ISLAND POND/GRANITE CANAL

RE-OPTIMIZATION AND COST UPDATE STUDY

Prepared for:

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Background

Final Feasibility studies were completed for the potential Island Pond and Granite Canal hydroelectric projects in 1988 with the issue of reports SMR-02-88 and SMR-10-88, respectively, in January 1988. Cost Summaries were also issued in January 1988 as separate documents under report numbers SMR-02-88 and SMR-06-88 for Island Pond and Granite Canal, respectively.

An optimization study was carried out in conjunction with the final feasibility studies and presented in a combined report, SMR-14-88, dated December 1988. The study optimized specific elements of each project against energy benefits, only, to provide the maximum possible net benefit.

This re-optimization and cost update study has been carried out to confirm whether "S" type turbines would be suitable at Island Pond, to re-optimize the specific elements of each project, based on new present worth values for energy and capacity, and to update the capital cost estimates to reflect current (1996) prices.

Summary of Findings

The study has effectively updated the information on "S" type turbines and compared the relative costs of multiple "S" units to two Francis units at Island Pond. The conclusion reached is that the problems earlier experienced with large "S" units have not been effectively resolved and that multiple small units (minimum of four) would be required to replace two Francis units. However, it was shown that this would not be cost effective and that there would be unquantifiable technical concerns with the "S" units.

It was concluded that two vertical Francis turbines would provide the best technical and economic installations at both Island Pond and Granite Canal.

The re-optimizations for energy and capacity resulted in a general increase in size for the elements re-optimized. However, some structures decreased in size for particular reasons. The plant capacities for Island Pond and Granite Canal increased from 30 MW to 36 MW and from 31 MW to 42 MW, respectively. The penstock diameter at Island Pond increased from 5.4m to 6.25m. The invert elevation of the Power Canal at Granite Canal was lowered from 297 m to 296 m and the invert width of the Tailrace Canal at Granite Canal was increased from 18.0 m to 20.0 m. The invert elevation of the Diversion Canal at Island Pond was raised from 258 m to 258.5 m and the penstock diameter at Granite Canal decreased from 4.25 m to 3.75 m. Table S1 summarizes the results of the previous (1988) optimization and the current (1996) re-optimization. The changes in the optimizations are hi-lited in the table.

The average net head and average energy output at Island Pond decreased from the previous (1988) values as a result of the re-optimizations. The average net head decreased from 22.69 m to 22.35 m and the average annual energy output decreased from 191 GWh to 188 GWh. At Granite Canal, the average net head decreased from 38.70 m to 38.30 m and the average annual energy output decreased from 218 GWh to 216 GWh.

The capital cost estimates have been updated from the previous December 1987 prices to December 1996 prices. Cost data to update the civil works prices was obtained from civil works contractors, and other sources, involved in current similar heavy civil projects. Cost data to update equipment prices was obtained as budget prices from manufacturers and combined with data from similar recent projects in Canada to develope cost formulae which were then used to cost different turbine / generator sizes for the re-optimizations. The increase in total direct costs from December 1987 to December 1996 are 32% and 38%, for Island Pond and Granite Canal, respectively. The following summarizes the costs for each project:

	Island Pond	Granite Canal
Total Direct Cost (including contingency)	$104,018,700	$ 79,143,000
Total Indirect Cost	47,918,500	33,381,700
Total Estimated Capital Cost	$151,937,200	$112,524,700
Installed Capacity (kW)	36,000	42,000
Cost per kW of Installed Capacity	$4,220	$2,680

The total estimated capital costs are exclusive of transmission line and switchyard structure costs.

The average annual energy output at each plant, and the net average annual energy output of each plant when each is considered as part of the overall Bay d'Espoir system, operated for maximum benefit, are as follows:

	Island Pond	Granite Canal
Average Annual Plant Energy (GWh)	188	216
Average Net Annual Plant Energy (GWh) (based on 1988 flow records)	182	216
Average Net Annual Plant Energy (GWh) (based on 1996 flow records and updated Energy Model [1])	192	212

The Project Planning Schedules for Island Pond and Granite Canal are shown in Figures 5.1 and 5.2, herein. These are similar to the schedules in the 1988 reports, with the same project durations, but were updated and generalized for this report, i.e. Year 1 = 1997 and Year 4 = 2000. A summary of these schedules is as follows:

	Island Pond	Granite Canal
Project release (start of engineering)	01 June - Year 1	01 June - Year 1
Start Construction	01 Aug. - Year 1	01 May - Year 2
Complete Construction	mid Dec. - Year 4	mid Dec. - Year 4
Total Project duration	42.5 months	42.5 months
Construction duration	40.5 months	31.5 months

Recommendations

The recommendations resulting from this update study are presented below. These recommendations do not exclude those made in the previous (1988) reports, except for the type of units at Island Pond.

1. Two vertical axis Francis turbines are recommended for both Island Pond and Granite Canal.
2. Plant capacities of 36 MW and 42 MW for Island Pond and Granite Canal, respectively.
3. Invert elevation of 258.5 m for the Diversion Canal at Island Pond.
4. Penstock diameter of 6.25 m at Island Pond.

[1] Reference Acres International Limited Final Report, "Bay d'Espoir ARSP Energy Model", November 27, 1996.

5. Invert elevation of 296.0 m for Power Canal at Granite Canal.
6. Penstock diameter of 3.75 m at Granite Canal.
7. Invert width of 20.0 m for Tailrace Canal at Granite Canal.

Table S1

Island Pond / Granite Canal

Summary of Optimization Results

Element	Unit	Island Pond Original (1988)	Island Pond New (1996)	Granite Canal Original (1988)	Granite Canal New (1996)	Comments
Plant Capacity	MW	30	36	31	42	New capacity at Granite canal is based on 60% capacity factor.
Maximum Flow	m3/s	152	182	92	124	
Peak Efficiency Flow	m3/s	140	167	85	114	Peak efficiency flow = 92% of maximum.
Average Net Head	m	22.69	22.35	38.7	38.3	
Average Annual Energy	GWh	191	188	218	216	
Penstock Diameter	m	5.40	6.25	4.25	3.75	1987 Granite Canal Study selected 4.25 m dia.; later optimized at 3.4 m dia. but larger diameter was retained in study report.
Diversion Canal						
- Invert elevation	m	258.0	258.5	-	-	0.5 m decrease in depth due to reduced energy value. Same average flow in canal (= 105 m3/s) for both optimizations, due to flow regulation effect of Island Pond
- Invert slope	m/m	0.0005	0.0005	-	-	
- Invert width	m	12.0	12.0	-	-	
Power Canal						
- Invert elevation	m	-	-	297.0	296.0	1.0 m increase in depth for larger flow area, required due to increased plant flow.
- Invert slope	m/m	-	-	0.00	0.00	
- Invert width	m	-	-	16.0	16.0	
Tailrace Canal						
- Invert elevation	m	-	-	260.0	260.0	
- Invert slope	m/m	-	-	0.00	0.00	
- Invert width	m	-	-	18.0	20.0	2.0 m increase in width for larger flow area, required due to increased plant flow.

Notes:
1. The 1988 Optimization Study was based on optimizing for energy only, with present worth value of energy set at $0.76 per kWh, for a 60 year plant life.
2. The 1996 Optimization Study is based on optimizing for energy and capacity, with present worth value of energy set at $0.6124/kWh and present worth value of capacity set at $2,186.30/kW, for a 60 year plant life.

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PART 1
INTRODUCTION

1.1 Authorization

This report has been prepared in accordance with the Scope of Work given in ShawMont Newfoundland Limited's letter proposal dated 03 May 1996, which was in response to Newfoundland and Labrador Hydro's letter Request for Proposal, dated 23 April 1996. Newfoundland and Labrador Hydro awarded this work to (then) ShawMont Newfoundland Limited, now AGRA ShawMont Limited, by Purchase Order No. 7003107, dated 17 May 1996.

1.2 Background

Feasibility Studies for the potential Island Pond and Granite Canal hydroelectric projects were completed by ShawMont in January 1988 with the issue of reports SMR-02-88 and SMR-10-88, respectively. The feasibility studies were based on extensive field investigations as well as review of all available data, to define the characteristics of the different structures, the practical methods of construction, practical construction schedules and realistic costs for the projects.

An Optimization Study of the Island Pond and Granite Canal Projects was undertaken by ShawMont in conjunction with the feasibility studies. The study was presented in report SMR-14-88, dated 15 December 1988. This study optimized specific elements of each project to size the structures and equipment to produce the maximum possible net benefit. The maximum net benefit occurring at the point where a small increase in size and/or energy could be provided as economically by an alternative means. In other words, at the point where the cost of construction, plus the present worth cost of lost energy is minimum. The present worth value of lost energy was given as $0.76 per kWh, based on a 60 year plant life. The project elements optimized were:

Island Pond

- Full supply level of Meelpaeg Reservoir - optimized at 265.5m.

- Size and invert elevation of the Diversion Canal - the geometry of the total canal was optimized for maximum benefit-cost ratio, then the overland section was optimized with an invert at elevation of 258.0 m, a width of 12 m and a gradient of 0.0005 m/m.
- Diameter of the Penstocks - optimized at 5.58 m but, for practical reasons, selected as 5.4 m.
- Plant capacity - optimized at 29.5 MW but selected at 30 MW.

Granite Canal

- Operating level of Granite Lake - for practical reasons, maximum level of 305.88 m was selected.
- Size and invert elevation of the Power Canal - optimized with a horizontal invert at elevation 297.0 m and an invert width of 16 m.
- Diameter of the Penstocks - optimized at 3.4 m (but 4.25 m diameter was retained in cost estimate).
- Plant capacity - optimized at 30.8 MW but selected at 31 MW.
- Size and invert elevation of the Tailrace Canal - a horizontal invert at elevation 260.0 m was selected, based on construction considerations, with an optimum invert width of 18 m.

The 1988 optimization results are included in Table S1 which is included in the Summary section of this report.

1.3 Scope of Work

This report updates the previous studies with respect to equipment technology, the optimization of specific project elements and the Capital Cost Estimates for each project, in accordance with the following scope of work:

a) Review impact of new energy and capacity values on previous optimizations.
b) Obtain budgetary prices for major equipment.
c) Review equipment technology, particularly with respect to "S" type units for Island Pond.

d) Confirm equipment arrangements, quantities and prices.

e) Review and update unit and lump sum prices for cost items of the Capital Cost Estimates.

f) Re-optimize the Island Pond diversion canal invert elevation.

g) Re-optimize the Granite Canal power canal and tailrace canal (power canal invert elevation only and the tailrace canal width only).

h) Re-optimize the penstock diameter for each project.

i) Re-optimize the plant capacity for each Development.

j) Add the cost for a fish compensatory flow structure at Granite Canal.

k) Update the Capital Cost Estimate for each project.

l) Prepare a summary report to include the updated cost estimates and re-optimizations for both projects.

1.4 Basis for Cost Up-date and Re-optimization

The basis for the cost up-date and re-optimization of the specific elements of the two projects was to reassess the Capital Costs of these projects based on:

- Current technology, with regards turbine/generator equipment and, particularly, "S" units for Island Pond,
- Addition of a fish compensatory flow structure at Granite Canal.
- Realistic capital costs (1996 dollars),
- An updated present worth value of energy, based on current system planning requirements and a 60 year plant life, from \$0.76 per kWh to \$0.6124 per kWh, and
- A new present worth value of capacity, not included in the previous (1988) optimizations, of \$2,186.30 per kW, also based on a 60 year plant life.

PART 2

TURBINE/GENERATOR SELECTION AND COSTS

2.1 General

One of the recommendations of the January 1988 Final Feasibility Report for Island Pond was to further investigate the possible cost savings associated with an installation using horizontal axis "S" units. It was noted that several problems had been experienced with earlier installations. The results of this review are discussed below. Also, considering the length of time that has expired since the previous cost update, it was considered prudent to review the comparative costs for Francis, Kaplan and Propeller turbines, as well as installation of single or multiple Francis turbines.

For reference purposes, pages 5-9 to 5-13 from the January 1988 Island Pond Final Feasibility Study, wherein turbine type is discussed, are included in Appendix I.

2.2 Technology

In the nine years since the feasibility study work was carried out for the Island Pond and Granite Canal projects, significant advances have been made both in the methodology used to compare different types of turbines, and in operating experience with large horizontal axis "S" units.

In 1990 the Canadian Electrical Association published a manual #712G688 titled "Hydroelectric Turbine Assessment for new units and runner retrofits", which can be used to compare the cavitation performance of all types of turbines. The procedures outlined in the manual have been used in this study to determine unit size, speed and setting based on a conservative minimal rate of expected blade cavitation erosion.

The parameters selected for this study are as follows:

(1) Cavitation factor k = 0.025

This means that the expected rate of cavitation erosion is kd^2 kg per annum, where d is the runner diameter in meters. For a 4 m diameter runner, the loss of metal would be 0.4 kg per annum. This can be compared with the IEC cavitation guarantee range which has a k value between 0.47 and 1.9, or about 40 times higher than the selected k value.

(2) Runner blades of stainless steel.

(3) Runner submergence about equal to one runner diameter, so that for a horizontal axis machine the shaft centerline would be about 0.7 d below tailwater, and for a vertical axis Francis machine, the turbine floor level would be at about low tailwater level.

(4) Synchronous speeds based on use of generators with the number of poles divisible by 4.

To see how the various preliminary technical proposals submitted by the manufacturers, in response to ShawMont's request for budgetary prices, compared with the above criteria, the runner settings were plotted as shown on Figure 2.1. On Figure 2.1, the submergence at sea level S_a is plotted against the runner throat velocity squared, divided by gravity. The value of S_a is obtained from the equation:

$$S_a = S - 0.002\,(TWL)^{0.92} + 0.25d$$

where: S = Level of spiral casing centerline with respect to tailwater, positive below tailwater level (TWL)

d = runner throat diameter.

In effect, S_a is the runner submergence below tailwater at sea level calculated to the bottom of the runner blades.

Island Pond / Granite Canal

Turbine Settings

Source - Water Power, Aug. 1989, page 24 article titled "FRANCIS TURBINE SETTING"

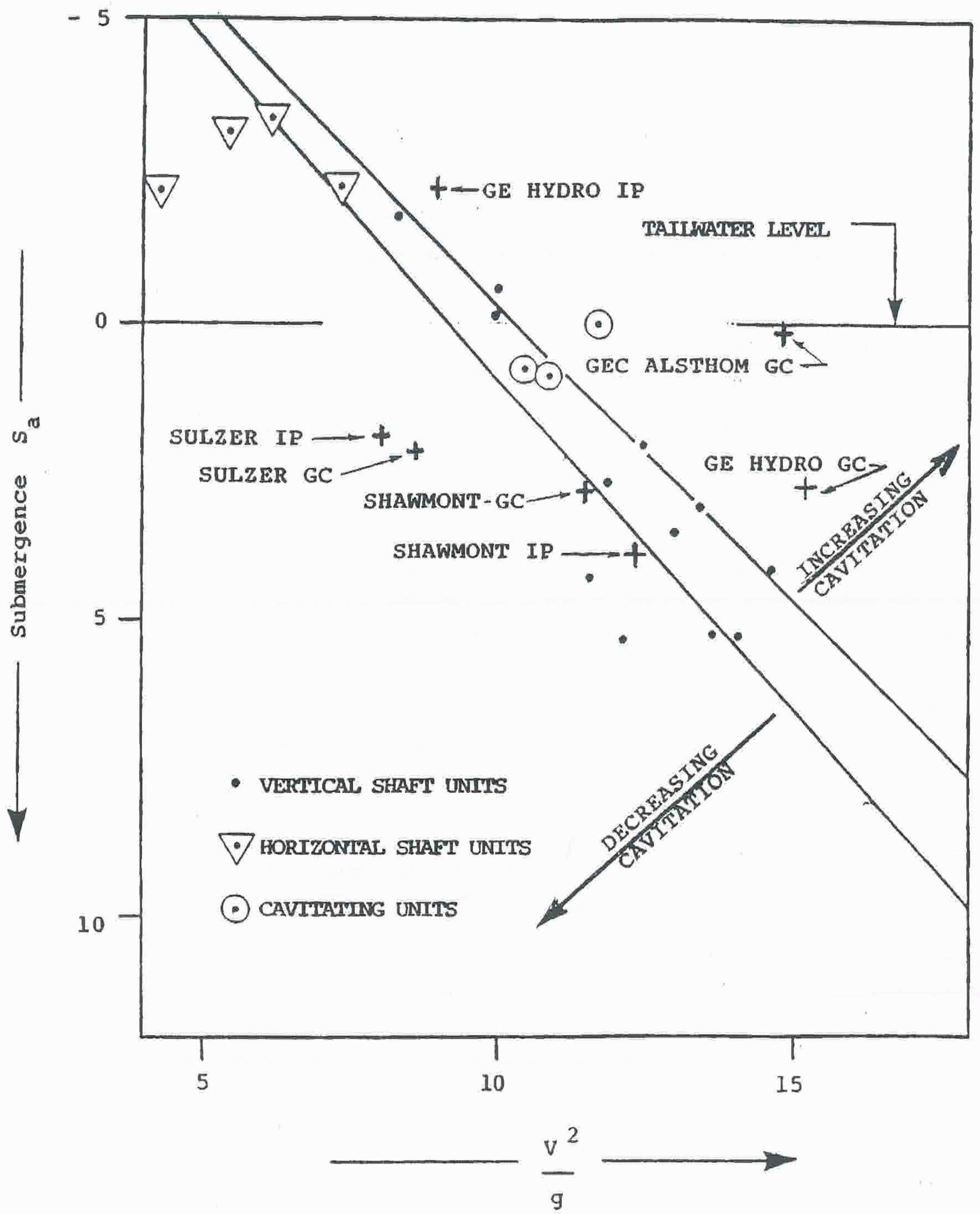


FIGURE 2.1

An examination of Figure 2.1 indicates:

- Sulzer selected very conservative settings, well into the zone of minimal cavitation.
- G.E. Hydro selected settings which would meet the IEC standards for cavitation, which today are considered to be on the high side.
- The GEC Alsthom setting is unacceptably high.

The settings selected by ShawMont are an acceptable compromise based on k= 0.025. If a more conservative setting is required, to provide a cavitation - free runner, then the settings would have to be lowered by about 2 meters, or alternatively, the runner diameter would have to be increased to reduce the throat velocity.

For the purposes of optimization, the runner diameter and setting selected by ShawMont were deemed to be reasonable, and were used in this study.

2.3 Turbine/Generator Costs

The budget quotations received for this study, and previous prices for other units, were used to develop cost formulae for the turbines and generators, based on runner size (d), generator capacity (kVA), rated head (h) and synchronous speed (n). The cost formulae were used to determine the cost of a range of unit sizies, for the purpose of optimizing plant capacities.

G.E. Hydro provided four prices for vertical axis generators and turbines. The generator prices, which included the exciter and installation, were used to develope the following cost formula:

$$\textit{Erected Generator + exciter cost (1996 Cdn \$)} = 2.98 \left(\frac{kVA}{n}\right)^{0.14} x\ 10^6$$

The accuracy of the formula is shown in the following tabulation.

Generator (kVA)	Speed (rpm)	Cost in 1996 Cdn $ x 10^6 Quoted	Calculated	% diff *
11,300	150.0	5.47	5.45	-0.4
22,600	105.9	6.32	6.31	-0.2
13,220	276.9	5.01	5.12	+2.2
26,500	200.0	6.08	5.91	-2.8

* An accuracy within +/- 3% is considered to be adequate.

The turbine prices were used to develop the following cost formula for vertical axis Francis turbines:

$$\text{Erected turbine and governor cost (1996 Cdn \$)} = 0.12\ d^{1.62}\ h^{0.59} \times 10^6$$

The accuracy of the formula is shown in the following tabulation:

Turbine Diameter (m)	Head (m)	Cost in 1996 Cdn $ x 10^6 Quoted	Calculated	% diff *
1.97	38.7	3.05	3.11	+1.9
2.79	38.7	5.36	5.47	+2.0
2.73	22.6	3.80	3.84	+1.0
3.86	22.6	6.63	6.73	+1.5

* An accuracy within +/- 3% is considered to be adequate.

This turbine cost formula was used to determine the cost of vertical axis Kaplan and propeller turbines by using a factor 25% higher (0.10 x 1.25 = 0.12) for Kaplans, and a factor 10% lower (0.10 x 0.9 = 0.09) for propeller turbines, all of which are equipped with steel spiral casings.

The formulae for turbine and generator were applied to the GEC Alsthom quote, resulting in a calculated cost of $17.7 million, far in excess of the GEC Alsthom quote of only $11.5 million, which included valves and switchgear. In other words, the GEC Alsthom quote was just over half the G.E. Hydro quote, indicating that there must be some difference in the source or quality of the equipment.

The formulae were also applied to the Sulzer quote, and it was found that the Sulzer prices ranged between 76% and 64% of the formula cost. On this basis, it was felt that the G.E. Hydro prices were on the high side, and the formulae coefficient were then reduced by 20% to the following:

$$\text{Erected generator and exciter cost} = 2.38\ \left(\frac{kVA}{n}\right)^{0.14}\ x\ 10^{6}$$

$$\text{Erected turbine and governor cost} = 0.10d^{1.62}\ h^{0.59}\ x\ 10^{6}$$

all in 1996 Cdn $.

For the horizontal axis units, only three budget quotations were provided. One from GEC Alsthom for an "elbow" unit with the turbine axis set 7.9 m below tailwater. The quotation included all controls for a water-to-wire unit. The quote from G.E. Hydro was for a Voith unit with a standard "S" configuration. The quote from Sulzer was also for a standard "S" configuration. The following tabulation shows the differences between the units.

Parameter	GEC Alsthom Quote	G.E. Hydro Quote	Sulzer Quote
Number of units	2	2	2
Runner diameter (m)	3.00	2.90	3.20
Submergence (m)	7.90	2.00	3.35
Unit flow (m^3/s)	76.0	55.0	60.0
Generator rating (kW)	15,600	11,257	11,850
Generator rpm	225.0	225.0	211.0
Runner throat velocity (m/s)	10.75	8.33	7.46
Price $ x 10^6, for 2 units	11.43	16.20	8.95

The Alsthom quote was far below the G.E. Hydro quote, and above the Sulzer quote. In this case, it was felt that the Alsthom quotation is reasonable, based on recent prices submitted by Sulzer Hydro for "S" units on other Canadian hydro developments. Using the Alsthom and Sulzer price data, the following equation was developed for a water-to-wire packaged "S" unit:

$$Cost\ (1996\ Cdn\ \$) = (0.33\ d^{1.8} + 1.21\ MW^{0.4}) \times 10^6$$

Applying this formula to the Alsthom quote produced a cost of $6.02 million for one unit and $11.7 million for two, based on the second unit costing 95% of the first.

2.4 Horizontal versus Vertical Axis Units for Island Pond

In the 1988 Final Feasibility Study, the question of unit type was left to a future date. However, the study did conclude that the choice would be between either horizontal axis "S" units or vertical axis Francis units.

To some extent, the quotations received for Island Pond confirm this conclusion since none of the quotes included either vertical Kaplan or Propeller units. As a further confirmation, the cost formulae were used to determine the cost of the following alternatives:

a) Three or four horizontal axis "S" units,
b) Two vertical axis Francis units,
c) Two vertical axis Kaplan units, and
d) Two vertical axis Propeller units,

all for a total capacity of 39,580 kW. In this exercise the cost of a Kaplan turbine was assumed to be 25% more than an identical diameter Francis turbine, and a Propeller turbine was assumed to cost 10% less.

The results are shown in the following tabulation.

Cost comparison of Island Pond Units

Total installed capacity 39,580 kW

Net head 22.6 m

Type of turbine	"S"	"S"	Francis	Kaplan	Propeller
Number of units	3	4	2	2	2
Runner submergence (m)	1.9	1.90	3.5	8	8
Runner diameter (m)	3.2	2.80	3.3	3.53	3.53
Speed (rpm)	200	225.0	116.2	166.3	166.3
Generator MVA	13.4	10.05	20.8	20.8	20.8
Total Cost $ x 10^6	17.3	19.20	24.4	27.7	23.9

The cost of four smaller 2.8 m diameter "S" units was calculated and found to be about $19.2 million.

This cost analysis indicates that for a total installed capacity of 39.6 MW, the choice would be between 3 horizontal axis "S" units and two vertical axis Francis units. The cost difference is $7.1 million in favour of the horizontal units.

This is a significant sum of money, but is based on the assumption that large horizontal axis, air cooled industrial generators are available in capacities over 10 MW. To our knowledge, this is not the case, and there are no known "S" units in operation with generator capacities over 10 MW. If this is correct, then four horizontal axis units would be required for a total plant capacity of around 40 MW.

Another consideration is that "S" units are based on a standard design, and performance drops off at very high heads and capacities. This is illustrated by the performance diagram issued by Sulzer Hydro, where, for a given turbine throat diameter, there is no significant increase in power output for heads in excess of 20 m, so that a runner with a diameter of 3.2 meters is required to produce an output of just under 10 MW.

The cost of a 3.2 m runner and 9850 kW generator can be estimated at $5.47 million, and four would cost $20.5 million, or over $3 million more than for three units.

However, if it is assumed that the horizontal axis generator capacity is limited to 10 MW, and that some further hydraulic design work can be undertaken on the runners, so that a unit of 2.8 m throat diameter can produce 10 MW at 22.6 m net head, then the cost of four horizontal axis units will be about $19.2 million.

Accordingly, for a maximum plant capacity of around 40 MW, four horizontal axis units would be required. This would necessitate the addition of butterfly valves and a bifurcation to pair units out of the two penstocks. Hence costs for the horizontal units have to be adjusted as follows:

> Cost of four butterfly valves, of 4.6 m diameter, 22.6 m head, estimated installed cost would be about $3,600,000.
>
> Cost of powerhouse concrete, estimated at 750 m^3 extra for the horizontal units, at about $700/$m^3$, additional cost would be about $500,000
>
> Cost of lost energy due to difference in generator efficiency, estimated conservatively at a 1.5% difference, with a value of about $2,300,000.

However, there would be a cost saving associated with the horizontal units, since they are normally purchased as a water-to-wire product. To specify and approve drawings for a series of contracts for the electro-mechanical equipment, it would normally cost about 6% of the contract cost in engineering fees. For a water-to-wire single contract, the cost of producing a detailed specification would be about 2% of the contract cost, for a saving of about 4% of about $20 million, or about $800,000.

On this basis the cost of four horizontal axis units, including butterfly valves and additional powerhouse concrete would be :

	1996 Cdn $ x 10^6
Cost of 4 units	19.2
Cost of 4 valves	3.6
Extra concrete	0.5
Value of lost power	2.3
Saving in engineering	-0.8
Total	$24.8 million

This is higher than the cost of alternative vertical axis Francis turbines. In view of this higher cost and the following four unquantifiable technical concerns about "S" units, it is recommended that the horizontal units be eliminated from further consideration. The technical concerns are:

- There have been problems with the shafts on large horizontal axis units. These have shown a tendency to crack and break at the corner of the shaft - flange at the upstream turbine end, due to fluctuating stresses over the long span between turbine and generator bearings. The breaks have been attributed to fatigue induced stress - corrosion.

