BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

FINAL DRAFT

HAT CREEK PROJECT
SITE EVALUATION STUDY

October 1976

Integ-Ebasco

1. SUMMARY

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1.1 SUMMARY

British Columbia Hydro and Power Authority commissioned Integ-Ebasco to conduct a site evaluation study for the Hat Creek Project. The purpose of the study was to identify a preferred site and viable alternative sites for the development of a 2,000 MW thermal generating station designed to burn Hat Creek coal. The study was conducted in two phases during the period May - September, 1976.

Phase I applied broad environmental and engineering criteria to screen candidate sites (see Fig. 1-2). The study identified the following eight sites: (see Fig. 1-1)

Dunsmuir	Mine Mouth
Britannia Beach	Harry Lake
Stave Lake	Big Bar Creek
Ashcroft	Soda Creek

Phase II carried out a detailed analysis to evaluate these eight sites. The method used was to group all the criteria having a potential environmental impact into three separate accounts:

environmental suitability
engineering - economics
engineering confidence

Environmental suitability measured the potential impact of plant construction and operation on site air quality, water resources, aquatic ecology, terrestrial ecology, land use - aesthetics and socio-economic character.

Engineering-economics measured the differential comparative costs associated with development of the alternative sites.

The engineering confidence account qualitatively assessed site characteristics which would either limit or support development.

The results of the analysis are summarized below:

Site	Environmental Impact Index* (Percent)	Total Differential Comparative Costs (Millions of Dollars) 5% Int.	10% Int.
Dunsmuir	65.8	744	217
Britannia Beach	100.0	620	242
Stave Lake	88.9	615	226
Ashcroft	37.8	74	28
Mine Mouth	47.6	0 (base)	0
Harry Lake	26.2	35	20
Big Bar Creek	27.9	352	142
Soda Creek	29.9	689	313

*Low values indicate environmental site compatibility.

These results strongly support the selection of Harry Lake as the preferred site as it exhibits a low environmental index together with a relatively low project cost.

Big Bar Creek and Soda Creek are viable alternatives having low environmental indices but are burdened with higher development costs.

In addition, neither Harry Lake, Big Bar Creek, nor Soda Creek exhibit any outstanding characteristics which limit development. Harry Lake also minimizes transportation and delivery linkages necessary for project construction and operation.

Of the remaining sites, Britannia Beach, Stave Lake, Ashcroft and Mine Mouth were considered environmentally incompatible with project development because of the impact on air quality which would result from station operation.

Dunsmuir site, although feasible for this project, incurs substantial environmental, engineering and economic penalties. For these reasons, it is not considered an appropriate location for a generating station burning Hat Creek coal.

1.2 INTRODUCTION

British Columbia Hydro and Power Authority contemplates the development of the Hat Creek Project to meet the growing electrical power and energy requirements of the Province.

The project comprises an open pit coal mine and a 2,000 MW thermal generating station. Although the plant would burn Hat Creek coal, its location depends upon various engineering, economic and environmental factors. Site evaluation must resolve these factors to yield the optimum plant location.

1.2.1 Project History

B.C. Hydro commissioned B.C. Research and Dolmage Campbell and Associates to prepare a Preliminary Environmental Impact Study of the proposed Hat Creek Project. The study, completed in August 1975, discussed the environmental concerns of the open pit mine and thermal generating station sites. However, no preferred site recommendations were made. Subsequently, B.C. Hydro commissioned Integ-Ebasco to conduct concurrent conceptual design and site evaluation studies for the project.

1.2.2 Purpose

The purpose of the site evaluation study was to identify a preferred site and viable, alternate locations for the construction and operation of the generating station. This report presents the results of the site evaluation study. Principal considerations and judgements applied in the investigation are discussed.

1.2.3 Scope

The site evaluation study includes a regional identification and evaluation of alternative sites and site-specific engineering, economic and environmental analyses. Specific tasks associated with the overall study include:

a) A regional analysis and evaluation of the alternative sites identified by B. C. Hydro.

b) A regional reconnaissance to identify other potential sites.

c) The development of specific discriminant engineering, engineering-economic and environmental criteria which could be used to characterize the alternative sites.

d) The characterization of specific sites in consideration of the criteria established.

e) The identification of a preferred site and viable alternative sites through a logical and consistent application of the discriminant criteria.

The site evaluation activities described herein were conducted during the period May through September, 1976.

1.3 MATERIALS AND METHODS

The Hat Creek Site Evaluation Study is executed in two distinct phases. Qualitative engineering and environmental criteria are utilized in Phase I to identify those sites which merit detailed evaluation and analysis. Phase II is a site-specific analysis wherein quantitative and qualitative engineering, engineering-economic and environmental criteria are synthesized to establish the preferential ranking of the alternative sites identified in Phase I.

1.3.1 Study Assumptions (Plant Character)

Engineering and operational characteristics of a thermal generating station greatly influence its location. Specific plant systems can affect site suitability. Systems which rely upon the surrounding environment to meet operational needs, or which affect the environment during operation determine the acceptibility of a site. Recognition of these facts, and that the Hat Creek Project conceptual design was concurrent with site evaluation, necessitated several station design and operation assumptions. Those specific assumptions which affect the analysis of a technical discipline, are presented in the Appendices to this report. Major assumptions, however, which affect the tone of this study are presented as follows:

a) The installation is planned as a 2,000 MW thermal generating station burning Hat Creek coal;

b) The coal will be blended but probably will not be beneficiated by a washing process;

c) Condenser cooling water systems at coastal sites will utilize sea water in either once-through, or recirculating modes;

d) Condenser cooling water systems at interior sites will use water from either the Fraser River or the Thompson River in a recirculating mode;

e) Station water management systems would be designed as zero-discharge systems wherever possible.

1.3.2 Preliminary Site Evaluation Procedure - Phase I

Preliminary site evaluation proceeded in three stages. During the first stage, B. C. Hydro identified seven sites. These sites were drawn from the Preliminary Environmental Impact Study prepared by B. C. Research and Dolmage Campbell and Associates. Two additional sites were identified during project planning discussions with B. C. Hydro.

In the second stage, regional screening identified other potential sites. Regional screening was applied over an area described by a circle centered in Hat Creek Valley with a radius equal to the distance between the Valley and Vancouver, B. C. The rationale for selection of this area was that the transport distance of coal should not exceed the distance between the mine and the load center.

Site characteristics sought within the area circumscribed included locations which possess neither grade nor space limitations, have an adequate water supply for plant operation, and have access to rail, road and transmission line facilities.

During the third stage, the sites were studied to determine whether important engineering or environmental conflicts would be associated with their development. Sites with conflicts sufficient to preclude thermal generating station development were dropped from consideration. Viable alternative sites from the Preliminary Site Evaluation Procedure, were subjected to detailed site evaluation analyses in Phase II.

1.3.3 Detailed Site Evaluation Procedure - Phase II

The Phase II site evaluation procedure was a comparative analysis of site discriminant criteria. Qualitative and quantitative information arrayed in three accounts established the site preference order. The accounts utilized in the Phase II analysis include the:

a) Environmental Suitability Account

b) Engineering-Economic Account

c) Engineering Confidence Account

Each account produced an independent preference order among the alternative sites. Comparison and combination of the quantitative and/or qualitative measures used to order sites in each account produced the final site preference hierarchy. Where the results of the separate accounts were concordant, the site rank was readily apparent. However, when conflicts existed between the account orders, informed professional judgement established trade-offs necessary to develop the ultimate site preference ordering.

1.3.3.1 Environmental Suitability Account

This account assessed the environmental suitability of each site. Environmental suitability described site environmental characteristics or criteria enhanced or degraded by the construction and operation of the generating station.

The measure of environmental suitability was a dimensionless number derived from quantitative criteria. This environmental suitability index was used to describe and compare quantitatively the potential generating station impacts on Air Quality, Water Resources, Aquatic Ecology, Terrestrial Ecology, Land Use - Aesthetics and Socio-economics.

The criteria selected for this evaluation are those factors which best measure, in a quantitative manner, impacts of station construction and operation on the environment. Important environmental factors, which cannot be readily quantified, are used as qualitative modifiers to weight each criterion, by judgement, in terms of relative importance at each site.

1.3.3.1.1 Development of Criteria

The criteria selected in each environmental discipline are as follows:

a) Meteorology/Air Quality

In this discipline, the criteria used are standard diffusion, plume trapping and fumigation. The measure of the standard diffusion criterion is the percentage of time predicted hourly average ground level SO_2 concentrations, calculated using a standard diffusion model, exceed the Level A guidelines of the Pollution Control Board of British Columbia (PCB) for this contaminant. Plume trapping is measured by the percentage of time meteorological conditions at a given site are conducive to trapping a plume within terrain features, causing high contaminant concentrations at ground level. Fumigation is measured by the percentage of time meteorological conditions at a given site could result in the formation of vertical air currents, which in turn could interact with a contaminant plume, bringing it down to the ground with little dilution and causing high contaminant concentrations at ground level. The qualitative modifiers used to weigh the criteria include background ambient air quality, the location of nearby population centres, and the relative applicability of available predictive techniques and input data to the site in question.

b) Water Resources

Six criteria are used to measure water resources impacts. These are grouped into two broad categories: impacts of the station on water resources and impacts of water resources on the station. The first group includes dredging effects, effects of chemical discharge and thermal discharge effects. The second group includes three intake water quality characteristics: total dissolved solids, suspended solids and chlorine demand.

The dredging criterion is measured by the sum of the cooling water drawn from and discharged to a natural water body in cfs. This total is used to represent the base area of the intake and discharge structures, and therefore the area of the water body bottom which would be disturbed during construction. The chemical discharge criterion is measured by the number of pounds per day of dissolved solids which would be discharged to a natural water body, causing an increase in its dissolved solids level. The thermal discharge criterion is measured by the heat content, in British Thermal Units (Btu) per hour, of the water which would be discharged to a natural water body. It reflects the potential for temperature increases in the receiving water. The total dissolved solids (TDS) criterion is quantified by the TDS level in station intake water in milligrams per liter (mg/l) and is a measure of potential scaling/corrosion problems in the condenser cooling water system. The suspended solids (SS) criterion is measured by the SS concentration in the station intake water in mg/l and is an indication of potential system blockage and abrasion problems. Chlorine demand, measured in mg/l, is an indicator of biofouling potential and biocide requirements. In all cases the criteria which reflect the effects of the station on the environment, are weighed more heavily than the criteria which measure the effects of the environment on the station.

c) Terrestrial Ecology

Four criteria are used to measure impacts on terrestrial ecology at each site, namely: habitat diversity, breeding birds and mammals, land capability for waterfowl and land capability for ungulates.

Habitat diversity is measured by a probability function (the Shannon Index) applied to the relative abundance of seven different land use categories within one mile of the station area at each site. All other things being equal the more diverse the habitat, the more valuable it is and the greater would be the impact of a generating station. The qualitative modifiers used to weigh this criterion among the sites include presence or absence of built-up areas, high and low number of breeding birds and mammals and the diversity of plant species.

The breeding birds and mammals criterion is a measure of the presence of breeding birds and mammals at each site and is quantified by assigning a value of 1.0 to each species, distributing the value equally among all of the sites where the species are known to occur (based on published data and field reconnaissance) and summing the values at each site. The greater the resultant index measure at a site, the greater would be the potential impact of a generating station located at the site. The only qualitative modifier used was the presence or absence of selected species.

The land capability for waterfowl criterion is a measure of the potential for each site to support a waterfowl population. The measure of the criterion is obtained by calculating the percentage of land area, within 2 miles of each site, which falls within each of the seven waterfowl capability categories established by the Canada Land Inventory (CLI). The higher the capability for waterfowl the greater would be the station impact on this resource. The qualitative modifiers used to weight this criterion include: the best class present (1 to 7), the location of migratory routes and proximity to large waterfowl habitat.

Land capability for ungulates criterion is a measure of the capability of each site to support a wild ungulate population. This criterion is qualified in the same manner as the waterfowl capability criterion. Again, the higher the index value for the criterion at a given site, the greater would be the impact of a generating station located at the site. This criterion was modified qualitatively in consideration of the best capability class present (1-7) and the presence of unique species.

d) Aquatic Ecology

Two quantitative criteria are used to evaluate impacts on aquatic ecology. These are intake effects and discharge effects.

Intake effects include the potential for entrainment, impingement and entrapment of aquatic biota and the criterion is measured by the quantity of water drawn from a natural water body for generating station use. Discharge effects are associated with the impacts of thermal, chemical and biocide releases from the station on aquatic biota in the receiving water body and are measured by the quantity of water released to a natural water body. The modifying factors applied to the intake and discharge effects criteria are the potential for obstruction to migratory routes of important fauna, loss of important habitat and average annual escapement of anadromous salmonids.

e) Land Use

The criteria used to evaluate land use effects include viewshed, productive forest, agricultural capability, recreational capability and Native Indians.

The viewshed criterion is measured by the area, in square miles, from which a generating station could be seen. All other things being equal, the adverse impact of the station is directly proportional to the size of the viewshed. Qualitative factors used as modifiers to these criterion from site to site are: the quality of the natural scenery at each site, the aesthetic character of the existing or contemplated development in the area, and the number of people who would view the area.

The productive forest criterion was selected because of the importance of this resource to the Province. It is measured by the areas of mature and immature forest within one mile of each site, based on CLI data. The larger this area the greater the potential impact of the station. The only modifier used in connection with this criterion is the presence of past or ongoing logging activities.

The agricultural capability criterion is an index of the relative range of crops an area can produce. The quantitative measure of this criterion is the total area within 1 mile of the station, which falls within the top four of seven CLI agricultural capability classes. Qualitative modifiers of the criterion include the existence of current agricultural uses within one mile of each site, the types of crops grown and the relative value thereof.

