.5
Normal tailwater elevation	241.0	175.0
TOTAL - CAPITAL INVESTMENT ($)	4,803,600	8,760,800

efficiency than the existing structure. The new concrete is reinforced and anchored to the existing concrete and foundation. The dam abutments are at El. 287.0. The crest lengths, including the spillways, are approximately 60 feet each.

Both spillways are located on the dam with their crests at El. 279.0. Each is 47 feet long, which is the same total length as the existing spillways. Five-foot-high hydraulically operated spillway crest gates are provided. They are float-controlled so that they are automatically lowered to the full open position when overtopped by 1 foot. They remain in the full open position until the reservoir level drops to El. 283.0, or 1 foot below normal level, at which time they are automatically raised to the full upright position. The gates are shaped to approximate a standard ogee crest, thereby providing maximum spillway discharge efficiency.

3. Generation Facilities - The generation facilities consist of the intake structure, penstocks, powerhouse, two turbine-generator units, transformer, and accessory electrical and mechanical equipment. The turbine-generator units are identical and can operate independently or in conjunction with each other.

A new intake structure is provided adjacent to the right, or east, abutment of the east dam; and the powerhouse is relocated to a site on the east bank downstream of the east dam. This relocation was made to eliminate the 90-degree waterway bend upstream of the intake and to improve hydraulic efficiency of the facility.

Trashracks are provided at the entrance to the intake, which is bell-mouthed to minimize entrance losses. The trashracks are cleaned by a trashrack rake that is mounted on rails that extend for the entire length of the intake structure deck at El. 287.0. The trashrack rake is electrically operated, and all cleaning can be performed by one operator.

Separate intake gates are provided for each of the two penstocks and are located near the entrance of the intake structure. They are raised or lowered by electric motor-driven hoists located at El. 287.0 on the intake structure deck.

Two 80-foot-long by 9.5-foot-diameter penstocks extend from just downstream of the intake gates to a butterfly valve at the upstream end of the turbine-generator unit. The penstocks are fabricated of 3/8-inch steel plate, which is the minimum allowable thickness for handling a pipe of this diameter.

The powerhouse is located downstream of the intake structure and contains two 2,100-kW generating units. The structure is 45 feet wide by 60 feet long; however, further consideration should be given to the possible future expansion discussed in Paragraph 4.5. A crane is not provided, and erection and maintenance is performed by mobile equipment using the hatches provided in the roof. A parking and service area is provided on the east side of the structure where mobile equipment can operate and have access to the roof if required. This area and the area upstream of the structure are backfilled to El. 259.0, one foot below the roof elevation. This level is above maximum tailwater elevation for the spillway design flood and is 34 feet above the foundation level.

The generating equipment is a predesigned, self-contained, tube-type, package unit and consists of an inlet valve, adjustable blade turbine, speed increaser, generator, governing equipment, and associated switchgear. The tube-type unit is considered to be most applicable of those presently available for this installation.

One three-phase transformer is located inside the powerhouse and increases the voltage from the 2,300 volt generation level to 69 kV for transmission. The transformer is rated at 4,950 kVa, 2.3 - 69 kV. Auxiliary electrical and mechanical equipment is provided to make the plant fully self-sustaining. The plant is unattended and is remotely controlled from the main control room at the Proctor site.

B. Huntington Falls

1. General - Improvements at Huntington Falls are similar in many respects to Beldens, and much of the discussion for that site is also applicable to this site.

The major modifications comprise increasing the dam height; improving the spillway; and providing entirely new generation facilities, including the intake structure, penstocks, powerhouse structure, and generating equipment. The adopted layout is shown on Exhibits A-9 and A-10. The features locations are generally the same as the existing facilities. Access to the site is the same as at present, and a new access road is provided to the powerhouse area.

2. Dam and Spillway Improvements - The dam is to be raised to increase the normal reservoir level from El. 218.1 to El. 230.0. This will be accomplished by removing about 1 foot of the existing concrete and placing a minimum of 3 feet of new concrete. The right abutment of the dam is at El. 239.0, and the left abutment is the intake structure. The crest length is about 320 feet, including the spillway.

The spillway is located on the dam, and the crest is at El. 212.0. Two 12-foot-high by 125-foot-long hydraulically operated gates are provided. The gates are float-controlled, similar to those at Beldens, and operate with similar 1-foot reservoir variations above or below normal level. The gates are shaped to approximate a standard ogee, thereby providing the maximum spillway discharge efficiency.

3. Generation Facilities - The generation facilities comprise the intake structure, penstocks, powerhouse, generating units, transformer, and accessory electrical and mechanical equipment. The units can operate together or separately.

A new intake structure is provided on the left bank of the dam. The approach channel to the intake structure is the same as the diversion channel. The intake is basically a mass concrete structure, but is reinforced in areas where required.

Trashracks are provided at the entrance to the intake and extend from the entrance channel invert at El. 200.00 to the operating deck at El. 239.0. The large trashrack area permits low velocities through the racks with a correspondingly low head loss. The trashracks are cleaned by a trashrack rake, which is identical to the one previously described for Beldens.

The entrance to the penstocks is elliptical upstream of the intake gates. Separate gates are provided for each of the two penstocks and are raised and lowered by electric motor-driven hoists on the operating deck at El. 239.0.

Two 220-foot-long by 11-foot-diameter penstocks extend from just downstream of the intake gates to a butterfly valve at the upstream end of the turbine-generator units. The penstocks are fabricated of 7/16-inch steel plate, which is the minimum allowable thickness for handling a pipe of this diameter.

The powerhouse is located downstream of the intake structure to the south of the existing building. It contains two 3,100-kW turbine-generator units. The structure is 55 feet wide by 70 feet long; however, consideration should be given to the possible future expansion discussed in Paragraph 4.5. No crane is provided, and erection and maintenance operations will be handled by mobile equipment. A parking and service area is provided on the south side of the powerhouse where mobile equipment can operate and have access to the roof if required. This area and the area behind the powerhouse are backfilled to El. 194.0, 1 foot below the powerhouse roof level. The roof is 41 feet below the foundation level and is above maximum tailwater elevation for the spillway design flood. Access to the parking and service area is by a short access road originating at the gravel road upstream of the dam.

The generating units are predesigned, self-contained, tube-type, package units and include the same components as the Beldens units except that they are rated at 3,100 kW and operate under a higher head and greater discharge. The discussion of the Beldens units is also applicable to the Huntington Falls units.

One three-phase transformer is located inside the powerhouse and increases the voltage from 2,300 volts to 69 kV for transmission. It is rated at 7,300 kVA, 2.3 - 69 kV. Auxiliary electrical and mechanical equipment is provided to make the plant fully self-sustaining. The plant is remotely controlled from Proctor.

C. Transmission Line

Transmission line losses were shown to be high in the evaluation of the existing facilities discussed in Paragraph 2.3E. The comparison of the present worth of costs presented in Table 3-8 in Paragraph 3.6D6 shows that 69 kV is more economical than 46 kV. The second line of Table 3-8 is the same as the recommended development and shows that the present worth of a 69-kV system is $507,000 compared to $591,000 for a 46-kV system. The comparison assumed that new conductors could be installed on the existing structures and without additional right-of-way. The previous results are adequate for the present purposes, and 69 kV has been adopted for the 27.6-mile transmission line between Huntington Falls and the Florence substation. The higher voltage requires that a 12,000-kVa, 69/46 kV autotransformer be provided at the substation. No other changes of the transmission system are required for the recommended development, although any other change in the system, such as increased capacity at Proctor or improvements at Center Rutland, could also result in other changes in the transmission system. The transmission line improvement can be deferred to a later date, if desired.

D. Design and Construction Schedule and Project Costs

The design and construction schedule for the two projects is shown on Figure 4-1 and extends over a period of 43 months. This schedule includes 23 months for preconstruction activities to provide time for amending the existing FERC license, final design and investigations, preparation of bidding documents and specifications, and construction contract bidding and award. The generating units and a few other pieces of equipment require from 12 to 18 months for delivery; therefore, the specifications for this equipment should be prepared near the beginning of the design studies.

Construction is scheduled to require 19 months, based on concurrent construction at both sites. The schedule is influenced by the severe winter season when construction operations of the type required will have to be almost entirely closed down. Diversion of the natural flows also exerts an influence on the construction schedule.

Project costs required for the recommended improvements at Beldens are contained in Table B-8, and costs for those at Huntington Falls are contained in Table B-5. These amounts are summarized in Table 3-9, which contains the costs of the nine project improvements considered during the selection procedure. Table 4-2 presents a summary of the costs for the recommended improvements at Beldens and Huntington Falls.

FIGURE 4-1
DESIGN AND CONSTRUCTION SCHEDULE
RECOMMENDED DEVELOPMENT

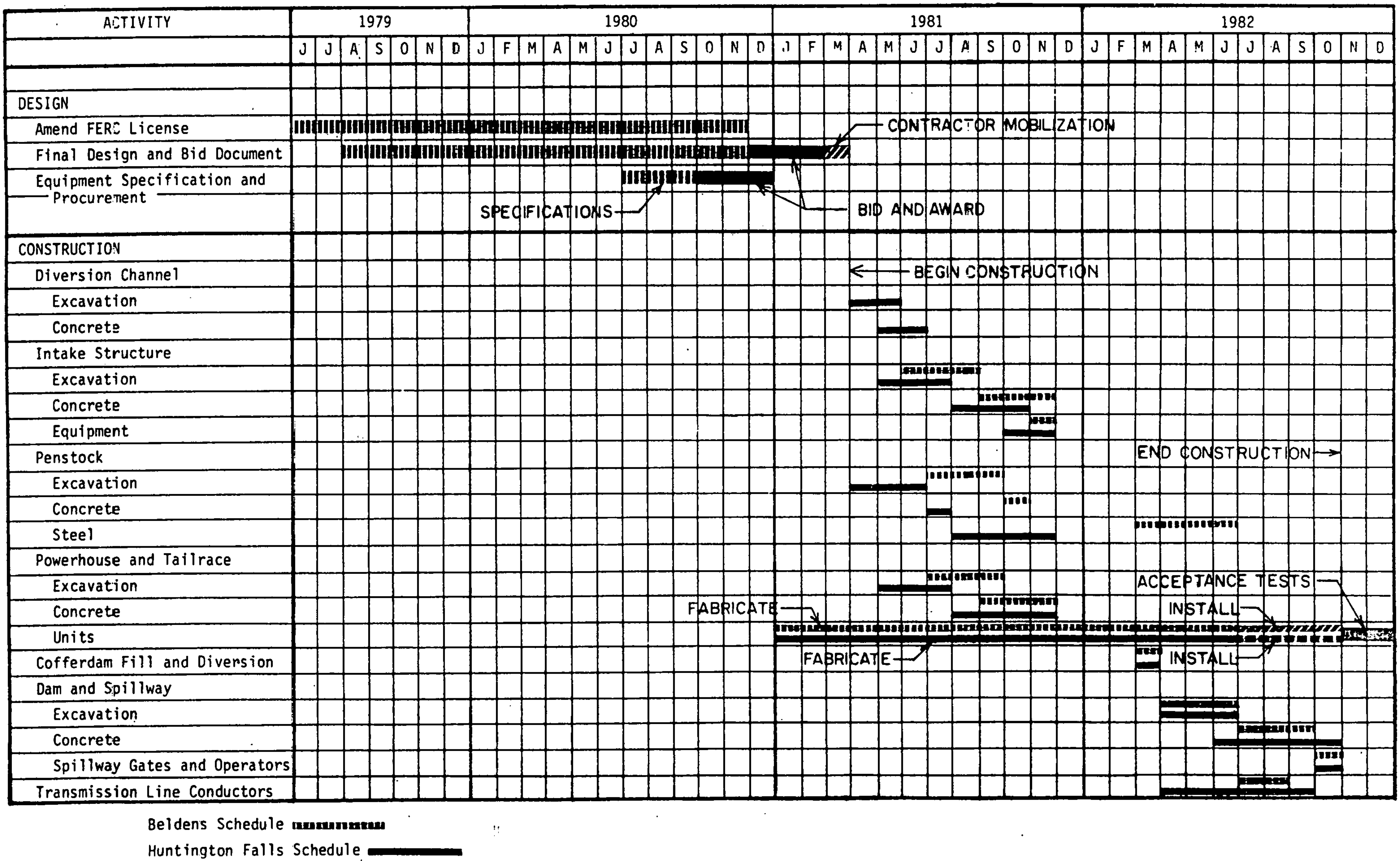


TABLE 4-2

SUMMARY OF INVESTMENT COSTS ($)
BELDENS AND HUNTINGTON FALLS
IMPROVED CONDITION

	BEL/2 - 4.2 - 284	HF/2 - 6.2 - 230	Total Development
Total Construction Cost	4,047,200	7,381,300	11,428,500
Engineering and Administration	404,700	738,100	1,142,000
Interest During Construction	351,700	641,400	993,100
Total Capital Investment	4,803,600	8,760,800	13,564,400
Cost per Installed kW	1,144	1,413	1,304

4.2 ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

This section discusses the environmental impacts that may arise during construction and operation of Beldens and Huntington Falls. It is a preliminary evaluation related to the projects and is mainly intended to identify possible problems so that they can be given a more indepth investigation during a subsequent phase of the work. These projects have been operating as run-of-river installations since near 1910 and will continue to operate the same upon completion of the proposed improvements. Consequently, only minor adverse environmental changes are anticipated.

A. Construction Impacts

The estimated construction time shown in Table 4-1 is nineteen months for Beldens and Huntington Falls. Some adverse environmental effects cannot be avoided during construction. Deterioration of air quality will occur in the areas as a result of emissions from heavy construction equipment and truck operation and as a result of particulate matter, or fugitive dust, becoming airborne from blasting, truck traffic on haul roads, dumping of rock spoils, and similar construction operations.

Table 4-3 shows that the amount of work that must be performed for both sites is relatively small. All quantities listed are the total for the site and are rounded values. The effects on the environment will be of correspondingly small severity and short duration.

TABLE 4-3

MAJOR QUANTITIES THAT AFFECT THE ENVIRONMENT

	Beldens	Huntington Falls
Rock excavation (cu yd)	7,000	15,000
Concrete demolition (cu yd)	1,300	1,300
Concrete (cu yd)	2,600	9,200

Discharge restrictions or reductions are not expected during the construction period. Cofferdams will be constructed at the project locations as part of the diversion schemes. However, they serve only to divert the river flow from the construction area and will have no influence on the natural river regime. The sediment problems normally associated with cofferdam construction will be almost entirely avoided because the existing dams will remain in place during this operation, and they will trap all but the finest suspended sediments.

Removal of deteriorated concrete, demolition of existing unserviceable structures, and tailrace excavation may slightly and temporarily increase the amount of sediment in the downstream reaches of the creek, but probably not enough to create any serious problem, if proper care is taken. Only a minor portion of the existing dams will be removed; and consequently, they will be a barrier to the heavier sediment components, which will be trapped either by the existing dams or in the downstream reservoirs.

Construction impact on population can be expected to be minimal, because most construction personnel can be obtained from the immediate locality and there will be little influx of people as a direct result of the project improvements. Huntington Falls and Beldens are located in sparsely populated areas, and there will be minimum displacement of the permanent residents.

B. Operational Impacts

1. Visual and Aesthetic Value - The Beldens dam will remain almost as it is at present, and the improved concrete surface will enhance its appearance. The spillway crest gates will have a more pleasing appearance than the flashboards presently used. More discharge will be used for power generation than at present; and consequently, there will be less discharge over the dam and falls. Reduced spillway discharge will resemble the dry periods when there is little or no discharge under existing conditions. The Huntington Falls reservoir will be raised from El. 218.1 to El. 230.0. The environmental impacts at this site will be similar to those at Beldens, except that the higher reservoir level will provide a more awesome sight than it does at present whenever there is a spillway discharge.

The new power plants will not significantly alter or impair the scenic quality of the sites. They are located adjacent to the river and only two sides are exposed to view. The other two sides are excluded from view by backfill to within 1 foot of the roof. The trenches in which the penstocks are installed are also backfilled to natural ground levels to the extent possible by slope limitations. These backfilled areas can be landscaped and aesthetically treated so that they blend with the natural environment.

No new or additional transmission lines will be built at any of the sites; however, new conductors are required. They will use the present right-of-way and structures, thereby resulting in minimal change in the environment.

2. Additional Land Inundated

a. Normal Operation Conditions - The additional land that will be inundated during normal operation of Beldens is minimal. Beldens reservoir will be raised only approximately 1 foot above its present level, and virtually no additional lands will be inundated. The Huntington Falls reservoir levels will be raised to El. 230.0, which will inundate only about 55 acres more than the existing facilities. Most of the additional permanently submerged area is within the flood plain of the creek and is covered with grass and light vegetation. Much of it has been flooded during past high river discharge. However, one parcel of commercial property is affected by the increased reservoir level. A campground, comprising a few acres near the confluence of the New Haven River and Otter Creek, is located at a nominal level of El. 228; and some of it would be inundated by reservoir El. 230.0.

The Morgan Horse Farm Road presently serves for access to the Huntington Falls site. Presently, a single lane bridge with a 3.5-ton load limit is located on this road, about 300 feet upstream of the dam. The bridge and road will have to be raised for the increased height of the reservoir level. The bridge deck is presently at approximately El. 227, and it will be raised to El. 242.0. The required improvements will disrupt traffic for a short period during construction, but otherwise will improve transportation facilities and have a favorable impact on the appearance of the area. No other roads or bridges were found during this investigation that would be affected by the higher reservoir level.

b. Flood Conditions - Flooding will be less severe for the improved condition than it is for the existing condition. This results from providing hydraulically operated crest gates, improving crest shapes, lowering the crest level, and increasing the length of the Huntington Falls spillway. The flood stage at Beldens for a 500-year design flood of 14,711 cubic feet per second would rise to El. 295.8 for the existing conditions, but only to El. 292.1 for the improved conditions. The corresponding flood stage at Huntington Falls for the existing condition with a normal reservoir level of El. 218.1 and a discharge of 70,000 cubic feet per second would rise to El. 244.4 for the present condition compared to El. 237.3 for the improved condition with a normal reservoir level of El. 230.0. The lower flood stages are a beneficial environmental impact that arises from improving these two sites.

3. Hydrology - The proposed improvements will have insignificant impacts on river regime since, basically, the plants will continue to operate as run-of-river plants as they have in the past. The reservoirs have virtually no storage capacity that can provide yearly carry-over or seasonal storage; and consequently, there will be no impacts from large reservoir drawdown. However, the plants may be operated during the daily peak load period for only a few hours. Peaking operation will necessitate daily variation of reservoir levels, which could produce some inconvenience, but only slight impact on the environment.

Minimum release for downstream needs will normally be exceeded by power production or spillway discharge, and only peak load operation creates any problem. Recently proposed legislation in the Vermont Legislature entitled "Steamflow Maintenance Act" specifies minimum discharge for downstream use. The proposed minimum discharges are estimated to be about 98 cubic feet per second at Beldens and 137 cubic feet per second at Huntington Falls. Provisions have been made to satisfy these minimum release requirements.

4. Water Quality - No change in water quality is anticipated as a result of project operations.

5. Fish and Wildlife - Fish in the study area include a variety of species, depending on the specific location on the main stem of the creek or one of its tributaries. Some of the species are brown trout, rainbow trout, smallmouth bass, northern pike, yellow perch, bullhead, and rock bass. The Vermont Fish and Game Department is still in the early stages of surveying Otter Creek to identify the species in the creek and to formulate a program for stocking and managing fish resources in the area. The extent and nature of continued action is presently uncertain, but it is likely to continue in some form. No endangered or threatened fish species are known to be present in the project waters.

Fishing activities are moderate in the study area, and there seems to be no great pressure or desire to increase fishing activity. There are no fishways or fish ladders in any of the dams on Otter Creek, and there is no commercial fishing or evidence of any such operation being planned. There appears to be no reason to conclude that fish and fishing in the study area will deteriorate as a result of the proposed modifications, and there are even possibilities that both can be enhanced.

Small game and deer inhabit the area, but mostly away from the waterway. There is only minor sport hunting in the area, and no endangered or threatened species have been identified as residents of the study area.

The Fish and Game Service of the U.S. Department of the Interior has recently reviewed an application for license for the Weybridge Project, downstream of Huntington Falls, and had no objection to its issuance. The only known reservation was in regards to a minimum instantaneous release with which to protect downstream fisheries. This condition has already been met, as previously discussed; and no adverse impacts are likely to arise.

6. Recreation - There is very little recreational activity in the study area. The known activities include small boats and canoes, limited fishing, and some hunting. The two sites proposed for improvement are somewhat remote and experience only a slight recreational use. Opportunities exist for improving recreational facilities, thereby enhancing the local environment. Small boat and bank access is adequate in the project area. The opportunities for improving boating, canoeing, fishing, and other recreational activities are significant, especially at Huntington Falls where the reservoir area and shoreline distance will be increased.

7. Archaeology and Historical Resources - No archaeological remains, historical shrines, cemeteries, or similar installations are known to exist in the areas affected by the proposed improvements.

8. Health - No health hazards or problems are expected for human, animal, fowl, fish, or plant life. The health of the area is expected to remain unchanged.

4.3 ENERGY PRODUCTION AND MARKET

A. Base Load Operation

The Beldens site contains two 2,100-kW units, which generate 18,152,000 kWh of energy during an average year. The corresponding values at Huntington Falls are two 3,100-kW units and 26,740,000 kWh. The combined total output is 10,400 kW and 44,892,000 kWh. The foregoing energies are the generated values and have not been reduced for transmission line losses. The selection of the installed capacities is discussed in Chapter 3, and the power studies on which energy generation is based are discussed in Appendix C. Table 4-4 contains a summary of the power and energy produced.

TABLE 4 - 4

SUMMARY OF POWER AND ENERGY PRODUCTION

	Beldens	Huntington Falls	Total
Installed capacity (kW)	2 @ 2,100 - 4,200	2 @ 3,100 = 6,200	10,400
Average year energy (kWh)			
Generated	18,152,000	26,740,000	44,892,000
Line losses	134,000	354,000	488,000
Net energy	18,018,000	26,386,000	44,404,000

The power duration curve is shown on Figure 4-2, and the corresponding energy-duration curve is shown on Figure 4-3.

The Huntington Falls energy production is based on 5 feet of reservoir drawdown, which is not required because the automatically controlled spillway gates will maintain the reservoir at its highest level for all except a very small percentage of the time. Maintaining the reservoir at its highest level would increase the head by 2.5 feet over that used in the power studies. This is equivalent to a 5 percent head increase and an approximately corresponding increase in the potential energy output. It has been considered unnecessary to make a revision for the extra head, because of simplifying assumptions

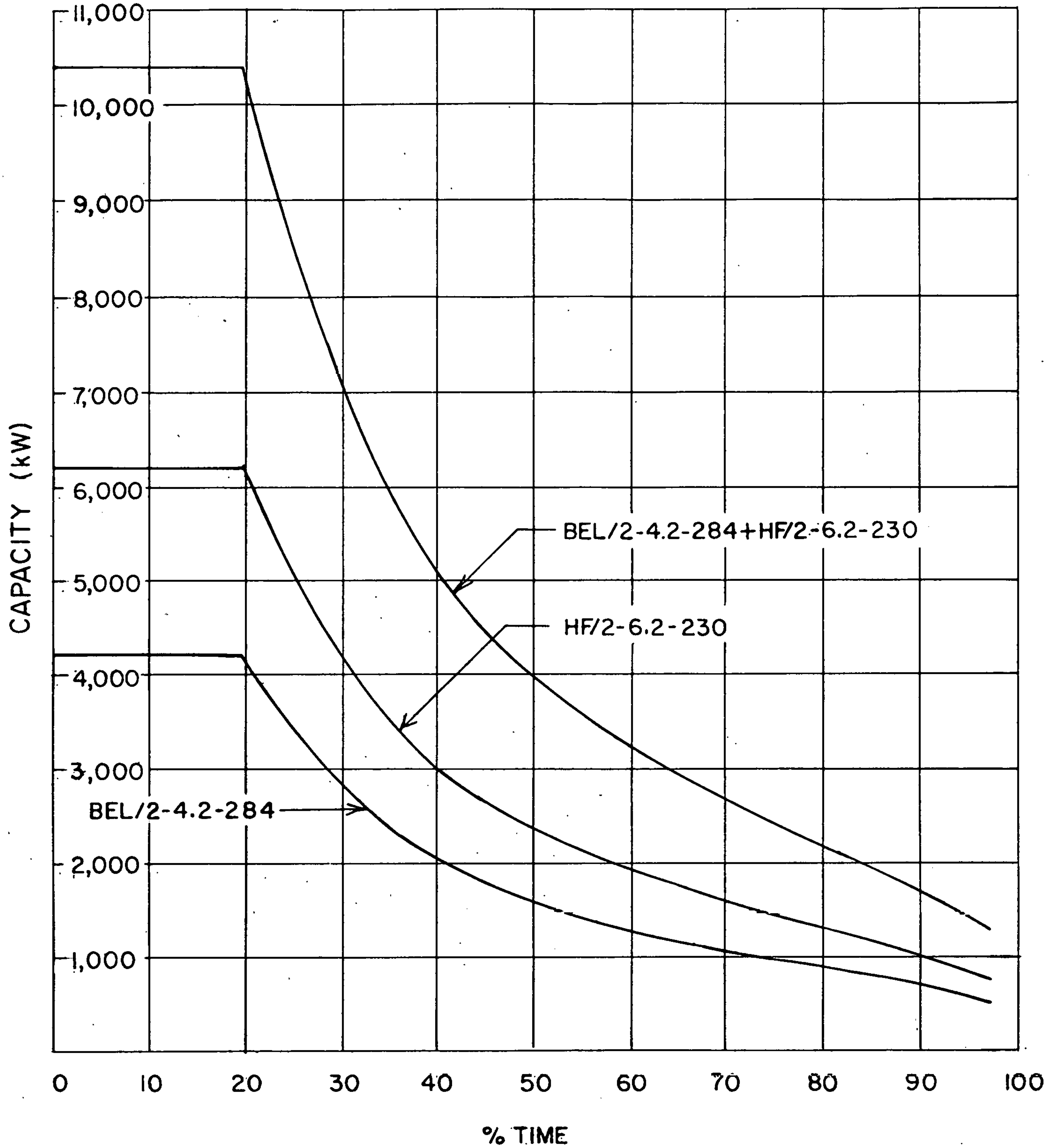


FIGURE 4-2

POWER-DURATION CURVE
RECOMMENDED DEVELOPMENT

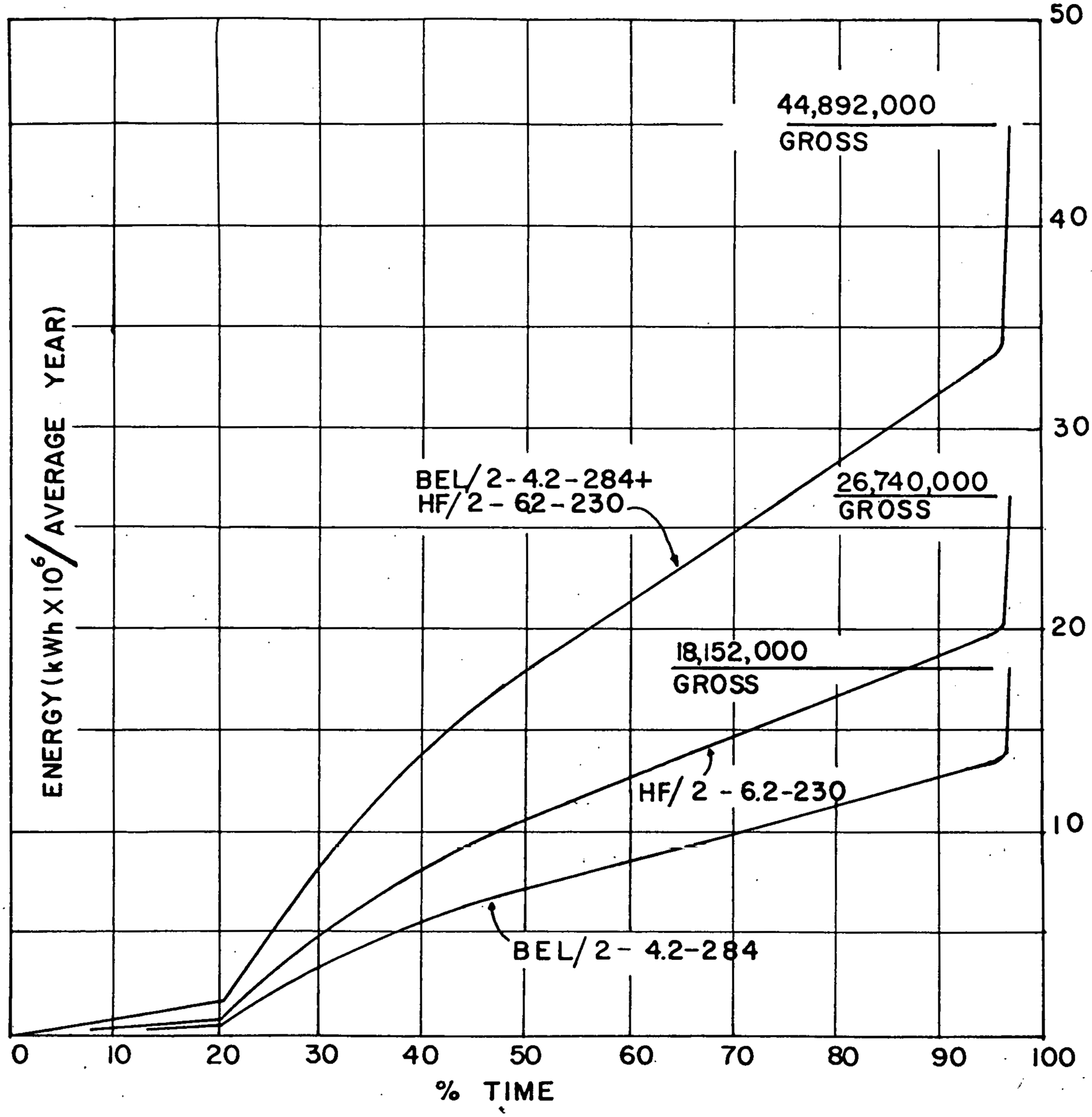


FIGURE 4-3

ENERGY- DURATION CURVE
RECOMMENDED DEVELOPMENT

used in the power study and to keep the results conservative and permit consideration of daily peak load operation discussed in Paragraph 4.3B. However, it is recognized that more energy can be generated than has been computed.

