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During Stage 2 of the Site C Project, studies are underway to update many of the historical studies and information known about the project.

The potential Site C project, as originally conceived, will be updated to reflect current information and to incorporate new ideas brought forward by communities, First Nations, regulatory agencies and stakeholders. Today's approach to Site C will consider environmental concerns, impacts to land, and opportunities for community benefits, and will update design, financial and technical work.

(b) Alternative Projects Available

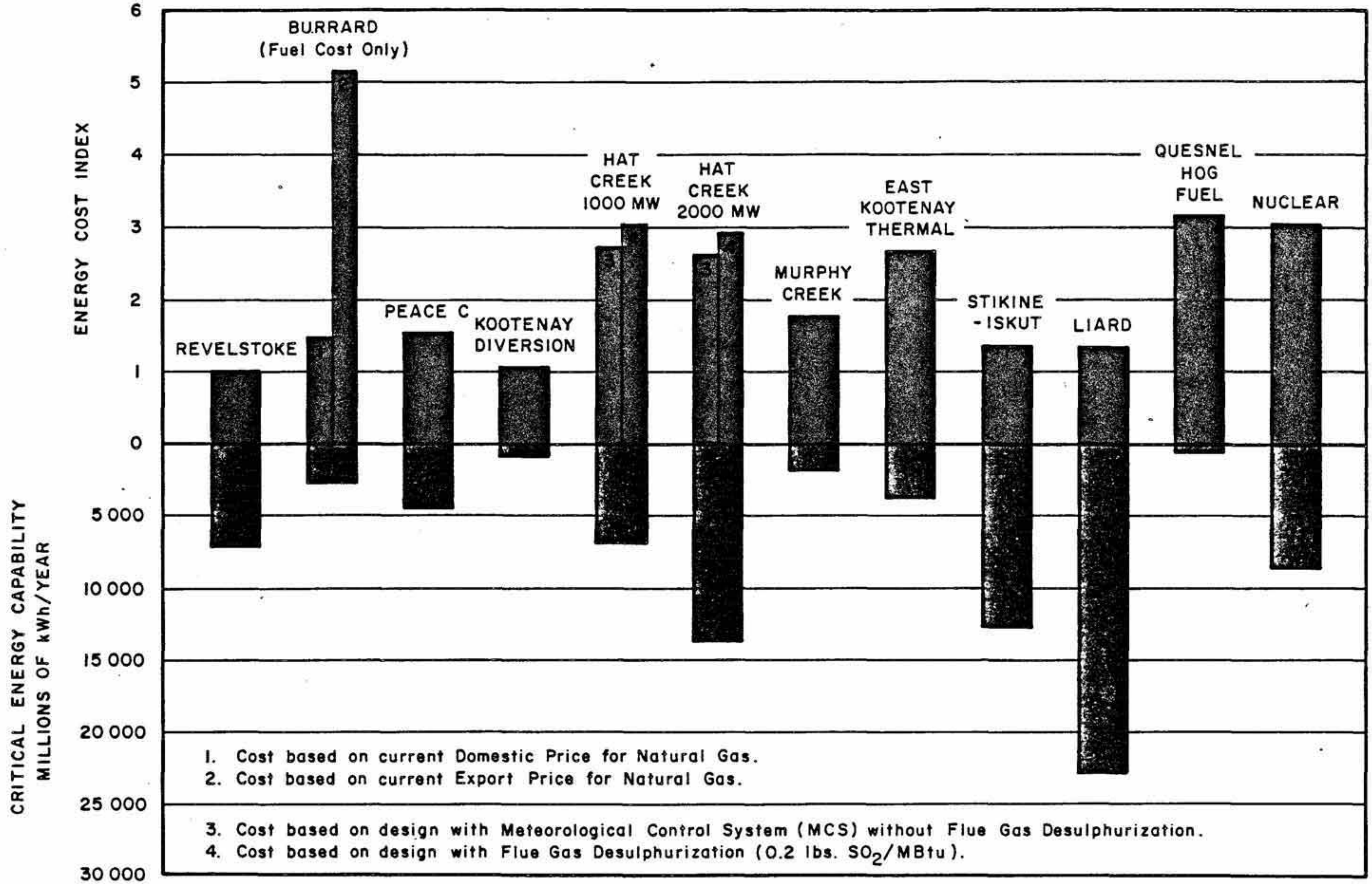
The number of feasible alternatives to the Peace Site C project at this stage of the planning process is rather limited. Although there are many potential future hydro and thermal power projects in British Columbia, the studies for most of these alternatives are not sufficiently advanced so that they could become feasible alternatives to the Peace Site C project for a 1987 in-service date. The earliest feasible in-service dates of major new generation projects that B.C. Hydro is now considering for future construction are summarized below:

Projects	Earliest Feasible In-Service Date
Hydro:	
Peace Site C	1987
Murphy Creek	1988
Stikine-Iskut	1991
Liard	1992
Thermal:	
Hat Creek, coal	1987
East Kootenay, coal	1988

The firm energy capabilities and the average energy costs of the above projects are summarized in Fig. 2-2. The average energy costs shown in Fig. 2-2, which are relative to the Revelstoke hydro project, are all at equivalent price levels, and include the costs of major project transmission required to deliver power to the integrated transmission system, as well as transmission losses. Although B.C. Hydro has no specific plans for a future nuclear powerplant in British Columbia, the average energy cost of nuclear power is included in Fig. 2-2 for comparison with other potential power sources.

FIGURE 2-2

COMPARISON OF LONG-TERM ENERGY COSTS AND CRITICAL ENERGY CAPABILITIES FOR EXISTING AND POTENTIAL PROJECTS



NOTE: All energy costs are compared with energy costs for the Revelstoke Project (4 Units) on the Columbia River (i.e. Revelstoke has an energy cost index of 1.0)

Only conventional proven power sources have been considered as feasible alternatives. Unconventional power sources such as solar power, wind power, tidal power, etc. have often been suggested in public debates. However, most of these unconventional sources are still in the research and development stage. Preliminary cost estimates of these alternatives indicate that with current technology they would be much more expensive than conventional power sources. Unless these costs can be reduced through further research and development, and until the technical feasibility and reliable operation of these alternatives is demonstrated with large scale commercial demonstration projects, B.C. Hydro must concentrate its studies of alternative power sources on more conventional alternatives. B.C. Hydro is currently conducting studies on geothermal power generation, but the technical feasibility and costs of this particular alternative have not yet been established to the point where it can seriously be considered as a realistic alternative for a major new source of power supply within the next decade.

(c) Reasons for Recommending Peace Site C

The Peace Site C project would be one of the most economic sources of new power supply for the B.C. Hydro system. Only the northern hydro developments of the Stikine and Liard may be competitive in costs with Peace Site C. However, they have received only preliminary study to date, and could not be developed before the early 1990s.

The alternative thermal power projects, Hat Creek and East Kootenay, would be significantly more expensive than Peace Site C. Hat Creek power costs would be about 70 percent higher than Peace Site C costs without flue gas desulphurization (FGD) and could be twice as high if the B.C. Pollution Control Branch requires full scrubbing to remove sulphur dioxide. If the Peace

Site C project could not be developed, the added direct costs of generating the 4530 GW.h/a of potential energy from Peace Site C with thermal power from Hat Creek instead would range from $44 to $65 million annually at 1980 price levels.