The recreational capability criterion is an index of the station impacts on the recreational use of adjacent lands because of noise, traffic and aesthetic intrusion. This criterion is measured by the area within one mile of the station which is classified by the CLI in the top four of seven recreational capability classes. The qualitative factors considered in connection with this criterion include the presence of organized recreational facilities within ten miles of each site and the area and user numbers associated with these sites.

The Native Indian criterion reflects the potential impact of the station on indigenous Native Indian populations, for each site. It is measured by the sum of the reciprocals of the distances from the site of all Native Indian Reserves within 10 miles. The associated modifying factors are the population within each reserve considered and the necessity for access to the site through, or immediately adjacent to these reserves.

f) Socioeconomics

Four criteria are used to assess socioeconomic factors. These include human population, housing, labor force and municipal affairs.

The human population criterion evaluates potential impact of the station on the local populace. It is measured by the population density of pertinent Electoral Areas. The modifiers include absolute population within the areas, population growth rate and age and sex characteristics.

The housing criterion assesses the impact of station construction and operation on the local housing market. Its quantitative measure is the number of dwelling units in the Regional District. Modifiers include percent of mobile homes, percent of crowded dwellings and percent of owned dwellings.

The labor force criterion evaluates local employment and income benefits associated with the project. Its measure is the number of construction workers in the relevant Canada Manpower Center (CMC). The modifiers include the total labor force in the CMC, the unemployment rate, and the percentage of the population constituting the labor force.

The municipal affairs criterion reflects the potential impact of the project on local municipal systems. Its measure is the total debenture debt of the Regional District divided by the Region's total taxable assessment for general purposes. The modifiers include debenture debt per capita, taxable assessments for schools and general purposes per capita, the local student/teacher ratio and the number of hospital beds in the region.

1.3.5.1.2 Application of Criteria/Site Characterization

(For examples of steps refer to the sample computation)

STEP A. Numerical values of each criterion were first computed at each site. For example the volume of makeup water, or the predicted percent of time that SO_2 ground-level concentrations would exceed regulatory guidelines, were measures used to characterize each site. The quantitative criteria were then modified by qualitative site data to assess relative importance. In the case of station water volume, an aquatic ecological criterion, a modifier used was the location of salmon spawning areas in relation to the site. Similarly, in the standard diffusion case (SO_2), the location of population centers modified the importance of the air quality phenomenon. Measures of each quantitative criterion, calculated for each discipline, at each site, utilized environmental and conceptual design data. Because the units and scales varied, each quantitative measure was reduced to a dimensionless scalar value between 1 and 0. The procedure used was to divide each criterion by its largest numerical value. The results were expressed as decimal fractions.

STEPS B & C. Application of qualitative criteria required that professional judgement and experience guide interpretation of importance.

STEP D. Thus, each team of technical specialists ranked its discipline's quantitative criteria in the order of importance at each site.

STEP E. A forced decision technique was used whenever more than three criteria were ranked by a team. Forced decision, or pair-wise comparison, permitted the results of repetitive decisions to be tallied. A "1" was recorded each time a criterion was judged more important than another criterion. When indifference was noted, a "1" was recorded for both criteria. The criterion with the highest total score was considered most important at that site, within that discipline. The next step in the procedure was the ranking within each discipline of the relative importance of each quantitative criterion from site to site.

STEP F. When appropriate, and applicable, a forced decision technique is again used.

The next step is a multidisciplinary consensus-ranking of all quantitative criteria at each site.

STEP G. The ranking is performed for one site at a time in a series of open meetings in which all disciplinary teams present their own criteria rankings and the rationale for the rankings. Other experienced professionals attend the meetings to assure that the criteria are realistically modelled and encompass all important environmental concerns. The procedure followed is for each discipline to present its most important criterion relating to one specific site for consideration. The group then selects one of these as the single most important criterion. The discipline group whose criterion is selected then introduces its second most important criterion which is compared with the highest remaining criterion of the other disciplines and the procedure is repeated until all criteria are ranked in order of importance. When differences of opinion develop on the relative ranking of criteria a poll of all present resolves the issue. The group then repeats the above procedure on the criteria of another site until all sites have been covered. This consensus ranking is then used in conjunction with the ranking by importance of each criterion from site to site to develop an overall criteria ranking.

STEP H. In the array, the criteria for each site are listed in vertical columns in the order agreed upon in the consensus ranking procedure. The relative vertical position of criteria from site to site (column to column) in the array is established by the importance ranking of each criterion from site to site.

STEPS I & J. The final steps are the mathematical interpretation of the overall criteria ranking to produce a single nondimensional numerical measure, which is used to compare sites.

Once the scalar values and the relative importance of criteria at each site and among all of the sites are established and arrayed as described above, each row in the array is assigned a weight increasing from least important to most important. The scalar value of each criterion is multiplied times the weight assigned to each row in which it appears to give the site index for each criterion. These are summed for each site to give the overall site index.

Those sites having the lowest site indices are environmentally most compatible with the proposed project. Subsequent analyses are performed to check the sensitivity of the procedure by changing the weights.

A simplified example of the site ranking procedure for environmental suitability follow:

SAMPLE COMPUTATION: AIR QUALITY

STEP A - Define Quantitative Criteria

AQ1. Standard Diffusion: The frequency with which SO_2 ground-level concentrations are in excess of Guidelines, based on a standard diffusion predictive model.

AQ2. Fumigation: The frequency with which meteorological conditions conducive to fumigation incidents occur.

AQ3. Trapping: The frequency with which meteorological conditions conducive to plume trapping incidents occur.

STEP B - Compute Values for Each Site

Sites

	A	B	C	D	E	
Criteria AQ1	0.36	14.56	9.09	9.16	4.51	% time
Criteria AQ2	6.62	4.65	4.80	4.00	1.34	% time
Criteria AQ3	4.70	33.60	28.43	17.51	1.62	% time

STEP C - Scale Computed Values from 0 to 1

	A	B	C	D	E
Criteria AQ1	0.02	1	0.62	0.63	0.31
Criteria AQ2	1	0.70	0.73	0.62	0.20
Criteria AQ3	0.14	1	0.85	0.52	0.05

STEP D - Describe Qualitative Aspects of Criteria

	Criteria Modified
Location of Population Centres	AQ1, AQ2, AQ3
Status of Ambient Air Quality	AQ1
Potential for Plume Recirculation	AQ3
Accuracy of Data and Plume Model	AQ1

STEP E - At Each Site Arrange the Criteria in Order of Importance Using Qualitative Aspects

This step is executed independently of the previous step. Both are necessary to evaluate consistency of the preference structure.

Sites

Sites:	A	B	C	D	E	
	AQ1	AQ1	AQ1	AQ3	AQ1	↑
	AQ2	AQ3	AQ3	AQ1	AQ3	IMPORTANCE
	AQ3	AQ2	AQ2	AQ2	AQ2	

STEP F - Rank Sites for Each Criterion, Using Qualitative Aspects Above (i.e., indicate relative importance of criterion among the sites)

Criteria

Criteria:	AQ1	AQ2	AQ3	
Indistinguishable (	B	A	D	
(	C	D	B	↑
	A	B	C	IMPORTANCE
	D	C	E	
	E	E	A	

STEP G - Using the Results from Step E for Each Discipline, Indicate the Relative Importance of all Discipline Criteria at a Site

(In practice, this step is executed in a meeting with all disciplinary teams. The ranking of criteria is decided upon by a poll of all present.)

Sites

A	B	C	D	E
Water Quality	Water Quality	Land Use	AQ3	Socio-Economics
Ecology	AQ1	AQ1	Socio-Economics	AQ1
AQ1	AQ3	Socio-Economics	AQ1	Land Use
AQ2	Ecology	Ecology	AQ2	Ecology
Land Use	AQ2	AQ3	Ecology	AQ3
AQ3	Land Use	AQ2	Land Use	AQ2
Socio-Economics	Socio-Economics	Water Quality	Water Quality	Water Quality

STEP H - Combine Results of Step F, for All Disciplines, and Step G by Filling Out the Array of Important Criteria From Bottom to Top

Sites

A	B	C	D	E	Initial Weights
Water Quality			AQ3		(9)
	Water Quality	Land Use	Socio-Economics		(8)
Ecology	AQ1	AQ1		Socio-Economics	(7)
AQ1		Socio-Economics	AQ1	AQ1	(6)
AQ2	AQ3	Ecology		Land Use	(5)
	Ecology	AQ3	AQ2	Ecology	(4)
Land Use	AQ2	AQ2	Ecology	AQ3	(3)
AQ3	Land Use	Water Quality	Land Use	AQ2	(2)
Socio-Economics	Socio-Economics		Water Quality	Water Quality	(1)

Note that all the conditions for air quality criteria AQ1, AQ2, and AQ3, (illustrated in Steps E and F), are satisfied. For example, the ordering of each criterion at each site is satisfied as is the relative ordering of each criterion among all of the sites. Likewise, the conditions under Step G are satisfied.

STEP I - Weights are Assigned and Site Ratings Computed

The ordering of criteria by importance in Step H provides an initial set of multiplicative weights (written in parentheses to the right of the table). The Site Index is computed as follows:

Site Index = Water Quality weights x Water Quality Scalar Values

+ Ecology	weights x Ecology Scalar Values
+ Land Use	weights x Land Use Scalar Values
+ Socio-Economic	weights x Socio-Economic Scalar Values
+ Air Quality	weights x Air Quality Scalar Values

Using the scalar values presented in Step C -

Site	Air Quality Index		
A	5.40	=	2(0.14) + 5(1) + 6(0.02)
B	14.10	=	3(0.70) + 5(1) + 7(1)
C	9.93	=	3(0.73) + 4(0.85) + 7(0.62)
D	10.86	=	4(0.60) + 6(0.63) + 9(0.52)
E	2.41	=	2(0.20) + 3(0.05) + 6(0.31)

Solely from an air quality viewpoint, the sites are then ranked in order of preference, as:

Site: E, A, C, D, B

STEP J - Weights are Changed and Site Rankings are Recomputed

After executing this step the sensitivity of site rankings to weight changes is analyzed.

In the example, suppose that a greater importance is attached to standard diffusion effects (Criterion 1) than was considered before, but that all the criteria are still ranked as is given in Step H. By multiplying weights 6 through 9 in the Table by a value "X", we find that the Air Quality Index values become:

Site	Air Quality Index
A	5.40 + 0.02 X
B	14.10 + X
C	9.96 + 0.62 X
D	10.86 + 1.15 X
E	2.41 + 0.31 X

As this table shows, Sites B, C and D are less favored than Sites A and E regardless of the choice of "X" (i.e., regardless of the weight assigned to standard diffusion effects). Either Site A or E could be ranked first, depending upon the value assigned to "X". For example, A becomes the preferred site from the air quality standpoint whenever "X" is greater than 10.

1.3.3.2 Engineering Economic Account

Engineering-economics measures the site differential costs associated with the construction, operation and maintenance of the generating station. The account includes the capital and operational costs of major plant systems which differ from site to site. They include:

a) The condenser cooling water system and miscellaneous station water systems. Specific components include: intake and discharge structures, pumps, piping, cooling tower and water treatment facilities;

b) The coal delivery systems, including conveyor installations, additional railroad installation and railroad rolling stock;

c) New plant access facilities including roads required for construction and operation of the plant;

d) Water storage reservoirs and ash disposal-storage areas;

e) New transmission lines to connect the plant into the B. C. Hydro electric grid (information obtained from B. C. Hydro).

The differential total comparative cost (DTCC) among the sites was used as a numerical criterion in the engineering-economics ranking of the sites. This criterion combined two components: the comparative capital cost of the thermal generating facility, and the comparative annual operating cost of the facility over its useful life.

After Total Comparative Costs (sum of comparative capital cost and comparative annual operating cost) were determined for each site, the data was arrayed in tabular form. The smallest value was assumed to be the "base" value and the DTCC of each site above the base cost was calculated. Site preference ranking was established by ordering the sites in terms of the magnitude of the value of DTCC. The preferred site was the base, or lowest, cost location. As the value of DTCC increased, site desirability decreased.

1.3.3.3 Engineering Confidence Account

Engineering confidence is a qualitative assessment of site-related engineering characteristcs. Because of the scale and time frame of the study, this account was not translated into economic terms. The account identified site aspects that could either enhance or frustrate the progress of the facility development. It also summarized factors which tend to assure reliability, integrity, security and economy. It is based on engineering judgement and experience. Qualitative criteria considered in the engineering confidence account were:

a) the "flexibility" of the site in terms of the potential for system optimization during the final engineering design;

b) "ease of construction" which estimated the potential to minimize or obviate true delays or cost increases;

c) the availability of on-site borrow areas. On-site borrow areas would minimize or preclude off-site environmental impacts;

d) the "expandability" of the site. Expandability estimated the potential to increase development beyond 2,000 MW;

e) the potential to minimize linkages or transit transfers attendant in site operation. This measure would minimize system exposure to the vagaries of man or nature (e.g., strikes, rock slides, inclement weather). As the number of linkages decreases, system reliability increases;

f) "site foundation stability". Foundation stability estimated ash pond and dam integrity over the operating life of the station;

g) the "potential for minimum seepage". This measure of soils permeability emphasized sites with low permeability soils.