VMCO loads are strongly influenced by mill requirements; and consequently, the load curves are relatively flat and constant from about 7:00 a.m. until about 7:00 p.m. The weekday load is about three times that of the weekend, which shows that the mill operation affects the load curve. Summer energy demands are about 75 percent of winter demands.

Typical daily load curves for 1976 and early 1977 are shown in Figure 4-4. The load has increased since 1976 as a result of a recently completed mill expansion and presently exceeds the installed capacity of about 7,200 kW in the four VMCO-owned hydroelectric projects. The maximum load shown on Figure 4-4 is about 6,000 kW in early 1976 and is not fully indicative of the present or future requirements.

VMCO has recently expanded its mill capacity and will continue expanding it until it reaches about four times its original capacity. The mill expansion and normal economic growth in the area has increased demand for electricity, which is projected to continue until the mill capacity reaches its expansion target. VMCO desires to meet as much of the increased demand as possible by improving and using its wholly owned hydroelectric facilities. The projected load growth is shown in Table 4-5.

TABLE 4-5

LOAD FORECAST

Year	MW	Load Factor (%)
1982	23	80
1983	26	85
1984	33	60
1985	34	70
1986	35	80
1987	36	80
1988	38	80
1989	40	80

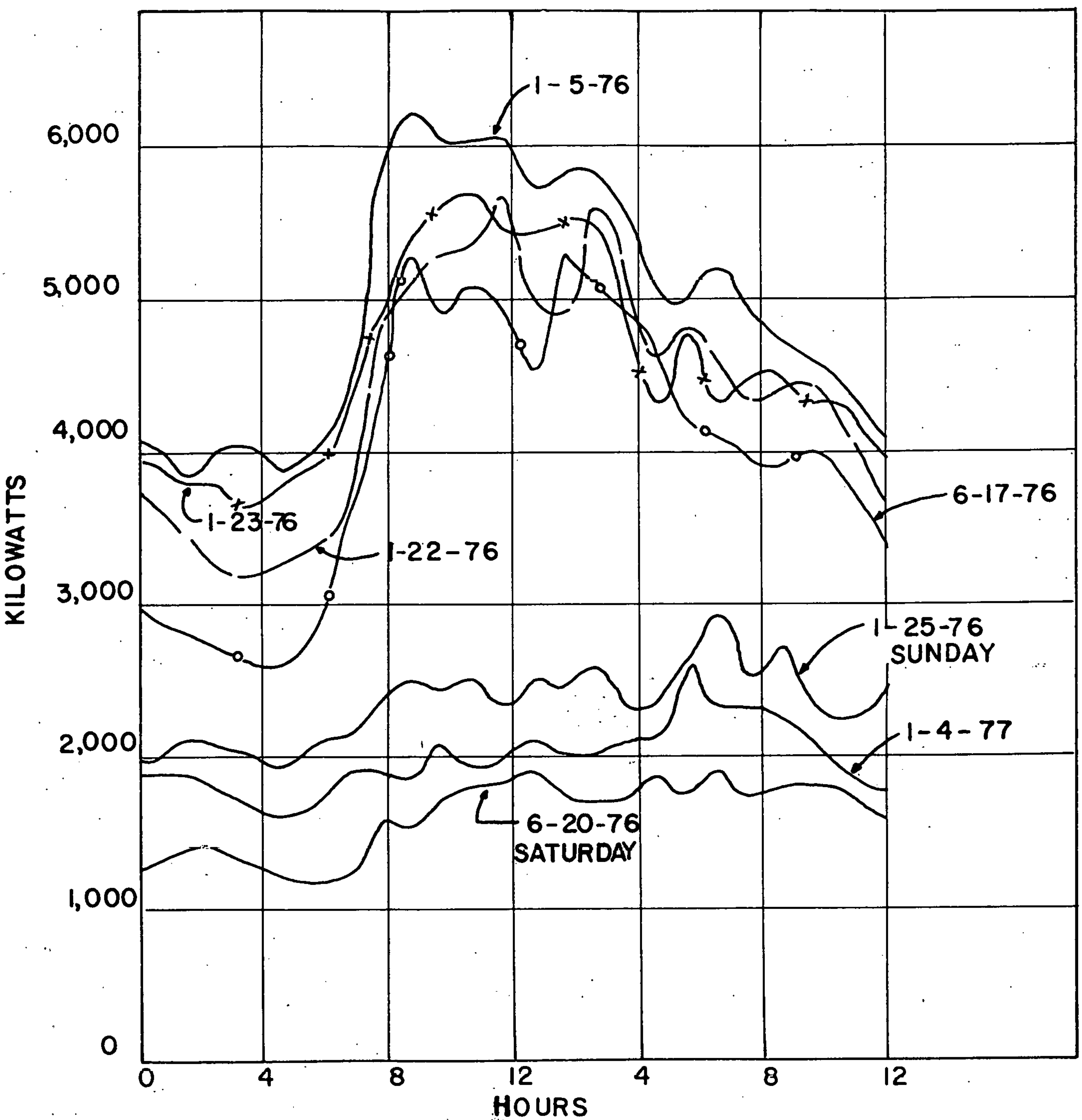


FIGURE 4-4

LOAD CURVES

All four of the VMCO-owned hydroelectric plants will not be able to meet their system demands. Improvements at Beldens and Huntington Falls will make a significant reduction in the amount of power and energy that must be purchased from another utility. Table 4-6 contains a summary of the existing and improved generation capabilities of the VMCO plants. The foregoing discussion clearly confirms that VMCO already needs additional electrical power and energy and that their needs will more than double during the next decade. All power and energy generation resulting from the recommended development will be used in the existing VMCO service area.

B. Peak Load Operation

Beldens and Huntington Falls reservoirs both have limited storage capacity, which places limitations on peaking possibilities. Seasonal peaking is not feasible, and both plants must operate basically as run-of-river installations. Nevertheless, the reservoirs have sufficient storage capacity to warrant an investigation of operation during the daily peak hours. However, Beldens should not be operated on daily peak because of adverse effects it may have on the next upstream dam. Operating Beldens on daily peak would also affect Huntington Falls operation because of the discharge lag time between the two sites. Operating Huntington Falls on daily peak load could also adversely affect the Weybridge Power Plant, which is located about 1.4 miles downstream. Therefore, daily peak load operation is not recommended at this time.

Despite the foregoing recommendation against peak load operation, it was deemed expedient to analyze Huntington Falls to determine the output if the adverse conditions did not exist or could be overcome and to permit a comparison with base load operation. The study was made for a minimum of 12 hours of operation, based on the load curves previously discussed, to simplify the calculations. A discharge of 137 cubic feet per second was released during the 12 hours that the plant would not be operating, to satisfy the minimum discharge discussed in Paragraph 4.2B3. The difference between this minimum release and the inflow was stored in the reservoir for

TABLE 4-6

EXISTING AND ESTIMATED IMPROVED GENERATION CAPABILITY
AVERAGE YEAR

	Existing Condition		Improved Condition		Improvement	
	Capacity (kW)	Energy (kWh)	Capacity (kW)	Energy (kWh)	Capacity (kW)	Energy (kWh)
Recommended Development						
Beldens	1,600	9,550,000	4,200	18,152,000	2,600	8,602,000
Huntington Falls	1,400	10,470,000	6,200	26,740,000	4,800	16,270,000
Subtotal	3,000	20,020,000	10,400	44,892,000	7,400	24,872,000
Other VMCO Projects						
Center Rutland	275	1,366,000	2,400	7,877,000	2,125	6,511,000
Proctor	3,930	19,952,000	3,930	19,952,000	0	0
Subtotal	4,205	21,318,000	6,330	27,829,000	2,125	6,511,000
GRAND TOTAL	7,205	41,338,000	16,730	72,721,000	9,525	31,383,000

Note: All energy shown hereon are generated amounts and have been rounded off.

the 12 hours that the plant was inoperative. Energy was generated by using this storage plus the inflow during the 12 hours when the plant was operating.

The plant reaches rated output when the turbine discharge is 1,837 cubic feet per second, which is the discharge equalled or exceeded 36.9 percent of the time. The plant can be operated for more than 12 hours per day when the discharge exceeds 1,837 cubic feet per second and will be able to operate 24 hours per day when the inflow reaches the rated discharge, which is 20.1 percent of the time. The results of the analysis are shown in Table 4-7. The methods illustrated on that table are the same as used for other power studies, except that they did not require an inflow-outflow computation because the plants were operating 24 hours per day, thereby automatically satisfying the minimum release requirements.

If programmed for peak load operation, the total Huntington Falls energy output is estimated to be 25,345,000 kWh during an average year (Table 4-7). The peak energy output is 17,989,000 kWh (Table C-7); therefore, it is about 71 percent of the total load output.

The previous economic evaluations used 25 mills per kWh as the value of base load energy. If peak load energy is assumed to be worth twice the rate of base load energy, or 50 mills, then the peak load energy, neglecting line losses, would be worth $899,450 during an average year. The remaining 7,356,000 kWh of base energy at 25 mills will produce an additional $183,900, making the total per average year $1,083,350.

This figure should be compared with the previous case when no attempt was made to specifically program the plant for peak operation. The total output in an average year in that case was 26,740,000 kWh. Assuming that, even in this case, half of the energy produced is peak energy and, consequently, worth 50 mills, the value of the total energy output becomes $1,002,750 during an average year.

The foregoing revenue comparisons are not overridingly in favor of programmed 12-hour peak operation of the Huntington Falls plant. However, a further

TABLE 4-7

PEAK LOAD POWER AND ENERGY
HUNTINGTON FALLS AT RESERVOIR EL. 230.0
2 UNITS @ 3,050 = 6,100 kW

% Time	Inflow (cfs)	Minimum Release (cfs)	Turbine Discharge (cfs)	Output (kW)	Average Output (kW)	Operating Hours Internal	Operating Hours Daily	Energy Generated kWh/Interval
1	2	3	4	5	6	7	8	9
100								
						136		0
96.9	230	137	323	1072			12	
					1149	83		95,329
95	253	137	369	1225			12	
					1952	1095		2,137,571
70	472	137	807	2679			12	
					2845	219		623,081
65	522	137	907	3011			12	
					3187	219		697,971
60	575	137	1013	3363			12	
					3569	219		781,593
55	637	137	1137	3775			12	
					4014	219		879,066
50	709	137	1281	4253			12	
					4535	219		993,200
45	794	137	1451	4817			12	
					5172	219		1,132,756
40	901	137	1665	5528			12	
					5814	136		790,704
36.9	987	137	1837	6100			12	
					6100	86		524,600
35	1052	137	1837	6100			12.9	
					6100	263		1,609,300
30	1260	137	1837	6100			15.9	
					6100	323		1,970,300
25	1526	137	1837	6100			19.5	
					6100	389		2,372,900
20.1	1837	0	1837	6100			24	
					6100	1761		10,742,100
0	1837	0	1837	6100			24	
					TOTAL	5586		25,344,871
					SAY			25,345,000

EXPLANATION OF COLUMNS

Col. 1 - % Time listed discharge equalled or exceeded.

Col. 2 - 24-hour inflow to reservoir at listed discharge.

Col. 3 - 12-hour minimum release during plant shut-down.

Col. 4 - 12-hour turbine discharge = 24 x Col. 2 - 12 x Col. 3 ÷ 12.

Col. 5 - kW at listed turbine discharge = QHe/11.8 = 3.32Q.

Col. 6 - Average of two outputs in Col. 5.

Col. 7 - Number hours plant operates during each time interval.

Col. 8 - Number hours plant operates daily at % Time.

Col. 9 - Energy generated during time interval = Col. 6 x Col. 7 = Col. 9.

study of the Huntington Falls plant peaking capabilities should be made based on more reliable topographic maps, which study should also include an investigation of the effect of this peaking operation on the other hydroelectric projects located on Otter Creek.

4.4 ECONOMIC AND FINANCIAL EVALUATION

A. Economic Analyses

The recommended improvements at Beldens and Huntington Falls were selected on a project basis, using the individual benefit/cost ratios described in Paragraph 3.6 and shown in Table 3-11. The two selected project improvements were combined and analyzed for other economic and financial considerations, using a 5 percent escalation factor and a 50-year analysis period. The project and combined benefit/cost ratios, based on the present worth method of analysis, are shown in Table 4-8.

TABLE 4-8

PROJECT AND RECOMMENDED BENEFIT/COST RATIOS
5% ESCALATION; 50-YEAR ANALYSIS PERIOD

Discount	Benefit/Cost Ratios		
Rate (%)	BEL/2-4.2-284	HF/2-6.2-230	Development
6	1.52	1.24	1.33
7	1.39	1.13	1.22
8	1.28	1.04	1.12
9	1.18	0.95	1.03
10	1.09	0.88	0.95
11	1.01	0.82	0.88

Net present value analyses were made for the Beldens two- and three-unit installations and for Beldens two-unit installation combined with the Huntington Falls two-unit installation using all three reservoir levels investigated. The project benefit/cost ratios for a three-unit installation at Huntington

Falls were too low to justify a net present value analysis. The results of net present value analyses for a 5 percent escalation factor and a 50-year analysis period are shown in Table 4-9 and Figures 4-5 and 4-6. These results confirm the selection of the recommended development.

B. Financial Analysis

A financial analysis was made for the recommended development using the annual cost method. This analysis included amortization and interest, replacement reserve, and operation and maintenance costs. It was assumed that the total capital investment shown in the cost estimates would be borrowed. An 8 percent interest rate and a 50-year amortization period were used. The sinking fund for replacement reserve was also based on 8 percent interest, but for only 35 years, at which time replacements are required. No replacement reserve was made after 35 years. An escalation factor of 5 percent was applied against operation and maintenance costs. The sinking fund reserve amount is also based on the 5 percent escalation rate to determine escalated value of replaceable items.

The results of this analysis are shown in Table 4-10. It shows the mill rate of costs for each year of the 50-year analysis period and the corresponding mill rate of revenue. The revenue mill rate is 25 mills during the first year of operation and is escalated at 5 percent for 25 years (one-half of the analysis period) and remains constant thereafter. It also shows that the annual mill rate of costs, or annual costs, is higher than the corresponding mill rate of revenue, or annual revenue, for about the first 11 years of operation. Therefore, the analysis was expanded to determine the year in which annual costs become equal to annual revenue for interest rates from 6 through 11 percent. All other factors remained the same as previously described. The results of this analysis are shown in Table 4-11. A similar analysis was made to determine the year in which total accumulated costs become equal to total accumulated revenue, and the results are shown in Table 4-12.

TABLE 4-9

NET PRESENT VALUE ANALYSES ($ x 10^6)*

RECOMMENDED DEVELOPMENT

COMBINED DEVELOPMENT

Discount Rate (%)	Present Worth Costs BEL/2-284	HF/2-241	Total	Present Worth Benefits BEL/2-284	HF/2-241	Total	B/C Ratio	Net Present Value
6	9.691	22.454	32.145	14.664	26.149	40.813	1.27	+ 8.668
7	8.938	20.797	29.735	12.404	22.118	34.522	1.16	+ 4.787
8	8.346	19.484	27.830	10.646	18.984	29.630	1.06	+ 1.800
9	7.876	18.434	26.310	9.261	16.513	25.774	0.98	- 0.536
10	7.498	17.586	25.084	8.154	14.539	22.693	0.90	- 2.391
11	7.193	16.896	24.089	7.258	12.942	20.200	0.84	- 3.889
	BEL/2-284	HF/2-230	Total	BEL/2-284	HF/2-230	Total		
6	9.691	17.446	27.137	14.664	21.469	36.133	1.33	+ 8.996
7	8.938	16.135	25.073	12.404	18.160	30.564	1.22	+ 5.491
8	8.346	15.099	23.445	10.646	15.587	26.233	1.12	+ 2.788
9	7.876	14.274	22.150	9.261	13.558	22.819	1.03	+ 0.669
10	7.498	13.609	21.107	8.154	11.938	20.092	0.95	- 1.015
11	7.193	13.069	20.262	7.258	10.626	17.884	0.88	- 2.378
	BEL/2-284	HF/2-218	Total	BEL/2-284	HF/2-218	Total		
6	9.691	13.878	23.569	14.664	16.291	30.955	1.31	+ 7.386
7	8.938	12.821	21.759	12.404	13.780	26.184	1.20	+ 4.425
8	8.346	11.987	20.333	10.646	11.828	22.474	1.11	+ 2.141
9	7.876	11.324	19.190	9.261	10.288	19.549	1.02	+ 0.359
10	7.498	10.792	18.290	8.154	9.059	17.213	0.94	- 1.077
11	7.193	10.359	17.552	7.258	8.063	15.321	0.87	- 2.231

BELDENS - 2 AND 3 UNITS

Discount Rate (%)	Net Present Worth BEL/2 Cost	Benefits	Net Present Value	Net Present Worth BEL/3 Cost	Benefits	Net Present Value
6	9.691	14.664	4.973	12.686	16.823	4.137
7	8.938	12.404	3.466	11.689	14.230	2.541
8	8.346	10.646	2.300	10.906	12.214	1.308
9	7.876	9.261	1.385	10.284	10.624	0.340
10	7.498	8.154	0.656	9.786	9.354	- 0.432
11	7.193	7.258	0.065	9.384	8.326	- 1.058

* 5% Escalation; 50 Year Period.

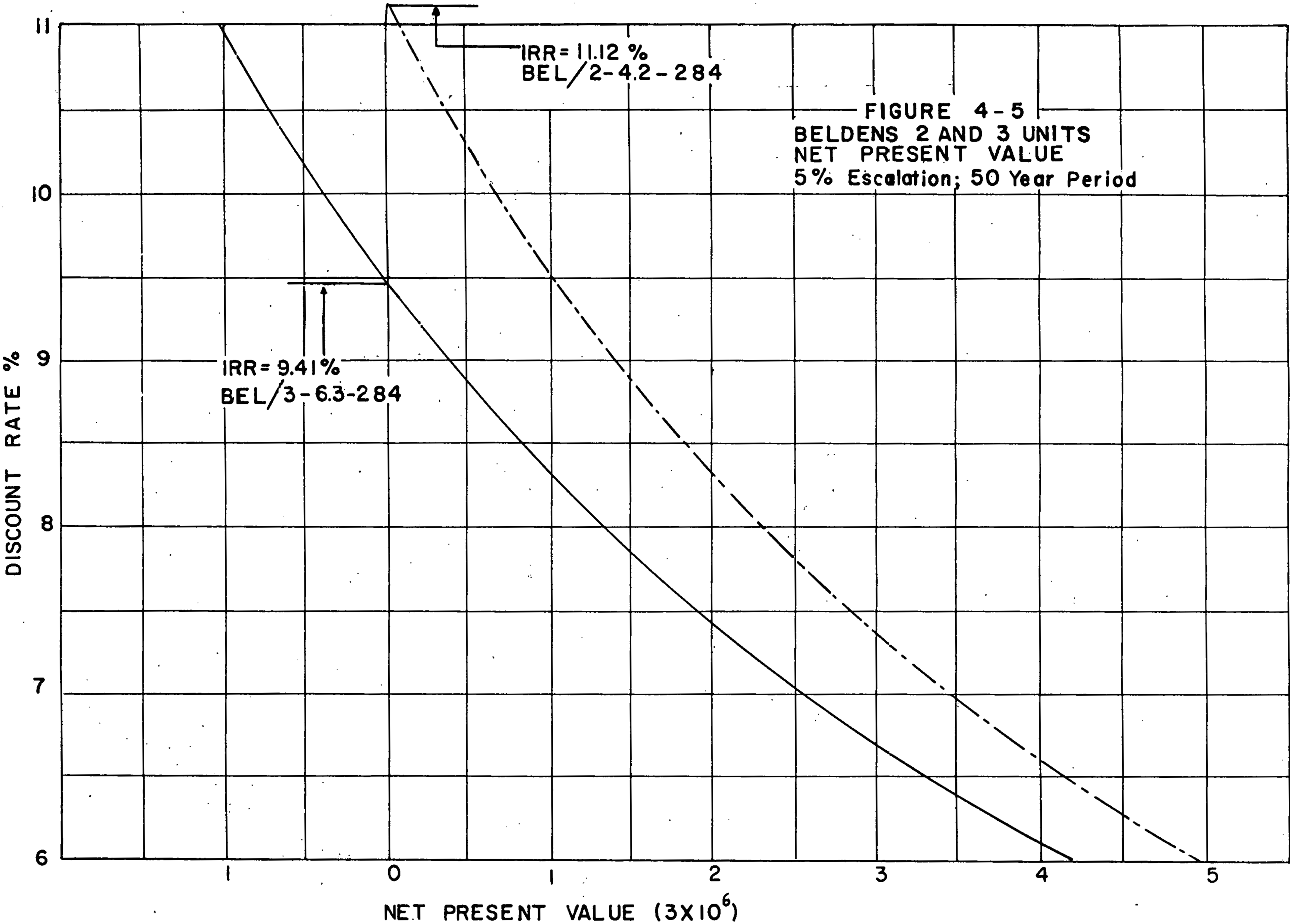


FIGURE 4-5
BELDENS 2 AND 3 UNITS
NET PRESENT VALUE
5% Escalation; 50 Year Period
IRR= 11.12 %
BEL/2-4.2-284
IRR= 9.41%
BEL/3-6.3-284
DISCOUNT RATE %
11
10
9
8
7
6
1
0
1
2
3
4
5
NET PRESENT VALUE ($3 X 10^6$)

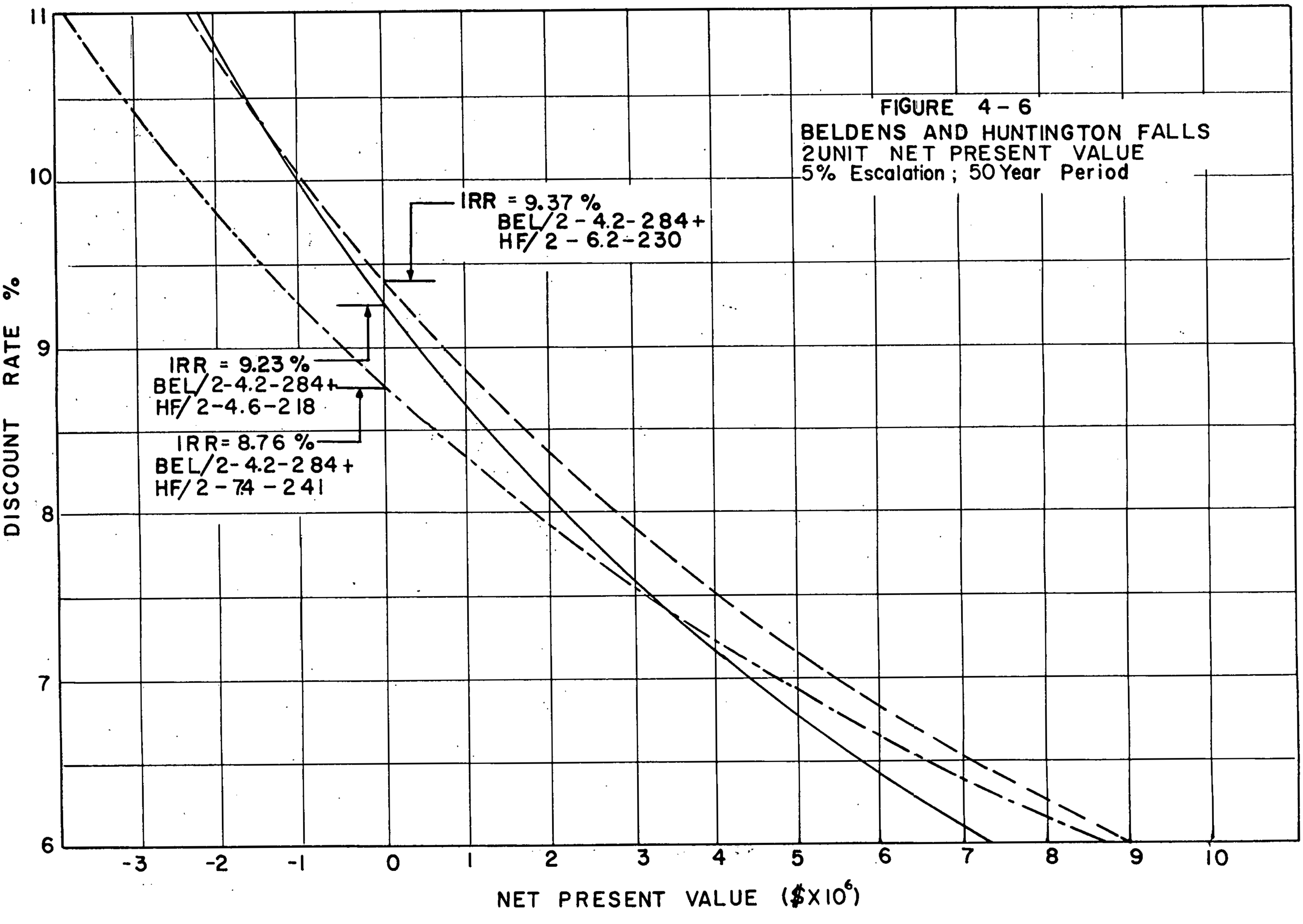


FIGURE 4 - 6
BELDENS AND HUNTINGTON FALLS
2UNIT NET PRESENT VALUE
5% Escalation ; 50 Year Period

TABLE 4-10

FINANCIAL ANALYSIS
TOTAL ANNUAL COST AND MILL RATES
RECOMMENDED DEVELOPMENT

	HF/2-6.2-230				BEL/2-4.2-284				Total HF/2-6.2-230 + BEL/2-4.2-284				Total HF/2 + BEL/2		
Year	A & I*	R.R.**	O&M***	Total	A & I*	R.R.**	O&M***	Total	A & I*	R.R.**	O&M***	Total	Net kWh/Year	Cost (mills/kWh)	Revenue*** (mills/kWh)
1	716,110	24,460	263,000	1,003,570	392,650	18,720	144,000	555,370	1,108,760	43,180	407,000	1,558,940	44,404,000	35.1	25.0
2	716,110	24,460	276,000	1,016,570	392,650	18,720	151,000	562,370	1,108,760	43,180	427,000	1,578,940	44,404,000	35.6	26.3
3	716,110	24,460	290,000	1,030,570	392,650	18,720	159,000	570,370	1,108,760	43,180	449,000	1,600,940	44,404,000	36.1	27.6
4	716,110	24,460	304,000	1,044,570	392,650	18,720	167,000	578,370	1,108,760	43,180	471,000	1,622,940	44,404,000	36.5	28.9
5	716,110	24,460	320,000	1,060,570	392,650	18,720	175,000	586,370	1,108,760	43,180	495,000	1,646,940	44,404,000	37.1	30.4
6	716,110	24,460	335,000	1,075,570	392,650	18,720	184,000	595,370	1,108,760	43,180	519,000	1,670,940	44,404,000	37.6	31.9
7	716,110	24,460	352,000	1,092,570	392,650	18,720	193,000	604,370	1,108,760	43,180	545,000	1,696,940	44,404,000	38.2	33.5
8	716,110	24,460	370,000	1,110,570	392,650	18,720	203,000	614,370	1,108,760	43,180	573,000	1,724,940	44,404,000	38.8	35.2
9	716,110	24,460	388,000	1,128,570	392,650	18,720	213,000	624,370	1,108,760	43,180	601,000	1,752,940	44,404,000	39.4	36.9
10	716,110	24,460	408,000	1,148,570	392,650	18,720	224,000	635,370	1,108,760	43,180	632,000	1,783,940	44,404,000	40.2	38.8
11	716,110	24,460	428,000	1,168,570	392,650	18,720	235,000	646,370	1,108,760	43,180	663,000	1,814,940	44,404,000	40.9	40.7
12	716,110	24,460	450,000	1,190,570	392,650	18,720	247,000	658,370	1,108,760	43,180	697,000	1,848,940	44,404,000	41.6	42.8
13	716,110	24,460	472,000	1,212,570	392,650	18,720	259,000	670,370	1,108,760	43,180	731,000	1,882,940	44,404,000	42.4	44.9
14	716,110	24,460	496,000	1,236,570	392,650	18,720	272,000	683,370	1,108,760	43,180	768,000	1,919,940	44,404,000	43.2	47.1
15	716,110	24,460	520,000	1,260,570	392,650	18,720	285,000	696,370	1,108,760	43,180	805,000	1,956,940	44,404,000	44.1	49.5
16	716,110	24,460	546,000	1,286,570	392,650	18,720	300,000	711,370	1,108,760	43,180	846,000	1,997,940	44,404,000	45.0	52.0
17	716,110	24,460	574,000	1,314,570	392,650	18,720	315,000	726,370	1,108,760	43,180	889,000	2,040,940	44,404,000	46.0	54.6
18	716,110	24,460	602,000	1,342,570	392,650	18,720	330,000	741,370	1,108,760	43,180	932,000	2,083,940	44,404,000	46.9	57.3
19	716,110	24,460	633,000	1,373,570	392,650	18,720	347,000	758,370	1,108,760	43,180	980,000	2,131,940	44,404,000	48.0	60.2
20	716,110	24,460	664,000	1,404,570	392,650	18,720	364,000	775,370	1,108,760	43,180	1,028,000	2,179,940	44,404,000	49.1	63.2
21	716,110	24,460	697,000	1,437,570	392,650	18,720	382,000	793,370	1,108,760	43,180	1,079,000	2,230,940	44,404,000	50.2	66.3
22	716,110	24,460	732,000	1,472,570	392,650	18,720	402,000	813,370	1,108,760	43,180	1,134,000	2,285,940	44,404,000	51.5	69.6
23	716,110	24,460	769,000	1,509,570	392,650	18,720	422,000	833,370	1,108,760	43,180	1,191,000	2,342,940	44,404,000	52.8	73.1
24	716,110	24,460	807,000	1,547,570	392,650	18,720	443,000	854,370	1,108,760	43,180	1,250,000	2,401,940	44,404,000	54.1	76.8
25	716,110	24,460	848,000	1,588,570	392,650	18,720	465,000	876,370	1,108,760	43,180	1,313,000	2,464,940	44,404,000	55.5	80.6
26	716,110	24,460	848,000	1,588,570	392,650	18,720	465,000	876,370	1,108,760	43,180	1,313,000	2,464,940	44,404,000	55.5	80.6
35	716,110	24,460	848,000	1,588,570	392,650	18,720	465,000	876,370	1,108,760	43,180	1,313,000	2,464,940	44,404,000	55.5	80.6
36	716,110	0	848,000	1,564,110	392,650	0	465,000	857,650	1,108,760	0	1,313,000	2,421,760	44,404,000	54.5	80.6
50	716,110	0	848,000	1,564,110	392,650	0	465,000	857,650	1,108,760	0	1,313,000	2,421,760	44,404,000	54.5	80.6

* 8% Interest, 50 years; Costs = $8,761,000 HF, $ 4,804,000 BEL.
** 8% Sinking Fund, 35 years; Cost = $4,216,700 HF, $3,227,000 BEL.
*** Escalated @ 5% per annum for 25 years.