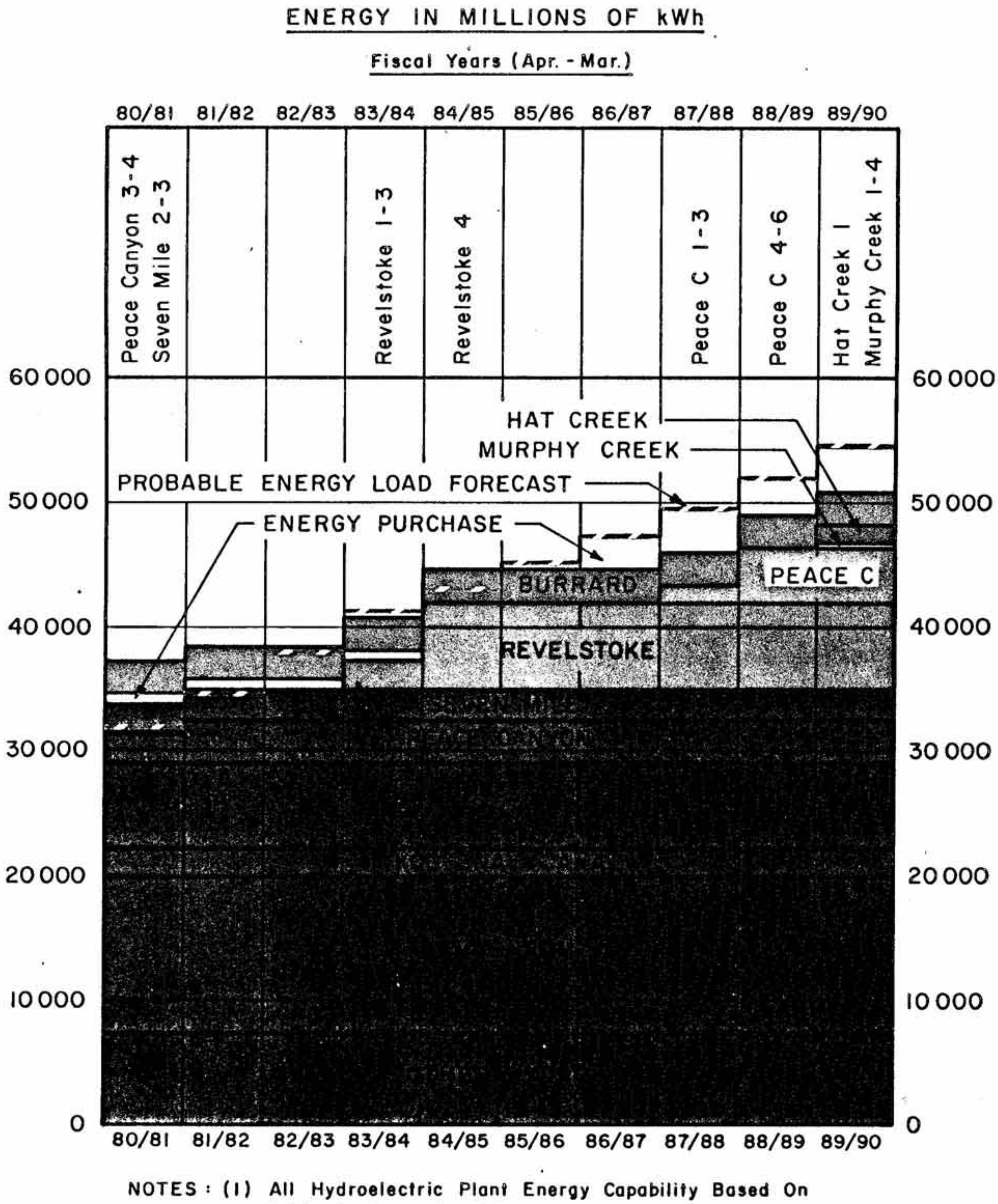
Fig. 2-3 shows the recommended system expansion plan to meet loads in the 1980s with Peace Site C, Murphy Creek and the first unit at Hat Creek added in that order. These projects are shown in relation to the capabilities of plants on line now and the Revelstoke project which is under construction. Also shown is the probable energy load forecast which these plants are intended to serve.

Parts two and three of this Environmental Impact Statement examine the potential environmental and socio-economic impacts which would result from the Site C project, and also the opportunities for mitigating these impacts or for compensating for them. B.C. Hydro is confident that, provided appropriate mitigation and compensation measures are implemented, the net project impacts can be kept to a minimum and the project can be made environmentally and socially acceptable to the people of British Columbia.

It is for these economic and environmental reasons that B.C. Hydro recommends the Peace Site C hydroelectric project as the next major generation project after Revelstoke.

FIGURE 2-3

INTEGRATED SYSTEM LOADS AND RESOURCES 1980/81 - 1989/90



NOTES : (1) All Hydroelectric Plant Energy Capability Based On Critical Water Conditions.

SECTION 3.0 - BENEFIT/COST ANALYSIS

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SECTION 3.0 - BENEFIT/COST ANALYSIS

3.1 INTRODUCTION

The Peace River Site C hydroelectric project is preferred by B.C. Hydro as the next addition to its electrical generating system. The project meets B.C. Hydro's objectives of providing minimum long-run cost of service to its customers safely and reliably at an acceptable level of environmental impact. Whether the environmental impacts are acceptable to the public will be determined during the course of public hearings held in connection with an application to the provincial government for a water licence. The government's responsibility for licensing also entails a responsibility to ensure that all resources committed to a project will be used efficiently from the point of view of maximizing provincial income and that regional or local consequences do not outweigh provincial income gains. The purpose of this section is to summarize the results of a social benefit/cost analysis from the provincial perspective presented in a separate document entitled "Peace Site C Benefit/Cost Analysis".

The "Guidelines for Benefit/Cost Analysis" published by the B.C. Environment and Land Use Committee's Secretariat propose a framework for evaluating public projects from three perspectives: provincial income, regional income and environmental. The provincial income account presents social benefits and social costs which can be evaluated in monetary terms. Social benefits produced by an electrical generating station are taken to be equal to the costs of the next best alternative for equivalent generation. Social costs are based on the value of capital, labour, materials and environmental resources in their next best alternative use. These costs will typically differ from the direct costs of construction and operation paid by B.C. Hydro but must be estimated to demonstrate that resources would be efficiently allocated if the project were built.

3.1 INTRODUCTION - (Cont'd)

The regional income framework evaluates income, employment and resource value changes at a regional level. This account is included because projects impose costs and benefits to different degrees upon different population groups in the province. In Section 16 it is argued that it is important to identify those affected and how severely they are affected to provide the essential information for compensation and mitigation decisions. The third account recommended in the Guidelines is concerned with environmental impacts which cannot be evaluated in dollar terms, and essentially describes the natural environment with and without the project. Much of this Environmental Impact Statement is devoted to assessing environmental changes which are not commensurable with social benefits and costs presented in the provincial income account. A summary table at the end of this section allows the direct comparison of unquantifiable impacts with provincial income gains.

3.2 SOCIAL COSTS OF PEACE SITE C

(a) Capital Cost Estimates

The total capital cost of the Peace Site C Project is estimated to be $1634.7 million in dollars of the year of expenditure for the dam and powerplant. The annual capital cost disbursement in both uninflated and inflated dollars is shown in Table 3-1. A breakdown of major components of the dam and powerplant costs is given in Table 3-2. The total cost of the transmission system required to connect the Peace Site C project to the existing system is estimated to be $254.6 million in dollars of the year of expenditure. The system is made up of two 500 kV ac circuits to link Site C with the Peace Canyon transmission terminal and a third 500 kV ac circuit from the Williston Substation near Prince George to the Kelly Lake Substation near Lillooet. The total capital cost of Peace Site C hydroelectric power delivered to the grid would thus be $1889.0 million including interest during construction and corporate overhead. It

TABLE 3-1

CAPITAL COSTS OF PEACE SITE C BY FISCAL YEAR
(October 1987 In-service Date)
($ Million)

