INTERNAL CORRESPONDENCE MEMORANDUM

TO: Mr. J. G. Fitzgerald,
Assistant Chief Engineer (Planning).

FROM: H. R. Young,
Planning Engineer.

DATE: 25 October 1971.

Enclosed herewith is a report on the review of all existing reports and documentation re - future hydro resources.

Costs are reported exactly as quoted in each report. The next project will be to convert these cost to present day values for comparison purposes.

H. R. YOUNG,
Planning Engineer.

HRY/mr
Encl.

THE NEWFOUNDLAND AND LABRADOR POWER COMMISSION

REVIEW AND CONSOLIDATION
OF EXISTING REPORTS OF
POTENTIAL HYDROELECTRIC DEVELOPMENTS
ON THE
ISLAND OF NEWFOUNDLAND

OCTOBER 25, 1971

Engineering Department
System Planning Division

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INTRODUCTION

This report was written following a meeting with Mr. J. G. Fitzgerald, Assistant Chief Engineer (Planning) on August 16, 1971. At this meeting, Mr. Fitzgerald requested a complete review of all existing reports and documentation re - future hydro resources.

A list of the reports reviewed is given in Appendix A, along with the date of the report, the Company that did the report, and the Power Commission's Library Number.

All of the figures included in this report are copied from the reports studied. Most of these figures come from the report "Water Resources Study of the Province of Newfoundland and Labrador for Atlantic Development Board."

The format adopted for this report was to treat each potential hydro development under a separate heading. By using this format, it is possible to follow the gathering of information on a specific development from the earliest reports up to the latest information available.

The report does not of itself make recommendations concerning any development, but does review and include the salient recommendations contained in the various reports covered.

PART 1

TERRA NOVA RIVER DEVELOPMENT

1.1 Report on Power Development Possibilities of the Terra Nova River for the Government of Newfoundland

This report was the earliest report reviewed for this development. The report was written in 1952 and was done by the Power Corporation of Canada Ltd.

Results of the study indicate that no site along the Terra Nova River offers advantages for development. However, the power potential of the river could be developed by diverting the water through Pitts Pond to Clode Sound and thus utilizing a gross head of 317 feet at a single power plant.

The general scheme of development involves a low rock-filled dam at the Southern End of Eastern Meelpaeg Lake in order to prevent loss of water to Long Harbour River. There is also a storage dam at Mollyguajeck to raise present water level by 50 feet. A dam at the outlet of Terra Nova Lake would raise the present water level about 20 feet to elevation 317.0 and divert water to Pitts Pond.

In this scheme there would be a 12,000 HP turbine installation at the Mollyguajeck storage dam and 70,000 HP turbine installation at Clode Sound. A 16 foot concrete lined tunnel 11,600 feet long through rock from the South end of Pitts Pond to Clode Sound would conduct the water to the turbines.

Note that be raising the level of Terra Nova Lake by 20 feet it becomes necessary to relocate a section of C.N. railway track and the removal of the village of Terra Nova to a new site.

A summary of the facts of this development is given in Table 1.1. A break down of the costs of the development, based on 1952 prices for labour, material, machinery and equipment, and on the scheme outlined above is given in Table 1.2A and Table 1.2B. These tables give the cost of power at the plant bus bar.

The general conclusions of this report are that preliminary investigations indicate that no difficult physical or geological conditions exist that would widly affect construction of the various structures. Also the high head at the selected site combined with good storage and flow regulation makes possible the development of a block of power at a cost which should be attractive for inductrial, commercial and domestic use.

Drainage Area	672 sq. miles
Natural Flow Average	1400 cfs
Storage Capacity	630 sq. mi. feet
Regulated Flow (90% of time)	1230 cfs
Gross Head: Maximum	319 ft.
Minimum	305 ft.
Storage: Mollyguajeck Lake	13.1 BCF
Terra Nova Lake	4.5 BCF

	At Clode Sound plus Mollyguajeck Lake	Transmitted to Arnold's Cove
Installed Capacity	82,000 HP	--
Power at 60% Load Factor	70,000 HP	66,000 HP
Annual Energy Output (Average)	314,000,000 KW hr	299,000,000 KW hr
Estimated Cost	$17,900,000	$21,049,000
Annual Charges		
Fixed	$1,342,000	$1,578,000
Operating	227,000	255,000
	$1,569,000	$1,833,000
Cost of Power, 60% L.F.	$22.41/HP/Yr	$27.77/HP/Yr
Cost of Energy	5.0 mills/KW hr	6.13 mills/KW hr

NOTE:-

Bond Discount	4½%
Fixed Charges	4½%, 3% Depreciation and Amortization
Water Rentals allowed at	$1.00 per HP/yr

TERRA NOVA DEVELOPMENT AS DESCRIBED IN 1952 REPORT FROM POWER CORPORATION OF CANADA

TABLE 1.1

General Expenses	$ 325,000
Eastern Meelpaeg Block Dam	30,000
Mollyguajeck Dam	830,000
Mollyguajeck - Tunnel, Pipe Line and Power Installation	1,945,000
Mollyguajeck - Transmission and Communication Facilities	410,000
Terra Nova Dam	745,000
Railway and Village Relocation	1,480,000
Clode Sound - Tunnel and Penstocks	4,315,000
Clode Sound - Power House and Equipment	2,305,000
Roads and Docks	605,000
Operators Quarters, etc.	110,000
Contingencies, Engineering, Construction Fees etc.	2,660,000
	$15,760,000
Interest During Construction	1,540,000
Construction Cost (Cash)	17,300,000
Allowance for Financial Expense, Bond Discount, etc.	600,000
Cost of Project	$17,900,000

Installation	82,000 HP
Cost per HP Installed	$218.30

COST OF DEVELOPMENT (1952)
EXCLUSIVE OF TRANSMISSION COSTS

TABLE 1.2A

Annual Charges and Cost of Power

Fixed Charges:-			
Interest	4½%	$805,000	
Depreciation and Amortization	3%	537,000	
			$1,342,000
Operation:-			
Administration		$ 35,000	
Operating Staff, Supplies, Expenses		85,000	
Maintenance		55,000	
Insurance and Taxes		15,000	
Water Rentals		37,000	
			227,000
Total Annual Charges			$1,568,000
Power Capacity at Power House, Clode Sound			82,000 HP
Cost of Power at Power House (Peak Capacity)			$19.15/HP/Yr
Power For Sale, 60% Load Factor			70,000 HP
Cost of Power For Sale, 60% Load Factor			$22.41/HP/Yr
Average Annual Energy Output			314,000,000 KW hr
Cost of Energy at Clode Sound Power House			5.0 mills/HW hr

COST OF DEVELOPMENT (1952)

EXCLUSIVE OF TRANSMISSION COSTS

TABLE 1.2B

1-2 Report on Studies of Hydro Electric Potential in Central Newfoundland, Part 1, General Appraisal (Terra Nova Development)

This report was done in January, 1966 by ShawMont Newfoundland Limited for the Newfoundland and Labrador Power Commission.

There are two separate developments on the Terra Nova River studied in this report. These are called the Upper Terra Nova River Development and the Lower Terra Nova River Development.

The Upper Terra Nova River Development utilizes the natural head of 460 feet which exists between Deer Pond and Tritons Brook. This development offers an economically feasible scheme to develop the power potential of the upper watersheds of the Terra Nova, North West, and Pipers Hole Rivers. Table 1.3A and Table 1.3B give a summary of the various methods studied for the utilization of these watersheds. This development appears to give the lowest cost of power of all developments east of Bay D'Espoir.

The Lower Terra Nova Development utilizes the natural head between Pitts Pond and Clode Sound, together with a supplementary development at the outlet of Mollyguajeck Lake.

Various methods were studied for utilizing the watersheds mentioned above. A summary of these methods is given in Table 1.4A and Table 1.4B. The total capacity and output of this scheme is approximately the same as that of the Upper Terra Nova River Development, but the cost of power is slightly higher.

Conclusions of this report were that more detailed studies of the Upper and Lower Terra Nova River Developments should be undertaken.

Development		1-A	1-B Extension of 1-A	2
Drainage Basins Development		Upper Terra Nova	-- Upper North West Eastern Meelpaeg Upper Pipers Hole	Upper Terra Nova Upper North West Eastern Meelpaeg Upper Pipers Hole
Total Drainage Area	sq. mi.	426	348	774
Total Regulated Flow	cfs	1150	920	2070
Full Supply Level	feet	570	570	570
Drawdown	feet	16	16	16
Low Supply Level	feet	554	554	554
Tailwater Level	feet	100	100	100
Average Gross Head	feet	462	462	462
Average Net Head at Regulated Flow	feet	450	442	454
Continous HP Available	HP	54,600	42,900	99,400
Annual Firm Energy	KW hr	323×10^6	254×10^6	586×10^6
Average Annual Secondary Energy	KW hr	29×10^6	$\sim 23 \times 10^6$	$\sim 53 \times 10^6$
INSTALLED CAPACITY B	HP	90,000 (2 units)	70,000 (1 unit)	165,000 (2 units)

NOTES: A. The estimates in this table, Table 1.3B and all other similar tables from this report are based on 1965 prices and do not include or take into account the following:

(i) Transmission lines and losses so that the cost of power presented is the cost at the plant busbar.

(ii) Clearing of flooded areas.

(iii) Facilities and storage releases for migrating fish.

(iv) Facilities and storage releases for logging operations.

(v) The effects of regulation or diversions of drainage area on existing hydro-electric developments.

(vi) Secondary benefits which might be realized from the construction of the reservoirs and roads associated with the power developments.

UPPER TERRA NOVA DEVELOPMENT

TABLE 1.3A

1-6

UPPER TERRA NOVA DEVELOPMENT

TABLE 1.3A (Cont'd)

B. Installed capacity based on 60% capacity factor.

C. At this time regulation studies to determine secondary energy had not been completed. Therefore, values given here are very approximate.

Development	1-A	1-B Extension of 1-A	2
Land Purchase	200×10^3	--	200×10^3
Land Clearing	10	15×10^3	25
Roads and Bridges	1,100	720	1,820
Railways, Diversion of Power Lines	--	--	--
Dam, Spillways and Reservoirs	2,600	6,448	8,835
Headworks, Water Conduits, Tailrace	6,830	7,567	13,018
Powerhouse and P.H. Equipment	4,120	1,600	5,120
Substation Including Transformers	640	350	880
Construction Indirect Costs	1,900	2,120	3,740
Project Management and Engineering	1,740	1,882	3,364
Contingency	2,610	2,820	5,040
Subtotal	21,750	23,522	42,042
Interest During Construction	1,410	1,530	3,990
Owner's Cost	217	235	420
TOTAL PROJECT COST	$\$23,377 \times 10^3$	$\$25,287 \times 10^3$	$\$46,452 \times 10^3$
Annual Fixed Charges at 6.73%	$1,570,000	$1,700,000	$3,120,000
Annual Operating and Maintenance Cost	153,000	67,000	225,000
Total Annual Charges	$1,723,000	$1,767,000	$3,345,000
Capital Cost per Installed HP	$ 260	$ 362	$ 281
Mean Cost of Energy (Firm and Secondary) Mills per KWH	~4.9	~6.4	~5.2
COST OF FIRM ENERGY mills/KWH	5.3	7.0	5.7

NOTES: Same restrictions hold as for Table 1.3A.

UPPER TERRA NOVA DEVELOPMENT
TABLE 1.3B

Development	1-A	1-B Extension of 1-A	2	3	4 Addition to 2	5 Addition to 3
Land Purchase	60 x 10^3	140 x 10^3	200 x 10^3	200 x 10^3	--	--
Land Clearing	20	5	25	30	2 x 10^3	2 x 10^3
Roads and Bridges	710	670	1380	1,330	--	--
Railways, Diversion of Power Lines	--	--	--	--	--	--
Dams, Spillways and Reservoirs	2,440	5,207	7,597	9,095	100	100
Headworks, Water Conduits, Tailrace	8,044	5,422	12,093	11,906	1,887	1,887
Powerhouse and PH Equipment	4,360	1,550	5,380	5,250	2,320	2,320
Substation Including Transformers	640	550	880	880	450	450
Construction Indirect Costs	2,020	1,670	3,440	3,590	560	560
Project Management and Engineering	1,828	1,521	3,099	3,228	532	532
Contingency	2,740	2,280	4,650	4,832	796	796
Subtotal	27,862	19,015	38,744	40,341	6,647	6,647
Owner's Cost	228	190	387	403	66	66
Interest During Construction	1,485	1,235	3,670	3,830	432	432
TOTAL PROJECT COST	$24,575 x 10^3	$20,440 x 10^3	$42,801x 10^3	$44,574 x 10^3	$7,145 x 10^3	$7,145 x 10^3
Annual Fixed Charges at 6.73%	1,650,000	1,375,000	2,880,000	3,055,000	480,000	480,000
Annual Operating and Maintenance Cost	145,000	58,000	203,000	196,000	84,000	84,000
Total Annual Charges	1,795,000	1,433,000	3,083,000	3,201,000	564,000	564,000
Capital Cost per Installed HP	$290	$372	$306	$330	$204	$204
Mean Cost of Energy (Firm and Secondary, Mills per KWH	~ 5.4	~7.0	~5.8 (5.8D)	~ 6.3 (5.5D)	~5.8	~3.2
COST OF FIRM ENERGY, mills per KWH	5.9	7.5	6.2 (6.2D)	6.7 (5.9D)	~ 6.3	~ 3.5

LOWER TERRA NOVA DEVELOPMENT

TABLE 1.4B

Development		1-A	1-B Extension of 1-A	2	3	4 Addition to 2	5 Addition to 3
Drainage Basins		Terra Nova -- -- -- -- -- --	Diverted to North West Pond -- North West Eastern Meelpaeg Upper Pipers Hole --	Diverted to North West Pond Terra Nova North West Eastern Meelpaeg Upper Pipers Hole --	Diverted to Mollyguajeck Lake Terra Nova Upper North West Eastern Meelpaeg Upper Pipers Hole	Upper Terra Nova -- -- -- -- --	Upper Terra Nova Upper North West Eastern Meelpaeg Upper Pipers Hole -- -- --
Total Drainage Area	sq. mi.	631	401	1,037	979	426	774
Total Regulated Flow	cfs	1,710	1,070	2,780	2,620	--	--
Full Supply Level	feet	297	297	297	297	562	545
Drawdown	feet	3	7	7	3	62	45
Low Supply Level	feet	294	290	290	294	500	500
Tailwater Level	feet	0	0	0	0	400	400
Average Gross Head	feet	295.5	293.5	293	295.5	~130	~130
Average Net Head at Regulated Flow	feet	286.5	284.5	284	290	--	--
Continous HP Available	HP	52,000	32,000	83,000	80,000	--	--
ANNUAL FIRM ENERGY	KWH	300×10^6	190×10^6	495×10^6	475×10^6	$\sim 90 \times 10^6$	$\sim 160 \times 10^6$
Average Annual Secondary Energy C	KWH	$\sim 24 \times 10^6$	$\sim 15 \times 10^6$	$\sim 40 \times 10^6$	$\sim 38 \times 10^6$	$\sim 8 \times 10^6$	$\sim 14 \times 10^6$
INSTALLED CAPACITY A	HP	85,000 (2 units)	55,000 (1 unit)	140,000 (2 units)	135,000 (2 units)	35,000 (1 unit) B	35,000 (1 unit) B

NOTES: A. Capacity Factor = 60%

B. Capacity based on maximum mean monthly storage release.

C. Regulation studies to determine secondary energy have not been completed.

D. (Table 1 - 4B) cost of energy including generation at Mollyguajeck Lake.

E. Same restriction apply as for Table 1.3A.

LOWER TERRA NOVA DEVELOPMENT
TABLE 1.4A

1.3 Interim Report on the Terra Nova Development

GENERAL

This report was done in June 1966 by ShawMont Newfoundland Limited for the Newfoundland and Labrador Power Commission.

The results of this report indicate that the Lower Terra Nova Development is more attractive than the Upper Terra Nova Development. Therefore, this report only deals with a method of developing the scheme referred to as the Lower Terra Nova Development. In future references to this development, it will be called the Terra Nova Development.

The scheme involves the installation of two power houses:-

(1) At Clode Sound where an average gross head of 316 feet would be developed and the rated installed capacity would be 100 MW.

(2) The outlet of Mollyguajeck Lake 3400 feet downstream from the main storage dam where an average gross head of 201 feet would be developed and the rated installed capacity would be 44 MW (firm capacity 35 MW).

DRAINAGE AREAS

For this development the following drainage areas would be diverted:-

Diversion Area	Drainage Area (sq. mi.)
Eastern Meelpaeg	56
Upper Northwest River	192
Upper Pipers Hole - North	31
Lower Northwest River and Salmon Brook	89

The diversion of Upper Pipers Hole - South was determined to be uneconomical.

With the diversions listed above, the total drainage area utilized by the Mollyguajeck plant would be:-

Upper Terra Nova River	426 sq. mi.
Eastern Meelpaeg	56 sq. mi.
Upper Northwest River	192 sq. mi.
Upper Pipers Hole - North	31 sq. mi.
TOTAL	705 sq. mi.

The total drainage area utilized by the Clode Sound Plant would include the above plus the following:-

Lower Terra Nova River	186 sq. mi.
Lower Northwest River and Salmon Brook	89 sq. mi.
TOTAL	980 sq. mi.

STRUCTURES

In order to effect the above diversions a large number of structures are required. The dams required are listed below:-

Name	Max Height Feet	Crest Length Feet	Probable Type
Mollyguajeck Dam	165	1420	rockfill
Terra Nova Lake Dam	45	1300	rock & earth fill
Eastern Meelpaeg Dam	8	--	timber crib
Terra Nova North Dam	70	5050	earthfill
Clode Sound Dam	55	1260	earth & rock fill
Upper North West River Dam	100	1625	rockfill
Salmon Brook Dam	10	--	timber crib
Upper Pipers Hole North Dam	10	250	timber crib

There are also several canals required in the development. A power canal is required to connect the Terra Nova drainage area to the powerhouse at Clode Sound; a diversion canal is required to connect the Mollyguajeck plant with the Upper Northwest drainage area; a diversion canal is required to connect the Upper Pipers Hole to the Upper Northwest River area; a diversion canal is required to connect the Lower Northwest River and Salmon Brook to the Clode Sound Plant.

At the Clode Sound Power Plant, structures would be located within Terra Nova National Park. Therefore, a check has been made of replacing the surface structures envisaged in this report with a power tunnel and underground works. It was concluded that the premium for underground construction would be prohibitively expensive.

STORAGE AND FLOWS

An analysis of the costs of the structures required at the Clode Sound site indicated the economic full supply level (F.S.L.) for the reservoir is at elevation 317 which is 20 feet above the natural level of Pitts Pond. At this elevation no canal is required between Terra Nova Lake and Pitts Pond. Note that at elevation 317 feet it becomes necessary to relocate a part of the Canadian National Railway track and to relocate the village of Terra Nova.

Analysis also determined that Pitts Pond and Terra Nova Lake are not suitable for a large volume of storage involving large drawdown. Therefore, this area will only be used for pondage. Studies indicate that it is economical to provide all storage on the Mollyguajeck reservoir rather than to provide storage at both Mollyguajeck Reservoir and Northwest Reservoir. Also, the economic F.S.L. at the Mollyguajeck reservoir is in the vicinity of elevation 575 feet. Drawdown would be 37 feet so L.S.L. would be elevation 538.

The economic storage offered by the Mollyguajeck reservoir permits a high degree of regulation. It is proposed to regualte to 90% of the long term average flow at the Clode Sound Plant which studies have indicated will not pose operating difficulties. The plant flows would be as follows:

	Drainage Area sq. miles	Long Term Average Flow cfs	Firm Flow cfs
Mollyguajeck Plant	705	2110	2125
Clode Sound Plant	980	2935	2645

The total storage requirement would be 17,600 cfs months or 46.4 BCF and would be provided on the Mollyguajeck Reservoir between operating levels of 575 F.S.L. and 538 L.S.L.

CAPITAL COST

Based on 1966 prices and excluding transmission lines, the Terra Nova Development is estimated to cost $51,460,000:-

Capital	$48,430,000
Interest	3,030,000
Total Project Cost	$51,460,000

A detailed breakdown of the cost estimates including transmission lines is given in Appendix V of the report entitled "Interim Report on the Terra Nova Development." These cost estimates also include contingencies to cover increases in quantities and unforeseen construction difficulties for the individual structures. No allowance has been made in the estimates for:-

- Clearing of flooded areas and for loss of merchantable timber.
- Relocation or reconstruction of logging camps and logging roads inundated by the reservoir.
- Facilities which may be required at the dams for log driving and fish conservation.