1.4 RESULTS

1.4.1 Preliminary Site Evaluation - Phase I

Preliminary Site Evaluation identified eight (8) sites with the potential to support a 2,000 MW thermal generating station. Figure 1-1 shows the sites. Geographically, they are divided between interior, lower mainland and coastal locations. Sites identified include:

a) Interior Sites

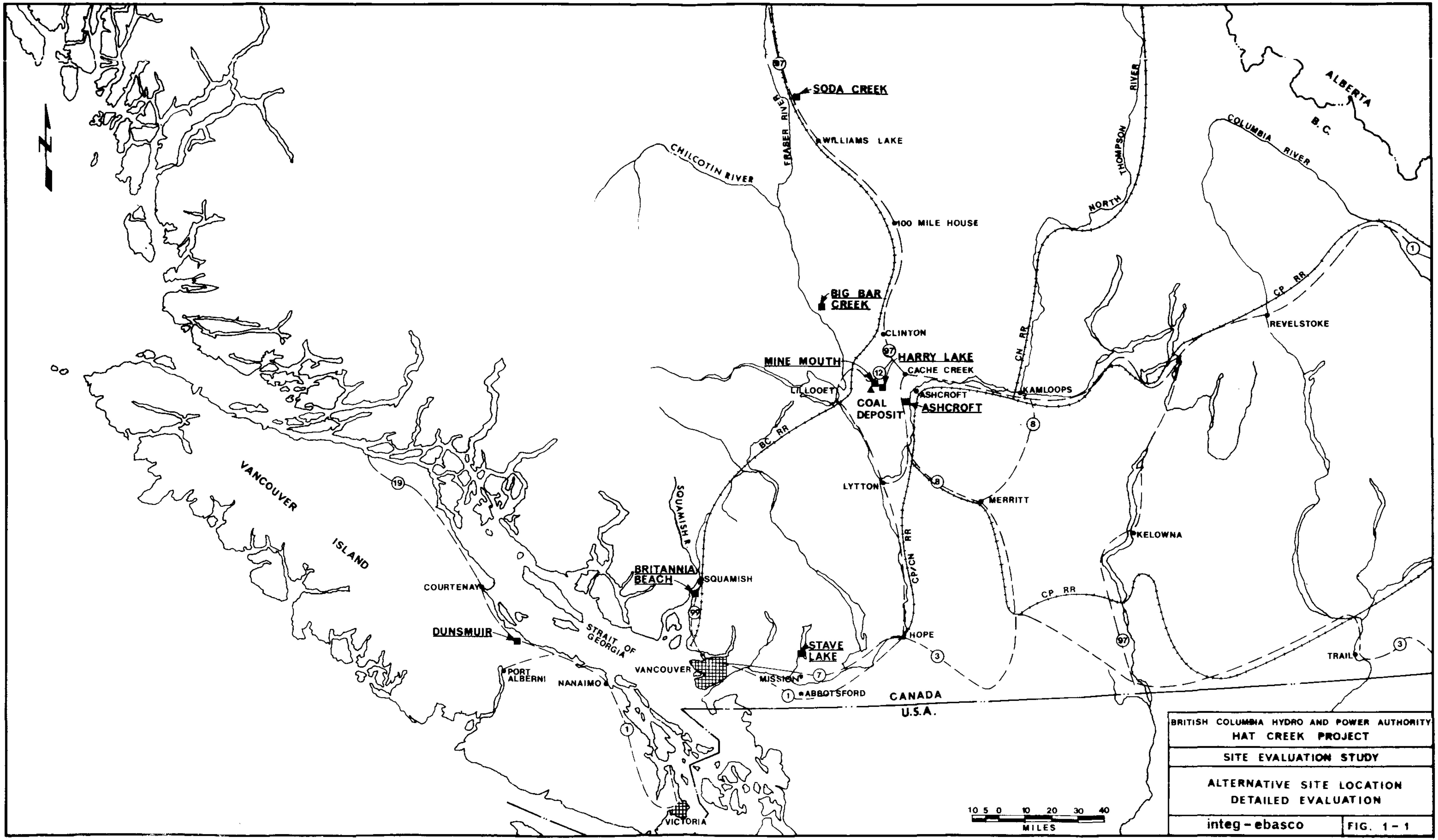
i) Mine Mouth - north end of the Upper Hat Creek Valley near B. C. Highway No. 12; site elevation approximately 3,100 feet MSL.

ii) Harry Lake - flat land east of Harry Lake in Hat Creek Valley; site elevation approximately 4,600 feet MSL.

iii) Big Bar Creek - east side of the Fraser River, north of Big Bar Creek; site elevation approximately 3,600 feet MSL.

iv) Ashcroft - west bank of Thompson River about 5 miles from Ashcroft; site elevation 1,000 to 2,000 feet MSL.

v) Soda Creek - located east of the Fraser River and north of the Town of Williams Lake; site elevation approximately 3,000 feet MSL.



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ALTERNATIVE SITE LOCATION DETAILED EVALUATION
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FIG. 1 – 1

b) Lower Mainland and/or Coastal Sites

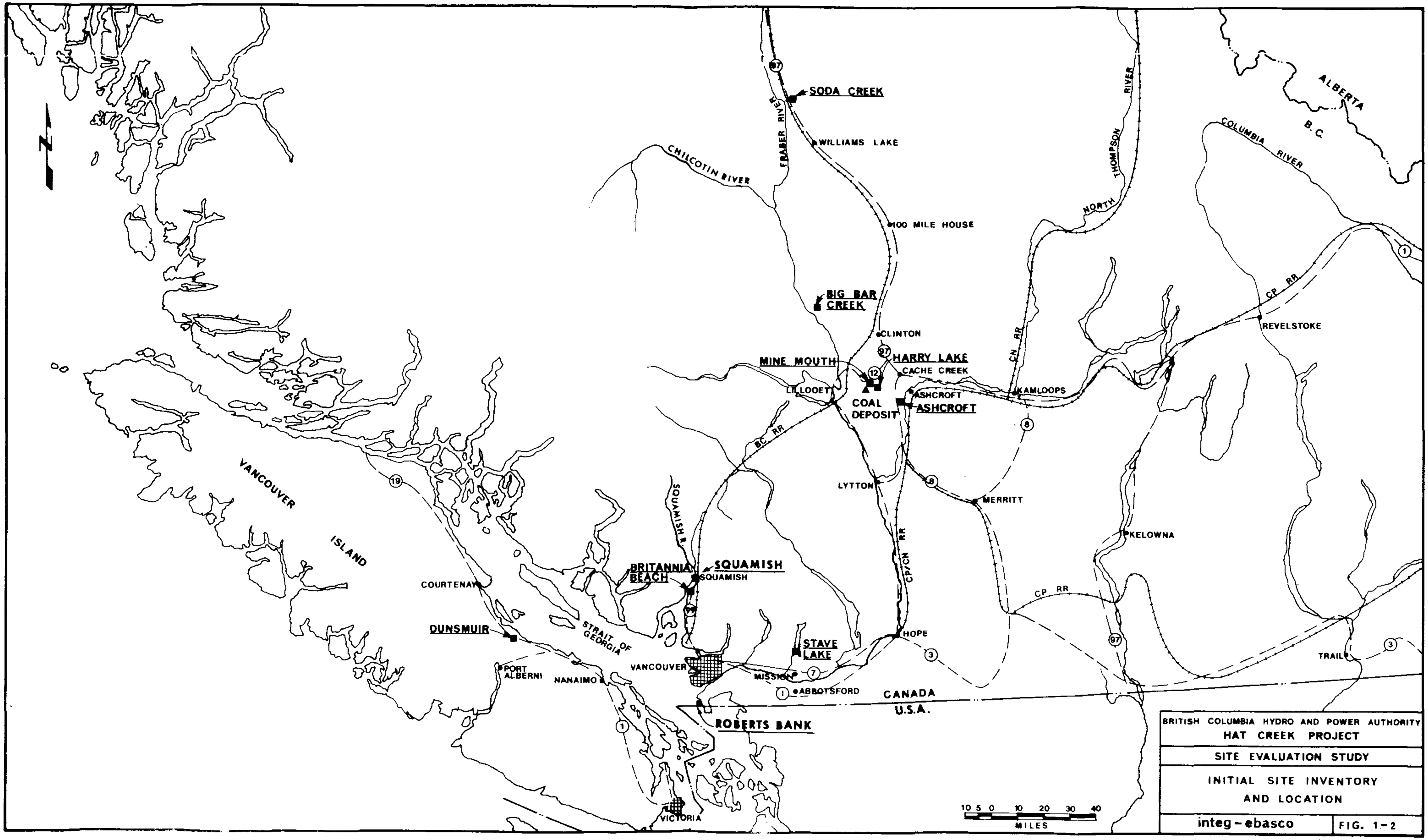
i) Stave Lake - adjacent to Stave Lake north of Abbotsford; site elevation about 280 feet MSL.

ii) Britannia Beach - on Howe Sound in the vicinity of Britannia Beach; site elevation about 150 feet MSL.

iii) Dunsmuir - on Vancouver Island, adjacent to the Strait of Georgia in the vicinity of Dunsmuir; site elevation about 300 feet MSL.

These sites were the result of preliminary screening of ten potential locations in the study region. Geographical distribution of the initial ten sites is shown on Figure 1-2. B. C. Hydro identified Mine Mouth, Harry Lake, Big Bar Creek, Ashcroft, Squamish, Britannia Beach and Roberts Bank from information contained in the Preliminary Environmental Impact Study of the proposed Hat Creek Development.

B. C. Hydro and Integ-Ebasco identified Stave Lake and Dunsmuir during initial project planning discussions. Stave Lake provides the potential for joint use of an existing hydroelectric facility and is located near the load center. Dunsmuir, which is located on Vancouver Island, would provide a generating station capable of meeting the electrical needs of Vancouver Island. It would also provide additional electrical energy to the lower mainland and eliminate the need to build additional transmission facilities across the Strait of Georgia. The Dunsmuir site was previously identified in a Vancouver Island Site Selection Study conducted for B. C. Hydro and Power Authority by Beak Consultants, Montreal Engineering and Commonwealth Associates.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

INITIAL SITE INVENTORY AND LOCATION

integ - ebasco | FIG. 1-2

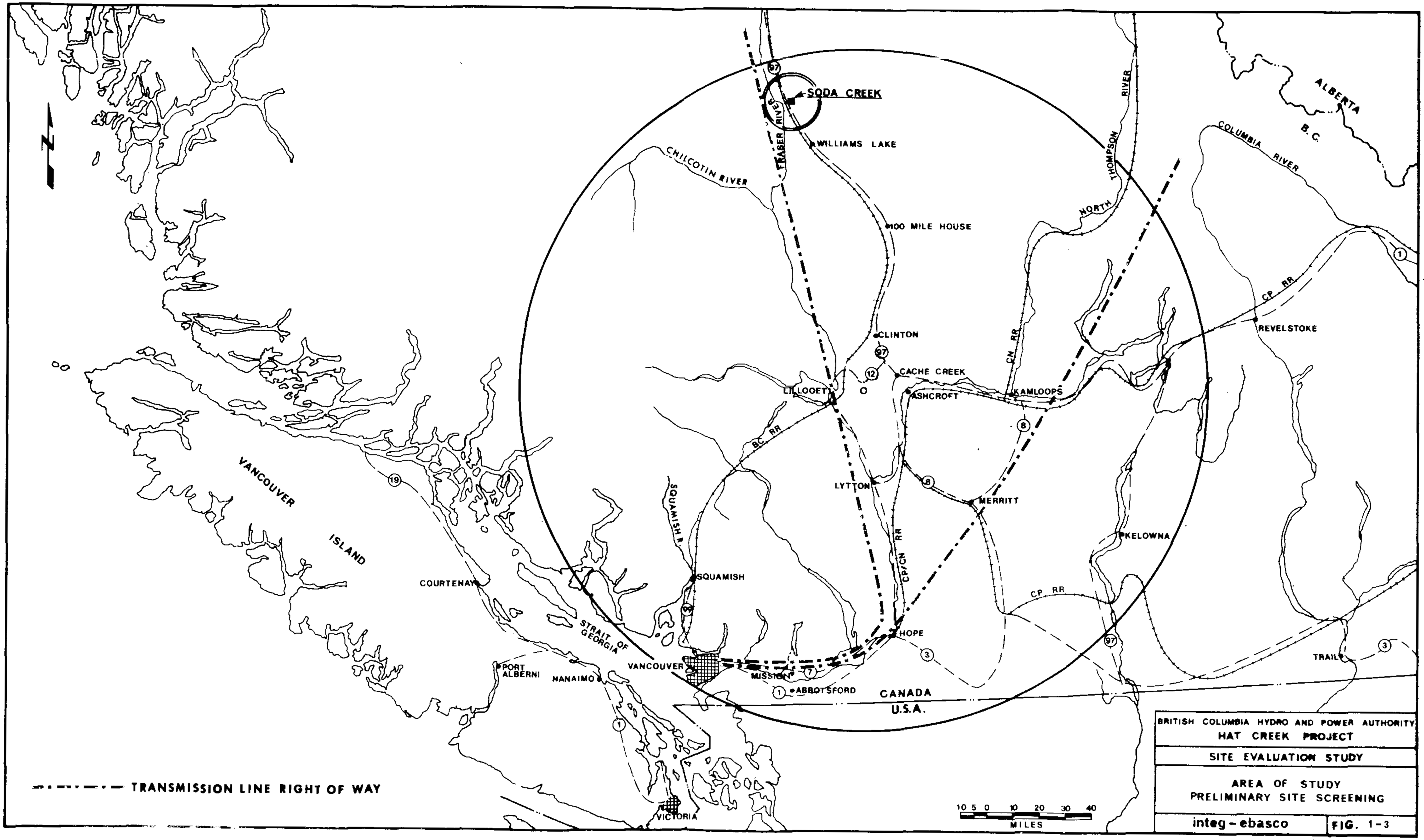
Soda Creek was identified by the Integ-Ebasco site evaluation team in a regional screening of the area delineated by a circle on Figure 1-3. Although this site is relatively distant from both the load center and the fuel source, it possesses many desirable features. It has neither grade nor space limitation, and is adjacent to an adequate water source. Rail and road facilities are nearby as are existing transmission line rights of way. Moreover, the site has no identifiable environmental or engineering limitations.