TABLE 4-11

TOTAL ANNUAL COST AND REVENUE ($)*
BREAK-EVEN ANALYSIS
RECOMMENDED DEVELOPMENT

Interest Rate (%)	Capital Recovery Factor	Amortization and Interest BEL/2-4.2-284	Amortization and Interest HF/2-6.2-230	Sinking Fund Factor	Sinking Fund BEL/2-4.2-284	Sinking Fund HF/2-6.2-230	Total Cost Excluding O&M
6	0.06344	304,770	555,800	0.00897	28,950	37,830	927,350
7	0.07245	348,050	634,730	0.00723	23,330	30,490	1,036,600
8	0.08174	392,680	716,120	0.00580	18,720	24,460	1,151,980
9	0.09122	438,220	799,180	0.00463	14,940	19,520	1,271,860
10	0.10085	484,480	883,550	0.00368	11,880	15,520	1,395,430
11	0.11059	531,270	968,880	0.00292	9,420	12,310	1,521,880

Interest Rate (%)	Year	Annual Cost Excluding O&M	Annual Cost O&M BEL/2-4.2-284	Annual Cost O&M HF/2-6.2-230	Annual Cost Total	Annual Revenue BEL/2-4.2-284	Annual Revenue HF/2-6.2-230	Annual Revenue Total
6	6	927,350	184,000	335,000	1,446,350	575,000	842,000	1,417,000
	7	927,350	193,000	352,000	1,472,350	604,000	884,000	1,488,000
7	8	1,036,600	203,000	370,000	1,609,600	634,000	928,000	1,562,000
	9	1,036,600	213,000	388,000	1,637,600	666,000	975,000	1,641,000
8	11	1,151,980	235,000	428,000	1,814,980	734,000	1,075,000	1,809,000
	12	1,151,980	247,000	450,000	1,848,980	770,000	1,128,000	1,898,000
9	13	1,271,860	259,000	472,000	2,002,860	809,000	1,185,000	1,994,000
	14	1,271,860	272,000	496,000	2,039,860	849,000	1,244,000	2,093,000
10	15	1,395,430	285,000	520,000	2,200,430	892,000	1,306,000	2,198,000
	16	1,395,430	300,000	546,000	2,241,430	937,000	1,371,000	2,308,000
11	16	1,521,880	300,000	546,000	2,367,880	937,000	1,371,000	2,308,000
	17	1,521,880	315,000	574,000	2,410,880	983,000	1,440,000	2,423,000

* Based on 5% Escalation; 50 Year Period.

TABLE 4-12

ACCUMULATED ANNUAL COST AND REVENUE ($)*
BREAK-EVEN ANALYSIS
RECOMMENDED DEVELOPMENT

Interest Rate (%)	Years	Accumulated Annual Cost				Accumulated Revenue		
			O&M					
		A&I + R.R.	BEL/2-4.2-284	HF/2-6.2-230	Total	BEL/2-4.2-284	HF/2-6.2-230	Total
6	11	10,200,850	2,048,000	3,734,000	15,982,850	6,403,000	9,373,000	15,776,000
	12	11,128,200	2,295,000	4,184,000	17,607,200	7,173,000	10,501,000	17,674,000
7	15	15,549,000	3,111,000	5,672,000	24,332,000	9,723,000	14,236,000	23,959,000
	16	16,585,600	3,411,000	6,218,000	26,214,600	10,660,000	15,607,000	26,267,000
8	19	21,887,620	4,407,000	8,027,000	34,317,620	13,759,000	20,147,000	33,906,000
	20	23,039,600	4,767,000	8,691,000	36,497,600	14,897,000	21,814,000	36,711,000
9	23	29,252,780	5,973,000	10,927,000	46,152,780	18,665,000	27,428,000	46,093,000
	24	30,524,640	6,438,000	11,696,000	48,658,640	20,118,000	29,358,000	49,476,000
10	26	35,281,180	7,346,000	13,392,000	57,019,180	22,955,000	33,612,000	56,567,000
	27	37,676,610	7,811,000	14,240,000	59,727,610	24,408,000	35,739,000	60,147,000
11	31	47,178,280	9,671,000	17,632,000	74,481,280	30,220,000	44,247,000	74,467,000
	32	43,700,160	10,136,000	18,480,000	77,316,160	31,673,000	46,374,000	78,047,000

* Based on 5% Excalation; 50 Year Period.

Subsequently, a financial analysis was made to see what happens if the future cost escalation, especially for energy, is higher than the one estimated now. It was assumed that the total capital investment shown in the cost estimates would be borrowed at 10 percent interest with a 50-year amortization period. The sinking fund for replacement reserve was also based on 10 percent interest, but for only 35 years, at which time replacements are required. An escalation factor of 8 percent was applied against operation and maintenance costs. This time, the cost and revenue per kWh were computed based only on the incremental energy produced by the project improvements (see Table 4-6). The results of this analysis are shown on Tables 4-13 and 4-14.

The revenue mill rate was set at 35 mills during the first year of operation, assuming that in 1982-1983 this may be the prevailing rate in the Vermont-New Hampshire area. The benefit/cost ratios, based on the data presented in Tables 4-13 and 4-14, are 1.16 for Center Rutland and 1.58 for Beldens and Huntington Falls considered together.

4.5 FUTURE EXPANSION

The benefit/cost ratios obtained for two- and three-unit installations at Huntington Falls during the project selection procedure are close enough to each other to justify considering an increase in the installed capacity in the future. The results of the peak load operation analysis also indicate that additional capacity could become desirable if technical difficulties related to it can be resolved. It is suggested that consideration be given to providing for this expansion at this time, because it would be relatively inexpensive and could add significantly to peak power potential and the corresponding revenue. A similar consideration may also be applicable to the Beldens site.

TABLE 4-13

FINANCIAL ANALYSIS
TOTAL ANNUAL COST AND MILL RATES
(HIGHER ESCALATION RATES)

CR/2-2.4-509

Year	A&I + R.R.[1]	O&M[2]	Total	kWh/yr[3]	Cost (mills /kWh)	Revenue[4] (mills /kWh)
1	516,946	123,726	640,672	6,511,000	98.4	35.0
2	516,946	133,624	650,570	6,511,000	99.2	38.5
3	516,946	144,300	661,300	6,511,000	101.6	42.4
4	516,946	155,800	672,800	6,511,000	103.3	46.6
5	516,946	168,200	685,200	6,511,000	105.2	51.2
6	516,946	181,600	698,600	6,511,000	107.3	56.4
7	516,946	196,100	713,100	6,511,000	109.5	62.0
8	516,946	211,800	728,800	6,511,000	111.9	68.2
9	516,946	228,700	745,700	6,511,000	114.5	75.0
10	516,946	247,000	764,000	6,511,000	117.3	82.5
11	516,946	266,800	783,800	6,511,000	120.4	90.8
12	516,946	288,100	805,700	6,511,000	123.7	99.9
13	516,946	311,100	828,100	6,511,000	127.2	109.8
14	516,946	336,000	853,000	6,511,000	131.0	120.8
15	516,946	362,900	879,900	6,511,000	135.1	132.9
16	516,946	391,900	908,900	6,511,000	139.6	146.2
17	516,946	423,300	940,300	6,511,000	144.4	160.8
18	516,946	457,200	974,200	6,511,000	149.6	176.9
19	516,946	493,800	1,010,800	6,511,000	155.2	194.6
20	516,946	533,300	1,050,300	6,511,000	161.3	214.1
21	516,946	575,960	1,092,960	6,511,000	167.9	235.5
22	516,946	621,970	1,138,970	6,511,000	174.9	259.0
23	516,946	671,600	1,188,600	6,511,000	182.6	284.9
24	516,946	725,300	1,242,300	6,511,000	190.8	313.4
25	516,946	783,300	1,300,300	6,511,000	199.7	344.7
26	517,000	845,960	1,362,960	6,511,000	209.3	379.2
27	517,000	913,630	1,430,630	6,511,000	219.7	417.1
28	517,000	986,720	1,503,720	6,511,000	230.9	458.8
29	517,000	1,065,630	1,582,630	6,511,000	243.1	504.7
30	517,000	1,150,840	1,667,840	6,511,000	256.2	555.1

[1] 10% interest, 50 years; 10% sinking fund, 35 years.
[2] 8% escalated at 8% per annum for 50 years.
[3] Energy exclusive of present generation.
[4] Escalated at 10% per annum for 50 years.

TABLE 4-13 (Continued)

Year	A&I + R.R.[1]	O&M[2]	Total	kWh/yr[3]	Cost (mills /kWh)	Revenue[4] (mills /kWh)
31	517,000	1,242,200	1,759,907	6,511,000	270.3	610.7
32	517,000	1,342,330	1,859,330	6,511,000	285.6	671.7
33	517,000	1,449,680	1,966,680	6,511,000	302.1	738.9
34	517,000	1,565,650	2,082,650	6,511,000	319.9	812.8
35	517,000	1,690,900	2,207,900	6,511,000	339.1	894.1
36	416,000	1,972,260	2,388,260	6,511,000	366.8	984.5
37	416,000	2,130,040	2,546,040	6,511,000	391.0	1,081.8
38	416,000	2,300,440	2,716,440	6,511,000	417.2	1,190.0
39	416,000	2,484,430	2,900,430	6,511,000	445.5	1,309.0
40	416,000	2,683,320	3,099,320	6,511,000	476.0	1,439.0
41	416,000	2,897,980	3,313,980	6,511,000	508.9	1,583.9
42	416,000	3,129,800	3,545,800	6,511,000	544.6	1,742.2
43	416,000	3,380,180	3,796,180	6,511,000	583.0	1,916.4
44	416,000	3,650,600	4,066,600	6,511,000	624.0	2,108.1
45	416,000	3,942,640	4,358,640	6,511,000	669.0	2,318.9
46	416,000	4,258,000	4,674,000	6,511,000	717.9	2,550.7
47	416,000	4,598,600	5,014,600	6,511,000	770.2	2,805.8
48	416,000	4,966,580	5,382,580	6,511,000	826.7	3,086.4
49	416,000	5,363,900	5,779,900	6,511,000	887.7	3,395.0
50	416,000	5,793,000	6,209,000	6,511,000	953.6	3,734.6

TABLE 4-14

FINANCIAL ANALYSIS
TOTAL ANNUAL COST AND MILL RATES
(HIGHER ESCALATION RATES)

TOTAL HF/2-6.2-230 AND BEL/2-4.2-284

Year	A&I + R.R.[1]	O&M[2]	Total	kWh/yr[3]	Cost (mills /kWh)	Revenue[4] (mills /kWh)
1	1,700,100	262,900	1,963,000	24,872,000	78.9	35.0
2	1,700,100	283,900	1,984,000	24,872,000	79.8	38.5
3	1,700,100	306,600	2,006,700	24,872,000	80.7	42.4
4	1,700,100	331,100	2,031,200	24,872,000	81.7	46.6
5	1,700,100	357,600	2,057,700	24,872,000	82.7	51.2
6	1,700,100	386,200	2,086,300	24,872,000	83.9	56.4
7	1,700,100	417,100	2,117,200	24,872,000	85.1	62.0
8	1,700,100	450,400	2,150,500	24,872,000	86.5	68.2
9	1,700,100	486,400	2,186,500	24,872,000	87.9	75.0
10	1,700,100	525,300	2,225,400	24,872,000	89.5	82.5
11	1,700,100	612,700	2,312,800	24,872,000	93.0	90.8
12	1,700,100	661,700	2,361,800	24,872,000	95.0	99.9
13	1,700,100	714,600	2,414,700	24,872,000	97.1	109.8
14	1,700,100	771,770	2,471,870	24,872,000	99.4	120.8
15	1,700,100	833,400	2,533,500	24,872,000	101.9	132.9
16	1,700,100	900,100	2,600,200	24,872,000	104.5	146.2
17	1,700,100	972,100	2,672,200	24,872,000	107.4	160.8
18	1,700,100	1,049,870	2,749,970	24,872,000	110.6	176.9
19	1,700,100	1,133,800	2,833,900	24,872,000	113.9	194.6
20	1,700,100	1,224,500	2,924,600	24,872,000	117.6	214.1
21	1,700,100	1,322,000	3,022,100	24,872,000	121.5	235.5
22	1,700,100	1,427,800	3,127,900	24,872,000	125.8	259.0
23	1,700,100	1,542,000	3,242,100	24,872,000	130.4	284.9
24	1,700,100	1,665,400	3,365,500	24,872,000	135.3	313.4
25	1,700,100	1,798,600	3,499,700	24,872,000	140.7	344.7
26	1,700,100	1,942,500	3,642,600	24,872,000	146.5	379.2
27	1,700,100	2,097,900	3,798,000	24,872,000	152.7	417.1
28	1,700,100	2,265,700	3,965,800	24,872,000	159.4	458.8
29	1,700,100	2,311,000	4,011,100	24,872,000	161.3	504.7
30	1,700,100	2,495,900	4,196,000	24,872,000	168.7	555.1

[1] 10% interest, 50 years; 10% sinking fund, 35 years.
[2] 8% escalated at 8% per annum for 50 years.
[3] Energy exclusive of present generation.
[4] Escalated at 10% per annum for 50 years.

TABLE 4-14 (Continued)

Year	A&I + R.R.[1]	O&M[2]	Total	kWh/yr[3]	Cost (mills /kWh)	Revenue[4] (mills /kWh)
31	1,700,100	2,695,600	4,395,700	24,872,000	176.7	610.7
32	1,700,100	2,911,200	4,611,300	24,872,000	185.5	671.7
33	1,700,100	3,144,100	4,844,200	24,872,000	194.8	739.9
34	1,700,100	3,395,600	5,095,700	24,872,000	204.9	812.8
35	1,700,100	3,667,200	5,367,300	24,872,000	215.8	894.1
36	1,369,000	3,960,600	5,329,600	24,872,000	214.3	984.5
37	1,369,000	4,277,400	5,646,400	24,872,000	227.0	1,081.8
38	1,369,000	4,619,600	5,988,600	24,872,000	240.8	1,190.0
39	1,369,000	4,989,200	6,358,200	24,872,000	255.6	1,309.0
40	1,369,000	5,388,300	6,757,300	24,872,000	271.7	1,439.0
41	1,369,000	5,819,400	7,188,400	24,872,000	289.0	1,583.9
42	1,369,000	6,284,900	7,653,900	24,872,000	307.7	1,742.2
43	1,369,000	6,787,700	8,156,700	24,872,000	327.9	1,916.4
44	1,369,000	7,330,700	8,699,700	24,872,000	349.8	2,108.1
45	1,369,000	7,917,200	9,286,200	24,872,000	373.4	2,318.9
46	1,369,000	8,550,600	9,919,600	24,872,000	399.8	2,550.7
47	1,369,000	9,234,600	10,603,600	24,872,000	426.3	2,805.8
48	1,369,000	9,973,400	11,342,400	24,872,000	450.6	3,086.4
49	1,369,000	10,771,300	12,140,300	24,872,000	488.1	3,395.0
50	1,369,000	11,633,000	13,509,300	24,872,000	543.2	3,734.6

4.6 GOVERNMENTAL REQUIREMENTS

All local, state, regional, and federal regulations have been respected in performing this investigation; and nothing contrary to any of them is proposed. The environmental impacts are more likely to be favorable than they are to be adverse, especially those related to flooding.

The State of Vermont's Water Resources Board, Public Service Board, and Natural Resources Conservation District have jurisdiction over these improvements; and the approval of one or all is required before construction can begin. The State Department of Fish and Wildlife and the Highway Department will also have to be contacted and their authority established in regards to the proposed improvements.

The U.S. Army Corps of Engineers has ruled that Otter Creek is navigable only up to Vergennes, which is almost 14 miles below the Huntington Falls site. However, their approval and that of the U.S. Department of Housing and Urban Development may be required in regards to flooding.

The present Federal Energy Regulatory Commission license must be amended prior to the start of construction. This is the major governmental regulation that must be satisfied, and the others will be fairly straightforward when this is done. Existing regulations require submittal of an application with complete documentation of the proposed project improvements. Since the improvements comprise more than 1,500 kW, many exhibits must be prepared, including statements on water rights, proposed financing, project operation, and an environmental impact statement. A proposal to establish a short form application for projects of less than 15,000-kW capacity is under consideration, and the procedure for obtaining a FERC license for a power development will be greatly simplified if this proposal is approved by Congress.

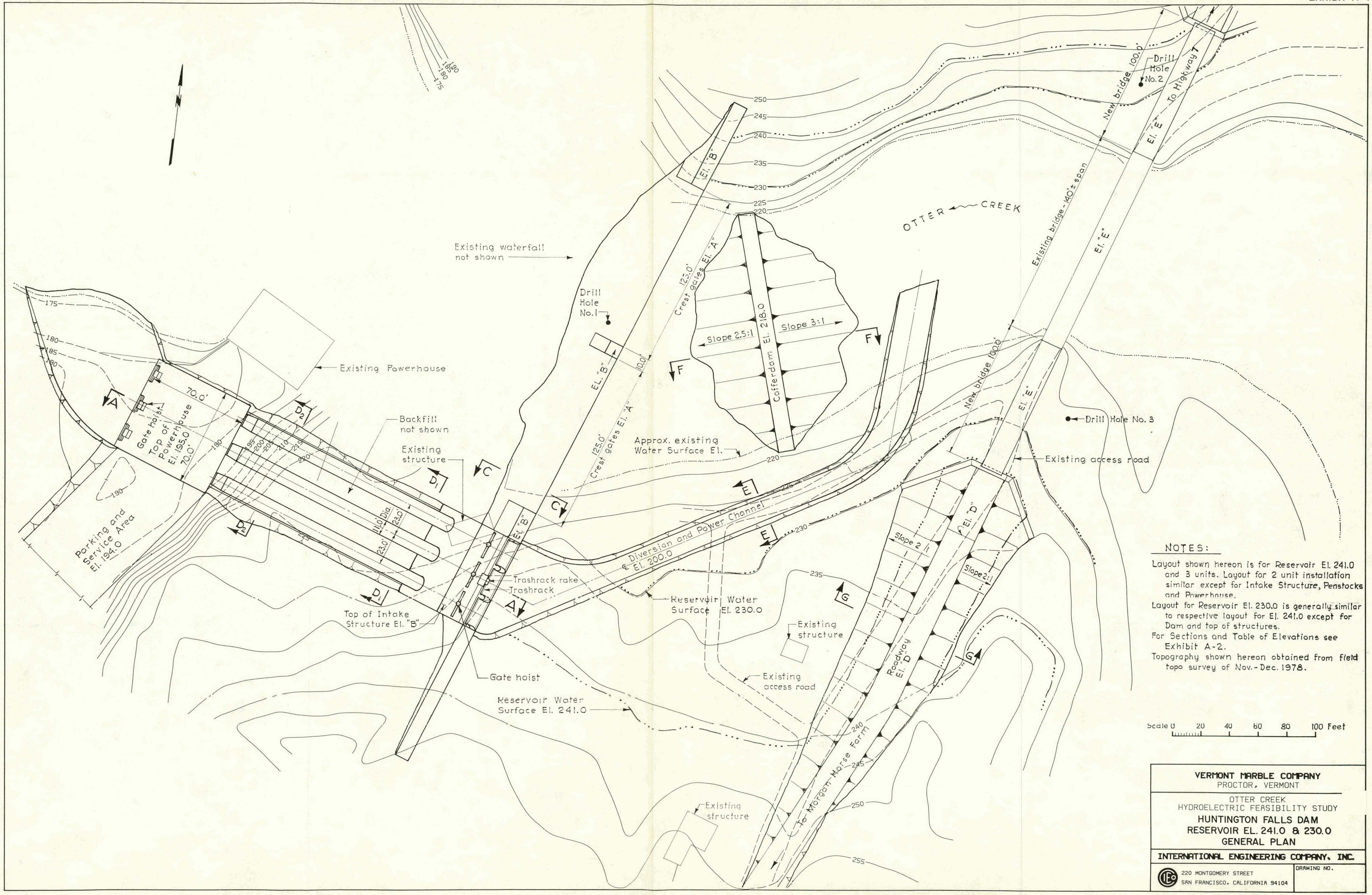
APPENDIX A
EXHIBITS

FOREWORD

Exhibits A-1 through A-7 were prepared for use during the selection of a recommended development alternative. Exhibits A-8 through A-10 show the recommended development at Beldens and Huntington Falls. The recommended development consists of improvements at Beldens and Huntington Falls, consisting of a dam for reservoir water surface El. 284.0 and a powerhouse containing two 2,100-kW units, and a dam for water surface El. 230.0 and a powerhouse containing two 3,100-kW units, respectively.

LIST OF EXHIBITS

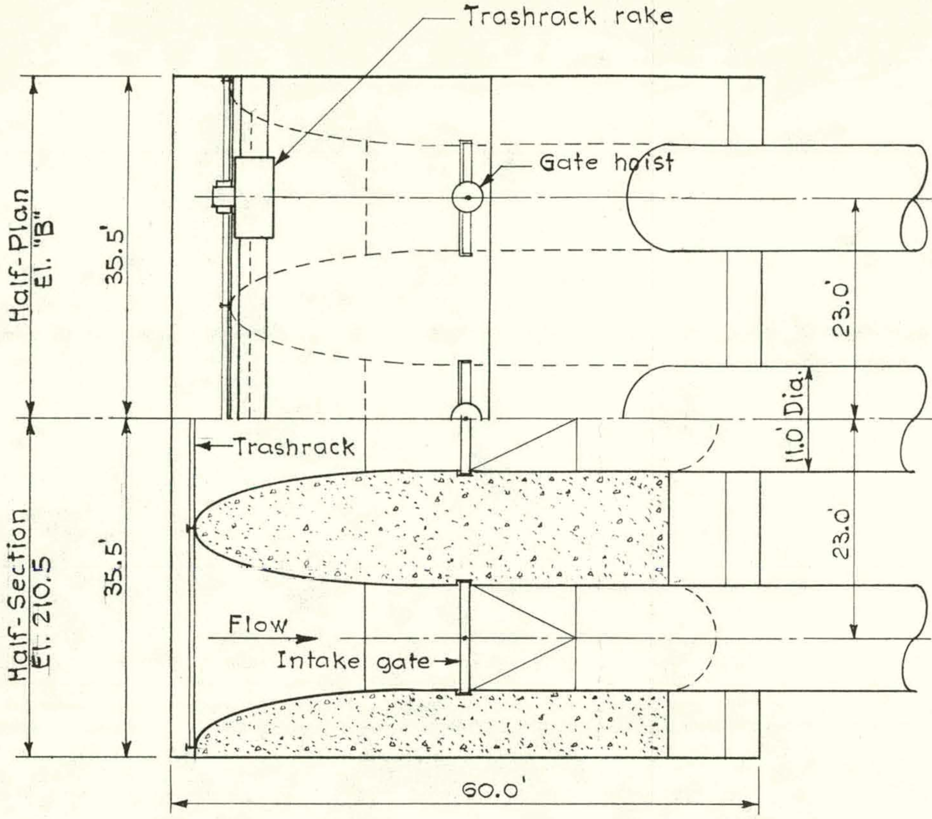
EXHIBIT A-1



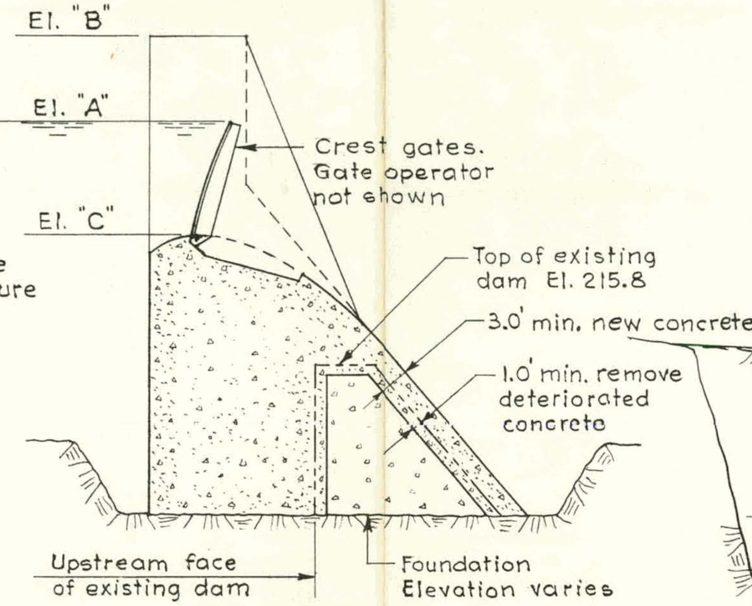
Existing Powerhouse
Existing waterfall not shown
Drill Hole No. 1
Drill Hole No. 2
Drill Hole No. 3
To Highway 7
New bridge 100.0'
Existing bridge - 140'± span
El. "E"
OTTER CREEK
El. "B"
Crest gates El. "A"
125.0'
10.0'
Cofferdam El. 218.0
Slope 2.5:1
Slope 3:1
Approx. existing Water Surface El.
Gate hoist
Top of Powerhouse El. 195.0
70.0'
Backfill not shown
Existing structure
11.0 Dia.
23.0'
Diversion and Power Channel
℄ El. 200.0
Trashrack rake
Trashrack
Top of Intake Structure El. "B"
Reservoir Water Surface El. 230.0
Reservoir Water Surface El. 241.0
Parking and Service Area El. 194.0
Existing access road
Slope 2:1
El. "D"
Roadway El. "D"
To Morgan Horse Farm
NOTES:
Layout shown hereon is for Reservoir El. 241.0 and 3 units. Layout for 2 unit installation similar except for Intake Structure, Penstocks and Powerhouse.
Layout for Reservoir El. 230.0 is generally similar to respective layout for El. 241.0 except for Dam and top of structures.
For Sections and Table of Elevations see Exhibit A-2.
Topography shown hereon obtained from field topo survey of Nov.-Dec. 1978.
Scale 0 20 40 60 80 100 Feet
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RESERVOIR EL. 241.0 & 230.0
GENERAL PLAN
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

TABLE OF ELEVATIONS				
EL. "A" Reservoir W.S.	EL. "B" Top of Struct.	EL. "C" Crest of Dam	EL. "D" Top of Road	EL. "E" Top of Bridge
241.0	250.0	229.0	250.0	253.0
230.0	239.0	218.0	239.0	242.0

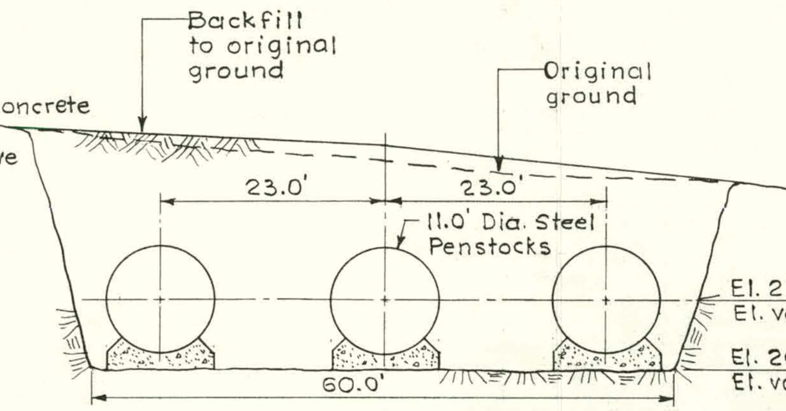
Dimensions and Elevations not included in the above Table but shown on the Sections are the same for both Reservoir W.S. levels.