- The powerhouse is very noisy due to the exposed turbine throat ring casing.

- The generator is below tailwater, a major concern.

- The generator is air cooled, which is acceptable for small generators, but becomes a problem with the larger generators due to the large volume of hot air expelled into the powerhouse.

Based on the foregoing, two vertical axis Francis units appear to be the best technical solution for Island Pond. To confirm the relative costs for a single unit versus two units at Island Pond, an analysis of the turbine and generator, as well as other associated variable costs was carried out, using the sizing and cost formulae developed above. Table 2.1 summarizes the significant unit data, the direct costs for alternative units and the direct costs for other significant variables for powerhouse equipment and construction, penstocks and intake.

The total costs presented in Table 2.1 show that a single Francis unit would have a lower direct cost. However for greater security of energy supply, and reduced down time of the units for maintenance, a two unit installation is recommended, at a premium direct cost of about $3.91 million.

The optimization of plant capacity for Island Pond was subsequently carried out using the formulae developed for sizing and costing of vertical axis units. This is described in the following sections.

2.5 Turbine Type for Granite Canal

At Granite Canal the head is 38.7 m, where either Francis or Kaplan units could be installed. To determine which would be the more economic, the sizing and cost formulae were used to cost four alternatives, one or two units in either Francis or Kaplan configurations, to provide a total capacity of 40 MW. Table 2.2 summarizes the significant unit data, the direct costs for alternative units and the direct costs for other significant variables for powerhouse equipment and construction, penstocks and intake.

The total costs presented in Table 2.2 show that the most economic installation would be with a single Francis unit. However for greater security of energy supply, and reduced down time of the units for maintenance, a two unit installation is recommended, at a premium direct cost of about $5.17 million. For a two unit installation, two Francis units are recommended over two Kaplan units, since the Francis units would have a lower direct cost, by about $2.74 million.

Table 2.1

Comparison of One (1) vs Two (2) Francis Units - Island Pond

No and Type of Turbine	Unit	1- Francis	2- Francis
Parameters:			
Req'd Total Capacity	kW	40,000	40,000
No. of Units (No.)		1	2
Output / Unit (kW)	kW	40,000	20,000
Net Head (h)	m	22.60	22.60
T - G efficiency (e)		0.882	0.882
Flow / Unit (Q)	m3/s	204.56	102.28
Tailwater Level (TWL)	m	240.5	240.5
Value of B	m	9.89	9.89
Submergence (S)	m	4.80	3.50
Number of Blades (b)		13	13
Calculated Throat Velocity (v)	m/s	11.57	11.04
Runner Diameter (d)	m	4.744	3.435
Calculated Speed (N)	rpm	84.7	116.1
Synchronous Speed (Ns)	rpm	85.7	112.5
Generator kVA	kVA	42,105	21,053
Costs:			
Turbine Cost	$million	7.84	4.65
Generator Cost	$million	7.10	6.20
Controls Cost	$million	1.28	1.12
Total Cost for one unit	$million	16.21	11.96
Total Cost for all units	**$million**	**16.21**	**23.32**
Total Cost - Variables *	**$million**	**17.96**	**14.76**
Total Cost - Units and Variables	**$million**	**34.17**	**38.08**

* Variables include powerhouse construction, penstocks & intake.

Table 2.2

Comparison of One or Two Units - Granite Canal
Francis versus Kaplan Turbines

Type of Turbine	Unit	Francis	Francis	Kaplan	Kaplan
Parameters:					
Req'd Total Capacity	kW	40,000	40,000	40,000	40,000
No. of Units		1	2	1	2
Output / Unit	kW	40,000	20,000	40,000	20,000
Net Head	m	38.70	38.70	38.70	38.70
T - G efficiency		0.882	0.882	0.892	0.892
Flow / Unit	m3/s	119.46	59.73	118.12	59.06
Tailwater Level	m	265.7	265.7	265.7	265.7
Value of B	m	9.86	9.86	9.86	9.86
Submergence (S)	m	3.70	2.70	7.30	5.40
Number of Blades		13	13	6	6
Calculated Throat Velocity	m/s	11.11	10.68	10.09	9.51
Runner Diameter (d)	m	3.700	2.668	3.860	2.813
Calculated Speed (N)	rpm	130.6	178.7	174.0	238.2
Synchronous Speed (Ns)	rpm	128.6	180.0	163.6	225.0
Generator kVA	kVA	42,105	21,053	42,105	21,053
Costs:					
Turbine Cost	$million	7.20	4.24	9.25	5.54
Generator Cost	$million	6.70	5.80	6.48	5.63
Controls Cost	$million	1.21	1.04	1.17	1.01
Total Cost for one unit	$million	15.11	11.09	16.90	12.18
Total Cost for all units	**$million**	**15.11**	**21.62**	**16.90**	**23.75**
Total Cost - Variables *	**$million**	**11.08**	**9.74**	**11.67**	**10.35**
Total Cost - Units and Variables	**$million**	**26.19**	**31.36**	**28.57**	**34.10**

* Variables include powerhouse construction, penstocks & intake.

At a head of 38.7 m, Francis and Kaplan units have about the same peak efficiency, in the region of 92.5% (see Figure 2.2). There could be an energy difference in favour of the Francis unit of less than 1%, depending on the particular design. On the other hand, the efficiency curve for a Kaplan unit is much flatter, and could result in a higher weighted efficiency, if the unit is operated at low gate opening (less than 70% gate) for extended periods. In order to determine the value of the energy difference between Francis and Kaplan units, more detailed information would be required from potential bidders, and also a detailed expected load-duration curve for the units. At present, such information is not available, and the expectation is that Francis units will prove the most economic due to the lower initial capital cost, and the lower maintenance cost due to the simpler runner with no rotating blades.

The optimization of plant capacity for Granite Canal was subsequently carried out using the formulae developed for sizing and costing of vertical axis units. This is described in the following sections.

Island Pond / Granite Canal

Typical Efficiencies - Francis, Kaplan & Propeller Turbines

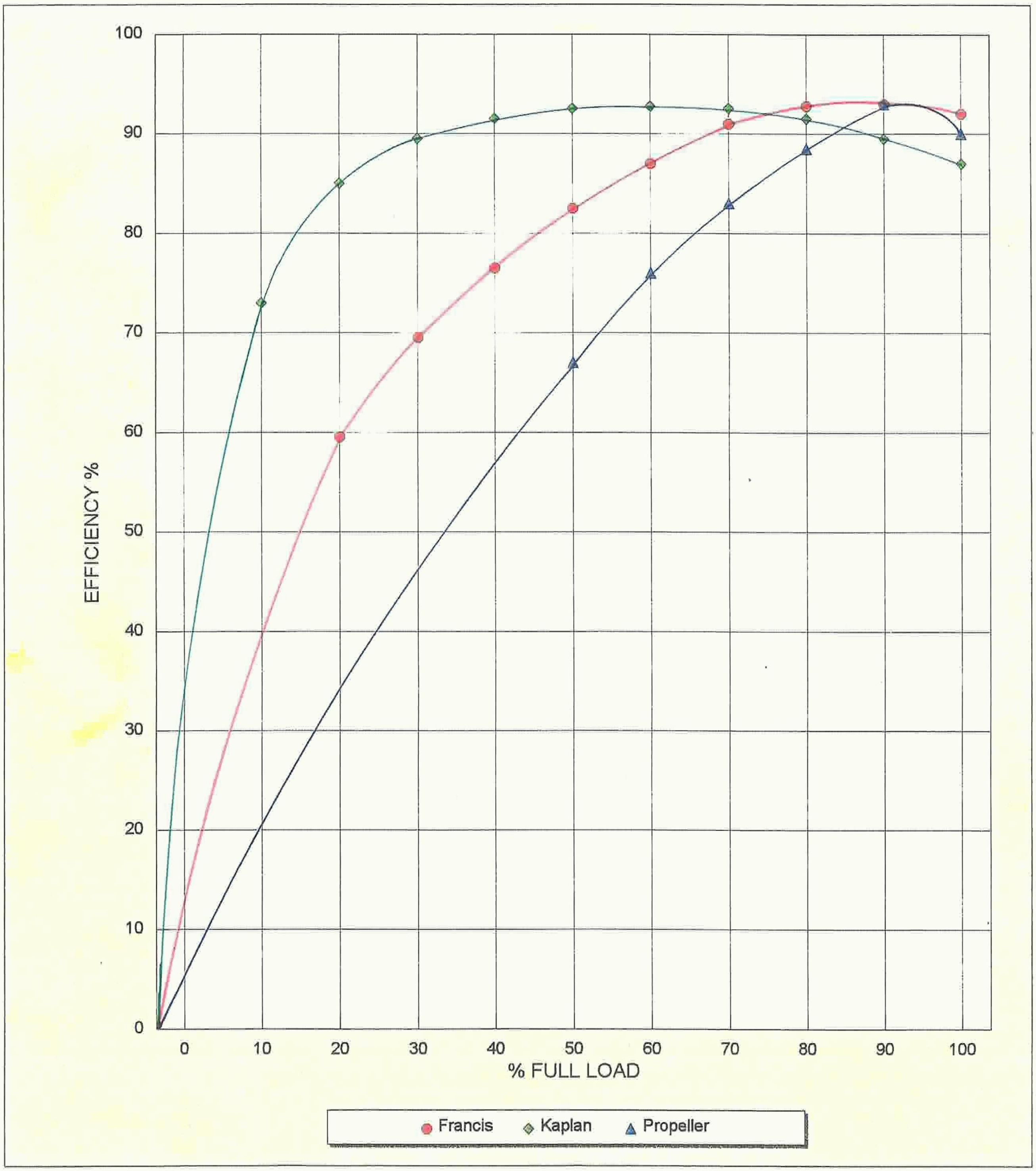


FIGURE 2.2

PART 3
RE-OPTIMIZATION OF ISLAND POND

3.1 General

It was agreed early in the study to exclude re-optimization of the full supply level (FSL) for Island Pond. In the 1988 Optimization Study, the FSL was optimized at elevation 265.5 m to maximize total system energy production. This criteria has not changed.

Three elements of the Island Pond project requiring re-optimization are:

- Plant capacity,
- Invert elevation of the Diversion Canal, and
- Diameter of the Penstocks.

The re-optimizations were based on 1996 dollars. The costs of lost energy and lost capacity were evaluated on the basis of the present worth values of $0.6124/kWh for energy and $2,186.30/kW for plant capacity, as provided by Newfoundland and Labrador Hydro.

The Island Pond project was considered separately from Granite Canal and any joint development benefits were not considered.

3.2 Plant Capacity

The plant capacity is the maximum power output of the plant and is directly proportional to the flow through the plant. Generally, the larger the plant capacity, the larger the average energy production of the plant, since the larger plant flow capacity would enable more water to be passed through the plant during periods of high runoff. However, as the plant capacity is increased, a point of diminishing returns will be reached where the value of the increased energy will be exceeded by the cost of providing the larger capacity.

Similarly, in a system where capacity has a value, a point of diminishing returns will be reached where the value of the increased capacity will be exceeded by the cost of providing the larger capacity.

Plant capacity factor (CF) is a measure of the plant's capacity to produce power. It is defined as the average annual energy output of the plant, divided by the maximum annual energy output of the plant, i.e.

$$\textit{Capacity Factor} = \frac{\textit{Average Annual Energy Output}}{\textit{Maximum Annual Energy Output}}$$

Generally, for a plant like Island Pond, i.e. an energy producing plant with some peaking capacity, the capacity factor should not, as a rule, be less than 50% - 55%. A capacity factor of 60% is normally accepted. Ideally, the plant capacity factor should match that of the system. In the case of the Newfoundland and Labrador Hydro system, the system capacity factor is 59% - 61%. See Table 3.1 for comparison of capacity factors and plant capacity.

The re-optimization of the plant capacity was based on the previous optimization, reference ShawMont Report SMR-14-88. The total system average energy and lost energy values for plant capacities from 24 MW to 36 MW were taken from Table 3.4 of that report. Above 36 MW, it was assumed that the total average system energy was peaked at 3,287.0 GWh/year.

Based on the headlosses for the intake to the powerhouse and for the tailrace, given in the ShawMont report SMR-02-88 for a maximum flow of 152 m^3/s (plant capacity of 30 MW), new headlosses for different plant capacities and associated maximum flows, were calculated. These were based on the 1988 optimized penstock diameter and tailrace size, and on the basis that headloss varies in proportion to the square of the water velocity in the penstock and the tailrace. New values for lost energy, based on the new headlosses, were then calculated.

The table included in Figure 3.1 of this report summarizes the benefits and costs for different plant capacities. The benefits are total average annual system energy (GWh/year) and plant capacity. This data is also shown graphically in Figure 3.1. The graph shows that the total costs are minimum at a capacity of about 40 MW (CF=54.2%); however, the costs

Table 3.1

Island Pond / Granite Canal

Comparison of Capacity factors and Unit Size

Island Pond

Unit Size	Capacity Factor
24	90.3%
26	83.3%
28	77.4%
30	72.2%
32	67.7%
34	63.7%
36	60.2%
38	57.0%
40	54.2%
42	51.6%
44	49.2%

$$\text{Capacity Factor} = \frac{\text{Avg. Annual Energy Output}}{\text{Maximum Annual Energy Output}}$$

$$= \frac{9.81 \times 109.3 \times 22.6 \times 0.894 \times 8760}{\text{Unit Size} \times 1{,}000 \times 8760}$$

For CF = 60% (see note 3)

$$\text{Unit Size} = \frac{9.81 \times 109.3 \times 22.6 \times 0.894 \times 8760}{0.6 \times 1{,}000 \times 8760}$$

= 36.1 MW (Use 36 MW)

Granite Canal

Unit Size	Capacity Factor
26	95.7%
28	88.9%
30	82.9%
32	77.7%
34	73.2%
36	69.1%
38	65.5%
40	62.2%
42	59.2%
44	56.5%
46	54.1%
48	51.8%
50	49.8%

$$\text{Capacity Factor} = \frac{\text{Avg. Annual Energy Output}}{\text{Maximum Annual Energy Output}}$$

$$= \frac{9.81 \times 73.3 \times 38.7 \times 0.894 \times 8760}{\text{Unit Size} \times 1{,}000 \times 8760}$$

For CF = 60% (see note 3)

$$\text{Unit Size} = \frac{9.81 \times 73.3 \times 38.7 \times 0.894 \times 8760}{0.6 \times 1{,}000 \times 8760}$$

= 41.5 MW (Use 42 MW)

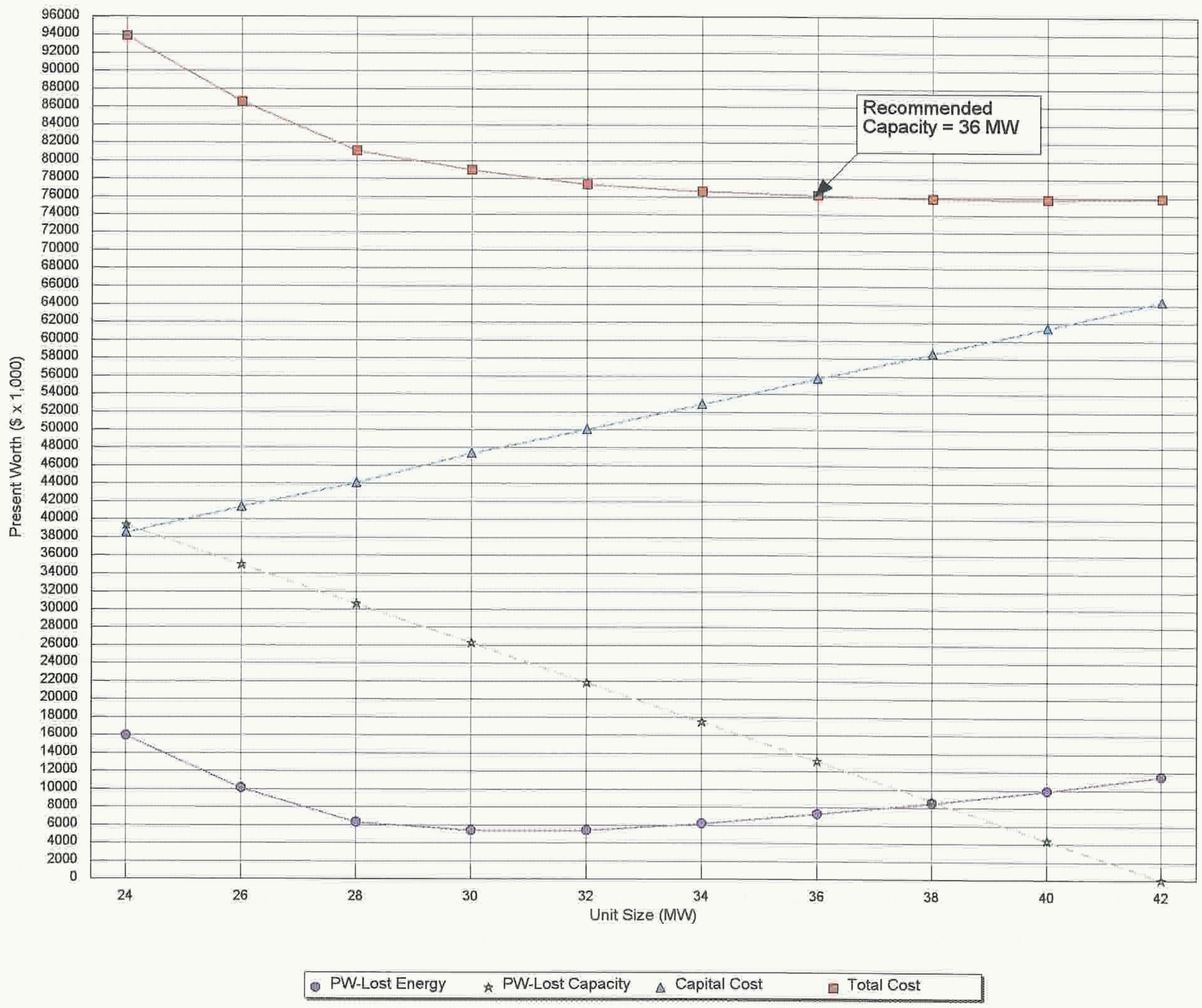
Notes:

1. For an energy producing plant, with some peaking capacity, the Capacity Factor should not be less than 50 - 55% ; 60% is ideal.
2. A plant with Capacity Factor less than 30 - 40% is run - of - river.
3. Nfld Hydro System Capacity (Load) Factor = 59% - 61%. Therefore, Island Pond & Granite Canal to be sized for CF = 60% (per telcon Brown / Piercy, 23 Aug 96).

Island Pond
Plant Capacity Optimization

Unit Size (m)	Lost capacity (MW)	(1) Total Average System Energy (GWh / yr)	Lost System Energy (kWh / yr)	(2) Head Loss Intake-Tailrace (m)	Lost Energy due to Headloss (kWh / yr)	(3) PW Value Total Lost Energy ($ x 1,000)	(4) PW Value Lost Capacity ($ x 1,000)	(5) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
24	18	3,264.5	22,500,000	0.40	3,507,000	15,927	39,353	38,516	93,796
26	16	3,274.9	12,100,000	0.47	4,458,000	10,140	34,981	41,403	86,524
28	14	3,282.2	4,800,000	0.55	5,567,000	6,349	30,608	44,091	81,048
30	12	3,285.0	2,000,000	0.63	6,849,000	5,419	26,236	47,329	78,984
32	10	3,286.4	600,000	0.72	8,311,000	5,457	21,863	50,021	77,341
34	8	3,286.8	200,000	0.81	9,971,000	6,229	17,490	52,865	76,584
36	6	3,286.9	100,000	0.91	11,835,000	7,309	13,118	55,715	76,142
38	4	3,287.0	0	1.01	13,917,000	8,523	8,745	58,563	75,831
40	2	3,287.0	0	1.12	16,235,000	9,942	4,373	61,391	75,706
42	0	3,287.0	0	1.24	18,792,000	11,508	0	64,337	75,845

PW Value of Energy = C$0.6124 /kWh
Value of Capacity = C$2,186.30 /kW



Notes:
(1) From Table 3.4 of 1988 Optimization Report for 24 MW to 36 MW. Includes Island Pond, Upper Salmon and Bay d'Espoir. Values for 38 MW and higher are estimated.
(2) New headloss based on original maximum plant flow (152 m3/s) and calculated in proportion to the ratio of the square of new & original velocities in penstock and tailrace.
(3) Based on present worth of 1 kWh for 60 years = $0.6124.
(4) Based on present worth of 1 kW for 60 years = $2,186.30.
(5) Capital cost includes direct and indirect costs.

FIGURE 3.1

do not vary significantly between capacities of 36 MW (CF=60.2%) and 42 MW (CF= 51.6%).

Therefore, to minimize capital cost and to match the system capacity factor as closely as possible, a plant capacity of 36 MW is recommended as the optimum plant capacity at Island Pond.

3.3 Diversion Canal

The re-optimization of the Diversion Canal was based on the previous optimization, reference ShawMont Report SMR-14-88. In that report, the method of optimization was described as having been done in two steps. The first step fixed the general geometry of the canal by comparing the benefit-cost ratios of several alternative cross-sections and longitudinal profiles. The alternative with the highest benefit - cost ratio was further analyzed in step two. In the second step, the invert width and longitudinal profile of the overland section of the canal were maintained, while the invert elevation was varied. This resulted in an optimized geometry for the overland section of the canal comprising an invert width of 12 m, an upstream invert elevation of 258.0 m and a longitudinal gradient of 0.0005 m/m.

The re-optimization, was carried out similar to the second step of the previous optimization in that only the invert elevation of the upstream end of the overland section of the canal was varied. This time, however, in addition to evaluating the present worth value of the lost energy resulting from headlosses in the canal, the lost plant capacity resulting from the headlosses was also evaluated.

For this re-optimization, the values for net head, average annual energy and lost energy were taken from Table 3.2 of Report SMR-14-88. These values are unchanged from the previous optimization since the flow of water in the Diversion Canal does not change with the larger plant capacity, due to the flow regulating effect of Island Pond. The new present worth value of energy was then used to calculate the present worth value, or cost, of the lost energy for each invert elevation.

The plant capacity was calculated, based on the new maximum flow of 182 m^3/s (plant capacity of 36 MW), for the average net head available at each invert elevation of the canal, as taken from Table 3.2 of the 1988 Optimization Report. The new present worth value of capacity was then used to calculate the present worth value, or cost, of lost capacity for each invert elevation.

The table included in Figure 3.2 of this report summaries the lost energy and capacity, and the associated costs for several different invert elevations. This data is also shown graphically in Figure 3.2. The graph shows that the total costs are minimum at an invert elevation of about 257.5 m; however, the costs do not vary significantly between invert elevations of 257.5 m and 258.5 m. Consequently, to minimize capital cost, an elevation of 258.5 m is recommended as the optimum invert elevation for the upstream end of the overland section of the Diversion Canal at Island Pond.

3.4 Penstock Diameter

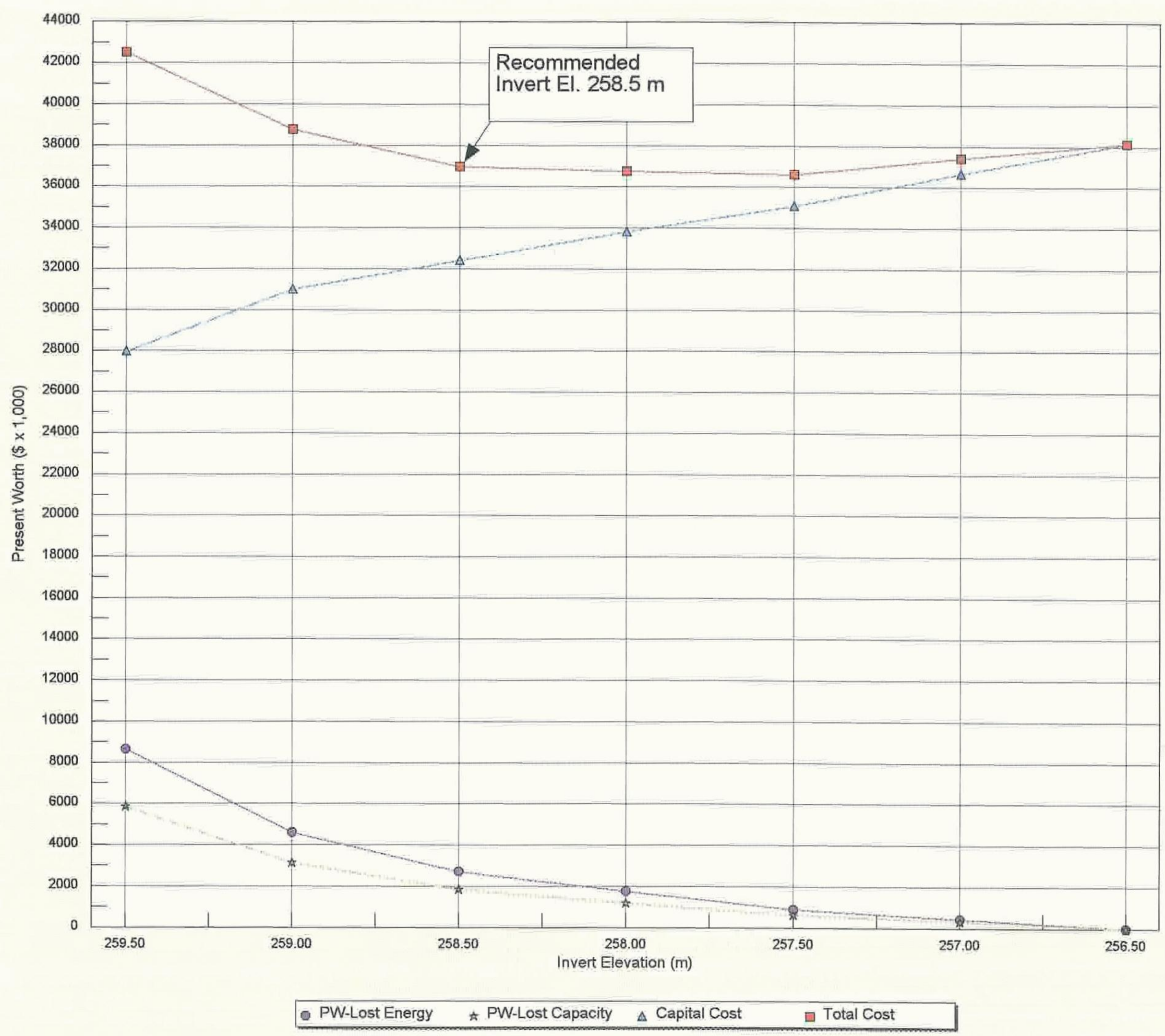
The re-optimization of the Penstock diameter was based on the previous optimization, reference ShawMont Report SMR-14-88. The values for lost energy for different penstock diameters were taken from Table 3.3 of that report. The headloss for each diameter, from 4.75 m to 5.75 m, was calculated based on the original peak efficiency flow of 140 m^3/s and projected, graphically, for diameters of 6.00 m to 6.75 m. New headlosses for all diameters were then calculated for the new peak efficiency flow of 167 m^3/s (for a 36 MW plant capacity), on the basis that headloss varies in proportion to the square of the water velocity in the penstock. New values for lost energy, based on the new headlosses were calculated. Also, values for lost capacity, associated with the lost energy, were calculated.