	Generating Station and Transmission	
Fiscal Year Ending 31 March	Uninflated 1980 Dollars (including Corporate Overhead)	Inflated Dollars[2] (including Corporate Overhead and Interest during Construction
1981[1]	27.8	31.9
1982	11.1	15.8
1983	40.0	53.9
1984	120.2	168.8
1985	203.5	313.9
1986	342.6	566.2
1987	257.3	508.3
1988	73.3	207.0
1989	10.4	23.5
	1086.2	1889.3

[1] Including prior year expenditures

[2] Assumed inflation rates:

1980/81	-	base
1981/82	-	8.5 percent
1982/83	-	8.25 percent
1983/84	-	8.0 percent
1984/85	-	7.0 percent
thereafter	-	6.0 percent

TABLE 3-2

CAPITAL COST BREAKDOWN OF PEACE SITE C
($ Million 1980)

Dam and Powerhouse		
Land and rights		$ 11.8
Reservoir clearing and relocation costs		47.3
Construction services		10.1
Site access		6.3
Site clearing		0.3
Cofferdams		13.0
Left bank stabilization		38.2
Diversion tunnels		86.9
Earthfill dam		56.3
Spillway and south gravity dam		110.1
Power intakes, penstocks and north gravity dam		91.1
Powerhouse and switchyard	- civil	65.2
	- mechanical	67.6
	- electrical	81.7
Contingencies		77.2
Engineering, investigations and supervision		61.0
Construction insurance and bonds		9.8
		$833.9

should be noted that the third 500 kV circuit from Williston to Kelly Lake would be needed for other potential northern hydro-electric developments. It is included here because Peace Site C would be the first project to require construction of the line.

(b) The Social Opportunity Cost of Capital and the Social Rate of Discount

The B.C. Environment and Land Use Committee's (ELUC) "Guidelines for Benefit/Cost Analysis" state that "The discount rate to be used in evaluation of public sector investments in British Columbia has its basis in the social opportunity cost of capital. The social opportunity cost of capital is measured by pre-tax rates of return on capital invested in the private sector". There are two options presented for determining the social discount rate. The first is to estimate the proportion of funds for a project that would be diverted from other potential investments within the province. The alternative, if the first approach cannot be followed, is to use the recommended rate of 10 percent net of inflation with 8 and 12 percent for purposes of sensitivity analysis.

The social opportunity cost of capital used by B.C. Hydro can be calculated by estimating the sources of funds to be used for future capital expenditures and then estimating the proportion of these funds that would be diverted from various sectors within the province. It is estimated that about one-half of B.C. Hydro's total borrowing over the next 10 years will come from provincial trusteed funds (superannuation and Canada Pension Plan funds), about 30 percent from the Canadian bond market and about 20 percent from the U.S. bond market.

The proportion of borrowed funds that would be diverted from private activity in B.C. cannot be calculated definitively, but a careful review of the way in which funds would be raised suggests that the social opportunity cost will lie within a range bounded at the lower end by the direct cost of financing and at the higher end by the average pre-tax rate of return in the private sector. This analysis presents results at a range of discount rates net of inflation from 3 to 10 percent with 6 percent as the most likely estimate of social opportunity cost. Three percent is the cost of finance to B.C. Hydro (uninflated), 10 percent is the discount rate recommended in the Guidelines and 6 percent is the estimate developed in the report "Peace River Site C Benefit/Cost Analysis".

(c) The Social Cost of Labour

The social opportunity cost of labour may differ from its wage. Social value is measured in terms of contributions to output. Where the wage earned in one job equals the value of labour's marginal product in the next best alternative employment, the wage and social opportunity cost are equal. If labour that would be employed on a project would otherwise be unemployed then its social cost is zero - that is, no output is given up by employing an unemployed worker; however, its wage is determined by union contract.

While there is an accepted methodology for calculating a shadow price for labour under conditions of unemployment in project analysis, it is not applied here, mainly because there is great uncertainty in forecasting labour availability by skill type several years into the future. The potential biases introduced by not estimating the social opportunity cost of labour would be in the direction of overstating the social costs of Peace Site C, and because the costs of Hat Creek energy are used to estimate the value of the output, overstating the social benefits of the project. Since the Hat Creek project is relatively more labour intensive the two effects will not completely cancel each other and there will be a corresponding upward bias in the estimation of net social benefits.

(d) The Social Cost of Resources

The evaluation of the social cost of natural resources which would be lost to alternative uses follows the same logic as that for capital and labour - that is, the value that would be generated in their next best use compared to use in the proposed hydroelectric development. Value is measured by the willingness to pay of consumers, whether it is registered in market transactions or in user satisfactions for which no direct price is paid.

The methodologies employed to calculate economic losses attributable to the project are described in detail in the report "Peace River Site C Hydroelectric Development Environmental and Socio-economic Assessment, Resource Evaluation" by Canadian Resourcecon Ltd., and summarized in the Peace Site C Benefit/Cost Analysis. The results for each resource are presented here.

In order to assess the changes in resource values with the project it is necessary first to define the base project. It could be argued that the base case is the project which maximizes energy output while minimizing cost and that any deviation in design away from these goals would be a form of mitigation. With this line of reasoning the base case would have an uncleared reservoir. Reservoir clearing would then be justified if and only if it were economically efficient. However, since it is B.C. Hydro's policy to clear reservoirs with recreation potential, the base case for Peace Site C includes a cleared reservoir. In Section 18.0 reservoir clearing is analyzed as a mitigation measure and shown to be an efficient expenditure. However, the resource values shown in Table 3-3 assume a cleared reservoir.

The results of the resource evaluation shown in Table 3-3 vary substantially across the three scenarios chosen for the real increase in resource values over time and the three

TABLE 3-3

PRESENT DISCOUNTED VALUE OF
PEACE SITE C RESOURCE IMPACTS BEFORE COMPENSATION
($ Thousand 1980)

	Resource Evaluation Scenario								
	Low Values[1]			Medium Values[2]			High Values[3] [4]		
	Discount Rate			Discount Rate			Discount Rate		
Resource	3%	6%	10%	3%	6%	10%	3%	6%	10%
Fishing	3,278	944	313	8,978	2,255	572	-4,857	299	504
Hunting	897	417	196	1,968	778	387	456	918	507
General Recreation	15,557	7073	3365	103,038	28,297	8551	47,238	29,857	13,604
Guiding and Trapping	27	13	6	27	13	6	27	13	6
Agriculture	13,855	5980	2453	47,116	17,766	7289	47,582	17,869	7310
Forestry	931	528	332	931	528	332	931	528	332
TOTAL	34,545	15,005	6,665	162,058	49,637	17,137	91,377	49,484	22,263

1 Low Value Increase Scenario

Real value of recreation per user-day increases at an annual rate of 0 to 2 percent (depending on the activity); no increase in agricultural land put into production.

2 Medium Value Increase Scenario

Real value of recreation per user-day increases at an annual rate of 2 to 4 percent (depending on the activity); increase in agricultural land put into production with vegetable acreage expanding to serve local market.

3 High Value Increase Scenario

Real value of recreation per user-day increases at an annual rate of 5 to 6 percent (depending on the activity); increase in agricultural land put into production with vegetable acreage expanding to serve regional market.

4 Income constraints that apply to the increase in real value of fishing, hunting and general recreation for this scenario result in net impacts that are smaller than in the medium value increase scenario.

discount rates. This exemplifies both the uncertainty in predicting future resource use and values and the rather underdeveloped state of resource evaluation techniques. They serve the purposes of benefit/cost analysis in that project economics are tested against a range of preservation values which give the benefit of the doubt to leaving resources in their present use. The results should, however, be interpreted with caution. Under some assumptions the imputed willingness-to-pay for a day of recreation becomes very large over time. Also the estimates of the amount of fishing, hunting and general recreational use of the river, as well as the likely use of land with agricultural capability, cannot be determined with certainty. The estimated economic rent from agricultural land, for example, is much higher than current market values.