SECTIONAL PLAN B-B

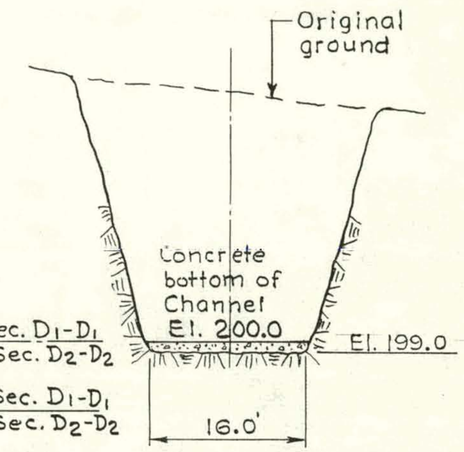


SECTION C-C

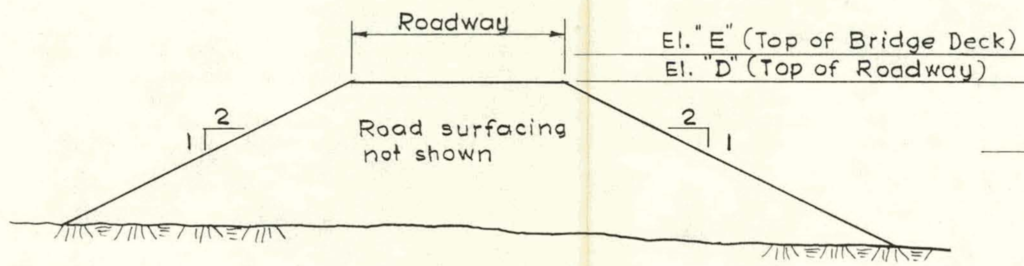


SECTION D_1-D_1

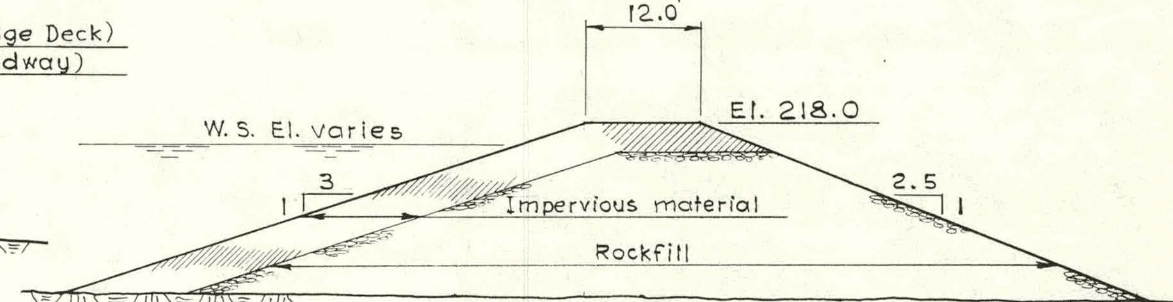
SECTION D_2-D_2



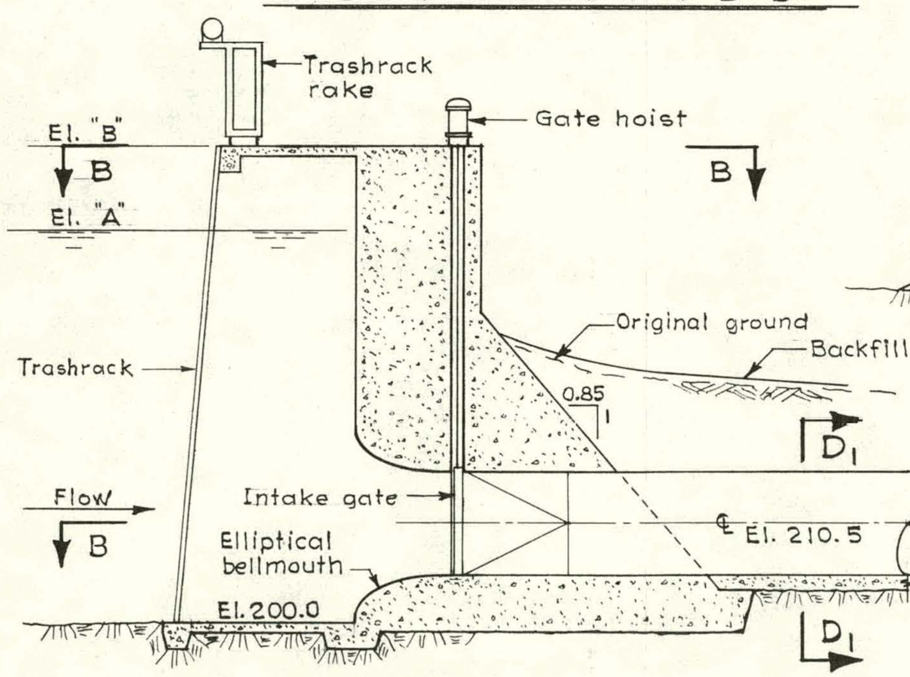
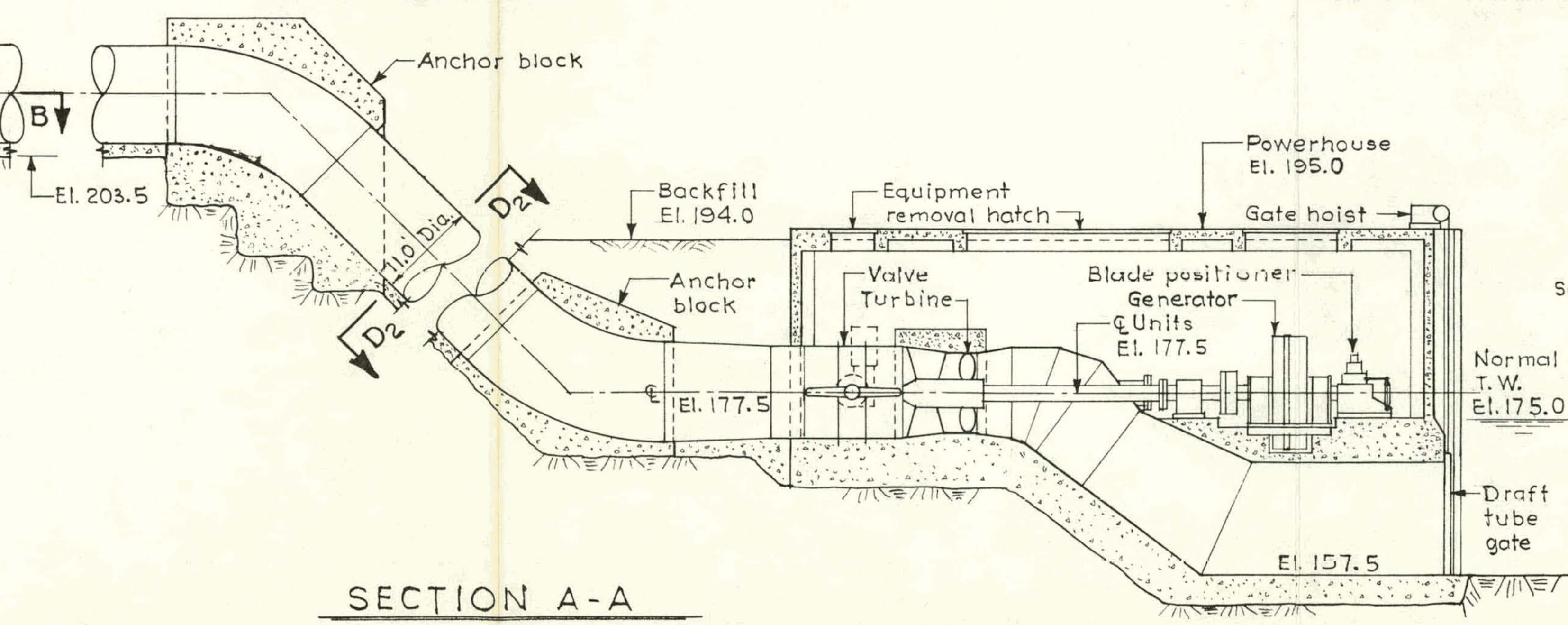
SECTION E-E



SECTION G-G



SECTION F-F

SECTION A-A

NOTES:

Sections shown hereon have been drawn for Reservoir W.S. El. 241.0. Sections for Res. W.S. El. 230.0 similar. For location of Sections see Exhibit A-1.

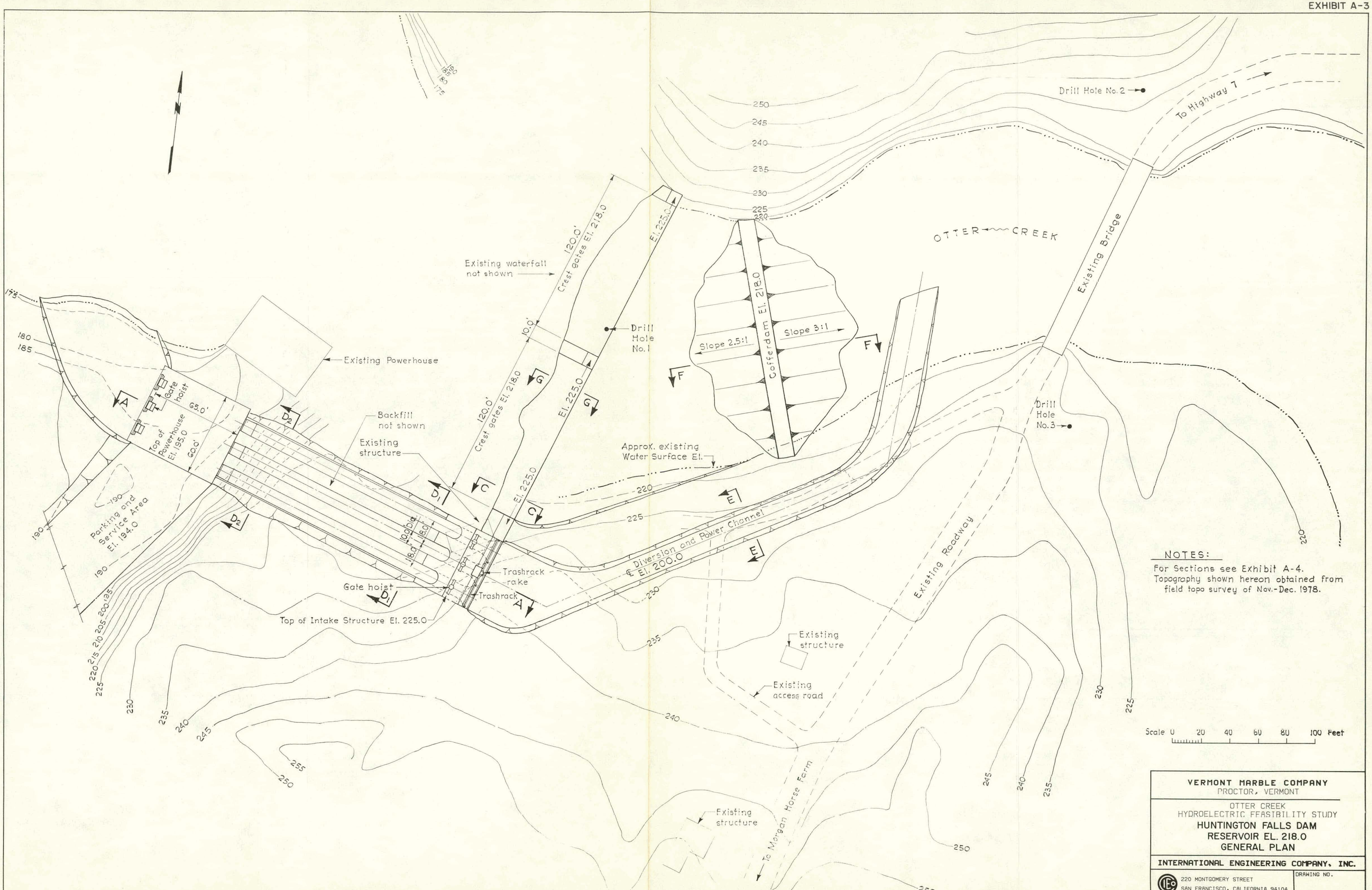
Scale 0 10 20 30 40 Ft.

VERMONT MARBLE COMPANY
PROCTOR, VERMONT

OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RESERVOIR EL. 241.0 & 230.0
SECTIONS

INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104

DRAWING NO.



NOTES:

For Sections see Exhibit A-4.
Topography shown hereon obtained from field topo survey of Nov.-Dec. 1978.

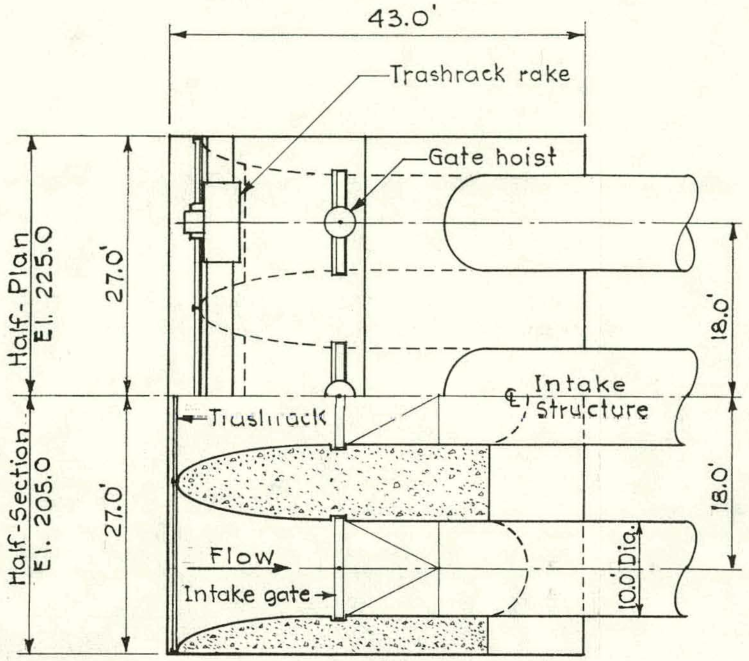
Scale 0 20 40 60 80 100 Feet

VERMONT MARBLE COMPANY
PROCTOR, VERMONT

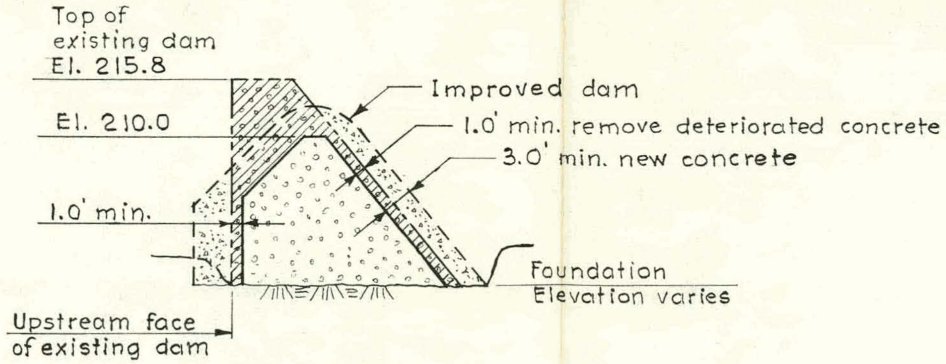
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RESERVOIR EL. 218.0
GENERAL PLAN

INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104

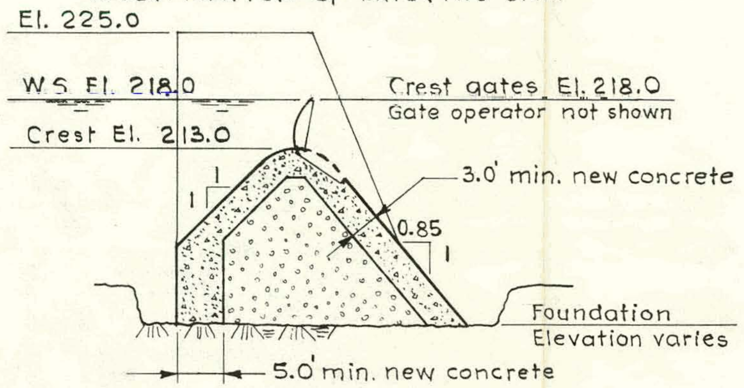
DRAWING NO.



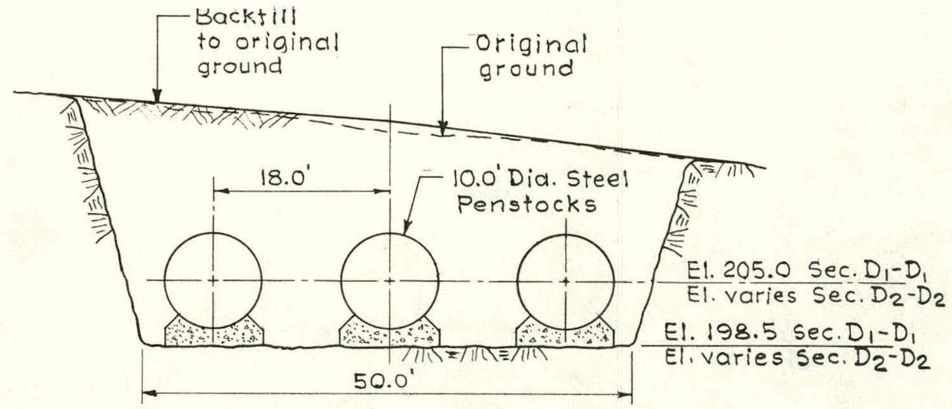
SECTIONAL PLAN B-B



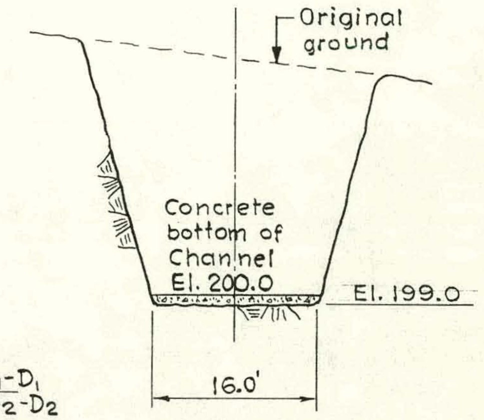
SECTION G-G
MODIFICATION OF EXISTING DAM



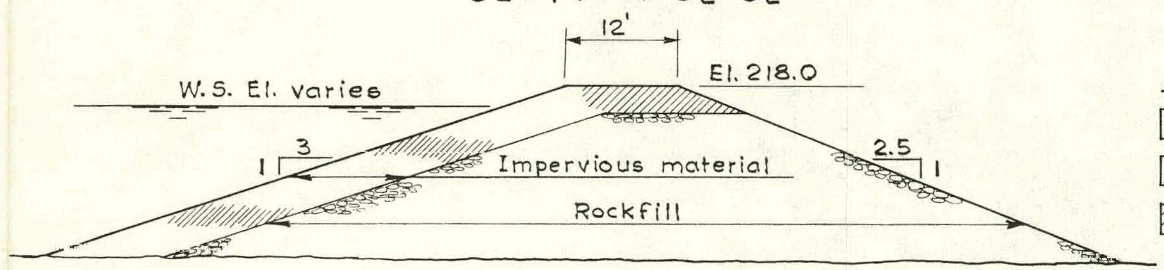
SECTION C-C
IMPROVED DAM



SECTION D_1-D_1
SECTION D_2-D_2



SECTION E-E



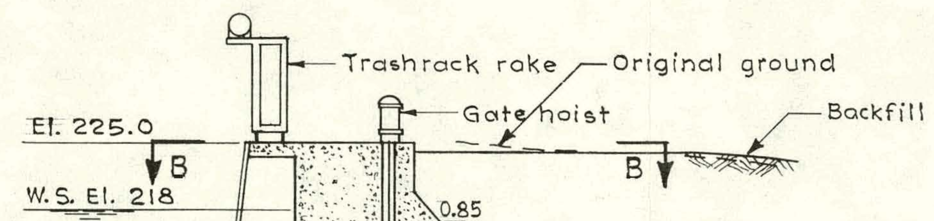
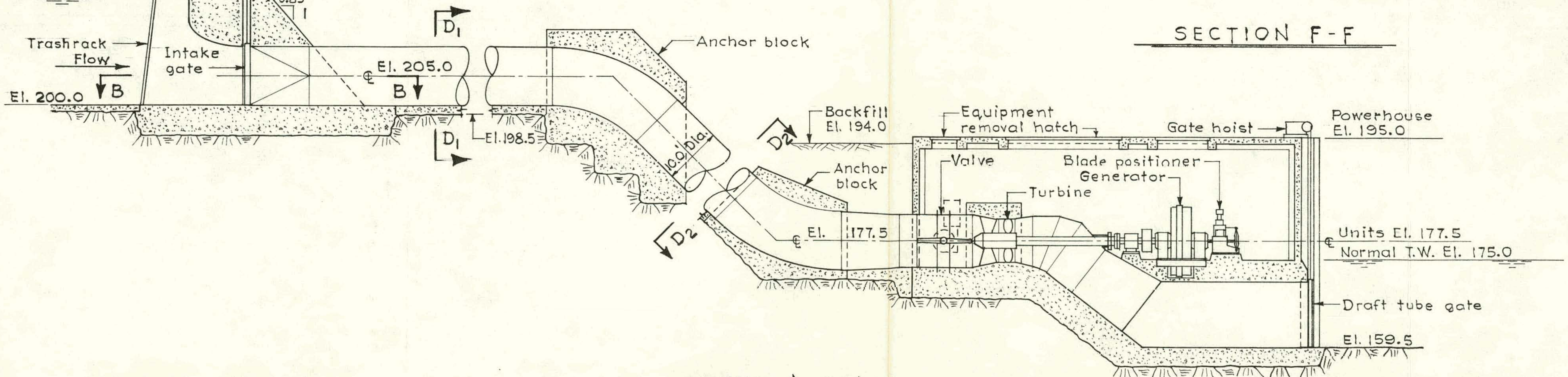
SECTION F-F

LEGEND

- Existing concrete
- New concrete capping
- Remove deteriorated concrete and cap with new concrete

NOTES:

For location of Sections see Exhibit A-3.

SECTION A-A

Scale 0 10 20 30 40 Ft.

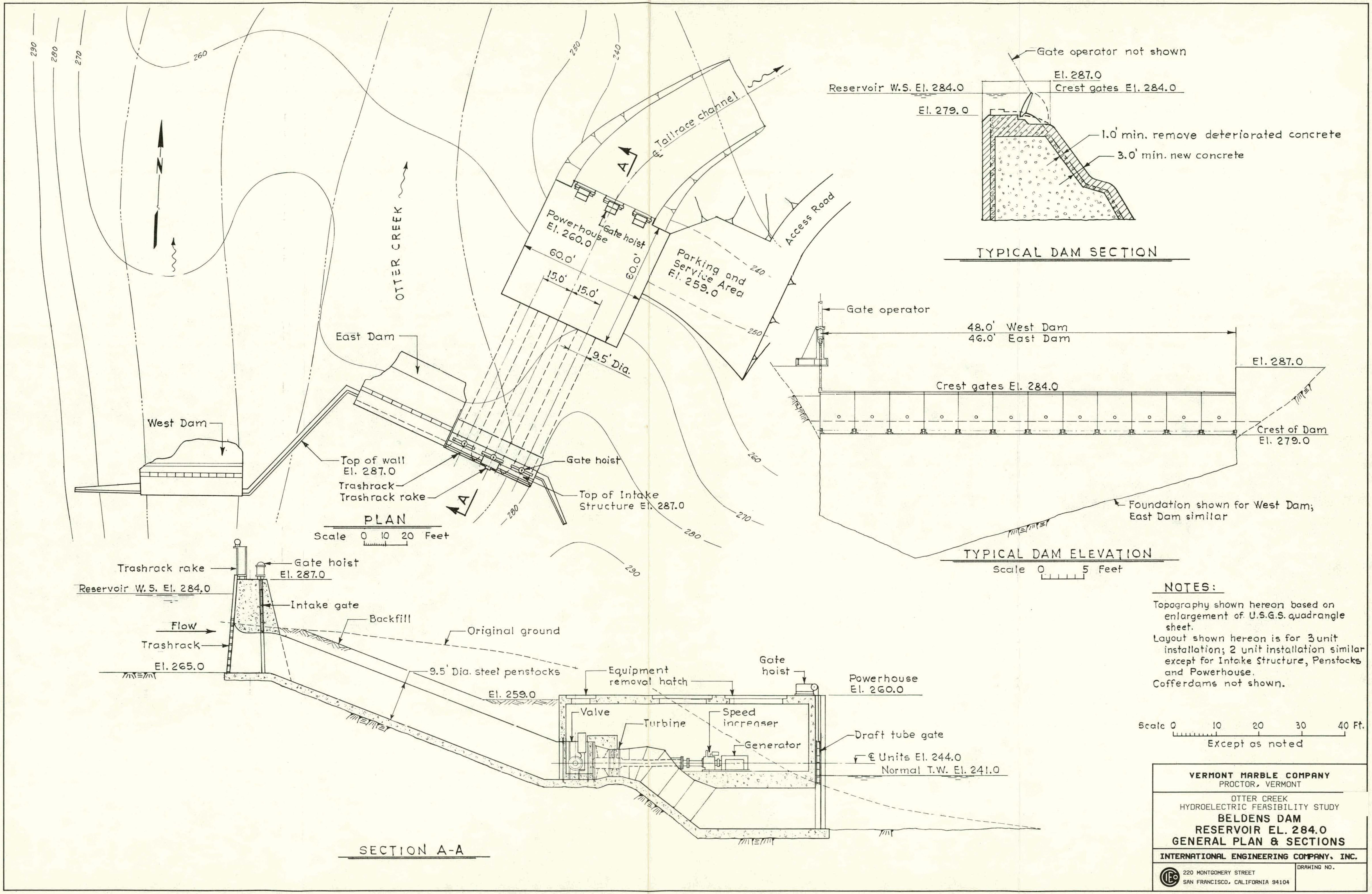
VERMONT MARBLE COMPANY
PROCTOR, VERMONT

OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RESERVOIR EL. 218.0
SECTIONS

INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104

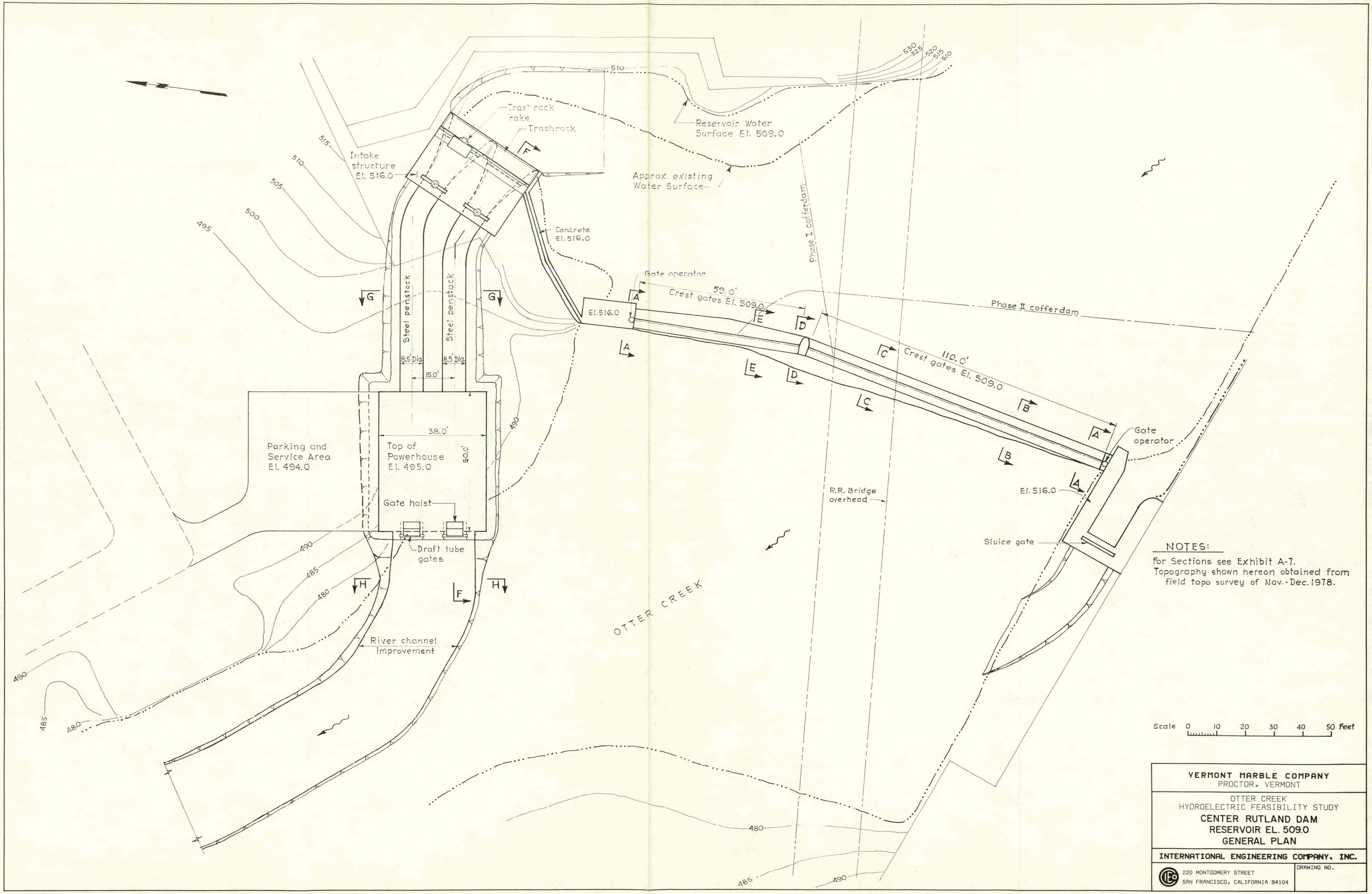
DRAWING NO.