A further development, during this phase of the study, was the elimination of Squamish and Roberts Bank. These sites were eliminated in consideration of the engineering and environmental conflicts described in succeeding paragraphs.

Squamish

The topography of Howe Sound is that of a coastal fjord, characterized by steep mountain shores, a deep channel, and a river (the Squamish) at its head. Because of the height of the mountains surrounding the site and the meteorological conditions which characterize the area, a large thermal generating station at this location could have a substantial effect on the ambient air quality of the region.

Additionally, industrial facilities at Wood Fibre and Squamish are significant sources of existing air pollution in the region. The situation is further aggravated by the high potential for plume trapping in the area. The frequency with which station plumes could impact human inhabitants in the region would be important in consideration of the aforementioned factors and the population concentrations in the valley, primarily at Squamish.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

AREA OF STUDY
PRELIMINARY SITE SCREENING

integ-ebasco

FIG. 1-3

The Squamish River estuary is an important nursery and rearing grounds for various species of fish. Anadromous fish use the brackish waters of the estuary to adapt to salinity and temperature changes when migrating. It would be very difficult to construct and operate intake and discharge facilities in this region without causing significant adverse impacts on the aquatic ecology of the area.

Engineering limitations at the site include the poor foundation conditions characteristic of a delta region,and limited space for ash storage facilities.

Construction of a generating station in the vicinity of Squamish would disturb a substantial area of the Squamish River Delta and could cause irreversible damage to valuable wildlife habitat. The disturbance and possible loss of such habitat would be aggravated by the fact that the Squamish River delta is the only substantial delta area on Howe Sound.

Roberts Bank

Stack emissions from a generating station located at Roberts Bank would impact the populated areas in Greater Vancouver and would add to current background air contaminant levels - moreover, the high stack (1000 feet or greater) required for the station could interfere with air traffic patterns at the nearby Vancouver International Airport.

Construction and operation of a generating station at Roberts Bank could have a notable adverse effect on the aquatic ecology of the area. Roberts Bank is located at the mouth of the Fraser River. It is the most important and most productive estuary system in British Columbia. Downstream migrant salmonids from the Fraser River system make the transition from a freshwater to a saltwater environment in the estuary. Mature salmon returning to a Fraser River system also pass through the area. Construction of 2000 MW thermal generating station at this site would result in the permanent loss of over 1500 acres of the estuary. This reduction in estuarine area could have a permanent effect on the availability of food organisms for higher trophic levels.

The geographical distribution of the eight sites selected for detailed evaluation is extensive and provides a diverse reuse of regional alternatives. These include:

a) sites located in close proximity to the lower mainland load center (Dunsmuir, Britannia Beach and Stave Lake);

b) sites located in close proximity to the fuel source (Mine Mouth, Harry Lake, Ashcroft);

c) sites located in relatively undeveloped areas, distant from both the fuel source and the load center. (Big Bar Creek, Soda Creek)

1.4.2 Detailed Site Evaluation - Phase II

1.4.2.1 Environmental Suitability Account

The detailed site evaluation environmental account favoured three sites - Harry Lake, Big Bar Creek and Soda Creek. Power plants at these sites would exhibit minimal environmental conflict.

However, further discrimination among these sites would not be possible with the present environmental information.

Harry Lake, Big Bar Creek and Soda Creek were identified by the combination of qualitative and quantitative criteria described in the Phase II methodology. The detailed results of the analysis appear below.

Calculated values for the 24 environmental indices at each site are presented in Table 1-1. Some values, particularly those dealing with population size, municipal debt and tax assessment income, residential housing levels and the size of the construction labor pool, were taken directly from published literature. The remainder were calculated from base maps, reported statistical data and plant conceptual design.

Application of the environmental criteria was discussed in open meetings with each technical study group. The views expressed in these meetings developed the relative importance of the criteria applied at each site. The result was an importance order of criteria at the sites. In addition, each study team indicated the relative importance of criteria evaluations among the sites. The among-site and within-site criteria hierarchies are summarized in Table 1-2. Criteria listed near the top of each column were of greatest concern at a given site; those listed near the bottom were considered of moderate concern. Spaces illustrate the importance attached to criteria among the sites. The integers listed to the right in Table 1-2 increase linearly when moving from moderate environmental concerns to outstanding ones. These integers served as primary weights or multipliers when computing the overall

TABLE 1-1

NUMERICAL VALUES OF ENVIRONMENTAL CRITERIA

Criteria	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek	Units
Standard Diffusion Effects	0.36	14.56	0.09	6.43	9.16	4.51	3.49	0.26	% Frequency
Fumigation Effects	6.62	4.65	4.80	4.32	4.00	1.34	2.20	0.	% Frequency
Trapping Effects	4.7	33.60	28.43	23.80	17.51	1.62	9.69	0.	% Frequency
Thermal Addition	9.45	945.	945.	0.	0.	0.	0.	0.	BTU x 10^9/hr.
Chemical Addition	43150.	1550.	8700.	0.	0.	0.	0.	0.	lbs/day
Dredging Effects	86.	3340.	3340.	50.	46.	47.	46.	47.	cfs
Chlorine Demand	5.	5.	1.	1.	1.	1.	1.	1.	mg/l
TDS	10000.	10000.	30.	70.	55.	55.	96.	90.	mg/l
TSS	10.	10.	10.	19.	10.	10.	70.	105.	mg/l
Population Centers	7.3	0.98	4.9	0.53	0.53	0.53	0.47	2.47	No. People/square mile
Housing Demand	0.0000655	0.0002886	0.0000835	0.0000497	0.0000497	0.0000497	0.0000497	0.0000958	$(\text{No. Dwelling Units})^{-1}$
Labor Force	0.0003795	0.0000327	0.0002635	0.0002911	0.0002911	0.0002911	0.0002911	0.0002415	$(\text{No. Construction Workers})^{-1}$
Municipal Affairs	0.1736	0.1701	0.1323	0.09372	0.09372	0.09372	0.09372	0.15974	Debt ($)/Tax Income ($)
Viewshed	168.30	78.0	44.66	31.14	12.46	8.87	49.98	13.1	Sq. Miles
Forests	7696.0	1612.0	6552.0	429.0	3315.0	3822.0	2301.0	4563.0	Acres
Native Indians	0.5	0.	0.	0.55	2.65	1.13	0.25	0.25	No. Reserves/Mile
Agriculture	4914.0	0.	3526.0	7605.0	12.66	0.	4934.0	6981.0	Acres
Recreation	1229.0	842.0	441.0	10140.0	317.0	0.	0.	465.	Acres
Intake Effects	28710.	751140.	750810.	21382.	20630.	21095.	20848.	21054.	cfs
Discharge Effects	10815.	750570.	752309.	0.	0.	0.	0.	0.	cfs
Habitat Diversity	0.6768	1.0371	1.0813	0.4753	0.9496	0.9736	0.8539	1.1273	Shannon Function
Birds and Mammals	27.8	36.6	39.0	30.3	30.3	30.3	30.4	40.4	Relative No. of Species
Waterfowl Capability	36.54	0.0	0.0	0.0	9.62	9.6	0.0	0.0	% Highest Capability
Ungulate Capability	100.0	0.0	0.0	36.54	50.0	0.0	50.0	92.31	% Highest Capability

TABLE 1-2

CRITERIA HIERARCHIES

Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar	Soda Creek	Primary Weights
		Thermal	Trapping	Trapping				41
		Chemical	Intake	Intake	Intake			40
	Diffusion	Diffusion	Discharge	Discharge	Discharge			39
Diffusion			Diffusion	Diffusion	Diffusion			38
	Labor					Diffusion		37
	Housing					Intake		36
	Intake					Discharge		35
	Discharge	Labor						34
Viewshed	Thermal	Dredging						33
	Trapping	Viewshed						32
	Viewshed							31
						Viewshed		30
			Housing	Housing	Housing	Housing	Viewshed	29
	Population		Indian	Indian			Diffusion	28
Population					Indian		Housing	27
Fumigation							Indian	26
Recreation							Intake	25
Intake							Discharge	24
Discharge			Mncpl Afrs	Mncpl Afrs	Mncpl Afrs	Mncpl Afrs	Mncpl Afrs	23
Housing	Mncpl Afrs							22
Mncpl Afrs								21
Indian		Population						20
Labor		Housing				Indian		19
	Chemical	Discharge				Labor	Labor	18
		Mncpl Afrs	Chemical	Chemical	Chemical	Chemical	Chemical	17
		Intake	Thermal	Thermal	Thermal	Thermal	Thermal	16
		Recreation	Labor	Labor	Labor			15
		Trapping	Fumigation	Fumigation				14
	Fumigation	Fumigation	Population	Population		Birds	Birds	13
		Forest		Population	Population	Population	Population	12
Forest			Birds	Birds	Birds			11
Chemical	Birds	Birds		Viewshed	Viewshed			10
Birds				Diversity	Diversity	Diversity	Diversity	9
Trapping	Indian				Trapping		Ungulates	8
Thermal	Dredging					Ungulates	Ungulates	7
Dredging					Fumigation	Trapping	Trapping	6
Water Fowl			Dredging	Ungulates		Fumigation	Fumigation	5
TDS			Recreation	Dredging	Dredging	Dredging	Dredging	4
			TDS	TDS	TDS	TDS	TDS	3
			TSS	TSS	TSS	TSS	TSS	2
		Diversity	Ungulates	Water Fowl	Water Fowl			1
Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar	Soda Creek	

suitability of each site. The formula:

Site Index = Criterion weight x Criterion value

determined the preference order of sites. The order, based solely upon the primary weights, is illustrated in Table 1-3.

The consensus relationships between environmental criteria, which appear in Table 1-2, formed the basic preference structure for the analysis. Criteria preference order implied that the size of weights must increase with criteria of greater importance. The order did not prescribe the relative values of these weights. Consequently, many weight selection alternatives were possible. The sensitivity of the site ranking to changes in weight selection was investigated through repeated calculations of the site index. Results of the sensitivity analysis appear in Table 1-4. The percentages listed in this table were obtained by dividing each index by the highest index calculated for that trial; lower percentages indicate greater site suitability.

The ranges of these percentages were compared to see if the site indices were statistically different. The results of the sensitivity analysis indicate that Harry Lake, Big Bar Creek and Soda Creek are sites which exhibit the greatest environmental compatibility with the proposed project. Statistically, these sites are environmentally indistinguishable.

1.4.2.2 Engineering-Economic Account

Table 1-5 presents total comparative costs and their associated differential costs for the eight alternative sites. Regardless of the interest rate used, the sites exhibiting minimum capital and operating

TABLE 1-3

SITE RANKING BASED UPON PRIMARY WEIGHTS

Site	Per Cent of Maximum Site Index[a]	Rank
Harry Lake	26.2	1
Big Bar Creek	27.9	2
Soda Creek	29.9	3
Ashcroft	37.8	4
Mine Mouth	47.6	5
Dunsmuir	65.8	6
Stave Lake	88.9	7
Britannia Beach	100	8

a - Lower values indicate greater suitability

TABLE 1-4

SENSITIVITY ANALYSIS
EFFECT OF VARYING CRITERIA WEIGHTS
ON SITE INDEX[a]

Site	Weighting Trial										Mean ± Standard Deviation
	1[b]	2	3	4	5	6	7	8	9	10	
Dunsmuir	65.8	38.9	58.5	45.6	77.5	53.0	70.2	74.2	74.4	85.7	64.3 ± 29.7
Britannia Beach	100	100	100	100	100	100	100	100	100	95.2	99.5 ± 2.8
Stave Lake	88.9	81.4	87.1	78.1	90.3	85.7	90.1	94.5	91.1	100	88.7 ± 12.5
Ashcroft	37.8	37.5	37.1	33.1	44.1	36.6	38.2	40.5	38.6	43.6	38.7 ± 6.6
Mine Mouth	47.6	41.8	45.4	40.4	50.2	43.8	48.9	51.4	50.2	55.8	47.6 ± 9.4
Harry Lake	<u>26.2</u>	17.0	<u>23.9</u>	18.3	<u>30.4</u>	<u>22.0</u>	<u>27.7</u>	<u>30.2</u>	<u>29.2</u>	<u>35.7</u>	26.1 ± 11.7
Big Bar Creek	27.9	16.7	25.1	18.2	34.8	23.0	29.6	32.3	31.3	38.8	27.8 ± 14.1
Soda Creek	29.9	<u>14.2</u>	25.9	<u>16.7</u>	39.8	22.9	32.4	36.0	34.8	45.2	29.8 ± 19.8

[a] Numbers indicate per cent of maximum site index in each trial
Lower values indicate greater environmental suitability

[b] Weighting Trial #1 used the primary weights.

TABLE 1-5

TOTAL DIFFERENTIAL COMPARATIVE COST

(Millions of Dollars)

Site	Interest Rate 5%	Interest Rate 10%
Dunsmuir	744	217
Britannia Beach	620	242
Stave Lake	615	226
Ashcroft	74	28
Mine Mouth	Base (0)	Base (0)
Harry Lake	35	20
Big Bar Creek	352	142
Soda Creek	689	313

costs are Mine Mouth, Harry Lake and Ashcroft. Taken as a group, the average total investment cost at these sites is approximately one half of the total cost at any other site.