The table included in Figure 3.3 of this report summaries the headlosses, lost energy, and lost capacity, and the associated costs, for several different penstock diameters. This data is also shown graphically in Figure 3.3. The graph shows that the total costs are minimum at a diameter of about 6.50 m; however, the costs do not vary significantly between diameters of 6.25 m and 6.75 m. Therefore, to minimize capital cost, a diameter of 6.25 m is recommended as the optimum penstock diameter at Island Pond.

Island Pond
Diversion Canal Invert Elevation Optimization

Invert El (m)	(1) Avg Net Head (m)	(2) Avg Ann Energy (GWh / yr)	Lost Energy (GWh / yr)	(3) Capacity (kW)	Lost Capacity (kW)	(4) PW Value Lost Energy ($ x 1,000)	(5) PW Value Lost Capacity ($ x 1,000)	(6) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
259.50	21.16	177.75	14.15	33,775	2,682	8,665	5,863	27,970	42,498
259.00	21.94	184.37	7.53	35,020	1,437	4,611	3,141	31,010	38,762
258.50	22.31	187.48	4.42	35,610	846	2,707	1,850	32,410	36,966
258.00	22.50	189.04	2.86	35,914	543	1,751	1,186	33,820	36,758
257.50	22.66	190.43	1.47	36,169	287	900	628	35,080	36,608
257.00	22.75	191.17	0.73	36,313	144	447	314	36,670	37,431
256.50	22.84	191.90	0.00	36,456	0	0	0	38,150	38,150

PW Value of Energy = C$0.6124 /kWh
PW Value of Capacity = C$2,186.30 /kW



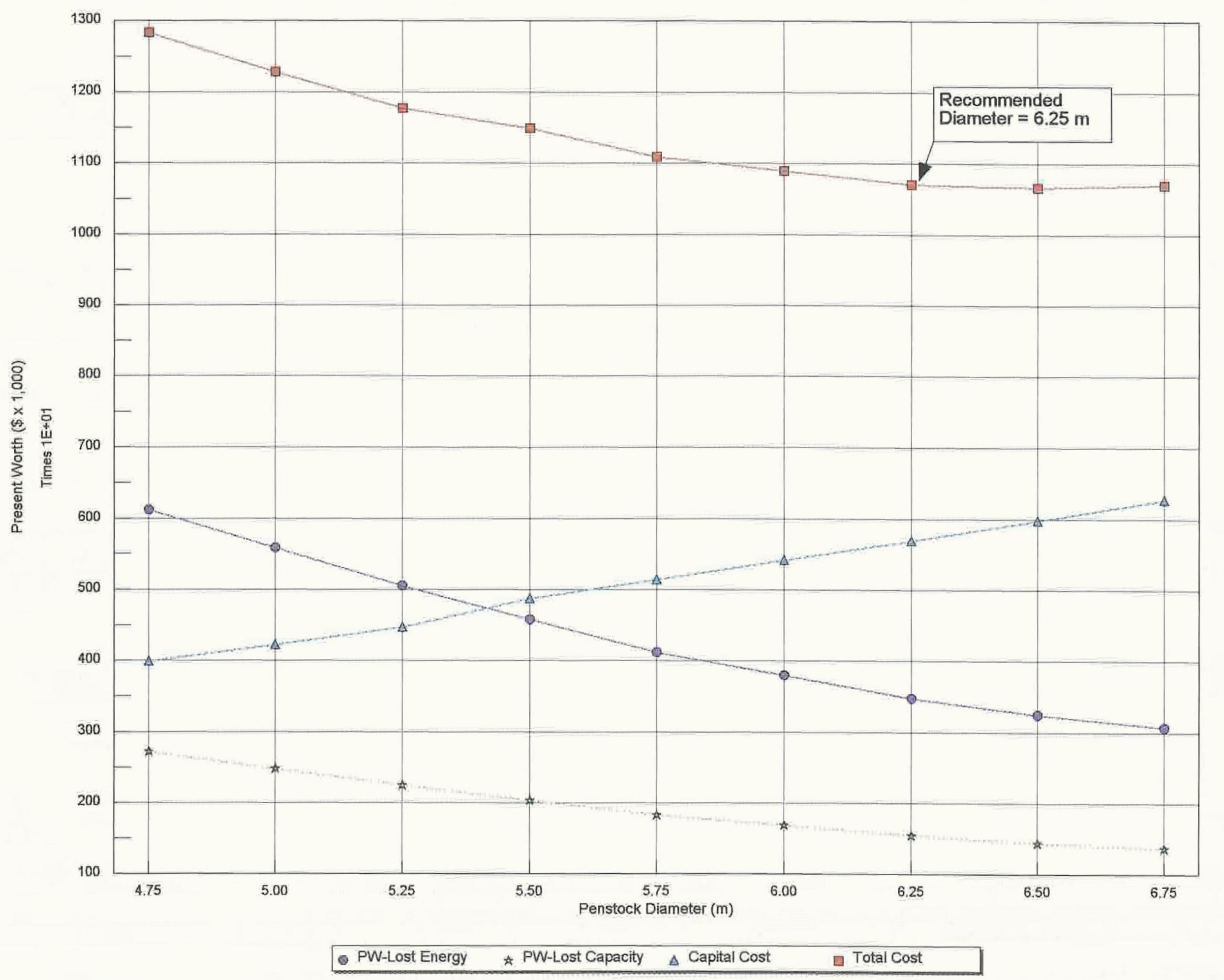
Notes:
(1) From Table 3.2 of 1988 Optimization Report, based on avg. water levels, avg. flow of 105 m3/s in Diversion Canal & peak efficiency flow of 140 m3/s downstream of Island Pond.
(2) From Table 3.2 of 1988 Optimization Report, based on avg. net head (1) and avg. flow of 109.3 m3/s from Island Pond.
(3) Based on max. flow of 182 m3/s.
(4) Based on present worth of 1 kWh for 60 years = $0.61.
(5) Based on present worth of 1 kW for 60 years = $2,186.30.
(6) Capital cost includes direct and indirect costs.

FIGURE 3.2

Island Pond
Penstock Diameter Optimization

Diameter (m)	(1) Original Lost Energy (kWh / yr)	(2) Original Lost Head (m)	(3) New Lost Head (m)	(4) New Lost Energy (kWh / yr)	(5) Lost Capacity (kW)	(6) PW Value Lost Energy ($ x 1,000)	(7) PW Value Lost Capacity ($ x 1,000)	(8) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
4.75	5,877,600	0.55	0.78	9,994,100	1,243	6,120	2,718	3,990	12,829
5.00	5,357,900	0.50	0.71	9,110,400	1,133	5,579	2,478	4,227	12,284
5.25	4,855,300	0.45	0.64	8,255,800	1,027	5,056	2,246	4,471	11,772
5.50	4,400,000	0.41	0.58	7,481,700	931	4,582	2,035	4,877	11,494
5.75	3,955,300	0.37	0.52	6,725,500	837	4,119	1,829	5,143	11,091
6.00	3,646,200	0.34	0.48	6,199,900	771	3,797	1,686	5,415	10,898
6.25	3,334,300	0.31	0.44	5,669,500	705	3,472	1,542	5,693	10,707
6.50	3,119,200	0.29	0.41	5,303,700	660	3,248	1,443	5,977	10,668
6.75	2,947,100	0.27	0.39	5,011,100	623	3,069	1,363	6,268	10,700

PW Value of Energy = C$0.6124 /kWh
PW Value of Capacity = C$2,186.30 /kW



Notes:
(1) From Table 3.3 of the 1988 Optimization Study and based on head loss from trashracks to tailrace.
(2) Based on lost energy (1) and peak efficiency flow of 140 m3/s.
(3) Based on peak efficiency flow of 167 m3/s.
(4) Based on new lost head (3) and peak efficiency flow of 167 m3/s.
(5) Based on new lost head (3) and maximum flow of 182 m3/s.
(6) Based on present worth of 1 kWh for 60 years = $0.61.
(7) Based on present worth of 1 kW for 60 years = $2,186.30.
(8) Capital cost includes direct and indirect costs.

FIGURE 3.3

3.5 Results of Re-Optimization

The following tables summarize the results of the re-optimization of the specific project elements and the consequent headlosses, compared to the previous study presented in the 1988 report (SMR-02-88).

Re-Optimization

Element	Original (1988)	New (1996)
Plant Capacity	30 MW	36 MW
Diversion Canal Invert El.	258.0 m	258.5 m
Penstock Diameter	5.4 m	6.25 m

Comparison of Headlosses

Location	Original (1988)	New (1996)	Reason for Change
Diversion Canal	0.82 m	1.01 m	Increase due to decrease in canal depth and flow area.
Forebay Canal	0.05 m	0.06 m	Original based on Q_{max} = 152 m^3/s, new based on PEF = 167 m^3/s. (where PEF = peak efficiency flow).
Intake & Penstock	0.40 m	0.44 m	Original based on PEF = 140 m^3/s, new based on PEF = 167 m^3/s.
Tailrace	0.22 m	0.32 m	Original based on Q_{max} = 152 m^3/s, new based on PEF = 167 m^3/s.

3.6 Available Net Head and Energy Output

The following shows the calculation of available head and energy output and compares the original (1988) and new (1996) values:

	Original	New
Average Reservoir Level	265.62 m	265.62 m
Headloss in Diversion Canal	0.82 m	1.01 m
Headloss across Island Pond	0.03 m	0.03 m
Island Pond drawdown	0.11 m	0.11 m
Headloss in Forebay Canal	0.05 m	0.06 m
Average Water Level at Intake	264.61 m	264.41 m
Average Crooked Lake WL	241.32 m	241.32 m
Headloss in Tailrace	0.22 m	0.32 m
Average Tailwater Level	241.52 m	241.62 m
Average Gross Head	23.09 m	22.79 m
Headloss in Intake & Penstock	0.40 m	0.44 m
Average Net Head	22.69 m	22.35 m
Average Energy Output	191 GWh	188 GWh

The above shows that there is a small decrease in the average net head on the plant and a corresponding small decrease in the average energy output of the plant (less than 2%).

The system model used to model the overall system energy output, in the 1988 Feasibility Study, showed that operation of the Bay d'Espoir system for maximum benefit, with the Island Pond Development in place, would result in a small decrease in output from the downstream plants (Upper salmon and Bay d'Espoir) of 6 GWh/year. Therefore, the net benefit to be derived from the addition of the Island Pond Development to the system was 185 GWh/year. For this update study, assuming the same decrease in downstream output, the net benefit to be derived from the addition of the Island Pond Development to the system would be 182 GWh/year.

The following summarizes the average annual energy output (GWh/year) of the Island Pond plant based on the foregoing average net heads and the average flow. The total simulated system energy output, based on the updated Bay d'Espoir ARSP Energy Model [1] and the 1996 flow records, is also shown:

1988 flow records

	Original (1988)	New (1996)
Island Pond plant, only	191	188
Change in output of other plants	- 6	- 6
Equals net output of Island Pond	185	182
Total system output (including Island Pond)	3,278	3,275

1996 flow records [2]

	Original (1988)	New (1996)
Island Pond plant, only	-	188
Change in output of other plants	-	+ 4
Equals net output of Island Pond	-	192
Total system output (including Island Pond)	-	3,285

[1] Reference Acres International Limited Final Report, "Bay d'Espoir ARSP Energy Model Update", November 27, 1996.

[2] 1996 flow records were used to update the Bay d'Espoir ARSP Energy Model results, only. This update study used the 1988 average flow for energy calculations.

PART 4

RE-OPTIMIZATION OF GRANITE CANAL

4.1 General

It was agreed early in the study to exclude re-optimization of the operating level of Granite Lake. In the 1988 Optimization Study, the operating level was selected at elevation 305.88 m to minimize the impact of a higher water level on structures upstream of Granite Lake, and to minimize the loss of water over the overflow spillways, along the southern perimeter of the lake. This criteria has not changed.

Three elements of the Granite Canal project requiring re-optimization are:

- Plant capacity,
- Invert elevation of the Power Canal,
- Diameter of the Penstocks, and
- Width of the Tailrace Canal.

The re-optimizations were based on 1996 dollars. The costs of lost energy and lost capacity were evaluated on the basis of the present worth values of $0.6124/kWh for energy and $2,186.30/kW for plant capacity, as provided by Newfoundland and Labrador Hydro.

The Granite Canal project was considered separately from Island Pond and any joint development benefits were not considered.

4.2 Plant Capacity

Based on the headlosses for the intake to the powerhouse and for the tailrace, given in the ShawMont report SMR-02-88 for a maximum flow of 92 m^3/s (plant capacity of 31 MW), new headlosses for different plant capacities and associated maximum flows, were calculated. These were based on the 1988 penstock diameter of 4.25 m and the optimized tailrace size, and on the basis that headloss varies in proportion to the square of the water velocity in the penstock and the tailrace. New values for lost energy, based on the new headlosses, were then calculated.

The table included in Figure 4.1 of this report summaries the benefits and costs for different plant capacities. The benefits are total average annual system energy (GWh/year) and plant capacity. This data is also shown graphically in Figure 4.1. The graph shows that the total costs do not minimize up to a capacity of 50 MW (CF=49.8%), which exceeds the practical plant capacity for a plant of this type (i.e. an energy producer with some excess capacity), and the system capacity factor of about 60%. Therefore, to minimize capital cost and to match the system capacity factor as closely as possible, a plant capacity of 42 MW (CF=59.2%) is recommended as the optimum plant capacity at Granite Canal.

4.3 Power Canal

The re-optimization of the Power Canal was based on the previous optimization, reference ShawMont Report SMR-14-88. In that report, the method of optimization was described as having been done in three steps. The first step fixed the general geometry of the canal by comparing the benefit-cost ratios of several alternative cross-sections and longitudinal profiles. The alternative with the highest benefit-cost ratio was further analyzed in step two. In the second step, the invert elevation of the canal was maintained, while the invert width was varied. The alternative with an invert width of 16 m had the least total cost of lost energy plus capital cost and was further analysed in step three. In the third step, the invert width of 16 m was maintained while the invert elevation was varied. The final result was a power canal with an invert width of 16 m and a horizontal invert at an optimized elevation of 297.0 m.

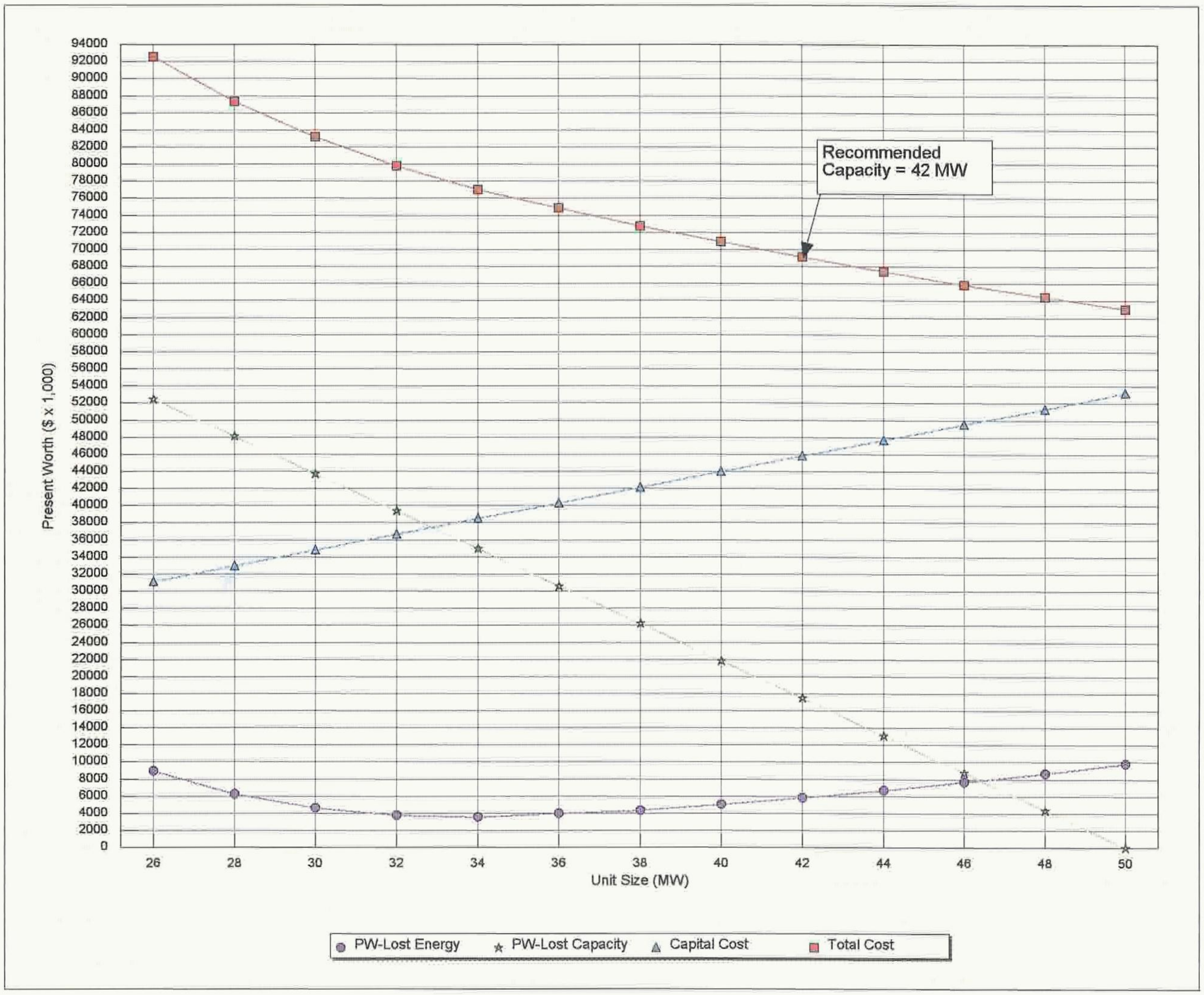
The re-optimization, was carried out similar to the third step of the previous optimization in that only the invert elevation of the canal was varied. This time, however, in addition to evaluating the present worth value of the lost energy resulting from headlosses in the canal, the lost plant capacity resulting from the headlosses was also evaluated.

For this re-optimization, the values for average net head, average annual energy and lost energy were taken from Table 4.4 of Report SMR-14-88. The headlosses for the different invert elevations were calculated as the difference in the net heads from Table 4.4. Since the net heads were originally calculated on the basis of peak efficiency flow, new net heads

Granite Canal
Plant Capacity Optimization

Unit Size (m)	Lost capacity (MW)	(1) Total Average System Energy (GWh / yr)	Lost System Energy (kWh / yr)	(2) Head Loss Intake-Tailrace (m)	Lost Energy due to Head loss (kWh / yr)	(3) PW Value Total Lost Energy ($ x 1,000)	(4) PW Value Lost Capacity ($ x 1,000)	(5) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
26	24	3,297.6	12,400,000	0.42	2,252,000	8,973	52,471	31,130	92,574
28	22	3,302.6	7,400,000	0.48	2,813,000	6,254	48,099	33,000	87,353
30	20	3,305.9	4,100,000	0.55	3,461,000	4,630	43,726	34,850	83,206
32	18	3,308.0	2,000,000	0.63	4,199,000	3,796	39,353	36,670	79,820
34	16	3,309.2	800,000	0.71	5,038,000	3,575	34,981	38,490	77,046
36	14	3,309.5	500,000	0.80	5,978,000	3,967	30,608	40,300	74,875
38	12	3,309.9	100,000	0.89	7,032,000	4,368	26,236	42,170	72,773
40	10	3,310.0	0	0.98	8,203,000	5,024	21,863	44,000	70,887
42	8	3,310.0	0	1.09	9,493,000	5,814	17,490	45,850	69,154
44	6	3,310.0	0	1.19	10,917,000	6,686	13,118	47,660	67,463
46	4	3,310.0	0	1.30	12,476,000	7,640	8,745	49,530	65,916
48	2	3,310.0	0	1.42	14,171,000	8,678	4,373	51,360	64,411
50	0	3,310.0	0	1.54	16,020,000	9,811	0	53,210	63,021

PW Value of Energy = C$0.6124 /kWh
Value of Capacity = C$2,186.30 /kW



Notes:
(1) From Table 4.6 of 1988 Optimization Report for 26 MW to 34 MW. Includes Granite Canal, Upper Salmon and Bay d'Espoir. Values for 38 MW and higher are estimated.
(2) New headloss based on original maximum plant flow (92 m3/s) and calculated in proportion to the ratio of the square of the new & original velocities in penstock and tailrace.
(3) Based on present worth of 1 kWh for 60 years = $0.6124.
(4) Based on present worth of 1 kW for 60 years = $2,186.30.
(5) Capital cost includes direct and indirect costs.

FIGURE 4.1

for all invert elevations were then calculated for the new peak efficiency flow of 114 m^3/s (for a 42 MW plant capacity), on the basis that headloss varies in proportion to the square of the water velocity in all the water passages. New values for average annual energy and lost energy, based on the new net heads were calculated. The new present worth value of energy was then used to calculate the present worth value, or cost, of the lost energy for each invert elevation.

The plant capacity was calculated, based on the new maximum flow of 124 m^3/s (plant capacity of 42 MW), for the new average net head available at each invert elevation of the canal. The new present worth value of capacity was then used to calculate the present worth value, or cost, of lost capacity for each invert elevation.

The table included in Figure 4.2 of this report summarizes the lost energy and capacity, and the associated costs for several different invert elevations. This data is also shown graphically in Figure 4.2. The graph shows that the total costs are minimum at an invert elevation of about 296.0 m. Therefore, an elevation of 296.0 m is recommended as the optimum invert elevation for the Power Canal for the Granite Canal project.

4.4 Penstock Diameter

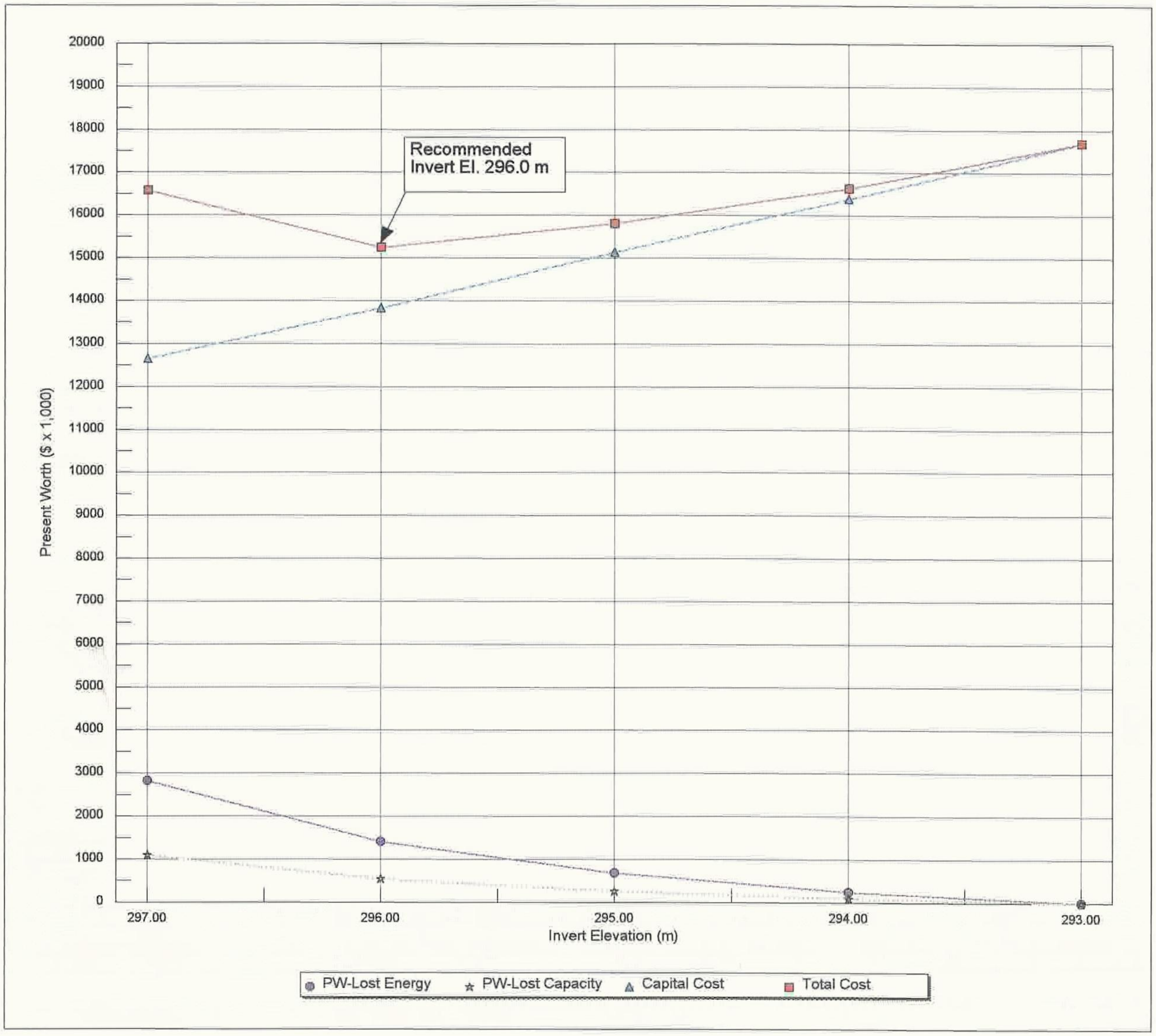
The re-optimization of the Penstock diameter was based on the previous optimization, reference ShawMont Report SMR-14-88. The values for lost energy for different penstock diameters were taken from Table 4.5 of that report. The headloss for each diameter, from 3.25 m to 4.75 m, was calculated based on the original peak efficiency flow of 85 m^3/s and projected, graphically, for diameters of 5.00 m and 5.25 m. New headlosses for all diameters were then calculated for the new peak efficiency flow of 114 m^3/s (for a 42 MW plant capacity), on the basis that headloss varies in proportion to the square of the water velocity in the penstock. New values for lost energy, based on the new headlosses were calculated. Also, values for lost capacity, associated with the new headlosses , were calculated.