The net values of resource impacts shown in Table 3-3 do not include the compensating effects of possible resource enhancement investments. These are evaluated in Section 18.0 and, using the same assumptions as Table 3-3, demonstrate that much of the net loss can be compensated for through investments in, for example, reservoir recreation facilities.

(e) Present Value of Capital, Operating and Resource Costs for Peace Site C

Table 3-4 shows the present discounted values of capital, operating and resource opportunity costs for the Peace Site C project. Cash flows are discounted over a 70-year period. Operating costs are calculated as a fixed percentage of capital costs (roughly one-half of 1 percent) including interim replacement charges. School taxes and water licence fees are excluded because they are not measures of opportunity cost, although they would be charged to B.C. Hydro's customers. The medium scenario for resource values is displayed.

3.2 SOCIAL COSTS OF PEACE SITE C - (Cont'd)

TABLE 3-4

PRESENT DISCOUNTED VALUE OF PEACE SITE C
CAPITAL, OPERATING AND RESOURCE COSTS

($ Millions 1980)

Discount Rate	Capital	Operating	Resource	Total
3	930.6	122.2	162.1	1214.9
6	813.4	56.9	49.6	919.9
10	685.4	27.4	17.1	729.9

3.3 SOCIAL BENEFITS OF PEACE SITE C

The traditional approach to evaluating the social benefits of a public project where the outputs are not priced in a market is to use the cost of the next best feasible alternative project as the measure of benefits. In Section 2.0 Part One "Need for the Project", several potential alternatives to the Peace Site C hydroelectric project are discussed. All but the Hat Creek thermalelectric project are, however, not considered to be true alternatives because of physical constraints in bringing them into service on time to meet forecast loads. Thus the Hat Creek project is the alternative which must be used to compare with Site C. In the long run, if the province chooses to leave Site C undeveloped, the power from that source would have to be provided from coal or nuclear fuel irrespective of which other hydroelectric sites are ultimately developed. In addition, therefore, to being the one project which could be brought in on time, using Hat Creek as the next best alternative gives an appropriate measure of the social benefits which could be secured by developing Site C.

The total capital cost (in dollars of the year of expenditure and including corporate overhead and interest during construction) of the Hat Creek project, for the powerplant and mine, is $4019 million for the base plant, $4282 million for the base plant plus 50 percent flue gas desulphurization (FGD) and $4449 million for the base plant plus 100 percent FGD. Table 3-5 shows the present discounted values of capital, operating and resource costs for the three alternative configurations of the Hat Creek project. Discounting is carried over 70 years; thermalelectric plants have an estimated economic life of 35 years and thus the Hat Creek plant would have to be replaced once during the assumed economic life of a hydroelectric project (70 years). The social opportunity cost of coal is calculated at direct mining cost. There is a potential for synthetic fuels from Hat Creek coal which could yield a higher return to the resource. This is an uncertain prospect, however, and in any case the calculation of fuel costs at the direct cost of mining serves the purposes of this analysis in that it could only understate the benefits from Peace Site C.

TABLE 3-5

PRESENT WORTH OF HAT CREEK COSTS
($ Million 1980)

Plant Design	Discount Rate	Present Value Capital Costs	Present Value Operating Costs	Present Value Resource Costs	Present Value Total Costs
Base	3	2451.9	2509.0	12.5	4973.4
	6	1735.2	1202.9	5.0	2943.1
	10	1292.6	577.3	2.1	1872.0
Base plus 50% FGD	3	2611.1	2867.5	12.5	5491.1
	6	1844.6	1372.7	5.0	3222.3
	10	1370.9	660.2	2.1	2033.2
Base plus 100% FGD	3	2711.7	3030.9	12.5	5755.1
	6	1913.7	1450.1	5.0	3368.8
	10	1420.3	697.9	2.1	2120.3

3.3 SOCIAL BENEFITS OF PEACE SITE C - (Cont'd)

The social cost of the Hat Creek project provides a basis for estimating the social benefits of Peace Site C. Since the projects have different firm energy and capacity characteristics the costs of Hat Creek have to be adjusted to reflect the benefits of the output of Peace Site C. With an average capacity factor of 65 percent the 2000 MW Hat Creek plant would have an average annual firm energy output of 11 400 GW.h. Peace Site C would generate 4530 GW.h of firm energy annually. After taking transmission line losses into account 4290 GW.h/a would be delivered to the grid at Kelly Lake (line losses would be negligible from the Hat Creek project because of its proximity to Kelly Lake.

A further adjustment has to be made to take into account the differential capacity factors of the two plants. Relative to firm energy the Peace Site C project has more capacity available to meet peak loads. While this is not of great value at present in a predominantly hydroelectric system (see discussion of technical planning criteria in Section 2.0) it will have value in the future. This is calculated by taking the present worth of future capacity additions.

Table 3-6 shows a range of estimates for the social benefits from the Peace Site C project. Energy benefits are calculated by applying the ratio of firm annual energy outputs of the two plants to the discounted capital and operating costs of the Hat Creek project for the base plant, the base plant plus 50 percent FGD and the base plant plus 100 percent FGD. Capacity benefits are calculated using the cost of future alternative capacity additions in the year in which it is estimated to be needed - in this case, additional units at Revelstoke and Mica followed by pumped storage units. None of these additions would be needed until after the year 2000.

3.3 SOCIAL BENEFITS OF PEACE SITE C - (Cont'd)

TABLE 3-6

SOCIAL BENEFITS OF PEACE SITE C
BASED ON THE COSTS OF HAT CREEK
($ Million 1980)

	Energy Benefits				Total Benefits		
Discount Rate	Base Plant	Base + 50% FGD	Base + 100% FGD	Capacity Benefits	Base Plant	Base + 50% FGD	Base + 100% FGD
3	1871.6	2066.4	2165.7	53.1	1924.7	2119.5	2218.8
6	1107.5	1212.6	1267.7	25.6	1133.1	1238.2	1293.3
10	704.5	765.1	797.9	10.1	714.6	775.2	808.0

3.4 SUMMARY BENEFIT/COST EVALUATION

A summary evaluation of the benefits and costs of Peace Site C on the Provincial Income Account is presented in this section. Also, following the recommendations of the ELUC "Guidelines for Benefit/Cost Analysis", a brief examination of the regional and environmental effects of the Peace Site C project is presented. No attempt is made to provide a detailed comparison on the regional and environmental accounts either in this section or in the document Peace Site C Benefit/Cost Analysis. Rather a framework is presented within which the results of the detailed environmental studies, as summarized in the Environmental Impact Statement, can be evaluated in qualitative terms.

(a) Provincial Income Account

Evaluating the net change in Provincial Income as a consequence of building Peace Site C indicates whether the result is economically efficient, that is, that resources employed in this use earn at least as much as they would in any other economic use within the province. Tables 3-7 to 3-9 show the benefits and costs of Peace Site C compared directly to Hat Creek. The energy from Site C is evaluated at the cost of energy from Hat Creek. Resource costs shown in column C are the mid-points of values from Table 3-3. With benefit/cost ratios ranging from 0.98:1 to 1.83:1 the Peace Site C project is an economically efficient development. It should be noted that Tables 3-7 to 3-9 include the cost of land acquisition in the capital costs of the project and the social opportunity cost of agricultural land in resource costs. Table 3-10, which removes the social opportunity cost estimates of both agricultural and forest land following compensation (for reasons outlined in Section 18), shows a more appropriate measure of the net benefits of Site C.