1.4.2.3 Engineering Confidence Account

Each site was evaluated in terms of its ability to enhance or limit the potential development of an integrated, secure, reliable, stable and economic system of energy conversion and delivery. The results of the study, presented in Table 1-6, are summarized as follows:

a) Those sites which would incur a large number of linkages (i.e., in-transit transfer) in the overall system of fuel supply and transport are judged less desirable than those sites exhibiting the converse. Thus, the interior sites are considered more reliable than the Dunsmuir, Britannia Beach and Stave Lake sites.

b) Those sites located in a seismic risk Zone II are judged more desirable than those located in seismic risk Zone III. The interior sites, therefore, are considered preferred to the coastal sites from this viewpoint.

c) Among the sites, those affording opportunity for plant system optimization (i.e., flexibility of arrangement), expansion beyond 2,000 MW, on-site borrow of fill material, easily developed road and railroad access and minimization of natural seepage are judged more desirable than those sites that are limiting in these respects. Thus, the Soda Creek, Harry Lake and Big Bar Creek sites are preferred over all other sites in respect to the foregoing.

TABLE 1-6

ENGINEERING CONFIDENCE ACCOUNT

Site	Engineering Character
Dunsmuir	. Easy development with good access and mild relief . Adjacent to load and transmission . Limited space provides for little flexibility and limited expansion potential . High soil permeability/seismic zone III
Britannia Beach	. Excellent accessibility to site . Severe space limitations with no potential for expansion and little flexibility for development . Located in seismic zone III
Stave Lake	. Generally difficult development located in seismic zone III with highly permeable soils . Space limitations preclude the potential for expansion and flexible plant development . Rail and road access to site would be difficult
Ashcroft	. Space limitations and topography preclude expansion and the potential for optimizing plant arrangement . Unstable foundation characteristics can result from seepage . Ease of access to site and proximity to fuel provides for ready development . Seismic zone II
Mine Mouth	. Although flexibility for plant arrangement exists, mine development and valley location would limit expansion . Valley location provides for difficult access and water supply . Seismic zone II location and closeness to fuel source enhances its character

.../

TABLE 1-6 (Continued)

ENGINEERING CONFIDENCE ACCOUNT

Harry Lake	. The site's remoteness provides for difficult access and water supply . Both expansion and flexibility potential exists at this site . Seismic zone II location and closeness to fuel source enhances its character
Big Bar Creek	. Site provides good potential for expansion and plant arrangement flexibility . Seismic zone II location . Site remoteness provides for difficult access and greater operation linkages
Soda Creek	. Distant from both load and fuel source provides for greater operation linkages and difficult access . Seismic zone II . Good potential for expansion as well as flexibility of arrangement

1.5 DISCUSSION AND CONCLUSION

1.5.1 Preferred Site Selection

The results of the multidisciplinary site evaluation study strongly support the conclusion that Harry Lake is the preferred site for the installation of a 2,000 MW thermal generating station burning Hat Creek coal. Harry Lake is one of three sites preferred for overall environmental suitability. It stands with Mine Mouth and Ashcroft as sites which would minimize both capital and operational costs. In addition, Harry Lake does not possess any outstanding site-engineering features which would reduce the engineering confidence associated with its development.

Although Harry Lake is indistinguishable from either Soda Creek or Big Bar Creek from an overall environmental standpoint, its proximity to Hat Creek Valley complements its desirability for development. The Harry Lake site confines physical-environmental disturbances associated with the Hat Creek Project mine and power station development to one area. A plant located at either Big Bar Creek or Soda Creek would result in incremental physical disturbances to other localities as well as Hat Creek Valley. These translation or dispersive effects, although not measured or fully evaluated in the environmental account, militate for the selection of Harry Lake as the preferred site.

In the engineering-economic account, three sites show least plant capital and operational costs. These sites are Mine Mouth, Harry Lake and Ashcroft. The average total investment cost for these sites is less than one half the total investment cost at any other site. Mine Mouth and Ashcroft, however, are environmentally unsuitable for thermal power development. Air quality considerations render them inappropriate or unacceptable for this project.

From an engineering standpoint, each of the environmentally preferred sites exhibits a high degree of site-engineering confidence. Development of any of these sites would ensure secure, reliable and stable power generation. Because Harry Lake is adjacent to the mine development, it affords the greatest flexibility for development and the fewest critical problems for reliable operation. Compared with Big Bar Creek or Soda Creek, these factors add additional support for its development.

1.5.2 Preferred Site Characteristics: Harry Lake

1.5.2.1 Facility Engineering and Economics

The Harry Lake site is located in the Trachyte Hills, one half mile southeast of Harry Lake and approximately 3 miles east of the Hat Creek coal deposit. The site is an area of gently sloping, sparsely forested land. Approximate elevation is 4,600 feet MSL.

Road access from Route 1 near Ashcroft would follow the Cornwall Creek and Medicine Creek valleys to the site. This route would involve upgrading about ten miles of existing road and the construction of three miles of new road. Railroad access would not be required. A three-mile long conveyor system would transport coal from the mine to the site.

Condenser cooling would be of the closed-cycle type. The evaporative, mechanical draft cooling towers would require a pumping and fan power of about 26,000 HP. Electrical power required would be about 20 MW. The installed pumping power for the makeup water system would be about 36,000 HP, with an electrical requirement up to about 30 MW. All fresh water for plant use would be pumped from the Thompson River, to the plant reservoir located beside the plant.

An ash storage pond constructed at Medicine Creek would lie below plant grade to permit gravity flow ash sluicing. The Medicine Creek drainage basin would be diverted around the ash storage area.

Other pertinent observations related to site development are that: the site is located in a seismic Zone II area; approximately 262 miles of new transmission line would be required; there is sufficient on-site fill material; the large land area would permit a flexible design arrangement; expansion beyond 2,000 MW is feasible and the total comparative cost for site development is $424 million (5% interest rate) or $246 million (10% interest rate). In addition, it may be possible to share roads, water supply and other facilities with the proposed coal mining development.

1.5.2.2 Environmental Characteristics

Air Quality

None of the three air quality characteristics appears critical at Harry Lake. Releases from a station at this site would generally travel over high surrounding terrain. Additionally, plumes from a plant at Harry Lake would be less likely to incur the problems associated with plume trapping and fumigation because they would be released outside the deeper parts of the Hat Creek Valley.

Plumes escaping the valley could have a potential effect upon Kamloops which already has air quality problems. Any further studies performed regarding this site should carefully investigate the possibility of plant effects upon Kamloops.

Water Resources and Water Quality

The Harry Lake Generating Station would withdraw 47 cfs from the preferred water source (the Thompson River), which is a narrow, rapid water course with a mean annual flow of about 26,000 cfs. This rate is less than one percent of the annual seven-day average low flow with an expected recurrence interval of ten years.

The conceptual plant design proposes that there would be no liquid waste discharge. Consequently, all chemical and thermal discharge effects would be eliminated. In-water construction, including dredging, is limited to a relatively small intake structure. Thus, any loss of benthic habitat or increase in turbidity or suspended solids would be minimal.

Makeup water drawn from the Thompson River is of superior quality, and would thus reduce chemical additions and treatments necessary for plant operation.

Terrestrial Ecology

Vegetation at Harry Lake consists of Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) associated with bunch grass. Several large meadows are present on the site. Trembling aspen (Populus tremuloides) occurs along the site drainages. In addition, small stands of willow (Salix spp.) and black cottonwood (Populus trichocarpa) are found along the Medicine Creek drainage basin.

Habitat diversity at Harry Lake is "high". Harry Lake is also characterized by moderate waterfowl and ungulate production capability.

Aquatic Ecology

Pink, chinook and coho salmon spawn in the Thompson River between Lytton and Kamloops Lake.

Although adult salmon are adapted to moderate and high currents, their larval stages are susceptible to entrainment by intake currents. They are also susceptible to impingement. However, because of the small quantities of water required for cooling tower makeup at Harry Lake, the impact of entrainment and impingement in juvenile salmon would be low. The absence of plant discharges to the Thompson River precludes discharge effects.

Land Use

Plant facilities would probably be seen from Highway No. 12, by tourists on their way to Marble Canyon Provincial Park. However, limited access to the immediate vicinity of the site, and its remoteness from populated areas preclude any major visual impacts.

Most of the forested area at this site is immature. Productive woodland consists principally of Douglas fir and ponderosa pine. Intermittent selective logging operations in this vicinity suggest the moderate commercial viability of the area for forestry. Most of the area surrounding the Harry Lake site falls within the lowest CLI agricultural capability class. The area supports limited cattle grazing. Recreational potential at this site is considered minimal.

A Native Indian Reserve of the Bonaparte Band is more than three and one half miles from the site. There are seven other Native Indian Reserves within ten miles of the site, with a total population of about 200.

Socio-Economics

Optimization of economic and employment benefits is more probable at the three Hat Creek sites than at any other location. There are over 20,000 dwelling units and a potential construction labor force of about 3,500 persons in the district containing this site. Thus, associated with coal mine operation and generating plant construction and operation, economic and employment benefits would probably accrue and be retained in the Kamloops area.

Such rapid economic and population growth will place a heavy burden on the municipalities in the vicinity of Harry Lake. The population density in the Thompson-Nicola Regional District is 0.53 persons per square mile. Plant construction and operational impacts on human populations are expected to be minimal because of this low density figure and the relative isolation of the plant facilities.

1.5.3 Alternative Site Selection: Big Bar Creek and Soda Creek

Big Bar Creek and Soda Creek are viable alternatives to the preferred Harry Lake site for this project. Each site is environmentally compatible with project development. Although more costly to develop than Harry Lake, neither Big Bar Creek nor Soda Creek exhibit any outstanding potential site-engineering limitations.

Big Bar Creek and Soda Creek are more distant from the load center and coal mine than Harry Lake. This relative isolation increases the number of transportation linkages necessary during construction and operation of the generating station.

Total comparative costs at Big Bar Creek are \$741M and \$388M at five and ten percent interest, respectively. Soda Creek costs are \$1,078M and \$539M at these respective interest rates. These comparative costs are approximately twice the cost associated with Harry Lake.

Meteorological and air quality considerations favor Soda Creek over Big Bar Creek and Harry Lake. The latter sites are approximately equal in this regard. The flat terrain of the Soda Creek site would promote diffusion of stack contaminants.

1.5.4 Alternative Site Characteristics

1.5.4.1 Big Bar Creek

The Big Bar Creek site is located on the south edge of a plateau between the Big Bar Mountains and Edge Hills, just north of the confluence of Big Bar Creek and the Fraser River. Road access would require substantial upgrading of an existing road and construction of a new road. Coal transportation to the site would be by unit train. The condenser cooling water system would be a closed-cycle system using evaporative-type mechanical draft cooling towers. Makeup water would be pumped from the Fraser River. The intake would be located on the east bank of the river about nine miles upstream of its confluence with Big Bar Creek. The makeup water would be pumped via a five mile overland pipeline. A water storage reservoir would be constructed at the site to provide a thirty-day water supply to operate the plant should the river water makeup system become temporarily inoperative. The proposed ash disposal facilities would consist of two main adjoining ponds with a total area of 1,200 acres.

The most important air quality concern at the Big Bar Creek site is the potential effect that the diffusion of contaminants under standard meteorological conditions would have on population centers. This concern was not felt to be a serious problem for this site because the quantitative meteorological and air quality values developed for Big Bar Creek indicate that diffusion problems will not be frequent and because the few areas which would experience these effects are sparsely populated.

A generating station at Big Bar Creek would withdraw 46 cfs. from the Fraser River. There would be no liquid waste discharges to the river. In-water construction, including dredging, is limited to a relatively small intake structure. Fraser River water quality is such that condenser cooling water system makeup would require treatment for the removal of suspended solids. The high hardness and TDS levels of Fraser River water would require greater acid addition rates than would the Thompson River water used for the Harry Lake site.

Vegetation at the Big Bar Creek site consists of Douglas fir (Pseudotsuga menziesii), blue bunch wheatgrass (Agropyron spicatum), june grass (Kolleria cristata), ponderosa pine (Pinus ponderosa), lodgepole pine (Pinus contorta var. latifolia) and trempling aspen (Populus tremuloides). Extensive upland meadows which are used to graze cattle, are also found within the borders of the site. Habitat diversity is high. The land capability for waterfowl production is low, although moderate for ungulates. Few anadromous salmonids spawn in the Fraser River at Big Bar Creek, which is located about fifty river miles upstream of Lillooet.

Approximately 2,300 acres of productive forest land and 4,900 of agricultural land would be affected by development of the Big Bar Creek site. This site has no recreational lands; impact on Native Indian populations is considered moderate.

Economic and social benefits are probable at the Big Bar Creek site. There are more than 20,000 dwelling units and a production labor force of 3,400 persons in the district containing this site. The population density for the electoral area containing the site is 0.47 persons per square mile. The population density of Clinton, the nearest city, is 4.02 persons per acre. Plant construction and operational impacts on human populations are expected to be minimal because of these low density values.

1.5.4.2 Soda Creek

The Soda Creek site is located on the east bank of the Fraser River about 160 miles upstream of its confluence with the Thompson

River. The site is on a flat plateau of approximately 3,000 acres, at an elevation of 3,000 feet (MSL). Road access to the site would require the construction of six miles of new road. Coal transportation would be by unit trains, with the distance from the mine to the site approximately 160 miles. Condenser cooling would be provided by a closed cycle system employing evaporative-type mechanical draft cooling towers. Makeup water for the condenser cooling would be drawn from the Fraser River and pumped via an overland pipeline. A reservoir with a storage capacity of 4,000 acre feet would be constructed at the site to provide a makeup water supply should the river water system become temporarily inoperable. Ash storage would require a pond covering 2,000 acres in area. Approximately 400 miles of new transmission line would be required to integrate a generating station at this site into the B.C. Hydro transmission network.

Standard diffusion considerations are the most important air quality concern at the Soda Creek site. No terrain features were found which could be associated with fumigation and plume trapping. The standard diffusion model indicated the fewest predicted values in excess of the most stringent PCB Guidelines for this site.