The cash flow of the project excluding transmission lines is estimated to be as follows:-

	Capital	Interest
Preliminary year(s) (Field investigation, Engineering, 5 miles of road)	$ 1,186,000	$ 25,000
First Construction Year	10,836,000	345,000
Second Construction Year	22,565,000	1,405,000
Third Construction Year	13,843,000	1,255,000
TOTAL	$48,430,000	$3,030,000

ENERGY PRODUCTION COST

The annual energy output of the Development at the busbars of the plants is estimated to be:-

	Firm	Average
Clode Sound Plant	500×10^6 KW hr	537×10^6 KW hr
Mollyguajeck Plant	240×10^6 KW hr	245×10^6 KW hr
TOTAL	740×10^6 KW hr	782×10^6 KW hr

The annual fixed charges of the Terra Nova Development, excluding transmission lines, are estimated to be $3,885,000 based on the following rates:-

Cost of Capital	7.00%
Depreciation (50 years)	0.25%
Interim Replacement	0.20%
Insurance	0.10%
	7.55%

Therefore, the cost of energy at the busbars of the plants is estimated to be as follows:-

Fixed Annual Charges, 7.55% of $51,460,000	$3,885,000
Direct Operating and Maintenance Costs	352,000
Total Annual Charges	$4,237,000
Average Annual Energy	782×10^6 KW hr
Cost of energy	5.40 mills/KW hr

The cost of increasing the installed capacity of the Development is estimated to be of the order of $180/KW for small increments of 5 to 10 MW. Larger increments of capacity would cost progressively less and the minimum would be of the order of $135/KW for the installation of a large block of peaking capacity.

The scheme described above is the full development planned on the Terra Nova River. Two partial developments were also studied, but the full development gives a lower cost of energy. Partial or intermediate development results in a much higher cost of power and therefore only the full development was dealt with in detail in the report studied.

1.4 Water Resources Study of the Province of Newfoundland and Labrador for Atlantic Development Board (Terra Nova Development)

This report was written in 1968 by The Shawinigan Engineering Company Limited and James F. MacLaren Limited.

The report contains a summary of the findings of the report by ShawMont Newfoundland Limited entitled "Interim Report on the Terra Nova Development." The report also discusses the Department of Fisheries policy of increasing Atlantic Salmon stocks in the river to the river's full potential.

The report states its conclusions and recommendations with respect to the Terra Nova River Basin as follows:-

CONCLUSIONS

a) The main resources of the Terra Nova River basin consist of forests, fresh water fisheries, and wildlife, with related recreation and tourism potential. In addition, the basin has significant hydro-electric potential.

b) The potential hydro-electric development involves a series of conflicts of interest with other existing and potential water resource users in the basin.

c) There are no natural resources or other conditions in the Terra Nova River basin, which would favor industrial development over other Island basins.

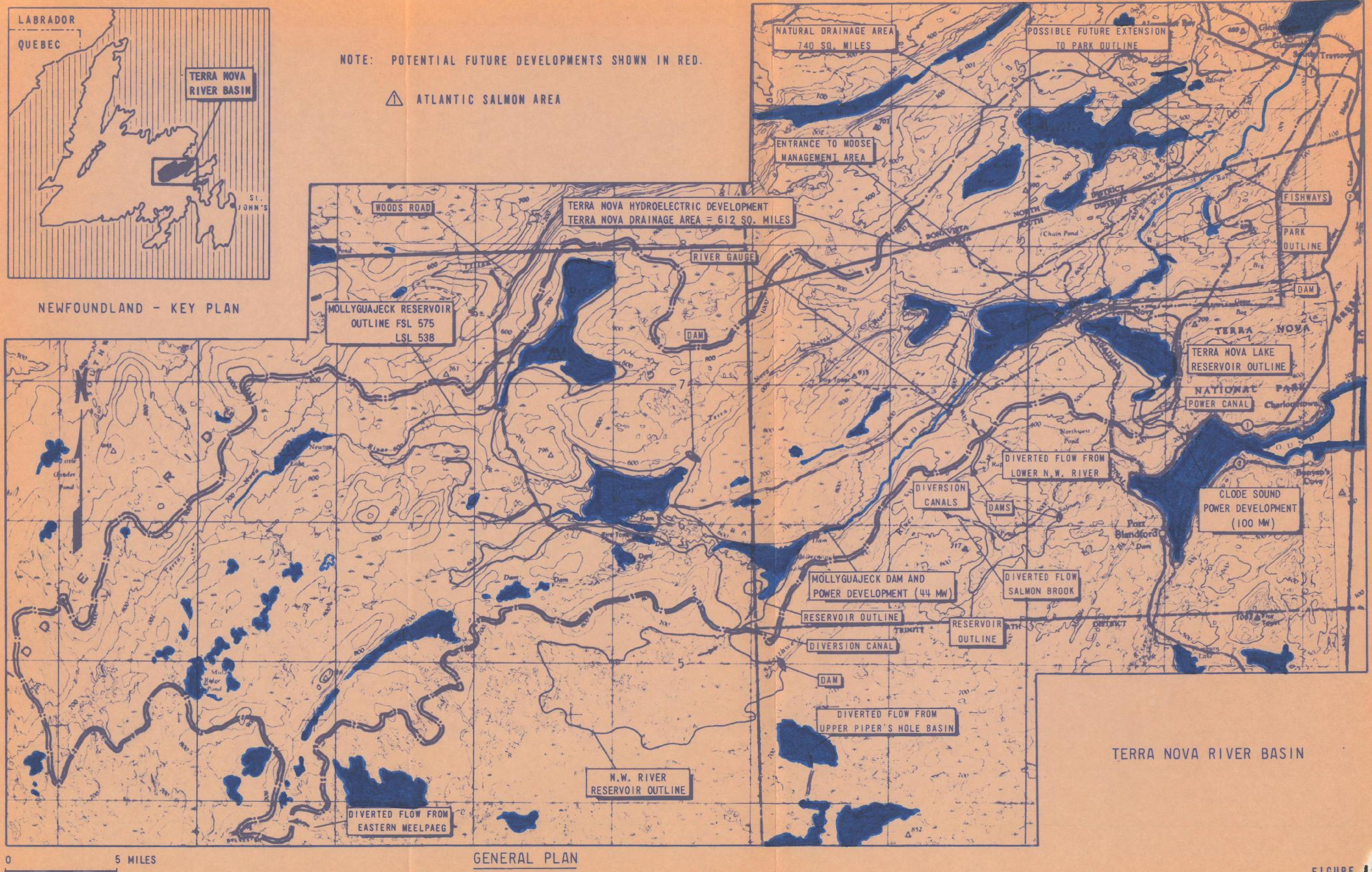
RECOMMENDATIONS

a) Industrial development should not be encouraged in this basin, and emphasis should be put on forestry, recreation and tourism, wildlife, and fisheries development.

b) The full implications of the proposed hydro-electric scheme which involves several diversions and will create several reservoirs, consequently affecting the fisheries, forestry, and wildlife resources of several adjacent basins should be studied. It is recommended that a water resources management study be carried out in advance of a decision to proceed with the hydro development to permit a careful evaluation of all factors.

c) Full attention should be given in the recommended study to the potential conflicts of interest between log driving and fisheries should forest exploitation recur in the basin.

d) Consideration should be given in the water resources management study to the possibility of enlarging the present boundary of the Terra Nova National Park to include the Terra Nova Lake area and the area along the main river stem from the lake to the river mouth.



TERRA NOVA RIVER BASIN

FIGURE 1-1

PART 11

BAY DU NORD RIVER -

HYDRO ELECTRIC POWER DEVELOPMENT

2.1 Report on Power Development Possibilities of the Bay du Nord River for the Government of the Province of Newfoundland

This report was written in June, 1952 by the Power Corporation of Canada Limited. The Bay du Nord River is located on the south coast of Newfoundland. The river flows into Fortune Bay approximately halfway between Bay D'Espoir and Terrenceville.

The report contemplates two power plants with a total installed capacity of 47,000 H.P. Storage will be provided by constructing a dam at the outlet of Meddonegonix Lake to raise the level of that lake by 26 feet and Koskakodde Lake by 24 feet. This will provide a total of 278,000 acre feet of storage.

The output from this 47,000 H.P. installation is assumed to be delivered to St. Alban's. This gives 174,000,000 KW hr. delivered to St. Alban's at a unit cost of approximately 7,75 mills/KW hr.

A summary of the development is given in Table 2.1. At Smokey Falls a concrete dam with a maximum height of 48 feet and crest length of 1,500 feet will be provided to raise the water level above the falls to elevation 340. An intake section with head gate and stoplogs is provided for a 13 foot diameter wood stave pipe line, approximately 540 feet long, leading to a surge tank. From the surge tank a steel penstock 1,000 feet long and 12 feet in diameter would lead to the turbine scroll case. The power house would contain a single 27,000 H.P. Francis vertical turbine direct - connected to a 27,000 KVA generator.

At Little Falls the dam would be of concrete with a maximum height of 160 feet above rock foundations and crest length of 412 feet. Intake works with headgate and stoplogs are provided for a steel pipe line and penstock 10 feet in diameter and 450 feet long leading to the turbine. A surge tank and butterfly valve at the power house included in the estimates. The power house would contain a single 20,000 H.P. Francis turbine direct connected to a 20,000 KVA generator.

The conclusions of this report are as follows:-

(i) Sufficient field investigations were carried out to give reasonable assurance that no difficult physical or geological conditions exist that would unduly affect the construction of the various structures required.

(ii) From an operating point of view, there would be no difficulties due to ice and winter conditions affecting the flow of water to the turbines at the power plants.

(iii) These sites, with storage developed at Meddonegonix Lake, can provide a block of power at a cost which, although not low, is not unduly high.

	Smokey Falls	Little Falls (as supplementary to Smokey Falls)	Total
Drainage Area, square miles	385	404	
Natural Flow, Average per annum cfs	940	980	
Proposed Storage Capacity,- sq. mi. ft.	435	435	
Regulated Flow (90% of time) CFS	800	800	
Gross Head - Maximum, feet	205	138	
- Minimum, feet	195	127	
Installed Capacity, H.P.	27,000	20,000	47,000
Power for Sale (St. Albans) H.P. (60% Load Factor)	23,000	15,200	38,200
Average Annual Energy Output, delivered at St. Albans, KW hr.	102,000,000	72,000,000	174,000,000
Cost of project	$ 9,560,000	$6,663,000	$ 16,223,000
Annual Charges			
Fixed	$ 717,000		$ 1,217,000
Operating	76,000		131,000
Total	$ 793,000		$ 1,348,000
Cost of Power (St. Albans) /H.P./yr.	$ 34.48		$ 35.30
Cost of Energy (St. Albans) mills/KW hr	7.77		7.75

NOTE:- Bond Discount -- 4½%
Fixed Charges -- 4½% interest
3% Depreciation and Amortization
Water rentals allowed at $1.00 per HP/yr.
Costs include for power delivery at St. Albans and assume usage of capability.

SUMMARY OF POWER DEVELOPMENT ON BAY DU NORD RIVER (1952)

Table 2.1

2.2 Report on Studies of Hydro Electric Potential in Central Newfoundland -- Part 1, General Appraisal (Bay du Nord River Development)

In this report various schemes of development along this river were studied. These schemes are summarized in Table 2.2A and Table 2.2 B.

Conclusions of these studies state that from the point of view of firm energy, the cost of power at the Bay du Nord Development would be high. However, a large block of secondary energy would be available in an average year and the cost of total energy approaches the cost of energy developments on the Terra Nova River. The Bay du Nord Development, therefore, may be economically feasible under system and market conditions which would allow all the energy to be considered as firm.

Diversion of the headwaters of the Terra Nova, North West, and Pipers Hole Rivers into the Bay du Nord drainage basin would not be economically feasible.

The possibility of backing the Bay du Nord River into the Little River and developing the available head at a power station on the Conne River would be totally uneconomic.

Recommendation of this report is that no further study be undertaken of this development at this time.

Bay Du Nord River Development		1-A	1-B, Extension of 1-A	2
Drainage Basins Developed		Bay du Nord	--- Upper Terra Nova Upper North West Eastern Meelpaeg Upper Pipers Hole	Bay du Nord Upper Terra Nova Upper North West Eastern Meelpaeg Upper Pipers Hole
Total Drainage Area	sq mi.	415	774	1,189
Total Regulated Flow	cfs	1,010	2,070	3,080
Full Supply Level	feet	542	542	542
Drawdown	feet	7	7	7
Low Supply Level	feet	535	535	535
Tailwater Level	feet	55	55	55
Average Gross Head	feet	484	484	484
Average Net Head at Regulated Flow	feet	475	475	475
Continuous HP available	HP	50,700	71,500	122,300
Annual Firm Energy	KWH	300×10^6	400×10^6	700×10^6
Average Annual Secondary Energy A	KWH	60×10^6	--	60×10^6
Installed Capacity B	HP	85,000 (2 units)	150,000 (2 units)	234,000 (3 units)

NOTES:- A: Regulation studies to determine secondary energy had not been completed at this date. Values given here are very approximate.

B: Installed capacity based on a 60% capacity factor.

C: Same restrictions apply as for Table 1.3A.

BAY DU NORD RIVER DEVELOPMENT
TABLE 2.2A

Bay du Nord River Development	1-A	1-B, extension of 1-A	2
Land Purchase	--	200×10^3	200×10^3
Land Clearing	10×10^3	20	30
Roads and Bridges	1,680	2,470	4,150
Railways, Diversion of Power Lines	420	--	420
Dams, Spillways and Reservoirs	8,643	13,063	21,706
Headworks, Water Conduits, Tailrace	3,867	8,655	12,522
Powerhouse and P.H. Equipment	3,930	7,650 B	10,255 B
Substation Including Trans-formers	600	2,090	2,690
Construction Indirect Costs	2,410	4,140	6,380
Project Management and Engineering	2,156	3,829	5,835
Contingency	3,234	5,743	8,752
Subtotal	26,950	47,860	72,940
Owner's Cost	269	479	729
Interest During Construction	1,750	3,110	6,930
TOTAL PROJECT COST	$28,969 $\times 10^3$	$51,449 $\times 10^3$	$80,599 $\times 10^3$
Annual Fixed Charges at 6.73%	1,950,000	3,470,000	5,420,000
Annual Operating and Main-tenance cost	148,000	163,000	311,000
Total Annual Charges	2,098,000	3,633,000	5,731,000
Capital Cost per Installed HP	$341	$343	$345
Mean Cost of Energy (Firm & Secondary), Mills/KW hr.	5.8	9.1A	7.5A
COST OF FIRM ENERGY, Mills/KW hr.	7.0	9.1A	8.2A

NOTES: A: Refers to net annual firm energy available to system after pumping requirement for diversion scheme has been met.
B: Includes cost of diversion pump house and equipment.
C: Same restrictions apply as for Table 1.3A.

BAY DU NORD RIVER DEVELOPMENT

Table 2.2B

PART 111

PIPERS HOLE RIVER, GISBORNE LAKE,
AND STAR LAKE DEVELOPMENTS

Pipers Hole River

This river basin is located directly south of the Terra Nova River basin and rains into Placentia Bay near Swift Current - see Fig. 2.1.

Two schemes were investiaged to utilize the hydro electric power potential of this river basin. A summary of the results of these studies is shown in Table 3.1A and Table 3.1B.

The general conclusion is that development of a large block of power on the Pipers Hole River to utilize the upper water sheds of the Terra Nova and North West Rivers together with the Pipers Hole watershed is not economically feasible. Such a development would require a large dam about 1½ miles above tidewater and the cost of diversion across the height of land would be excessive.

Development of a peaking at Pipers Hole utilizing the direct run-off only, would also not be economically feasible.

The recommendation was that no further study be undertaken of this development at this time.

Gisborne Lake

This lake flows into Long Harbour, which is a part of Fortune Bay. The direct drainage area of Gisborne Lake is very small, so that almost all the flow required for a large scale development at this site would have to be diverted from adjacent drainage basins. The cost of diversion would be excessive due to unfavourable topography and as a result, the Gisborne Lake Development is indicated to be quite uneconomic. A summary of this development is given in Table 3.1A and Table 3.1B.

The recommendation was that no further study be undertaken of this development at this time.

Star Lake

A natural head of about 400 feet exists between Star Lake and Red Indian Lake. However, the drainage area of Star Lake is only 172 square miles and consequently the available flow is relatively small. Diversion of the Shandithet River which lies to the east was considered but appears to be impracticable. A summary of this development is given in Table 3.1A and Table 3.1B.

All the structures required for this development are modest in size but even so, the cost of power is relatively high due to the small flow.

The recommendation was that no further study be undertaken of this development at this time.

Development		Pipers Hole River 1	Pipers Hole River 2 - 20% C.F.	Gisborne Lake	Star Lake
Drainage Basins Developed		Pipers Hole Upper Terra Nova Upper North West Eastern Meelpaeg	Pipers Hole	Gisborne Lake Upper Long Harbour Meta Pond Eastern Meelpaeg Upper Pipers Hole Upper North West Upper Terra Nova	Star
Total Drainage Area	sq. mi.	965	291	1,007	172
Total Regualted Flow	cfs	2,540	613(2.1 cfs/sq mi)	2,650	430
Full Supply Level	feet	400	350	518	1,000
Drawdown	feet	7	10	5	18
Low Supply Level	feet	393	340	513	982
Tailwater Level	feet	5	5	5	545
Average Gross Head	feet	391.5	340	510.5	446
Average Net Head at Regulated Flow	feet	383.5	333	495	435
Continuous HP Available	HP	103,000	21,600	138,800	19,750
ANNUAL FIRM ENERGY	KW hr	610×10^6	128×10^6	820×10^6	117×10^6
Average Annual Secondary Energy B	KW hr	$\sim 55 \times 10^6$	$\sim 30 \times 10^6$	$\sim 80 \times 10^6$	$\sim 9 \times 10^6$
INSTALLED CAPACITY A	HP	170,000 (2 units)	110,000 (2 units)	231,000 (3 units)	35,000 (1 unit)

NOTES: A: Installed capacity based on 60% capacity factor unless stated otherwise.
B: At this time regulation studies to determine secondary energy had not been completed. Values given here are very approximate.
C: Same restrictions apply as for Table 1.3A.

PIPERS HOLE, GISBORNE LAKE AND STAR LAKE DEVELOPMENTS

TABLE 3.1A

Development	Pipers Hole River 1	Pipers Hole River 2 - 20% C.F.	Gisborne Lake	Star Lake
Land Purchase	200×10^3	--	200×10^3	--
Land Clearing	53	13×10^3	100	6×10^3
Roads and Bridges	1,500	1,370	3,300	1,630
Railways, Diversion of Power Lines	--	--	--	--
Dams, Spillways and Reservoirs	33,107	7,892	27,020	1,947
Headworks, Water Conduits, Tailrace	6,033	4,242	26,518	1,754
Powerhouse and P.H. Equipment	5,600	5,000	7,350	1,740
Substation Including Transformers	880	750	1,270	450
Construction Indirect Costs	6,010	2,406	8,344	919
Project Management and Engineering	5,338	2,167	7,410	845
Contingency	8,007	3,251	11,115	1,267
Subtotal	66,728	27,091	92,627	10,558
Owner's Cost	667	271	926	106
Interest During Construction	6,340	1,761	8,800	686
TOTAL PROJECT COST	\$ $73,735 \times 10^3$	\$ $29,123 \times 10^3$	\$ $102,353 \times 10^3$	\$ $11,350 \times 10^3$
Annual Fixed Charges at 6.73%	$4,962,000	$1,960,000	$6,890,000	$764,000
Annual Operating and Maintenance Costs	238,000	174,000	302,000	84,000
Total Annual Charges	$5,200,000	$2,134,000	$7,192,000	$848,000
Capital Cost per Installed HP	434	265	443	324
Mean Cost of Energy (Firm and Secondary) Mills per KWH	~ 7.8	~ 13.5	~ 8.0	~ 6.7
COST OF FIRM ENERGY Mills Per KWH	8.5	16.7	8.8	7.2

PIPERS HOLE, GISBORNE LAKE AND STAR LAKE DEVELOPMENTS

TABLE 3.1B

Star Lake

This scheme was re-evaluated because the recent road construction, which connects the community of Buchans to the Star Lake area, permits a significant reduction in the road costs originally charged to the scheme. The scheme was costed at 60 percent capacity factor using updated cost figures.

The scheme investigated here would develop a head of about 450 feet between Star Lake and the Lloyds River upstream of Red Indian Lake. The drainage area of Lake of the Hills is diverted into the Star Lake area.

Re-appraisal of the scheme indicates a reduction of the firm energy costs by about 10 percent from 7.2 mills to 6.5 mills at the plant bus bar. This scheme is recommended for further studies as it may be economically feasible under market and system conditions which would allow more of the energy to be considered as firm. In addition, the storage of about 7 BCF provided by this scheme would result in an increase in the low flows occuring downstream on the Exploits River. Consequently, the problems created as a result of the Upper Exploits River diversion to Bay D'Espoir would be significantly reduced.

Diversion of the Shanadithit Brook to the Star Lake drainage areas was also reconsidered. The cost of firm energy at the plant bus bar came to 7.4 mills making the scheme less attractive from this view point than the Star Lake scheme.

A summary of this development is given in Table 3.2A and Table 3.2B.

Development		Star Lake	Shandithit Brook
Drainage Basins Developed		Star Lake Lake of the Hills	Star Lake Lake of the Hills
Total Drainage Area	sq. mi.	180	301
Total Regulated Flow	cfs	450	782
Full Supply Level	feet	1,000	880
Drawdown	feet	19	5
Low Supply Level	feet	981	845
Tailwater Level	feet	525	495
Average Gross Head	feet	465	362
Average Net Head at Regulated Flow	feet	451	342
Continuous HP available	HP	21,000	28,000
Annual Firm Energy	KW hr	127×10^6	167×10^6
INSTALLED CAPACITY		35,000 (1 Unit)	50,000 (1, Unit)

NOTE: Capacity Factor is 60%.