The table included in Figure 4.3 of this report summaries the headlosses, lost energy, and lost capacity, and the associated costs, for several different penstock diameters. This data

Granite Canal
Power Canal Invert Elevation Optimization

Invert El (m)	(1) Original Net Head (m)	(2) Original Avg Ann Energy (GWh / yr)	Original Lost Energy (GWh / yr)	(3) New Net Head (m)	New Lost Energy (GWh / yr)	(4) Capacity (kW)	Lost Capacity (kW)	(5) PW Value Lost Energy ($ x 1,000)	(6) PW Value Lost Capacity ($ x 1,000)	(7) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
297.00	36.40	202.95	2.57	36.02	4.61	39,585	500	2,825	1,094	12,657	16,576
296.00	36.63	204.23	1.29	36.43	2.31	39,835	250	1,413	547	13,838	15,251
295.00	36.75	204.90	0.62	36.65	1.10	39,966	120	676	262	15,135	15,811
294.00	36.82	205.29	0.23	36.77	0.40	40,042	43	246	95	16,386	16,631
293.00	36.86	205.52	0.00	36.84	0.00	40,085	0	0	0	17,694	17,694

PW Value of Energy = C$0.6124 /kWh
PW Value of Capacity = C$2,186.30 /kW



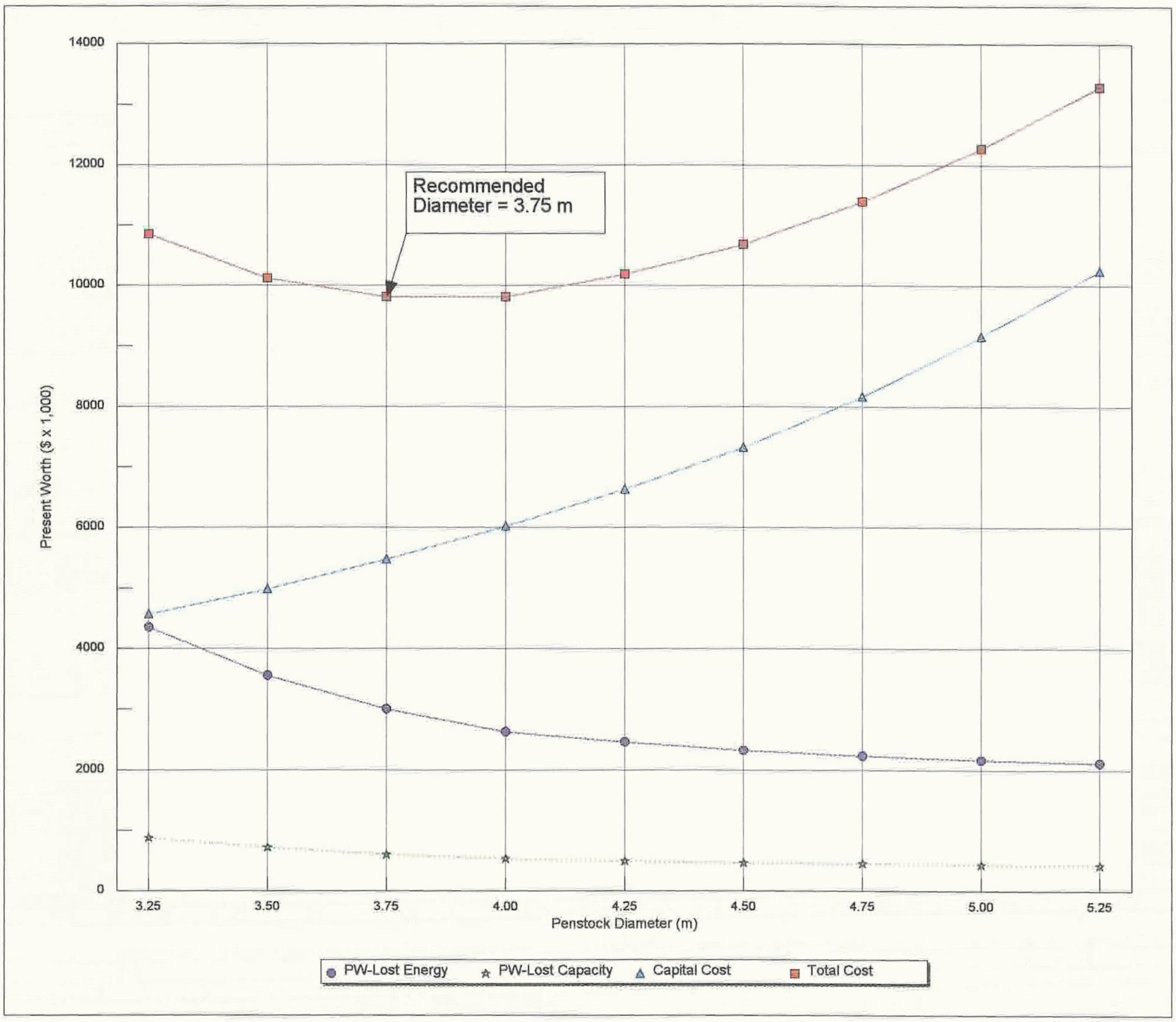
Notes:
(1) From Table 4.4 of the 1988 Optimization Report and based on avg. water levels and original peak efficiency flow of 85 m3/s (plant capacity of 31 MW) through the Power Canal & Plant.
(2) Based on avg. net head (1) and avg. flow of 73.3 m3/s from the Power Canal.
(3) Based on original avg. net head (1) and increased in proportion to the new peak efficiency flow of 114 m3/s (plant capacity of 42 MW) and the square of the new and original flow velocities in the canal.
(4) Based on new maximum flow of 124 m3/s (plant capacity of 42 MW).
(5) Based on present worth of 1 kWh for 60 years = $0.6124.
(6) Based on present worth of 1 kW for 60 years = $2,186.30.
(7) Capital cost includes direct and indirect costs.

FIGURE 4.2

Granite Canal
Penstock Diameter Optimization

Diameter (m)	(1) Original Lost Energy (kWh / yr)	(2) Original Lost Head (m)	(3) New Lost Head (m)	(4) New Lost Energy (kWh / yr)	(5) Lost Capacity (MW)	(6) PW Value Lost Energy ($ x 1,000)	(7) PW Value Lost Capacity ($ x 1,000)	(8) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
3.25	2,961,900	0.45	0.81	7,107,900	883	4,353	1,930	4,567	10,850
3.50	2,421,300	0.37	0.66	5,810,600	721	3,558	1,577	4,984	10,120
3.75	2,044,100	0.31	0.56	4,905,400	609	3,004	1,332	5,479	9,814
4.00	1,785,000	0.27	0.49	4,283,600	532	2,623	1,163	6,027	9,813
4.25	1,672,400	0.26	0.46	4,013,400	498	2,458	1,090	6,642	10,189
4.50	1,582,300	0.24	0.43	3,797,200	471	2,325	1,031	7,329	10,685
4.75	1,520,400	0.23	0.42	3,648,600	453	2,234	990	8,165	11,390
5.00	1,469,300	0.23	0.40	3,526,000	438	2,159	957	9,161	12,278
5.25	1,436,700	0.22	0.39	3,447,600	428	2,111	936	10,246	13,293

PW Value of Energy = C$0.6124 /kWh
PW Value of Capacity = ************** /kW



Notes:
(1) From Table 4.5 of the 1988 Optimization Study and based on head loss from trashracks to tailrace.
(2) Based on lost energy (1) and peak efficiency flow of 85 m3/s.
(3) Based on peak efficiency flow of 114 m3/s.
(4) Based on new lost head (3) and peak efficiency flow of 114 m3/s.
(5) Based on new lost head (3) and maximum flow of 124 m3/s.
(6) Based on present worth of 1 kWh for 60 years = $0.6124.
(7) Based on present worth of 1 kW for 60 years = $2,186.30.
(8) Capital cost includes direct and indirect costs.

FIGURE 4.3

is also shown graphically in Figure 4.3. The graph shows that the total costs are minimum at a diameter of about 3.85 m; however, the costs do not vary significantly between diameters of 3.75 m and 4.00 m. Therefore, to minimize capital cost, a diameter of 3.75 m is recommended as the optimum penstock diameter at Granite Canal.

During this re-optimization, it was noted that the Granite Canal Development Final Feasibility Study Report, SMR-10-88, described the penstock as being 4.25 m in diameter. The costs for the penstock included in the CCE, in Report SMR-06-88, were also for a 4.25 m diameter penstock. The diameter was subsequently optimized at 3.4 m, as described in Report SMR-14-88, but the reduction in quantities and cost, as a result of the smaller size, was not noted in the Final Feasibility Report or the 1988 CCE. Consequently, there is a reduction in quantities for this structure from those included in the 1988 CCE, even though the optimum diameter has increased.

4.5 Tailrace Canal

The re-optimization of the Tailrace Canal was based on the previous optimization, reference ShawMont Report SMR-14-88. In that report, it was noted that various layouts and arrangements for the tailrace canal were considered during the feasibility study and that construction considerations dictated a horizontal invert at an elevation of 260 m. The invert width was then optimized by comparing energy benefits to construction costs for several different widths. The final result was a tailrace canal with a horizontal invert at elevation 260 m and an invert width of 18.0 m.

The re-optimization was carried out similar to the previous optimization in that only the invert width of the canal was optimized. This time, however, in addition to evaluating the present worth value of the lost energy resulting from headlosses in the canal, the lost plant capacity resulting from the headlosses was also evaluated.

For this re-optimization, the values for average net head and lost energy were taken from Table 4.7 of Report SMR-14-88. The headlosses for the different invert widths were calculated as the difference in the net heads from Table 4.7. The lost energy was originally calculated on the basis of maximum plant flow through the canal. New headlosses for the canal were calculated for the new peak efficiency flow of 114 m^3/s (for a 42 MW plant capacity), on the basis that headloss varies in proportion to the square of the water velocity in the canal. New values for net head, lost energy and capacity were then calculated. The new present worth value of energy was then used to calculate the present worth value, or cost, of the lost energy for each invert width.

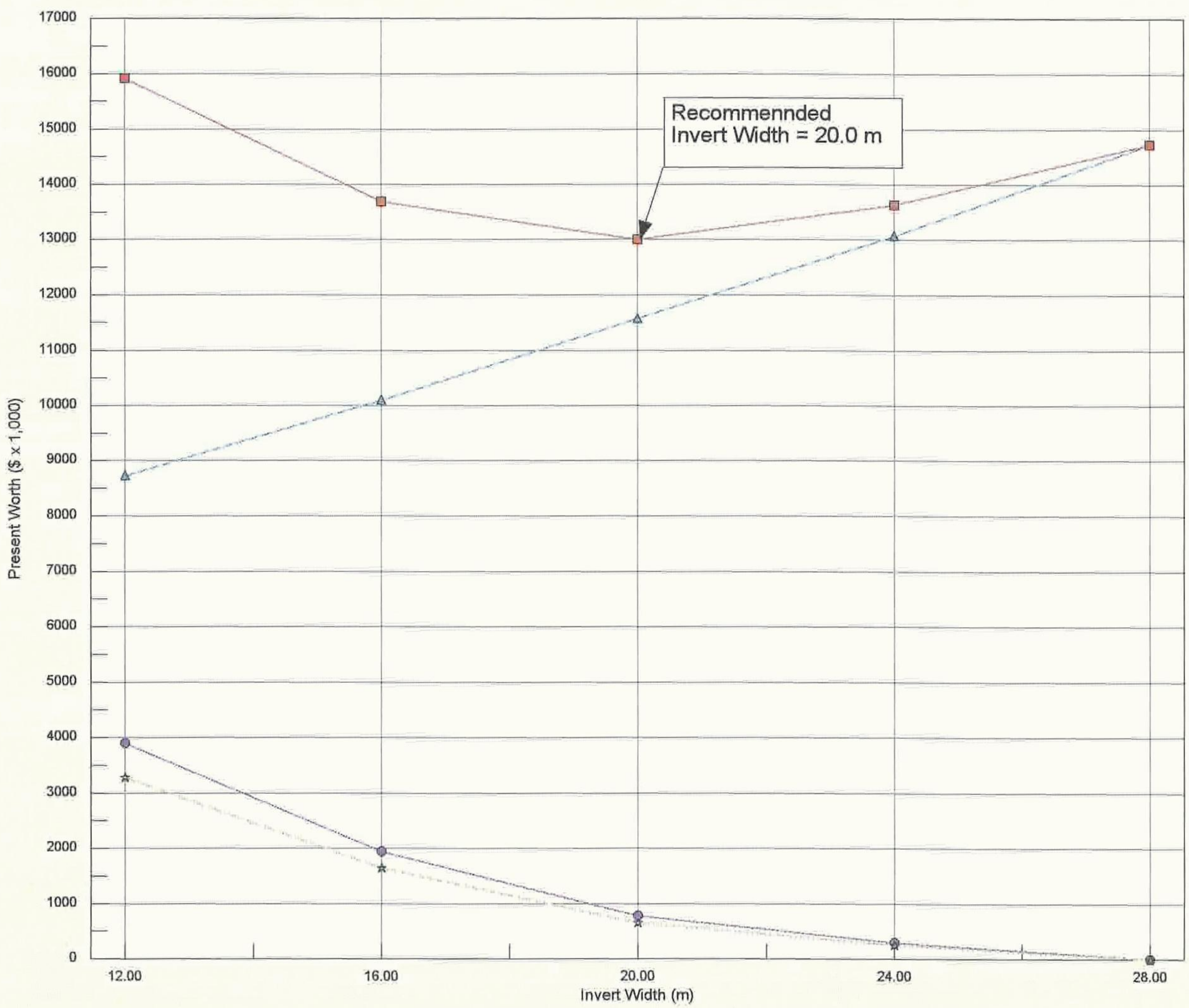
The plant capacity was calculated, based on the new maximum flow of 124 m^3/s (plant capacity of 42 MW), for the new net head available at each invert width of the canal. The new present worth value of capacity was then used to calculate the present worth value, or cost, of lost capacity for each invert width.

The table included in Figure 4.4 of this report summarizes the lost energy and capacity, and the associated costs for several different invert widths. This data is also shown graphically in Figure 4.4. The graph shows that the total costs are minimum at an invert width of 20.0 m. Therefore, a width of 20.0 m is recommended as the optimum invert width for the Tailrace Canal for the Granite Canal project.

Granite Canal
Tailrace Canal Width Optimization

Width (m)	(1) Original Lost Energy (GWh / yr)	Original Lost Head (m)	(2) New Lost Head (m)	New Net Head (m)	(3) New Lost Energy (GWh / yr)	(4) Capacity (kW)	Lost Capacity (kW)	(5) PW Value Lost Energy ($ x 1,000)	(6) PW Value Lost Capacity ($ x 1,000)	(7) Cap Cost ($ x 1,000)	Total Cost ($ x 1,000)
12.00	6.36	0.90	1.38	35.40	12.10	38,495	1,503	3,895	3,285	8,730	15,910
16.00	3.18	0.45	0.69	36.09	6.05	39,247	751	1,947	1,643	10,100	13,690
20.00	1.27	0.18	0.28	36.50	2.42	39,698	300	778	657	11,568	13,002
24.00	0.49	0.07	0.11	36.67	0.93	39,882	116	300	255	13,070	13,625
28.00	0.00	0.00	0.00	36.78	0.00	39,998	0	0	0	14,720	14,720

PW Value of Energy = C$0.6124 /kWh
PW Value of Capacity = ************* /kW



Notes:
(1) From Table 4.7 of the 1988 Optimization Report and based on headloss in Tailrace Canal with Meelpaeg Reservoir elevation constant and a canal flow equal to maximum plant flow of 92 m3/s (plant capacity = 31 MW).
(2) Based on Net Heads in Table 4.7 of 1987 Optimization Report. Original headloss increased in proportion to the ratio of the square of new & original flow velocities in the canal (new velocity = peak eff flow of 114 m3/s, original = 92 m3/s).
(3) Based on New Lost Head (2) and peak efficiency flow of 114 m3/s in the canal.
(4) Based on New Net Head and new maximum plant flow of 124 m3/s (plant capacity = 42MW).
(5) Based on present worth of 1 kWh for 60 years = $0.6124.
(6) Based on present worth of 1 kW for 60 years = $2,186.30.
(7) Capital cost includes direct and indirect costs.

FIGURE 4.4

4.6 Results of Re-Optimization

The following tables summarize the results of the re-optimization of the specific project elements and the consequent headlosses, compared to the previous study presented in the 1988 report (SMR-10-88).

Re-Optimization

Element	Original (1988)	New (1996)
Plant Capacity	31 MW	42 MW
Power Canal Invert El.	297.0 m	296.0 m
Penstock Diameter	4.25 m	3.75 m
Tailrace Canal Invert Width	18.0 m	20.0 m

Comparison of Headlosses

Location	Original (1988)	New (1996)	Reason for Change
Granite Canal & Power Canal	1.08 m	1.05 m	Decrease due to increase in canal depth and flow area.
Intake & Penstock	0.40 m	0.88 m	Increase due to decrease in diameter and increased flow.
Tailrace	0.20 m	0.15 m	Decrease due to increase in width and flow area.

4.7 Available Net Head and Energy Output

The following shows the calculation of available head and energy output and compares the original (1988) and new (1996) values:

	Original	New
Average Granite Lake Level	305.88 m	305.88 m
Headloss in Granite Canal and Power Canal	1.08 m	1.05 m
Average Water Level at Intake	304.80 m	304.83 m
Average Meelpaeg WL	265.50 m	265.50 m
Headloss in Tailrace Canal	0.20 m	0.15 m
Average Tailwater Level	265.70 m	265.65 m
Average Gross Head	39.10 m	39.18 m
Headloss in Intake & Penstock	0.40 m	0.88 m
Average Net Head	38.70 m	38.30 m
Average Energy Output	218 GWh	216 GWh

The above shows that there is a small decrease in the average net head on the plant and a corresponding small decrease in the average energy output of the plant (approx 1%).

The system model used to model the overall system energy output, in the 1988 Feasibility Study, showed that operation of the Bay d'Espoir system for maximum benefit, with or without the Granite Canal Development in place, would result in the same output from the downstream plants (Upper salmon and Bay d'Espoir). Therefore, the net benefit to be derived from the addition of the Granite Canal Development to the system was 218 GWh/year.

The following summarizes the average annual energy output (GWh/year) of the Granite Canal plant based on the foregoing average net heads and the average flow. The total simulated system energy output, based on the updated Bay d'Espoir ARSP Energy Model, and the 1996 flow records, is also shown:

1988 flow records

	Original (1988)	New (1996)
Granite Canal plant, only	218	216
Change in output of other plants	0	0
Equals net output of Granite canal	218	216
Total system output (including Granite Canal)	3,311	3,309

1996 flow records [1]

	Original (1988)	New (1996)
Granite Canal plant, only	-	216
Change in output of other plants	-	- 4
Equals net output of Granite canal	-	212
Total system output (including Granite Canal)	-	3,305

[1] 1996 flow records were used to update the Bay d'Espoir ARSP Energy Model results, only. This update study used the 1988 average flow for energy calculations.

PART 5
COST UPDATE

5.1 Background

The Capital Cost Estimates (CCE) prepared in January 1988 for both the Island Pond and the Granite Canal hydroelectric projects were based on December 1987 prices, with escalation effective the beginning of 1988. The CCE's were based on project schedules with engineering/construction starting in 1988 and with construction completed by the end of 1991. They were also based on reasonably detailed layouts of each major structure, field surveys and the geotechnical information collected at each of the project sites. The unit and lump sum prices used in estimating the civil works were selected with due care, based mainly on actual bid prices for similar projects in previous years, appropriately adjusted to account for particular conditions at each site, to provide the most up to date unit and lump sum prices possible for the civil works items at that point in time. The costs of major items of equipment, as well as electrical and mechanical auxiliaries, were based on general enquiries to suppliers and cost data available for similar projects on the Island, appropriately adjusted to provide current prices, at that point in time.

An overall contingency allowance of 10% of direct construction costs was provided on all civil work items to cover unforseen conditions and construction problems. For major electrical and mechanical equipment, 5% of the supply and installation costs was added to quoted prices to cover uncertainties in design, fabrication, transportation and erection.

5.2 Updating of Quantities

Quantities were revised as necessary in the 1996 CCE to reflect the current re-optimization results. Generally, because the plant capacities were increased, the water conveying structures (canals, intakes, penstocks, powerhouses and tailraces) increased in size; however, only specific cost items for these structures necessitated quantity increases, as noted below. Two exceptions to this were the Island Pond Diversion Canal and the Granite Canal penstock, where quantities were decreased.

The Island Pond Diversion Canal decreased in cross-sectional area since it's re-optimized invert elevation is a half meter higher, resulting in less excavation. The Granite Canal penstock diameter decreased from that included in the 1988 capital cost estimate, as explained in Part 4.4, resulting in less excavation, backfill, steel, protective wrapping, and concrete for anchor blocks. Quantity changes for other cost items are either nil, or are so insignificant that they were ignored for this update.

The structures for each project, and the associated cost items for which there are quantity changes, are listed below; otherwise the quantity changes are either nil, or are so insignificant that they were ignored for this update. Lump sum prices for the associated cost items listed below were increased due to either resizing of the structure, or escalation.

Island Pond

Structure	Cost Item	Reason for Change
Diversion Canal	Type II excavation	Decreased due re-optimized invert elev.
Intake	Type II excavation Pre-shearing Formwork Reinforcement Concrete Fdn preparation Gates & trashracks Building	Increased due increased flow.
Penstock	Excavation Pipe & wrapping Backfill	Increased due re-optimization.
Powerhouse	Stripping Type I & II excav. Pre-shearing Formwork Reinforcement Concrete Building Misc. Civil Turbines/governors Gates & Crane Generators/excitors	Increased due increased capacity.
Tailrace	Stripping Type II excavation	Increased due increased flow.

Granite Canal

Structure	Cost Item	Reason for Change
Power Canal	Type II excavation	Increased due re-optimized invert elev.
Intake	Same as for Island Pond.	
Penstock	Excavation Pipe & wrapping Backfill	) Decreased due decreased diameter.
Powerhouse	Same as for Island Pond.	
Tailrace	Clearing/stripping Type I & II excav.	) Increased due re-optimized invert width.

In addition to the above quantity changes to the structures included in the previous reports, quantities for a new fish compensatory flow structure at Granite Canal were added. The cost for this structure was added to the CCE for Granite Canal. This structure comprises a gated inlet, an approximately 800 m long, 1.5 m diameter fibreglas pipeline, and an energy dissipating outlet structure. The inlet would be located at, or near, the main intake structure and would be of concrete construction with a cast iron, power operated, slide gate. The pipeline would be a fibreglas pipe, buried along the sidehill from the main intake structure to the outlet structure, located at the north end of the small pond which presently supplies the fish compensatory water to the Grey River. The pipeline would be sized to consume, in friction losses, a large portion of the differential head of water between the inlet and the outlet. The outlet structure would be designed to dissipate any remaining energy in the water from the pipeline, prior to the water discharging into the existing pond.

5.3 Updating of Unit and Lump Sum Prices

No major civil works projects, comparable to the Island Pond and Granite Canal hydroelectric projects, have been completed on the Island since the Paradise River hydroelectric project was completed in 1989. Therefore, recent historic cost data on comparable types of work was not available to use as a basis for this cost update. Instead other approaches were taken to determine up to date cost data.

Turbine/Generators

Enquiries sent to several equipment suppliers, based on the head and flow parameters for each site and the optimized plant capacities from the 1988 Optimization Study (SMR-14-88), i.e. 30MW at Island Pond and 31 MW at Granite Canal, resulted in three responses. These were from GEC Alsthom, GE Hydro and Sulzer. The cost data in each of these responses was analyzed and compared to similar data from other recent Canadian hydroelectric projects. This analysis is discussed in detail in Part 2 of this report. The data was used to develop formulae to generate total installed costs for various plant capacities, in 1996 Canadian dollars. This information was then used to determine the costs for the major equipment for the new plant capacities selected for this cost update, i.e. 36 MW at Island Pond and 42 MW at Granite Canal. This included costs for the turbines and governors, the generators and exciters, and the control equipment.

Electrical and Mechanical Equipment

The costs for other large equipment such as power transformers, overhead cranes, switchgear, and hydraulic gates were determined through enquiries to suppliers to obtain unit or lump sum budget prices.

Options of two smaller power transformers, instead of a single large transformer, at each site, were considered. Prices were obtained from suppliers for these transformers and for additional switchgear in the switchyards. These options would result in a net increase of $315,000 for Island Pond and $510,000 for Granite Canal. No additional switchgear would be required inside the powerhouses.

The costs carried in the CCE for the power transformer, at each site, include the costs for a large single power transformer and all the associated electrical equipment in the switchyard. The costs for the switchyard structures are not included.

Penstocks and Steel Fabrications

The costs for fabricated steel items such as penstocks, structural steel and miscellaneous steel were determined from budget prices provided by several steel fabricators. Based on this information, it was determined that the December 1987 unit prices are still applicable.

For Island Pond, where the penstock diameter has increased to 6.25 m, which is larger than the 5.4 m diameter which can be shipped in full cans, the larger penstock would have to be shipped in half cans, thereby necessitating additional fabrication at site. The unit price for steel for the Island Pond penstock diameters, above 5.4 m, was increased by about 5% to allow for this extra cost. This was included in the re-optimization of the penstock diameter.

Civil Work Related Items

The unit and lump sum prices for most civil work cost items were determined by applying an average escalation factor (1.25) to the December 1987 unit and lump sum prices. The escalation factor was determined by comparison of current unit prices provided by sources involved in recent bidding for the Star Lake Hydroelectric project and the current construction of the new power canal for Abitibi Price at Grand Falls. Based on this information, the unit prices for access roads, clearing, stripping, excavation, backfill and other civil work related items were increased an average of 25% and the unit prices for concrete and formwork were increased by an average of 6%. However, the unit prices for steel bridges, structural steel and reinforcing steel have not increased significantly and the December 1987 unit or lump sum prices are still applicable.

Architectural Related Items

The unit and lump sum prices for architectural and building related cost items for the intakes and the powerhouses such as roofing, cladding, windows, doors, interior architectural work and painting, were determined by applying an escalation factor (1.25) and, where necessary, a size factor, to the December 1987 unit and lump sum prices. The escalation factor was based on the ratio of 1996 to 1987 "all-up" building cost indices (Hanscomb) for St. John's. The size factor was determined by the proportional increase in size of the associated building as a result of increased plant capacity and flow.

5.4 Capital Cost Estimate

Summaries of the CCEs for Island Pond and Granite Canal are provided in Section I of Appendices II and III, respectively, followed by the detailed CCEs. The CCEs are based on December 1996 prices, with escalation effective the beginning of 1997.

The capital cost of each project, including allowances for contingency, escalation and interest during construction, is based on the same project/construction schedule as given in the respective January 1988 Final Feasibility Study Report (ShawMont Report numbers SMR-02-88 and SMR-10-88, for Island Pond and Granite Canal, respectively), except that the first year of each program is now 1997, instead of 1988. The updated Project Planning Schedules for both projects are included as Figures 5.1 and 5.2 at the end of Part 5. These costs will vary with the rates for escalation and interest during construction, if the rates used in the final analysis are different from those assumed, or if the starting dates of the project/ construction schedules are changed.