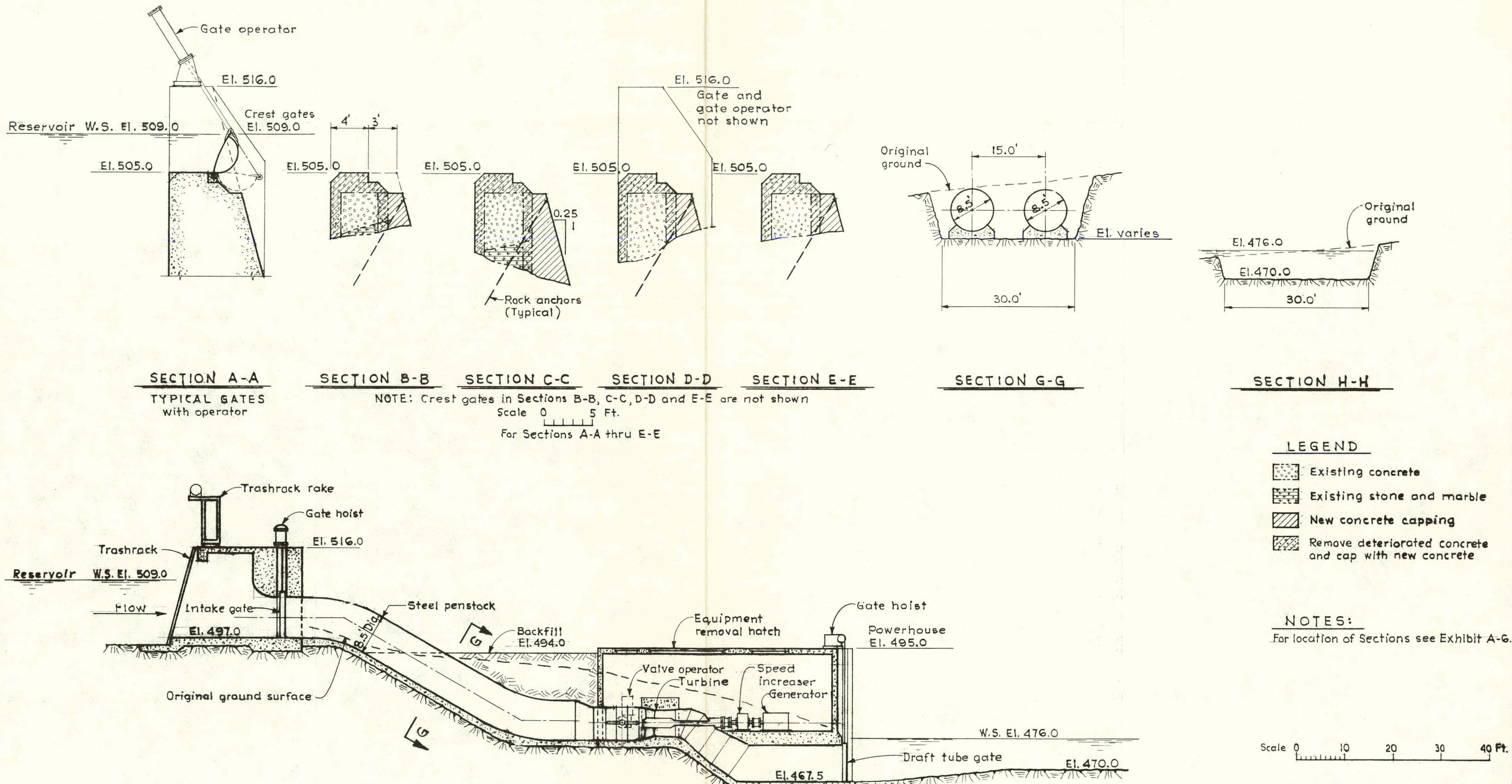
EXHIBIT A-5



OTTER CREEK
Powerhouse El. 260.0
Gate hoist
60.0'
15.0'
15.0'
Tailrace channel
Access Road
Parking and Service Area El. 259.0
East Dam
West Dam
9.5' Dia.
Top of wall El. 287.0
Trashrack
Trashrack rake
Gate hoist
Top of Intake Structure El. 287.0
PLAN
Scale 0 10 20 Feet
Gate operator not shown
Reservoir W.S. El. 284.0
El. 287.0
Crest gates El. 284.0
El. 279.0
1.0' min. remove deteriorated concrete
3.0' min. new concrete
TYPICAL DAM SECTION
Gate operator
48.0' West Dam
46.0' East Dam
El. 287.0
Crest gates El. 284.0
Crest of Dam El. 279.0
Foundation shown for West Dam; East Dam similar
TYPICAL DAM ELEVATION
Scale 0 5 Feet
Trashrack rake
Gate hoist El. 287.0
Reservoir W.S. El. 284.0
Intake gate
Backfill
Flow
Original ground
Trashrack
El. 265.0
9.5' Dia. steel penstocks
Equipment removal hatch
Gate hoist
Powerhouse El. 260.0
El. 259.0
Valve
Turbine
Speed increaser
Generator
Draft tube gate
℄ Units El. 244.0
Normal T.W. El. 241.0
SECTION A-A
NOTES:
Topography shown hereon based on enlargement of U.S.G.S. quadrangle sheet.
Layout shown hereon is for 3 unit installation; 2 unit installation similar except for Intake Structure, Penstocks and Powerhouse.
Cofferdams not shown.
Scale 0 10 20 30 40 Ft.
Except as noted
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
BELDENS DAM
RESERVOIR EL. 284.0
GENERAL PLAN & SECTIONS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

EXHIBIT A-6


Trash rack rake
Trashrack
Intake structure El. 516.0
Reservoir Water Surface El. 509.0
Approx. existing Water Surface
Concrete El. 516.0
Phase I cofferdam
Gate operator
59.0'
Crest gates El. 509.0
El. 516.0
Phase II cofferdam
110.0'
Crest gates El. 509.0
Gate operator
El. 516.0
Sluice gate
Steel penstock
Steel penstock
8.5 Dia.
8.5 Dia.
15.0'
38.0'
50.0'
Parking and Service Area El. 494.0
Top of Powerhouse El. 495.0
Gate hoist
Draft tube gates
River channel improvement
OTTER CREEK
R.R. Bridge overhead
NOTES:
For Sections see Exhibit A-7.
Topography shown hereon obtained from field topo survey of Nov.-Dec. 1978.
Scale 0 10 20 30 40 50 Feet
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
CENTER RUTLAND DAM
RESERVOIR EL. 509.0
GENERAL PLAN
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.



SECTION F-F

VERMONT MARBLE COMPANY
PROCTOR, VERMONT

OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY

CENTER RUTLAND DAM
RESERVOIR EL. 509.0
SECTIONS

INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

EXHIBIT A-8

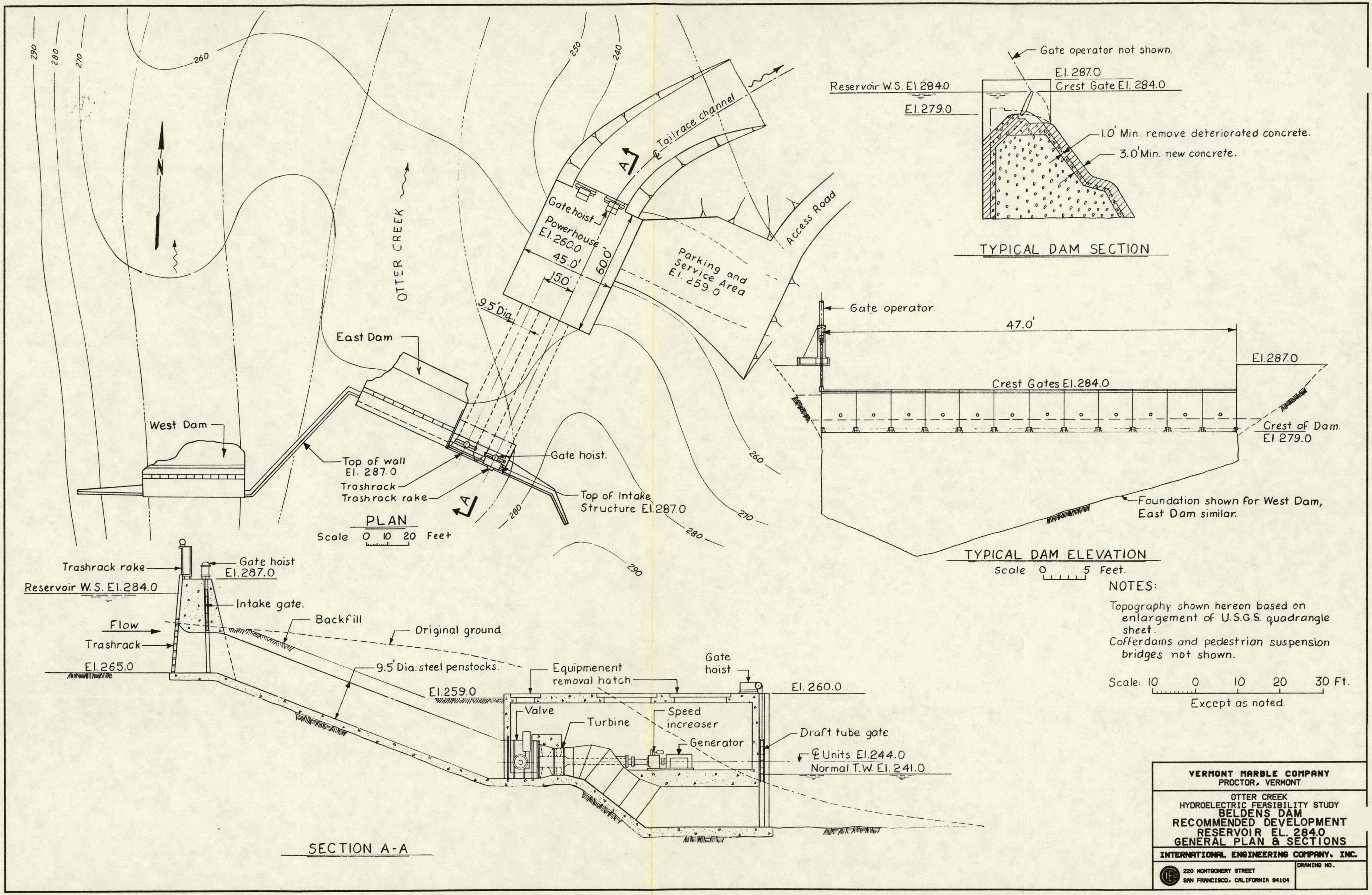
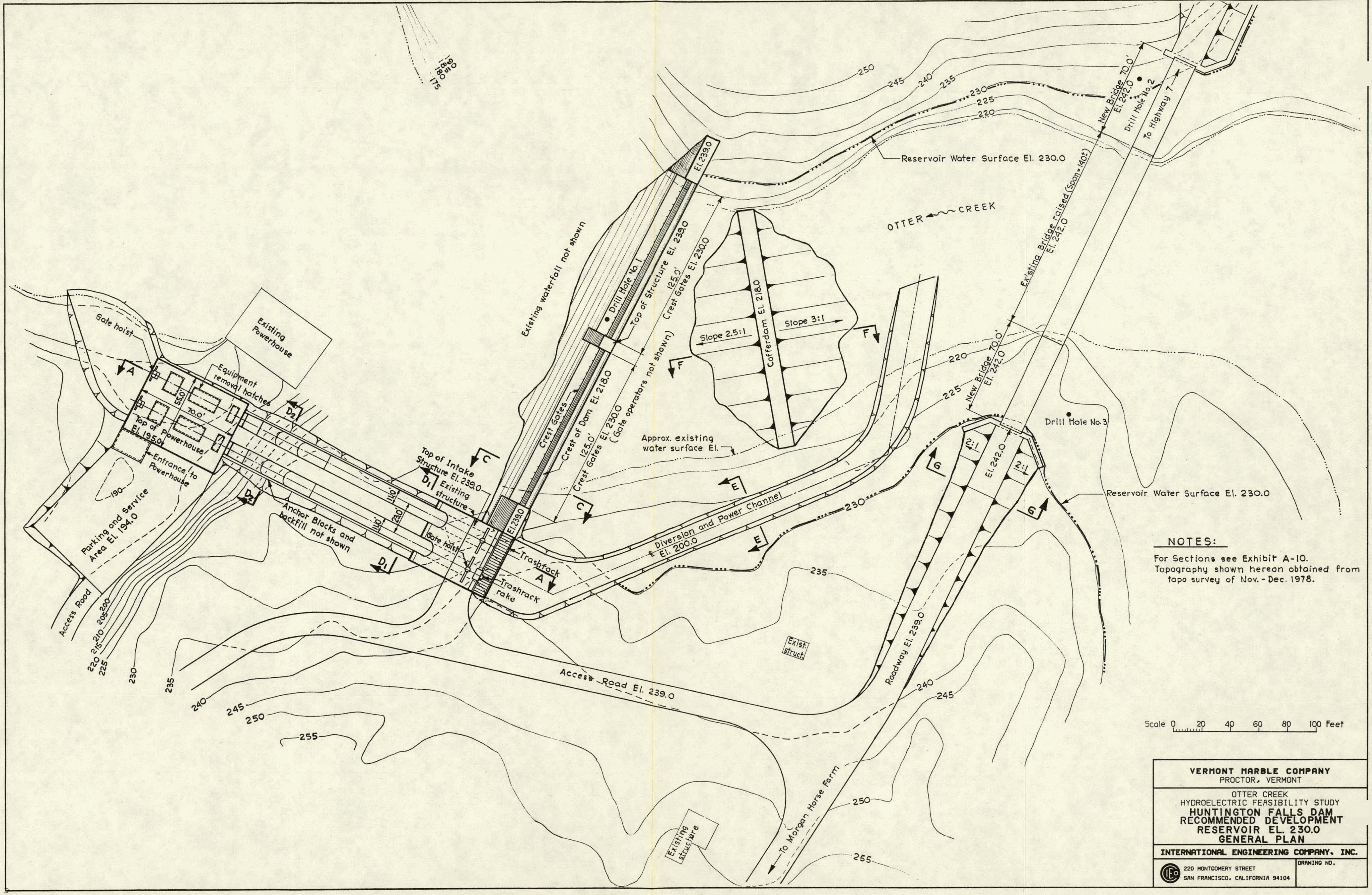
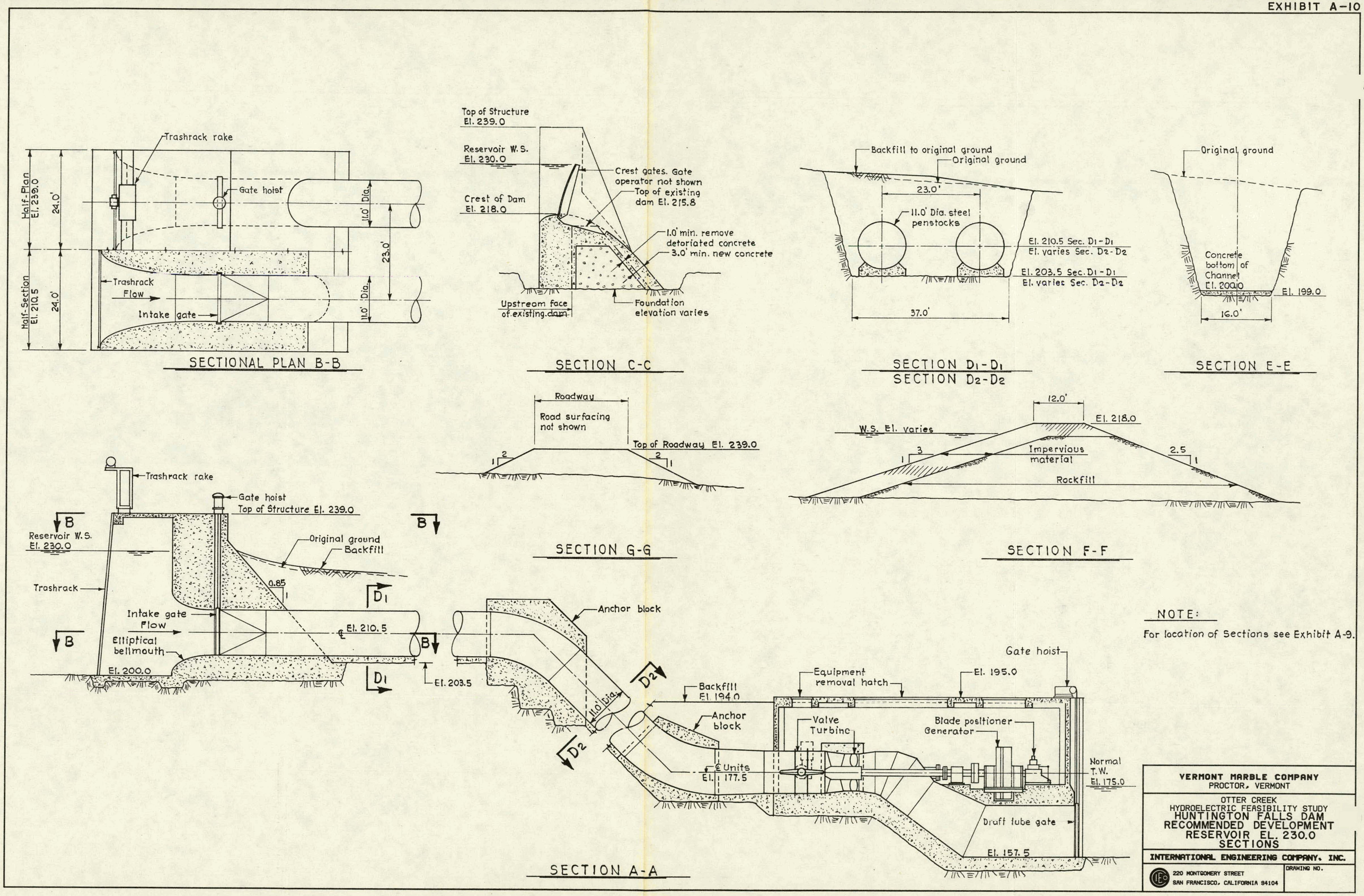

Gate operator not shown.
El. 287.0
Crest Gate El. 284.0
Reservoir W.S. El. 284.0
El. 279.0
1.0' Min. remove deteriorated concrete.
3.0' Min. new concrete.
TYPICAL DAM SECTION
Tailrace channel
Access Road
Gate hoist
Powerhouse El. 260.0
45.0'
60.0'
15.0'
Parking and Service Area El. 259.0
OTTER CREEK
9.5' Dia.
East Dam
West Dam
Top of wall El. 287.0
Gate hoist.
Trashrack
Trashrack rake
Top of Intake Structure El. 287.0
PLAN
Scale 0 10 20 Feet
Gate operator.
47.0'
El. 287.0
Crest Gates El. 284.0
Crest of Dam. El. 279.0
Foundation shown for West Dam, East Dam similar.
TYPICAL DAM ELEVATION
Scale 0 5 Feet.
Trashrack rake
Gate hoist El. 287.0
Reservoir W.S. El. 284.0
Intake gate.
Flow
Trashrack
Backfill
Original ground
El. 265.0
9.5' Dia. steel penstocks.
Equipmenent removal hatch
Gate hoist
El. 260.0
El. 259.0
Valve
Turbine
Speed increaser
Generator
Draft tube gate
℄ Units El. 244.0
Normal T.W. El. 241.0
SECTION A-A
NOTES:
Topography shown hereon based on enlargement of U.S.G.S. quadrangle sheet.
Cofferdams and pedestrian suspension bridges not shown.
Scale: 10 0 10 20 30 Ft.
Except as noted.
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
BELDENS DAM
RECOMMENDED DEVELOPMENT
RESERVOIR EL. 284.0
GENERAL PLAN & SECTIONS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

EXHIBIT A-9



OTTER CREEK
Reservoir Water Surface El. 230.0
New Bridge 70.0'
El. 242.0
Drill Hole No. 2
To Highway 7
Existing Bridge raised (Span=140'±)
El. 242.0
Drill Hole No. 3
El. 239.0
Drill Hole No. 1
Top of Structure El. 239.0
125.0'
Crest Gates El. 230.0
Existing waterfall not shown
Cofferdam El. 218.0
Slope 2.5:1
Slope 3:1
Crest Gates
Crest of Dam El. 218.0
Crest Gates El. 230.0
(Gate operators not shown)
Approx. existing water surface El.
Existing Powerhouse
Gate hoist
Equipment removal hatches
55.0'
70.0'
Top of Powerhouse El. 195.0
Entrance to Powerhouse
Parking and Service Area El. 194.0
Access Road
Anchor Blocks and backfill not shown
Top of Intake Structure El. 239.0
Existing structure
Gate hoist
Trashrack
Trashrack rake
El. 239.0
℄ Diversion and Power Channel El. 200.0
2:1
El. 242.0
Roadway El. 239.0
Access Road El. 239.0
Exist. struct.
To Morgan Horse Farm
Existing structure
NOTES:
For Sections see Exhibit A-10.
Topography shown hereon obtained from topo survey of Nov.-Dec. 1978.
Scale 0 20 40 60 80 100 Feet
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RECOMMENDED DEVELOPMENT
RESERVOIR EL. 230.0
GENERAL PLAN
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

EXHIBIT A-10



SECTIONAL PLAN B-B
Trashrack rake
Gate hoist
Half-Plan El. 239.0
Half-Section El. 210.5
24.0'
11.0' Dia.
23.0'
Trashrack
Flow
Intake gate
SECTION C-C
Top of Structure El. 239.0
Reservoir W.S. El. 230.0
Crest gates. Gate operator not shown
Top of existing dam El. 215.8
Crest of Dam El. 218.0
1.0' min. remove detoriated concrete
3.0' min. new concrete
Upstream face of existing dam
Foundation elevation varies
SECTION D1-D1
SECTION D2-D2
Backfill to original ground
Original ground
23.0'
11.0' Dia. steel penstocks
El. 210.5 Sec. D1-D1
El. varies Sec. D2-D2
El. 203.5 Sec. D1-D1
El. varies Sec. D2-D2
37.0'
SECTION E-E
Original ground
Concrete bottom of Channel El. 200.0
El. 199.0
16.0'
SECTION G-G
Roadway
Road surfacing not shown
Top of Roadway El. 239.0
SECTION F-F
12.0'
El. 218.0
W.S. El. varies
Impervious material
Rockfill
SECTION A-A
Trashrack rake
Gate hoist
Top of Structure El. 239.0
Reservoir W.S. El. 230.0
Original ground
Backfill
Trashrack
0.85
Intake gate
Flow
Elliptical bellmouth
El. 200.0
El. 210.5
El. 203.5
Anchor block
11.0' Dia.
Backfill El. 194.0
Anchor block
Equipment removal hatch
El. 195.0
Gate hoist
Valve
Turbine
Blade positioner
Generator
℄ Units El. 177.5
Normal T.W. El. 175.0
Draft tube gate
El. 157.5
NOTE:
For location of Sections see Exhibit A-9.
VERMONT MARBLE COMPANY
PROCTOR, VERMONT
OTTER CREEK
HYDROELECTRIC FEASIBILITY STUDY
HUNTINGTON FALLS DAM
RECOMMENDED DEVELOPMENT
RESERVOIR EL. 230.0
SECTIONS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104
DRAWING NO.

APPENDIX B

QUANTITY AND COST ESTIMATES

APPENDIX B

QUANTITY AND COST ESTIMATES

TABLES

TABLE B-1
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
3-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND AND LAND RIGHTS				
Rural	ac	160	500.00	80,000
Developed	L.S.			200,000
Reservoir Clearing	ac	160	100.00	16,000
Total				296,000
DIVERSION AND CARE OF THE RIVER	L.S.			250,000
Total				250,000
DAM				
Rock Excavation	cu yds	2,500	10.00	25,000
Unclassified Excavation	cu yds	1,500	5.00	7,500
Foundation Preparation	sq yds	1,100	10.00	11,000
Removal of Deteriorated Dam Concrete	cu yds	350	100.00	35,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	10,000	110.00	1,100,000
Reinforcement	tons	200	1,000.00	200,000
Foundation Anchors	ft	6,400	25.00	160,000
Crest Gates and Operators	each	2	460,000.00	920,000
Total				2,508,500

TABLE B-1
Sheet 2 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
3-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	5,400	10.00	54,000
Unclassified Excavation	cu yds	600	5.00	3,000
Concrete	cu yds	3,400	200.00	680,000
Reinforcement	tons	85	1,000.00	85,000
Gates and Hoists	each	3	45,000.00	135,000
Trashracks	tons	18	3,000.00	54,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			8,000
Embedded Metal and Miscellaneous Metalwork	tons	10	3,000.00	30,000
Total				1,199,000
PENSTOCKS				
Rock Excavation	cu yds	8,000	10.00	80,000
Unclassified Excavation	cu yds	1,000	5.00	5,000
Concrete	cu yds	1,500	150.00	225,000
Reinforcement	tons	44	1,000.00	44,000
Backfill	cu yds	4,400	5.00	22,000
Penstock Steel	tons	190	2,300.00	437,000
Total				813,000

TABLE B-1
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
3-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	8,600	10.00	86,000
Unclassified Excavation	cu yds	900	5.00	4,500
Substructure Concrete	cu yds	2,300	150.00	345,000
Superstructure Concrete	cu yds	400	200.00	80,000
Reinforcement	tons	100	1,000.00	100,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	25	3,000.00	75,000
Draft Tube Bulkhead Gate and Hoist	each	3	30,000.00	90,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	3	1,160,000.00	3,480,000
Auxiliary Electrical and Mechanical Equipment	L.S.			60,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	190,000.00	190,000
Circuit Breakers	each	3	10,000.00	30,000
Circuit Breakers	each	1	30,000.00	30,000
Total				4,630,500

TABLE B-1
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
3-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT				
Roadway Embankment and Gravel Surfacing	mi	0.35	130,000.00	45,500
Raise Existing Bridge	L.S.			50,000
New Bridge Spans	sq ft	3,000	70.00	210,000
Total				305,500
TRANSMISSION LINE				
Conductor	mi	26	7,000.00	182,000
Transformer	each	1	91,000.00	91,000
Total				273,000
SUBTOTAL				10,275,500
Contingency				1,541,300
TOTAL				11,816,800
Engineering and Administration				1,181,700
TOTAL				12,998,500
Interest During Construction				1,299,900
GRAND TOTAL				14,298,400

TABLE B-2
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
3-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND AND LAND RIGHTS				
Rural	ac	100	500.00	50,000
Developed	L.S.			100,000
Reservoir Clearing	ac	100	100.00	10,000
Total				160,000
DIVERSION AND CARE OF THE RIVER	L.S.			250,000
Total				250,000
DAM				
Rock Excavation	cu yds	1,700	10.00	17,000
Unclassified Excavation	cu yds	600	5.00	3,000
Foundation Preparation	sq yds	600	10.00	6,000
Removal of Deteriorated Dam Concrete	cu yds	350	100.00	35,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	4,000	110.00	440,000
Reinforcement	tons	80	1,000.00	80,000
Foundation Anchors	ft	3,400	25.00	85,000
Crest Gates and Operators	each	2	460,000.00	920,000
Total				1,636,000

TABLE B-2
Sheet 2 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
3-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	5,400	10.00	54,000
Unclassified Excavation	cu yds	600	5.00	3,000
Concrete	cu yds	2,900	200.00	580,000
Reinforcement	tons	73	1,000.00	73,000
Gates and Hoists	each	3	45,000.00	135,000
Trashracks	tons	15	3,000.00	45,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			7,000
Embedded Metal and Miscellaneous Metalwork	tons	8	3,000.00	24,000
Total				1,071,000
PENSTOCKS				
Rock Excavation	cu yds	8,000	10.00	80,000
Unclassified Excavation	cu yds	1,000	5.00	5,000
Concrete	cu yds	1,500	150.00	225,000
Reinforcement	tons	44	1,000.00	44,000
Backfill	cu yds	4,400	5.00	22,000
Penstock Steel	tons	190	2,300.00	437,000
Total				813,000

TABLE B-2
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
3-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	8,000	10.00	80,000
Unclassified Excavation	cu yds	800	5.00	4,000
Substructure Concrete	cu yds	2,100	150.00	315,000
Superstructure Concrete	cu yds	400	200.00	80,000
Reinforcement	tons	95	1,000.00	95,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	22	3,000.00	66,000
Draft Tube Bulkhead Gate and Hoist	each	3	30,000.00	90,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	3	1,000,000.00	3,000,000
Auxiliary Electrical and Mechanical Equipment				50,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	156,000.00	156,000
Circuit Breakers	each	3	10,000.00	30,000
Circuit Breakers	each	1	30,000.00	30,000
Total				4,056,000

TABLE B-2
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
3-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT				
Roadway Embankment and Gravel Surfacing	mi	0.06	130,000.00	7,800
Raise Existing Bridge	L.S.			30,000
New Bridge Spans	sq ft	1,000	70.00	70,000
Total				107,800
TRANSMISSION LINE				
Conductor	mi	26	7,000.00	182,000
Transformer	each	1	74,000.00	74,000
Total				256,000
SUBTOTAL				8,349,800
Contingency				1,252,500
TOTAL				9,602,300
Engineering and Administration				960,200
TOTAL				10,562,500
Interest During Construction				834,400
GRAND TOTAL				11,396,900

TABLE B-3
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
3-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND ACQUISITION	L.S.			50,000
Total				50,000
DIVERSION AND CARE OF THE RIVER	L.S.			250,000
Total				250,000
DAM				
Rock Excavation	cu yds	700	10.00	7,000
Unclassified Excavation	cu yds	300	5.00	1,500
Foundation Preparation	sq yds	300	10.00	3,000
Removal of Deteriorated Dam Concrete	cu yds	700	100.00	70,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	2,000	110.00	220,000
Reinforcement	tons	60	1,000.00	60,000
Foundation Anchors	ft	3,000	25.00	75,000
Crest Gates and Operators	each	2	320,000.00	640,000
Total				1,126,500

TABLE B-3
Sheet 2 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
3-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	3,100	10.00	31,000
Unclassified Excavation	cu yds	500	5.00	2,500
Concrete	cu yds	1,500	200.00	300,000
Reinforcement	tons	50	1,000.00	50,000
Gates and Hoists	each	3	32,000.00	96,000
Trashracks	tons	8	3,000.00	24,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			6,000
Embedded Metal and Miscellaneous Metalwork	tons	7	3,000.00	21,000
Total				680,500
PENSTOCKS				
Rock Excavation	cu yds	7,700	10.00	77,000
Unclassified Excavation	cu yds	900	5.00	4,500
Concrete	cu yds	1,400	150.00	210,000
Reinforcement	tons	40	1,000.00	40,000
Backfill	cu yds	4,000	5.00	20,000
Penstock Steel	tons	160	2,300.00	368,000
Total				719,500

TABLE B-3
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
3-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	6,200	10.00	62,000
Unclassified Excavation	cu yds	800	5.00	4,000
Substructure Concrete	cu yds	1,800	150.00	270,000
Superstructure Concrete	cu yds	350	200.00	70,000
Reinforcement	tons	82	1,000.00	82,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	20	3,000.00	60,000
Draft Tube Bulkhead Gate and Hoist	each	3	26,000.00	78,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	3	900,000.00	2,700,000
Auxiliary Electrical and Mechanical Equipment	L.S.			40,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	118,000.00	118,000
Circuit Breakers	each	3	10,000.00	30,000
Circuit Breakers	each	1	30,000.00	30,000
Total				3,604,000

TABLE B-3
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
3-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT AND MAINTENANCE	L.S.			30,000
Strengthen Existing Bridge	L.S.			30,000
Total				60,000
TRANSMISSION LINE				
Conductor	mi	26	4,100.00	106,600
Transformer	each	1	55,000.00	55,000
Total				161,600
SUBTOTAL				6,652,100
Contingency				997,800
TOTAL				7,649,900
Engineering and Administration				765,000
TOTAL				8,414,900
Interest During Construction				664,800
GRAND TOTAL				9,079,700