STAR LAKE DEVELOPMENT

Table 3.2A

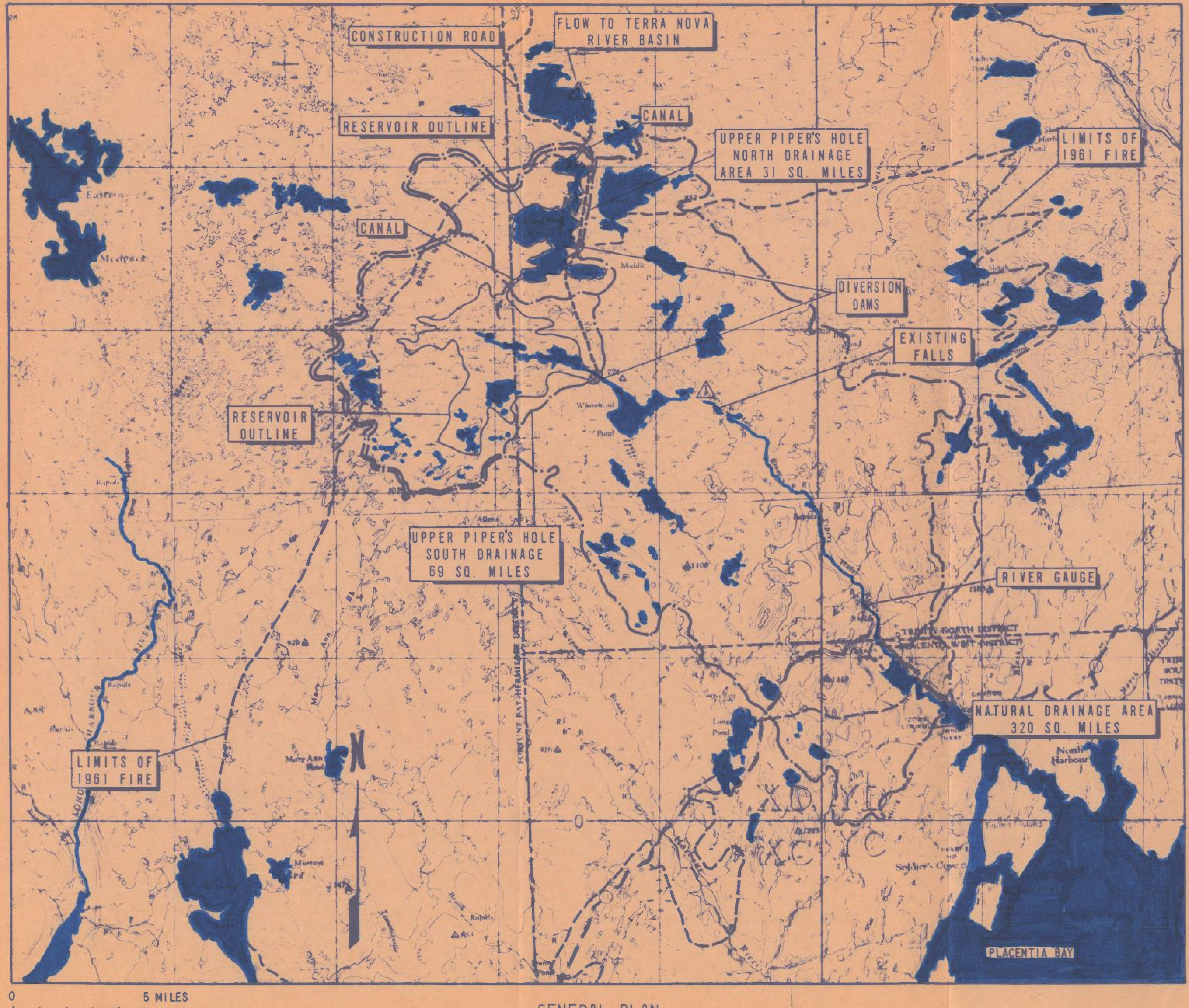
Development	Star Lake	Shandethit Brook
Land Purchase	--	--
Land Clearing	12×10^3	8×10^3
Roads and Bridges	700	905
Railways, Diversions of Power Lines	--	--
Dams, Spillways, and Reservoirs	2,215	3,195
Headworks, Water Conduits, Tailrace	2,222	4,275
Powerhouse and PH Equipment	1,730	2,190
Substation Including Transformers	450	500
Construction Indirect Costs	894	1,370
Project Management and Engineering	822	1,245
Contingency	1,233	1,867
Subtotal	10,279	15,555
Owner's Cost	103	155
Interest During Construction	668	1,010
TOTAL PROJECT COST	$11,050 \times 10^3$	$16,720 \times 10^3$
Annual Fixed Charges at 6.73%	745×10^3	$1,128 \times 10^3$
Annual Operating and Maintenance Costs	84×10^3	108×10^3
Total Annual Charges	829×10^3	$1,238 \times 10^3$
Capital Cost per Installed HP	$313	$334
COST OF FIRM ENERGY (at Plant Busbar) mills per KW hr	6.5	7.4

STAR LAKE DEVELOPMENT

TABLE 3.2B

The Shawinigan Engineering Company Limited

James F. MacLaren Limited



GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

NOTE: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED.

1 ATLANTIC SALMON AREA UPSTREAM OF EXISTING FALLS.

2 UPPER AREA DIVERSION TO TERRA NOVA HYDROELECTRIC DEVELOPMENT.

PIPER'S HOLE RIVER BASIN

FIGURE 2.1

PART lV

REPORTS DONE FOR BOWATER POWER COMPANY
ON HYDRO ELECTRIC POTENTIAL OF
LITTLE GRAND LAKE AND HINDS LAKE

4.1 Report on Proposed Power Development at Little Grand Lake for the Bowater Power Company Limited

GENERAL

This report was written in 1959 by The Shawinigan Engineering Company Limited. It presents a preliminary study and estimate of cost for the development at Little Grand Lake to supply additional power to the Bowater system.

LOCATION

Little Grand Lake is located in the west central part of the island of Newfoundland. The drainage basin is located to the south of, and drains into, Grand Lake. It forms a part of the Humber River drainage system feeding the Deer Lake Power Development from Grand Lake. The drainage area to be used is 173 square miles.

PROPOSED SCHEME

The proposed scheme calls for the construction of a dam of earth and rock fill at the outlet of Little Grand Lake to raise the operating level approximately 33 feet. This will provide a storage volume of 4.73 BCF and provide a flow of 546 cfs 100 percent of the time. The flow duration curves are shown in Fig. 6.

An intake in the north bank leads the water from Little Grand Lake through a power tunnel to the power house near Grand Lake. A surge tank is provided on the tunnel line.

The forebay and tailrace levels are tabulated below:-

Maximum reservoir flood level	522.0
Reservoir full supply level	513.0
Reservoir minimum supply level	483.0
Maximum tailrace level	287.0
Minimum tailrace level	277.0

Based on the regulation studies it is proposed to install a single unit, vertical Francis type rated at 14,000 H.P. under a net head of 205 feet and rotating a 375 rpm. The size of the unit will ensure complete use of the available water in most years and the unit can operate at a load factor comparable to that of the Bowater Power Company system.

AVAILABLE ENERGY AND CAPACITY

The available energy and capacity are determined from the hydrograph of regulated flows using the following assumptions:-

a) NO turbine overload.
b) An overall electrical efficiency to the transformer high tension bus of 95%.
c) A utilization factor of 90 per cent applied to energy.
d) All the energy produced by the plant can be absorbed by the Bowater system.
e) The prime power is based on the mean net head and minimum regulated flow for each year of record.

The average capability of the plant is listed below:-

Prime Power	11,300 HP
Primary Energy	63.3×10^6 KW hr/year
Secondary Energy	5.0×10^6 KW hr/year
Total Energy	68.3×10^6 KW hr/year
Annual Capacity Factor	78.5 per cent

ESTIMATE OF COST

This estimate is listed below:-

Job Administration*	$ 685,000
Temporary Construction*	700,000
Auxiliary Work*	315,000
Permanent Structures*	2,725,000
Permanent Equipment*	1,350,000
Construction Fee	215,000
Interest during Construction	360,000
Contingencies	650,000
Total cost of Development	$7,000,000
Cost of transmission from Little Grand Lake to Corner Brook sub-station	375,000
Total Cost	$7,375,000

*These costs are computed in more detailed in the report studied.

The estimated cost presented here is based on present day costs (1959), and a 28-month construction schedule for the scheme proposed in this report. The estimate does not include the cost of the following:-

(i) Clearing of flooded area.
(ii) Construction of main access road to powerhouse site.
(iii) Terminal facilities at Corner Brook.
(iv) Preliminary Investigations.
(v) Bowater Power Company charges.
(vi) Financing and legal expenses.
(vii) Payments to Federal or Provincial Governments other than sales taxes and customs duties where applicable.

ESTIMATED COST PER KILOWATT-HOUR

Fixed Charges

Interest	6%
Depreciation	2%
Total	8%

Operation and Maintenance

	Development	Transmission Line
Insurance	5,000	
Operation	10,000	
Maintenance	25,000	
Administration	10,000	
Total	$50,000	$20,000

Cost per Kilowatt-Hour

	Development	Transmission Line	Total
Estimated Cost	$ 7,000,000	$ 375,000	$ 7,375,000
Fixed Charges	560,000	30,000	590,000
Operation and Maintenance	50,000	20,000	70,000
Total Cost	$ 610,000	$ 50,000	$ 660,000
Annual KW hr Available at HV bus	68,300,000	(1,550,000 loss)	66,750,000
Mills per KW hr.	8.93		9.89

* Energy delivered at Corner Brook.

CONCLUSIONS

The general conclusion is that due to the high cost per horsepower, it is recommended that other available power sites be studies to ascertain if there is not a cheaper scheme.

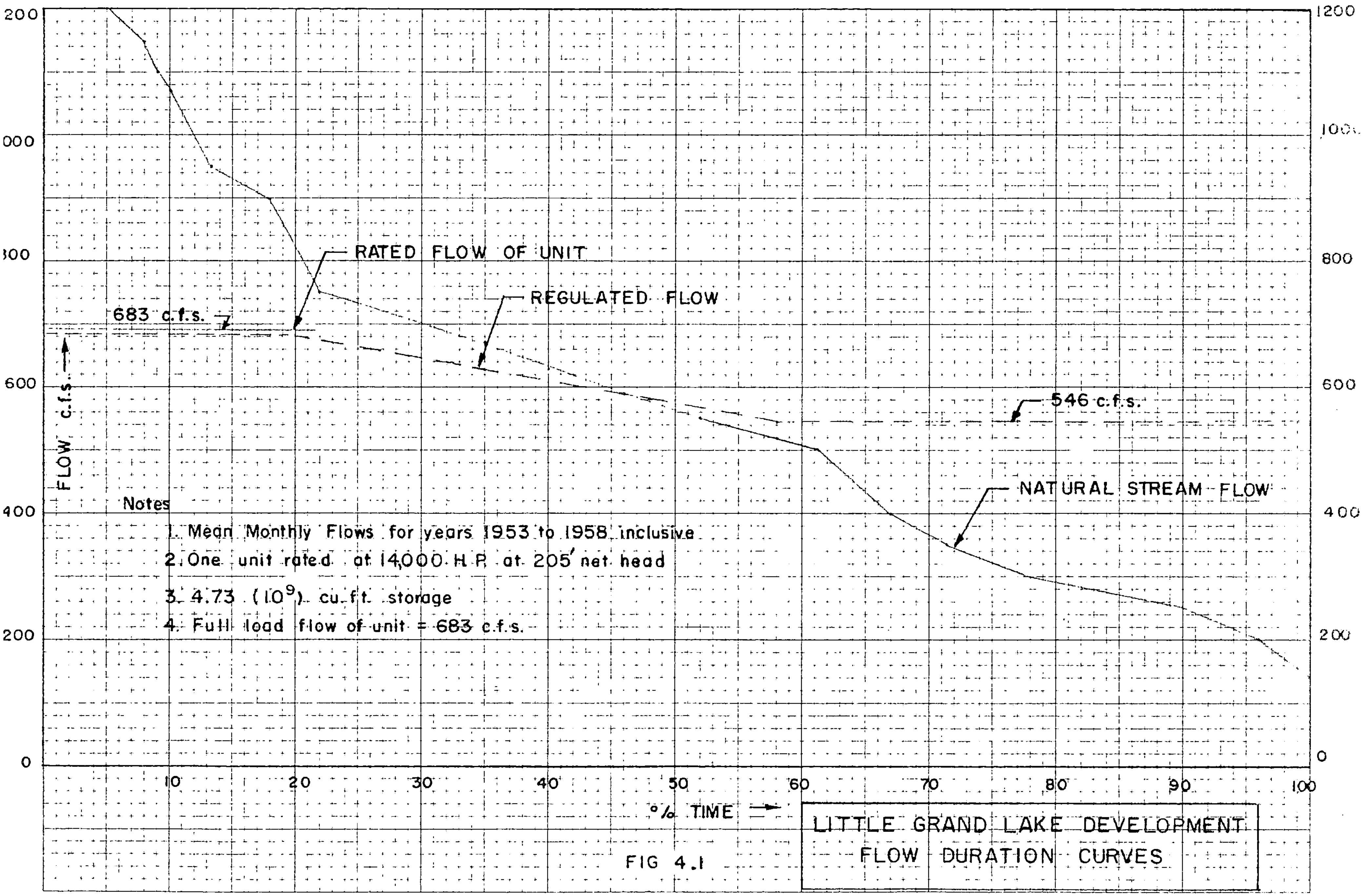

200
000
300
600
400
200
0
1200
1000
800
600
400
200
0
FLOW c.f.s.
RATED FLOW OF UNIT
REGULATED FLOW
683 c.f.s.
546 c.f.s.
NATURAL STREAM FLOW
Notes
1. Mean Monthly Flows for years 1953 to 1958 inclusive
2. One unit rated at 14,000 H.P. at 205′ net head
3. 4.73 (10⁹) cu. ft. storage
4. Full load flow of unit = 683 c.f.s.
10
20
30
40
50
60
70
80
90
100
% TIME
LITTLE GRAND LAKE DEVELOPMENT
FLOW DURATION CURVES

FIG 4.1

4.2 Report on Proposed Power Development at Hinds Lake for the Bowater Power Company Limited

GENERAL

This report was written in 1957 by The Shawinigan Engineering Company Limited. It presents a preliminary study and estimate of cost for a development at Hinds Lake. The scheme is based on raising the level of Hinds Lake by approximately 15 feet and utilizing the 732 foot fall between it and Grand Lake.

PROPOSED SCHEME

The proposed scheme calls for the utilization of the drainage areas of Hinds Lake (189 sq. mi.) and Goose Pond (42 sq. mi.). The plan calls for the construction of an earth and rockfill dam on Hinds Brook, 5 miles from its present outlet and a small earth dam at the east end of Hinds Lake. The flow from Goose Pond will be diverted by means of small dykes and a canal.

This will give a reservoir on Hinds Lake at an elevation of 1017 feet and will provide a storage volume of 7 BCF. The mean gross head will be 726 feet and the dependable regulated flow (90% of the time) will be 540 cfs. The water is transported from Hinds Lake to the penstock by an open canal along the north bank of Hinds Brook. This canal is 23,000 feet long and the steel penstock leading to the powerhouse on the shore of Grand Lake is 4,800 feet long and 8 feet in diameter.

The turbines installed in the powerhouse are based on a load factor of 75 percent and correspond to a flow of 790 cfs which is available 7 per cent of the time. There will be two 27,000 HP units installed. These will operate under a net head of 684 feet at 600 rpm. The generators will be rated 22 MVA, 13.8 KV, three phase, 50 HZ, 0.95 p.f., and 600 rpm. The powerhouse will be unattended and automatic in operation, with the units controlled from Deer Lake.

AVAILABLE ENERGY AND POWER

The flow duration curves for this development are shown in Fig. 7. From these curves the energy and capacity factors have been determined based on the following assumptions:-

(a) All the energy produced by the plant can be absorbed by the Bowater system.
(b) A utilization factor of 90 percent.
(c) An overall electrical efficiency to the transformer high tension bus of 95 per cent.

(d) NO turbine overload.
(e) NO storage at Goose Pond.
(f) Constant net head of 684 feet.

The mean annual available energy is 238 x 10^6 KW hr and the capacity factor is 75.0 per cent.

The primary power is based on the above assumptions, except that no utilization factor is included. The value of primary power derived from the flow available 90 per cent of the time on the duration curve is 37,500 H.P.

ESTIMATED COST

The estimated cost is based on present-day (1957) costs of labour, material and equipment, and a 30-month construction period for the development described above. The estimate does not include the cost of the following:-

(a) Transmission Lines.
(b) Clearing of Flooded Areas.
(c) Preliminary Investigations.
(d) Bowater Power Company Charges.
(e) Financing and Legal Expenses.
(f) Payments to the Federal and Provincial Governments other than sales taxes and custom duties where applicable.

Based on this the total project cost is estimated to be $16,000,000. A detailed list of the cost of the various parts of this development is given in Table 41.

ESTIMATED COST PER KW HR

These costs are based on the following fixed charges:-

Interest	5.5%
Depreciation	2.0%
Total	7.5%

Operation and Maintenance are estimated as follows:-

Insurance	$10,000
Operation	20,000
Administration	15,000
Maintenance	40,000
Total	$85,000

Therefore, the cost per KW hr. is computed as follows:-

Estimated Cost	$ 16,000,000
Annual KW hr. Available	238,000,000
Fixed Charges	$ 1,200,000
Operation and Maintenance	85,000
Total	$ 1,285,000
Mills per KW hr.	5.4

CONCLUSIONS

The cost of $295 per HP for this development is primarily a consequence of the great distance between the powerhouse and Hinds Lake when the full available head is developed.

The large storage in Hinds Lake makes the plant particularly suited to meet block load peaks in addition to its energy contrubition to the system.

Job Administration	1,520,000	
Temporary Construction	1,100,000	
Auxiliary Work	325,000	
Penstock	1,700,000	
Powerhouse	550,000	
Goose Pond Dam and Canal	550,000	
Hinds Brook Dam	1,940,000	
Bypass and Intake Sections	850,000	
Canal	2,500,000	
Channel Improvement	100,000	
Permanent Dwelling	25,000	
Hydraulic Equipment	600,000	
Electrical Equipment	1,550,000	
Supervisory Control Equipment	50,000	
Auxiliary Equipment	175,000	
Sluice and Intake Section Equipment	175,000	13,710,000
Construction Fee	400,000	
Interest During Construction	800,000	
Contingencies	1,090,000	2,290,000
Total Estimate of Cost		$16,000,000