The estimates include the same costs as the 1987 estimates (as described in Part 8.2 - Capital Cost Estimate, in the respective 1988 reports, noted above), except that the assumed annual escalation rates were changed to (start year to end year) as follows:

Year	Rate
1997	2.0%
1998	2.0%
1999	3.0%
2000	3.0%
2001	3.0%

and, for Granite Canal, the contingency allowance on the major equipment quotation prices is 5% and not 7.5%, as stated in Part 8.2.7 of the 1988 report.

The same exclusions to the estimates, as stated in Part 8.2 of the 1988 reports, also apply.

5.5 Cost and Cash Flows

The estimated Project Cost and Cash Flow for each project is provided in Section II of each Appendix. These were prepared on the same basis and in the same format used in 1988, i.e. on a monthly basis. The Cost and Cash Flows provide the data on which the escalation and interest during construction are computed.

5.6 Summary of Costs

The following summarizes the Capital Cost Estimates for each project and provides the cost per kilowatt (kW) of installed capacity and the cost per kilowatt-hour (kWh) of energy:

	Island Pond	Granite Canal
Total Direct Cost (including contingency)	$104,018,700	$ 79,143,000
Total Indirect Cost	47,918,500	33,381,700
Total Estimated Capital Cost	$151,937,200	112,524,700
Installed Capacity (kW)	36,000	42,000
Cost per kW of installed capacity	$4,220	$2,680
Average Annual Energy Output (GWh)	188	216

The total estimated capital costs are exclusive of transmission line and switchyard structure costs.

Table 5.1 and Table 5.2, following, provide a Project Cash Flow Summary for Island Pond and Granite Canal, respectively.

5.7 Schedules

The Project Planning Schedules for both projects were updated, based on the same project durations as in the previous reports. Both schedules show a 42.5 month schedule from project release on 01 June of year 1 to completion at mid December of year 4. The start of construction would be 01 August of year 1 for Island Pond and 01 May of year 2 for

Granite Canal. Completion of construction would be mid December of year 4 for both projects.

Figure 5.1 and Figure 5.2, at the end of Part 5, provide the updated Project Planning Schedule for Island Pond and Granite Canal, respectively.

Table 5.1

Island Pond

Project Cash Flow Summary ($ x 1000)

08 October 1996

ITEM	TOTALS	1997				1998				1999				2000				2001
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st
SITE ESTABLISHMENT	7,607.6			1,893.7	4,942.2	461.7			310.0									
RESERVOIR CLEARING	522.9											392.2	130.7					
MEELPAEG FREEBOARD DYKE	1,031.8											404.5	627.3					
DIVERSION CANAL	20,333.0						54.8	2,851.3	6,240.3	2,236.7	3,376.9	3,558.6	1,782.4	116.0		116.0		
FOREBAY CANAL	3,488.7			111.4	1,780.1	1,048.6	75.6		137.5		137.5					198.0		
DAM	3,982.7										940.9	1,394.2	1,647.7					
INTAKE AND APPROACH CHANNEL	8,082.5							4.8	1,217.1	476.8	957.6	3,013.4	1,504.1	485.8	140.9	281.9		
PENSTOCK	3,221.3								200.6	186.7	846.8	976.0	684.2	326.8				
POWERHOUSE	35,603.7						211.9	1,271.6	1,687.7	2,191.7	2,892.0	3,985.1	4,257.3	3,249.7	5,226.2	4,548.3	2,673.2	3,408.8
TAILRACE	3,225.3								14.3		996.5	1,328.7	885.8					
SWITCHYARD	679.6											106.9	159.0		206.9	206.9		
PROJECT SUPPORT	7,445.0			2.9	11.3	13.8	1,805.6	1,146.0	476.9	476.9	478.1	480.5	480.5	480.5	480.5	480.5	476.6	154.7
TOTAL (BEFORE CONTINGENCIES)	**95,223.9**			**2,008.0**	**6,733.6**	**1,524.0**	**2,147.9**	**5,273.7**	**10,284.4**	**5,568.9**	**10,626.4**	**15,640.0**	**12,159.0**	**4,658.7**	**6,054.4**	**5,831.5**	**3,149.8**	**3,563.6**
CONTINGENCIES	8,794.6			200.8	673.4	152.4	204.2	552.1	1,097.3	493.3	999.1	1,478.7	1,165.2	364.5	472.7	476.2	269.6	195.3
TOTAL DIRECT COST	**104,018.5**			**2,208.8**	**7,407.0**	**1,676.4**	**2,352.1**	**5,825.7**	**11,381.7**	**6,062.2**	**11,625.4**	**17,118.7**	**13,324.1**	**5,023.2**	**6,527.1**	**6,307.7**	**3,419.4**	**3,758.9**
MANAGEMENT AND ENGINEERING	15,602.8			725.7	1,451.4	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	1,088.6	362.9
OWNER'S COSTS	3,640.6			77.3	259.2	58.7	82.3	203.9	398.4	212.2	406.9	599.2	466.3	175.8	228.4	220.8	119.7	131.6
TOTAL UNESCALATED COST	**123,261.9**			**3,011.9**	**9,117.6**	**2,823.7**	**3,523.0**	**7,118.2**	**12,868.6**	**7,362.9**	**13,120.9**	**18,806.4**	**14,879.1**	**6,287.6**	**7,844.1**	**7,617.1**	**4,627.6**	**4,253.3**
ESCALATION	6,820.9			40.0	148.6	60.9	96.5	229.4	476.6	319.2	669.6	1,104.4	976.8	468.0	647.5	683.4	453.2	446.9
INTEREST DURING CONSTRUCTION	21,854.1				127.1	320.2	398.7	515.0	746.3	1,057.3	1,310.5	1,715.2	2,259.7	2,651.8	2,894.0	3,194.7	3,461.6	1,202.0
TOTALS	**151,936.9**			**3,051.9**	**9,393.4**	**3,204.7**	**4,018.1**	**7,862.6**	**14,091.5**	**8,739.5**	**15,101.0**	**21,626.1**	**18,115.5**	**9,407.4**	**11,385.6**	**11,495.1**	**8,542.4**	**5,902.3**
CUMULATIVE TOTALS				3,051.9	12,445.2	15,649.9	19,668.0	27,530.6	41,622.0	50,361.5	65,462.5	87,088.5	105,204.1	114,611.5	125,997.1	137,492.2	146,034.7	151,936.9

Table 5.2

Granite Canal

Project Cash Flow Summary ($ x 1000)

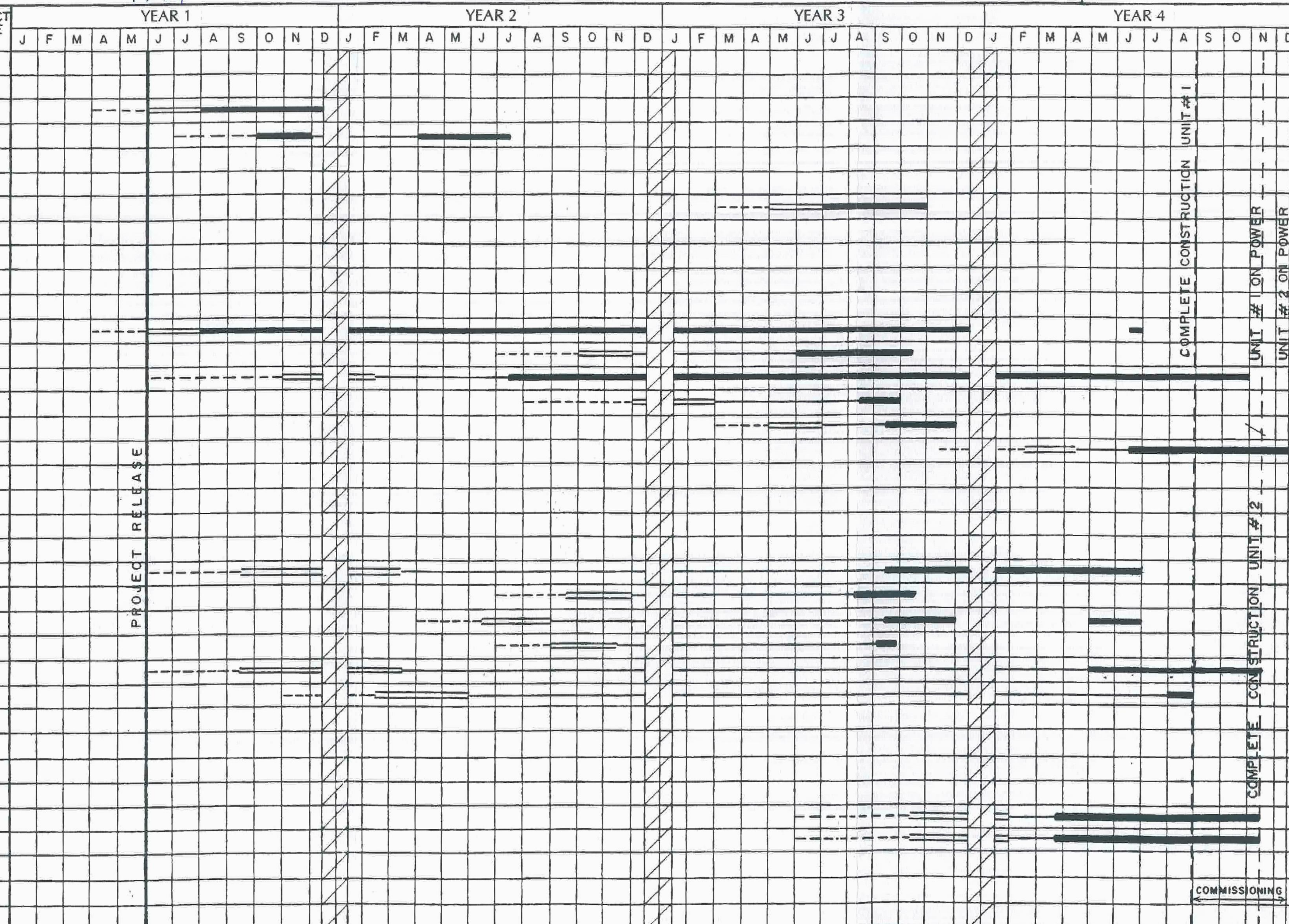
08 October 1996

ITEM	TOTALS	1997 1st	1997 2nd	1997 3rd	1997 4th	1998 1st	1998 2nd	1998 3rd	1998 4th	1999 1st	1999 2nd	1999 3rd	1999 4th	2000 1st	2000 2nd	2000 3rd	2000 4th	2001 1st
ACCESS ROADS	5,516.5						842.4	2549.0	1781.6						188.6	155.0		
EXISTING OVERFLOW SPILLWAY IMPROVEMENTS	1,232.3															1014.5	217.8	
CANAL CLOSURE / LOW LEVEL OUTLET STRUCTURE	969.2															969.2		
POWER CANAL / OVERFLOW SPILLWAY	9,723.0										1122.4	2356.7	1923.0	320.5	1193.5	2806.9		
FISH COMPENSATION sTRUCTURE	1,690.9														14.7	1174.8	501.4	
INTAKE	3,667.8												147.4		880.9	2639.5		
PENSTOCK	3,317.1								214.1			3.7	374.2		690.3	2034.9		
POWERHOUSE	31,262.5						204.2	1225.2	1670.5	1932.0	4464.5	3288.5	2448.9	2246.4	3849.3	4265.0	2427.2	3340.8
TAILRACE	7,424.5								1241.1	463.8	833.0	2443.4	2443.4					
SWITCHYARD	436.0														42.5	393.5		
PROJECT SUPPORT	7,694.0						5.0	2009.8	744.7	582.9	588.9	592.9	596.9	596.9	596.9	596.9	588.9	193.0
TOTAL BEFORE CONTINGENCIES	**72,933.8**						**1051.6**	**5784.0**	**5551.9**	**2978.7**	**7008.7**	**8685.3**	**7933.8**	**3163.8**	**7456.6**	**16050.2**	**3735.3**	**3533.8**
CONTINENCIES	6,209.4						94.9	517.1	492.8	227.5	629.2	755.9	686.9	206.9	609.1	1472.8	329.7	186.3
TOTAL DIRECT COST	**79,143.1**						**1146.5**	**6301.1**	**6,044.8**	**3206.2**	**7638.0**	**9441.2**	**8,620.7**	**3370.7**	**8065.8**	**17523.0**	**4,065.0**	**3720.1**
MANAGEMENT AND ENGINEERING	11,871.5			1319.1	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	791.4	263.8
OWNER'S COSTS	2,770.0						40.1	220.5	211.6	112.2	267.3	330.4	301.7	118.0	282.3	613.3	142.3	130.2
TOTAL UNESCALATED COST	**93784.6**			**1319.1**	**791.4**	**791.4**	**1978.1**	**7313.1**	**7047.8**	**4109.8**	**8696.7**	**10563.1**	**9713.9**	**4280.1**	**9139.5**	**18927.8**	**4998.7**	**4114.1**
ESCALATION	6,183.2			14.9	13.2	17.2	54.9	232.6	260.5	175.6	446.7	616.8	644.5	318.7	760.5	1706.6	488.2	432.3
INTEREST DURING CONSTRUCTION	12,557.0			8.9	36.9	58.0	79.7	165.7	352.9	530.4	666.2	925.7	1223.4	1481.5	1647.7	2008.7	2490.8	880.6
TOTALS	**112,524.8**			**1342.8**	**841.5**	**866.6**	**2112.7**	**7711.4**	**7661.2**	**4815.8**	**9809.6**	**12105.6**	**11581.8**	**6080.2**	**11547.7**	**22643.1**	**7977.7**	**5427.0**
CUMULATIVE TOTALS				1342.8	2184.4	3051.0	5163.7	12875.1	20536.2	25352.1	35161.7	47267.3	58849.1	64929.3	76477.0	99120.1	107097.8	112524.8

FIGURE 5.1

1997

CONTRACTS	CONTRACT PACKAGE №
GENERAL	
PERMANENT ACCESS ROAD	G1
CONSTRUCTION CAMP – POWERHOUSE SITE	G2
RESERVOIR CLEARING	R1
CIVIL WORKS	
CANALS & UPGRADING OF EXISTING ROADS	C1
MEELPAEG RESERVOIR FREEBOARD DYKE	C2
POWER COMPLEX STRUCTURES	C3
POWERHOUSE STRUCTURAL STEEL	C4
POWERHOUSE ROOFING & CLADDING	C5
POWERHOUSE ARCHITECTURAL & PAINTING	C6
MAJOR EQUIPMENT	
TURBINES & GOVERNORS	M1
PENSTOCKS	M2
HYDRAULIC GATES	M3
POWERHOUSE CRANE	M4
GENERATORS & EXCITERS	E1
POWER TRANSFORMER	E2
OTHERS	
MECHANICAL SERVICES & AUXILIARY EQUIPMENT	M5
ELECTRICAL SERVICES & AUXILIARY EQUIPMENT	E3



LEGEND

- - - - DESIGN & PREPARATION OF TENDER DOCUMENTS

TENDER / AWARD — TENDERING, EVALUATION & AWARD

▬▬ SITE CONSTRUCTION

—— MANUFACTURING

KEY DATES

PROJECT RELEASE	01 JUN YEAR 1
COMMENCEMENT OF CONSTRUCTION	01 AUG YEAR 1
COMPLETION OF INSTALLATION & CONSTRUCTION	15 DEC YEAR 4
ON POWER – UNIT 1	15 NOV YEAR 4
– UNIT 2	15 DEC YEAR 4

NOTE:

SCHEDULE IS BASED ON PROJECT TIME SPAN OF 42.5 MONTHS WITH PROJECT RELEASE ON 01 JUN YEAR 1.

HYDRO NEWFOUNDLAND AND LABRADOR HYDRO

ISLAND POND DEVELOPMENT

SHAWMONT NEWFOUNDLAND LIMITED

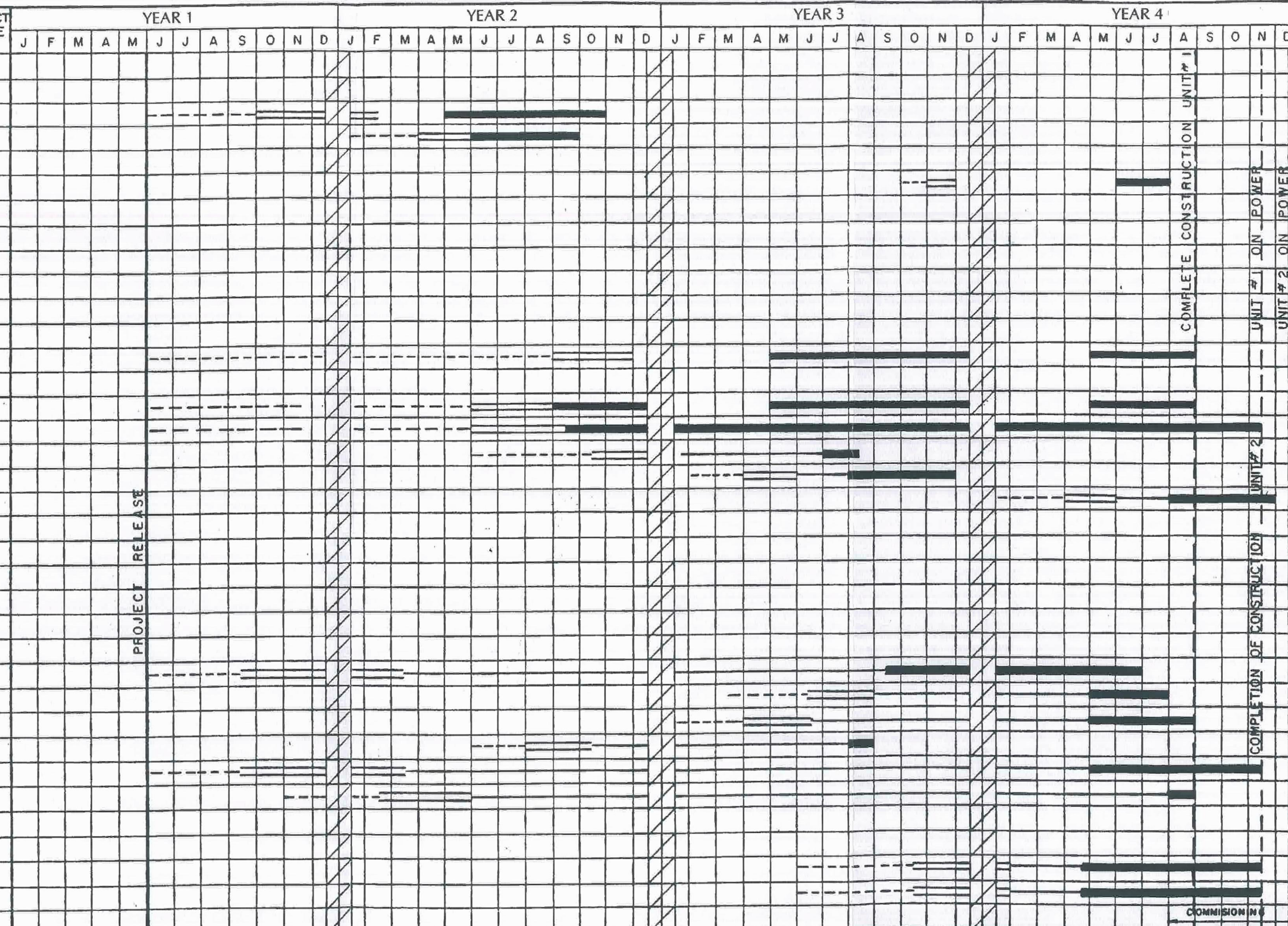
PROJECT PLANNING SCHEDULE

DESIGNED: | DRAWN: | SCALE: | DATE: JAN 1997

SMR - 05 - 96 | APPROVED: [signature]

FIGURE 5.2

CONTRACTS	CONTRACT PACKAGE NO.
GENERAL	
PERMANENT ACCESS ROAD & UPGRADING EXISTING ROADS	G1
CONSTRUCTION CAMP	G2
12.5KV. POWERLINE - POWERHOUSE TO INTAKE	
CIVIL WORKS	
POWER CANAL, GRANITE CANAL CLOSURE STRUCTURE & GRANITE LAKE SPILLWAY MODIFICATIONS	C1
TAILRACE CANAL	C2
POWER COMPLEX STRUCTURES	C3
POWERHOUSE STRUCTURAL STEEL	C4
POWERHOUSE ROOFING & CLADDING	C5
POWERHOUSE ARCHITECTURAL & PAINTING	C6
MAJOR EQUIPMENT	
TURBINES & GOVERNORS	M1
PENSTOCKS	M2
HYDRAULIC GATES	M3
POWERHOUSE CRANE	M4
GENERATORS & EXCITERS	E1
POWER TRANSFORMER	E2
OTHERS	
MECHANICAL SERVICES & AUXILIARY EQUIPMENT	M5
ELECTRICAL SERVICES & AUXILIARY EQUIPMENT	E3



LEGEND

- - - - - DESIGN & PREPARATION OF TENDER DOCUMENTS
TENDER — AWARD: TENDERING, EVALUATION & AWARD
▬▬▬ SITE CONSTRUCTION
——— MANUFACTURING

KEY DATES

PROJECT RELEASE	01 JUN YEAR 1
COMMENCEMENT OF CONSTRUCTION	01 MAY YEAR 2
COMPLETION OF INSTALLATION & CONSTRUCTION	15 NOV YEAR 4
ON POWER — UNIT 1	15 NOV YEAR 4
UNIT 2	15 DEC YEAR 4

NOTE:

SCHEDULE IS BASED ON PROJECT TIME SPAN OF 42.5 MONTHS WITH PROJECT RELEASE ON 01 JUN YEAR 1.

HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO
GRANITE CANAL DEVELOPMENT
SHAWMONT NEWFOUNDLAND LIMITED

PROJECT PLANNING SCHEDULE

DESIGNED: | DRAWN: | SCALE: | DATE: JAN 1997
SMR - 05 - 96 | APPROVED:

PART 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Type of Turbine - Island Pond

The problems earlier experienced with large "S" units have not been effectively resolved. Considering these problems, together with several other technical concerns, the use of these units at Island Pond cannot be justified. In addition, "S" units are not available in sizes larger than 10 MW, necessitating the use of multiple small units (minimum of four) to provide the required 36 MW capacity for the optimum development of Island Pond. Since this would not be cost effective, compared to the cost of two vertical axis Francis units, the installation of two vertical axis Francis units is recommended.

6.2 Type of Turbine - Granite Canal

Either Francis or Kaplan units would be suitable at this site; however, since the most economic installation would be with two vertical Francis units, these are recommended.

6.3 Re-optimization - Plant Capacity

The re-optimization of plant capacity for Island Pond, resulted in a minimum total cost at a capacity of 40 MW. The total cost difference between capacities of 36 MW and 42 MW was found to be very small but, since a plant capacity of 36 MW would have a capacity factor of 60.2%, this size is recommended as it will best match the Newfoundland and Labrador Hydro's system capacity (load) factor, which is between 59% and 61%.

At Granite Canal, the minimum total cost appears to be at a capacity in excess of 50 MW. However, this would provide a capacity factor of less than 49.8%. A plant capacity of 42 MW, with a capacity factor of 59.2%, is recommended as it will best match Newfoundland and Labrador Hydro's system capacity (load) factor.

6.4 Re-optimization - Other

The re-optimizations for energy and capacity resulted in other changes to the 1988 Optimization Study: These are:

- The penstock diameter at Island Pond increased from 5.4 m to 6.25 m. Although the minimum total cost occured at a diameter of about 6.5 m, since the total cost difference between this and 6.25 m, is so small, the smaller diameter is recommended to minimize capital cost.

- The penstock diameter at Granite Canal decreased from 4.25 m to 3.75 m. Although the minimum total cost occured at a diameter of about 3.85 m, since the total cost difference between this and 3.75 m, is so small, the smaller diameter is recommended to minimize capital cost.

- The Diversion Canal invert elevation at Island Pond increased from 258 m to 258.5 m, as a result of the lower value of energy from that used in the 1988 Optimization Study. The value of capacity used in this study did not affect the optimization of the canal since the flow in the canal did not change because of the flow regulation provided by Island Pond. Although the minimum total cost occured at an elevation of about 257.5 m, since the total cost difference between this and 258.5 m, is so small, the higher elevation is recommended to minimize capital cost.

- The Power Canal invert elevation at Granite Canal decreased from 297 m to 296 m. This provides the minimum total cost and is, therefore, recommended.

- The Tailrace Canal invert width at Granite Canal increased from 18.0 m to 20.0 m. This provides the minimum total cost and is, therefore, recommended.

6.5 Available Net Head and Energy Output

The re-optimizations resulted in changes to the average net head and the average annual energy output at Island Pond and Granite Canal, as follows:

- The average net head decreased at Island Pond from 22.69 m to 22.35 m, and at Granite Canal from 38.70 m to 38.30 m.

- The average annual energy output decreased at Island Pond from 191 GWh to 188 Gwh, and at Granite Canal from 218 GWh to 216 Gwh.

The following compares the simulation modelling of the overall Bay d'Espoir system for maximum annual energy output, using the original (1988) energy model and 1988 flow records, versus using the 1996 updated energy model and 1996 flow records, with the Island Pond and Granite Canal Developments in place. The addition of either Island Pond or Granite Canal would result in a change in the energy output of the downstream plants (Upper Salmon and Bay d'Espoir), thereby affecting the net output to be derived from the addition of the Development to the system, and the total system energy output, as follows (all outputs are in Gwh/year):

Based on 1988 Energy Model and Flow Records:

Development	Plant Output	Change in D/S Plant Output	Net Plant Output	Total System Output
Island Pond	188	- 6	182	3,275
Granite Canal	216	0	216	3,309

Based on 1996 Updated Energy Model and Flow Records:

Development	Plant Output	Change in D/S Plant Output	Net Plant Output	Total System Output
Island Pond	188	+ 4	192	3,285
Granite Canal	216	- 4	212	3,305

APPENDIX I

Reference pages 5-9 to 5-13 from
January 1988 Island Pond Final
Feasibility Study

5.6 TURBINE TYPE

At a net head of 22.6 m, four types of turbines could be installed at Island Pond, namely:

- Vertical axis fixed blade propellors
- Vertical axis moveable blade propellors (Kaplans)
- Vertical axis Francis turbines
- Horizontal axis, axial flow moveable blade propellor turbines (Tube or "S" units)

The factors which enter into the selection of the turbine unit are cost, efficiency, operating mode and previous experience. Each of these factors are discussed for the four types of units, based on data provided by manufacturers*, a summary which is included in Appendix II.

Comparison of Propellor and Francis Units

Propellor units operate at a higher speed than comparable Francis units and therefore require more submergence; the actual submergence depending on the turbine design. Based on data provided by three manufacturers (Table 5.2), it is apparent that a propellor unit would require a setting about 4.0 to 4.5 m lower than a Francis unit.