TABLE 3-7

BENEFITS AND COSTS OF PEACE RIVER SITE C
COMPARED TO HAT CREEK
BASE PLANT
($ Million 1980)

	A	B	C	D	E
Discount Rate	Present Worth Benefits (Cost of Hat Creek Energy)	Present Worth Capital and Operating Costs Peace Site C	Present Worth Resource Costs Peace Site C	Present Worth Net Benefits Peace Site C A-(B+C)	B/C Ratio $\frac{A}{B+C}$
3	1924.7	1052.8	162.1	709.8	1.58
6	1133.1	870.3	49.6	213.2	1.23
10	714.6	712.8	17.1	-15.3	0.98

TABLE 3-8

BENEFITS AND COSTS OF PEACE RIVER SITE C
COMPARED TO HAT CREEK
BASE PLANT PLUS
50% FGD
($ Million 1980)

	A	B	C	D	E
Discount Rate	Present Worth Benefits (Cost of Hat Creek Energy)	Present Worth Capital and Operating Costs Peace Site C	Present Worth Resource Costs Peace Site C	Present Worth Net Benefits Peace Site C A-(B+C)	B/C Ratio $\frac{A}{B+C}$
3	2119.5	1052.8	162.1	904.6	1.75
6	1238.2	870.3	49.6	318.3	1.35
10	775.2	712.8	17.1	45.3	1.06

TABLE 3-9

BENEFITS AND COSTS OF PEACE RIVER SITE C
COMPARED TO HAT CREEK
BASE PLANT PLUS
100% FGD
($ Million 1980)

	A	B	C	D	E
Discount Rate	Present Worth Benefits (Cost of Hat Creek Energy)	Present Worth Capital and Operating Costs Peace Site C	Present Worth Resource Costs Peace Site C	Present Worth Net Benefits Peace Site C A-(B+C)	B/C Ratio $\frac{A}{B+C}$
3	2218.8	1052.8	162.1	1003.9	1.83
6	1293.3	870.3	49.6	373.4	1.41
10	808.0	712.8	17.1	78.1	1.11

TABLE 3-10

NET BENEFITS OF PEACE SITE C
WITH COMPENSATION AND MITIGATION
($ Million 1980)

	A	B	C	D	E
Discount Rate	Present Worth Benefits (Cost of Hat Creek Energy with 50% FGD)	Present Worth Capital and Operating Costs Peace Site C (including compensation)	Present Worth Resource Costs Peace Site C (including compensation)	Present Worth Net Benefits Peace Site C A-(B+C)	B/C Ratio $\frac{A}{B+C}$
3	2119.5	1057.5	58.0	1004.0	1.90
6	1238.2	872.7	12.1	353.4	1.40
10	775.2	714.0	3.0	58.2	1.08

The evaluation on the provincial income account thus reinforces project selection based on the engineering and corporate financial evaluations. Developing Peace Site C in 1987 would be economically efficient over a range of discount rates from 3 percent to 10 percent. With the availability of export markets at a price significantly higher than the cost of energy from Peace Site C the project would also be economically efficient with a reduced load forecast.

Mitigation (reservoir clearing) and compensation measures would substantially reduce the net resource impacts of Peace Site C. Table 3-10 shows the present value of capital and operating costs with reservoir clearing and enhancement and the net resource costs (presented in detail below in Section 18.0). Agriculture and Forestry social opportunity costs are reduced to zero (the cost of private land acquisition is included in project capital costs). Benefits of Peace Site C are shown based on Hat Creek with 50 percent FGD.

In the context of the total cost of the project, reductions in resource opportunity costs have little impact, barely altering project benefit/cost ratios, but in terms of the resource costs alone compensation and mitigation measures would be significant. The regional effects of such measures would thus be much more important than provincial income account effects.

(b) The Regional Account

In the regional account, explicit consideration is given to the effects of the project upon particular subgroups within the province, rather than upon British Columbians as a whole.

The Provincial Income Account deliberately ignores such distributional considerations, due to its preoccupation with economic efficiency. A basic premise of the income account is that if all benefits from the project exceed all costs, the project is socially desirable. No weight is given to questions of which groups bear the costs, and which groups enjoy the benefits.

The net benefits of electrical generation are shared throughout the entire province. B.C. Hydro uses a postage stamp rate system (a uniform rate structure throughout the province regardless of costs except for isolated areas served by diesel units), whereby higher cost of service regions, such as the Fort St. John area, receive transfers from lower than average cost service regions. As for indirect (nonenergy) benefits of the Site C project, local residents at public meetings held in the area repeatedly asked: "What will Peace River residents gain from this project?" The primary gain will be through increased employment and income opportunities for local residents during the construction of the dam, and the spin-off effects of expenditures by construction workers. However, these effects are mostly short term and, judging from experience with the Peace Canyon and Seven Mile projects, are relatively modest on a regional scale. Although the B.C. government has exempted Peace River generation facilities from school tax levies, construction facilities would be taxed and also transmission lines and substations when they are completed. Existing Provincial school financing policies provide for annual subsidies from the Ministry of Education which would protect local taxpayers from tax increases caused by the project.

On the cost side, the project will alter the resource base of the region: in some instances the opportunity costs associated with these changes will be borne in large measure by the local residents. Also, negative effects on community services, housing and prices will most likely be felt by residents who will not be direct recipients of income and employment benefits.

(c) Income and Employment

Table 3-11 shows the change in regional income and employment resulting from the construction and operation of the Peace Site C project. Peace Site C would have a short-term impact during the construction phase but minimal long-term benefits in terms of operating work force. Regional income would increase about 7 percent during the peak year of construction in the Peace River area with the project, but would decline afterwards to about the same level as without the project.

The present discounted value of gross disposable income benefits in uninflated 1980 dollars would be about $164 million. It is difficult to estimate how much of this total would be a net gain to the region, that is, earnings in excess of opportunity cost. Under conditions of full employment the net gains would be small as local workers who take jobs on the dam would have to be replaced in their previous employment by in-migrants. Alternatively, if the newly created positions, both direct and induced, were filled either by previously unemployed workers or by new entrants to the labour force from the local population most of the total income benefits would be net gains to the region.

TABLE 3-11

REGIONAL INCOME AND EMPLOYMENT
PEACE SITE C

Construction	Income ($ Million 1980)[1]	Employment (man-years)
Direct	74.6	2300
Indirect	74.1	50
SUBTOTAL	148.7	
Operation		
Direct	7.4	0-25/year
Indirect	8.2	0-27/year
	15.6	
TOTAL	164.3	

1 Present value discounted at 6 percent.

(d) Resources

An important consideration in assessing the distributional consequences of development relates to ownership of resources. In the case of crown resources, the government owns and manages in the public interest. In the case of privately-owned resources, B.C. Hydro pays compensation to the owners if the development imposes costs on them. For Crown resources for which use or access rights are claimed equity considerations in the form of compensation may be required.

The forest resource is a Crown resource. Both the benefits and costs resulting from Site C will fall directly within the jurisdiction of the provincial government. No equity or distributional considerations would arise with either project. The forestry resource in the Site C reservoir area is insignificant vis-a-vis the regional logging and sawmilling industry and no secondary costs or regional income loss will therefore be experienced.

Agricultural land is either privately owned or Crown lease or Crown land. For the privately-owned land, the rights of ownership dictate that compensation be paid by B.C. Hydro in order that the owner not be left worse off than before. The amount of compensation monies to be paid will be determined by negotiation between developer and owner. For Crown lease land, there are similar provisions for compensation for deletions of e.g., grazing rights. Equity considerations are, in general, adequately handled through the transfer of land ownership.

Although recreation resources are usually recognized as a Crown resource, the right to use recreational resources has evolved over time to the point where many consider it an inalienable public right. By definition, recreation rights as a common property resource do not confer any special privileges to specific groups. Consequently, compensation for losses of recreational resources would be paid to all resource owners (the people of British Columbia) via Crown agencies. However, Peace River area residents have only a limited number of recreation sites that are similar in both quality and accessibility to the Peace River. While the project would not have a significant impact on recreational resources when seen from the provincial perspective, the regional impact of Peace Site C would clearly be significant.