Makeup water at the rate of 47 cfs will be drawn from the Fraser River. An extensive treatment system will be required to remove suspended solids (average concentration 105 mg/l) and TDS (90 mg/l). Biocide additions to maintain condenser tubes and cooling tower systems should be minimal. No liquid waste water will be discharged into the water bodies in the vicinity of the plant. Dredging effects in the river will be minimized, due to the small size of the intake structure.

The vegetation of the Soda Creek site consists primarily of Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta var. latifolia), and bluebunch wheatgrass (Agropyron spicatum). Habitat diversity is quite high. The land capability for waterfowl production is minimal, although moderate for ungulate production.

Approximately 4,500 acres of productive forest land and 6,900 acres of agricultural land would be affected by development of the Soda Creek site. The viewshed is approximately 13 square miles. Native Indian and recreational considerations are not an important factor for this site.

Some socio-economic effects can be expected from development of the Soda Creek site. The population densities of Williams Lake, Quesnel and 100 Mile House, which are the closest population centers, are 1.09, 1.71 and 3.47 persons per acre, respectively. The Soda Creek site is suitable from a population standpoint, since the overall regional population density is low. Approximately 10,430 dwelling units are located in the vicinity of the Soda Creek site. Development of the site would have impacts on the housing situation in Williams Lake and Quesnel due to the proximity of these towns to the site. The labour force statistics suggest limited manpower availability in the Williams Lake CMC. Employment benefits wouldaccrue to the interior regions as additional workers would probably come from the Prince George, Quesnel, and Williams Lake areas. Regarding municipal affairs, the development of the Soda Creek site would place additional demands on the educational system.

1.5.5 Other Sites

Of the remaining sites, Britannia Beach, Stave Lake, Ashcroft and Mine Mouth are incompatible with project development.

Meteorological and air quality concerns alone account for their incompatibility. A Dunsmuir site, although feasible, would incur substantial economic penalties for this project. Environmental ratings for these sites were significantly higher than for the environmentally preferred alternatives.

Engineering and engineering-economic conflicts also exist. These conflicts are obvious from the results presented in the previous section. For this reason, only the outstanding environmental concerns at each site are discussed.

Dunsmuir

Socio-economic and land use characteristics in the surrounding region accounted for more than two-thirds of Dunsmuir's high index. A plant located at Dunsmuir would conflict with present land uses.

Within ten miles of the site are four Provincial Parks. These parks offer camping, picnicking and hiking to over 60,000 annual visitors. Beaches and boating are available in the immediate vicinity. In addition to the disruption of local recreational areas, the railroad line from the Hat Creek Coal Mine would probably pass through Marble Canyon Provincial Park. Rail lines would have a detrimental impact on use of Marble Canyon Park. A railroad line near or through Indian Reserve Land, combined with increased plant-related activity would disrupt the activities of the Native Indian People.

The Dunsmuir plant would be seen over an area of 168 sq. miles. This viewshed is three times greater than at any other site. The total number of observers from either the landward side or from the Strait of Georgia is estimated to be high.

Residential population density at Dunsmuir is higher than at any other site. Thus, disruptions to normal activity would be felt by a greater number of persons. The site's proximity to Vancouver, and the shortage of adequate construction worker housing implies that local economies would not benefit greatly from this project. Rapid housing development would not mitigate this problem because present municipal services are also inadequate. Expansion or improvement of these services is unlikely. Municipal debt is high and taxable assessments are low.

Britannia Beach

Britannia Beach is considered unsuitable for the development of an electric generating station. Deleterious effects on air quality, aquatic ecology and socio-economics alone account for more than 80 percent of the numerical site index.

The diffusion of contaminant plumes under standard meteorological conditions is the most important concern at Britannia Beach. The site is approximately 20 miles from Vancouver and its densely populated suburbs. Existing air quality problems in Vancouver could be exacerbated by the effects of the plant's stack emissions.

The Britannia Beach site and the conceptual plant design pose a great threat to aquatic biota. Over one quarter of a million chum, coho, chinook and ponk salmon pass through Howe Sound annually. The proposed once-through cooling system design calls for an intake and discharge rate of over 750,000 cfs. This system portends major disruptions of salmon migration and spawning.

Britannia Beach is the most incompatible of all sites on the basis of optimizing economic benefits to the selected region. Its municipal debt is high and its income from taxable sources is low. Given such difficulties, construction workers will probably reside either in Squamish and points north, or in the suburbs of Greater Vancouver. There is no adequate housing locally, which would aggravate the problem. Neither the local economy nor the municipal government will benefit from a project of this type.

Stave Lake

Expected impacts would focus on reservoir water resources and socio-economic considerations. Socio-economic considerations alone account for over two-thirds of Stave Lake's high numerical index.

The once-through cooling system design would discharge 9.45×10^9 Btu/hr to the lake. The lake's water quality constituents would increase due to discharge of other process wastewaters. Because of the high potential for recirculation, thermal and chemical loads are likely to change the character of the reservoir. Potential effects on fisheries downstream of the lake could occur from the elevated lake temperatures and gas supersaturation. In addition, a substantial amount of marshland dredging would be required to build the necessary intake and discharge structures.

As with the two coastal sites, income and employment benefits would probably accrue in the greater Vancouver area, rather than in rural environs.

The district's population density is high. Local tourism could increase the impact on Davis Park's recreational potential.

Air quality problems, similar to those at Britannia Beach, are sufficient reason alone to adjudge this site unaccaptable.

Ashcroft

Air quality problems at Ashcroft account for nearly 75 per cent of this site's moderately high numerical index.

The most serious concern at Ashcroft is the potential for frequent trapping of airborne contaminants deep in the Thompson River Valley. An analysis of the terrain surrounding this site supports the conclusion that trapping conditions are possible regardless of wind direction. Trapping would appreciably raise ground-level SO_2 concentrations at several local population centers. Similarly, fumigation on the high terrain surrounding the valley could effect these populations. Problems associated with standard diffusion effects apply to the Ashcroft site. Plumes generated by the plant could have a potential effect on Kamloops which already has air quality problems. Any further studies performed regarding this site should carefully investigate the possibility of plume effects on Kamloops.

Mine Mouth

The major conflicts surrounding the development of the Mine Mouth site relate to air quality and land use. Together, they account for over 80 percent of the site's high numerical rating.

The Mine Mouth site is located in a deep valley. Plume trapping could result in high ground level contaminant concentrations and therefore this site would require extensive diffusion monitoring and modelling efforts. However, the population density in the immediate vicinity of the Mine Mouth is low and the effects are considered less critical than at Ashcroft. Plumes from a Mine Mouth plant could also potentially have an impact upon the air quality of Kamloops. This potential impact should be addressed in detail if any further consideration is given to this site.

Plant activity would affect many of the eight nearby Native Indian Reserves occupied by over 200 Indians from the Pavilion and Bonaparte Bands. The nearest populated reserve is within one mile of the site. Roads that might be used for access of construction workers and materials are adjacent to several of these reserves. In addition, Marble Canyon Provincial Park is five miles to the northwest of Mine Mouth, and increased noise and traffic congestion might result in an indirect impact on the use of the park and its facilities.

GLOSSARY OF TECHNICAL TERMS

Ash	- incombustible material in coal; the residue remaining upon complete oxidation of the combustible substances.
Biocide	- a substance toxic to life, i.e., insecticide, herbicide.
Biofoul	- bacterial plant or animal growth which interferes with normal operation in the circulating water systems of a power plant.
Blowdown	- the total discharge from a power plant to a receiving body; blowdown usually consists primarily of cooling water.
British Thermal Unit	- (BTU); the heat required to raise one pound of water one degree Farenheit; a unit used to measure the heating value of coal.
Central station	- a base load, thermal generating station.
Chlorine demand	- the addition of chlorine gas or hypochlorite necessary to achieve a specified residual chlorine concentration in water; chlorine demand is a characteristic of the plant water supply.
Consensus decision	- a technique to make decisions in a multidisciplinary forum with multiple objectives.

GLOSSARY OF TECHNICAL TERMS (Continued)

Condenser	- the principal heat exchange system in a thermal generating station.
Diversity	- the richness of species association and evenness of their distribution.
Escapement	- spawning run of anadromous salmon and trout.
Fry	- recently hatched, or very young fish.
Turbidity	- a measure of the cloudiness or opacity to light, of water.
Ungulate	- hoofed animal.
Vegetation association	- an aggregation of plants common to a region.

2. ENGINEERING AND ENGINEERING ECONOMICS

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2.1 SUMMARY

The site selected for a 2000 MW steam electric generating station burning Hat Creek coal must be responsive to site specific engineering and engineering - economic factors and the overall system of energy supply, conversion and delivery. In order to ensure a secure, reliable, stable and economic energy system, an engineering and engineering-economic study was conducted to evaluate alternative sites and to select a preferred site for station development. The evaluation and selection process has taken cognizance of:

a) The fuel source: Hat Creek coal

b) the transport and delivery of Hat Creek coal to the generating station

c) the thermal generating station development requirements at the eight alternative sites.

d) the load center: City of Vancouver/Lower Mainland

e) the transmission of electrical energy

f) engineering and economic data and information secured and developed during the study

g) the informed judgement and experience of the study participant in engineering, economic and environmental matters

The comparative capital and annual costs associated with plant and system construction and operation at the eight alternative sites have been identified. These costs were then combined using standard economic analysis methods and interest rates of 5% and 10%, to determine the total comparative cost attendant to each site. The difference in total comparative cost of each site from the least cost, or base, was then determined and used as a quantitative criterion to rank the sites in order of engineering-economic preference. The resulting site ranking, in order from the most to least preferred, is as follows:

5% Interest Rate	10% Interest Rate
a) Mine Mouth	a) Mine Mouth
b) Harry Lake	b) Harry Lake
c) Ashcroft	c) Ashcroft
d) Big Bar Creek	d) Big Bar Creek
e) Stave Lake	e) Dunsmuir
f) Britannia Beach	f) Stave Lake
g) Soda Creek	g) Britannia Beach
h) Dunsmuir	h) Soda Creek

Inspection of the discreet data indicates that a significant difference in total comparative cost exists between sites. The first three sites are, as a group, far more economical than the remaining sites.

Those engineering factors that are not suited to simple quantitative analysis but which, based on the informed judgement and experience of the study participants, could significantly enhance or limit the potential to develop a stable, reliable, secure and economic system of integrated energy supply, conversion and delivery have also been identified. These qualitative engineering confidence factors include consideration of:

a) the "flexibility" of the site in terms of the potential to allow for plant systems optimization during final system engineering design.

b) the potential of the site to allow for "ease of construction" in terms of minimizing or obviating project delays or cost increases.

c) the "opportunity for on-site borrow" of fill material which, if significant, would minimize or obviate the need to incur the potential for off-site environmental impacts.

d) the "expandibility" of the site in terms of ability to efficiently and economically allow development of greater than 2000 MW of generating capacity.

e) the potential to minimize the number of linkages (i.e., in transit transfers) attendant to site operation which would minimize exposure of the overall system to the vagaries of man or nature (e.g., strikes, rock slides, inclement weather) and thereby increase overall system reliability.

f) "site foundation stability" in terms assaying ash pond and dam integrity over the operating life of the station.

g) the "potential for minimum seepage" at the sites by assaying the natural soil permeability at the various sites and identifying as preferred, the opportunity to utilize sites with low permeability soils.

The results of this engineering analysis indicate that:

a) Those sites which would incur a large number of linkages (i.e., in transit transfers) in the overall system of fuel supply and transport are judged less desirable than those sites exhibiting the converse. Thus, the interior sites are considered more reliable than the Dunsmuir, Britannia Beach and Stave Lake sites.

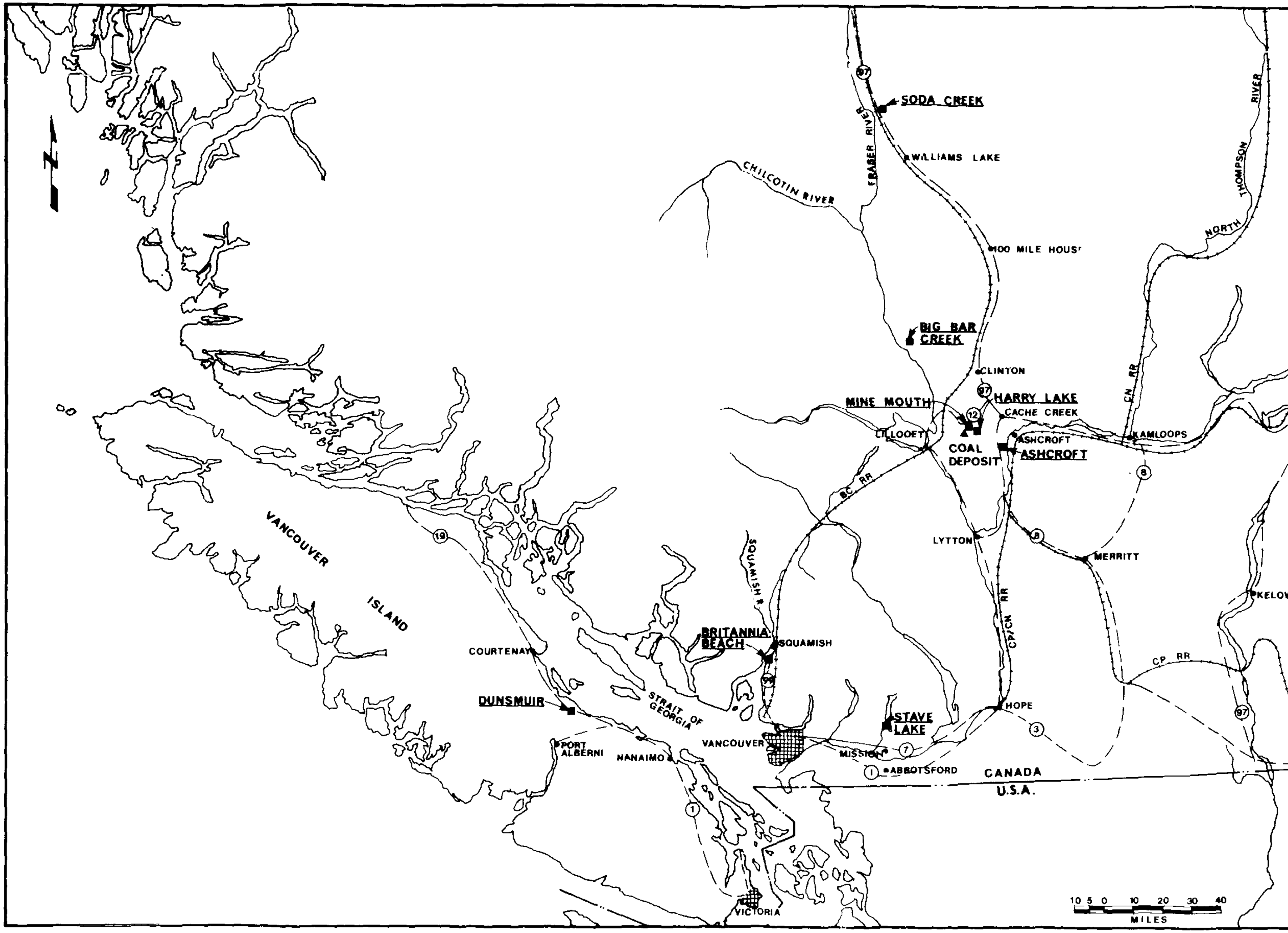
b) Those sites located in a seismic risk zone II are judged more desirable than those located in seismic risk zone III. The interior sites, therefore, are considered preferable to the coastal sites from this viewpoint.