The deeper setting of the propellor unit would require additional rock excavation. Additional excavations for the penstock approach to the powerhouse, the powerhouse substructure, and the tailrace adjacent to the powerhouse, with a plan area of about 1680 m^2 and excavated a further 4.25 m deep, would result in an additional rock excavation volume of about 7140 m^3. For the same unit capacity, there is no appreciable difference in the size of the turbines for Propellor or Francis units, hence the powerhouse layout should not change. Since rock is relatively low in the proposed repair bay area, the floor level would be adjusted to limit any increased excavation outside the unit blocks. The total additional rock excavation required, therefore, would be about 8,000 m^3, which would increase the cost by about $200,000.

The cost saving associated with a propellor turbine, due to the higher speed, is in the region of $1,700,000 to $4,600,000 based on the Canadian budget prices received. The probable saving is likely to be in the region of $2,000,000, or more than sufficient to compensate for the additional rock excavation.

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* Budget data and prices were recieved from Dominion Bridge-Sulzer Inc. (DBS), Dominion Engineering Works (DEW) and Voith Hydro, Inc. (Voith).

5.6 TURBINE TYPE (Cont'd)

Comparison of Propellor and Francis Units (Cont'd)

The unit efficiency and operating mode should also be included in the comparison. In general, the efficiency curve of a propellor unit is more peaked than that for a Francis unit. This is of no consequence provided the units can be operated continuously 'on peak'; but does represent an advantage for a Francis unit if the occasional 'off peak' generation will occur, as often happens in practise.

Another advantage for a Francis unit is that the peak efficiency can be expected to be in the region of 92-93%, whereas that for a propellor unit will be in the region of 91.5-92.5%. Depending on the models selected by the manufacturers, peak efficiency for a Francis unit could be in the region of 0.25 to 1.25% more than that for a propellor unit. Assuming an average gain of 0.5% in efficiency this would represent an additional $775,000 of capitalized energy value.

The cost comparison for Propellor and Francis units, therefore, is as follows:

Saving in equipment cost (Propellor)	$2,000,000
Less extra cost of excavation	$ 200,000
Less value of capitalized energy	$ 775,000
Net saving about	$1,025,000

On this basis, a Propellor unit is more economical than a Francis unit.

However, this analysis depends on two factors which can vary by a considerable margin, namely:

- Equipment cost - Depending on the market situation at the time of bidding, the cost difference between Francis and Propellor units may not be as high as assumed.

- Efficiency - Depending on the models developed by manufacturers, the peak efficiency of a Francis unit could be over 1.2% higher than a propellor unit.

For example, if the analysis is confined to data provided by DEW, the difference in peak efficiency is 1.21%, and the cost comparison becomes:

Saving in equipment cost (Propellor)	$1,700,000
Less extra cost of excavation	$ 200,000
Less value of capitalized energy	$1,875,000
Net additional cost about	$ 375,000

5.6 TURBINE TYPE (Cont'd)

Comparison of Propellor and Francis Units (Cont'd)

On this basis, a Francis unit is slightly more economical than a propellor unit. This result is not unexpected, since DEW have developed hydraulic models for low head Francis runners, whereas other manufacturers do not recommend the use of Francis runners at a head of 22.6 m, and instead have concentrated on developing propellor models for this head.

In view of this indefinite cost margin a firm recommendation on unit type cannot be made at this time. Since the principle difference between the two types of units is the unit speed and setting, the decision should be deferred to the final bidding stage, by calling for bids on turbine-generators of either Francis or Propellor type, and then basing the decision on an analysis of cost, weighted efficiency, and turbine setting.

Comparison of Vertical Axis Propellor and Kaplan Units

Both these units have the same submergence requirements, and throat diameters are also about equal. However the Kaplan unit usually costs about 25% more than an equivalent propellor, for a cost increase of about $1,200,000.

The advantage of a Kaplan lies in the very flat efficiency curve, which is negated in this case by operation of the units 'on peak' by daily start-stop operation during periods of low flow, as discussed in Part 4.5.

On this basis, Kaplan units cannot be justified.

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines)

During the past decade, the energy crisis in the United States prompted a review of the hydro potential at existing low head dams. A large number of sites were found to be attractive, and manufacturers responded by developing the 'tube' or 'S' turbine. Also, due to the potential market, manufacturers developed a range of 'standard' units, where the basic hydraulic design was undertaken with computers. By using gear boxes between the generator and turbine, generator speeds became independent of turbine speeds, and manufacturers could then make use of industrial motors as the generating unit instead of 'hydro' generators; all in the interest of reducing the initial cost. In fact, DBS have also used motors when quoting budget prices for the vertical axis propellor, as will be evident by comparing the DEW and DBS generator prices. DEW quoted $5.2 million whereas DBS quoted $4.2 million, both based on 200 rpm units from CGE (Peterborough), with the higher cost being a 'hydro' generator and the lower cost being an industrial motor.

5.6 TURBINE TYPE (Cont'd)

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines) (Cont'd)

Of course there is a penalty to pay for the lower cost motor, in efficiency and inertia. Motors usually have an efficiency in the region of 97-98% and generators in the region of 98-99%. Motor inertia is usually about half that of an equivalent generator. No data on motor or generator efficiencies have been provided by the manufacturers. Instead, reference was made to the Cat Arm generator peak efficiency of 98.78% and the Paradise River motor peak efficiency of 97.0%, for a difference of 1.78%. A 1.5% difference in efficiency represents a capitalized cost of $2,325,000.

DBS have provided details on the equipment arrangement for a powerplant with two horizontal axis propellor units, and this data has been used to develop the powerhouse layout shown on Plate 14, wherein it will be noted that:

- The deep submergence, and area occupied by the units requires a larger excavation.
- The generators are below tailwater.
- The plan area of the powerhouse, and the powerhouse volume are larger than that required for equivalent vertical axis units.

A comparison of the differences between the horizontal and vertical layouts is given in Table 5.3, where the ancilliary electro-mechanical costs have been neglected as being almost equal. Table 5.2 indicates that the civil work costs associated with the horizontal units are about equal to those required for vertical axis units. The crane and draft tube gate costs are approximately equal, and the generating units cost about $2,200,000 less with horizontal units, for a total difference of $2,127,000, favouring the horizontal units. However, when the lower generation from horizontal units is included in the comparison, the analysis favours the installation of vertical axis units by a small margin of only $200,000, or just over 1% of the powerplant costs.

On the other hand, manufacturers advise that delivery of horizontal axis units will be much quicker than vertical axis units. This could result in a commissioning date about one year sooner, saving about $7,800,000 in interest during construction, based on a compounded quarterly rate of 2.5% (10.38% per annum), and an even cash flow. A more realistic assumption would be a 6-9 month saving for a difference of about $3.8 to $5.8 million.

5.6 TURBINE TYPE (Cont'd)

Comparison of Vertical Axis Fixed Blade Propellor with Horizontal Axis Tube Type Axial Flow Moveable Blade Propellor Turbines (Tube or 'S' Turbines) (Cont'd)

A saving in cost of this magnitude would favour the horizontal units. The question now becomes one of risk, since manufacturers have not built horizontal axis units of 15 MW capacity at 23 m head. Manufacturers have built smaller units at 23 m head, and units of the same physical size (turbine throat diameter) at lower heads.

Some of the risk could be overcome by installing a larger number of smaller horizontal axis units. However, this would increase the cost, and negate the savings.

A conservative design philospophy would require selection of the vertical axis alternative. If cost savings are paramount, then a horizontal axis unit could be used provided:

a) Detailed discussions are held with manufacturers to confirm cost and delivery of the units.

b) Detailed engineering discussions are undertaken with manufacturers to review the speed regulation problem associated with using horizontal axis units on 100 m long penstocks with generators having low inertia.

Based on the information available to date, the vertical axis alternative is the recommended approach.

APPENDIX II
CAPITAL COST ESTIMATE
ISLAND POND

SECTION 1

SUMMARY CCE - ISLAND POND

ISLAND POND DEVELOPMENT

CAPITAL COST ESTIMATE

SUMMARY

RESERVOIR CLEARING	522,900
ACCESS ROADS	8,752,200
FREEBOARD DYKE	965,200
DIVERSION CANAL	19,922,300
FOREBAY CANAL	3,385,100
DAM	3,419,000
INTAKE	8,082,500
PENSTOCK	3,221,300
POWERHOUSE	35,603,700
TAILRACE	3,225,300
SWITCHYARD	679,600
PROJECT SUPPORT	7,445,000
Sub-Total Before Contingency	95,224,100
CONTINGENCY	8,794,600
Total Direct Cost	$104,018,700
MANAGEMENT & ENGINEERING	15,602,800
OWNER'S COSTS	3,640,700
ESCALATION	6,820,900
INTEREST DURING CONSTRUCTION	21,854,100
Total Indirect Cost	$47,918,500
TOTAL ESTIMATED CAPITAL COST	$151,937,200

08 October 1996

SECTION II
DETAILED CCE - ISLAND POND
PROJECT COST & CASH FLOW

RESERVOIR CLEARING

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	RESERVOIR CLEARING				
	Clearing - Island Pond	ha	38.0	6,300	239,400
	Clearing - Forebay Canal	ha	45.0	6,300	283,500
	SUB TOTAL - RESERVOIR CLEARING				522,900
				Contingency	52,300

ACCESS ROADS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CONSTRUCT PERMANENT ROADS				
	Upper Salmon Div.Canal - Ebbegunbaeg Control Str.	km	15.5	156,000	2,418,000
	Ebbegunbaeg Road - Powerhouse	km	7.0	156,000	1,092,000
	Powerhouse - Dam/Intake	km	0.5	156,000	78,000
	CONSTRUCT TEMPORARY ROADS				
	Ebbegunbaeg Road - Diversion Canal	km	6.4	37,000	236,800
	To Diversion Canal & Channel Improvements	km	3.4	37,000	125,800
	To Forebay Canal	km	2.8	37,000	103,600
	Dam - Intake - Penstock - Powerhouse	km	0.5	37,000	18,500
	To Borrow Pits and Quarries	km	5.8	94,000	545,200
	Ebbegunbaeg Road - Div. Canal in Meelpaeg	km	1.3	37,000	48,100
	To Ebbegunbaeg Freeboard Dyke	km	1.8	37,000	66,600
	UPGRADE EXISTING ROADS				
	Permanent				
	- North Salmon Road to Upper Salmon Div Canal	km	4.0	31,000	124,000
	- Ebbegunbaeg Control Str. - Powerhouse Intersection	km	4.5	63,000	283,500
	Temporary				
	- Millertown - Lake Ambrose	km	21.5	1,500	32,250
	- Lake Ambrose - Noel Paul's Brook	km	8.5	56,000	476,000
	- Noel Paul's Brook - Diversion Canal	km	20.0	56,000	1,120,000
	- Diversion Canal - Powerhouse Intersection	km	9.2	1,500	13,800
	- Repair Wood Bridges & Culverts	L.S.	1	125,000	125,000
	BRIDGES				
	Permanent				
	- Upper Salmon Diversion Canal	L.S.	1	940,000	940,000
	- Diversion Canal	L.S.	1	310,000	310,000
	Temporary				
	- Noel Paul's Brook	L.S.	1	375,000	375,000
	STREAM CROSSINGS				
	Upper Salmon Div.Canal - Ebbegunbaeg Control Str.	ea	8.0	22,000	176,000
	Powerhouse Intersection - Powerhouse	ea	2.0	22,000	44,000
	SUB TOTAL - ACCESS ROADS				8,752,150
				Contingency	875,200

FREEBOARD DYKE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	2.0	6,300.00	12,600
	EXCAVATION				
	Type I Excavation	m3	2,000	10.00	20,000
	UNWATERING				
	Cofferdam - Impervious fill	m3	400	38.00	15,200
	Pumping	L.S.	1	1,500.00	1,500
	BACKFILL				
	Zone 1 Impervious Fill (Hand Compacted)	m3	1,000	50.00	50,000
	Zone 2 Impervious Fill (Machine Compacted)	m3	18,000	38.00	684,000
	Zone 3 Rockfill	m3	2,000	25.00	50,000
	Zone 4 Gravel	m3	600	19.00	11,400
	BUTYL MEMBRANE	m2	3,500	13.00	45,500
	ALLOWANCE FOR CONSTRUCTION CAMP	L.S.	1	75,000.00	75,000
	SUB TOTAL - FREEBOARD DYKE				965,200
				Contingency	96,500

DIVERSION CANAL

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	3.0	6,300.00	18,900
	Stripping	m3	54,500	7.50	408,750
	EXCAVATION				
	Bog Excavation	m3	59,000	9.00	531,000
	Mud Excavation	m3	56,000	9.00	504,000
	Type I Excavation - Chan Impvts (Is Pond)	m3	242,300	18.00	4,361,400
	Type II Excavation - Chan Impvts (Is Pond)	m3	1,400	38.00	53,200
	Type I Excavation - Meelpaeg Reservoir	m3	85,000	10.00	850,000
	Type I Excavation	m3	400,000	10.00	4,000,000
	Type II Excavation	m3	296,000	18.00	5,328,000
	BACKFILL				
	Rock Berms Through Ponds	m3	43,000	4.00	172,000
	UNWATERING				
	Pumping & Settling Basins	L.S.	1	625,000	625,000
	Cofferdam at Meelpaeg	L.S.	1	310,000	310,000
	PROVISIONAL ALLOWANCES				
	Construction Camp	L.S.	1	750,000	750,000
	Road Maintenance	km-mo	1,680	750.00	1,260,000
	Winter Work	L.S.	1	750,000	750,000
	SUB TOTAL - DIVERSION CANAL				19,922,250
				Contingency	2,271,000

FOREBAY CANAL

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	3.4	6,300.00	21,420
	Stripping	m3	5,000	7.50	37,500
	EXCAVATION				
	Type I Excavation - Stage I	m3	500	10.00	5,000
	Type I Excavation - Stage II	m3	1,800	10.00	18,000
	Type II Excavation - Stage I	m3	27,000	25.00	675,000
	Type II Excavation - Stage II	m3	50,000	25.00	1,250,000
	UNWATERING				
	Excavate Pilot Channel	m3	2,000	20.00	40,000
	Homogeneous Fill (Stage I Cofferdams)	m3	7,600	12.50	95,000
	Excavate Stage I Cofferdams	m3	4,000	5.00	20,000
	Homogeneous Fill (Stage II Cofferdams)	m3	9,700	18.00	174,600
	Canal Closure Structure - Rockfill	m3	3,700	12.50	46,250
	- Construct Membrane	L.S.	1	25,000.00	25,000
	- Remove	m3	4,200	18.00	75,600
	Forebay Filling Structure	L.S.	1	37,500.00	37,500
	Homogeneous Fill (Stage III Cofferdams)	m3	22,000	12.50	275,000
	Excavate Stage III Cofferdam (Canal only)	m3	11,000	18.00	198,000
	PROVISIONAL ALLOWANCES				
	Construction Camp	L.S.	1	125,000.00	125,000
	Road Maintenance	km-mo	355	750.00	266,250
	SUB TOTAL - FOREBAY CANAL				3,385,120
				Contingency	338,500

DAM

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	8.3	6,300.00	52,290
	Stripping	m3	15,500	7.50	116,250
	EXCAVATION				
	Type I Excavation	m3	16,200	10.00	162,000
	Dental Excavation	m3	100	38.00	3,800
	FOUNDATION PREPARATION				
	Hand Cleanup	m2	7,000	40.00	280,000
	Drilling Grout Holes	m	2,000	85.00	170,000
	Pressure Grouting	bag	2,000	70.00	140,000
	Slush Grouting	m2	2,300	23.00	52,900
	Dental Concrete	m3	100	500.00	50,000
	UNWATERING				
	Cofferdam - Dumped Imp Fill (Zone 1)	m3	2,200	12.50	27,500
	Cofferdam - Dumped Filter (Zone 2)	m3	1,500	45.00	67,500
	Pumping	L.S.	1	62,500.00	62,500
	BACKFILL				
	Zone 1 Impervious Fill	m3	32,800	15.00	492,000
	Zone 2 Fine Filter	m3	11,500	45.00	517,500
	Zone 2A Gravel	m3	1,500	12.50	18,750
	Zone 3 Rockfill (from excavation)	m3	10,000	7.50	75,000
	Zone 3 Rockfill (from stockpile)	m3	54,000	9.00	486,000
	Zone 3A Selected Rockfill	m3	28,000	15.00	420,000
	Zone 4 Riprap	m3	6,000	37.50	225,000
	SUB TOTAL - DAM				3,418,990
				Contingency	341,900

INTAKE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing (including channel)	ha	0.7	6,300.00	4,410
	Stripping	m3	700	7.50	5,250
	EXCAVATION				
	Type I Excavation (structure)	m3	1,250	10.00	12,500
	Type I Excavation (upstream channel)	m3	7,500	10.00	75,000
	Type II Excavation (structure)	m3	9,800	30.00	294,000
	Type II Excavation (upstream channel)	m3	31,700	25.00	792,500
	Pre-shearing at 300 mm Centres	m2	940	65.00	61,100
	ROCK SUPPORT				
	Rock Dowels, S & I, Drilling/Grouting	m	120	70.00	8,400
	UNWATERING				
	Pumping & Settling Basin	L.S.	1	25,000.00	25,000
	FORMWORK				
	Formwork - Straight	m2	4,300	230.00	989,000
	- Curved one Direction	m2	280	450.00	126,000
	REINFORCEMENT				
	Concrete Reinforcement	kg	210,000	2.50	525,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	4,140	380.00	1,573,200
	Concrete - 25 MPa - 20 mm	m3	10	400.00	4,000
	Concrete Finish - U2	m2	200	12.50	2,500
	Bedding Grout	m3	1	1,250.00	1,250
	FOUNDATION PREPARATION				
	Hand Cleanup	m2	320	50.00	16,000
	Drilling Grout Holes	m	260	85.00	22,100
	Pressure Grouting	bag	260	70.00	18,200
	HYDRAULIC GATES				
	Bulkhead Gate & Hoist (S&I) 1 gate 6.6m x 8.6m	L.S.	1	1,050,000.00	1,050,000
	Head Gates & Hoists (S&I) 2 gates 6.0m x 7.5m	L.S.	1	1,666,000.00	1,666,000
	TRASHRACKS				
	Trashracks (S&I) 2 sets 8.8m x 10.5m	kg	32,000	10.00	320,000
	BUILDING				
	Supply and Erect Building	L.S.	1	280,000.00	280,000
	MISCELLANEOUS CIVIL				
	Install Anchor Bolts	L.S.	1	5,000.00	5,000
	Embedded Piping	L.S.	1	3,800.00	3,800
	Embedded Sleeves	L.S.	1	1,250.00	1,250
	Embedded Metal Frames	L.S.	1	6,300.00	6,300
	Waterstop,Joint Sealer & Filler	L.S.	1	3,500.00	3,500
	Chain Link Fencing	m	30	88.00	2,640
	Gate - double	each	1	1,250.00	1,250
	Gate - single	each	1	500.00	500
	Guard rail	m	40	150.00	6,000
	MECHANICAL				
	Trashrack WL Diff. Measuring System	L.S.	1	30,000.00	30,000
	Louvres & Air Vent	L.S.	1	10,000.00	10,000
	Fire Detection & Prevention System	L.S.	1	5,000.00	5,000
	ELECTRICAL				
	Grounding	L.S.	1	6,300.00	6,300
	Lighting & Receptacle System	L.S.	1	12,500.00	5,000
	Intruder Alarm System	L.S.	1	2,500.00	2,500
	Electric Heating System	L.S.	1	2,500.00	2,500
	Telecontrol System	L.S.	1	19,000.00	19,000
	12.5kV Power Line from Powerhouse	L.S.	1	62,500.00	62,500
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	38,000.00	38,000
	SUB TOTAL - INTAKE				8,082,450
				Contingency	808,200

PENSTOCK

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.8	6,300.00	5,040
	Stripping	m2	600	7.50	4,500
	EXCAVATION				
	Type I Excavation	m3	5,450	10.00	54,500
	Type II Excavation	m3	24,570	25.00	614,250
	DRAINAGE SYSTEM				
	Corrugated Drainage Tile	m	360	12.50	4,500
	Crushed Stone	m3	200	50.00	10,000
	PIPE				
	Supply & Install Pipe	tonne	430	4,750.00	2,042,500
	Pipe Wrapping	m2	3,260	70.00	228,200
	BACKFILL				
	Sand Bedding	m3	2,000	50.00	100,000
	Granular Fill	m3	4,530	25.00	113,250
	Rock Fill (from stockpile)	m3	780	9.00	7,020
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	37,500.00	37,500
	SUB TOTAL - PENSTOCK				3,221,260
				Contingency	322,100

POWERHOUSE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	3.8	6,300.00	23,940
	Stripping	m3	2,230	7.50	16,725
	EXCAVATION				
	Type I Excavation	m3	2,230	10.00	22,300
	Type II Excavation (substructure)	m3	12,800	37.50	480,000
	Type II Excavation	m3	10,800	25.00	270,000
	Pre-shearing at 300 mm Centres	m2	2,500	65.00	162,500
	BACKFILL				
	Granular Fill	m3	200	25.00	5,000
	Common Fill (from excavation)	m3	500	5.00	2,500
	Crushed Stone	m3	20	50.00	1,000
	UNWATERING				
	Pumping & Settling Basin	L.S.	1	375,000	375,000
	FORMWORK				
	Formwork - Straight	m2	6,400	230.00	1,472,000
	- Curved one Direction	m2	220	450.00	99,000
	- Curved two Directions	m2	220	625.00	137,500
	REINFORCEMENT				
	Concrete Reinforcement	kg	484,000	2.50	1,210,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	5,950	400.00	2,380,000
	Concrete - 25 MPa - 20 mm	m3	500	450.00	225,000
	Concrete Finish - U3	m2	700	15.00	10,500
	Bedding Grout	L.S.	1	1,250.00	1,250
	BUILDING				
	Supply and Erect Structural Steel	kg	108,000	3.50	378,000
	Supply and Erect Crane Rails	kg	3,800	3.50	13,300
	Miscellaneous Steel	kg	36,000	8.00	288,000
	Supply and Install Metal Roof Decking	m2	1,080	37.50	40,500
	Supply and Install Built Up Roofing	m2	1,080	87.50	94,500
	Supply and Install Cladding and Louvers	m2	1,330	125.00	166,250
	Supply and Install Windows	L.S.	1	13,000.00	13,000
	Supply and Install Doors & Frames & Hdwre	L.S.	1	12,500.00	12,500
	Supply and Install O/H Door	L.S.	1	37,500.00	37,500
	Interior Architectural Work	L.S.	1	187,000	187,000
	Painting	L.S.	1	67,000.00	67,000
	MISCELLANEOUS CIVIL				
	Install Anchor Bolts	L.S.	1	7,500.00	7,500
	Install Embedded Parts	L.S.	1	7,000.00	7,000
	Install Draft Tube Linings	L.S.	1	28,000.00	28,000
	Embedded Piping	L.S.	1	37,500.00	37,500
	Embedded Sleeves	L.S.	1	25,000.00	25,000
	Embedded Metal Frames	L.S.	1	37,500.00	37,500
	Waterstop, Joint Sealer, Filler & Bituminus Sealant	L.S.	1	19,000.00	19,000
	Exterior Grading ,Surfacing and Drainage	L.S.	1	100,000.00	100,000
	Chain Link Fencing	m	30	88.00	2,640
	Gate - Double	each	1	1,250.00	1,250
	Gate - Single	each	1	500.00	500
	Guard rail	m	80	150.00	12,000
	MECHANICAL				
	Turbines, Governors & Pumps	L.S.	1	8,330,000	8,330,000
	Draft Tube Gates, Embedded Parts & Hoist (5.5m x 4.7m)	L.S.	1	615,000	615,000
	Powerhouse Crane (13.5 m span, 75 t capacity)	L.S.	1	870,000	870,000
	Service Water System	L.S.	1	125,000	125,000
	Domestic Water Supply System	L.S.	1	40,000.00	40,000
	Plumbing, Sanitary and Drainage Systems	L.S.	1	119,000.00	119,000
	Fire Protection Systems	L.S.	1	225,000	225,000
	Compressed Air System	L.S.	1	100,000	100,000
	Water Level Measurement System	L.S.	1	13,000.00	13,000
	Instrumentation	L.S.	1	69,000.00	69,000
	Air Conditioning	L.S.	1	34,000.00	34,000
	Powerhouse Ventilation System	L.S.	1	60,000.00	60,000

POWERHOUSE (Cont'd)

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	ELECTRICAL				
	Generators - 19.2 MVA, 0.95 p.f., 13.8 kV	L.S.	1	10,900,000	10,900,000
	Excitation Systems	L.S.	1	900,000	900,000
	Power Transformer - 40 / 53 MVA, ONAN / ONAF, 230 kV	L.S.	1	1,043,000	1,043,000
	13.8kV Metalclad Switchgear	L.S.	1	300,000	300,000
	Power Cable System	L.S.	1	190,000	190,000
	Station Service System	L.S.	1	190,000	190,000
	Grounding System	L.S.	1	190,000	190,000
	Emergency Generation System	L.S.	1	190,000	190,000
	D.C. Systems	L.S.	1	125,000	125,000
	Fire Alarm System	L.S.	1	63,000.00	63,000
	Intruder Alarm System (P.H.)	L.S.	1	25,000.00	25,000
	Lighting & Receptacle Systems	L.S.	1	100,000.00	100,000
	Electric Heating Systems	L.S.	1	63,000.00	63,000
	Control and Protection Systems	L.S.	1	1,830,000	1,830,000
	Control Cable System	L.S.	1	300,000	300,000
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	125,000	125,000
	SUB TOTAL - POWERHOUSE				35,603,655
				Contingency	2,553,900

TAILRACE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.3	6,300.00	1,890
	Stripping	m3	1,650	7.50	12,375
	EXCAVATION				
	Type I Excavation	m3	19,600	10.00	196,000
	Type II Excavation	m3	120,600	25.00	3,015,000
	SUB TOTAL - TAILRACE				3,225,265
				Contingency	322,500

SWITCHYARD

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.3	6,300.00	1,890
	Stripping	m3	3,400	7.50	25,500
	EXCAVATION				
	Type I Excavation	m3	5,200	10.00	52,000
	Type II Excavation	m3	2,300	25.00	57,500
	BACKFILL				
	Common Fill (from excavation)	m3	24,000	5.00	120,000
	Crushed Stone	m3	1,600	50.00	80,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	240	900.00	216,000
	Anchor Bolts	L.S.	1	1,250.00	1,250
	Precast Cable Trenches	m	150	250.00	37,500
	FENCING				
	Chain Link Fencing	m	230	88.00	20,240
	Gate - Double	each	3	1,250.00	3,750
	Gate - Single	each	3	500.00	1,500
	GROUNDING	L.S.	1	62,500.00	62,500
	SUB TOTAL - SWITCHYARD				679,630
				Contingency	68,000