3.4 SUMMARY BENEFIT/COST EVALUATION - (Cont'd)

The redistribution of project costs and benefits via investment in enhancement projects is one means of decreasing the recreation impacts of Site C. Compensation measures, including campgrounds, picnic grounds, spawning facilities, and fish and wildlife management plans, are evaluated in Section 18. However, to ensure that such investments adequately offset resource losses, the distributional consequences of mitigation and enhancement projects must also be assessed. Under certain circumstances some people who would benefit from compensation may not have experienced any loss of resource benefits while those people who are adversely affected by resource development will receive no benefits if a particular compensation scheme is implemented. For example, investment in recreation facilities on the reservoir might provide benefits mainly to recreationists different from those who enjoyed the river. River recreationists might not perceive enhanced reservoir recreation opportunities as compensation for the loss of the Peace River.

(e) The Environmental Account

Benefits and costs which can be quantified are often the least controversial aspects of project analysis. With the emergence of consensus on broad analytical approaches as exemplified by the ELUC "Guidelines for Benefit/Cost Analysis", disagreement over results is typically not difficult to resolve. However, there is a danger in the benefit/cost approach that values which cannot be quantified are treated as less important than those which can be quantified. Uncertainty over social and environmental change, safety, a desire to see familiar surroundings left untouched and so on cannot be covered in an analytical framework. There is simply no acceptable response to the individual who wants to preserve his lifestyle and environment intact. Table 3-12 presents a summary of the environmental impacts of Peace Site C.

3.4 SUMMARY BENEFIT/COST EVALUATION - (Cont'd)

In its choice amongst alternative energy developments B.C. Hydro can make explicit its decision criteria. Social choices encompassing a broader range of values are appropriately left to governmental decision-making. To forego Peace Site C in favour of thermalelectric development is not defensible on economic efficiency grounds. At a regional level many of the quantifiable resource impacts of Peace Site C could be compensated for by investments in enhancement facilities (see Section 18.0). Accounting for income and employment benefits there may indeed be a net regional gain on the quantifiable side of the ledger. However, within the region the gains and losses with the project will be felt by different groups. The unquantifiable visual, aesthetic and relocation impacts which cannot be mitigated or compensated for have to be viewed within the context of the provincial income gains which would be foregone if the Peace Site C Project is left undeveloped.

TABLE 3-12

ENVIRONMENTAL ACCOUNT SUMMARY OF PEACE SITE C IMPACTS

Impact	Significance	Direction	Potential for Mitigation	Potential for Compensation
Land Resource				
Agriculture	2	-	N	F
Forestry	1	-	N	N
Minerals	0		N	N
Wildlife	1	-	P	F
Water Resources				
Quality	0		N	N
Supply	1	+	N	N
Fish	1	-	P	F
Air and Climate				
Air quality	0		N	N
Climate	1	-	0	0
Aesthetic/Visual	2	-	0	0
Recreation	2	-	P	P
Community Resources				
Physical infrastructure	1	-	0	P
Relocation	2	-	0	P
Community Stability	1	-	0	P
Social infrastructure	1	-	0	F
Income	1	+	N	N
Employment	1	+	N	N
Heritage Resources	1	-	P	P

Significance	Direction	Potential for Mitigation	Potential for Compensation
(0) Insignificant	(+) Positive	(F) Full mitigation	(F) Full compensation
(1) Minor	(-) Negative	(P) Partial mitigation	(P) Partial compensation
(2) Major		(0) None	(0) None
		(N) Not applicable	(N) Not applicable

SECTION 4.0 - PROJECT DESCRIPTION

CONTENTS

FIGURES

SECTION 4.0 - PROJECT DESCRIPTION

4.1 PRESENT HYDROELECTRIC FACILITIES

As shown on Fig. 4-1 the W.A.C. Bennett Dam is located about 177 km (110 mi) upstream of the British Columbia-Alberta border. The associated Williston Lake reservoir provides substantial multi-year-regulation of the Peace River. The G.M. Shrum Generating Station located at the 183 m (600 ft) W.A.C. Bennett Dam houses 10 generating units with a maximum continuous generating capacity of 2730 megawatts (MW).

Peace Canyon hydroelectric facilities, located 22.5 km (14 mi) downstream of the W.A.C. Bennett Dam, are currently under construction. The development comprises a 50 m (165 ft) high dam and a four-unit powerplant having a maximum generating capacity of 700 MW.

4.2 PROPOSED SITE C PROJECT SITE

The proposed Site C damsite and reservoir are located where the Peace River has carved a valley a few kilometres wide and 180 to 230 m (600 to 750 ft) deep in a relatively flat to slightly rolling plain. The valley slopes are continually undergoing adjustment; landslides, confined mostly to overburden, are common. The proposed damsite is about 7 km (4.5 mi) southwest of the city of Fort St. John and 0.8 km (0.5 mi) downstream of the mouth of the Moberly River.

At the proposed axis, the river channel contains up to 10 m (33 ft) of sand and gravel and some cobbles and boulders overlying weathered shales and siltstone bedrock.

The left (north) bank rises at a slope averaging 1.75H:1V to an extensive terrace about 150 m (500 ft) above river level. Silty

4.2 PROPOSED SITE C PROJECT SITE - (Cont'd)

shale bedrock is exposed to about 57 m (185 ft) above river level. The overburden above the bedrock consists of sand, gravel, cobbles and boulders for about 20 m (65 ft) overlain by 88 m (290 ft) of sands, silts and clays, and a gravel cover.

The right (south) bank is a series of shale terraces overlain by a few metres of sand and gravel with a thin covering of silt. The valley slopes and terraces are forested and are not subject to ravelling except in an area a little downstream of the dam axis where many shallow slides have occurred.

4.3 PROJECT ARRANGEMENT

The proposed project arrangement (shown in Fig. 4-2) would have a zoned earthfill dam across the main river channel. An approach channel excavated in the river terrace on the right abutment would lead to a power intake and a gated chute spillway slightly downstream of the main dam axis. Six partially buried penstocks down the right bank of the river would supply the six-unit powerplant located at the foot of the bank immediately downstream of the toe of the earthfill dam.

(a) Earthfill Dam

The zoned earthfill embankment 1180 m (3870 ft) long and up to 60 m (200 ft) high would be founded primarily on 8 m (25 ft) deep riverbed sediments; however, an impervious central core would extend down to the shale bedrock. The embankment slopes would be somewhat flatter than usual for an earthfill dam because of the foundation characteristics of the site. The shell zones of the dam would be constructed of granular fill from excavation for the spillway power intake channel and materials from the left bank excavation. Coarse gravel would provide an outer protective facing to the full downstream slope and the upper part of the upstream slope. Riprap would protect the upper part of the upstream face from reservoir wave action.

The central dam core would be formed of impervious material obtained by selection of clayey-silt material from the left bank excavation. Processed filters and a transition zone required between the core and the shells and a downstream drain would utilize clean, select pit-run granular fill from an adjacent borrow area.

(b) Power Intakes and Penstocks

The intake forebay channel, which would also carry flow to the spillway, would be excavated in the river terrace on the right side of the valley.

The concrete intake structure would be parallel to the right river bank and would extend from the earthfill dam axis to the spillway headworks. The gravity structure would be 435 m (1430 ft) long and 38.4 m (125 ft) high incorporating six power intakes each controlled by vertical lift gates.

The penstocks connecting the intake to the turbines in the powerhouse located parallel to the river channel at the foot of the bank would be laid in trenches cut into the shale bedrock surface and backfilled.

(c) Spillway

The spillway would be located adjacent to the power intake structure on the right riverbank and would be supplied from the common forebay channel. The spillway would have a maximum discharge capacity of 16 600 m^3/s (586,000 cfs).* It could pass the Project Flood of 11 900 m^3/s (420,000 cfs) which has an estimated 1000-year return period, without the reservoir level exceeding El. 463.3 m (1520 ft).