c) The sites affording opportunity for plant systems optimization (i.e., flexibility of arrangement), expansion beyond 2,000 MW, on-site borrow of fill material, proximity to developed road and railroad, and minimizing natural seepage are judged more desirable than those sites that are limiting in these respects. Therefore, the Soda Creek, Harry Lake and Big Bar Creek sites are deemed preferable over all other sites with respect to the foregoing.

2.2 INTRODUCTION

The site selected for a large electric power generating facility must be responsive to engineering and engineering - economic factors which will assure long-term operation of the facility in a reliable, secure, stable and economic manner.

Eight sites (see Figure 2-1) have been identified as potentially suitable for thermal generating station development utilizing Hat Creek Coal. These sites differ with respect to:



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

ALTERNATIVE SITE LOCATIONS

integ - ebasco

FIGURE 2-1

a. Proximity to the fuel source
b. Proximity to the load center
c. Site specific features
d. Proximity to auxiliaries (i.e. water, rail, roads)

Three of the sites, Britannia Beach, Dunsmuir, and Stave Lake, are located in close proximity to the load center along the lower Mainland. Three other sites, Mine Mouth, Harry Lake and Ashcroft, are located in close proximity to the fuel source. The Big Bar Creek and Soda Creek sites are located on the Fraser River relatively distant from both fuel source and load center.

2.2.1 Purpose

The purpose of this Engineering/Engineering Economic Study is to evaluate the differential engineering and engineering-economic aspects of the alternative sites, to select a preferred site from the engineering-economic viewpoint, and to identify the engineering opportunities and limitations at each site that could affect the potential to achieve a secure, reliable and economic system of power generation and electrical energy delivery. Because certain of the costs or features of the various sites would be essentially the same regardless of site (e.g., turbine generator, boiler, etc.) no attempt has been made to characterize these non-differentiating aspects in this evaluation.

2.2.2 Scope

The scope of this investigation includes:

a) Identification of plant facility requirments related to: makeup water supply; road and rail access; fuel handling; transmission intertie; and solid wastes disposal.

b) Evaluation of the geologic character of each site.

c) Development of conceptual layouts of plant facilities at each site.

d) Identification of potential limitations or advantages associated with development at the various sites based on the prudent application of engineering judgment and experience.

e) Estimating, at the conceptual level, the comparative investment and annual costs associated with development at the various sites.

f) Evaluation on a differential basis, of the total comparative costs that accrue with development at the various sites.

g) Selection of a preferred site for thermal generation based on engineering-economics.

h) Identification, based on consideration of qualitative criteria that reflect engineering judgement and experience, of those engineering aspects of each site that would be expected to enhance or limit the potential to maximize plant security, reliability, integrity and economy.

2.3 MATERIALS AND METHODS

2.3.1. Data and Information Sources

The data, information and assumptions utilized in the evaluation of various system features included:

2.3.1.1 Conceptual Site Development Parameters

Generic parameters relating to power plant and auxiliary features were developed by Integ-Ebasco based on current state-of-the-art information and practice. These parameters are identified on Table 2-1 and reflect initial conceptual design understandings and assumptions necessary to begin this site evaluation study.

2.3.1.2 Makeup Water Supply and Transport

The results of the Sandwell and Company Ltd. report[1] were used as the basis for establishing the delivery and routing of the stations water supply at each site.

2.3.1.3 Coal Transport

The results of the Swan Wooster Engineering Company Ltd. report[2] were used as the basis for establishing the optimum routing of access roads and fuel supply, railroads and facilities at each site.

2.3.1.4 Site Specific Geology

Site specific surficial geological information was developed based on in-field reconnaisance and data and information developed in previous investigations (see Appendix 2-1).

TABLE 2-1

SITE DEVELOPMENT PARAMETERS

Generating Capacity: 2,000 MW consisting of four 500 MW units
Plant Heat Rate: 9,800 BTU/KW hr
Raw Fuel High Heat Value (HHV): 5,440 BTU/lb

Coal Delivery Rate: 40,000 Tons/day, or 11 x 10^6 Tons/yr at 75 percent plant capacity factor.

Ash Production: 2.86 x 10^6 Tons/year at 75 percent plant capacity factor.

Required 35 year storage volume: 50,000 acre-feet, based on storage density of 90 lbs./$ft.^3$

Space Requirements: Provisions to be made for: plant island; sludge ponds; construction materials laydown; 30 days "dead" coal storage; 7 days "live" coal storage.

Cooling System: Once through or closed-cycle with the following features:

= Once-through: 750,000 US gpm circulating water flow assuming a condenser temperature rise of 25^{o}F.

= Closed cycle: 30,000 US gpm makeup flow

TABLE 2-1 (CONT)

Makeup Storage Pond:	30 day supply of water
Supply Piping from Makeup Pond to Power Station	Provide 2 pipelines, each at 70 percent required supply rate.
Access Roads:	All weather type with maximum grade of 6 percent
Railroads:	Fuel supply railroads to have maximum grade limited to 2 percent.
Material Supply Railroads:	Maximum grade limited to 3 percent.
Coal Conveyor Belts:	Maximum slope not to exceed 16 percent.
Dikes and Dams:	Assume 20 feet crest width; side slope of 2.5 horizontal to 1 vertical; 10 foot wide berms at 50 foot rise intervals.
Land Rights:	Avoid locating plant and auxilliary facilities on Indian Reserves.
Costs:	In 1976 dollars except where stated otherwise

A

2.3.1.5 Site Topography

Information regarding specific site topography was secured from current maps at the scale of 1:5000 prepared by the Surveys and Mapping Branch, Department of Energy, Mines and Resources and verified by site reconnaisance. No site mapping was performed as part of this investigation.

2.3.1.6 Site Specific Facilities Layouts

Conceptual level site specific layouts were prepared by Integ-Ebasco. The layouts are not to be construed as final. Final layouts will be prepared after a specific preferred site has been selected and detailed engineering, environmental and economic analysis has been initiated at the preferred site.

2.3.1.7 Economic Data

a) Unit investment and annual cost data have been based on the judgement and experience of Integ-Ebasco and represent conceptual level estimates, reflective of current conditions in the Province.
b) Unit quantities were developed by Integ-Ebasco.
c) Capacity and fuel penalties at each site were estimated by Integ Ebasco.
d) Econometric data reflecting interest rates, discount rates, escalation, and return periods were established by B.C. Hydro for application by Integ-Ebasco.

2.3.1.8 Transmission Facilties

The required transmission facility costs associated with each site layout were provided by B.C. Hydro.

2.3.2 Methodology

2.3.2.1 Site Layout

Based on the data and information secured during the preliminary evaluations, site specific layouts were prepared by power plant and civil engineers in respect of engineering, economic and environmental concerns. After initial layouts were prepared, they were reviewed by other disciplinary participants in the overall site selection study to assure that realistic conceptual layouts resulted. Final conceptual layouts were then prepared and used in the engineering and engineering-economic evaluations given herein and in the evaluations by other disciplines.

2.3.2.2 Engineering Evaluation

2.3.2.2.1 Criteria Development

Site selection represents the first step in a long-term process that culminates in plant construction and operation and the realization of the desired end-product, reliable electrical energy. The overall process is one in which the scope and depth of investigation is constantly increased while the focal point of the work is constantly refined. At this site selection phase of work, it is important to recognize that: the site selection stage reflects only a conceptual level understanding of the various sites under investigation; time and economics necessarily limits the extent of investigation at the various sites; that subsequent phases of work will refine understanding of the preferred site; and, that subsequent stages in the overall process of preferred site analysis and the long-term success of the operating plant could be either severely frustrated or enhanced by decision-making at this stage. In respect of the foregoing, an evaluation of the potential sites in terms of various qualitative criteria that transcend matters presented in the engineering-economics section was undertaken. These qualitative criteria, based on engineering judgement and experience, give consideration to those aspect of the sites that would enhance progress in the overall facility development and tend to assure the reliability, integrity, security and economy of the development and its operation.

The following section identifies the qualitative criteria that have been developed by the study participants to reflect those concerns and opportunities.

2.3.2.2.2 Criteria Identification

The various aspects of engineering concern and opportunity are identified below as criteria and are subsequently discussed:

a) Flexibility of the site
b) Ease of site development
c) Opportunity for on-site borrow
d) Site expandability
e) Potential to minimize the exposure of the project to the vagaries of man and nature
f) Site foundation stability
g) Minimum potential for seepage

The "flexibility" criterion is directed at assaying the constraints that site features (i.e. geology, topographic relief, etc.) impose on locating plant facilities. For example, a site which appears to "fix" the location of major facilities to only one location at the site is considered less desirable than a site which allows for "moving" facilities about the site.

The site that is more "flexible" provides more opportunity to optimize plant systems and interconnections thereby increasing the opportunity to reduce plant investment and annual costs during the final engineering, design and construction phases of work.

The "ease of development" criterion reflects concern regarding the potential for project delays or cost increases due to access and/or space limitations and/or due to the potential to adversely affect design resolution. By way of example, a site remote from existing, reliable road or rail transportation routes is considered less desirable than a site where the converse occurs. Similarly, a site that presents features that would appear to require more extensive field or office evaluation or effort to resolve design or construction conflicts is considered less desirable than a site where the converse situation results. In this context, sites which exhibit surface expressions of possible underground faults are considered less desirable than sites where reasonable confidence has been established during this study that subsurface faults will not be encountered.

A site that exhibits a limited opportunity for "on-site borrow' of soil for dike or dam construction is considered less desirable than a site exhibiting the converse. Although borrow material may be readily available at reasonable cost in both cases, the site necessitating off-site borrow would result in other off-site impacts related to traffic, noise, and disruption of other Provincial land.

The "site expandability' criterion is directed at assaying whether a site precludes development beyond 2000 MW. Implicit in consideration of this criterion at a particular site is: whether additional land is available adjacent to the site; and, whether costs to develop beyond 2000 MW appear to militate against the potential to accrue savings related to economy-of-scale. Sites with distinct potential for expansion beyond 2000 MW are considered preferred over those limited to development of only up to 2000 MW.

It is recognized that as the distance from the fuel source to the generating facility and/or the number of "linkages" (i.e. in transit transfers) in the delivery system increase, the reliability associated with fuel delivery decreases. This is due to such unquantifiable, unpredictable "vagaries of man or nature" as: labor strikes; inclement weather (on land or sea); and, rock slides. Sites closer to the fuel source minimize this risk to overall system reliability and are, therefore, preferred over those sites more distant from, or requiring more "linkages" to, the source of coal.

The "site foundation stability" criterion assays the preferability of the sites in terms of dike foundation stability. The river banks in the Thompson River Valley, for example, exhibit a tendency to "slough off" because of intensive irrigation and, therefore, represent a concern regarding ash pond dike stability. Sites with apparent greater stability conditions are, therefore, considered preferred over sites exhibiting the converse.

Given that required protection against possible seepage from ash ponds and coal pile areas at all sites will be provided, the "seepage" criterion considered herein directs attention to the possibility of groundwater contamination due to potential lining failures over the operating life of the project. Sites exhibiting naturally low soil permeabilities are, therefore, considered preferred over sites where the converse situation exists.

2.3.2.2.3 Criteria Application

The engineering criteria were considered at each site by the study participants in a qualitative manner. The results of investigation were then arrayed in tabular form for use in the overall site evaluation process as an "engineering confidence" account.

2.3.2.3 Engineering-Economic Evaluation

2.3.2.3.1 Criteria Development

Construction and operation of a facility incurs capital and annual operating costs that could vary significantly depending on:

a) site specific elements
b) system elements reflecting integration of the facility into the overall system of energy transport and delivery

In order to preferentially rank the eight alternative sites in terms of engineering-economic factors, a single numerical criterion was established and applied which accounts for capital and annual operating costs incurred because of both site-specific and system elements.