PROJECT SUPPORT

ITEM NO	DESCRIPTION	UNIT	QUANTITY	1996 UNIT PRICE	AMOUNT
	CONSTRUCTION CAMP (200 Men)				
	Buildings (supply, deliver and install)				
	- 20 man Bunkhouses	each	10	85,000.00	850,000
	- Kitchen/Diner	each	1	500,000	500,000
	- Rec. Hall	each	1	125,000	125,000
	- Manager's Office	each	1	185,000	185,000
	- Family Trailers	each	10	38,000.00	380,000
	Site Preparation and Services				
	- Site Preparation (including clearing & grading)	L.S.	1	250,000	250,000
	- Water, Sewer & Fire Protection	L.S.	1	375,000	375,000
	Power Supply				
	- Electrical Distribution	L.S.	1	125,000	125,000
	- Diesel Generators (3 - 150kw @ $60,000)	L.S.	1	260,000	260,000
	- Fuel	L.S.	1	1,000,000	1,000,000
	Camp & Road Maintenance				
	- Camp Maintenance	L.S.	1	375,000	375,000
	- Road Maintenance (North Salmon Rd - Powerhouse)	km-mo	930	1,500.00	1,395,000
	- Safety and Security	L.S.	1	625,000	625,000
	- Warehouse	L.S.	1	125,000	125,000
	- Telephone Communications	L.S.	1	375,000	375,000
	Site Vehicles	L.S.	1	375,000	375,000
	Field Office, Laboratory Equipment and Supplies	L.S.	1	125,000	125,000
	SUB TOTAL - PROJECT SUPPORT				7,445,000
				Contingency	744,500

ISLAND POND DEVELOPMENT
PROJECT COST AND CASH FLOW ($1000)

08 October 1996

ACTIVITIES	COST	DURATION (MONTHS)	COST/ MONTH	TOTAL
1 SITE ESTABLISHMENT				
UPGRADE EXISTING ROADS				
- Millertown to Diversion Canal	1753.3	3	584.4	1753.3
- Diversion canal to Ph. Intersection	13.8	1.0	13.8	13.8
- Ph. Intersection to Ebbegunbaeg	283.5	1.5	189.0	283.5
- Upper Salmon Road to U.S. Diversion Canal	124.0	1.0	124.0	124.0
PERMANENT ROADS				
- U.S. Diversion Canal to Ebbegunbaeg	2594.0	4.5	576.4	2594.0
- Ph. Intersection to Powerhouse	1214.0	3.5	346.9	1214.0
BRIDGES				
- Noel Pauls brook	375.0	1.5	250.0	375.0
- Diversion Canal	310.0	2.0	155.0	310.0
- U.S. Diversion Canal	940.0	2.0	470.0	940.0
SUB-TOTAL	7607.6			7607.6
2 RESERVOIR CLEARING				
CLEARING (Including Access Roads Required)	522.9	4.0	130.7	522.9
3 EBBEGUNBAEG FREEBOARD DYKE				
ACCESS ROAD	66.6	1.0	66.6	66.6
CLEARING	12.6	1.0	12.6	12.6
FOUNDATION EXCAVATION	36.7	2.0	18.4	36.7
MEMBRANE & IMPERVIOUS FILL	865.9	1.5	577.3	865.9
ROCKFILL	50.0	1.5	33.3	50.0
SUB-TOTAL	1031.8			1031.8
4 DIVERSION CANAL				
ACCESS ROADS	410.7	7.5	54.8	410.7
CLEARING & STRIPPING	427.7	8.5	50.3	427.7
OVERLAND SECTION - EXCAVATE OVERBURDEN	6587.0	12.0	548.9	6587.0
OVERLAND SECTION - EXCAVATE ROCK	7333.0	13.5	543.2	7333.0
MEELPAEG RESERVOIR SECTION	1160.0	5.0	232.0	1160.0
ISLAND POND CHANNEL IMPROVEMENTS	4414.6	5.0	882.9	4414.6
SUB-TOTAL	20333.0			20333.0
5 FOREBAY CANAL				
ACCESS ROAD	103.6	2.00	51.8	103.6
CLEARING & STRIPPING	58.9	2.25	26.2	58.9
EXCAVATE BYPASS CHANNEL	40.0	0.50	80.0	40.0
FOREBAY FILLING STRUCTURE	37.5	0.50	75.0	37.5
COFFERDAMS - STAGE I	95.0	1.00	95.0	95.0
- STAGE II	174.6	1.50	116.4	174.6
- STAGE III	137.5	1.00	137.5	137.5
EXCAVATE CANAL	2359.3	4.50	524.3	2359.3
CANAL CLOSURE STRUCTURE - INSTALL STAGE II	71.3	0.50	142.5	71.3
- REMOVE STAGE II	75.6	0.25	302.4	75.6
- INSTALL STAGE III	137.5	0.50	275.0	137.5
- REMOVE STAGE III	198.0	0.50	396.0	198.0
SUB-TOTAL	3488.7			3488.7
6 DAM				
ACCESS ROADS	563.7	5.00	112.7	563.7
CLEARING & STRIPPING	168.5	2.00	84.3	168.5
COFFERDAM	95.0	1.00	95.0	95.0
FOUNDATION PREPARATION	558.3	2.50	223.3	558.3
FOUNDATION GROUTING	362.9	3.00	121.0	362.9
IMPERVIOUS CORE, FILTERS & GRAVEL	1028.3	4.00	257.1	1028.3
ROCKFILL & RIPRAP	1206.0	3.00	402.0	1206.0
SUB-TOTAL	3982.7			3982.7
7 INTAKE AND APPROACH CHANNEL				
CLEARING & STRIPPING	9.7	0.50	19.3	9.7
EXCAVAVATE OVERBURDEN	87.5	1.00	87.5	87.5
EXCAVATE ROCK	1181.0	3.00	393.7	1181.0
FOUNDATION PREPARATION	56.3	1.00	56.3	56.3
CONCRETE & EXTERIOR FINISHING	3289.2	4.00	822.3	3289.2
HYDRAULIC GATES & TRASHRACKS - MANUFACTURE	1457.3	8.00	182.2	1457.3
- DELIVER	485.8	1.00	485.8	485.8
- INSTALL	607.2	2.00	303.6	607.2
- HOLDBACK	485.8	1.00	485.8	485.8
ENCLOSURE BUILDING, ELECTRICAL & MECHANICAL	422.8	3.00	140.9	422.8
SUB-TOTAL	8082.5			8082.5
8 PENSTOCK				
CLEARING & STRIPPING	9.5	0.50	19.1	9.5
EXCAVATION	668.8	5.25	127.4	668.8
STEEL PIPE - MANUFACTURE	980.4	5.25	186.7	980.4
- DELIVER	326.8	1.00	326.8	326.8
- INSTALL	674.2	2.25	299.6	674.2
- HOLDBACK	326.8	1.00	326.8	326.8
DRAINAGE SYSTEM & BACKFILL	234.8	2.50	93.9	234.8
SUB-TOTAL	3221.3			3221.3
9 POWERHOUSE				
CLEARING & STRIPPING	40.7	1.25	32.5	40.7
EXCAVATION & BACKFILL	1318.3	3.75	351.5	1318.3
CONCRETE	5759.3	11.75	490.1	5759.3
STRUCTURAL STEELWORK	679.3	1.25	543.4	679.3
OVERHEAD CRANE - MANUFACTURE	417.6	8.75	47.7	417.6
- DELIVER	139.2	1.00	139.2	139.2
- INSTALL	174.0	1.00	174.0	174.0
- HOLDBACK	139.2	1.00	139.2	139.2
ROOFING & SIDING	364.3	2.25	161.9	364.3
TURBINES - MANUFACTURE	3998.4	20.75	192.7	3998.4
- DELIVER (EP)	666.4	1.00	666.4	666.4
- DELIVER (RP)	666.4	1.00	666.4	666.4
- INSTALL (EP)	833.0	4.75	175.4	833.0
- INSTALL (RP)	833.0	3.75	222.1	833.0
- HOLDBACK	1332.8	1.00	1332.8	1332.8
GENERATORS - MANUFACTURE	5664.0	24.50	231.2	5664.0
- DELIVER	1888.0	2.00	944.0	1888.0
- INSTALL	2360.0	6.50	363.1	2360.0
- HOLDBACK	1888.0	1.00	1888.0	1888.0
POWER TRANSFORMERS - MANUFACTURE	500.6	12.00	41.7	500.6
- DELIVER	166.9	1.00	166.9	166.9
- INSTALL	208.6	1.00	208.6	208.6
- HOLDBACK	166.9	1.00	166.9	166.9
DRAFT TUBE GATES - MANUFACTURE	295.2	8.00	36.9	295.2
- DELIVER	98.4	1.00	98.4	98.4
- INSTALL	123.0	2.00	61.5	123.0
- HOLDBACK	98.4	1.00	98.4	98.4
EXTERNAL WORK	116.4	2.00	58.2	116.4
ELECTRICAL & MECHANICAL AUXILIARIES	4413.5	7.75	569.5	4413.5
ARCHITECTURAL FINISHING & PAINTING	254.0	6.00	42.3	254.0
SUB-TOTAL	35603.7			35603.7
10 TAILRACE				
CLEARING & STRIPPING	14.3	0.50	28.5	14.3
EXCAVATION	3211.0	7.25	442.9	3211.0
SUB-TOTAL	3225.3			3225.3
11 SWITCHYARD				
CLEARING & STRIPPING	27.4	1.00	27.4	27.4
EXCAVATION, GROUNDING, BACKFILL & FENCING	397.5	5.00	79.5	397.5
CONCRETE	254.8	2.00	127.4	254.8
SUB-TOTAL	679.6			679.6
12 PROJECT SUPPORT				
SITE PREPARATION & BUILDINGS	2685.0			2685.0
POWER SUPPLY	1385.0	29.5	46.9	1385.0
CAMP & ROAD MAINTENANCE	2895.0	29.5	98.1	2895.0
SITE VEHICLES	375.0	41.0	9.1	375.0
FIELD, LABORATORY EQUIPMENT & SUPPLIES	125.0	29.5	4.2	125.0
SUB-TOTAL	7445.0			7445.0
SUB-TOTAL BEFORE CONTINGENCY				95223.9
13 CONTINGENCY	8794.6			8794.6
TOTAL DIRECT COST	104018.5			104018.5
14 MANAGEMENT AND ENGINEERING	15602.8	43.0	362.9	15602.8
15 OWNER'S COSTS	3640.6			3640.6
SUB-TOTAL (Unescalated Cost)	123261.9			123261.9
16 ESCALATION	6820.9			6820.9
SUB-TOTAL (Escalated Cost)	130082.8			130082.8
17 INTEREST DURING CONSTRUCTION	21854.1			21854.1
TOTAL PROJECT COST	151936.9			151936.9
ACCUMULATED CASH FLOW				

APPENDIX III
CAPITAL COST ESTIMATE
GRANITE CANAL

SECTION 1

SUMMARY CCE - GRANITE CANAL

GRANITE CANAL DEVELOPMENT

CAPITAL COST ESTIMATE

SUMMARY

ACCESS ROADS	5,726,400
EXISTING OVERFLOW SPILLWAY IMPROVEMENTS	1,209,800
CANAL CLOSURE/LOW LEVEL OUTLET STRUCTURE	969,200
OVERFLOW SPILLWAY	818,900
POWER CANAL	8,761,100
FISH COMPENSATION STRUCTURE	1,690,900
INTAKE	3,667,800
PENSTOCK	3,309,700
POWERHOUSE	31,262,500
TAILRACE	7,387,500
SWITCHYARD	436,000
PROJECT SUPPORT	7,694,000
Sub-Total Before Contingency	$72,933,800
CONTINGENCY	6,209,200
Sub-Total Directs	$79,143,000
MANAGEMENT & ENGINEERING	11,871,500
OWNER'S COSTS	2,770,000
ESCALATION	6,183,200
INTEREST DURING CONSTRUCTION	12,557,000
Sub-Total Indirects	$33,381,700
TOTAL ESTIMATED CAPITAL COST	$112,524,700

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SECTION II

DETAILED CCE - GRANITE CANAL

PROJECT COST & CASH FLOW

ACCESS ROADS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CONSTRUCT PERMANENT ROADS				
	Existing Road - Switchyard - Existing Road	km	0.6	125,000	75,000
	Existing Road - Spillway	km	0.3	125,000	37,500
	Existing Road - Intake	km	0.2	156,000	31,200
	Existing Road - Powerhouse	km	0.1	125,000	12,500
	CONSTRUCT TEMPORARY ROADS				
	Spillway - Power Canal	km	2.0	37,000	74,000
	Intake - Penstock - Powerhouse	km	0.2	37,000	7,400
	Powerhouse - Tailrace	km	1.0	37,000	37,000
	To Burrow Pits & Quarries	km	0.5	63,000	31,500
	UPGRADE EXISTING ROADS				
	Permanent				
	- Millertown - Lake Ambrose	km	21.5	56,000	1,204,000
	- Lake Ambrose - Granite Junction	km	8.5	69,000	586,500
	- Granite Junction - Granite Canal Bridge	km	45.5	69,000	3,139,500
	- Granite Canal Bridge - Powerhouse	km	1.8	69,000	124,200
	- Granite Canal Bridge - Canal Closure	km	0.6	56,000	33,600
	Temporary				
	- Existing Road - Existing Overflow Spillways	km	15.0	1,500	22,500
	BRIDGE				
	Granite Lake Road at Power Canal	L.S.	1.0	310,000	310,000
	SUB TOTAL - ACCESS ROADS				5,726,400
				Contingency	572,600

EXISTING OVERFLOW SPILLWAY IMPROVEMENTS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	EXCAVATION				
	Remove Existing Riprap	m3	1,000	31.00	31,000
	Remove Existing Filter	m3	300	19.00	5,700
	BACKFILL				
	Zone 1 Impervious Fill	m3	500	19.00	9,500
	Zone 2 Filter	m3	700	45.00	31,500
	Styrofoam	m2	5,500	25.00	137,500
	Zone 3 Riprap	m3	5,000	38.00	190,000
	Zone 4 Oversize Rockfill (Wave Barrier)	m3	6,600	31.00	204,600
	STEEL SHEET PILES				
	Supply & Deliver Steel Piles	tonne	200	2,300.00	460,000
	Drive Piles	tonne	200	700.00	140,000
	SUB TOTAL - SPILLWAY IMPROVEMENTS				1,209,800
				Contingency	121,000

CANAL CLOSURE / LOW LEVEL OUTLET STRUCTURE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	ROCK SUPPORT				
	Rock Dowels, S & I, Drilling/Grouting	m	120	70.00	8,400
	UNWATERING				
	Cofferdam, Pumping & Settling Basin	L.S.	1	63,000.00	63,000
	FORMWORK				
	Formwork - Straight	m2	600	230.00	138,000
	REINFORCEMENT				
	Concrete Reinforcement	kg	30,000	2.50	75,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	750	380.00	285,000
	Concrete - 25 MPa - 20 mm	m3	10	400.00	4,000
	Bedding Grout	m3	1	1,250.00	1,250
	FOUNDATION PREPARATION				
	Hand Cleanup	m2	250	50.00	12,500
	Drilling Grout Holes	m	200	85.00	17,000
	Pressure Grouting	bags	200	70.00	14,000
	HYDRAULIC GATES				
	Supply & Install Sluice Gates & Screw Stems	each	2	125,000	250,000
	Buried 600 V Power Supply Cable	km	2	38,000	76,000
	MISCELLANEOUS CIVIL				
	Install Anchor Bolts	L.S.	1	5,000.00	5,000
	Miscellaneous Steel	kg	2,000	10.00	20,000
	SUB TOTAL - CANAL CLOSURE/LOW LEVEL OUTLET STRUCTURE				969,200
				Contingency	96,900

OVERFLOW SPILLWAY

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing (including channel)	ha	1.6	6,300.00	10,080
	Stripping	m3	9,000	7.50	67,500
	EXCAVATION				
	Type I Excavation	m3	41,000	10.00	410,000
	Type II Excavation	m3	12,000	20.00	240,000
	Pre-shearing at 300 mm Centres	m2	300	65.00	19,500
	FORMWORK				
	Formwork - Straight	m2	150	230.00	34,500
	REINFORCEMENT				
	Concrete Reinforcement	kg	4,000	2.50	10,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	72	380.00	27,360
	SUB TOTAL - SPILLWAY				818,900
				Contingency	81,900

POWER CANAL

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	15.0	6,300.00	94,500
	Stripping	m3	80,000	7.50	600,000
	EXCAVATION				
	Type I Excavation	m3	170,000	10.00	1,700,000
	Type II Excavation	m3	301,200	18.00	5,421,600
	DYKE				
	Zone 1 Impervious Fill	m3	20,000	19.00	380,000
	Zone 2 Filter	m3	2,000	45.00	90,000
	Zone 5 Rockfill (from excavation)	m3	30,000	7.50	225,000
	UNWATERING				
	Pumping & Settling Basins	L.S.	1	250,000	250,000
	SUB TOTAL - POWER CANAL				8,761,100
				Contingency	876,100

FISH COMPENSATION STRUCTURE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	1.8	6,300.00	11,340
	Stripping	m3	2,400	7.50	18,000
	EXCAVATION				
	Type I Excavation - pipeline	m3	7,000	10.00	70,000
	Type I Excavation - outlet	m3	280	10.00	2,800
	Type II Excavation - pipeline	m3	780	18.00	14,040
	Type II Excavation - outlet	m3	180	18.00	3,240
	PIPE				
	Supply and Install	m	800	1,375.00	1,100,000
	BACKFILL				
	Sand Bedding - pipeline	m3	2,600	50.00	130,000
	Granular Fill - pipeline	m3	4,500	25.00	112,500
	Common Fill (from excavation) - outlet	m3	120	5.00	600
	Selected Rockfill (from stockpile) - pipeline	m3	2,500	9.00	22,500
	Riprap (from excavation) - outlet	m3	130	30.00	3,900
	CONCRETE				
	Inlet	m3	30	900.00	27,000
	Outlet	m3	50	900.00	45,000
	HYDRAULIC GATE	L.S.	1	30,000	30,000
	UNWATERING				
	Pumping, Sediment Traps & Cofferdam	L.S.	1	100,000	100,000
	SUB TOTAL - FISH COMPENSATION STRUCTURE				1,690,900
				Contingency	169,100

INTAKE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.2	6,300.00	1,260
	Stripping	m3	700	7.50	5,250
	EXCAVATION				
	Type I Excavation	m3	1,200	10.00	12,000
	Type II Excavation	m3	3,500	25.00	87,500
	Pre-shearing at 300 mm Centres	m2	390	65.00	25,350
	ROCK SUPPORT				
	Rock Dowels, S & I, Drilling/Grouting	m	50	70.00	3,500
	UNWATERING				
	Pumping & Settling Basin	L.S.	1	12,500.00	12,500
	FORMWORK				
	Formwork - Straight	m2	1,200	230.00	276,000
	- Curved one Direction	m2	210	450.00	94,500
	REINFORCEMENT				
	Concrete Reinforcement	kg	106,700	2.50	266,750
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	1,600	380.00	608,000
	Concrete - 25 MPa - 20 mm	m3	10	400.00	4,000
	Bedding Grout	m3	1	1,250.00	1,250
	FOUNDATION PREPARATION				
	Hand Cleanup	m2	200	50.00	10,000
	Drilling Grout Holes	m	100	85.00	8,500
	Pressure Grouting	bag	100	70.00	7,000
	HYDRAULIC GATES				
	Bulkhead Gate & Hoist (S&I) 1 gate 4.5 m x 6.0 m	L.S.	1	560,000	560,000
	Head Gates & Hoists (S&I) 2 gates 3.8 m x 5.0 m	L.S.	1	980,000	980,000
	TRASHRACKS				
	Supply & Install Trashracks	kg	21,000	10.00	210,000
	BUILDING				
	Supply and Erect Building	L.S.	1	220,000.00	220,000
	MISCELLANEOUS CIVIL				
	Install Anchor Bolts	L.S.	1	3,800.00	3,800
	Embedded Piping	L.S.	1	2,500.00	2,500
	Embedded Sleeves	L.S.	1	1,250.00	1,250
	Embedded Metal Frames	L.S.	1	5,000.00	5,000
	Waterstop, Joint Sealer & Filler	L.S.	1	3,400.00	3,400
	Chain Link Fencing	m	30	88.00	2,640
	Gate - double	each	1	1,250.00	1,250
	Gate - single	each	1	500.00	500
	Guard rail	m	40	150.00	6,000
	MECHANICAL				
	Trashrack WL Diff. Measuring System	L.S.	1	30,000.00	30,000
	Louvres & Air Vent	L.S.	1	10,000.00	10,000
	Fire Detection and Protection	L.S.	1	5,000.00	5,000
	Water Level Measuring System	L.S.	1	6,200.00	6,200
	ELECTRICAL				
	Grounding	L.S.	1	6,300.00	6,300
	Lighting & Receptacle System	L.S.	1	6,300.00	6,300
	Intruder Alarm System	L.S.	1	6,300.00	6,300
	Electric Heating System	L.S.	1	2,500.00	2,500
	Telecontrol System	L.S.	1	12,500.00	12,500
	12.5kV Power Line from Powerhouse	L.S.	1	62,500.00	62,500
	Provision for Trashrack Heating	L.S.	1	62,500.00	62,500
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	38,000.00	38,000
	SUB TOTAL - INTAKE				3,667,800
				Contingency	366,800

PENSTOCK

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	1.0	6,300.00	6,300
	Stripping	m3	4,000	7.50	30,000
	EXCAVATION				
	Type I Excavation	m3	5,700	10.00	57,000
	Type II Excavation	m3	19,650	25.00	491,250
	DRAINAGE SYSTEM				
	Corrugated Drainage Tile	m	500	12.50	6,250
	Crushed Stone	m3	300	50.00	15,000
	PIPE				
	Supply & Install Penstock Pipe	tonne	375	4,750.00	1,781,250
	Pipe Wrapping	m2	3,600	70.00	252,000
	BACKFILL				
	Sand Bedding	m3	1,500	50.00	75,000
	Granular Fill	m3	10,750	25.00	268,750
	Zone 5 Rock Fill (from stockpile)	m3	1,900	9.00	17,100
	ANCHOR BLOCKS				
	Formwork	m2	170	275.00	46,750
	Reinforcement	kg	24,600	2.50	61,500
	Concrete - 25MPa - 40 mm	m3	410	400.00	164,000
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	37,500.00	37,500
	SUB TOTAL - PENSTOCK				3,309,700
				Contingency	331,000

POWERHOUSE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.3	6,300.00	1,890
	Stripping	m3	880	7.50	6,600
	EXCAVATION				
	Type I Excavation	m3	1,900	10.00	19,000
	Type II Excavation (substructure)	m3	2,900	37.50	108,750
	Type II Excavation	m3	18,700	25.00	467,500
	Pre-shearing at 300 mm Centres	m2	720	65.00	46,800
	BACKFILL				
	Granular Fill	m3	200	25.00	5,000
	Common Fill (from excavation)	m3	500	5.00	2,500
	Crushed Stone	m3	50	50.00	2,500
	UNWATERING				
	Pumping & Settling Basin	L.S.	1	187,500	187,500
	FORMWORK				
	Formwork - Straight	m2	3,700	230.00	851,000
	- Curved one Direction	m2	750	450.00	337,500
	- Curved two Directions	m2	290	625.00	181,250
	REINFORCEMENT				
	Concrete Reinforcement	kg	260,000	2.50	650,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	3,200	400.00	1,280,000
	Concrete - 25 MPa - 20 mm	m3	290	450.00	130,500
	Concrete Finish - U3	m2	300	15.00	4,500
	Bedding Grout	L.S.	1	1,250.00	1,250
	BUILDING				
	Supply and Erect Structural Steel	kg	94,700	3.50	331,450
	Supply and Erect Crane Rails	kg	2,800	3.50	9,800
	Miscellaneous Steel	kg	23,700	8.00	189,600
	Supply and Install Metal Roof Decking	m2	730	37.50	27,375
	Supply and Install Built Up Roofing	m2	730	87.50	63,875
	Supply and Install Cladding and Louvers	m2	1,320	125.00	165,000
	Supply and Install Windows	L.S.	1	14,000.00	14,000
	Supply and Install Doors & Frames & Hdwre	L.S.	1	12,500.00	12,500
	Supply and Install O/H Door	L.S.	1	37,500.00	37,500
	Interior Architectural Work	L.S.	1	163,000.00	163,000
	Painting	L.S.	1	59,000.00	59,000
	MISCELLANEOUS CIVIL				
	Install Anchor Bolts	L.S.	1	6,300.00	6,300
	Install Embedded Parts	L.S.	1	7,000.00	7,000
	Install Draft Tube Linings	L.S.	1	28,000.00	28,000
	Embedded Piping, Sleeves & Frames	L.S.	1	110,000.00	110,000
	Waterstop, Joint Sealer, Filler & Bituminous Sealant	L.S.	1	18,000.00	18,000
	Exterior Grading ,Surfacing and Drainage	L.S.	1	62,500.00	62,500
	Chain Link Fencing	m	30	88.00	2,640
	Gate - Double	each	1	1,250.00	1,250
	Gate - Single	each	1	500.00	500
	Guard rail	m	80	150.00	12,000
	MECHANICAL				
	Turbines, Governors & Pumps	L.S.	1	8,000,000	8,000,000
	Draft Tube Gates, Embedded Parts & Hoist (4 @ 4.5m x 3.9m)	L.S.	1	420,000	420,000
	Powerhouse Crane (11.7m span, 75 tonnes)	L.S.	1	800,000	800,000
	Service Water System	L.S.	1	100.00	100
	Domestic Water Supply System	L.S.	1	40.00	40
	Plumbing, Sanitary & Drainage Systems	L.S.	1	119,000.00	119,000
	Fire Protection Systems	L.S.	1	225,000	225,000
	Compressed Air System	L.S.	1	100,000.00	100,000
	Water Level Measurement System	L.S.	1	13,000.00	13,000
	Instrumentation	L.S.	1	69,000.00	69,000
	Air Conditioning	L.S.	1	34,000.00	34,000
	Powerhouse Ventilation System	L.S.	1	60,000.00	60,000

POWERHOUSE (Cont'd)

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	ELECTRICAL				
	Generators	L.S.	1	10,600,000	10,600,000
	Excitation Systems	L.S.	1	800,000	800,000
	Power Transformer (1 @ 40/53 MVA, 230/13.8 kV ONAN/ONAF)	L.S.	1	1,060,000	1,060,000
	13.8kV Metalclad Switchgear	L.S.	1	200,000	200,000
	Power Cable System	L.S.	1	175,000	175,000
	Station Service System	L.S.	1	190,000	190,000
	Grounding System	L.S.	1	160,000	160,000
	Emergency Generation System	L.S.	1	150,000	150,000
	D.C. Systems	L.S.	1	125,000	125,000
	Fire Alarm System	L.S.	1	63,000.00	63,000
	Intruder Alarm System	L.S.	1	25,000.00	25,000
	Lighting & Receptacle Systems	L.S.	1	94,000.00	94,000
	Electric Heating Systems	L.S.	1	50,000.00	50,000
	Control and Protection Systems	L.S.	1	1,800,000	1,800,000
	Control Cable System	L.S.	1	200,000	200,000
	PROVISIONAL ALLOWANCE - CONSTRUCTION POWER	L.S.	1	125,000	125,000
	SUB TOTAL - POWERHOUSE				31,262,500
				Contingency	2,042,000