ESTIMATED COST OF HINDS LAKE DEVELOPMENT

TABLE 4.1

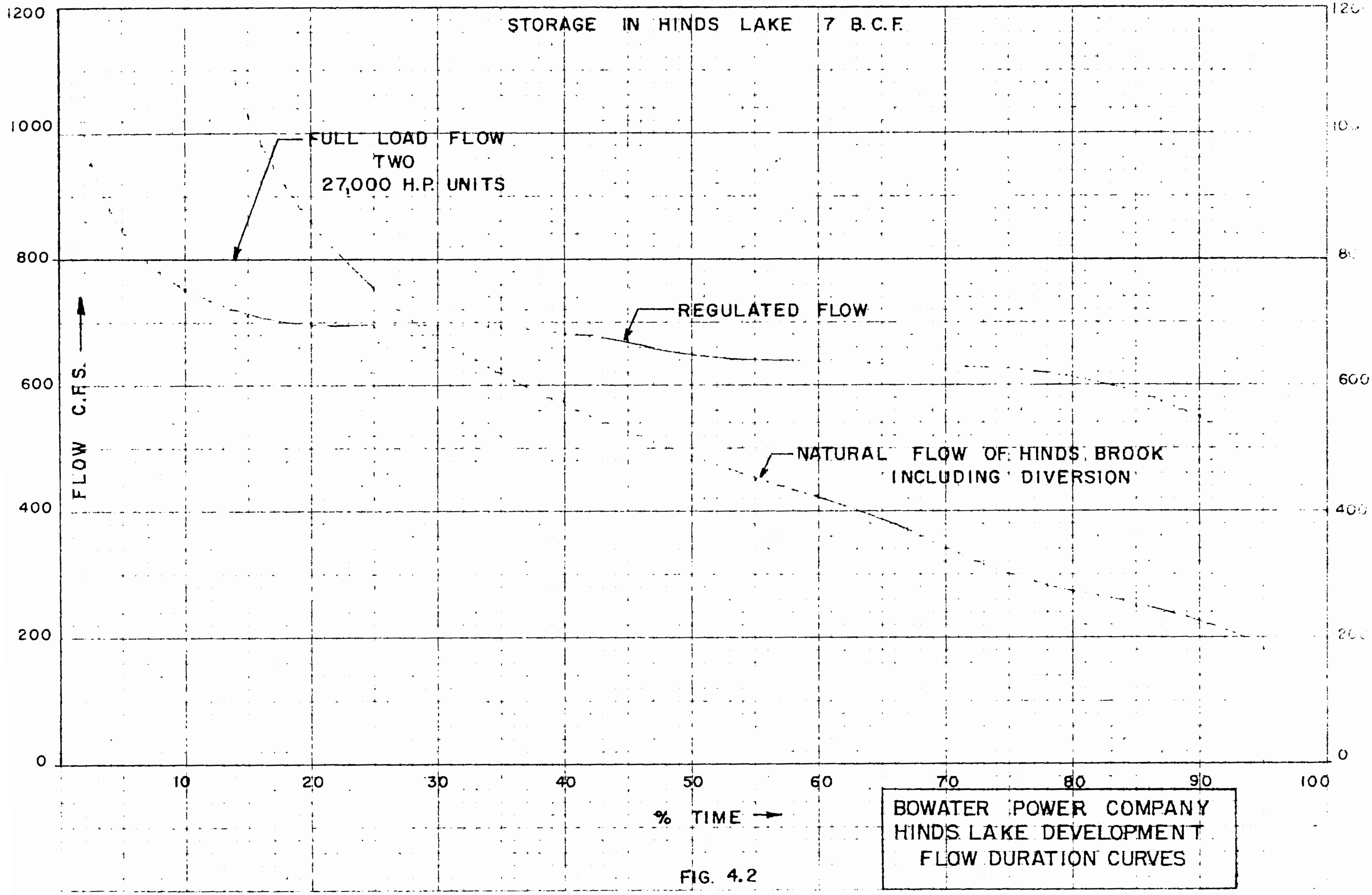
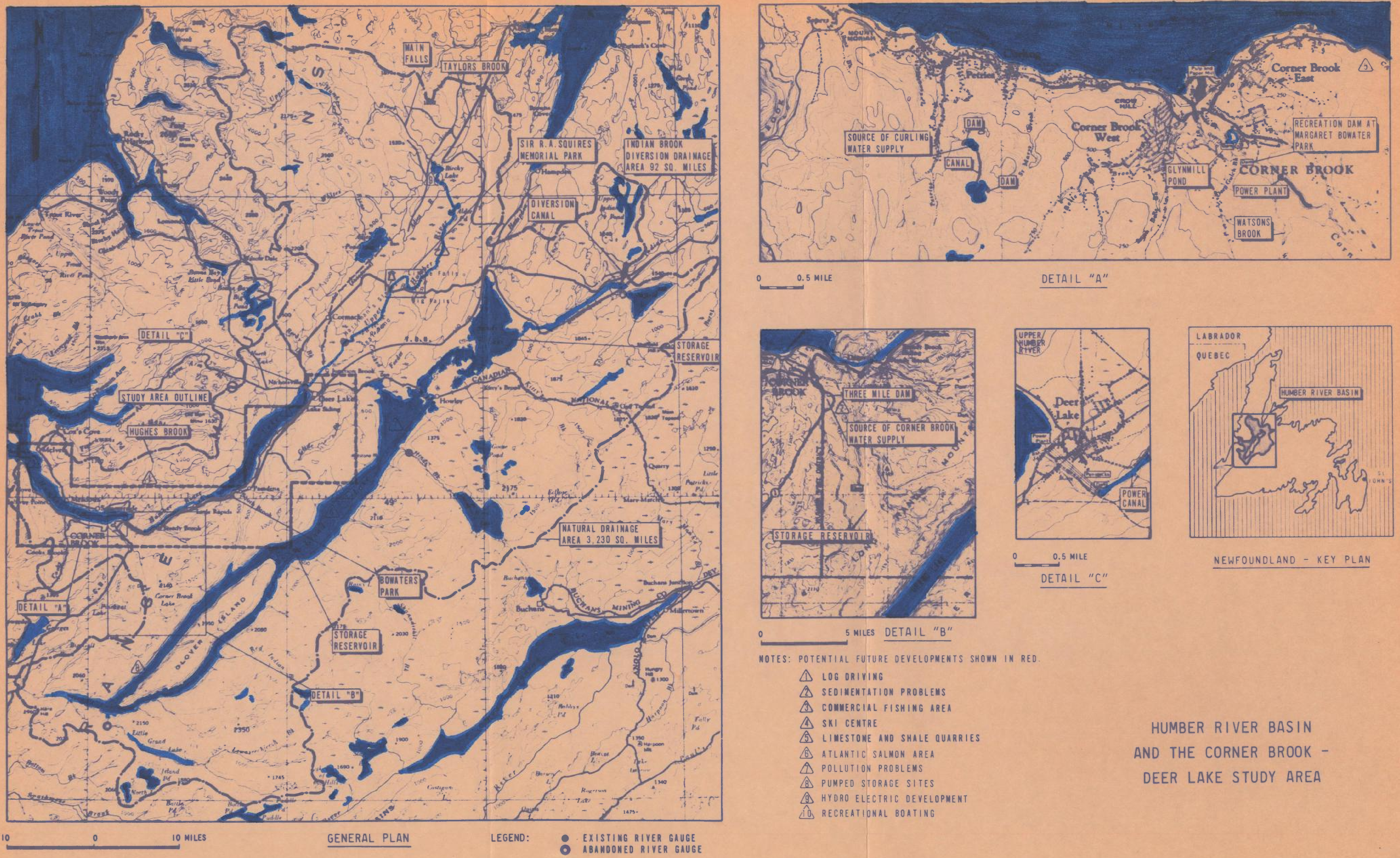

STORAGE IN HINDS LAKE 7 B.C.F.
FULL LOAD FLOW
TWO
27,000 H.P. UNITS
REGULATED FLOW
NATURAL FLOW OF HINDS BROOK
INCLUDING DIVERSION
FLOW C.F.S.
1200
1000
800
600
400
200
0
10
20
30
40
50
60
70
80
90
100
% TIME
BOWATER POWER COMPANY
HINDS LAKE DEVELOPMENT
FLOW DURATION CURVES

FIG. 4.2



HUMBER RIVER BASIN AND THE CORNER BROOK - DEER LAKE STUDY AREA

FIGURE 4-3

PART V

POWER DEVELOPMENTS ON EXPLOITS RIVER
PRICE (NFLD) LIMITED

5.1 Report on Proposed Hydro Electric Station and Improvements to Steam Plant, Paper and Pulp Mills

This report was done in 1923 by G.F. Hardy, Consulting Engineer, New York City, N.Y. The report considers four possible sources of additional electric power for use at Grand Falls:-

(a) A new plant on the west side of the river at Grand Falls.
(b) An extension of the present hydro-electric plant.
(c) A new power house at Badger Chute.
(d) A new power house at Red Indian Falls.

Duration flow curves for the Exploits River at Grand Falls show that 4000 cfs is available 88 per cent of the time and 5000 cfs is available 75 per cent of the time. Based on previous use of water at Grand Falls it was concluded that it was possible to increase the use of water at Grand Falls by from 2000 to 3000 cfs. This would produce from 20,000 to 30,000 HP. If this power is developed it would be necessary to develop additional storage on Red Indian Lake and Victoria Lake.

Power Plant on West Side of River at Grand Falls

This scheme is referred to as Proposal "A" in the report and is shown in Fig. 8. The west shore of the river from the dam to the mouth of Stoney Brook is a steep ledge bank rising in places at an angle of 45° and having little or no earth overlay. Ice was believed to be a problem if this scheme was used - difficult to divert slush away from racks.

The estimate of cost for this development (based on 1923 prices) was $1,860,000 for 28,000 HP or $60 per horsepower.

Extension of the Present Hydro-Electric Plant

This scheme is referred to as Proposal "B" in the report and is also shown in Fig. 8.

For this proposal, estimated cost, including complete headworks for four penstocks, change in penstock #2, new penstocks #3 and #4, surge tank for four penstocks, extension of housing to include all penstocks, new power house with two units to give approximately 28,000 HP maximum at the generator switchboard, is approximately $1,680,000 or $60 per HP.

This compares favourably with Proposal "A" in first cost, and when operating cost is considered, becomes the more attractive of the two.

Another proposal sets the rack at an angle in the opposite direction from that shown in Fig. 8. . The total cost is approximately the same but the opinion of Mr. Hardy is that this proposal is the better choice.

Badger Chute

This development would use a maximum flow of 4700 cfs and a gross head of 37 feet. The dam for this development would consist of: starting at southwest end, 200 feet of spillway dam with crest elevation of 403 feet, then two sluice gates and then 300 feet of spillway dam with crest elevation of 403 feet. The power house would be an integral part of the dam. The maximum output would be 15,000 HP at terminals of step down transformers at Grand Falls.

The dam, power house, transmission line and step down transformer would cost approximately $1,350,000 or $90 per HP delivered.

Red Indian Falls

This development would use a flow of 4000 cfs, and a head of 46.4 feet. It would deliver 15,800 HP at Grand Falls.

No estimate of cost was given. However, Mr. Hardy judged that the cost per HP will be considerably more than the proposal at Badger Chute.

Conclusion

Mr. Hardy recommends that Proposal "B" (extension of the present hydro-electric plant) be developed, if any improvement at all is to be made for using surplus water.

5.2 Report on The Red Indian Falls Power Development

This report was written in 1959 by The Newfoundland Light and Power Company Limited.

The proposal was to install under 60 feet of lead one 25,000 HP, 50 HZ unit operated so that 20,000 HP would be delivered in Grand Falls up to a monthly load factor of 85 per cent and one 12,500 HP duel frequency unit. This unit would operate when streamflows in excess of that required by the large unit were available. At this time Rattling Brook output would be cut back in order to store water in the Rattling Brook reservoir.

The present water level at the foot of Red Indian Falls is 355 feet and at head of the falls is 372 feet. It is proposed to raise the water level at the head of the falls to 415 feet giving a gross head of 60 feet across the falls and create a pond about 7 miles long. Surface area of headpond at elevation of 415 feet is about 1150 acres. Development of this headpond makes it necessary to relocate about six miles of the Badger to Buchans highway.

Newfoundland Light and Power Company proposed that Price (Nfld) Ltd. keep complete control over water rights and control over storage.

No estimate of the cost of this development is given. However, a proposal for sale of power is presented based on 1959 equipment and construction costs. Two main features of this proposal are that Price pay $525,000 per annum for an initial 15,000 HP of motive power and $35,000 per annum for each additional block of 1,000 HP of motive power. Note this is for delivery to Price of 15,000 HP initially plus such additional power as Price may require from time to time up to 20,000 HP.

5.3 Letter Report to Chief Engineer of the Anglo Development Company Limited from Montreal Engineering Co. Ltd.

This letter is dated April 14, 1960. It mentions that previously it was decided to study the operation of the Exploits River and the storage at Red Indian Lake for provision of 5300 cfs at Grand Falls with reference to the power which could be developed at Red Indian Falls. This method of operation would result in very low flows in 1946 - 48. Therefore, it was decided to study some modifications of the operating rule curve.

The report studies three modifications of the rule curve. The results of these studies state that the calculations tend to substantiate Montreal Engineering's earlier estimates of power available at Red Indian Falls. An estimated 12,000 KW continuous could be delivered in Grand Falls from a 60 foot head development at Red Indian Falls except for infrequent short periods of extreme draught.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OF
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PART V1

CAT ARM RIVER DEVELOPMENT

6.1 Water Resources Study of the Province of Newfoundland and Labrador for Atlantic Development Board (Cat Arm River)

The Cat Arm River, with a total natural drainage area of 324 square miles, is located on the east side of the Long Range Mountains on the Great Northern Peninsula. The upper reaches of the drainage area exceed 2000 feet in elevation, and the total area has one of the highest average drainage area elevations on the Island.

Several development opportunities exist along the river. These developments were investigated in order to determine the optimum scheme. A summary of these investigations is given in Table 6.1A and Table 6.1B.

From these tables it can be seen that the most attractive scheme is 2B. This scheme was first investigated at a capacity factor of 50 per cent. Then it was appraised at 60 per cent capacity factor in order to compare it with schemes reported in ShawMont reports. Scheme 2C investigates the cost of increased storage while schemes 2D and 2E investigate the effects of varied capacity factors on energy and capital costs per installed horsepower.

Development 2 requires a rock-fill type storage dam with a maximum height of approximately 170 feet. This would create a reservoir with a full supply level of 1280 feet. A low supply level of 1249 would provide a storage volume of 257,000 acre feet which is required to regulate the flow from the 241 square mile drainage area to a 725 cfs minimum plant outflow.

Conclusions of this report state that the Cat Arm River basin has attractive hydro-electric potential which is competitive with other undeveloped sites on the island. No conflict with fishery resources is likely since anadromous fish cannot pass a natural barrier located at the river mouth. Some conflict may occur with the forestry resource due to flooding of some of the timber area.

Recommendations are that the river should be considered for future development and more detailed studies be carried out to assess the basins hydro-electric potential. This should be done in conjunction with a complete assessment of the other natural resources to permit integrated resource development in this area.

Development		1 50% CF	2A 50% CF	2B 60% CF	2C 60% CF	2D 40% CF	2E 30% CF
Drainage Basins Development		Upper Cat Arm Middle Cat Arm	Upper Cat Arm	Upper Cat Arm	Upper Cat Arm	Upper Cat Arm	Upper Cat Arm
Total Drainage Area	sq. mi.	296	241	241	241	241	241
Total Regulated Flow	cfs	770	725	725	725	725	725
Full Supply Level	feet	742	1,280	1,280	1,292(A)	1,280	1,280
Drawdown	feet	5	31	31	52	31	31
Low Supply Level	feet	735	1,249	1,249	1,240	1,249	1,249
Tailwater Level	feet	100	0	0	0	0	0
Average Gross Head	feet	640	1,265	1,265	1,262	1,265	1,265
Average Net Head at Regulated Flow	feet	620	1,227	1,227	1,234	1,227	1,227
Continous HP Available	HP	50,000	94,000	94,000	97,000	94,000	94,000
Annual Firm Energy	KW hr	299×10^6	554×10^6	554×10^6	560×10^6	554×10^6	554×10^6
INSTALLED CAPACITY	HP	100,000 (2 units)	190,000 (3units)	164,000(3 units)	160,000 (3 units)	250,000 (3 units)	325,000 (3 units)

NOTES: 1. A: Indicates effects of increasing storage demand from 257,000 (Scheme 2B) to 430,000 acre feet.
2. Cost of energy shown in Table 6.1B are firm energy only. Secondary energy benefits, which may amount to as much as 20% of the firm energy have not been calculated for the schemes investigated.
3. Estimates do not include the cost of clearing flooded areas or those costs related to other uses of water resources.

CAT ARM RIVER DEVELOPMENT (1968)

TABLE 6.1A

Development	1 50% C.F.	2A 50% C.F.	2B 60% C.F.	2C 60% C.F.	2D 40% C.F.	2E 30% C.F.
Land Purchase	--	--	--	--	--	--
Land Clearing	20×10^3	46×10^3	46×10^3	46×10^3	46×10^3	46×10^3
Roads and Bridges	1,600	1,425	1,425	1,425	1,425	1,425
Railways, Diversion of Power Lines	--	--	--	--	--	--
Dams, Spillways & Reservoirs	7,102	6,952	6,952	8,612	6,952	6,952
Headworks, Water Conduits, Tailrace	6,663	11,076	9,775	9,775	12,501	14,274
Power House and PH Equipment	4,300	5,960	5,420	5,420	6,650	7,220
Substation Including Transformers	620	1,450	1,200	1,200	2,000	2,700
Construction Indirect Costs	2,556	3,304	3,064	3,280	3,579	3,883
Project Management and engineering	2,286	3,021	2,788	2,976	3,315	3,650
Contingency	3,429	4,532	4,182	4,464	4,973	5,475
Subtotal	28,576	37,766	34,852	37,198	41,441	45,625
Owner's Cost	286	377	348	372	414	456
Interest During Construction	1,857	2,455	2,265	2,418	2,694	2,966
TOTAL PROJECT COST	$30,719 \times 10^3$	$40,598 \times 10^3$	$37,465 \times 10^3$	$39,988 \times 10^3$	$44,549 \times 10^3$	$49,047 \times 10^3$
Annual Fixed Charges at 6.73%	2,067,000	2,732,000	2,522,000	2,691,000	2,998,000	3,300,000
Annual Operating & Maintenance Cost	164,000	265,000	224,000	224,000	313,000	407,000
Total Annual Charges	2,231,000	2,997,000	2,746,000	2,915,000	3,311,000	3,707,000
Capital Cost per Installed HP ($/HP)	307	214	234	250	178	151
COST OF FIRM ENERGY (At Plant Busbar) Mills per HWH	7.5	5.4	5.0	5.2	6.0	6.7

CAT ARM RIVER DEVELOPMENT (1968)

TABLE 6.1B

6.2 Hydro Electric Potential of Cat Arm River

This report was done for the Newfoundland and Labrador Power Commission by ShawMont Newfoundland Limited in July, 1971.

All costs quoted in this report are based on 1:50,000 scale topographic mapping and the visual observations made during a one day field reconnaissance. It is the opinion of the writer of the above report that these cost estimates could be in error by as much as15 per cent.

River flows were computed using a multiple regression analysis on the Shawinigan Engineering computer and using several other rivers in the vicinity of Cat Arm. The average flow for the period studied is 3.4 cfs per square mile which is less than the 5.4 cfs per square mile originally anticipated.

The line storage required was determined as a function of firm regulated flow. This variation is shown below:-

Firm Flow	Line Storage Requirements	
cfs	cfs-months	acre feet
500	2870	173,500
600	3870	234,000
700	4870	294,000
750	5870	325,000
800	6328	382,000

The average energy capability of the Cat Arm site at different firm flows and capacity factors was also determined as shown below:-

Firm Flow cfs	Load Factor %	Installation cfs	Average Energy cfs-years
600	60	1000	803
	50	1200	811
	40	1500	815
	30	2000	821
700	60	1165	814
	50	1400	818
	40	1750	820
	30	2340	824
750	60	1250	810
	50	1500	816
	40	1875	820
	30	2500	822

Storage will be developed on the Cat Arm River by means of a dam across the river immediately downstream of the guaging station on Cat Arm River. Cut-off dams and spillways will be located 15,000 feet north of the main dam. Lake levels will be raised approximately 130 feet and 155 feet to provide 35 feet of live storage for the lower storage development, and 60 feet of live storage for the higher development. The various developments studied in this report are described below.

DESCRIPTION OF ALTERNATIVES STUDIED

Anternative 1 Power Canal, intake dam and intake, 26,000 feet of pipeline and penstock, surge tank, and power house at sea level in Devil Cove. Development runs west to east through natural valley along latitude 50°01'. Installed capacity is 105 MW with a capital cost of $48,000,000.

Alternative 2 Stage 1. Power Canal beside storage dam, intake dam and intake 10,000 feet northwest of storage dam, 6,000 feet of pipeline and penstock, surge tank, and power house at elevation 850 on Cat Arm River.

Stage 2. Dam on Cat Arm River approximately 12,000 feet from mouth of river to create forebay storage and head, intake through this dam, 19,000 feet of pipeline and penstock, surge tank, and powerhouse at sea level at mouth of river. Installed capacity of 105 MW at a capital cost of $63,000,000.

Alternative 3 Power Canal approximately 11,000 feet long, intake dam and intake, 13,000 feet of pipeline and penstock, surge tank, and power house at sea level in Devil Cove. Development runs west to east through natural valley along latitude 50°02'. Installed capacity is 105 MW with a capital cost of $58,000,000.

Alternative 4 Development running through valley as in Alternative 1. Power Canal, intake dam and intake, 5,000 feet of pipeline, surge tank, and powerhouse at lake elevation about 950. Second intake dam and intake about 5,000 feet east of first powerhouse, 13,000 feet of pipeline and penstock, surge tank, and powerhouse at sea level south of Devil Cove. Installed capacity is 100 MW at a capital cost of $55,000,000.

Alternative 5 Diversion canal and dam in natural valley used in Alternatives 1 and 4. Power canal, intake dam and intake, 12,000 feet of pipeline and penstock, surge tank, and powerhouse at sea level located at head of Devil Cove. Installed capacity is 105 MW at a capital cost of $181,000,000.

Alternative 6 Power canal with regulating structure, intake dam, and intake, 16,000 feet of pipeline and penstock, surge tank, and powerhouse at sea level south of Devil Cove. Installed capacity is 92 MW at a capital cost of $43,000,000

A summary of each of these alternatives is given in Table 6.2.

CONCLUSIONS

Neither alternative studied can be developed at a cost which is competitive with other alternative sites on the island. The basic layout described by Shawinigan - MacLaren offers the cheapest energy (Alternative 1). The incremental cost of providing additional energy with an Alternative 1 arrangement by increasing storage is about 5.6 mills per HW hr. This is the cost of energy alone with no increase in capacity.