* Corresponding to the Probable Maximum Flood (see Section 4.4).

The spillway structures would comprise a seven-bay gated overflow structure with a chute terminating into a stilling basin. The headworks structure would contain seven vertical lift gates.

The spillway of the proposed Site C project will require a deep stilling basin designed to effectively dissipate the energy of the spillway discharge and prevent extensive scouring of the downstream river channel during large spillway discharges. Special design of the spillway would be necessary to reduce possible high gas supersaturation levels during the infrequent spillway discharges.

(d) Powerplant and Switchyard

The six-unit powerplant would be located immediately downstream of the toe of the earthfill dam parallel to the river and intake forebay channels. The service bay would be situated at the west end of the powerhouse adjacent to the toe of the earthfill dam. Powerhouse access would be from a left (north) bank project access road via the downstream toe berm of the main earthfill embankment.

Under a net head of 48.4 m (159 ft) with the reservoir at normal operating level El. 461.8 (1515 ft), the six-unit full plant capacity would be about 900 MW.

The control building would be located adjacent to the southwest side of the service bay. Although it is expected that the plant would normally be controlled from the G.M. Shrum Generating Station and from the Burnaby Mountain System Control Centre near Vancouver, it could also be controlled from the project control building.

4.3 PROJECT ARRANGEMENT - (Cont'd)

Power from the plant would be fed to a switchgear building on the right bank of the river. The initial stage of the plant would require one 500 kV transmission line from Site C to Peace Canyon. By the time all six units are completed, a second 500 kV line from Site C to Peace Canyon along the same right-of-way as the first line will be required. In addition, provision would be made in the switchgear building for the addition of a future 500 kV line and four 138 kV lines. The future 500 kV lines could be used as interconnection with Alberta while the 138 kV lines will be used to supply future load growth in the Fort St. John and Dawson Creek areas.

(e) Diversion Tunnels and Auxiliary Outlet Facilities

Diversion of the river during construction of the earthfill embankment across the river channel would be by means of three concrete-lined tunnels through the left abutment.

Low-level outlet facilities would be incorporated into the plug of one diversion tunnel during the low flow season prior to final closure and filling of the reservoir. The other diversion tunnels would then be closed off with concrete plugs upon completion of the earthfill embankment and the spillway structures. During filling of the reservoir, releases would be made from the project to maintain the minimum flow requirements downstream of the dam.

(f) Abutment Slopes and Project Access Road

Extensive excavation would be required at the damsite to flatten the slope of the overburden material above the shale bedrock on the left (north) bank of the river. Although the left bank is relatively stable in its present state, flattening would be necessary to ensure a conservative factor of safety for the stability of the newly excavated slopes required for diversion tunnel portals and temporary and permanent access roads.

4.4 HYDROLOGY

Detailed analyses have been made of meteorological factors affecting the flood flows in the Site C drainage area to compute the Probable Maximum Flood. Based on these analyses and taking into consideration the regulating effect of upstream reservoirs as well as the Site C reservoir, the peak spillway discharge from the Probable Maximum Flood would be 16 600 m^3/s (586,000 cfs). This discharge has an expected return period of more than 1 million years.

Frequency analysis of regulated peak discharges at Site C yielded a Project Flood of 11 900 m^3/s (420,000 cfs) with an estimated 1000-year return period. This smaller flood discharge was selected for design purposes where dam safety would not be involved.

The flows available for power at Site C would be made up of regulated releases from the W.A.C. Bennett Dam and local tributary inflow. Operation of the 42 billion m^3 (34 million ac/ft) of live storage in Williston Lake provides significant regulation of the natural river flows. Based on records for 1945 to 1975, the average flow at Site C would be 1210 m^3/s (42,725 cfs). Because of Williston Lake regulation, almost all of this flow could be used to generate power.

4.5 RESERVOIR

The proposed reservoir normal operating level at Site C would be El. 461.8 m (1515 ft). The reservoir would have a surface area of about 9440 ha (23,600 ac) of which approximately 4840 ha (12,100 ac) would be water area within the existing river channel. The reservoir volume would be about 2.31 billion m^3 (1.87 million ac/ft). To achieve maximum energy output at Site C very small reservoir level changes from the normal operating level would be required at this run-of-river plant. Drawdown to accommodate optimum daily and weekly regulation would not generally exceed 0.6 to 1 m (2 or 3 ft).

4.5 RESERVOIR - (Cont'd)

When passing small floods, the reservoir might temporarily rise 0.3 to 0.6 m (1 or 2 ft) due to operational requirements. To pass the Project Flood, which has an estimated 1000-year return period, the reservoir level would not exceed El. 463.3 m (1520 ft).

Out of the total 9440 ha (23,600 ac) of reservoir area 3560 ha (8900 ac) of tree-covered land would be inundated. B.C. Hydro would propose that this area be completely cleared, merchantable timber logged and removed, and residual growth burned. Remaining debris would be cleaned from the reservoir during the initial years of operation.

Existing bank conditions along the Peace River show evidence of sloughing and sliding. The Site C reservoir would impound water at a higher level than has occurred under natural flood flows, increasing groundwater levels and precipitating or reactivating some slides and causing an initial increase in sloughing. Also, there would be some beaching and local sloughing of silty slopes resulting from wave action. However, investigations have shown that flooding of the reservoir would not result in a large scale increase in landslide activity. The erosive effect of flowing water along the banks would be removed and in some areas this could decrease bank undercutting and erosion.

It is estimated that the main Site C reservoir would not fill with sediments for 700 years or more. However, deltas would build up at the heads of the tributary reservoir arms which would progressively be filled in with suspended sediment. This would not interfere with operation of the project.

4.6 CONSTRUCTION SCHEDULE

The proposed construction schedule would be about 6 years duration from issue of the first tender documents to the in-service date of Units 1 and 2.

4.6 CONSTRUCTION SCHEDULE - (Cont'd)

The first major construction activities would be project access work and excavation on the left bank for the diversion facilities. Then, cofferdams on both banks would be constructed, restricting the Peace River to the main river channel.

The diversion tunnels would be constructed behind the left bank cofferdam. Behind the right bank cofferdam, and on the slope above, excavation for the powerplant and spillway facilities would be completed. In addition, earthfill embankments would be started behind the cofferdams using materials from the excavations.

Closure of the dam would be accomplished by placing a cofferdam across the remaining river channel connecting portions of the main earthfill embankment already constructed within the initial right and left bank cofferdams. This would divert flows through the diversion tunnels and result in temporary raising of water levels during spring freshets up to approximately El. 426 m. Following closure, construction of the major powerplant and spillway facilities on the right bank would continue for about 31 months. Towards the end of this period, one diversion tunnel would be closed to permit construction of low-level outlet facilities, with river flows restricted to the other two tunnels. The earthfill dam, powerplant and spillway facilities would then be completed.