TAILRACE

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	9.0	6,300.00	56,700
	Stripping	m3	45,200	7.50	339,000
	EXCAVATION				
	Type I Excavation	m3	65,500	10.00	655,000
	Type II Excavation	m3	332,200	19.00	6,311,800
	UNWATERING				
	Pumping	L.S.	1	25,000.00	25,000
	SUB TOTAL - TAILRACE				7,387,500
				Contingency	738,800

SWITCHYARD

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CLEARING AND STRIPPING				
	Clearing	ha	0.6	6,300.00	3,780
	Stripping	m3	3,000	7.50	22,500
	EXCAVATION				
	Type I Excavation	m3	2,000	10.00	20,000
	Type II Excavation	m3	500	25.00	12,500
	BACKFILL				
	Common Fill (from excavation)	m3	2,000	5.00	10,000
	Crushed Stone	m3	1,200	50.00	60,000
	CONCRETE				
	Concrete - 25 MPa - 40 mm	m3	200	900.00	180,000
	Anchor Bolts	L.S.	1	1,250.00	1,250
	Precast Cable Trenches	m	150	250.00	37,500
	FENCING				
	Chain Link Fencing	m	230	88.00	20,240
	Gate - Double	each	3	1,250.00	3,750
	Gate - Single	each	3	500.00	1,500
	GROUNDING	L.S.	1	63,000.00	63,000
	SUB TOTAL - SWITCHYARD				436,000
				Contingency	43,600

PROJECT SUPPORT

ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	CONSTRUCTION CAMP (150 Men)				
	Buildings (supply, deliver and install)				
	- 20 man Bunkhouses	each	7	85,000.00	595,000
	- 10 man Bunkhouses	each	1	50,000.00	50,000
	- Kitchen/Diner	each	1	435,000	435,000
	- Rec. Hall	each	1	125,000	125,000
	- Manager's Office	each	1	185,000	185,000
	- Family Trailers	each	8	38,000	304,000
	Site Preparation and Services				
	- Site Preparation (including clearing & grading)	L.S.	1	225,000	225,000
	- Water, Sewer & Fire Protection	L.S.	1	310,000	310,000
	Power Supply				
	- Electrical Distribution	L.S.	1	110,000.00	110,000
	- Diesel Generators (2 - 150kw @ $60,000)	L.S.	1	120,000	120,000
	- Fuel	L.S.	1	650,000	650,000
	Camp & Road Maintenance				
	- Camp Maintenance	L.S.	1	310,000	310,000
	- Road Maintenance (Millertown Dam - Powerhouse)	km-mo	1,850	1,500.00	2,775,000
	- Safety and Security	L.S.	1	625,000	625,000
	- Warehouse	L.S.	1	125,000	125,000
	- Telephone Communications	L.S.	1	375,000	375,000
	Site Vehicles	L.S.	1	250,000	250,000
	Field Office, Laboratory Equipment and Supplies	L.S.	1	125,000	125,000
	SUB TOTAL - PROJECT SUPPORT				7,694,000
				Contingency	769,400

GRANITE CANAL DEVELOPMENT
PROJECT COST AND CASH FLOW ($1000)

06 October 1996

ACTIVITIES	COST	DURATION (MONTHS)	COST/ MONTH	TOTAL
1. SITE ESTABLISHMENT				
UPGRADE EXISTING ROADS				
- Millertown to Site	5054.2	6.0	842.4	5054.2
- Existing Road to Canal Closure	33.6	0.5	67.2	33.6
PERMANENT ROADS				
- Existing Road to Intake	31.2	1.0	31.2	31.2
- Existing Road to Powerhouse	12.5	1.0	12.5	12.5
- Existing Road to Switchyard to Road	75.0	1.5	50.0	75.0
- Bridge on Granite Lake Road at Power Canal	310.0	2.0	155.0	310.0
SUB-TOTAL	5516.5			5516.5
2. GRANITE LAKE OVERFLOW SPILLWAYS				
ACCESS ROAD	22.5	0.5	45.0	22.5
EXCAVATION	36.7	1.0	36.7	36.7
SHEET PILING & FROST PROTECTION	737.5	1.0	737.5	737.5
BACKFILL AND ARMOUR ROCK	231.0	1.0	231.0	231.0
WAVE BARRIER	204.6	1.0	204.6	204.6
SUB-TOTAL	1232.3			1232.3
3. CANAL CLOSURE / LOW LEVEL OUTLET STRUCTURE				
CONCRETE	643.2	2.0	321.6	643.2
HYDRAULIC GATES	326.0	0.5	652.0	326.0
SUB-TOTAL	969.2			969.2
4. POWER CANAL				
ACCESS ROAD	143.0	1.5	95.3	143.0
CLEARING AND STRIPPING	772.1	2.0	386.0	772.1
EXCAVATE OVERBURDEN	1700.0	11.5	147.8	1700.0
EXCAVATE ROCK	5671.6	11.5	493.2	5671.6
DYKE - IMPERVIOUS FILL	380.0	2.0	190.0	380.0
- FILTER	90.0	2.0	45.0	90.0
- ROCKFILL	225.0	2.0	112.5	225.0
OVERFLOW SPILLWAY - EXCAVATE OVERBURDEN	410.0	2.0	205.0	410.0
- EXCAVATE ROCK	259.5	1.5	173.0	259.5
- CONCRETE	71.9	0.5	143.7	71.9
SUB-TOTAL	9723.0			9723.0
5. FISH COMPENSATION STRUCTURE				
CLEARING AND STRIPPING	29.3	2.0	14.7	29.3
EXCAVATE OVERBURDEN	72.8	2.0	36.4	72.8
EXCAVATE ROCK	117.3	1.0	117.3	117.3
HYDRAULIC GATE	30.0	1.0	30.0	30.0
PIPELINE	1100.0	3.0	366.7	1100.0
BEDDING AND BACKFILL	269.5	4.0	67.4	269.5
CONCRETE	72.0	2.0	36.0	72.0
SUB-TOTAL	1690.9			1690.9
6. INTAKE				
CLEARING AND STRIPPING	6.5	0.5	13.0	6.5
EXCAVATE OVERBURDEN	12.0	0.5	24.0	12.0
EXCAVATE ROCK	128.9	1.5	85.9	128.9
CONCRETE AND EXTERIOR FINISHING	1321.3	4.5	293.6	1321.3
HYDRAULIC GATES AND TRASHRACKS	1750.0	2.5	700.0	1750.0
ENCLOSURE BUILDING ELECTRICAL & MECH.	449.1	1.0	449.1	449.1
SUB-TOTAL	3667.8			3667.8
6. PENSTOCK				
ACCESS ROAD	7.4	1.0	7.4	7.4
CLEARING & STRIPPING	36.3	1.0	36.3	36.3
EXCAVATE OVERBURDEN	57.0	1.0	57.0	57.0
EXCAVATE ROCK	491.3	1.5	327.5	491.3
STEEL CONDUIT	2070.8	3.0	690.3	2070.8
DRAINAGE SYSTEM AND BACKFILL	382.1	3.0	127.4	382.1
CONCRETE ANCHOR BLOCK	272.3	0.5	544.5	272.3
SUB-TOTAL	3317.1			3317.1
7. POWERHOUSE				
CLEARING & STRIPPING	8.5	0.5	17.0	8.5
EXCAVATION AND BACKFILL	839.6	4.0	209.9	839.6
CONCRETING STAGE I	3537.3	3.5	1010.7	3537.3
CONCRETING STAGE II	130.5	3.5	37.3	130.5
STRUCTURAL STEEL	530.9	1.5	353.9	530.9
OVERHEAD CRANE - MANUFACTURE	384.0	8.8	43.9	384.0
- DELIVER	128.0	1.0	128.0	128.0
- INSTALL	160.0	1.0	160.0	160.0
- HOLDBACK	128.0	1.0	128.0	128.0
ROOFING AND CLADDING	320.3	3.0	106.8	320.3
TURBINES - MANUFACTURE	3840.0	20.8	185.1	3840.0
- DELIVER (EP)	640.0	1.0	640.0	640.0
- DELIVER (RP)	640.0	1.0	640.0	640.0
- INSTALL (EP)	800.0	4.8	168.4	800.0
- INSTALL (RP)	800.0	3.8	213.3	800.0
- HOLDBACK	1280.0	1.0	1280.0	1280.0
GENERATORS - MANUFACTURE	5472.0	24.5	223.3	5472.0
- DELIVER	1824.0	2.0	912.0	1824.0
- INSTALL	2280.0	6.5	350.8	2280.0
- HOLDBACK	1824.0	1.0	1824.0	1824.0
POWER TRANSFORMER - MANUFACTURE	508.8	12.0	42.4	508.8
- DELIVER	169.6	1.0	169.6	169.6
- INSTALL	212.0	1.0	212.0	212.0
- HOLDBACK	169.6	1.0	169.6	169.6
DRAFT TUBE GATE - MANUFACTURE	201.6	8.0	25.2	201.6
- DELIVER	67.2	1.0	67.2	67.2
- INSTALL	84.0	2.0	42.0	84.0
- HOLDBACK	67.2	1.0	67.2	67.2
EXTERNAL WORK (SITE GRADING)	78.9	0.5	157.8	78.9
ELECTRICAL AND MECHANICAL AUXILIARIES	3914.6	7.5	522.0	3914.6
ARCHITECTURAL FINISHING AND PAINTING	222.0	4.0	55.5	222.0
SUB-TOTAL	31262.5			31262.5
8. TAILRACE				
ACCESS ROAD	37.0	2.0	18.5	37.0
CLEARING & STRIPPING	395.7	3.5	113.1	395.7
EXCAVATE OVERBURDEN	655.0	9.5	68.9	655.0
EXCAVATE ROCK	6336.8	8.5	745.5	6336.8
SUB-TOTAL	7424.5			7424.5
9. SWITCHYARD				
CLEARING & STRIPPING	26.3	1.0	26.3	26.3
EXCAVATION	32.5	1.0	32.5	32.5
GROUNDING, BACKFILL & FENCING	158.5	1.5	105.7	158.5
CONCRETE FOOTINGS & TRENCHES	218.8	2.0	109.4	218.8
SUB-TOTAL	436.0			436.0
10. PROJECT SUPPORT				
SITE PREPARATION & BUILDINGS	2229.0	4.0		2229.0
POWER SUPPLY	880.0	27.5	32.0	880.0
CAMP & ROAD MAINTENANCE	4210.0	27.5	153.1	4210.0
SITE VEHICLES	250.0	32.0	7.8	250.0
FIELD, LABORATORY EQUIPMENT & SUPPLIES	125.0	29.0	4.3	125.0
SUB-TOTAL	7894.0			7894.0
SUB TOTAL BEFORE CONTINGENCY	72933.8			72933.8
11. CONTINGENCY	6209.4			6209.4
TOTAL DIRECT COST	79143.1			79143.1
12. MANAGEMENT AND ENGINEERING	11871.5	45.0	263.8	11871.5
13. OWNER'S COSTS	2770.0			2770.0
SUB TOTAL (Unescalated Cost)	93784.6			93784.6
14. ESCALATION	6183.2			6183.2
SUB TOTAL (Escalated Cost)	99967.8			99967.8
15. INTEREST DURING CONSTRUCTION	12557.0			12557.0
TOTAL PROJECT COST	112524.8			112524.8
ACCUMULATED CASH FLOW				

1997

ACTIVITIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
12. MANAGEMENT AND ENGINEERING						527.6	527.6	263.8	263.8	263.8	263.8	263.8
SUB TOTAL (Unescalated Cost)						627.6	627.6	263.8	263.8	263.8	263.8	263.8
14. ESCALATION						5.3	6.1	3.5	3.9	4.4	4.8	5.3
SUB TOTAL (Escalated Cost)						532.9	533.8	267.3	267.8	268.2	268.6	269.1
15. INTEREST DURING CONSTRUCTION							2.2	6.7	10.0	12.3	14.6	17.0
TOTAL PROJECT COST						532.9	536.0	274.0	277.8	280.6	283.3	286.0
ACCUMULATED CASH FLOW							532.9	1068.8	1342.8	1620.6	1901.1	2184.4

1998

ACTIVITIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1. SITE ESTABLISHMENT												
- Millertown to Site					842.4	842.4	842.4	842.4	842.4	842.4		
- Existing Road to Intake								15.6	15.6			
- Existing Road to Powerhouse								6.3	6.3			
- Existing Road to Switchyard to Road									50.0	25.0		
SUB-TOTAL					842.4	842.4	842.4	864.2	914.2	867.4		
6. PENSTOCK												
ACCESS ROAD									3.7			
CLEARING & STRIPPING										18.2		
EXCAVATE OVERBURDEN										28.5		
EXCAVATE ROCK										163.8		
SUB-TOTAL									3.7	210.4		
7. POWERHOUSE												
CLEARING & STRIPPING										8.5		
EXCAVATION AND BACKFILL										104.9	209.9	104.9
OVERHEAD CRANE - MANUFACTURE											21.9	43.9
TURBINES - MANUFACTURE					92.5	185.1	185.1	185.1	185.1	185.1	185.1	185.1
GENERATORS - MANUFACTURE					111.7	223.3	223.3	223.3	223.3	223.3	223.3	223.3
SUB-TOTAL					204.2	408.4	408.4	408.4	408.4	521.8	640.2	557.2
8. TAILRACE												
ACCESS ROAD									18.5			
CLEARING & STRIPPING									113.1	113.1	113.1	56.5
EXCAVATE OVERBURDEN										68.9	68.9	34.5
EXCAVATE ROCK											745.5	372.8
SUB-TOTAL									131.6	182.0	927.5	463.8
10. PROJECT SUPPORT												
SITE PREPARATION & BUILDINGS						691.0	802.4	490.4	245.2			
POWER SUPPLY									16.0	32.0	32.0	32.0
CAMP & ROAD MAINTENANCE									76.5	153.1	153.1	153.1
SITE VEHICLES					5.0	5.0	5.0	6.0	7.0	7.0	5.0	5.0
FIELD, LABORATORY EQUIPMENT & SUPPLIES								10.0	10.0	3.9	3.9	3.9
SUB-TOTAL					5.0	696.0	807.4	506.4	354.7	196.0	194.0	194.0
SUB TOTAL BEFORE CONTINGENCY					1051.6	1946.8	2068.2	1779.0	1812.6	1977.6	1761.7	1216.0
11. CONTINGENCY					94.9	174.3	185.4	157.5	160.8	177.3	154.7	98.9
TOTAL DIRECT COST					1146.6	2121.0	2243.6	1936.5	1973.5	2154.9	1916.4	1313.9
12. MANAGEMENT AND ENGINEERING	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8
13. OWNER'S COSTS					40.1	74.2	78.5	67.8	69.1	75.4	67.1	46.0
SUB TOTAL (Unescalated Cost)	263.8	263.8	263.8	263.8	1450.5	2459.1	2586.0	2268.1	2306.3	2494.2	2247.3	1623.0
14. ESCALATION	5.7	6.2	6.6	7.1	41.3	74.1	82.4	76.1	81.3	92.2	86.9	65.6
SUB TOTAL (Escalated Cost)	269.5	270.0	270.4	270.9	1491.7	2533.2	2668.3	2344.2	2387.7	2586.4	2334.2	1689.2
15. INTEREST DURING CONSTRUCTION	19.3	21.7	24.1	26.8	29.0	36.6	53.6	75.6	96.9	117.2	138.8	160.3
TOTAL PROJECT COST	288.9	291.7	294.5	297.4	1520.7	2569.8	2721.9	2419.7	2484.6	2703.6	2473.0	1849.5
ACCUMULATED CASH FLOW	2470.4	2759.3	3051.0	3345.5	3642.9	5163.7	7733.4	10455.3	12875.1	15359.6	18063.3	20536.2

1999

ACTIVITIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
4. POWER CANAL												
ACCESS ROAD					95.3	47.7						
CLEARING AND STRIPPING					386.0	386.0						
EXCAVATE OVERBURDEN					147.8	147.8	147.8	147.8	147.8	147.8	147.8	73.9
EXCAVATE ROCK					493.2	493.2	493.2	493.2	493.2	493.2	493.2	246.6
SUB-TOTAL					1122.4	1074.7	641.0	641.0	641.0	641.0	641.0	320.5
6. INTAKE												
CLEARING AND STRIPPING									6.5			
EXCAVATE OVERBURDEN										12.0		
EXCAVATE ROCK										43.0	85.9	
SUB-TOTAL									6.5	55.0	85.9	
6. PENSTOCK												
ACCESS ROAD								3.7				
CLEARING & STRIPPING									18.2			
EXCAVATE OVERBURDEN									28.5			
EXCAVATE ROCK										327.5		
SUB-TOTAL								3.7	46.7	327.5		
7. POWERHOUSE												
EXCAVATION AND BACKFILL	209.9	209.9										
CONCRETING STAGE I			1010.7	1010.7	1010.7	505.3						
STRUCTURAL STEEL						177.0	353.9					
OVERHEAD CRANE - MANUFACTURE	43.9	43.9	43.9	43.9	43.9	43.9	43.9	11.0				
- DELIVER								128.0				
- INSTALL									160.0			
- HOLDBACK											128.0	
ROOFING AND CLADDING									106.8	106.8	106.8	
TURBINES - MANUFACTURE	185.1	185.1	185.1	185.1	185.1	185.1	185.1	185.1	185.1	185.1	185.1	185.1
- DELIVER (EP)								640.0				
- INSTALL (EP)									84.2	168.4	168.4	84.2
GENERATORS - MANUFACTURE	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3
POWER TRANSFORMER - MANUFACTURE							42.4	42.4	42.4	42.4	42.4	42.4
DRAFT TUBE GATE - MANUFACTURE	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2				
- DELIVER									67.2			
SUB-TOTAL	687.4	687.4	1488.2	1488.2	1488.2	1159.8	873.8	1255.0	869.0	726.0	854.0	535.0
8. TAILRACE												
ACCESS ROAD					18.5							
EXCAVATE OVERBURDEN					68.9	68.9	68.9	68.9	68.9	68.9	68.9	
EXCAVATE ROCK					745.5	745.5	745.5	745.5	745.5	745.5	745.5	
SUB-TOTAL					833.0	814.5	814.5	814.5	814.5	814.5	814.5	
10. PROJECT SUPPORT												
POWER SUPPLY	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
CAMP & ROAD MAINTENANCE	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1
SITE VEHICLES	5.0	6.0	7.0	7.0	8.0	8.0	9.0	9.0	10.0	10.0	10.0	10.0
FIELD, LABORATORY EQUIPMENT & SUPPLIES	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
SUB-TOTAL	194.0	195.0	196.0	196.0	197.0	197.0	198.0	198.0	199.0	199.0	199.0	199.0
SUB TOTAL BEFORE CONTINGENCY	881.4	882.4	1684.1	1684.1	3640.6	3246.9	2527.2	2912.1	2576.6	2762.9	2594.3	1054.6
11. CONTINGENCY	64.3	64.4	144.5	144.5	340.2	300.7	226.7	228.5	219.5	245.3	222.1	78.7
TOTAL DIRECT COST	945.6	946.7	1828.7	1828.7	3980.6	3546.6	2754.0	3140.6	2796.1	3008.2	2816.4	1133.2
12. MANAGEMENT AND ENGINEERING	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8
13. OWNER'S COSTS	33.1	33.1	64.0	64.0	139.3	124.1	96.4	109.9	97.9	105.3	98.6	39.7
SUB TOTAL (Unescalated Cost)	1242.5	1243.7	2156.5	2156.5	4383.8	3934.6	3114.2	3514.3	3157.8	3377.3	3178.8	1436.7
14. ESCALATION	53.4	56.6	103.8	109.3	233.6	219.9	182.2	214.7	201.2	224.1	219.3	102.9
SUB TOTAL (Escalated Cost)	1295.9	1300.3	2260.2	2265.8	4617.4	4154.5	3296.3	3729.1	3359.0	3601.4	3398.0	1539.6
15. INTEREST DURING CONSTRUCTION	178.2	191.9	204.2	220.7	241.2	271.8	310.3	343.6	375.5	407.9	440.0	472.6
TOTAL PROJECT COST	1474.1	1492.2	2464.5	2486.5	4858.6	4426.3	3606.6	4072.7	3734.5	4009.3	3838.1	2012.1
ACCUMULATED CASH FLOW	22385.7	23859.8	25352.1	27816.6	30303.1	35161.7	39588.0	43194.6	47267.3	51001.8	55011.1	58849.1

2000

ACTIVITIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	JAN. 2001
1. SITE ESTABLISHMENT													
- Existing Road to Canal Closure				33.6									
- Bridge on Granite Lake Road at Power Canal					155.0	155.0							
SUB-TOTAL				33.6	155.0	155.0							
2. GRANITE LAKE OVERFLOW SPILLWAYS													
ACCESS ROAD						22.5							
EXCAVATION							36.7						
SHEET PILING & FROST PROTECTION							368.8	368.8					
BACKFILL AND ARMOUR ROCK								115.5	115.5				
WAVE BARRIER								102.3	102.3				
SUB-TOTAL						22.5	405.5	586.6	217.8				
3. CANAL CLOSURE / LOW LEVEL OUTLET STRUCTURE													
CONCRETE							321.6	321.6					
HYDRAULIC GATES								326.0					
SUB-TOTAL							321.6	647.6					
4. POWER CANAL													
EXCAVATE OVERBURDEN					147.8	147.8	147.8	147.8					
EXCAVATE ROCK					493.2	493.2	493.2	493.2					
DYKE - IMPERVIOUS FILL					190.0	190.0							
- FILTER					45.0	45.0							
- ROCKFILL					112.5	112.5							
OVERFLOW SPILLWAY - EXCAVATE OVERBURDEN					205.0	205.0							
- EXCAVATE ROCK						86.5	173.0						
- CONCRETE							71.9						
SUB-TOTAL					1193.5	1280.0	885.9	641.0					
5. FISH COMPENSATION STRUCTURE													
CLEARING AND STRIPPING					14.7	14.7							
EXCAVATE OVERBURDEN						36.4	36.4						
EXCAVATE ROCK							117.3						
HYDRAULIC GATE							30.0						
PIPELINE							366.7	366.7	366.7				
BEDDING AND BACKFILL							67.4	67.4	67.4	67.4			
CONCRETE						36.0	36.0						
SUB-TOTAL					14.7	87.1	653.7	434.0	434.0	67.4			
6. INTAKE													
CONCRETE AND EXTERIOR FINISHING			293.6	293.6	293.6	293.6	146.8						
HYDRAULIC GATES AND TRASHRACKS						350.0	700.0	700.0					
ENCLOSURE BUILDING ELECTRICAL & MECH.								449.1					
SUB-TOTAL			293.6	293.6	293.6	643.6	846.8	1149.1					
6. PENSTOCK													
STEEL CONDUIT					690.3	690.3	690.3						
DRAINAGE SYSTEM AND BACKFILL						127.4	127.4	127.4					
CONCRETE ANCHOR BLOCK							272.3						
SUB-TOTAL					690.3	817.6	1089.9	127.4					
7. POWERHOUSE													
CONCRETING STAGE II	18.6	37.3	37.3	37.3									
TURBINES - MANUFACTURE	185.1	46.3											
- DELIVER (RP)		640.0											
- INSTALL (EP)	84.2	168.4	42.1										
- INSTALL (RP)			160.0	213.3	213.3	213.3							
- HOLDBACK												1280.0	
GENERATORS - MANUFACTURE	223.3	223.3	223.3	223.3	223.3								
- DELIVER				912.0		912.0							
- INSTALL					350.8	350.8	350.8	350.8	350.8	350.8	175.4		
- HOLDBACK													1824.0
POWER TRANSFORMER - MANUFACTURE	42.4	42.4	42.4	42.4	42.4	42.4							
- DELIVER							169.6						
- INSTALL								212.0					
- HOLDBACK												169.6	
DRAFT TUBE GATE - INSTALL					42.0	42.0							
- HOLDBACK												67.2	
EXTERNAL WORK (SITE GRADING)										78.9			
ELECTRICAL AND MECHANICAL AUXILIARIES				522.0	522.0	522.0	522.0	522.0	522.0	522.0	261.0		
ARCHITECTURAL FINISHING AND PAINTING								55.5	55.5	55.5	55.5		
SUB-TOTAL	553.7	1157.7	505.1	1950.3	1393.8	2082.5	1042.3	1140.2	928.2	1007.1	491.9	1516.8	1824.0
9. SWITCHYARD													
CLEARING & STRIPPING					26.3								
EXCAVATION					16.3	16.3							
GROUNDING, BACKFILL & FENCING						105.7	52.8						
CONCRETE FOOTINGS & TRENCHES						109.4	109.4						
SUB-TOTAL					42.5	231.3	162.2						
10. PROJECT SUPPORT													
POWER SUPPLY	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	
CAMP & ROAD MAINTENANCE	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	153.1	
SITE VEHICLES	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.0	8.0	5.0	4.0	
FIELD, LABORATORY EQUIPMENT & SUPPLIES	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	
SUB-TOTAL	199.0	199.0	199.0	199.0	199.0	199.0	199.0	199.0	198.0	197.0	194.0	193.0	
SUB TOTAL BEFORE CONTINGENCY	752.6	1356.7	997.7	2476.6	3982.4	5618.5	5606.8	4924.8	1778.0	1271.5	685.8	1709.8	1824.0
11. CONTINGENCY	48.5	79.6	76.4	178.1	354.6	473.8	534.7	464.3	160.3	109.6	59.8	95.1	91.2
TOTAL DIRECT COST	801.2	1436.3	1074.1	2654.6	4337.0	6092.4	6141.5	5389.2	1938.3	1381.1	745.7	1804.9	1915.2
12. MANAGEMENT AND ENGINEERING	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	263.8	
13. OWNER'S COSTS	28.0	50.3	37.6	92.9	151.8	209.7	215.0	188.6	67.8	48.3	26.1	63.2	67.0
SUB TOTAL (Unescalated Cost)	1093.0	1750.4	1375.5	3011.4	4752.6	6565.9	6620.2	5841.6	2270.0	1693.2	1035.6	2131.9	1982.2
14. ESCALATION	81.2	134.6	109.4	247.6	403.5	566.2	597.5	542.9	217.1	166.5	104.6	221.2	211.1
SUB TOTAL (Escalated Cost)	1174.2	1885.0	1485.0	3259.0	5156.1	7032.1	7217.7	6384.5	2487.0	1859.7	1140.2	2353.1	2193.3
15. INTEREST DURING CONSTRUCTION	496.8	512.1	529.0	547.3	571.4	611.1	686.6	731.1	793.3	836.4	861.1	880.6	
TOTAL PROJECT COST	1671.0	2397.1	2013.9	3806.2	5727.5	7643.2	7904.3	7115.6	3280.4	2696.1	2001.3	3233.7	2193.3
ACCUMULATED CASH FLOW	60861.2	62532.2	64929.3	66943.3	70749.5	76477.0	84120.2	92004.5	99120.1	102400.5	105096.6	107097.8	112524.8

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