	Alternative 1	Alternative 1 High Storage	Alternative 2 Stage 1	Alternative 2 Stage 2	Alternative 3	Alternative 4 Stage 1	Alternative 4 Stage 2	Alternative 5	Alternative 6
Drainage Area	241	241	241	53	241	241	--	241	241
Line Storage	295,000	410,000		295,000	295,000	295,000	--	295,000	295,000
Drawdown	35	60		35	35	35		35	35
Full Supply Level	1,285	1,310		1,285	1,285	1,285		1,285	1,285
Firm Flow	700	800	700	50	700	700		700	700
Forebay Level	1,285	1,310	1,285	785	1,285	1,285	850	1,285	1,000
Drawdown	35	60	35	0	35	35	0	35	0
Tailwater Level	0	0	850	0	0	950	0	0	0
Average Gross Head	1,269	1,280	417	785	1,269	317	850	1,269	1,000
Capacity Factor	60%	68½%	60%	60%	60%	60%	60%	60%	60%
Capacity - KW	114,000	115,000	113,000		114,000	105,000		114,000	90,000
- HP	155,000	157,000	51,000		155,000	39,000		155,000	123,000
			103,000			104,000			
Cost	$48,000,000	$53,000,000	$63,000,000		$58,000,000	$55,000,000		$181,000,000	$43,000,000
Cost per KW Installed Capacity	$421	$462	$558		$509	$524		$1,600	$478

CAT ARM RIVER DEVELOPMENT (1971)

TABLE 6.2 Page 1 of 2

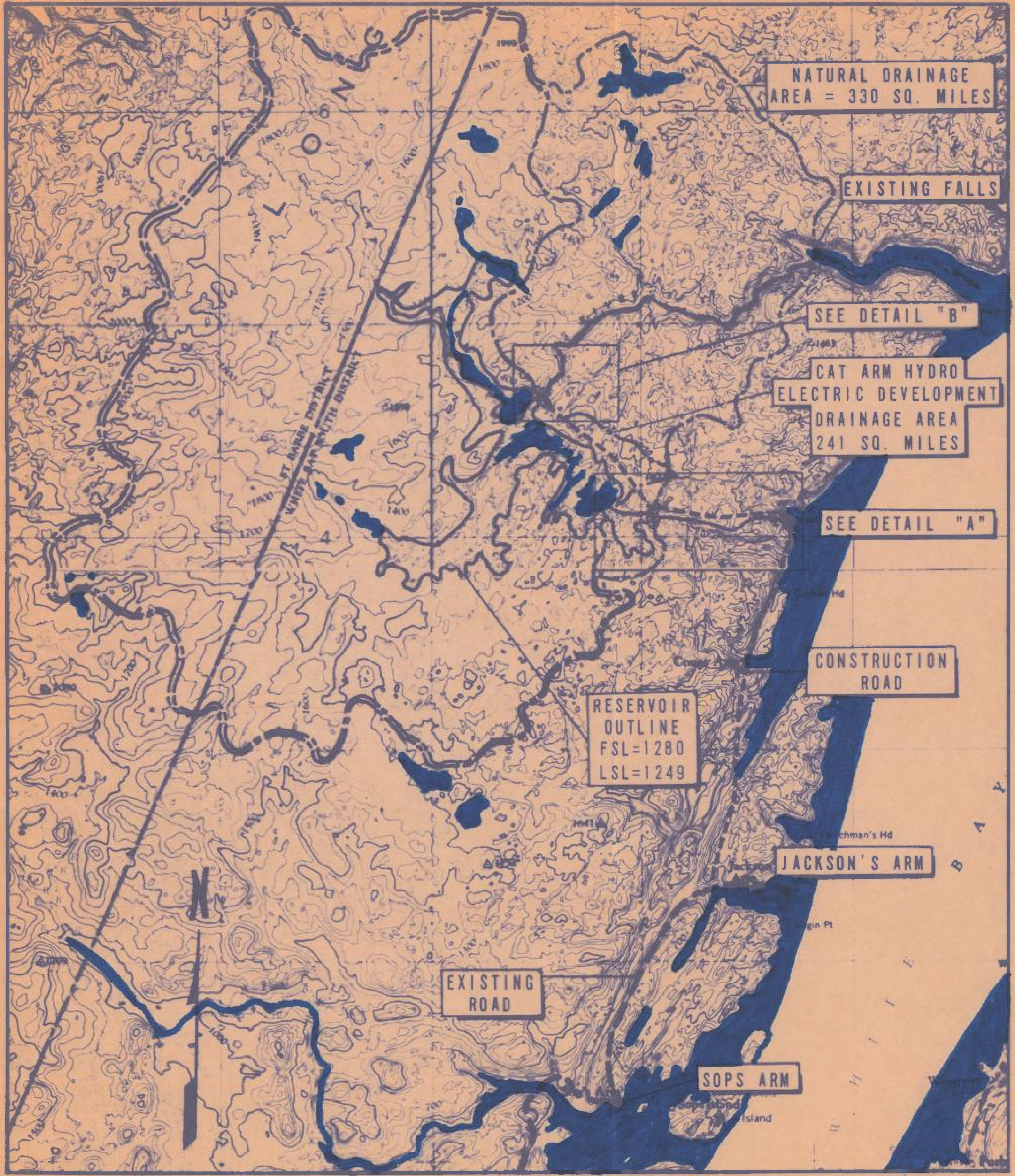
	Alternative 1	Alternative 1 High Storage	Alternative 2 Stage 1 Stage 2	Alternative 3	Alternative 4 Stage 1 Stage 2	Alternative 5	Alternative 6
Annual Charges @9½%	$4,550,000	$5,050,000	$6,000,000	$5,500,000	$5,200,000	$17,200,000	$4,100,0000
Annual Firm Energy Production X10 KWhr.	538	622	535	538	495	538	425
Cost per KW hr, mills	8.45	8.14	11.2	10.2	10.5	32	9.7

NOTES:

1. Firm energy is calculated assuming an overall plant, conduit and operating efficiency of 82%.
2. Rated capacity in HP is calculated assuming an overall turbine and conduit efficiency of 92%.
3. Rated capacity in kilowatts is calculated assuming a generator efficiency of 98%.

CAT ARM RIVER DEVELOPMENT (1971)

TABLE 6.2 Page 2 of 2



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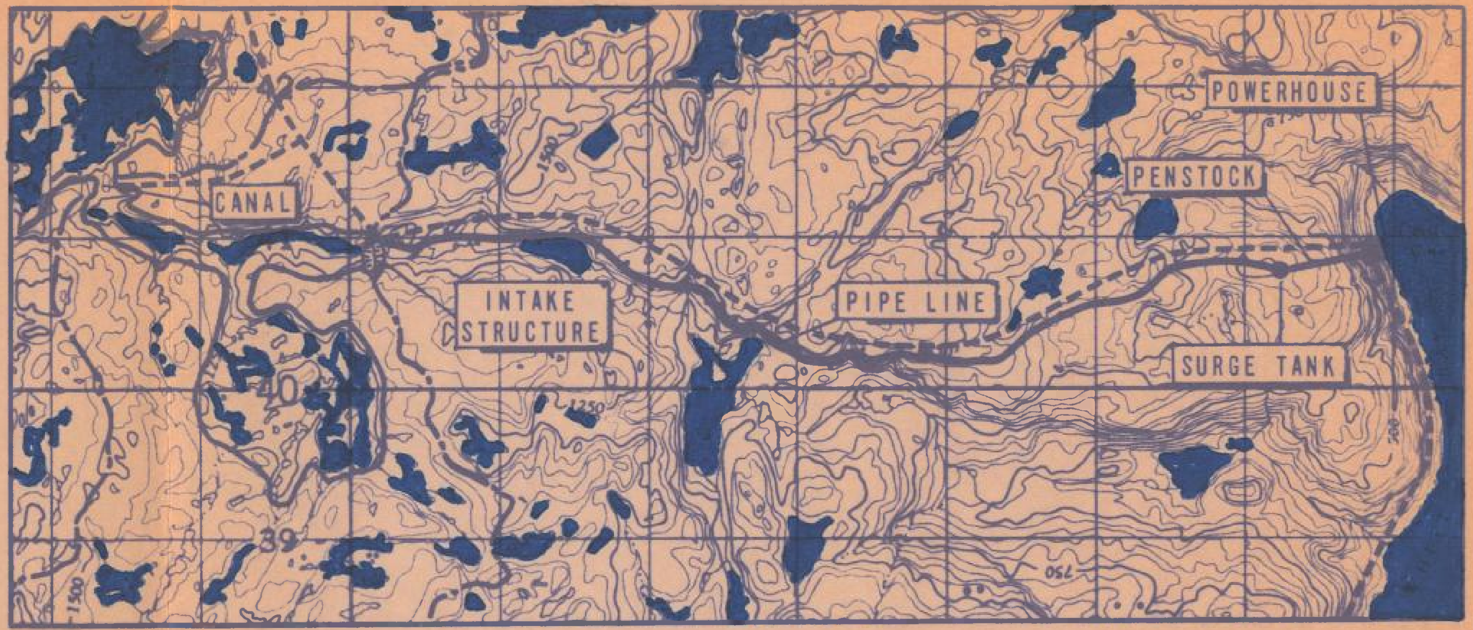
GENERAL PLAN



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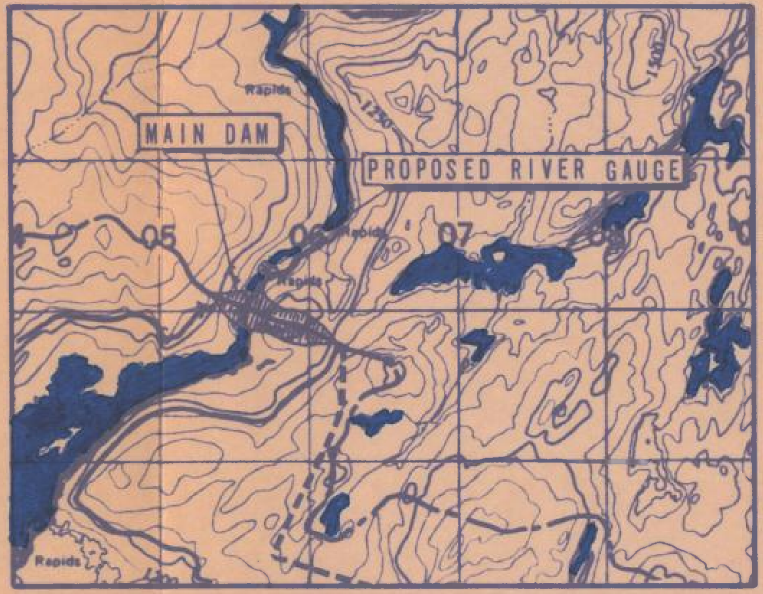
DETAIL "A"



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DETAIL "B"

NEWFOUNDLAND - KEY PLAN

CAT ARM RIVER BASIN

NOTE: POTENTIAL FUTURE DEVELOPMENT SHOWN IN RED

FIGURE 6.1

PART V11

Power Developments on North-West Coast of the

Great Northern Peninsula

7.1 Power Study - Great Northern Peninsula

This was the subject of a letter from ShawMont Newfoundland Limited to Mr. L. J. Cole, Chief Engineer, Newfoundland and Labrador Power Commission. The letter was dated June 29, 1971 and gives the results of four investigations carried out on the Great Northern Peninsula.

The four schemes examined were; one on Ten Mile Lake, one on the Torrent River, and two on the Castor's River. All schemes were evolved from a study of the 1:50,000 scale topographic maps. Hence, the cost estimates, although, in general, conservative, should be considered "Order-of-magnitude" only.

TEN MILE LAKE

Development consisting of a dam and spillway at the St. Geneviere River outlet from Ten Mile Lake, and a dam and canal at the north end of Ten Mile Lake to divert the flow of the West River into Ten Mile Lake. Construction of a fish ladder. Construction of a power canal, intake, pipeline and powerhouse containing one 6300 KW unit located two miles east of Brig Bay. Capital cost would be $6,300,000.

TORRENT RIVER

Development consisting of a dam, fish ladder, and spillway on the Torrent River five miles upstream of the town of Hawke Bay to raise the level of Western Brook Pond for storage. Construction of a power canal, intake, penstock and power house containing one 4600 KW unit two miles south of Hawke Bay on the west end of Western Brook Pond. Capital cost would be $3,700,000.

CASTOR'S RIVER - SCHEME 1

Development consisting of a dam, intake, and spillway at the rapids on the Castor's River about four miles upstream from the town of Castor's River, to raise the level of Leg Pond. Construction of a penstock, and powerhouse containing one 3900 KW unit located five thousand feet below the dam. Capital cost would be $3,500,000.

CASTOR'S RIVER - SCHEME 2

Development consisting of a dam and intake on the Castor's River above the rapids mentioned in Scheme 1. Construction of a spillway at a low point one mile south of the dam, and construction of a cut-off dam and diversion canal one and a half miles north of the main dam. The level of Leg Pond would be raised an additional sixty feet above the level anticipated in Scheme 1. Construction of a penstock and powerhouse containing one 8600 KW unit located seven thousand feet below the dam. Capital cost would be $6,800,000.

A summary of each of these developments is given in Table 7.1. It can be seen that the most attractive scheme from the point of view of firm energy is Scheme 2 of the Castor's River alternative. However, it has a much higher capital cost. This is also a good salmon river and it will not be easy to construct a by-pass arrangement for fish.

The next best alternative for the cost of firm energy is the Torrent River scheme. This is a poorer salmon river than the other two rivers studied. However, the Department of Fisheries indicates that conservation of Atlantic Salmon would present a problem in the development of any of these rivers.

Note that the cost of energy from Torrent River is presently competitive with the cost of energy from diesel generating sets. The Torrent River scheme is considered viable when compared to an operating diesel installation. However, if hydro is to be compared to the cost of standby diesel, the economics would be marginal indeed and it would be difficult to justify construction of a hydro plant even though hydro has a number of inherent advantages such as reliability, freedom from down time maintenance and the like.

Recommendations are that, if the Commission is interested in further study of hydro development in this area, then the Commission should have a site reconnaissance done by senior engineers, discuss the salmon problem with the Department of Fisheries, and the effect of integration of a hydro plant in the system. If the situation still look optomistic after this work, then a normal investigative and study program should be commenced.

Development		Ten Mile Lake Hydro Development	Torrent River Hydro Development	Castors River Hydro Development Scheme 1	Castors River Hydro Development Scheme 2
Storage	acre ft.	78,000	50,000	21,000	149,000
Drawdown	feet	6.5	9	20	44
Drainage Area	sq. mi.	137	240	170	168
Average Head at regulated flow	feet	151	88	129	175
Rated Head	feet	136	84	110	160
Overall efficiency		84%	84%	84%	84%
Capacity	KW	6,300	4,600	3,900	8,650
Capacity Factor		61.2%	60%	60%	60%
Total Capital Cost		6,300,000	3,700,000	3,500,000	6,800,000
Production in minimum year	KWH x 10^6	24.5	22.6	13.65	45.5
Production in average year	KWH x 10^6	36.5	30.75	30.0	63.1
Cost per KW hr in minimum year	mills	25.7	16.4	25.6	14.9
Cost per KW hr in average year	mills	17.3	12.0	11.7	10.8
Annual charge rate as percentage of capital cost		10%	10%	10%	10%
Firm energy cost assuming secondary sold at 3.0 mills/ KW hr	mills	24.2	15.2	22.0	13.8

NOTE: For calculating the cost of energy an annual charge rate of 10% was used. Bond interest, interim replacement, insurance and sinking fund payments were assumed to be 9%, and 1% was allowed for operation and maintenance.

POWER DEVELOPMENTS ON NORTH-WEST COAST OF THE GREAT NORTHERN PENINSULA

TABLE 7.1

PART Vll 1

UPPER SALMON DEVELOPMENT

LLOYDS RIVER DIVERSION

HYDRO DEVELOPMENT ON GRANITE CANAL

8.1 Report on Studies of Hydro-Electric Potential in Central Newfoundland Part 1 - General Appraisal

This report describes a development on the Upper Salmon River which would utilize a head of about 162 feet between Cold Spring Pond and Godaleich Pond and the outflow of the Grey Reservoir together with the run-off of the Upper Salmon. The basic development is made up of a dam at the outlet of Great Burnt Lake on the North Salmon River and a dam at the outlet of Cold Spring Pond on the West Salmon River with a long conduit leading to a power house on the west shore of Godaleich Pond.

A summary of this development is given in Table 8.1A and Table 8.1B. In the above report, developments utilizing only the White Bear and Grey River diversions were described. However, since the Grey, White Bear and Victoria diversions have already been completed, only developments utilizing all three are shown in Table 8.

The recommendation of this report is that further studies be undertaken of this development

Development		Upper Salmon River 60% C.F.	Upper Salmon River 90% C.F.
Drainage Basins Developed		Upper Salmon Grey White Bear Victoria	Upper Salmon Grey White Bear Victoria
Total Drainage Area	sq. mi.	1,668	1,668
Total Regulated Flow	cfs	4,085	4,085
Full Supply Level	feet	817	817
Drawdown	feet	6	6
Low Supply Level	feet	811	811
Tailwater Level	feet	640	640
Average Gross Head	feet	174	174
Average net Head at Regulated Flow	feet	169	169
Continous HP Available	HP	73,000	73,000
ANNUAL FIRM ENERGY	KW hr.	432×10^6	432×10^6
Average Annual Secondary Energy	KW hr.	32×10^6	--
INSTALLED CAPACITY	HP	125,000 (2 units)	80,000 (2 units)

NOTES:

1. Regulation studies to determine secondary energy were not completed at this time. Therefore, values given for secondary energy are very approximate.
2. Same restrictions apply as for Table 1.3A.

UPPER SALMON RIVER DEVELOPMENT

TABLE 8.1A

Development	Upper Salmon River	
	60% C.F.	90% C.F.
Land Purchase	--	--
Land Clearing	14×10^3	14×10^3
Roads and Bridges	1,735	1,735
Railways, Diversion of Power Lines	--	--
Dams, Spillways and Reservoirs	1,572	1,572
Headworks, Water Conduits, Tailrace	11,338	8,810
Powerhouse and PH Equipment	5,750	4,760
Substation Including Transformers	800	640
Construction Indicrect Costs	2,651	2,194
Project Management and Engineering	2,386	1,973
Contingency	3,579	2,959
Subtotal	29,825	24,657
Owner's Cost	298	247
Interest During Construction	1,939	1,603
TOTAL PROJECT COST	$32,062,000A	$26,507,000A
Annual Fixed Charges at 6.73%	2,158,000	1,784,000
Annual Operating and Maintenance Cost	190,000	145,000
Total Annual Charges	$ 2,348,000	$ 1,929,000
Cost per Installed HP	$256	$331
Mean Cost of Energy (Firm & Secondary) mills/KW hr.	~5.1	~4.5
COST OF FIRM ENERGY mills/KW hr.	5.4B	4.5B

NOTES: A. The costs of the White Bear and Victoria Lake diversions are not included.

B. No account has been taken of the loss of generation at the Grand Falls hydro electric station resulting from the Victoria Lake diversion.

C. Same restrictions apply as for Table 1.3A.

UPPER SALMON RIVER DEVELOPMENT

TABLE 8.1B.

8.2 Bay D'Espoir - Stage 11
Victoria Lake and Lloyds River Diversions. Effect on
Energy Production at Grand Falls and Bishop's Falls

This report was written in December, 1966 by ShawMont Nfld Ltd and was written after the report discussed in Section 8.1. The purpose of this report was to estimate the effects of the proposed diversion on the power production of the Exploits plants and on the power supply to the paper mill.

The area to be diverted has a drainage area of 592 sq. mi., made up of 408 sq. mi. of the Victoria River watershed and 184 sq. mi. of the Upper Lloyds River watershed. This area forms 25 percent of the drainage of Red Indian Lake and 16 percent of the main power site at Grand Falls. The effects of this diversion were simulated on a computer.

Results of this simulation indicate that average flow at Grand Falls after the diversion will be reduced by 1840 cfs from 8140 cfs to 6300 cfs. It is concluded that the diversion of flow of the Upper Lloyds River and Victoria Lake drainage area from the Exploits drainage area to the Bay D'Espoir development will reduce the average production of the Grand Falls and Bishop's Falls plants by 15,246,000 KW hr. However, the effect of the diversion in dry periods will be much more marked, and Price (Nfld) prime energy production will be reduced by 56,673,000 KW hr. Assuming a permissable monthly load factor of 100 percent on purchased power, it is estimated that Price (Nfld) will have to increase its purchases from the Newfoundland and Labrador Power Commission by 6,470 KW requiring an average energy supply of 15,246,000 KW hr.

Also, note that when the diversion is completed, the average tailrace levels will be reduced at Grand Falls and Bishop's Falls and the head on these plants will be increased. For prime flows, the estimated increase in head will be 1.1 feet at Grand Falls and 0.7 feet at Bishop's Falls. For average flows, the increase in head is estimated to be 2.1 feet at Grand Falls and 0.9 feet at Bishop's Falls.

8.3 Interim Report on the Upper Salmon Development Victoria Lake Diversion, Lloyds River Diversion

This report was written in February, 1967 by ShawMont Newfoundland Limited. It describes the benefits of a development on the Upper Salmon River and the benefits of the Victoria Lake and Lloyds River diversions. However, assumptions made in this report differ from the actual conditions of today. For instance, in evaluating the benefits of the Upper Salmon Development, it is assumed there are 6 units at Bay d'Espoir having a plant capacity of 525 MW. Also, in evaluating the Victoria Lake and Lloyds River Diversions, it is assumed there are 5 units at Bay D'Espoir having a plant capacity of 412 MW.

The Victoria Lake diversion has already been completed and, therefore, the only development discussed here will be the Upper Lloyds River Diversion and the Upper Salmon Development. In discussing the Upper Salmon Development the following drainage areas are assumed to be utilized: Salmon, Grey, White Bear, Victoria Lake, and Upper Lloyds River. The Upper Lloyds River Diversion will be discussed first.

UPPER LLOYDS RIVER DIVERSION

The Upper Lloyds River Diversion would direct the flow of 184 sq. mi. of the Lloyds River drainage basin into the Victoria River drainage basin for utilization at the Bay D'Espoir Development.