TABLE B-4
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
2-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND AND LAND RIGHTS				
Rural	ac	160	500.00	80,000
Developed	L.S.			200,000
Reservoir Clearing	ac	160	100.00	16,000
Total				296,000
DIVERSION AND CARE OF THE RIVER	L.S.			245,000
Total				245,000
DAM				
Rock Excavation	cu yds	2,500	10.00	25,000
Unclassified Excavation	cu yds	1,500	5.00	7,500
Foundation Preparation	sq yds	1,100	10.00	11,000
Removal of Deteriorated Dam Concrete	cu yds	350	100.00	35,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	10,000	110.00	1,100,000
Reinforcement	tons	200	1,000.00	200,000
Foundation Anchors	ft	6,400	25.00	160,000
Crest Gates and Operators	each	2	460,000.00	920,000
Total				2,508,500

TABLE B-4
Sheet 2 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
2-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	3,500	10.00	35,000
Unclassified Excavation	cu yds	600	5.00	3,000
Concrete	cu yds	2,400	200.00	480,000
Reinforcement	tons	58	1,000.00	58,000
Gates and Hoists	each	2	45,000.00	90,000
Trashracks	tons	12	3,000.00	36,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			8,000
Embedded Metal and Miscellaneous Metalwork	tons	7	3,000.00	21,000
Total				881,000
PENSTOCKS				
Rock Excavation	cu yds	5,000	10.00	50,000
Unclassified Excavation	cu yds	500	5.00	2,500
Concrete	cu yds	1,100	150.00	165,000
Reinforcement	tons	30	1,000.00	30,000
Backfill	cu yds	3,000	5.00	15,000
Penstock Steel	tons	128	2,300.00	294,400
Total				556,900

TABLE B-4
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
2 - 3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	5,000	10.00	50,000
Unclassified Excavation	cu yds	700	5.00	3,500
Substructure Concrete	cu yds	1,600	150.00	240,000
Superstructure Concrete	cu yds	300	200.00	60,000
Reinforcement	tons	670	1,000.00	67,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	17	3,000.00	51,000
Draft Tube Bulkhead Gate and Hoist	each	2	30,000.00	60,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	2	1,163,000.00	2,326,000
Auxiliary Electrical and Mechanical Equipment	L.S.			50,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	130,000.00	130,000
Circuit Breakers	each	2	10,000.00	20,000
Circuit Breakers	each	1	30,000.00	30,000
Total				3,147,500

TABLE B-4
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 241.0
2-3,700 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT				
Roadway Embankment and Gravel Surfacing	mi	0.35	130,000.00	45,500
Raise Existing Bridge	L.S.			50,000
New Bridge Spans	sq ft	3,000	70.00	210,000
Total				305,500
TRANSMISSION LINE				
Conductor	mi	26	5,700.00	148,200
Transformer	each	1	61,200.00	61,200
Total				209,400
SUBTOTAL				8,149,800
Contingency				1,222,500
TOTAL				9,372,300
Engineering and Administration				937,200
TOTAL				10,309,500
Interest During Construction				1,031,000
GRAND TOTAL				11,340,500

TABLE B-5
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
2-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND AND LAND RIGHTS				
Rural	ac	100	500.00	50,000
Developed	L.S.			100,000
Reservoir Clearing	ac	100	100.00	10,000
Total				160,000
DIVERSION AND CARE OF THE RIVER	L.S.			245,000
Total				245,000
DAM				
Rock Excavation	cu yds	1,700	10.00	17,000
Unclassified Excavation	cu yds	600	5.00	3,000
Foundation Preparation	sq yds	600	10.00	6,000
Removal of Deteriorated Dam Concrete	cu yds	350	100.00	35,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	4,000	110.00	440,000
Reinforcement	tons	80	1,000.00	80,000
Foundation Anchors	ft	3,400	25.00	85,000
Crest Gates and Operators	each	2	460,000.00	920,000
Total				1,636,000

TABLE B-5
Sheet 2 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
2-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	3,000	10.00	30,000
Unclassified Excavation	cu yds	400	5.00	2,000
Concrete	cu yds	2,000	200.00	400,000
Reinforcement	tons	50	1,000.00	50,000
Gates and Hoists	each	2	45,000.00	90,000
Trashracks	tons	10	3,000.00	30,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			7,000
Embedded Metal and Miscellaneous Metalwork	tons	6	3,000.00	18,000
Total				777,000
PENSTOCKS				
Rock Excavation	cu yds	5,000	10.00	50,000
Unclassified Excavation	cu yds	500	5.00	2,500
Concrete	cu yds	1,100	150.00	165,000
Reinforcement	tons	30	1,000.00	30,000
Backfill	cu yds	3,000	5.00	15,000
Penstock Steel	tons	128	2,300.00	294,400
Total				556,900

TABLE B-5
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
2 - 3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	5,000	10.00	50,000
Unclassified Excavation	cu yds	600	5.00	3,000
Substructure Concrete	cu yds	1,500	150.00	225,000
Superstructure Concrete	cu yds	300	200.00	60,000
Reinforcement	tons	62	1,000.00	62,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	15	3,000.00	45,000
Draft Tube Bulkhead Gate and Hoist	each	2	30,000.00	60,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	2	1,003,000.00	2,006,000
Auxiliary Electrical and Mechanical Equipment	L.S.			40,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	106,000.00	106,000
Circuit Breakers	each	2	10,000.00	20,000
Circuit Breakers	each	1	27,000.00	27,000
Total				2,764,000

TABLE B-5
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 230.0
2-3,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT				
Roadway Embankment and Gravel Surfacing	mi	0.06	130,000.00	7,800
Raise Existing Bridge	L.S.			30,000
New Bridge Spans	sq ft	1,000	70.00	70,000
Total				107,800
TRANSMISSION LINE				
Conductor	mi	26	4,600.00	119,600
Transformer	each	1	52,200.00	52,200
Total				171,800
SUBTOTAL				6,418,500
Contingency				962,800
TOTAL				7,381,300
Engineering and Administration				738,100
TOTAL				8,119,400
Interest During Construction				641,400
GRAND TOTAL				8,760,800

TABLE B-6
Sheet 1 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
2-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND ACQUISITION	L.S.			50,000
Total				50,000
DIVERSION AND CARE OF THE RIVER	L.S.			245,000
Total				245,000
DAM				
Rock Excavation	cu yds	700	10.00	7,000
Unclassified Excavation	cu yds	300	5.00	1,500
Foundation Preparation	sq yds	300	10.00	3,000
Removal of Deteriorated Dam Concrete	cu yds	700	100.00	70,000
Demolition and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	2,000	110.00	220,000
Reinforcement	tons	60	1,000.00	60,000
Foundation Anchors	ft	3,000	25.00	75,000
Crest Gates and Operators	each	2	320,000.00	640,000
Total				1,126,500

HUNTINGTON FALLS - W.S. EL. 218.0
2-2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	2,100	10.00	21,000
Unclassified Excavation	cu yds	360	5.00	1,800
Concrete	cu yds	1,100	200.00	220,000
Reinforcement	tons	35	1,000.00	35,000
Gates and Hoists	each	2	32,000.00	64,000
Trashracks	tons	6	3,000.00	18,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			6,000
Embedded Metal and Miscellaneous Metalwork	tons	5	3,000.00	15,000
Total				530,800
PENSTOCKS				
Rock Excavation	cu yds	5,000	10.00	50,000
Unclassified Excavation	cu yds	500	5.00	2,500
Concrete	cu yds	1,000	150.00	150,000
Reinforcement	tons	28	1,000.00	28,000
Backfill	cu yds	2,800	5.00	14,000
Penstock Steel	tons	100	2,300.00	230,000
Total				474,500

TABLE B-6
Sheet 3 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
2 - 2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	4,200	10.00	42,000
Unclassified Excavation	cu yds	600	5.00	3,000
Substructure Concrete	cu yds	1,200	150.00	180,000
Superstructure Concrete	cu yds	240	200.00	48,000
Reinforcement	tons	55	1,000.00	55,000
Backfill	cu yds	2,000	5.00	10,000
Embedded Metal and Miscellaneous Metalwork	tons	13	3,000.00	39,000
Draft Tube Bulkhead Gate and Hoist	each	2	26,000.00	52,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	2	900,000.00	1,800,000
Auxiliary Electrical and Mechanical Equipment	L.S.			35,000
Service Road and Parking Area	L.S.			50,000
Transformer	each	1	74,000.00	74,000
Circuit Breakers	each	2	10,000.00	20,000
Circuit Breakers	each	1	27,000.00	27,000
Total				2,435,000

TABLE B-6
Sheet 4 of 4

HUNTINGTON FALLS - W.S. EL. 218.0
2 - 2,300 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
ROAD IMPROVEMENT AND MAINTENANCE	L.S.			30,000
Strengthen Existing Bridge	L.S.			30,000
Total				60,000
TRANSMISSION LINE				
Conductor	mi	26	4,600.00	119,600
Transformer	each	1	40,200.00	40,200
Total				159,800
SUBTOTAL				5,081,600
Contingency				762,200
TOTAL				5,843,800
Engineering and Administration				584,400
TOTAL				6,428,200
Interest During Construction				507,800
GRAND TOTAL				6,936,000

TABLE B-7
Sheet 1 of 4

BELDENS - W.S. EL. 284.0
3-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND ACQUISITION	L.S.			50,000
Total				50,000
DIVERSION AND CARE OF THE RIVER	L.S.			100,000
Total				100,000
DAM				
Rock Excavation	cu yds	100	10.00	1,000
Unclassified Excavation	cu yds	100	5.00	500
Foundation Preparation	sq yds	100	10.00	1,000
Removal of Deteriorated Dam Concrete	cu yds	250	100.00	25,000
Concrete	cu yds	400	125.00	50,000
Reinforcement	tons	10	1,000.00	10,000
Foundation Anchors	ft	1,500	25.00	37,500
Crest Gates and Operators	each	2	255,000.00	510,000
Total				635,000

TABLE B-7
Sheet 2 of 4

BELDENS - W.S. EL. 284.0
3-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	650	10.00	6,500
Unclassified Excavation	cu yds	200	5.00	1,000
Demolation and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	350	200.00	70,000
Reinforcement	tons	26	1,000.00	26,000
Gates and Hoists	each	3	33,000.00	99,000
Trashracks	tons	5	3,000.00	15,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			6,000
Embedded Metal and Miscellaneous Metalwork	tons	6	3,000.00	18,000
Total				441,500
PENSTOCKS				
Rock Excavation	cu yds	2,500	10.00	25,000
Unclassified Excavation	cu yds	200	5.00	1,000
Concrete	cu yds	350	150.00	52,500
Reinforcement	tons	10	1,000.00	10,000
Backfill	cu yds	1,600	5.00	8,000
Penstock Steel	tons	56	2,300.00	128,800
Total				225,300

TABLE B-7
Sheet 3 of 4

BELDENS - W.S. EL. 284.0
3-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	3,500	10.00	35,000
Unclassified Excavation	cu yds	500	5.00	2,500
Substructure Concrete	cu yds	1,200	150.00	180,000
Superstructure Concrete	cu yds	300	200.00	60,000
Reinforcement	tons	55	1,000.00	55,000
Backfill	cu yds	500	5.00	2,500
Embedded Metal and Miscellaneous Metalwork	tons	15	3,000.00	45,000
Draft Tube Bulkhead Gate and Hoist	each	3	20,000.00	60,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	3	760,000.00	2,280,000
Auxiliary Electrical and Mechanical Equipment	L.S.			30,000
Access Road Improvement and Parking Area	L.S.			40,000
Transformer	each	1	106,000.00	106,000
Circuit Breakers	each	3	10,000.00	30,000
Circuit Breakers	each	1	27,000.00	27,000
Total				2,953,000

TABLE B-7
Sheet 4 of 4

BELDENS - W.S. EL. 284.0
3-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
TRAINING WALLS				
Rock Excavation	Cu Yds	50	10.00	500
Concrete	Cu Yds	150	170.00	25,500
Reinforcement	Tons	8	1,000.00	8,000
Total				34,000
TRANSMISSION LINE				
Conductor	mi	24	4,000.00	96,000
Transformer	each	1	51,000.00	51,000
Total				147,000
SUBTOTAL				4,585,800
Contingency				687,900
TOTAL				5,273,700
Engineering and Administration				527,400
TOTAL				5,801,100
Interest During Construction				458,300
GRAND TOTAL				6,259,400

TABLE B-8
Sheet 1 of 4

BELDENS - W.S. EL. 284.0
2-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND ACQUISITION	L.S.			50,000
Total				50,000
DIVERSION AND CARE OF THE RIVER	L.S.			100,000
Total				100,000
DAM				
Rock Excavation	cu yds	100	10.00	1,000
Unclassified Excavation	cu yds	100	5.00	500
Foundation Preparation	sq yds	100	10.00	1,000
Removal of Deteriorated Dam Concrete	cu yds	250	100.00	25,000
Concrete	cu yds	400	125.00	50,000
Reinforcement	tons	10	1,000.00	10,000
Foundation Anchors	ft	1,500	25.00	37,500
Crest Gates and Operators	each	2	255,000.00	510,000
Total				635,000

TABLE B-8
Sheet 2 of 4

BELDENS - W.S. EL. 284.0
2-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	460	10.00	4,600
Unclassified Excavation	cu yds	140	5.00	700
Demolation and Removal of Concrete Structures	cu yds	1,000	50.00	50,000
Concrete	cu yds	245	200.00	49,000
Reinforcement	tons	18	1,000.00	18,000
Gates and Hoists	each	2	33,000.00	66,000
Trashracks	tons	4	3,000.00	12,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			6,000
Embedded Metal and Miscellaneous Metalwork	tons	4	3,000.00	12,000
Total				368,300
PENSTOCKS				
Rock Excavation	cu yds	1,750	10.00	17,500
Unclassified Excavation	cu yds	140	5.00	700
Concrete	cu yds	245	150.00	36,800
Reinforcement	tons	7	1,000.00	7,000
Backfill	cu yds	1,120	5.00	5,600
Penstock Steel	tons	37	2,300.00	85,100
Total				152,700

TABLE B-8
Sheet 3 of 4

BELDENS - W.S. EL. 284.0
2-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	2,450	10.00	24,500
Unclassified Excavation	cu yds	360	5.00	1,800
Substructure Concrete	cu yds	840	150.00	126,000
Superstructure Concrete	cu yds	210	200.00	42,000
Reinforcement	tons	39	1,000.00	39,000
Backfill	cu yds	500	5.00	2,500
Embedded Metal and Miscellaneous Metalwork	tons	11	3,000.00	33,000
Draft Tube Bulkhead Gate and Hoist	each	2	20,000.00	40,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	2	760,000.00	1,520,000
Auxiliary Electrical and Mechanical Equipment	L.S.			20,000
Access Road Improvement and Parking Area	L.S.			40,000
Transformer	each	1	75,000.00	75,000
Circuit Breakers	each	2	10,000.00	20,000
Circuit Breakers	each	1	27,000.00	27,000
Total				2,010,800

TABLE B-8
Sheet 4 of 4

BELDENS - W.S. EL. 284.0
2-2,100 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
TRAINING WALLS				
Rock Excavation	cu yds	100	10.00	1,000
Concrete	cu yds	250	170.00	42,500
Reinforcement	tons	12	1,000.00	12,000
Total				55,500
TRANSMISSION LINE				
Conductor	mi	24	4,000.00	96,000
Transformer	each	1	51,000.00	51,000
Total				147,000
SUBTOTAL				3,519,300
Contingency				527,900
TOTAL				4,047,200
Engineering and Administration				404,700
TOTAL				4,451,900
Interest During Construction				351,700
GRAND TOTAL				4,803,600

TABLE B-9
Sheet 1 of 4

CENTER RUTLAND - W.S. EL. 509.0
2-1,200 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
LAND ACQUISITION	L.S.			50,000
Total				50,000
DIVERSION AND CARE OF THE RIVER	L.S.			100,000
Total				100,000
DAM				
Rock Excavation	cu yds	200	20.00	4,000
Unclassified Excavation	cu yds	500	5.00	2,500
Foundation Preparation	sq yds	150	10.00	1,500
Removal of Deteriorated Dam Concrete	cu yds	150	150.00	22,500
Demolition and Removal of Concrete and Masonry Structures	cu yds	100	50.00	5,000
Concrete	cu yds	550	110.00	60,500
Reinforcement	tons	20	1,000.00	20,000
Foundation Anchors	ft	1,500	25.00	37,500
Crest Gates and Operators	L.S.			411,000
Total				564,500

TABLE B-9
Sheet 2 of 4

CENTER RUTLAND - W.S. EL. 509.0
2-1,200 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
INTAKE STRUCTURE				
Rock Excavation	cu yds	600	10.00	6,000
Unclassified Excavation	L.S.			5,000
Demolition and Removal of Concrete and Masonry Structures	cu yds	390	50.00	19,500
Concrete	cu yds	350	200.00	70,000
Reinforcement	tons	14	1,000.00	14,000
Gates and Hoists	each	2	25,000.00	50,000
Trashracks	tons	5	3,000.00	15,000
Trashrack Rake	each	1	150,000.00	150,000
Trash Boom	L.S.			6,000
Embedded Metal and Miscellaneous Metalwork	tons	5	3,000.00	15,000
Total				350,500
PENSTOCKS				
Rock Excavation	cu yds	800	10.00	8,000
Unclassified Excavation	cu yds	400	5.00	2,000
Demolition and Removal of Concrete and Masonry Structures	cu yds	50	50.00	2,500
Concrete	cu yds	150	200.00	30,000
Reinforcement	tons	4	1,000.00	4,000
Backfill	cu yds	500	5.00	2,500
Penstock Steel	tons	35	2,500.00	87,500
Total				136,500

TABLE B-9
Sheet 3 of 4

CENTER RUTLAND - W.S. EL. 509.0
2 - 1,200 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
POWERHOUSE AND TAILRACE				
Rock Excavation	cu yds	3,400	10.00	34,000
Unclassified Excavation	cu yds	2,000	5.00	10,000
Demolition and Removal of Concrete and Masonry Structures	cu yds	450	50.00	22,500
Substructure Concrete	cu yds	600	150.00	90,000
Superstructure Concrete	cu yds	200	200.00	40,000
Reinforcement	tons	40	1,000.00	40,000
Backfill	cu yds	700	5.00	3,500
Embedded Metal and Miscellaneous Metalwork	tons	14	3,000.00	42,000
Draft Tube Bulkhead Gate and Hoist	each	2	25,000.00	50,000
Generating Equipment including Turbine, Generator, Butterfly, Valve, Governor and Associated Switchgear	each	2	675,000.00	1,350,000
Auxiliary Electrical and Mechanical Equipment	L.S.			15,000
Service Road and Parking Area	L.S.			15,000
Transformer	each	1	36,000.00	36,000
Circuit Breakers	each	2	10,000.00	20,000
Circuit Breakers	each	1	27,000.00	27,000
Total				1,795,000

CENTER RUTLAND - W.S. EL. 509.0
2-1,200 KW UNITS

QUANTITY AND COST ESTIMATE

	Unit	Quantity	Unit Price ($)	Total Cost ($)
TRANSMISSION LINE				
Conductor and Accessories	L.S.			25,000
Total				25,000
SUBTOTAL				3,021,500
Contingency				453,200
TOTAL				3,474,700
Engineering and Administration				347,500
TOTAL				3,822,200
Interest During Construction				302,000
GRAND TOTAL				4,124,200

APPENDIX C

HYDROLOGY AND POWER STUDY

APPENDIX C

HYDROLOGY AND POWER STUDY

CONTENTS

TABLES

FIGURES

APPENDIX C

HYDROLOGY AND POWER STUDY

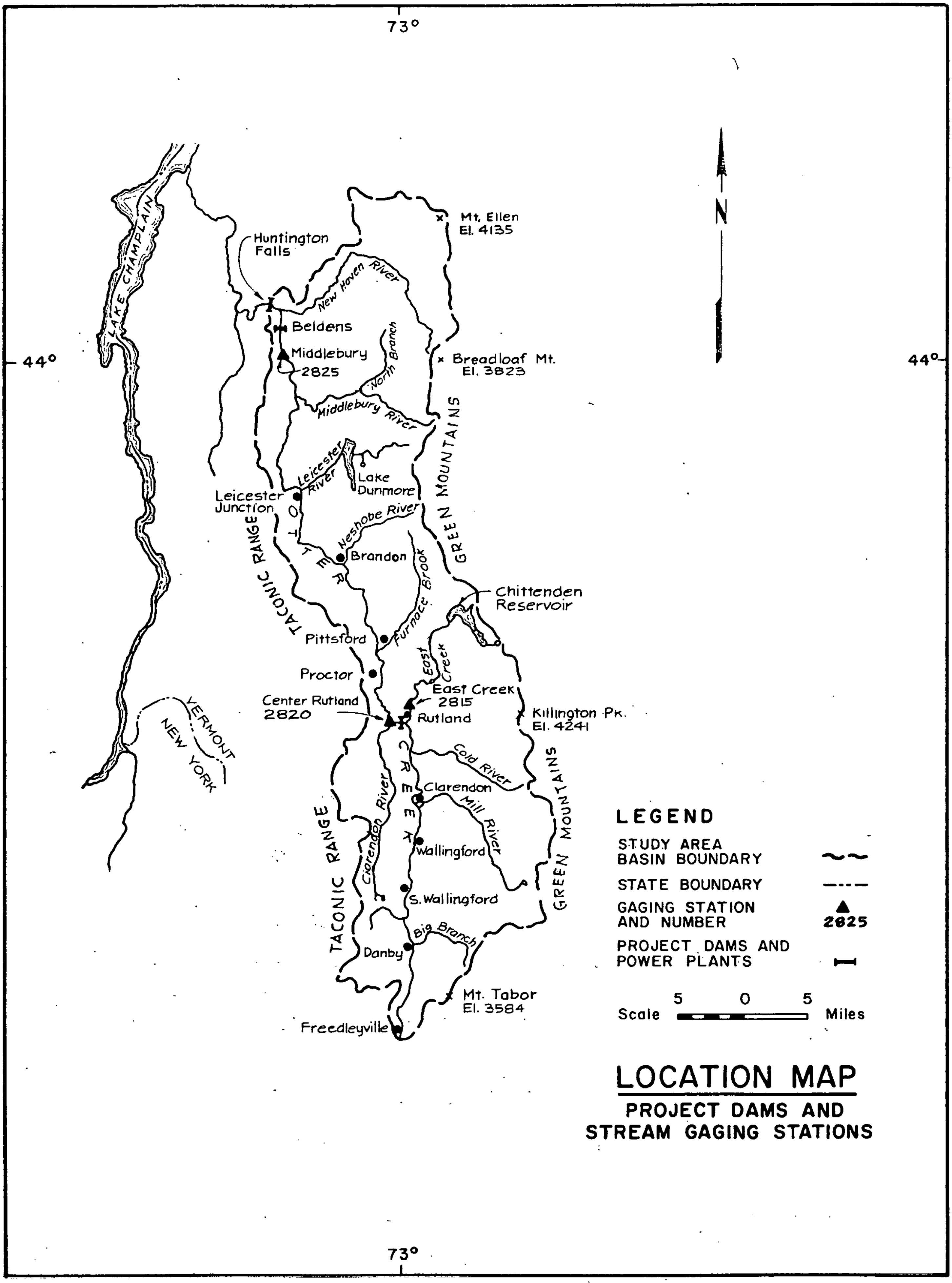
This appendix describes the hydrologic investigations and power studies made for three hydroelectric projects on Otter Creek and identified as Center Rutland, Beldens, and Huntington Falls. It briefly discusses the drainage basin, streamflow data and characteristics, flood flows and frequencies, and power studies performed to evaluate the improvements most applicable to the individual projects and the combined development.

C.1 STUDY AREA

A. Description of Drainage Basin

The Otter Creek basin is situated in west central Vermont and is shown on Figure C-1. Otter Creek is the longest waterway entirely contained within the state and originates near Freedleyville in the Green Mountains. It flows north to Rutland, continues slightly west of north to the New Haven River, and then flows northwest into Lake Champlain. The drainage area is 749 square miles at Huntington Falls — the downstream limit of the study area — about 5 miles downstream of Middlebury. Streams draining the heavily forested western slopes of the divide formed by the principal range of the Green Mountains are steep and flashy. Main tributaries are Mill River, Cold River, East Creek, Clarendon River, Furnace Brook, Neshobe River, Leicester River, Middlebury River, and New Haven River. The surface area of natural lakes and storage reservoirs in the basin is about 5 square miles, of which 1.6 square miles are in Lake Dunmore and 1.2 square miles are in Chittenden Reservoir.

The Otter Creek valley from the headwaters to Clarendon is confined by steep, forested mountains, limiting the valley floor to a width of about 1,500 feet. The average width of the valley bottom between Clarendon and



LOCATION MAP

PROJECT DAMS AND STREAM GAGING STATIONS

Brandon is about 1/2 mile, except for constrictions at Center Rutland and Proctor. The slope of Otter Creek from Brandon to Middlebury is very mild, and the valley width varies from 1 to 2 miles. The widening forms a flat plain of about 23 square miles area, which has a storage capacity of about 14,000 acre-feet for each foot of rise of water elevation. This area is inundated on the average of once every 2 years. Under extreme flood conditions, the valley bottom throughout the entire length of Otter Creek is inundated. The waterway below Middlebury is essentially restricted to the channel width as Otter Creek passes through rolling hills. The average elevation of the divide formed by the Green Mountains to the east is about 2,500 feet; the highest point, Killington Peak, reaches 4,241 feet above sea level. The divide on the west below Proctor is generally below elevation 1,000 feet.

The entire course of the Otter Creek valley is over calcareous rocks, except for a band of quartz in Rutland. The Green Mountains chain to the east is composed of quartz and granite and to the west, below Pittsford, of talcoid schist formations. Extensive beds of marble occur in the western part of the upper reaches of the Otter Creek valley. The principal outcrops occur near West Rutland and Proctor.

Table C-1 shows drainage areas above selected points on Otter Creek and the drainage areas of the principal tributaries. Table C-2 lists dam crest and tailrace elevations of existing dams on Otter Creek within the study area.

B. Climate

1. Precipitation - Mean annual precipitation, including water equivalent of snow, averages about 44 inches over the 749 square miles of drainage area at Huntington Falls. Annual precipitation is usually evenly distributed throughout the year. The most intense rainfall generally occurs during summer thunderstorms. Average seasonal snowfall is about 80 inches.

TABLE C-1

DRAINAGE AREAS OF OTTER CREEK AND PRINCIPAL TRIBUTARIES

Location	River Miles Above Mouth	Average Land Elevation (feet)	Total Drainage Area (sq mi)
Huntington Falls	21.2	280	749
Beldens	23.2	330	632
Middlebury	26.3	400	628
Leicester Junction	41.0	360	489
Proctor	63.5	500	363
Center Rutland	70.8	520	307
Rutland above East Creek	72.0	600	246
Wallingford	85.6	580	105
South Wallingford	91.5	640	82
Danby	97.2	680	20
Freedleyville (vicinity)	105.0	800	Negligible
TRIBUTARIES AT MOUTH			
New Haven River	22.4	240	113
Middlebury River	30.0	344	64
Leicester River	39.3	345	37
Neshobe River	49.3	360	21
Furnace Brook	61.1	400	46
Clarendon River	70.5	500	49
East Creek	72.0	530	58
Cold River	74.9	540	38
Mill River	83.1	570	67

Source of data: References 11, 12 and 13.

TABLE C-2

EXISTING DAMS ON OTTER CREEK

	Owner	River Miles Above Mouth	Existing Elevation (feet) Spillway Crest	Tailrace	Normal Water Surface
Vergennes*	3	7.5			
Weybridge*	2	19.8	168.3	143.3	174.3
Huntington Falls**	1	21.2	215.8	174.8	218.1
Beldens**	1	23.3	280.5	241.0	283.0
Middlebury Lower	2	25.2	312.4	285.4	
Middlebury Upper	2	26.2	336.2	313.2	
Proctor	1	63.7	466.9	351.5	
Center Rutland**	1	70.8	505.6	480.6	507.1
Ripley (Rutland)	4	71.7	520.8	509.4	

* Downstream of study area.

** Study Installation.

Owner Designation

1. Vermont Marble Company.
2. Central Vermont Public Service Corporation.
3. Green Mountain Power Corporation.
4. Owner uncertain.

Note: Elevations for study installations are based on USGS datum. Other elevations are not necessarily referred to that datum.

Source of Data: Reference 13, field survey of study installations and other published information.

2. Temperature - July is the warmest month of the year with temperatures usually between 57° and 81°F in the vicinity of Rutland. January is the coldest month with temperatures usually between 11° and 30°F.

C. Soils and Land Use

Soils in the area range from poorly drained silty soil in the lowlands to well drained loamy soil in the hills. Principal land use is devoted to cropland, pasture and woodland. Timber stands of pine, oak, cherry, maple, ash and cedar are abundant and cover about 75 percent of the area. The flood plain is sparsely covered and the hillsides are thickly wooded. About 50 percent of the region is farmed. The major crops are corn and hay which are grown for use in dairy farming.

C.2 HYDROLOGIC STUDIES

A. Streamflow Data

Long-term records of streamflow in Otter Creek basin have been obtained by the U.S. Geological Survey (USGS) at three sites in the study area:

USGS Station Number	Station Name	Drainage Area (sq mi)	Average Flow (cfs)	Period of Record Available From	To
2815	East Creek at Rutland	51	96.8	8/40	9/77
2820	Otter Creek at Center Rutland	307	551.0	5/28	9/77
2825	Otter Creek at Middlebury	628	982.0	4/03	4/07
				10/11	1/20
				10/29	9/77

The gage at Center Rutland is located just below the dam and powerhouse operated by Vermont Marble Company. The gage at Middlebury is about 2 miles upstream of the dam and powerhouse at Beldens, which is also operated by Vermont Marble Company. Two small dams and one powerhouse, operated as run-of-the-river installations by Central Vermont Public Service Corporation, are located between the Middlebury gage and Beldens. Accuracy of the daily discharge records is generally considered to be within 10 percent, except at times during the winter months when the effects of ice raise the limit to 15 percent.

B. Streamflow Analysis

The streamflow records at Center Rutland are directly applicable to the dam and power operation at that site. Flows at the Beldens site are essentially the same as those recorded at the Middlebury gage. A simple drainage area ratio adjustment of 749/628 was applied to the flow records of the Middlebury gage to estimate flows for the Huntington Falls site. An essentially similar ratio is obtained from estimating unit runoff of the New Haven River basin by means of a comparison with unit runoff for the areas above the gages at Center Rutland and East Creek. Streamflow at the study area sites is regulated to a small extent, principally by storage in Chittenden Reservoir, which was completed in 1902.