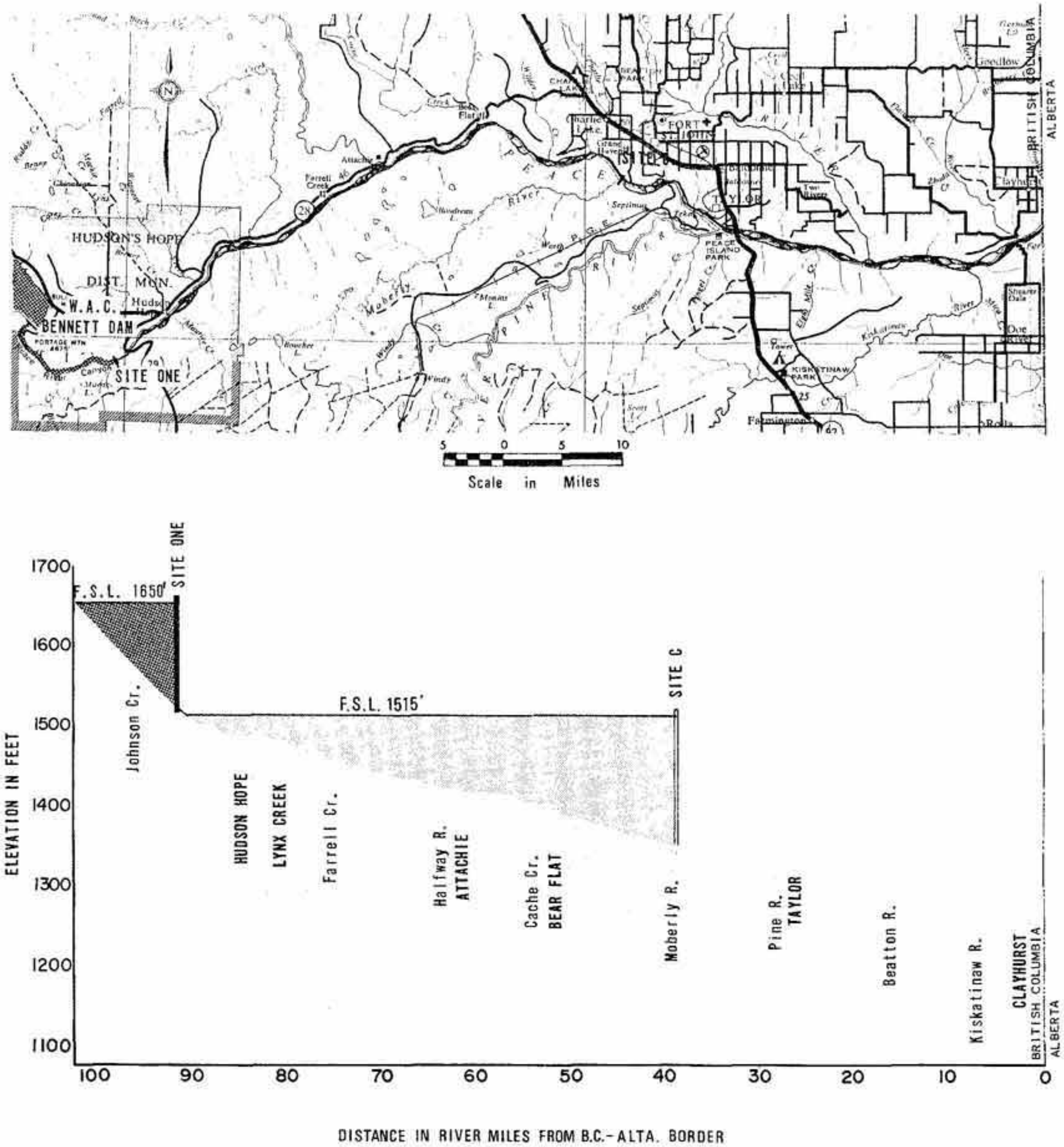
Finally, the other two diversion tunnels would be closed and the reservoir filled. The low-level outlet facilities would be operated during the filling period.

Units 1 and 2 would be commissioned in October of Year 6, followed by the remaining four units at 6-month intervals.

4.6 CONSTRUCTION SCHEDULE - (Cont'd)

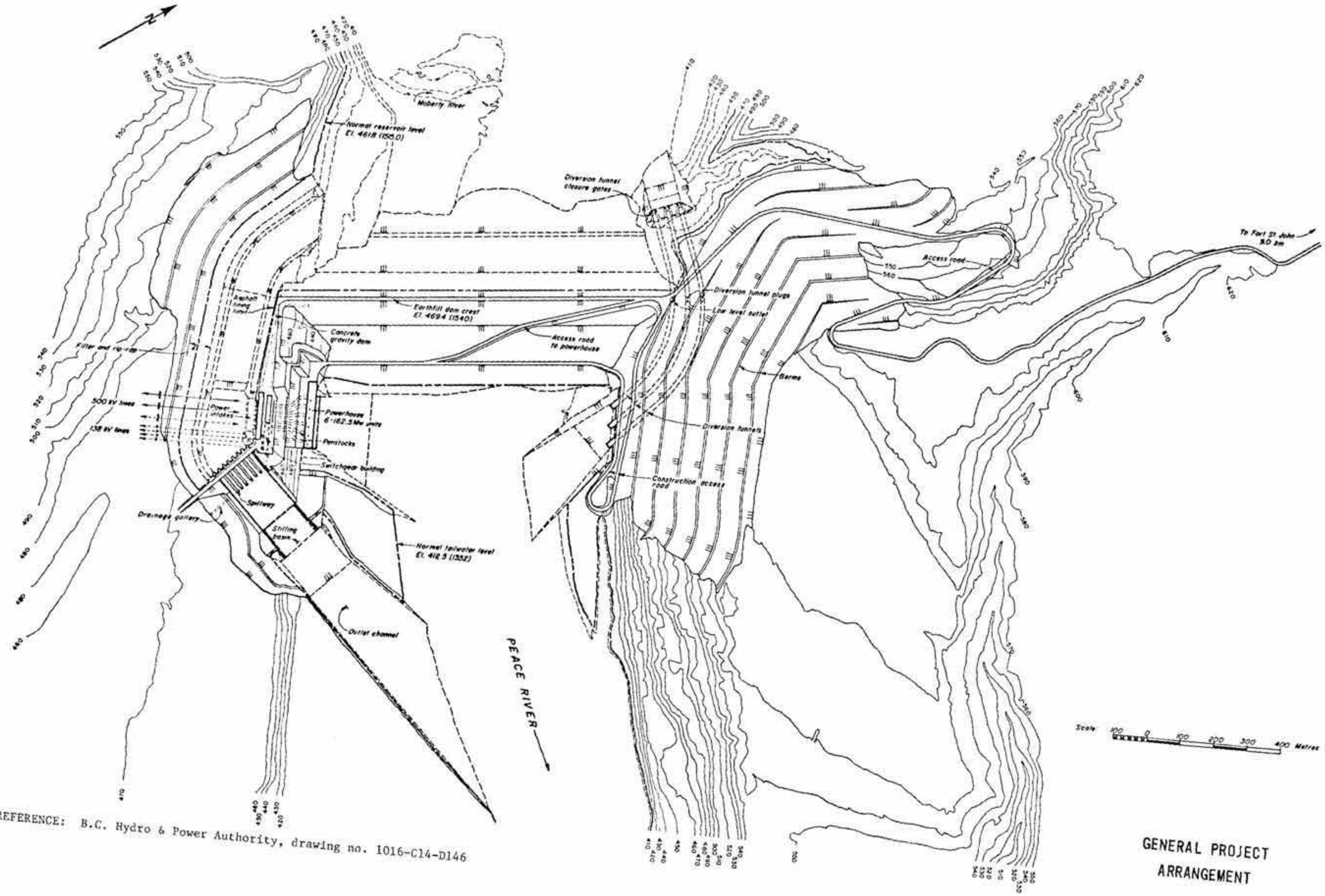
Construction scheduling is based on using large volumes of excavated materials from both abutments in the earthfill dam. Additional sources of aggregate, embankment borrow, filter and drain material are also available from river benches on both banks to supplement materials obtained from the required excavations.

Construction facilities would be located on the plateau above the left abutment and access to the area would be by existing municipal roads. Potential construction facility areas for the selected project arrangement are shown on Map 4 Sheet 1 at the end of Part Two of this Report.



PEACE RIVER
GENERAL LOCATION OF SITE C DEVELOPMENT

FIGURE 4-1



REFERENCE: B.C. Hydro & Power Authority, drawing no. 1016-C14-D146

GENERAL PROJECT ARRANGEMENT

FIGURE 4-2