A dam 70 feet high, located on the Lloyds River about one mile below King George lV Lake would raise the natural level of the lake from its present elevation of 1134 to a full supply level of 1165 before spilling would occur. A diversion canal would be required between King George lV Lake and Wood Lake in the Victoria drainage basin.

The results of power studies to determine the energy available at Bay D'Espoir from the Lloyds River Diversion are shown in Table 8.2. The figure of 93 BCF has since been revised and it now seems likely that rather more storage than this will be provided and consequently the estimate of firm energy may be low. The estimate of average total energy, however, will only be slightly affected.

If an arbitrary reduction of 2% (10cfs) is allowed for secondary water uses and dam leakage, the long term benefits of the Lloyds River Diversion at the Bay D'Espoir Development would be:-

Annual Firm Energy	152×10^6 KW hr.
Average Annual Secondary Energy	14×10^6 KW hr.
Average Annual Total Energy	166×10^6 KW hr.

The estimate of capital cost is as follows:-

Structures at King George lV Lake	$3,735,000
Escalation if constructed in 1969	$ 165,000
Total Capital Cost	$3,900,000

The annual fixed charges of the Lloyds River Diversion are estimated to be 0.0755 x $3,900,000 = $295,000 based on the following rates:-

Cost of Capital	7.00%
Depreciation (50 years)	0.25%
Interim Replacement	0.20%
Insurance	0.10%
Total	7.55%

Direct operationg and maintenance costs are estimated to be about $20,000, giving total annual charges of $315,000.

The cost of energy made available by the Lloyds River Diversion at Bay D'Espoir would be:-

Gross average annual energy	166×10^6 KW hr.
Annual charges	$315,000
Cost of energy	1.90 mills/KW hr.

Note that 90 percent of this energy would be firm.

Power Study	Prior to the Lloyds River Diversion	After the Lloyds River Diversion	Benefit of the Lloyds River Diversion
Period of Study	Oct 1/55 to Sept 30/65	Oct 1/55 to Sept 30/65	
Duration of critical low flow period (months)	34	34	
Total storage utilized (BCF)	86.6	86.6	
Total storage available (BCF)	93.0	93.0	
Annual firm energy (KW hr x 10^6)	2120	2275	155
Average annual secondary energy (KW hr x 10^6)	231	245	14
Average annual total energy (KW hr x 10^6)	2351	2520	169
Average spill (cfs)	70	135	

NOTES:

1. No allowance has been made for storage releases for fish conservation, logging, operations, compensation, water, or dam leakage.
2. No compensation to Price (Nfld) Ltd. for loss of generation at their Hydro Electric Stations resulting from the Lloyds River Diversion.
3. The total storage in the system is at the operating rule curve at the commencement of the period.
4. Bay D'Espoir capacity, 5 units, 412 MW.
5. Overall plant efficiency is 84 percent.

BENEFIT OF THE LLOYDS RIVER DIVERSION
ENERGY GENERATION AT BAY D'ESPOIR DEVELOPMENT

TABLE 8.2

UPPER SALMON RIVER DEVELOPMENT

The Upper Salmon Development involves diverting the flow of the North Salmon River into Cold Spring Pond by means of a dam at the outlet of Great Burnt Lake and a canal across the height of land. The construction of a dam and a canal on the West Salmon River would deliver the flow to a power station on the west shoreline of Godaleick Pond.

The development would utilize the flows of the Upper Salmon River, Gray River, White Bear River, Victoria Lake, and Upper Lloyds River. This would give a total drainage area of 1837 sq. mi. and a long term average flow of 5330 cfs or 2.90 cfs per sq. mi. The average net head would be 174 feet and the rated installed capacity would be 80 MW.

The cost of this installed capacity is 50% higher than at Bay D'Espoir due to the long power canal and relatively low head. Consequently, for overall economy of the Bay D'Espoir - Upper Salmon Complex, the Upper Salmon Development should be installed at as high a capacity factor as practicable. Therefore, a capacity of 80 MW has been selected which corresponds to a capacity factor of 80 per cent.

Power studies were made for the 10 year period, October 1, 1955 to September 30, 1965. The principle of operation adopted in the power studies was based on maintaining at least the firm output of the Upper Salmon Development except when either the total storage in the system fell below the secondary energy rule curve or Long Pond was at a close to F.S.L. The benefit of the Upper Salmon Development is shown in Table 8.3.

Assuming average annual losses on transmission line of 4 x 10^6 KW hr. and allowing an arbitrary 2 percenr reduction in firm output for secondary storage releases and other water losses, the estimated output of the Upper Salmon Development delivered to Bay D'Espoir is:-

Firm	513 x 10^6 KW hr.
Secondary	26 x 10^6 KW hr.
Total	539 x 10^6 KW hr.

The slight improvement in the Bay D'Espoir output resulting from the storage provided by the Upper Salmon Development must be added as follows:-

Firm	25 x 10^6 KW hr.
Secondary	-20 x 10^6 KW hr.
Total	5 x 10^6 KW hr.

Therefore, the total annual energy at the Bay D'Espoir substation resulting from the Upper Salmon Development is 544 x 10^6 KW hr.

The capital cost of this development, based on 1966 prices, is:-

	Including 230 KV Transmission Line to Bay D'Espoir	Excluding Transmission Line
Capital	$30,691,000	$28,983,000
Interest	1,979,000	1,911,000
Total Project Cost	$32,670,000	$30,894,000

The cash flow of the project excluding transmission lines is as follows:-

	Capital	Interest
Preliminary Year (Roads, Field Investigation, Engineering)	$2,803,000	$ 85,000
First Construction Year	11,873,000	515,000
Second Construction Year	14,307,000	1,311,000
Total	$28,983,000	$1,911,000

Annual fixed charges are estimated to be 7.55 percent of the capital cost. This percentage is determined as follows:

Cost of capital	7.00%
Depreciation (50 year)	0.25%
Interim Replacement	0.20%
Insurance	0.10%
Total	7.55%

Total annual charges are determined as follows:-

Annual fixed charges at 7.55% (including transmission line) is:- 0.0755 x 30,691,000	=	$2,467,000
Direct operating & maintenance (excluding operating cost of transmission line)	=	188,000
Total annual charges		$2,655,000

Therefore, the cost of energy at the Bay D'Espoir substation is estimated to be:-

Average annual energy	544×10^6 KW hr.
Total annual charges	\$2,655,000
Cost of energy	4.88 mills

The cost of producing energy at the plant busbar of the Upper Salmon Development can also be computed. From above, the output delivered to Bay D'Espoir is 539×10^6 KW hr. Average annual losses on the 230 KV transmission line are estimated to be 4×10^6 KW hr; therefore, energy production at the Upper Salmon plant is 543×10^6 KW hr.

Annual charges can be computed as follows:-

Annual fixed charges at 7.55% (excluding transmission line) is:- 0.0755 x ~~\$28,983,000~~ 30,894,000	=	\$2,~~188~~ 332,000
Direct operating & maintenance costs	=	188,000
Total annual charges	=	\$2,~~376~~ 520,000

Therefore, the cost of energy at the Upper Salmon plant busbar is estimated to be:-

Average annual energy	543×10^6 KW hr.
Total annual charges	\$2,~~376~~ 520,000
Cost of energy	4.~~38~~ 64 mills

Note that an additional 5×10^6 KW hr. is produced at Bay d'Espoir.

Power Study	Prior to Addition of Upper Salmon Development	After Addition of Upper Salmon Development	Benefit of the Upper Salmon Development
Period of Study	Oct 1/55 to Sept 30/65	Oct 1/55 to Sept 30/65	
Duration of Critical low flow period	34 months	34 months	
Total storage utilized (BCF)	86.6	92.6	
UPPER SALMON DEVELOPMENT			
Annual Firm Energy (KW hr x 10^6)	--	528	528
Average Annual Secondary Energy (KW hr x 10^6)	--	26	26
Average Annual Total Energy (KW hr x 10^6)	--	554	554
Average spill (cfs)	--	209	
BAY D'ESPOIR DEVELOPMENT			
Annual Firm Energy (KW hr x 10^6)	2275	2300	25
Average Annual Secondary Energy (KW hr x 10^6)	283	263	(-20)
Average Annual Total Energy (KW hr. x 10^6)	2558	2563	5
Average Spill (cfs)	33	20	
TOTAL			
Annual Firm Energy (KW hr x 10^6)	2275	2828	553
Average Annual Secondary Energy (KW hr x 10^6)	283	289	6
Average Annual Total Energy (KW hr x 10^6)	2558	3117	559

NOTES:
1. Drainage areas utilized: Salmon, Grey, White Bear, Victoria Lake, and Upper Lloyds River.
2. Plant capacitites: Upper Salmon 80 MW; Bay D'Espoir (units 1-6) 525 MW.
3. No allowance has been made for storage releases for fish conservation, logging operations, and compensation water.
4. Trasmission losses not included.
5. Overall plant efficiency of 84 per cent.
6. Energy is at plant high voltage bus.

BENEFIT OF UPPER SALMON DEVELOPMENT

TABLE 8.3

8.4 Water Resources Study of the Province of Newfoundland and Labrador for the Atlantic Development Board

This 1968 report contains a detailed section entitled "Water Resource Implications of the Diversion of the Upper Lloyds and Victoria Rivers". Some of the conclusions and recommendations of this section are stated below.

CONCLUSIONS

The effects of the Victoria River diversion has intensified the actual and potential water resources conflicts between the various users of the Exploits River basin. Reduction in river flows will increase pollution in the river and this will affect the fisheries resource in the river.

A significant alleviation of the deleterious effects of the diversion in the area downstream of the Exploits dam can be obtained by developing additional storage reservoirs in the basin. The additional energy production resulting from these storages would serve to offset most, if not all, of the investment required.

RECOMMENDATIONS

Detailed investigations should be carried out as soon as possible to avoid the loss of anadromous fish in the Exploits River due to the increased pollution concentrations which will follow the diversion of the Victoria and Lloyds Rivers. These investigations should include a critical review of water quantity and quality and field and office investigations of the location, arrangements and costs of additional storage facilities in the upper part of the basin. Investigations should also include methods of dealing with waste materials from the mill at Grand Falls and the mine at Buchans.

An economic appraisal should also be carried out of the possibilities of further hydro-electric development in the basin including the replacement of outdated hydro-electric facilities and resulting effects on other uses.

8.5 Hydro Development of Granite Canal

This is the subject of a letter dated July 8, 1971 to Mr. L. J. Cole, Chief Engineer, Newfoundland and Labrador Power Commission, from ShawMont Newfoundland Limited.

It gives a preliminary appraisal of the cost of developing the head between Granite Lake and the Meelpaeg Storage. Capital cost would be of the order of $11,400,000 with a firm energy production of 178 GWH, resulting in a firm energy cost of 6.65 mills per KWH. An additional benefit of about 25 GWH firm energy would be realized at the Bay D'Espoir plant with the creation of additional storage on Granite Lake by this development. Thus the total firm energy benefit accruing to this development would be of the order of 200 GWH at a rough cost of 5.9 mills/KWH. The above costs do not include any transmission.

8.6 Report on Economic Considerations of Meeting the Estimated 1973 - 1992 Load Growth of the Island of Newfoundland (Upper Salmon Development and Extension to Bay d'Espoir)

In this report comparisons were made between the following expansion schemes for meeting the load growth of the Island of Newfoundland.

(a) HVDC 3 x 720 MW - Based on three ± 300 KV DC, 720 MW transmission lines.

(b) HVDC 2 x 1080 MW - Based on two ± 450 KV DC, 1080 MW transmission lines

(c) Isolated Island - Based on oil-fired thermal plants constructed near St. John's and Stephenville

Two hydro plants are included in these alternatives: an extension of Bay D'Espoir by 4 x 112 MW units and the Upper Salmon Development.

For the three alternatives mentioned above, the hydro plants will be added as follows:-

HVDC 3 x 720 MW

YEAR	PLANT
1979	Bd'E No. 7 112
1980	Bd'E No. 8 112
1986	Bd'E No. 9 112
1987	Bd'E No. 10 112

HVDC 2 x 1088 MW

YEAR	PLANT
1979	Bd'E No. 7 112
1980	Bd'E No. 8 112
1987	Bd'E No. 9&10 224

ISOLATED ISLAND SYSTEM

YEAR	PLANT	
1973	Upper Salmon	80
1978	Bd'E No. 7	112
1980	Bd'E No. 8	112
1982	Bd'E No. 9	112
1984	Bd'E No. 10	112

Cost estimates for the extensions to Bay D'Espoir and the Upper Salmon Development are shown in Table 8.4 and Table 8.5 respectively. The estimates for the extension to Bay D'Espoir were derived from detailed studies done for Stage 11 of the Bay D'Espoir Development. Upper Salmon Hydro Development estimates have been obtained by updating the costs contained in the report entitled "Interim Report on Upper Salmon Development, Victoria Lake Diversion, Lloyds River Diversion."

The cost estimates in Table 8.4 and 8.5 are given in 1968 dollar values and interest during construction has been omitted.

ITEM	UNIT 7	UNIT 8	UNIT 9	UNIT 10
Roads and Bridges	100,000		55,000	
Canals and Tailrace	3,606,000	450,000		
Intakes	1,655,000		90,000	
Pressure Conduit & Surge Tank	4,763,000		4,520,000	
Powerhouse	1,630,000	100,000	690,000	100,000
Mechanical & Electrical	3,350,000	2,610,000	3,350,000	2,610,000
SUBTOTAL	15,104,000	3,160,000	8,705,000	2,710,000
Indirect Costs	3,760,000	530,000	1,490,000	310,000
Contingencies	1,576,000	230,000	785,000	150,000
Management & Engineering	1,280,000	270,000	740,000	230,000
Management Indirect Costs	530,000	110,000	305,000	95,000
Owner's Costs	890,000	170,000	480,000	140,000
	23,140,000	4,470,000	12,505,000	3,635,000
Cash Flow				
1st year	11,440,000	4,470,000	4,160,000	3,635,000
2nd year	11,700,000		8,345,000	
	23,140,000	4,470,000	12,505,000	3,635,000

NOTES: 1. Based on 1968 dollars
2. Interest during construction excluded

ESTIMATE FOR EXTENSION TO BAY D'ESPOIR

TABLE 8.4

Roads & Bridges	$2,108,000
Dams, Spillways & Reservoirs	3,571,000
Canals	4,980,000
Intake	890,000
Penstock	1,282,000
Tailrace	280,000
Powerhouse	950,000
Electrical	3,050,000
SUB TOTAL	$17,099,000
Indirect Costs	4,277,000
Contingencies	2,144,000
Management & Engineering	1,596,000
Management Indirect Costs	656,000
Owner's Cost	1,031,000
TOTAL	$26,803,000

CASH FLOW

First Year	$ 2,800,000
Second Year	11,140,000
Third Year	12,863,000
TOTAL	$26,803,000

NOTES:
1. Based on 1968 dollars
2. Interest during construction excluded

ESTIMATE FOR UPPER SALMON DEVELOPMENT

TABLE 8.5

EXPLOITS RIVER BASIN AND THE BADGER-BOTWOOD STUDY AREA

NOTE: POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

LEGEND: ⚒ MINE

FIGURE 8.1

PART lX

Water Resources Study

of the

Province of Newfoundland and Labrador

for

Atlantic Development Board

9.1 Hydro Development Possibilities

The 1968 report by Shawinigan Engineering Company Limited and James F. MacLaren Limited on the water resources of Newfoundland and Labrador describes several potential hydro developments which are presently undeveloped and have not been investigated by others. Detailed investigations were restricted to the Island of Newfoundland and to potential developments generally greater than 30,000 HP, preferably at a site which would utilize a major proportion of the available head and stream flow. Possibilities of pumped storage power sites have also been investigated in a preliminary way.

These investigations consisted of office studies of the 1:50,000 scale, 50-foot contour National Topographic Series maps of the areas under consideration to ascertain maximum usable drainage areas and effective head, possible storage sites, best apparent structure layouts for various alternative schemes of development and an appraisal of their feasibility.

Air photo interpretation was used for schemes that warranted further investigation. However, field investigations necessary to enable a detailed study of the more promising schemes were not carried out.

The development data, estimated generation, and order of magnitude costs of the developments are presented in Table 9.1A and Table 9.1B. Transmission costs were not included as they will depend on future loads and system configurations. Also, the economic evaluation of the developments were carried out on the basis of available firm energy.

DESCRIPTION OF DEVELOPMENTS

Upper Humber River Development No. 1

This development requires a dam located at approximately 49°36'00" latitude and 57°18'30" longitude on the Upper Humber River. A forebay dyke is located on the same drainage area about five miles to the southeast of the dam. An 11 foot diameter wood pipeline 13,500 feet long connects the forebay intaketo the upstream end of a 15,700 foot long steel penstock leading to the power house located near the northwest shore of Birchy Lake. A surge tank is provided for turbine regulation.

The firm energy cost of this development is 9.7 mills which is not competitive with other sources of energy. Nevertheless, more detailed investigations are recommended because the scheme has considerable peaking potential which, combined with secondary energy production, could make the scheme more economically attractive.

Upper Humber River Development No. 2

This scheme requires a dam located just upstream of the bridge on Highway 1A, which crosses the Upper Humber River three miles downstream from Big Falls. Small dykes are required about one mile south of the main dam to contain the full supply level of elevation 250.

The firm energy cost of this development is 9.3 mills at the plant busbar. This study ignored the fisheries problems inherent in a hydro scheme on this section of the river, the solution of which would increase the costs. Conequently, the development is not considered competitive at this time, and is not recommended for further investigations.

Upper Humber River Development No. 3

This development involves the diversion of the Upper Humber River into Grand Lake to develop the 250 foot head which exists between Grand Lake and Deer Lake. The scheme requires a long low dam across the Humber River just upstream of the bridge which crosses the river near Little Falls on Highway 1A. Also required are a side hill canal, a spillway at the main dam site, and a control structure at the canal entrance. The cost estimates include an allowance for two additional units at the existing Deer Lake plant with a total additional capacity of 65,000 HP.

The firm energy costs for this development are 7.6 mills at a 75 per cent capacity factor and over 9 mills at a 50 percent capacity factor. Disadvantages of this scheme include the flooding of existing recreational facilities at Sir Richard Squires Memorial Provincial Park and the fisheries problems. Therefore, this scheme is not recommended for further study at this time.

River of Ponds Development

This development requires a dam located at 50°27'30" latitude and 57°14'00" west longitude on the River of Ponds, which is located on west side of Great Northern Peninsula. Runoff would be diverted from the main river to a point about one mile west of the dam where a 4000 foot long power canal would lead to an intake dyke.

The cost of firm energy for this development is 10.6 mills at the plant busbar. This is due to the relatively high cost of the dam for a scheme of this magnitude. Therefore, it is recommended that no further investigations of this development be undertaken.

Southwest Brook Development

This brook drains westward into St. Georges River upstream of Stephenville Crossing. The development involves the diversion of Southwest Brook into Bottom Brook by a dam at 48°30'24" north latitude and 58°12'00" west longitude. A canal is required to divert the flow to a forebay dyke located in the Bottom Brook drainage area. A short penstock connects the forebay dyke to the powerhouse located on the east bank of Bottom Brook.

The cost of firm energy for this development is 11.9 mills at the plant busbar. This is due to the high cost of the dam. Further investigation of the scheme is not recommended due to high cost and low installed capacity.

Great Rattling Brook Development

This brook flows in a northerly direction and joins the Exploits River between Grand Falls and Bishop's Falls. The scheme investigated requires a dam located about two miles upstream of the junction with the Exploits River and a pipeline and penstock leading from the dam to the powerhouse located near the Exploits River. Lack of sufficient head and economical storage facilities makes the development of the 563 square mile drainage area totally uneconomical.

Main River Development

The Main River has its headquarters on the east side of the Long Range Mountains of the Great Northern Peninsula. Various schemes were studied for a development on this river. The scheme described in the report requires a forebay dyke one mile west of a main dam on the river, two spillway structures, and a combination of pipeline and penstocks to lead water a distance of five miles to the power house located about two miles from the river mouth.

The cost of firm energy of 7.7 mills at the plant busbar is higher than the cost of energy from competitive sources. However, if a large block of secondary energy is available in an average year, the cost of total energy might be competitive. Therefore, if more of the energy available could be considered as firm due to system and market conditions, then the scheme may become competitive. Therefore, the scheme may warrent more detailed investigations at some later point in time.

Western Brook Pond (Pumped Storage)

This development is not included in Table 9.1. The site is just north of Bonne Bay on the Great Northern Peninsula. The gross head for this development would be about 1500 feet with storage on Western Brook Pond (Surface area 8.8 sq. mi.) and on an unnamed lake (Surface area 0.3 sq. miles). Approximately 300,000 HP can be developed without creating severe drawdown conditions on the Upper reservoir, depending on the capacity factor chosen.

Further investigations would be necessary to ascertain the cost of development. It should also be recognized that a pumped storage peaking source will not be practical for the Island in the near future.