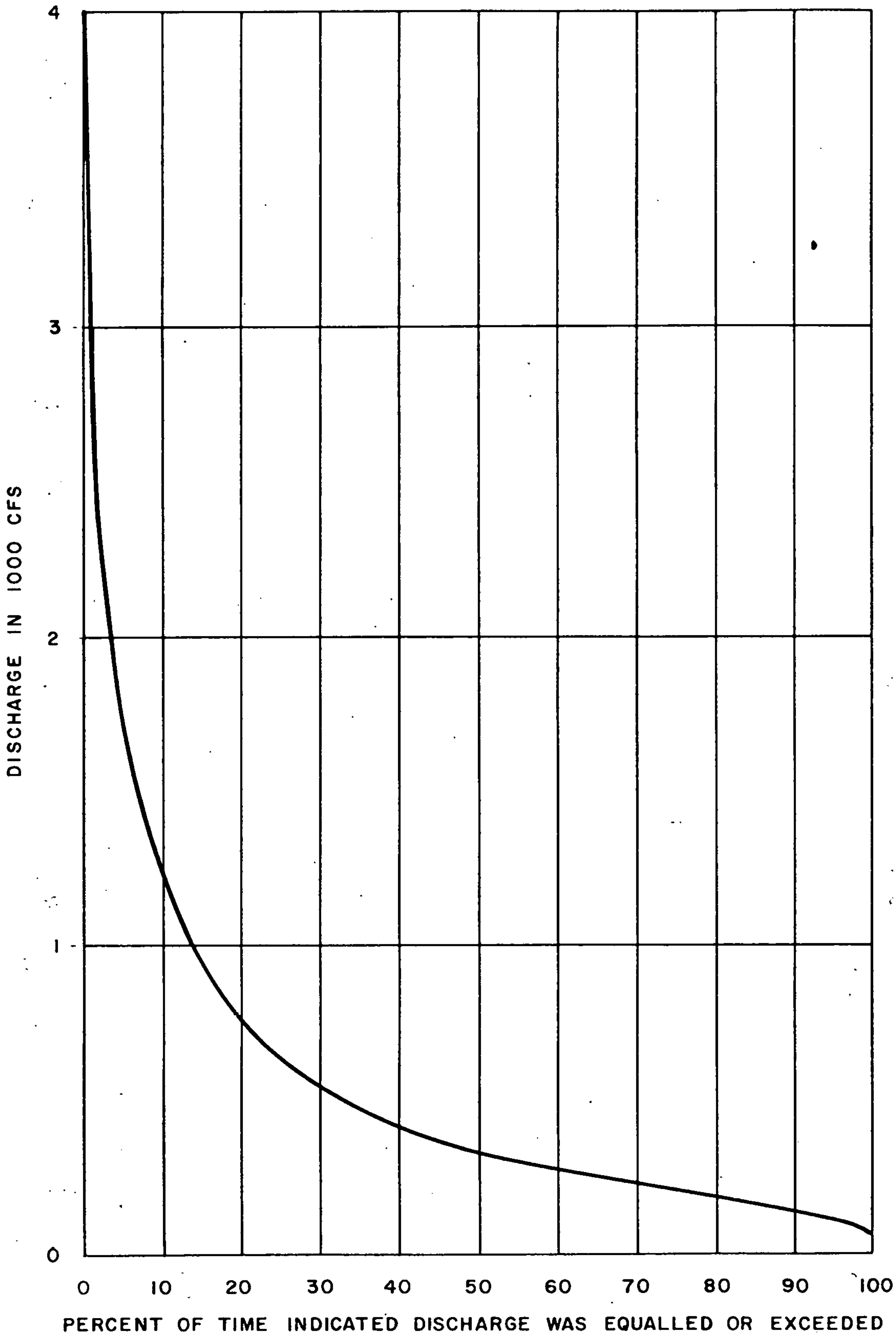
The residual-mass curve of annual flows at the Middlebury gage for the water years 1929 to 1977 is shown on Figure C-2. The minimum year was 1965 and occurred in the series of below-average years between 1961 and 1967. The maximum year was 1976 and occurred in the series of above-average years beginning in 1971. These extremes are for the entire period of recorded flow beginning in 1903.

Flow-duration curves based on mean daily discharges at Center Rutland, Beldens, and Huntington Falls sites are shown on Figures C-3, C-4, and C-5, respectively. Points for plotting the curves for Center Rutland and Beldens were obtained from the USGS. The frequency of discharge occurrences at Beldens was assumed to be identical with those at

RESIDUAL MASS CURVE OF ANNUAL DISCHARGE

MIDDLEBURY

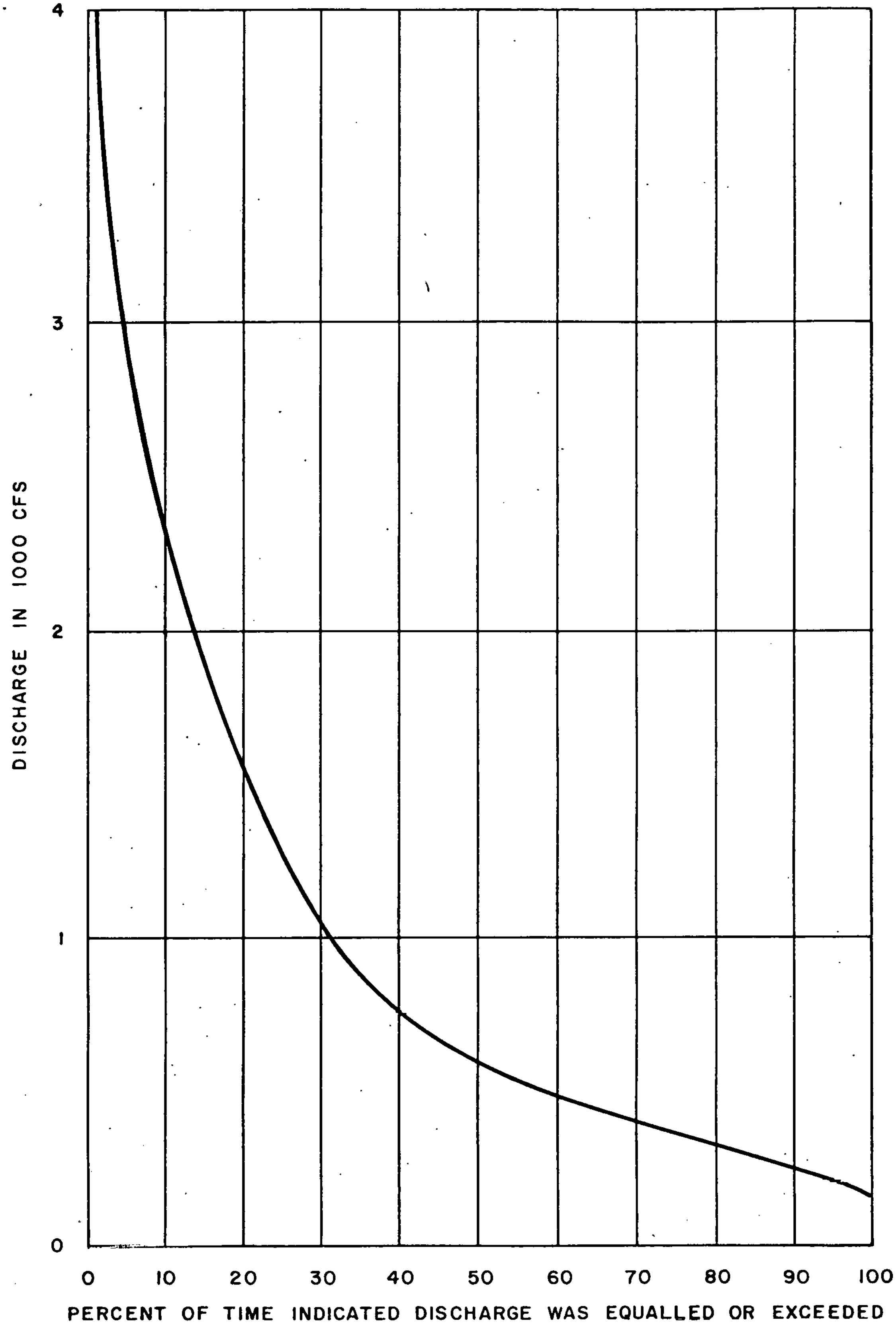
FIGURE C-2



FLOW- DURATION CURVE

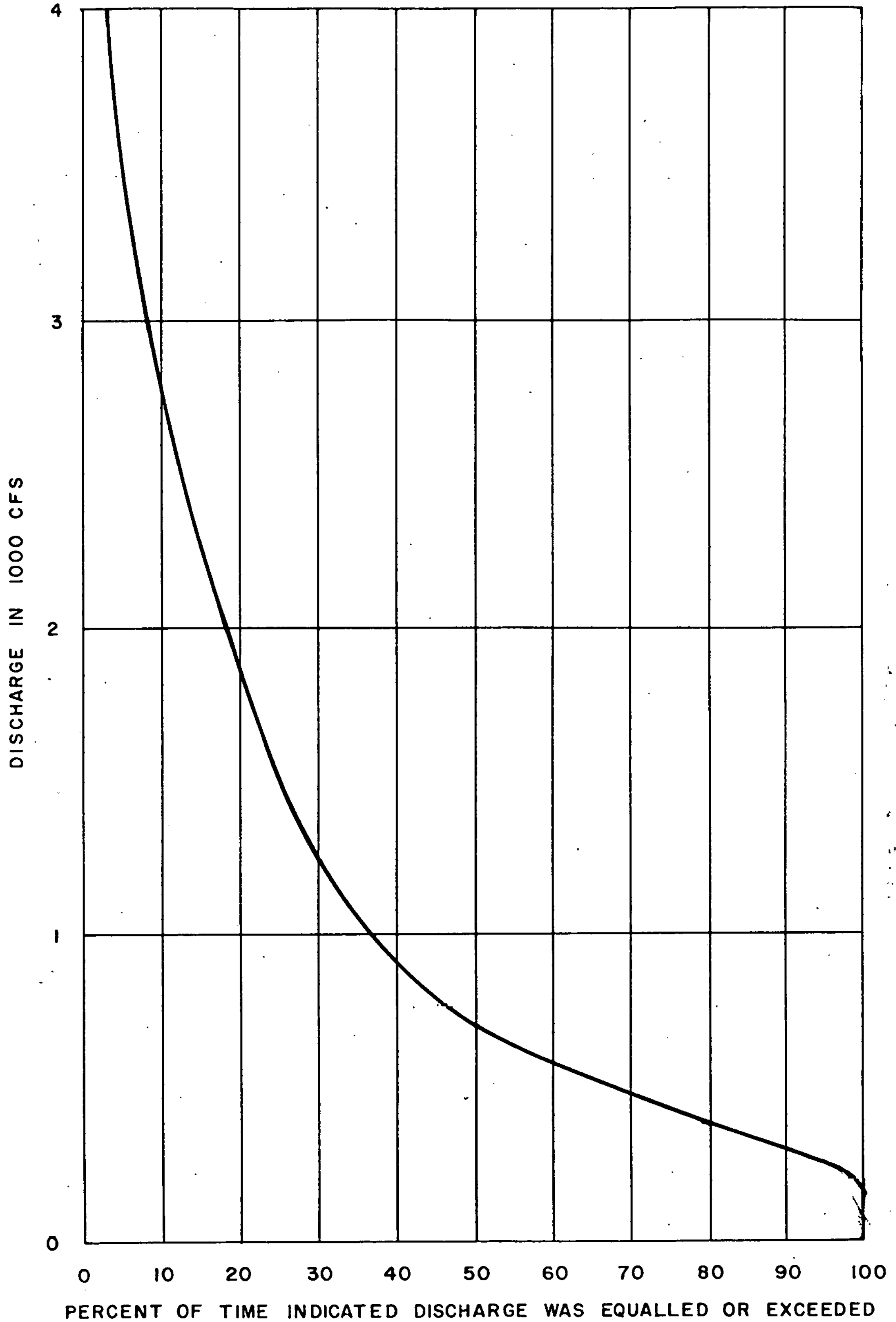
CENTER RUTLAND

FIGURE C-4



FLOW-DURATION CURVE

BELDENS



FLOW- DURATION CURVE

HUNTINGTON FALLS

Middlebury. The estimated curve for Huntington Falls is based on the drainage area ratio adjustment of flows at Middlebury. There is an insignificant difference between the Middlebury gage flow-duration curve for the total period of record and a shorter period from 1929 to 1976.

C. Flood Frequency

Flood-frequency analyses, based on log-Pearson Type III curve fitting for Center Rutland and Middlebury gaging stations, were obtained from the USGS and are shown as the at-station values in Table C-3. Regional equations developed by the USGS (Reference 1) were used to estimate the flood magnitude and frequency at Huntington Falls shown in Table C-3. The standard error of the regional formulae ranges from 38 percent for the 2-year to 59 percent for the 100-year frequency; therefore, close agreement is not to be expected between the at-station and regional values. A factor for channel storage effects is not included in the regional equations. Failure to include this factor may explain the variation in computed Middlebury values and increase the uncertainty of Huntington Falls flood frequency estimates.

Flood-frequency analysis for the Center Rutland gaging site, included in the Flood Insurance Study (Reference 2) of the U.S. Department of Housing and Urban Development (HUD) and shown in Table C-3, differs from the USGS at-station analysis. The deviation presumably results from the relative amounts of historic flood data incorporated and the choice of skew values used in the common analytic procedure recommended by the Water Resources Council (Reference 3) and followed by both agencies.

D. Inflow Design Floods

Reference 4 provides generally accepted criteria for selecting inflow design floods, subject to interpretation and engineering judgment. In accordance with these standards, the ranges for selection of inflow design floods at the study damsites are as follows:

TABLE C-3

FLOOD FREQUENCY AT DAMSITES

Recurrence Interval Years	At-Station Discharge (cfs) USGS Expected Probability	HUD	USGS Regional Equation (cfs)
	CENTER RUTLAND		
2	5,467		6,430
5	7,532		9,710
10	9,007	10,370	12,390
25	10,993		15,530
50	12,638	16,560	18,340
100	14,356	19,900	21,370
200	16,288		
500	18,782	29,180	
	MIDDLEBURY = BELDENS		
2	4,332		11,290
5	5,907		17,800
10	7,043	7,550*	21,320
25	8,585	9,440*	26,720
50	9,860		31,330
100	11,204	11,000*	36,680
200	12,711		
500	14,711	16,000*	
	HUNTINGTON FALLS (Ungaged)		
2			13,230
5			20,000
10			25,330
25			31,730
50			37,080
100			43,730

* Preliminary unpublished values.

Site	Inflow Design Flood
Center Rutland	100-year to 1/2 PMF
Beldens	100-year to 1/2 PMF
Huntington Falls	100-year to 1/2 PMF

The largest known flood at or near each site is as follows:

Site	Drainage Area (sq mi) Total	Drainage Area (sq mi) Effective	Peak Discharge (cfs)	Flood Date
Center Rutland	306	281	21,600*	Nov. 1927
Middlebury	682	582	13,600	Nov. 1927
Huntington Falls	749	703	18,800	Nov. 1927

* At Ripley Dam

The above data were extracted from Reference 5, which also provides peak discharge estimates for outstanding floods since 1811. Most of the larger storm events have occurred during the late summer and fall seasons. The flood of November 1927 resulted from a general New England storm of 3-day duration, which originated in the tropics. Total rainfall over the Otter Creek basin during that storm was about 7 inches.

Estimates of the probable maximum flood (PMF) were made only for the Huntington Falls site. The probable maximum precipitation (PMP) was assumed to occur in the fall of the year. Procedures for the flood estimate and the results are discussed in the following paragraphs.

1. Unit Hydrographs - The fall in Otter Creek, from its source near Freedleyville, is about 300 feet in the 35-mile distance to Rutland. The principal tributaries in this reach are Mill River and Cold River, which are steep and more indicative of the critical concentration characteristics of the Otter Creek basin above Rutland. The cascade formed by Ripley and

Center Rutland dams provides a relatively concentrated drop of about 40 feet at Rutland. Otter Creek then falls about 14 feet in the 7 miles to Proctor, where the creek drops about 115 feet at Sutherland Falls. Proctor marks the beginning of the principal storage basin in the course followed by Otter Creek to Middlebury. A drop in water level of about 15 feet occurs in the intervening 37 miles between the Proctor damsite and Middlebury. Recorded flood peaks of some large floods at Center Rutland and Middlebury indicate a flood-wave travel time of at least 3 days between these locations. Timing and amount of tributary inflow from the east is another factor in this relationship. The New Haven River enters Otter Creek just upstream of Huntington Falls. Its characteristics with respect to critical concentration closely resemble those of the area above Proctor. Therefore, the peak of large floods at Huntington Falls may result from New Haven River outflow followed by a later, but lesser, peak coming from Otter Creek. However, the peak of abnormally large floods at Huntington Falls will result from the discharge of Otter Creek at Beldens building on the recession discharge of the New Haven River.

To account for the response of the study area to storm input, the basin was divided into the following three sub-areas for flood studies and development of unit hydrographs:

Sub-area A:	above Proctor	363 sq mi
Sub-area B:	between Proctor and Beldens	273 sq mi
Sub-area C:	New Haven River basin	113 sq mi

The Taylor-Schwarz method (Reference 6) was used to develop the synthetic unit hydrographs for each sub-area, because — in addition to its convenience — the method is based on studies of basins with drainage areas ranging from 20 to 1,600 square miles located in the Middle Atlantic states. Some of the basins used in developing the Taylor-Schwarz method are located in New Hampshire, Vermont, Massachusetts, and New York.

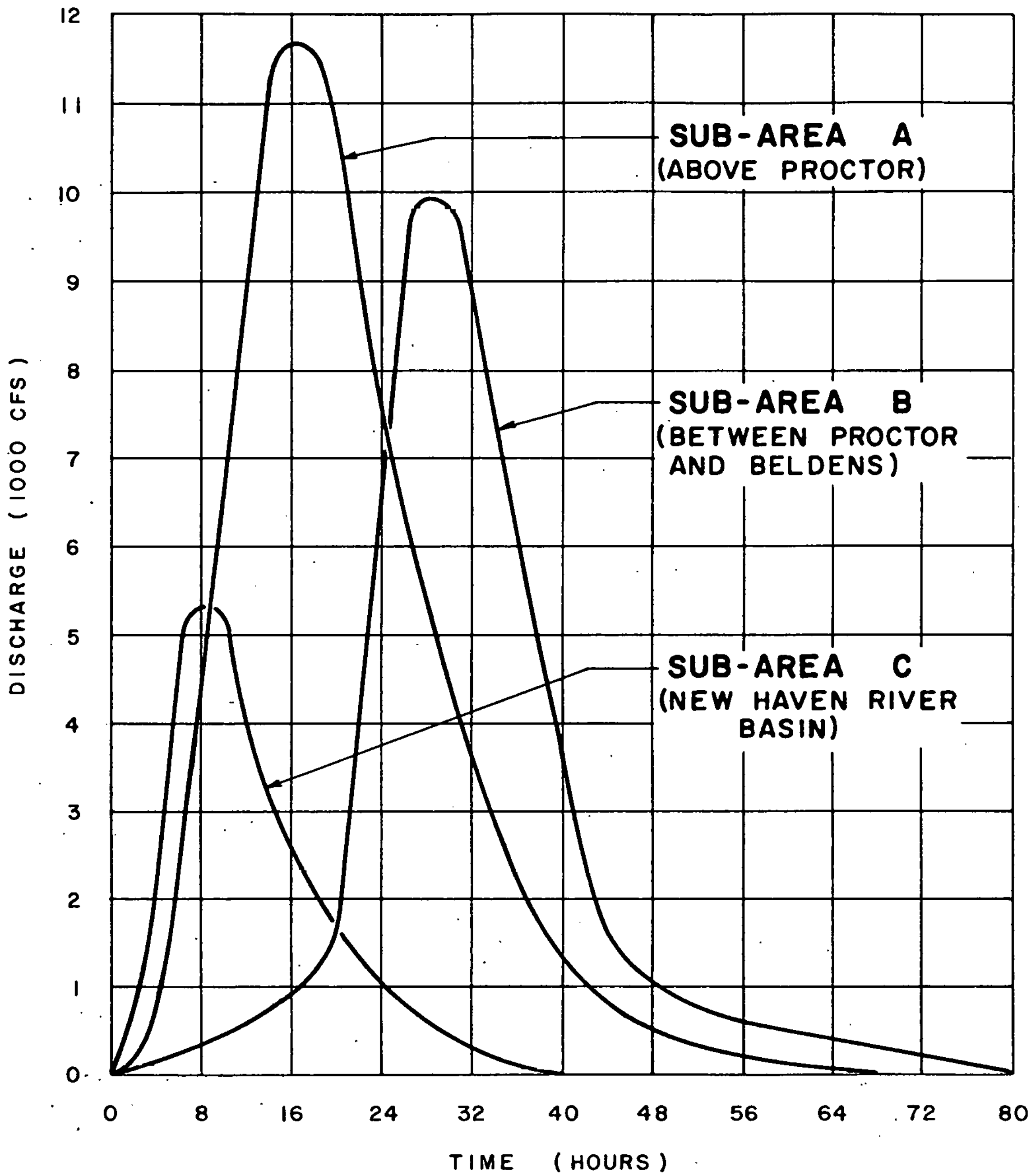
A period of two hours was selected as the unit duration for the hydrograph computations because of the 113-square mile size of the New Haven River basin. Derived values of lag, or the time from the centroid of rainfall excess to the time of unit-hydrograph peak, and unit hydrograph peak discharge are as follows:

Sub-area	Lag (hrs)	Peak Discharge (cfs)
A	16	11,700
B	27	9,960
C	7	5,370

The shapes of these unit-hydrographs are shown on Figure C-6.

2. Probable Maximum Precipitation - The probable maximum precipitation (PMP) over the study area of 749 square miles was determined from Hydrometeorological Report 51 (Reference 7) to be 20.9 inches gross in 72 hours. The PMP design arrangement of incremental time periods and incremental rainfall followed the sequence given in Reference 8 for computation of inflow design floods east of the 105° meridian.

Direct-runoff increments were computed using the rainfall-runoff relation developed by the U.S. Soil Conservation Service. The predominant hydrologic soil group for each sub-area was determined from general soil maps of the area (References 9 and 10). For antecedent moisture condition II (AMC-II), rainfall-runoff curve numbers were computed based on hydrologic soil-cover complexes estimated from topographic maps (References 11 and 12) and a minimum retention loss rate was selected. The results for each sub-area were the same: Hydrologic Soil Group C, AMC-II, Curve Number 73 and minimum retention rate of 0.12 inches per hour. The gross PMP, losses and direct runoff are shown in Table C-4.



TWO-HOUR UNIT HYDROGRAPHS

SUB-AREAS A, B, & C

TABLE C-4

GROSS PMP, LOSSES AND DIRECT RUNOFF
INCREMENTAL AND TOTAL

Time (ending hour)	Gross PMP (inches)	Losses (inches)	Direct Runoff (inches)
1	0.9	0.89	0.01
2	1.0	0.73	0.27
3	1.3	0.60	0.70
4	5.7	1.07	4.63
5	1.7	0.14	1.56
6	1.0	0.12	0.88
12	3.3	0.72	2.48
24	2.4	1.44	0.96
48	2.8	2.8	0
72	0.8	0.8	0
Total 72-hours	20.9	9.31	11.59

3. Probable Maximum Flood at Huntington Falls - The unit hydrographs developed for each sub-area were used to distribute the direct-runoff increments and form the respective net flood hydrographs. A constant baseflow was added to the net flood hydrographs: 2,000 cfs for Sub-area A, 1,500 cfs for Sub-area B, and 700 cfs for Sub-area C. The flood hydrograph for Sub-area A was routed to Huntington Falls, using Muskingum constants K = 24 hours, x = 0.15, and t = 2 hours, and added to the flood hydrographs of Sub-areas B and C. The resulting estimate of the probable maximum flood hydrograph at Huntington Falls, with a peak discharge of 174,000 cfs, is shown on Figure C-7.

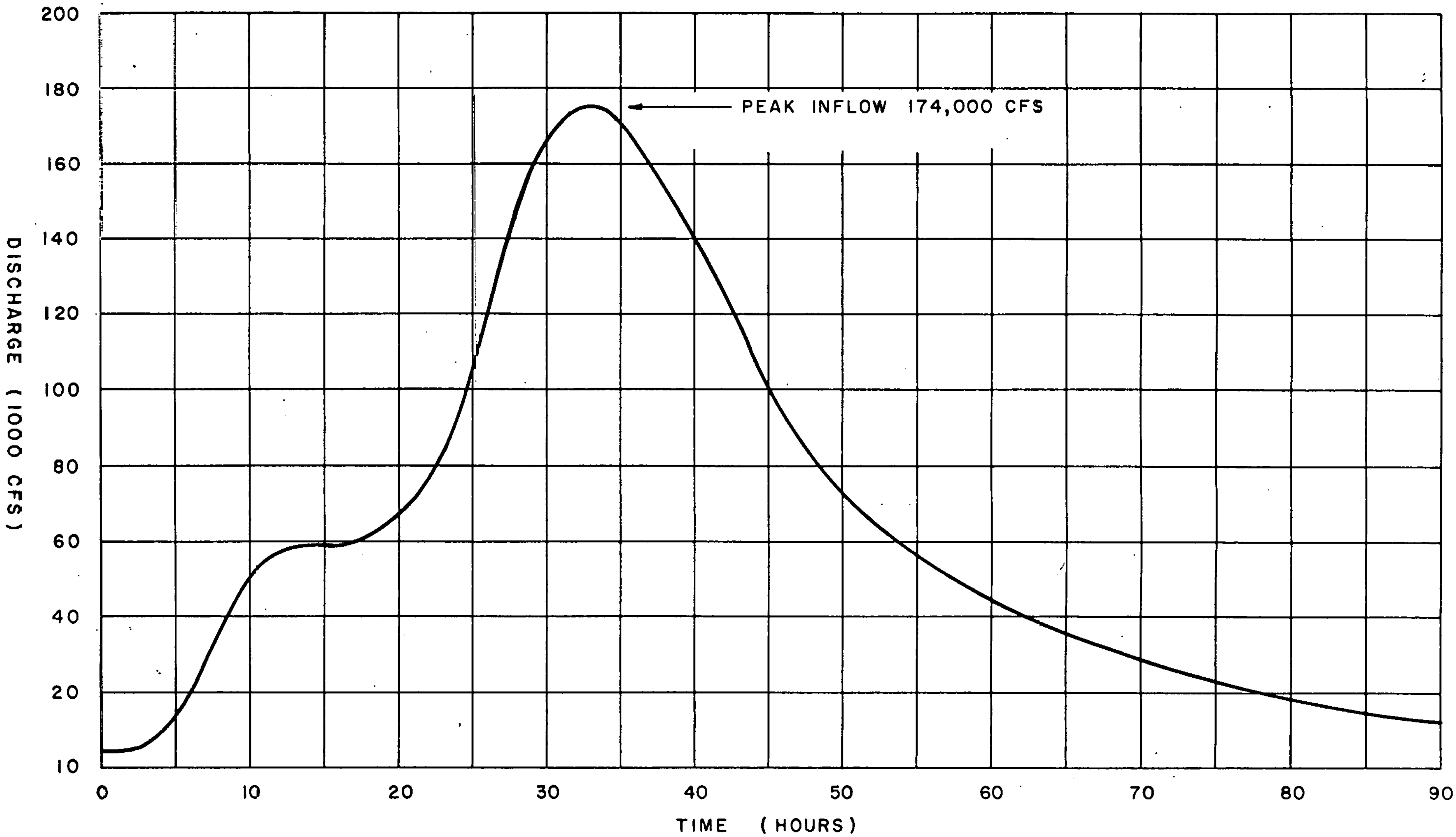


FIGURE C-7

PROBABLE MAXIMUM FLOOD

HUNTINGTON FALLS

C.3 POWER STUDY

A. General

Power studies were made for three heads and for from one to three units for each of the heads at Center Rutland, Beldens, and Huntington Falls. Simplifying assumptions were required because of the limited amount and accuracy of available data and the short time during which this study has been performed. Simplifications were made for head determination, hydraulic losses, unit efficiency, reservoir drawdown, and the manner in which the flow-duration curve data was applied.

B. Head

The normal headwater and tailwater levels were either known or were established with reasonable accuracy during this investigation. However, sufficiently accurate data for preparing reliable reservoir area-capacity curves and tailwater-rating curves were not available. Therefore, it was assumed that the headwater and tailwater fluctuations were identical so that the head remained constant. The effects of flood stages were neglected, because of the assumption made for fluctuation uniformity and because there is ample discharge during floods to produce rated output under varying head conditions.

The Huntington Falls reservoir was assumed to undergo a 5-foot drawdown. The head used for this site was the average obtained from the normal reservoir level and the drawdown level. The other two sites were assumed to operate at a constant reservoir level.

C. Headwater and Tailwater Rating Curves

Reservoir area-capacity curves were prepared using USGS topographic quadrangle sheets having a contour interval of 10 feet at Huntington Falls and Beldens and 20 feet at Center Rutland. The resulting area-capacity curves did not provide any reservoir fluctuation data that were considered to be any more reliable for determining head than resulted from the uniform headwater-tailwater fluctuation assumption.

Three river cross sections were surveyed during this investigation for the Huntington Falls and Center Rutland tailraces and were intended to serve as a basis for tailwater studies. However, they were only about 150 feet apart and did not clearly show the drop in water levels and other data required to accurately compute hydraulic properties of the sections. Normal turbine discharges flow over exposed rocks and cascade down several small drops in the tailraces at both of these sites. Sections upstream and downstream of the cascades are required for backwater studies under low flow conditions. In addition, it was assumed that the tailraces would be excavated to eliminate these drops and lower the tailwater. The cascades are drowned out during higher discharges. The tailwater level at Huntington Falls is controlled by the backwater of the Weybridge Dam, about 1.5 miles downstream. The discharge at all three sites was also approximate; therefore, it was not practicable to make a tailwater-rating curve of an acceptable degree of reliability.