Development		Upper Humber River 1 (50% CF)	Upper Humber River 2 (50% CF)	Upper Humber River 3 (75% CF)	River of Ponds 50% C.F.	South West Brook 50% C.F.	Great Rattling Brook 50%CF	Main River 50% C.E
Drainage Areas Developed		Upper Area	Upper Area Middle Area	Upper Area Middle Area	River of Ponds	South West Brook	Great Rattling Brook	Upper Main
Total Drainage Area	sq. mi.	188	724	734	262	225	563	293
Total Regulated Flow	cfs	564	1,450	1,835	786	562	619	880
Full Supply Level	ft.	1,118	250	280	240	318	230	970
Drawdown	ft.	53	18	0 (D)	16	53	45	63
Low Supply Level	ft.	1,065	232	280	224	265	185	907
Tailwater Level	ft.	250	140	15	40	40	90	100
Average Gross Head	ft.	841	101	265	202	253	118	839
Average Net Head at Regulated Flow	ft.	815	98	247	198	245	115	814
Continous HP available	HP	50,000	15,000	48,000	16,500	15,000	7,500	75,000
Annual Firm Energy	KW hr	287×10^6	89×10^6	283×10^6	97×10^6	86×10^6	45×10^6	448×10^6
INSTALLED CAPACITY	HP	100000 (2 units)	30000 (1 unit)	65000 (2 units)	35,000 (1 unit)	30,000 (1 unit)	15,000 (1 unit)	150,000 (3 units)

NOTES:
A. Cost estimates are based on 1967 prices and do not take into account transmission lines or losses. Thus, the cost of power presented is the cost at the plant busbar.
B. Annual fixed charges of 6.73%.
C. Costs are based on firm energy alone. Secondary energy benefits have not been calculated.
D. Storage reservoir located upstream of plant intake.

HYDRO DEVELOPMENTS DISCUSSED IN WATER RESOURCES REPORT (1968)

TABLE 9.1A

Development	Upper Humber River 1 (50% CF)	Upper Humber River 2 (50% CF)	Upper Humber River 3 (75% CF)	River of Ponds 50% CF	South West Brook 50% CF	Great Rattling Brook 50% CF	Main River 50% CF
Land Purchase	--	--	85 x 10^3	--	--	--	--
Land Clearing	30 x 10^3	6 x 10^3	50	20 x 10^3	61 x 10^3	14 x 10^3	75 x 10^3
Roads and Bridges	875	400	1,000	650	100	300	475
Railways, Diversion of Power Lines	--	--	--	--	--	--	--
Dams, Spillways & Reservoirs	7,732	2,940	9,081	4,632	6,432	5,830	9,953
Headwork, Water Conduits, Tailrace	11,843	1,515	5,581	1,762	540	422	14,765
Powerhouse & P.H. Equipment	4,500	2,250	4,000	1,995	1,875	1,650	4,380
Substation including Transformers	700	300	450	300	300	170	1,100
Construction Indirect Costs	3,243	924	2,567	1,175	1,163	1,066	3,852
Project Management & Engineering	2,892	833	2,281	1,053	1,047	945	3,460
Contingency	4,339	1,250	3,422	1,580	1,571	1,418	5,190
Subtotal	36,153	10,418	28,517	13,167	13,089	11,815	43,250
Owner's Cost	362	104	285	132	131	118	432
Interest During Construction	2,350	677	1,853	856	851	768	4,108
TOTAL PROJECT COST	38,866 x 10^3	11,199 x 10^3	30,655 x 10^3	14,155 x 10^3	14,071 x 10^3	12,701 x 10^3	47,790 x 10
Annual Fixed Charges at 6.73%	2,616,000	754,000	2,063,000	953,000	947,000	885,000	3,220,000
Annual Operating and Maintenance Costs	165,000	75,000	88,000	84,000	75,000	36,000	217,000
Total Annual Charges	2,781,000	829,000	2,151,000	1,037,000	1,022,000	891,000	3,437,000
Capital Cost per Installed HP	$389	$373	~~$439~~ 472	$405	$469	$847	$319
COST OF FIRM ENERGY (at plant busbar) Mills/KW hr.	9.7	9.3	7.6	10.7	11.9	19.8	7.7

HYDRO DEVELOPMENTS DISCUSSED IN WATER RESOURCES REPORT (1968)

TABLE 9.1B

9.2 Gross River Hydro Power Potential

The gross hydro power potential along the main river stem was calculated for several selected river basins on the Island. The formulae used to calculate the river potential are as follows:-

a) $$S = \frac{H_1 - H_2}{L_1 - L_2}$$

b) $$P = \int_0^L S \times Q \times dL$$

Where $H_1 - H_2$ = difference in elevation of two given adjacent plants along river.

$L_1 - L_2$ = distance between two points.

Q = discharge at given points along river.

L = length of river.

P = hydro-electric gross potential.

Table 9.2 summarizes the gross river potential studies for the rivers on the Island.

River	Average Annual Flow at River Mouth		Total Head	Length	Cumulative Gross Potential
	cfs	cfs/sq mi	ft	KM	MW
Exploits	10,300	2.3	1,700	270	407
White Bear	2,780	3.3	1,500	107	180
Upper Humber	3,210	3.6	2,350	129	170
Cat Arm	1,580	5.0(B)	2,000	44	155
Salmon	2,970	2.9	1,330	110	135
Grey	3,130	3.2	1,000	115	140
Gander	4,960	2.4	1,000	174	75
Terra Nova	1,970	2.7	700	140	70
Pipers Hole	875	3.2	700	43	27
Conne	715	2.9	900	55	23

NOTES:-

A. Figures shown here refer to potential available on main river stem only.

B. Figure shown here for Cat Arm was revised in 1971 report by ShawMont to 3.4 cfs/sq. mi.

GROSS RIVER POTENTIAL FOR SELECTED RIVERS ON THE ISLAND OF NEWFOUNDLAND

TABLE 9.2

9.3 Natural Water Resources Inventory

This is the title of Volume 2A of the Water Resources Study. This volume contains a great deal of information regarding the quantity and quality of the inland water resources on the island. No detailed summary of this information will be given in this report. Instead, a list of the various topics discussed will be given, so that the reader will know what is availalbe and can study the appropriate sections if so desired.

Part 1 - Methodology

This part describes the method of attach used to perform the main objective of this part of the report. This objective is described as "an assessment of natural water availability and of changes induced by man's activity in the natural hydrologic and hydrogeologic conditions."

Part 11 - Physiographic Characteristics

The subheadings listed under Part 11 are as follows:- Geomorphology and Topography, Bedrock Geology, Surficial Geology, Soils, Vegetation and Climate. Some of the topics discussed under Climate include the following:- humidity, mean annual precipitation, annual precipitation variation, monthly precipitation variation, storm precipitation, snow and maximum possible seasonal snowfall, drought frequency and duration, and evaporation. Tables are available showing the records available for the topics listed above.

Part 111 - Man's Activity Causing Changes in Water Quantity and/or Quality

One of the topics discussed in this part is changes due to Hydro Electric Power Production.

Part 1V - Inland Surface Water - Quantity

The subheadings discussed in this part are shown below:-

(i) Hydrographic Network
(ii) Hydrometric Data
(iii) Average Runoff Distribution
(iv) Annual, Seasonal, and Monthly Flow Variation
(v) Maximum Flows
(vi) Minimum Flows
(vii) Water Levels and Ice Conditions
(viii) Hydrologic Regions
(ix) Recommendations For Further Hydrologic Studies.

A large number of figures and tables are provided in this section of the report, giving data and statistics for the topics listed above. Some of these tables and figures include a list of river guaging stations, and flow reporting plants, flow data from these locations, and index hydrographs of average, maximum and minimum flows for various rivers.

9.4 General Conclusions and Recommendations

CONCLUSIONS (Hydro Electric Developments)

The report states that hydro-electric power generation has been accepted as a paramount use of the water resource virtually without regard to other actual or potential users. Therefore, conflicts with other users have occured such as with fisheries development plans on the Exploits River. Resource conflicts are inherent in the proposed Terra Nova hydro development. The report also states that significant benefits have resulted from improved flow regulation in some areas.

The report also gives, for various river basins, a list of priorities which must be considered in a detailed development of these river basins.

RECOMMENDATIONS

The Province should immediately establish a comprehensive policy for the management of its water resources. This policy should recognize the multi-purpose nature of the resources and be designed to achieve maximum benefits for all users.

With respect to potential hydro developments, a thorough examination should be carried out to identify possible conflicts with other users such as fisheries, forestry, recreation, and tourism. To complete the inventory of hydro power potential for the Island, the Newfoundland and Labrador Power Commission should carry out more detailed investigations to assess the economic viability of the following schemes:-

- Cat Arm
- Upper Humber River
- Main River
- Star Lake
- Hinds Brook
- Western Brook Pond (pumped storage)

These investigations should take into account the system requirements, transmission costs, and the requirements of other water users.

The report also gives a list, by river basins, of recommendations and major considerations which should be taken into account in any comprehensive planning of a development on these river basins. Recommendations concerning the Terra Nova River Basin and Cat Arm River Basin can be found in parts 1 and V1 of this report.

Recommendations for the other river basins are mostly concerned with water pollution and development of recreation, tourism, and fisheries on these rivers. For the Pipers Hole River it is recommended that the effects of the diversion for the proposed Terra Nova Development should be investigated.

APPENDIX A

REPORTS ON FUTURE HYDRO RESOURCES ON THE ISLAND

	Name of Report	Date Report Was Done	Report Done By	Library No.
1.	Report on Proposed Hydro Electric Sta. and Improvements to Steam Plant and Pulp Mills (Price Nfld Ltd.)	1923	George F. Hardy Consulting Engineer	
2.	Power Development Possibilities of the Terra Nova River for the Government of Newfoundland	1952	Power Corporation of Canada	RG 900.11
3.	Power Development Possibilities of the Bay du Nord River for the Government of Newfoundland	1952	Power Corporation of Canada	RG 900.10
4.	Proposed Power Development at Hinds Lake for the Bowater Power Company	1957	Shawinigian Engineering Company	RG 900.25
5.	Report on Proposed Power Development at Little Grand Lake for the Bowater Power Company Limited	1959	Shawinigian Engineering Company	RG 900.5
6.	Report on Red Indian Falls Power Development (for Price Brothers)	1959	Nfld. Light & Power Co.	
7.	Letter Report to Chief Engineer of the Anglo Development Company Limited from Montreal Engineering Company Ltd.	1960	Montreal Engineering Company Ltd.	
8.	Report on Studies of Hydro Electric Potential in Cdntral Nfld., Part 1, General Appraisal	1966	ShawMont Nfld. Ltd.	BDE 300.10
9.	Interim Report on the Terra Nova Development	1966	ShawMont Nfld Ltd.	BDE 300.14

	Name of Report	Date Report Was Done	Report Done By	Library No.
10.	Bay D'Espoir - Stage 11 Victoria Lake and Lloyds River Diversion. Effect on Energy Production at Grand Falls and Bishop's Falls.	1967	ShawMont Nfld. Ltd.	BD'E 300. 7
11.	Interim Report on the Upper Salmon Development Lloyds River Diversion	1967	ShawMont Nfld. Ltd.	BD'E 300.12
12.	Water Resources Study, Newfoundland and Labrador for Atlantic Development Board	1968	Shawinigin Engineering Co. & James F. MacLaren Ltd.	1100.3
13.	Hydro Electric Potential of Cat Arm River	1971	ShawMont Nfld. Ltd.	
14.	Letter to Mr. L. J. Cole on Hydro Development on Granite Canal	1971	ShawMont Nfld. Ltd.	
15.	Letter to Mr. L. J. Cole on Power Study - Great Northern Peninsula	1971	ShawMont Nfld. Ltd.	
16.	Report on Economic Consideration of Meeting the Estimated 1973 - 1992 Load Growth of the Island of Newfoundland	1968	ShawMont Nfld. Ltd.	

TO: Mr. J. G. Fitzgerald
Assistant Chief Engineer (Planning)

FROM: H. R. Young
Planning Engineer

DATE: November 18, 1971

Enclosed herewith are the cost estimates based on 1971 dollars for the Hydro-Electric Developments described in report Number 71-012.

This report should be attached as Appendix B to report number 71-012.

H. R. YOUNG
Planning Engineer.

Appendix B

Conversion of Cost Estimates

for

Hydro-Electric Generating Stations

to 1971 prices

The purpose of this appendix is to convert the costs given for each hydro-electric development to 1971 values. This was done by using a Dominion Bureau of Statistics publication entitled "Construction Price Indexes for Hydro-Electric Generating Stations", catalogue number 62-533. This was published in June, 1971. The publication gives price indexes from 1961 to 1970 based on 1961=100.0 for various facets of construction of hydro-electric generating stations.

However, the breakdown given by DBS does not agree exactly with that given by ShawMont in their reports to the Power Commission. Therefore, it was necessary to make some modifications to the DBS price indexes in order to be able to apply them to the costs given in the ShawMont reports. This was done by using the quite detailed breakdown of price indexes given by DBS and the weights given for each individual index. It was also necessary to extend these indexes to 1971 and back to 1957.

A detailed description of the procedure followed in deriving these price indexes and applying them to the cost estimates will be given in a later report (71-013) to Mr. J. G. Fitzgerald. The indexes used for cost conversion for the years 1961 to 1971 are given in Table B.1.

There are several points which should be noted with respect to every development:

1. Cost estimates are given at the plant low voltage bus. Therefore, all costs relating to substations, step-up transformers, and transmission lines are excluded.

2. Contingencies are given as a fixed percentage of a subtotal of the Capital cost. By examining the ShawMont reports, it was determined that this percentage was 13.6% of the subtotal of the costs reported before the contingencies.

3. The Owner's Cost was computed to be 1% of another subtotal of the Capital Cost.

4. All developments are assumed to operate at the capacity factor at which they were originally investigated, as described in the appropriate parts of this report.

5. Annual Fixed Charges where computed as follows:

Cost of Money	8.25%
Depreciation (50 year Sinking Fund)	0.16%
Interim Replacement	0.40%
Insurance	0.20%
TOTAL	9.01%

These values for Interim Replacement and Insurance come from the U.S. Federal Power Commission publication entitled "Hydro-Electric Power Evaluation".

6. No escalation is applied to land purchases.

7. The Cat Aim Development, Granite Canal, and Developments on the North West Coast of the Great Northern Peninsula are already quoted in 1971 dollars.

8. No attempt was made to convert the costs of the Price (Nfld.) Reports on power developments on the Exploits River. One report was written in 1923 and there is no way one can come up with a valid cost at today's prices. The other report (On Red Indian Falls) does not give any cost estimates.

9. In calculating the MW available from the horsepower rating given, an overall generator efficiency of 98% was assumed.

The cost estimates for each development are given in tables B.2 to B.11.

A summary of the cost of each development is given in Table B.12. This table is arranged in order of increasing costs for firm energy.

DBS CLASSIFICATION	SHAWMONT CLASSIFICATION	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1971/1965	1971/1966	1971/1967	1971/1968
POWER HOUSE ELECTRICAL EQUIPMENT MECHANICAL EQUIPMENT	POWERHOUSE & P.H. EQUIPMENT	100.0	103.1	106.9	110.6	114.9	120.2	121.8	123.5	128.7	136.1	142.9	1.24	1.19	1.17	1.16
DAMS, RESERVOIRS AND WATERWAYS	LAND CLEARING DAMS, SPILLWAYS & RESERVOIRS HEADWORKS, WATER CONDUITS, TAILRACE	100.0	103.4	108.5	112.1	119.1	126.6	130.7	135.0	142.9	150.1	153.7	1.29	1.21	1.18	1.14
TEMPORARY CONSTRUCTION CAMPS	INDIRECT COSTS	100.0	101.0	103.7	106.6	111.2	117.7	123.2	127.2	134.1	139.3	145.8	1.31	1.24	1.18	1.15
ENGINEERING & ADMINISTRATION	PROJECT MANAGEMENT AND ENGINEERING	100.0	102.9	104.6	108.4	115.1	122.4	131.0	139.8	150.8	163.4	176.0	1.53	1.44	1.34	1.26
INTEREST DURING CONSTRUC-TION	INTEREST DURING CONSTRUCTION	100.0	100.2	98.7	100.7	101.8	114.6	122.0	138.4	153.0	162.2	171.0	1.68	1.49	1.40	1.24
TOTAL INDEX (BASEWEIGHED)	-	100.0	102.7	106.0	109.5	114.8	121.8	126.2	131.3	139.2	147.4	154.3	1.34	1.27	1.22	1.18
HIGHWAY CONSTRUCTION PRICE INDEXES A	ROADS & BRIDGES RAILWAYS, DIVERSION & POWER LINES	100.0	102.0	109.1	113.2	122.9	130.0	125.6	123.5	131.0	130.0	128.0	1.04	0.98	1.02	1.04
SUBSTATIONS A,C,	SUBSTATIONS INCLUDING TRANSFORMERS	100.0					122.5	121.2	117.1	120.4	120.3	120.3	0.98	0.98	0.99	1.03
ELECTRICAL EQUIPMENT A,B,	OPERATION AND MAINTEN-ANCE	100.0	102.2	103.3	107.8	111.2	114.3	111.9	108.1	111.8	118.7	123.2	1.11	1.08	1.10	1.14

NOTES: A: These three price indexes are excluded from the baseweighed total index.

B: The index for electrical equipment is assumed to be close to the index for operation and maintenance. The index is weighed for equipment and for wages.

C: This index is not actually used, since the cost of substations and transformers is excluded from the costs given in this report

PRICE INDEXES FOR HYDRO-ELECTRIC GENERATING STATIONS Table B.1

Roads & Bridges	$ 1,838,000
Railways, Diversion of Power Lines	960,000
Dams, Spillways, & Reservoirs	11,595,000
Canals	4,778,000
Headworks, Water Conduits, Tailrace	11,333,000
Powerhouse & P. H. Equipment	10,674,000
Construction Indirect costs	11,747,000
Project Management & Engineering	5,458,000
Subtotal	$58,383,000
Owners Costs B	634,000
Interest During Construction	4,515,000
TOTAL PROJECT COST	$63,532,000
Annual Fixed Charges AT 9%	5,718,000
Operation & Maintenance Charges	380,000
TOTAL ANNUAL CHARGES	$ 6,098,000

Installed Capacity, MW at 60% CF	144
Firm Energy, KWH	740×10^6
Average Annual Secondary Energy, KWH	42×10^6
Average Annual Energy, KWH	782×10^6
Cost per Installed KW	$441
Cost of Firm Energy, Mills/KWH	8.2
Cost of Average Energy, Mills/KWH	7.8

CASH FLOW

	CAPITAL	INTEREST
Preliminary years (Field Investigation, Engineering, 5 miles of road)	1,445,000	37,000
First Construction year	13,205,000	514,000
Second Construction year	27,498,000	2,094,000
Third Construction year	16,869,000	1,870,000
TOTAL	$59,017,000	4,515,000

NOTES: A. Development described in Part 1.3

B. This cost is assumed. The original report gives the capital cost including transmission lines as $55,126,000.

TERRA NOVA DEVELOPMENT
Table B.2 Page 1 of 2

TABLE 3.2 Continued

The report also states that the total cost is $51,460,000, excluding transmission lines. No mention is made of Owner's cost when transmission lines are excluded and in order to get the total cost to add up to $51,460,000, we must assume an Owner's cost of $440,000. Corrected to 1971 dollars, this becomes $634,000.

C. No allowance made in the estimates for:

(A) Clearing of flooded areas and for loss of merchantable timber.

(B) Relocation or reconstruction of logging camps and logging roads inundated by the reservoir.

(C) Facilities which may be required at the dams for log driving and fish conservation.

D. Contingencies are included in the estimates for the individual structures.

E. It was decided to convert only the most recent cost estimates to 1971 dollars. No attempt was made to convert the various schemes described in part 1.2.

TERRA NOVA DEVELOPMENT
TABLE B.2 Page 2 of 2

DEVELOPMENT	BAY Du NORD DEVELOPMENT 1 - A	1 - B Extension of 1 - A	2
Land Purchase	-	$200x10^3$	200×10^3
Land Clearing	13×10^3	26	39
Roads and Bridges	1,747	2,569	4,316
Railways, Diversion of Power Lines	437	-	437
Dams, Spillways and reservoirs	11,149	16,851	28,001
Headworks, Water Conduits, Tailrace	4,988	11,165	16,153
Powerhouse and P.H. Equipment	4,873	9,486 B	12,716 B
Construction Indirect Costs	3,157	5,423	8,358
Project Management and Engineering	3,299	5,858	8,928
SUBTOTAL A	$29,663,000	$51,578,000	$79,148,000
Contingency (13.6% of Subtotal A)	4,034,000	7,015,000	10,764,000
SUBTOTAL B	$33,697,000	$58,593,000	$89,912,000
Owner's Cost (1% of Subtotal B)	337,000	586,000	899,000
Interest During Construction	2,940,000	5,225,000	11,642,000
TOTAL PROJECT COST	$36,974,000	$64,404,000	$102,453,000
Annual Fixed Charges at 9%	3,328,000	5,796,000	9,221,000
Annual Operating And Maint. Costs	164,000	181,000	345,000
TOTAL ANNUAL CHARGES	$ 3,492,000	$ 5,977,000	$ 9,566,000
Installed Capacity. MW at 60%CF	62 (2 Units)	110 (2 Units)	171 (3 Units)
Firm Energy, KWH	300×10^6	400×10^6	700×10^6
Average Annual Secondary Energy KWH	60×10^6	Not Given	60×10^6
Average Annual Energy	360×10^6		760×10^6
Cost per Installed KW	$596	$585	$599
Cost of Firm Energy, mills/KWH	11.6	14.9 A	13.7 A
Cost of Average Energy, mills/KWH	9.7		12.6 A

NOTES:
1. Development descrived in part 2.2
2. Values given for secondary energy are very approximate.
3. As in the original report this estimate does not take into account the items listed in Table 1.3A, which are repeated here for convenience:

(1) Transmission lines or losses.
(2) Clearing of Flooded areas.
(3) Facilities and storage releases for migrating fish.
(4) Facilities and storage releases for logging operations.
(5) The effects of regulation or diversions of drainage area on existing hydro-electric developments.
(6) Secondary benefits which might be realized from the Construction of the reservoirs and roads associated with the power development.