D. Conveyance Losses

Hydraulic losses in the conveyance system were computed for several assumed conditions. Entrance, friction, exit and minor losses were included. The total losses were subsequently combined and rounded off to three feet for all analyses.

E. Unit Efficiency

The overall unit efficiency was assumed to be 79 percent for all operating conditions. This percentage was essentially derived as a weighted average for the range of operating conditions likely to be encountered. The average percentages used in approximating the overall efficiency basically were 87 percent for the turbine, 98 percent for the gear reducer, 95 percent for the generator and 98 percent for the transformer.

F. Power Computations

All three plants will operate as run-of-the-river installations; and the flow-duration curves shown on Figures C-3, C-4, and C-5 were used for power studies. The curves are based on mean daily discharges for the period of record. The discharge equalled or exceeded about 10 percent of the time was used initially for computing the total power potential at each site and was assumed to be the installed capacity. Installation of three units at each site was initially adopted to provide flexibility of operation and permit minimum plant outage. The same installed capacity using two units and one unit was also investigated. Finally, installation of two units of the same unit size as the three-unit installation was analyzed to ascertain the effect of a lower installed capacity. The smaller installed capacity resulted in utilizing the discharge that was equalled or exceeded about 20 percent of the time.

The flow-duration curves were divided into percentage time intervals and the discharge at each point determined. The duration of the intervals was varied so that they conformed closely to the degree of curvature of the flow-duration curves and permitted minimizing the effects of the averaging method used in the analyses. The discharge at each selected point was converted to kilowatt capacity, and the capacities at the beginning and end of each interval were averaged to obtain the equivalent capacity during each time interval. The hours during each interval were computed as a percentage of the total hours during a year. The kilowatt-hours for each interval were obtained by multiplying the average kilowatt capacity by the applicable number of hours. The incremental outputs were added to obtain the total output for an average year.

Using the percentage time interval method described above results in an insignificantly greater amount of energy than would be produced if the flow-duration curves were integrated. However, there are two offsetting influences that have been neglected in the analysis. No overload has been used and the units were assumed to be entirely inoperable when the unit discharge falls to 25 percent of the rated value. However, the units can be overloaded when there is sufficient discharge and part-time operation can be used for low discharges. The effects of these two possibilities will more than offset the excess introduced by using the percentage point method of analysis.

The power studies were made for each individual site and the applicable heads. The separate results were combined into four development alternatives, each of which included all three sites. The four development alternatives are shown in Table C-5, and the corresponding results to the power studies are shown in Table C-6. The first alternative made maximum use of existing facilities, because this would result in the minimum capital expenditure; however, it would not fully develop the available hydraulic resources. The second would fully develop the hydraulic resources, but would require the largest capital expenditure. The other two alternatives are intermediate between the first two and were selected to include the full range of development possibilities. The selection of project components and their combination into development alternatives was made in a manner that permits making other combinations, if desired.

G. Peak Load Potential

Two studies were made for peak load operation at the Huntington Falls site with the reservoir water surface at El. 230.0 and El. 218.0. These studies were conducted for this site using the data for two units at 3,050 kW each, as shown in Alternative III, for reservoir El. 230.0 and for two units at 2,300 kW each, as shown in Alternative I, for reservoir El. 218.0. Both studies assumed a 12-hour operation period and allowed for a minimum release of 137 cubic feet per second during the other 12 hours, when the plant is completely shutdown. The minimum release conforms to pending legislation in the Vermont Legislature. The base load and peak output for these two analyses are shown in Table C-7.

TABLE C-5

PRELIMINARY DEVELOPMENT ALTERNATIVES

ALTERNATIVE I

1. Upgrade and rehabilitate all sites.
2. Make maximum use of existing facilities, except generating units.
3. Excavate tailraces to lower tailwater.
4. Use wood or metal flashboards or crest gates.
5. Install new generating units.

ALTERNATIVE II

1. Raise Huntington Falls reservoir from El. 218.0 to El. 241.0.
2. Upgrade and rehabilitate Beldens and raise reservoir from El. 283.0 to El. 284.0.
3. Raise Center Rutland reservoir from El. 507.0 to El. 514.0.
4. Excavate tailraces to lower tailwater at Huntington Falls and Center Rutland.

ALTERNATIVE III

1. Raise Huntington Falls reservoir from El. 218.0 to El. 230.0.
2. Upgrade and rehabilitate Beldens and raise reservoir from El. 283.0 to El. 284.0.
3. Raise Center Rutland reservoir from El. 507.0 to El. 509.0.
4. Excavate tailraces to lower tailwater.

ALTERNATIVE IV

1. Raise Huntington Falls reservoir from El. 218.0 to El. 230.0.
2. Relocate Beldens powerhouse to recover head lost at Huntington Falls.
3. Raise Center Rutland reservoir from El. 507.0 to El. 514.0.
4. Excavate tailraces to lower tailwater.

TABLE C-6
Sheet 1 of 2

POWER STUDY
SUMMARY OF RESULTS

Plant	Head (ft)	Installed Capacity (kW)	Output (kWh/yr)	Installed Capacity (kW)	Output (kWh/yr)
ALTERNATIVE I					
Center Rutland	28.0	3 @ 770 = 2,310	7,617,000	2 @ 1,155 = 2,310	7,409,000
Beldens	43.0	3 @ 2,250 = 6,750	22,484,000	2 @ 3,375 = 6,750	21,678,000
Huntington Falls	37.5	3 @ 2,300 = 6,900	23,275,000	2 @ 3,450 = 6,900	22,694,000
Total		9 15,960	53,376,000	6 15,960	51,781,000
Center Rutland	28.0	1 @ 2,310 = 2,310	6,206,000	2 @ 770 = 1,540	6,685,000
Beldens	43.0	1 @ 6,750 = 6,750	18,134,000	2 @ 2,250 = 4,500	19,609,000
Huntington Falls	37.5	1 @ 6,900 = 6,900	18,845,000	2 @ 2,300 = 4,600	20,225,000
Total		3 15,960	43,185,000	6 10,640	46,519,000
ALTERNATIVE II					
Center Rutland	35.0	3 @ 960 = 2,880	9,453,000	2 @ 1,440 = 2,880	9,189,000
Beldens	40.0	3 @ 2,067 = 6,200	20,855,000	2 @ 3,100 = 6,200	20,159,000
Huntington Falls	60.5	3 @ 3,700 = 11,100	37,525,000	2 @ 5,550 = 11,100	36,230,000
Total		9 20,180	67,833,000	6 20,180	65,578,000
Center Rutland	35.0	1 @ 2,880 = 2,880	7,674,000	2 @ 960 = 1,920	8,301,000
Beldens	40.0	1 @ 6,200 = 6,200	16,915,000	2 @ 2,067 = 4,134	18,152,000
Huntington Falls	60.5	1 @ 11,100 = 11,100	30,423,000	2 @ 3,700 = 7,400	32,631,000
Total		3 20,180	55,012,000	6 13,454	59,084,000

POWER STUDY
SUMMARY OF RESULTS

Plant	Head (ft)	Installed Capacity (kW)		Output (kWh/yr)	Installed Capacity (kW)		Output (kWh/yr)
ALTERNATIVE III							
Center Rutland	30.0	3 @ 800 =	2,400	8,088,000	2 @ 1,200 =	2,400	7,877,000
Beldens	43.0	3 @ 2,250 =	6,750	22,484,000	2 @ 3,375 =	6,750	21,678,000
Huntington Falls	49.5	3 @ 3,050 =	9,150	30,797,000	2 @ 4,575 =	9,150	29,749,000
Total		9	18,300	61,369,000	6	18,300	59,304,000
Center Rutland	30.0	1 @ 2,400 =	2,400	6,632,000	2 @ 800 =	1,600	7,083,000
Beldens	43.0	1 @ 6,750 =	6,750	18,134,000	2 @ 2,250 =	4,500	19,609,000
Huntington Falls	49.5	1 @ 9,150 =	9,150	24,932,000	2 @ 3,050 =	6,100	26,740,000
Total		3	18,300	49,698,000	6	12,200	53,432,000
ALTERNATIVE IV							
Center Rutland	35.0	3 @ 960 =	2,880	9,453,000	2 @ 1,440 =	2,880	9,189,000
Beldens	51.0	3 @ 2,650 =	7,950	26,349,000	2 @ 3,975 =	7,950	25,287,000
Huntington Falls	49.5	3 @ 3,050 =	9,150	30,797,000	2 @ 4,575 =	9,150	29,749,000
Total		9	19,980	66,599,000	6	19,980	64,225,000
Center Rutland	35.0	1 @ 2,880 =	2,880	7,674,000	2 @ 960 =	1,920	8,301,000
Beldens	51.0	1 @ 7,950 =	7,950	21,212,000	2 @ 2,650 =	5,300	23,220,000
Huntington Falls	49.5	1 @ 9,150 =	9,150	24,932,000	2 @ 3,050 =	6,100	26,740,000
Total		3	19,980	53,818,000	6	13,320	58,261,000

TABLE C-6
Sheet 2 of 2

TABLE C-7

HUNTINGTON FALLS DAM

COMPARISON OF BASE LOAD AND PEAK LOAD ENERGY PRODUCTION

Reservoir Water Surface Elevation	Installed Capacity kW	Energy Production (kWh/yr) Base Load	Peak Load	% Peak ÷ Base
230.0	2 @ 3,050 = 6,100	26,740,000	17,989,000	67.2
218.0	2 @ 2,300 = 4,600	20,225,000	13,586,000	67.2

NOTE: Energy production based on 12-hour operation. Longer operating periods are possible during high discharge and would produce correspondingly more energy.

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APPENDIX D

GEOTECHNICAL INVESTIGATION

APPENDIX D

GEOTECHNICAL INVESTIGATION

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FIGURES

APPENDIX D

GEOTECHNICAL INVESTIGATION

This appendix contains the findings of geotechnical investigations performed for three hydroelectric projects on Otter Creek known as Huntington Falls, Beldens and Center Rutland. It discusses the geological conditions of the region and at each of the three sites. It contains the logs of three drill holes that were made at Huntington Falls during this investigation and recommends additional geotechnical investigations for the next stage of work leading to construction of proposed improvements.

A field inspection of the three sites was conducted during the last week of September 1978 and surface geology observed. Published geological data were reviewed during this inspection. The drilling was performed between December 7, 1978 and December 20, 1978.

D.1 REGIONAL GEOLOGY

The topography of the entire state of Vermont was profoundly altered by the glaciation ending about 10,000 years ago. Large areas are presently covered by glacial till and many of the exposed rocks exhibit polished and striated surfaces produced by glaciation.

Otter Creek, on which all of the Vermont Marble Company's hydroelectric developments are located, flows generally toward the north through western Vermont, eventually emptying into Lake Champlain about 21 miles north of the study area.

The meandering of Otter Creek is generally restricted to the eastern limb of the Middlebury Synclinorium, which strikes north-south and dips gently to moderately west. The Middlebury Synclinorium consists of a sedimentary sequence of carbonate and quartzite rocks deposited during Cambrian and

Ordovician times. The relatively flat, glacially scoured valley of the Middlebury Synclinorium is flanked to the east by the mountains of the west-verging Green Mountain Anticlinorium. The core, which is predominantly exposed throughout the range axis, consists of Precambrian gneiss overlain by Cambrian and Ordovician schists, amphibolites, phyllites, slates, and quartzites. South of Brandon, the mountains of the Taconic Klippe rise to the west, continuing south beyond the state border. The Taconic Klippe is a sedimentary sequence of shales, slates and phyllites with minor dolomite, limestone, marble and schist. Thrust from the east, the Taconic Klippe unconformably overlies sediments of the Middlebury Synclinorium.

The Middlebury Synclinorium, through which Otter Creek flows, consists of limestones, dolomites, quartz and calcareous sandstones, marbles, and quartzites. Between Weybridge and Center Rutland, Otter Creek cuts across the majority of the Middlebury Synclinorium stratigraphy. The Huntington Falls damsite near Weybridge, situated on the western limb of the Middlebury Synclinorium, is in the massive gray weathered dolomitic limestone of the Beldens Formation. West of Huntington Falls, Otter Creek cuts sequentially through the Crown Point Limestone and the Bascom Formation. The Beldens Formation constitutes the core of the synclinorium and as Otter Creek proceeds from the town of Beldens, it meanders through the eastern limb of the synclinorium. From Beldens to Center Rutland, Otter Creek cuts down-section through the limestones, dolomites, quartzites and marbles of the Beldens, Bascom, Cutting, Shelburne, Clarendon Springs and Danby Formations. Further east, it flows through the dolomites and quartzites of the Winooski, Monkton, Dunham, and Cheshire Formations. The Center Rutland damsite is in the Cheshire quartzite which is an extremely massive, white to pink or buff, vitreous quartzite. The Center Rutland dam is just east of a fault along which the Cambrian Cheshire was thrust over carbonaceous slates and phyllites of the Ordovician Hortonville Formation.

Formation of solution channels in the marbles and dolomites in the area of the damsites is not uncommon and has reached advanced stages of development in some places.

D.2 SITE GEOLOGY

A. Huntington Falls

The rock is interbedded dolomite and limestone, generally gray to blue-gray in color, moderately hard to hard and quite fresh. Thickness of bedding varies from 1/8 inch through 4 feet. Beds are 18 inches to 4 feet thick at dam crest to near tailwater level. Beds average 1/8 inch in thickness for some distance downstream of the base of the dam.

The rock is locally folded. The axis of an anticline lies a short distance downstream and approximately parallel to the dam axis. The dam itself is on the upstream dipping flank of this anticline; bedding strikes about north-south and dips 35°-55° east (upstream).

The rock is broken by the following joints set:

- East-west dipping 70° N through 70° S - spacing on this prominent set is between 1 and 6 feet.
- About N 20° E/30° - 35° SW spaced 2 inches through 1 foot.
- About N 70° E - north-south/70° N - vertical.
- About N 10° E/60° W.

There is some rock solution, as evidenced by cavities along the bedding downstream on the right abutment. No actual leakage around the dam was found; however, the possibility of such leakage developing upon impounding higher reservoir water levels cannot be ruled out. Some grouting or other remedial work might be required if this occurs.

Three exploratory holes were drilled during December 1978. The approximate locations of these drill holes are shown on Exhibit A-1 in Appendix A. The drill logs and descriptions of the cores are shown on Figure D-1, D-2 and D-3.

A report prepared in 1929 by Jackson and Moreland, Engineers, expressed the possibility of the existence of a crushed zone within or near the foundation of a dam of increased height. There is a questionable area downstream on the right abutment; however, no convincing evidence that a crushed zone passes through or close to the expanded foundation area could be found. Nevertheless, it was not possible to conclusively eliminate the existence of such a zone and further subsurface investigation will be required to determine actual conditions.

There are at least three alternatives available for investigating the existence and extent of the crushed zone. These are:

- Perform sufficient drilling to determine if the zone exists and to define its extent--probably a minimum of 4 to 5 holes.

- Expose the rock continuously with trenches plus any drilling required to clarify the extent of such a zone, if encountered.

- Design the raised dam as if no such zone exists and modify the design or provide the required foundation treatment if foundation excavation reveals that such a zone exists.

Concrete aggregates and impervious fill for the cofferdam are the two most important construction materials to be locally obtained. The following three possibilities exist for concrete aggregates:

- Adequate quantities of suitable materials may be located downstream of the dam.

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG

PROJECT	JOB NO.	HOLE NO.
OTTER CREEK	8901	1

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING
Huntington Falls	12/7/78	12/12/78	NX 0-44'9" BX 44'9"-52'9"	Vertical

COORDINATES	DEPTH/EL. GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
Top of Dam	+3'3"		32'

DRILLING CONTRACTOR	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
Guild Drilling	48'10"/52'9" 93%	14		52'9"

DRILL MAKE AND MODEL	LOGGED BY:
	E. Peterson, Driller/D. G. Ogden, Geologist

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
NX Core Barrel ~ 3" dia.	Cored	54"	54"	100%		0–4	0.0'-32.0' CONCRETE.
		60"	26"	43%		4–8	Aggregate mostly composed of limestone and quartzite. 42" of lost recovery, mostly between 5' and 12', due to poor aggregate. Material was ground up, during drilling, in areas of weak bond due to low aggregate content in this zone. Three areas of poor bond were specifically caused by local poor aggregate--a piece of rotten dolostone, a chunk of wood, and a piece of burlap at 23.5', 25', and 32' respectively. Rest of aggregate below 12' was in excellent condition.
		22"	17"	77%		12	
		26"	24"	92%			
		30"	30"	100%		16	
		56"	56"	100%		20	
		12	12	100%			
		50"	50"	100%		24	Overall Concrete Recovery 23'1"/35' = 80%.
		60"	59"	98%		28	
						32	Top of Rock 32'.

HOLE NO. 1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT OTTER CREEK	JOB NO. 8901	HOLE NO. 1

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY		REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
										Top of Rock
NX Core Barrel ~ 3" dia.	Cored	50"	50"	100%						32.0'-52.9" DOLOMITIC LIMESTONE Massive blue-gray, of the Beldons Formation; good bedrock, complete recovery. Dip of bedrock generally 15°-45°, locally to 75°. Rare calcite veins and a few thin shaley carbonaceous beds are present. A few well-cemented joints dipping 70°-75° at 33.5', 35.5', 37.5' and 38.5'. From 39' to 42' is a long nearly vertical well-cemented joint.
		57"	56"	98%			36			
		60"	60"	100%			40			At 47' are two small bedding plane shears at about 60° and 75°, where there is probably very slight movement along slickensides in slightly shaley carbonaceous limestone.
NX Core Barrel ~ 2-3/8" dia.		60"	60"	100%			44, 48			
		36"	36"	100%			52			
					Pumped 3 bags of cement into hole.					Total Depth 52.'9". Overall Rock Recovery 20'9"/20'9" = 100%.

HOLE NO. 1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT	JOB NO.	HOLE NO.
OTTER CREEK	8901	2

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING
Huntington Falls	12/13/78	--	SS 0-5'6" NX 5'7"-16' BX 16'-25'8"	Vertical

COORDINATES	DEPTH/EL. GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
North Side of Bridge on Bank			13'6"

DRILLING CONTRACTOR	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
Build Drilling	19'/10.5 = 93%	5		25'8"

DRILL MAKE AND MODEL	LOGGED BY:
	E. Peterson, Driller/ D. C. Ogden, Geologist

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
Split Spoon ~1-3/8" dia.		18"	12"			0–4	0'0"-5'6" GLACIAL TILL Sand, some silt, trace of cobbles and boulders.
		18"	12"				5'6"-10'0" GLACIAL TILL Consolidated limey till, with pebbles and boulders of regional bedrock.
NX Core Barrel ~ 3" dia.		54"	51"	94%		8	10'0"-13'0" GLACIAL TILL Gravel and boulders, well rounded gravel from distant geologic units at top. Angular boulders of regional bedrock at base.
		42"	31"	74%		12	13'0"-13'6" GLACIAL TILL Consolidated clay.
	CORED	30"	30"	100%		16	13'6"-14'5" DOLOMITIC LIMESTONE Blue-gray, massive, of the Beldons Formation. Complete recovery. Bedding plane - 30°. 14'5"-14'9" DOLOMITIC LIMESTONE Brown weathered. Crumbly. Bedding plane about 30°.
BX Core Barrel ~ 2-3/8" dia.		75"	75"	100%		20	14'9"-25'8" DOLOMITIC LIMESTONE Blue-gray, massive. Bedding changes rapidly over top few inches from 30° to 60°. Bedding varies between 30° and 60° throughout rest of core. Slightly shaley carbonaceous beds scattered throughout with an occasional minor fracture in some zones. No major calcite veins and only one recemented joint.
		41"	41"	100%		24	
						28	Total Depth 25'8". Overall Rock Recovery 12.17/12.17 = 100%.

HOLE NO. 2

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT: OTTER CREEK - VERMONT MARBLE			JOB NO.: 8901	HOLE NO.: 3
SITE: Huntington Falls	BEGUN: 12/19/78	COMPLETED: 12/20/78	HOLE SIZE: SS 0-9'8" NW 9'8"-24'6"	ANGLE FROM HORIZ. & BEARING: Vertical
COORDINATES: South Side - Corner of Bridge	DEPTH/EL. GROUND WATER: 3/6" 12/20/78		GROUND EL.:	DEPTH/EL. TOP OF ROCK: 9'8"
DRILLING CONTRACTOR: Guild Drilling	CORE RECOV. LENGTH/%: 14.83/14.83-100%	SAMPLES: 4	CORE BOXES:	DEPTH/EL. BOTTOM OF HOLE: 24'6"
DRILL MAKE AND MODEL:	LOGGED BY: E. Peterson, Driller/D. G. Ogden, Geologist			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION / PHYSICAL DESCRIPTION
Split Spoon ~ 1-3/8" dia.	6, 4, 8, 5, 4, 8, 4, 5, 4, 12			Top of Rock 9'8"		0–8			0'-8' SAND Silty, clayey, fine to medium, dark gray. 8'-9'8" SAND & SILT Fine to medium, blue-gray.
NW Core Barrel ~ 3" dia.	Cored	54"	54"	100%		12			9'8"-10'7" DOLOMITIC LIMESTONE Blue-gray; Beldons Formation. Solid bedrock, complete recovery. Bedding plane 20°-30°. Fracture spacing 1"-9". 10'7"-13'6" DOLOMITIC LIMESTONE Blue-gray dolomotic vuggy limestone with 6 joints dipping from 60° to vertical. Has been some movement along joints but most are recemted. Abundant calcite veins. An area of past ground movement and present water movement. Fracture spacing 5"-14".
		62"	62"	100%		16–20			13'6"-14'2" LIMESTONE Dark blue-gray slightly shaley carbonaceous; fossils present. 14'2"-16'9" DOLOMITIC LIMESTONE Dark blue-gray with two long re-cemented joints, dipping 80°-85°. No recent movement. 16'9"-20'2" DOLOMITIC LIMESTONE Dark blue-gray. No fractures; a few calcite veins along 20°-30° bedding planes.
		59"	59"	100%		24–28			20'-23'3" LIMESTONE Dark blue-gray with abundant (25-30%) calcite veins along bedding planes. Well cemented rock except for several thin graphite shaley beds. Mottled bedding. Fracture spacing ½"-15".

HOLE NO. 3

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT OTTER CREEK - VERMONT MARBLE	JOB NO. 8901	HOLE NO. 3

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									23'3"-24'6" LIMESTONE Dark blue-gray, massive. No jointing, few calcite veins.
									Total Depth 24'6".
									Overall Rock Recovery 14.83/14.83 = 100%.

HOLE NO. 3

- Rock from required excavation could be crushed.

- Material may be purchased from a local commercial source.

Impervious material will have to be brought to the site from several nearby locations.

B. Beldens

The rock is an interbedded blue-gray limestone and white marble. There are numerous solution cavities, generally following a joint set at about N 50° E/70° W to vertical. One such cavern, evidently following one or more intersections of this joint system with the bedding (N 50° W/15° NE), is quite well developed and is passing an estimated 50 cubic feet per second of water around the dam.

Bedding is uniform and only two persistent joint sets were located:

- N 15° W dipping 70° W to vertical and spaced from about 1 foot through about 10 feet.

- N 50° E dipping 85° N and spaced at about 3 feet.

Locally there are other joints, but they appear to be of very limited lateral extent.

No present or potential problems of stability were observed.

Reducing or eliminating the leakage through the cavern described above could probably be accomplished by filling the cavern with concrete.

No geologic condition was found at the site which would indicate any problems with the continued operation of the dam and power plant as it is, or with a moderate head increase consistent with topography and water supply. If the dam were raised it might be advisable to provide a seepage barrier, such as a cutoff wall or grout curtain. Filling of the existing cavern would improve efficiency and provide some additional firm water supply, whether the dam is raised or left at its present elevation.

C. Center Rutland

The rock is a fine-grained white to gray quartzite underlain at about 20 feet below the dam crest by a thinly laminated shale which is dark brown in color. The quartzite is moderately hard, fresh and massive. Two joint sets are visible in the quartzite:

- N 15° - 35° W dipping vertically and spaced about 6 feet apart.
- N 80° W/85° N.

Bedding of the quartzite is N-S dipping 35° E. Beds appear to be about 1 foot thick; however, there are incipient bedding planes spaced approximately 1 inch apart. Bedding in the shale undulates, but is generally concordant with that of the quartzite. Shale jointing is N 30° E/60° SW on 3-inch to 3-foot centers.

Cultural activity in the area has masked most of the rock. An abandoned sawmill on the left virtually covers the abutment. Powerhouse, retaining walls and an old bridge abutment cover most rock on the right.

No stability or other geology related problems were found. There is no apparent leakage. As far as can be determined, there is no geologic reason for concern in the continued operation of this facility.

D.3 SEISMICITY

There have been a number of earthquakes in the area. Those with epicenters near Boston, Massachusetts; along the the St. Lawrence River; and near Attica, New York, are among the more significant.

The map appearing as Figure 1 in the U.S. Army Corps of Engineers publications "Recommended Guidelines for Safety Inspection of Dams" and other seismic zone maps generally place the project area within Zone 2. Figure D-4 on the following page is a reproduction of the Corps of Engineers' Figure 1. Zone 2 is described as those areas where potential damage is expected to be moderate, with a coefficient of about 0.05G.

A map prepared by the Department of the Interior (USGS) in 1976 shows an expectable level of earthquake shaking for the project area of about 0.1G.

Any earthquake-generated accelerations are likely to be of short duration.

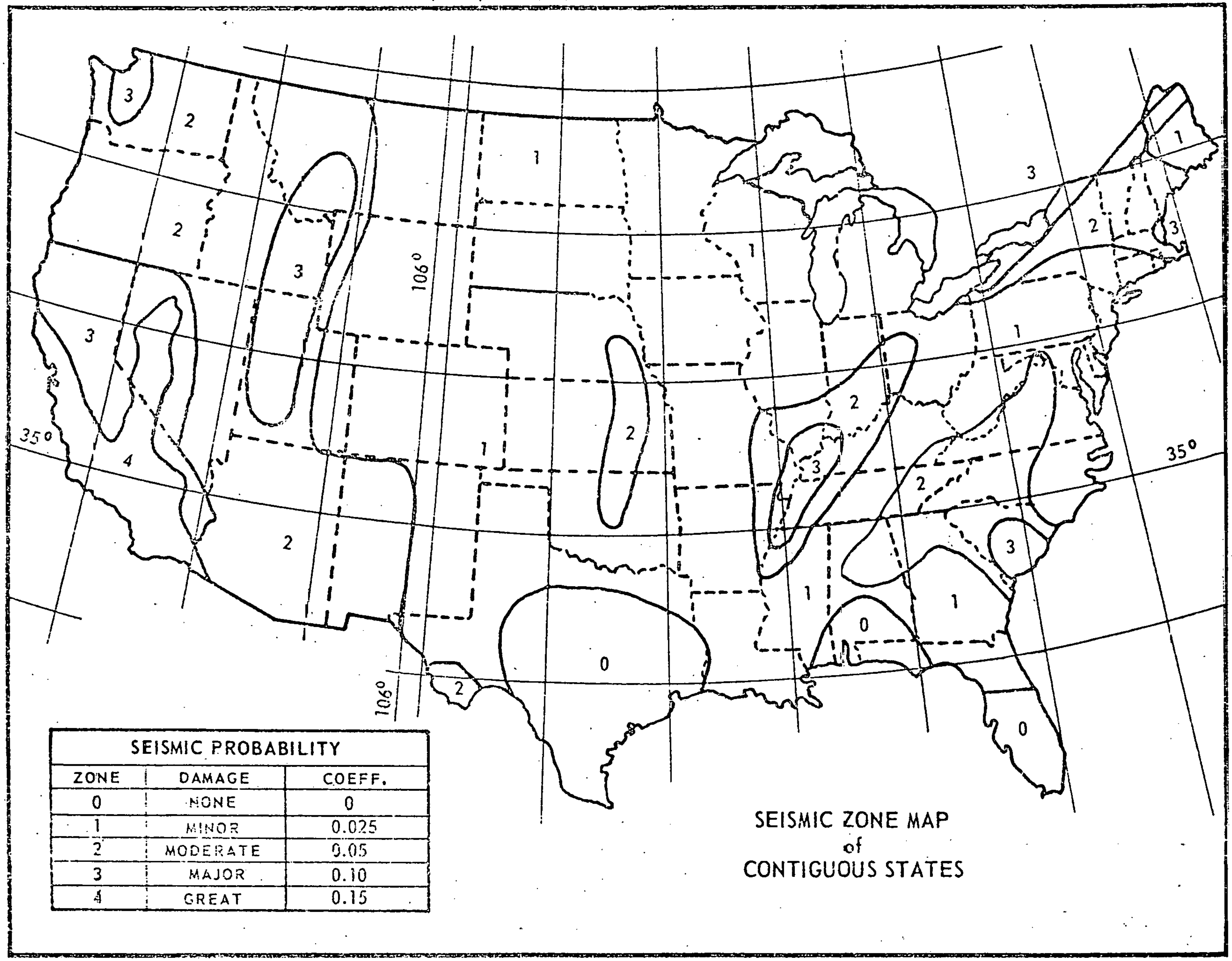
D.4 RECOMMENDED FURTHER GEOTECHNICAL EXPLORATION

The following recommendations assume that all three sites will be improved. Changes to the recommendations may be required during performance of the explorations, if the improvement program differs from that indicated herein or if any of the sites are not improved.

A. Huntington Falls

- Drill holes 30 feet into bedrock in the left abutment, right abutment and channel just downstream of the existing dam.
- Expose the rock with a bulldozer trench along the extension of the axis on the left abutment.

From TM 5-809-10/ NAVFAC P-355/AFM 88-3, Chapter 13; April 1973



SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

FIGURE D-4

- Run a resistivity survey along the axis of the dam and along the downstream toe of the dam to locate any major or large solution cavities.
- Perform a radar survey of the site. This survey should detect smaller cavities.

B. Beldens

- Examine the solution cavern by a physical inspection.
- Perform a resistivity survey along the axis and downstream toe of the dam.
- Perform a radar survey of the site.

C. Center Rutland

- Drill a hole through the dam and about 20 feet into the bedrock.
- Drill at least two holes through the old sawmill area on the left abutment, 20 to 30 feet into bedrock.
- Drill one or two holes 20 to 30 feet into bedrock, on the right abutment.