A: Refers to net annual firm energy available to system after pumping requirement for diversion scheme has been met.

B: Includes cost of diversion pump house and equipment.

BAY DU NORD DEVELOPMENT
TABLE B.3

DEVELOPMENT	PIPER'S HOLE #1 60% C.F.	PIPERS HOLE #2 20% C.F.	GIBSON LAKE 60% C.F.
Land Purchase	200 x 10^3	-	200 x 10^3
Land Clearing	68	17 x 10^3	129
Roads and Bridges	1,560	1,425	3,432
Dams, Spillways, and Reservoirs	42,708	10,181	34,856
Headworks, Water Conduits, Tailrace	7,783	5,472	34,208
Powerhouse & P.H. Equipment	6,944	6,200	9,114
Construction Indirect Costs	7,873	3,152	10,931
Project Management & Engineering	8,167	3,316	11,337
SUBTOTAL A	$75,303,000	$29,763,000	$104,207,000
Contingency (13.6% of subtotal A)	10,241,000	4,048,000	14,172,000
SUBTOTAL B	$85,544,000	$33,811,000	$118,379,000
Owner's Cost (1% of Subtotal B)	855,000	338,000	1,118,000
Interest During Construction	10,651,000	2,958,000	14,784,000
TOTAL PROJECT COST	$97,050,000	$37,107,000	$134,281,000
Annual Fixed charges at 9%	8,734,000	3,340,000	12,085,000
Operation and Maintenance Costs	264,000	193,000	335,000
TOTAL ANNUAL CHARGES	$ 8,998,000	$ 3,533,000	$ 12,420,000
Installed Capacity, MW	124 (2 Units)	80 (2 Units)	169 (3 Uni
Firm Energy KWH	610 x 10^6	128 x 10^6	820 x 10^6
Average Annual Secondary Energy KWH	~55 x 10^6	~30 x 10^6	~80 x 10^6
Average Annual Energy, KWH	665 x 10^6	158 x 10^6	900 x 10^6
Cost per installed KW	$783	$464	$795
Cost of Firm Energy. Mills/KWH	14.8	27.6	15.1
Cost of Average Energy. Mills/KWH	13.5	22.4	13.8

NOTES:

1. Development described in part 3.1
2. Values for secondary energy are very approximate.
3. Same restrictions apply as listed in note 3 of Table B.3

PIPERS HOLE AND GISBORNE LAKE DEVELOPMENTS

TABLE B.4

DEVELOPMENT	Star Lake 60% C.F.	Shandethit Brook 60% C.F.
Land Purchase	-	-
Land Clearing	14×10^3	9×10^3
Roads and Bridges	714	923
Dams, Spillways, and Reservoirs	2,614	3,770
Headworks, Water Conduits, Tailrace	2,622	5,045
Powerhouse & P.H. Equipment	2,024	2,562
Construction Indirect Costs	1,055	1,617
Project Management and Engineering	1,101	1,668
SUBTOTAL A	$10,144,000	$15,594,000
Contingency (13.6% of subtotal A)	1,380,000	2,121,000
SUBTOTAL B	$11,524,000	$17,715,000
Owner's Cost (1% of Subtotal B)	115,000	177,000
Interest During Construction	935,000	1,414,000
TOTAL PROJECT COST	$12,574,000	$19,306,000
Annual Fixed Charges at 9%	1,132,000	1,738,000
Operation & Maintenance Costs	92,000	119,000
TOTAL ANNUAL CHARGES	$ 1,224,000	$ 1,857,000
Installed Capacity, MW	26 (1 Unit)	37 (1 Unit)
Firm Energy, KWH	127×10^3	167×10^6
Average Annual Secondary Energy, KWH	not given	not given
Average Annual Energy, KWH		
Cost per Installed KW	$484	$522
Cost of Firm Energy, mills/KWH	9.6	11.1
Cost of Average Energy, mills/KWH		

NOTES: 1. Development described in part 3.1 and 3.2.

STAR LAKE DEVELOPMENT

Table -- B.5

DEVELOPMENT	Little Grand Lake 78.5% CF	Hinds Lake 75% CF
Total Project Cost	$11,494,000	$26,272,000
Total Annual Charges at 9½%	1,092,000	2,496,000
Installed Capacity MW	10.2	39.5
Prime Energy, KWH	63.3×10^6	238×10^6
Average Annual Secondary Energy, KWH	5.0×10^6	not given
Average Annual Energy, KWH	68.3×10^6	
Cost per Installed KW	$1,127	$668
Cost of Prime Energy, mills/KWH	17.3	10.5
Cost of Average Energy, mills/KWH	16.0	

NOTES:

1. Developments described in parts 4.1 and 4.2

2. Costs are in 1971 dollars and all assumptions listed in the above sections are also applicable to the above table.

3. These reports were done in 1959 and 1957, and the price indexes for hydro-electric construction do not extend back beyond 1961. In order to derive a price index for these developments, it was necessary to extend the total price index back to 1957 by trying to correlate it with other available indexes which extend back this far. This was done using the best information available. Since this procedure had to be followed, costs quoted for this report are probably not as accurate as for the other reports quoted. Due to this, it was decided that it was sufficient to only use the total index, rather than attempt to extend each individual index back to 1957.

LITTLE GRAND LAKE AND HINDS LAKE DEVELOPMENTS

Table B.6

Land Purchase	----
Roads and Bridges	$1,181,000
Dams, Spillways and Reservoirs	1,166,000
Canals	477,000
Headwork, Water Conduits, Tailrace	-----
Powerhouse and P.H. Equipment	-----
Indirect Costs	795,000
Project Management and Engineering	369,000
SUBTOTAL	$3,988,000
Owner's Cost	72,000
Interest During Construction	335,000
TOTAL PROJECT COST	$4,395,000
Annual Fixed Charges at 9%	396,000
Operating and Maintenance Costs	22,000
Total Annual Charges	$ 418,000
Firm Energy, KWH	152×10^6
Average Annual Secondary Energy, KWH	14×10^6
Average Annual Energy, KWH	166×10^6
Cost of Firm Energy, mills / KWH	2.75
Cost of Average Energy, mills/ KWH	2.50

NOTES:

1. Development described in part 8.3 of report.
2. Firm Energy as given above allows for an arbitrary reduction of 2% for secondary water uses and dam leakage.
3. No compensation to Price (Nfld.) Limited for loss of generation at their Hydro Electric Stations resulting from the Lloyds River Diversion.
4. Bay D ' Espoir capacity, 5 units, 412 MW
5. Overall plant efficiency is 84 percent.
6. The total storage in the system is at the operating rule curve at the commencement of the period.

UPPER LLOYDS RIVER DIVERSION

Table B.7

Land Purchase	-------
Roads And Bridges	$2,272,000
Dams, Spillways, and Reservoirs	4,398,000
Canals	7,072,000
Headworks, Water Conduits, Tailrace	3,267,000
PowerHouse and P.H. Equipment	7,449,000
Indirect Costs	6,977,000
Engineering and Project Management	3,241,000
SUBTOTAL	$34,676,000
Owner's Cost (1% of subtotal)	347,000
Interest During Construction	2,847,000
TOTAL PROJECT COST	$37,870,000
Annual Fixed Charges at 9%	3,408,000
Operating and Maintenance Charges	203,000
TOTAL ANNUAL CHARGES	$ 3,611,000
Installed Capacity, MW (80% CF)	80
Firm Energy, KWH	517×10^6
Average Annual Secondary Energy, KWH	26×10^6
Average Annual Energy, KWH	543×10^6
Cost per Installed KW	$473
Cost of Firm Energy, mills per KWH	7.0
Cost of Average Energy, mills per KWH	6.7

NOTES:

1. Development described in part 8.3 of report
2. The Upper Lloyds River drainage area is assumed to be utilized in the above table
3. An annual loss of 4×10^6 KWH on a transmission line and 2 percent reduction in firm output for secondary storage releases and other water losses is assumed.
4. Improvement to Bay D' Espoir output resulting from storage provided by Upper Salmon Development is as follows:

Firm	25×10^6 KWH
Secondary	-20×10^6 KWH
Total	5×10^6 KWH

5. Since the Upper Lloyds River Diversion has not yet been done, it was decided to calculate the energy cost of the Upper Salmon Development without the benefit of the Lloyds River Diversion.
6. A calculation of energy costs for constructing the Upper Salmon Development and Lloyds River Diversion together was also done.
7. An assumption necessary to both notes 5 and 6 is that the energy benefits of the Lloyds River Diversion at Bay D' Espoir can also be used at the Upper Salmon.
8. These calculations are performed in Table B.9
9. Contingencies are included in cost of individual structures.

UPPER SALMON DEVELOPMENT

B.8

Calculation of energy available at plant bus of Upper Salmon Development without benefit of Lloyds River Diversion:

	Firm	Secondary	Total
Energy Available with Lloyds River Diversion	517×10^6	26×10^6	543×10^6
Less Benefit of Lloyds River	152×10^6	14×10^6	166×10^6
Energy available from Upper Salmon Development	365×10^6	12×10^6	377×10^6

Annual charge for Upper Salmon Development is $3,611,000

Energy cost in mills per KWH:

For firm energy: 9.9 mills/KWH
For average energy: 9.6 mills/KWH

Calculation of Energy Costs for doing both Upper Salmon Development and Lloyds River Diversion: Note that full energy benefits are calculated both at the Upper Salmon and at Bay D' Espoir. Therefore, the energy cost given below includes energy generation at both generating stations together. Note, however, that no costs are included for substations or for transmission lines.

Total Project cost of both developments is $42,265,000
Total Annual Charges of both developments is $4,029,000

Cost per installed KW is $528

Energy Benefits

	Firm	Secondary	Total
1. At Bay D ' Espoir due to Upper Lloyds River Diversion	152×10^6	14×10^6	166×10^6
2. At Upper Salmon Due to Lloyds River Diversion	152×10^6	14×10^6	166×10^6
3. At Upper Salmon due to Upper Salmon Development	365×10^6	12×10^6	377×10^6
4. At Bay D' Espoir due to Upper Salmon Development	25×10^6	-20×10^6	5×10^6
Total Energy	694×10^6	20×10^6	714×10^6
Cost in mills per KWH	5.8		5.6

EFFECT OF UPPER LLOYDS RIVER
DIVERSION ON UPPER SALMON DEVELOPMENT
Table B.9

Development	Upper Humber Dev. #1 50% CF	Upper Humber Dev. #2 50% CF	Upper Humber Dev. #3 75% CF	River of Ponds 50% CF	South West Brook 50% CF	Great Rattling Bk. 50% CF	Main River 50% CF
Land Purchase	-	85×10^3	-	-	-	-	-
Land Clearing	35×10^3	7	59×10^3	24×10^3	72×10^3	16×10^3	88×10^3
Roads and Bridges	892	408	1,020	663	102	306	485
Dams, Spillways & Reservoirs	9,124	3,469	10,716	5,466	7,590	6,879	11,745
Headworks, Water Conduits, Tailrace	13,975	1,788	6,586	2,079	637	498	17,423
Power House and P.H. Equip.	5,265	2,633	4,680	2,334	2,194	1,930	5,125
Construction Indirect Costs	3,827	1,090	3,029	1,386	1,372	1,258	4,545
Project Management & Engineering	3,875	1,116	3,056	1,411	1,403	1,266	4,636
SUBTOTAL A	$36,993,000	$10,596,000	$29,146,000	$13,363,000	$13,370,000	$12,154,000	$44,047,000
Contingency (13.6% of S. Total A)	5,031,000	1,441,000	3,964,000	1,817,000	1,818,000	1,653,000	5,990,000
SUBTOTAL B	$42,024,000	$12,037,000	$33,110,000	$15,180,000	$15,188,000	$13,807,000	$50,037,000
Owner's Cost (1% of S. Total B)	420,000	120,000	331,000	152,000	152,000	138,000	500,000
Interest during Construction	3,290,000	948,000	2,594,000	1,198,000	1,191,000	1,075,000	5,751,000
TOTAL PROJECT COST	$45,734,000	$13,105,000	$36,035,000	$16,530,000	$16,531,000	$15,020,000	$56,288,000
Annual Fixed Charges at 9%	4,116,000	1,179,000	3,243,000	1,488,000	1,488,000	1,352,000	5,066,000
Annual Operating and Maintenance Costs	182,000	82,000	97,000	92,000	82,000	40,000	239,000
TOTAL ANNUAL CHARGES	$ 4,298,000	$ 1,261,000	$ 3,340,000	$ 1,580,000	$ 1,570,000	$ 1,392,000	$ 5,305,000
Installed Capacity, MW	73 (2 units)	22 (1 unit)	47 (2 units)	26 (1 unit)	22 (1 unit)	11 (1 unit)	110 (3 units)
Firm Energy, KWH	287×10^6	89×10^6	283×10^6	97×10^6	86×10^6	45×10^6	448×10^6
Average Annual Secondary Energy KWH	not given	not given	not given	not given	not given	not given	not given
Average Annual Energy, KWH							
Cost per Installed KW	$626	$596	$767	$636	$751	$1,365	$512
Cost of Firm Energy, mills/KWH	15.0	14.2	11.8	16.3	18.3	30.9	11.8
Cost of Average Energy, mills/KWH							

NOTES: 1. Developments are described in Part 9.1

HYDRO DEVELOPMENTS DISCUSSED IN WATER RESOURSES REPORT (1968)
TABLE B.10

Development	Unit 7	Unit 8	Unit 9	Unit 10
Roads and Bridges	$104,000		$57,000	
Canals and Tailrace	$4,111,000	$513,000		
Intakes	1,887,000		$103,000	
Pressure Conduit and Surge Tank	5,430,000		$5,153,000	
Powerhouse	1,923,000	118,000	814,000	$118,000
Mechanical and Electrical	3,819,000	$2,975,000	3,819,000	$2,975,000
SUBTOTAL A	$17,274,000	$3,606,000	$9,946,000	$3,093,000
Indirect Costs	4,324,000	610,000	1,714,000	356,000
SUBTOTAL B	$21,598,000	$4,216,000	$11,660,000	$3,449,000
Contingencies (Same percentages as in original report)	1,803,000	263,000	905,000	171,000
Management and Engineering	1,613,000	340,000	932,000	290,000
Management Indirect Costs	668,000	139,000	384,000	120,000
SUBTOTAL C	$25,682,000	$4,958,000	$13,881,000	$4,030,000
Owner's Cost (4% of Subtotal C)	1,027,000	198,000	555,000	161,000
SUBTOTAL D	$26,709,000	$5,156,000	$14,436,000	$4,191,000
Interest during Construction	2,083,000	402,000	1,126,000	327,000
TOTAL PROJECT COST	$28,792,900	$5,558,000	$15,562,000	$4,518,000
Installed Capacity	112	112	112	112
Cost per Installed KW	$257	$50	$139	$40

NOTES: 1. Development is described in part 8.6
2. Interest is assumed to be 7.8% of capital cost. This is the percentage that the interest is of the capital cost in 1971 for most of the developments studied.

PROPOSED EXTENSION TO BAY D" ESPOIR

Table B.11

NO.	Development	Capital Cost	Annual Charges	Installed Capacity MW	Firm Energy KWH x 10^6	Average Energy KWH x 10^6	Cost per Installed KW	Cost of firm Energy mills/KWH	Cost of Average Energy mills/KWH
1.	Upper Lloyds River Diversion	$4,395,000	$418,000	-	152	166	-	2.75	2.50
2.	Upper Lloyds River and Upper Salmon developed together	$42,265,000	$4,029,000	80	~~694~~ 600	~~714~~ 710	$528	5.8	~~5.6~~ 5.7
3.	Granite Canal	$11,400,000	$1,180,000	unknown	200	-	unknown	5.9	-
4.	Upper Salmon (Assuming Lloyds River already Diverted)	$37,870,000	$3,611,000	80	~~517~~ 538	~~543~~ 544	$473	~~7.0~~ 6.7	~~6.7~~ 6.6
5.	Cat Arm, Alternative 1 (High Storage)	$53,000,000	$5,050,000	115	622	-	$462	8.14	-
6.	Terra Nova Development	$63,532,000	$6,098,000	144	740	782	$441	8.2	7.8
7.	Cat Arm, Alternative 1	$48,000,000	$4,550,000	114	538	-	$421	8.45	-
8.	Star Lake	$12,574,000	$1,224,000	26	127	-	$484	9.6	-
9.	Cat Arm, Alternative 6	$43,000,000	$4,100,000	90	425	-	$478	9.7	-
10.	Upper Salmon Development (Without Lloyds River Diversion)	$37,870,000	$3,611,000	80	~~365~~ 484	~~377~~ 489	$473	~~9.9~~ 7.5	~~9.6~~ 7.4
11.	Cat Arm, Alternative 3	$58,000,000	$5,500,000	114	538	-	$509	10.2	-
12.	Cat Arm, Alternative 4	$55,000,000	$5,200,000	105	495	-	$524	10.5	-
13.	Hinds Lake	$26,272,000	$2,496,000	39.5	238	-	$668	10.5	-

SUMMARY SHEET FOR HYDRO-ELECTRIC GENERATING STATIONS

Table B.12

No.	Development	Capital Cost	Annual Charges	Installed Capacity MW	Firm Energy KWH x 10^6	Average Energy KWH x 10^6	Cost per Installed KW	Cost of Firm Energy mills/KWH	Cost of Average Energy mills/KWH
14.	Shandethit Brook	$19,306,000	$1,857,000	37	167	-	$522	11.1	-
15.	Cat Arm, Alternative 2	$63,000,000	$6,000,000	113	535	-	$558	11.2	-
16.	Bay du Nord, Alt. 1-A	$36,974,000	$3,492,000	62	300	360	$596	11.6	9.7
17.	Upper Humber, Alt. 3	$36,035,000	$3,340,000	47	283	-	$767	11.8	-
18.	Main River	$56,288,000	$5,305,000	110	448	-	$512	11.8	-
19.	Bay du Nord, Alt. 2	$102,453,000	$9,566,000	171	700	760	$599	13.7	12.6
20.	Upper Humber, Alt. 2	$ 13,105,000	$1,261,000	22	89	-	$596	14.2	-
21.	Pipers Hole, Alt. 1	$ 97,050,000	$8,998,000	124	610	665	$783	14.8	13.5
22.	Bay du Nord, Alt. 1-B	$ 64,404,000	$5,977,000	110	400	-	$585	14.9	-
23.	Castors River, Alt. 2	$ 6,800,000	$ 680,000	8.65	45.5	63.1	$786	14.9	10.8
24.	Upper Humber, Alt. 1	$ 45,734,000	$4,298,000	73	287	-	$626	15.0	-
25.	Gisbourne Lake	$134,281,000	$12,420,000	169	820	900	$795	15.1	13.8
26.	River of Ponds	$ 16,530,000	$ 1,580,000	26	97	-	$635	16.3	-

SUMMARY SHEET FOR HYDRO-ELECTRIC GENERATING STATIONS
Page 2 of 3
Table B.12

No.	Development	Capital Cost	Annual Charges	Installed Capacity MW	Firm Energy KWH x 10^6	Average Energy KWH x 10^6	Cost per Installed KW	Cost of Firm Energy mills/KWH	Cost of Average Energy mills/ KWH
27.	Torrent River	$3,700,000	$370,000	4.6	22.6	30.75	$804	16.4	12.0
28.	Little Grand Lake	$11,494,000	$1,092,000	10.2	63.3	68.3	$1,127	17.3	16.0
29.	South West Brook	$16,531,000	$1,570,000	22	86	-	$ 751	18.3	-
30.	Castors River, Alternative 1	$ 3,500,000	$ 350,000	3.9	13.65	30.0	$ 897	25.6	11.7
31.	Ten Mile Lake	$ 6,300,000	$ 630,000	6.3	24.5	36.5	$1,000	25.7	17.3
32.	Pipers Hole, Alternative 2	$37,107,000	$3,533,000	80	128	158	$ 464	27.6	22.4
33.	Great Rattling Brook	$15,020,000	$1,392,000	11	45	-	$1,365	30.9	-
34.	Cat Arm, Alternative 5	$181,000,000	$17,200,000	114	538	-	$1,600	32	-
35.	Bay D'Espoir, Unit 7	$ 28,792,000		112			$ 257		
36.	Bay D'Espoir,Unit 8	$ 5,558,000		112			$ 50		
37.	Bay D'Espoir, Unit 9	$ 15,562,000		112			$ 139		
38.	Bay D'Espoir, Unit 10	$ 4,518,000		112			$ 40		

NOTES:

1. Capacity factor is same as that used in the original investigation of the developments.

2. Extension to Bay D'Espoir is only grouped at the end because it has no energy costs. If the table was ordered with respect to cost per installed KW, this development would rank high.

SUMMARY SHEET FOR HYDRO-ELECTRIC GENERATING SYSTEMS