2.3.2.3.2 Criteria Identification

The differential total comparative cost (DTCC) among the alternative sites has been used as a numerical criterion in the engineering-economics ranking of the sites. This criterion is a combined measure of two components: the comparative capital cost of the integrated thermal generating facility; and, the comparative annual operating cost of the facility over its useful life.

2.3.2.3.2.1 Comparative Capital Cost

a) Conceptual level, order-of-magnitude 1976 capital costs to develop all the related plant and system integration facilities is first estimated. This value takes account of: road construction; coal handling and transportation facilities (including rolling stock and barges); earthwork at the site;

cooling system construction; and, transmission line construction. It does not include the capital cost of those plant systems (boiler, turbine etc.) which remain the same at each site.

b) Given that construction would span an approximate 5 year period from about 1979 through 1983, it is assumed that all capital costs would be incurred in the average construction year of 1981, and that cost escalation between 1976 and 1981 would be zero.

c) The comparative capital cost was then determined by calculating the present worth (1976) of the 1981 capital cost at compound interest rates of 5 percent and 10 percent.

2.3.2.3.2.2 Comparative Annual Operating Cost

a) Conceptual level, order-of magnitude estimates of annual operating costs were estimated in 1976 dollars for the following: fuel delivery and handling; makeup water pumping and treatment; circulating water pumping; transmission losses; capacity penalty. (Energy costs were assumed at 20 mills per kilowatt hr. and a yearly system capacity factor of 75 percent).

b) Equivalent capital costs in 1983 for interest rates of 5 percent and 10 percent were then calculated for 35 years of uniform annual operating costs. This calculation assumed a plant life of 35 years whose commercial operation begins in 1983. and no escalation of operating costs over the life of the plant.

c) The comparative annual cost was then determined by calculating the present worth (1976) of the 1983 equivalent capital costs at compound interest rates of 5 percent and 10 percent.

2.3.2.3.2.3 Total Comparative Cost (TCC)

The Total Comparative Cost (TCC) for each integrated site develpment was then calculated as the sum of the Comparative Capital Cost and the Comparative Annual Operating Cost. The following costs have not been included in this analysis:

a) Cost of acquiring land for the plant facilities as well as for rights-of-way for railroad and water pipeline corridors.
b) Costs of water,if required to be purchased.
c) Ad Valorem taxes on plant and equipment
d) Sales taxes and income taxes.

2.3.2.3.3 Criteria Application Methodology

After Total Comparative Costs (TCC) were determined for each integrated site, this data was arrayed in tabular form. The smallest value was then assumed to be the "base" value and the Differential Total Comparative Cost (DTCC) of each site above the base cost was determined. Site preference ranking was then established by ordering the sites in terms of the magnitude of the value of DTCC. The preferred site is the one that represents the base, or least, cost site. As the value of DTCC increases, the associated sites are considered increasingly less preferred.

2.4 RESULTS

2.4.1 Results of Engineering Evaluation

Each site was assayed qualitatively in terms of its ability to enhance or limit the potential for development of an integrated, secure, reliable, stable and economic system of energy conversion and delivery. The results of the study are presented in Table 2-2 and are summarized as follows:

a) Those sites which would incur a large number of linkages (i.e., in-transit transfer) in the overall system of fuel supply and transport are judged less desirable than those sites exhibiting the converse. Thus, the interior sites are considered more reliable than the Dunsmuir, Britannia Beach and Stave Lake sites.

b) Those sites located in a seismic risk zone 11 are judged more desirable than those located in seismic risk zone 111. The interior sites, therefore, are considered preferable to the coastal sites from this viewpoint.

c) Among the sites, those affording opportunity for plant systems optimization (i.e., flexibility of arrangement), expansion beyond 2,000 MW, on-site borrow of fill material, proximity to developed road and railroad, and minimizing natural seepage are judged more desirable than those sites that are limiting in these respects. Therefore, the Soda Creek, Harry Lake and Big Bar Creek sites are deemed preferable over all other sites with respect to the foregoing.

TABLE 2-2

ENGINEERING CONFIDENCE

SITE	ENGINEERING CHARACTER
Dunsmuir	• Easy development with good access and mild topography. • Adjacent to load and transmission. • Limited space provides for little flexibility and limited expansion potential. • High soil permiability/Seismic III zone.
Britannia Beach	• Excellent accessibility to site. • Severe space limitations with no potential for expansion and little flexibility for development. • Located in Seismic III zone.
Stave Lake	• Generally difficult development located in Seismic III zone with highly permiable soils. • Space limitations preclude the potential for expansion and flexible plant development. • Rail and Road access to the site would be difficult.
Ashcroft	• Space limitations and topography preclude expansion and the potential for optimizing plant arrangement. • Unstable foundation characteristics can result from seepage. • Ease of access to site and proximity to fuel provides for ready development. • Seismic II zone.

Cont'd

TABLE 2-2

ENGINEERING CONFIDENCE

SITE	ENGINEERING CHARACTER
Mine Mouth	• Although flexibility for development exists, mine development and valley location would limit expansion potential. • Valley location provides for difficult access and water supply. • Seismic II zone location and closeness to feel source enhances its character.
Harry Lake	• Site remoteness provides for difficult access and water supply. • Both expansion and flexibility potential exists at this site. • Seismic II zone location and closeness to fuel source enhances its character.
Big Bar Creek	• Site provides good potential for expansion and plant arrangement flexibility. • Seismic II zone location. • Site remoteness provides for difficult access.
Soda Creek	• Distant from both load and fuel source, also provides for difficult access. • Seismic II zone. • Good potential for expansion as well as flexibility of arrangement.

2.4.2 Results of Engineering - Economic Evaluation

2.4.2.1 Numerical Results

The results of engineering-economic analysis are presented in Tables 2-3 through 2-6 and are summarized as follows:

a) The capital cost data in Table 2-3 presents component costs, total capital cost and comparative capital costs at each site. In terms of 1981 dollars, the dollars capital costs range from a minimum of 155.4 million dollars to a maximum of 420.7 million dollars, respectively, at the Dunsmuir and Soda Creek sites for a compound interest rate of 5 percent. For a compound interest rate of 10 percent the capital costs range from a minimum of 18.8 million dollars at Dunsmuir to a maximum of 354.7 million dollars at Soda Creek. The Comparative Capital Cost (1976 dollars) range from 121.8 million dollars at Dunsmuir to 329.6 million dollars at Soda Creek for an interest rate of 5 percent, and from 11.7 million dollars at Dunsmuir to 220.2 million dollars at Soda Creek for an interest rate of 10 percent.

b) The total annual operating cost data in Table 2-4 indicates a range from a low of 19.0 million dollars at the Mine Mouth site to a high of 86.9 million dollars at Dunsmuir. The Comparative Annual Operating Costs (1976 dollars) range from a low of 221 million dollars for Mine Mouth to a high of 1011 million dollars at Dunsmuir for an interest rate of 5 percent. For an interest rate of 10 percent the Comparative Annual Operating Costs range from 95 million dollars at Mine Mouth to 431 million dollars at Dunsmuir.

TABLE 2-3

CAPITAL COSTS SUMMARY

(All Costs in Millions of Dollars)

		CAPITAL COSTS (1981)								COMPARATIVE CAPITAL COST (1976)	
Site	Roads	Coal * Handling & Transp.		Earth-work	Cooling System	Make-up Water System	Trans-mission	Total			
		5%	10%					5%	10%	5%	10%
Dunsmuir	0.6	332.6	195.9	33.4	38.7	10.2	(260)	155.5	18.8	121.8	11.7
Britannia Beach	-	199.9	117.8	18.1	47.0	14.0	31.7	310.7	228.6	243.7	142.2
Stave Lake	2.6	153.1	90.5	28.5	9.2	0	25.3	218.7	151.1	171.4	96.9
Ashcroft	0.5	100.9	59.4	39.0	35.9	10.7	101.2	288.2	246.7	225.8	153.2
Mine Mouth	12.0	8.2	4.8	7.4	35.9	49.7	101.2	214.4	211.0	168.0	131.0
Harry Lake	13.0	24.6	14.5	26.0	35.9	47.8	101.2	248.5	238.4	194.7	148.0
Big Bar Creek	20.0	145.9	85.9	43.4	35.9	35.2	99.7	380.1	320.1	297.8	198.8
Soda Creek	3.2	160.5	94.5	42.9	35.9	35.2	143.0	420.7	354.7	329.6	220.2

* Represents equivalent capital costs as developed from the proposed Hat Creek Development Transportation Study economic data summarized in Table 2-7 of this report.

TABLE 2-4

ANNUAL OPERATING COSTS SUMMARY

(All Costs in Millions of Dollars)

Site	ANNUAL OPERATING COSTS						EQUIVALENT CAPITAL COST (1983)		COMPARATIVE ANNUAL OPERATING COST (1976)	
	Coal Transit	Make-up System	Make-up Pumping	Circulating Water Pump	Transit	Total	5%	10%	5%	10%
Dunsmuir	80.5	0.1	0	2.7	3.6	86.9	1,422.9	838.1	1,011	431
Britannia Beach	62.0	0.1	0	1.4	2.3	65.8	1,077.4	634.6	765	326
Stave Lake	67.0	0	0	1.4	3.2	71.6	1,172.4	690.5	833	355
Ashcroft	6.2	0.3	0.7	2.7	10.5	20.4	334.0	196.7	237	101
Mine Mouth	0.7	0.2	4.9	2.7	10.5	19.0	311.1	183.2	221	95
Harry Lake	1.8	0.2	4.5	2.7	10.5	19.7	322.6	190.0	229	98
Big Bar Creek	18.8	0.6	4.3	2.7	11.7	38.1	623.8	367.4	443	189
Soda Creek	42.6	0.6	4.3	2.7	14.1	64.3	1,052.3	620.1	748	319

TABLE 2-5

COMPARATIVE COSTS SUMMARY

(All Costs in Millions of Dollars)

ASSUMING 5% INTEREST RATE

Site	Comparative Capital Costs	Comparative Annual Operating Costs	Total Comparative Costs	Differential Total Comparative Costs
Dunsmuir	122	1,011	1,133	744
Britannia Beach	244	765	1,009	620
Stave Lake	171	833	1,004	615
Ashcroft	226	237	463	74
Mine Mouth	168	221	389	base 0
Harry Lake	195	229	424	35
Big Bar Creek	298	443	741	352
Soda Creek	330	748	1,078	689

TABLE 2-6

COMPARATIVE COSTS SUMMARY

(All Costs in Millions of Dollars)

ASSUMING 10% INTEREST RATE

Site	Comparative Capital Costs	Comparative Annual Operating Costs	Total Comparative Costs	Differential Total Comparative Costs
Dunsmuir	12	431	443	217
Britannia Beach	142	326	468	242
Stave Lake	97	355	452	226
Ashcroft	153	101	254	28
Mine Mouth	131	95	226	base (0)
Harry Lake	148	98	246	20
Big Bar Creek	199	189	388	142
Soda Creek	220	319	539	313

TABLE 2-7

SUMMARY OF COAL TRANSPORTATION COSTS
(All Costs in Millions of Dollars)
(from SWAN-WOOSTER ENGINEERING CO. LTD. REPORT)*

Site	Capital Cost	Equivalent Annual Cost	Equivalent Capital Cost 35 years		Annual Cost	Equivalent Capital Cost 35 years		Total Comparative Costs	
			5%	10%		5%	10%	5%	10%
Dunsmuir	176.6	20.3	332.6	195.9	80.5	1,318.8	776.6	1,651.3	972.6
Britannia Beach	107.0	13.2	199.9	117.8	62.0	1,001.4	590.0	1,200.5	707.7
Stave Lake	60.7	9.4	153.1	90.5	67.0	1,096.9	646.1	1,250.0	736.3
Ashcroft	50.6	6.2	100.9	59.4	6.2	100.9	59.4	201.7	118.8
Mine Mouth	4.4	0.5	8.2	4.8	0.7	10.6	6.3	18.9	11.1
Harry Lake	12.2	1.5	24.6	14.5	1.8	31.9	18.8	56.5	33.27
Big Bar Creek	72.9	8.9	145.9	85.9	18.8	308.0	181.4	453.9	267.4
Soda Creek	72.2	9.8	160.5	94.5	42.6	698.2	411.3	858.7	505.77

*These costs are adjusted by Integ-Ebasco to reflect specific site requirements.

TABLE 2-8

SUMMARY MAKE-UP WATER COSTS

(from SANDWELL & CO. LTD. REPORT)

	DUNSMUIR	BRITANNIA BEACH	STAVE ** LAKE	ASHCROFT	MINE MOUTH	HARRY LAKE	BIG BAR CREEK	SODA * CREEK
CAPITAL COST	10,200,000	14,000,000	0	10,700,000	49,700,000	47,800,000	35,200,000	35,200.00
ANNUAL OPERATING COST	138,000	138,000	0	335,000	170,000	170,000	635,000	635,000
ANNUAL PUMPING COST	44,000	42,000	0	650,000	4,940,000	4,480,000	4,345,000	4,345,000

* Soda Creek costs estimated by INTEG/EBASCO.

** No separate make-up water costs are identified for Stave Lake. The costs are part of and accounted for in circulating water system costs.

c) Tables 2-5 and 2-6 present Total Comparative Cost data (1976 dollars) for each of the sites for discount rates of 5 and 10 percent, respectively. The Mine Mouth site incurs the least total comparative cost for both interest rates whereas, the Dunsmuir site incurs the greatest total comparative cost for an interest rate of 5 percent and Soda Creek incurs the greatest total comparative costs for an interest rate of 10 percent.

d) Differential Total Comparative Costs for the alternative sites are given in Tables 2-5 and 2-6. The base or least cost, site is Mine Mouth followed by Harry Lake for both the 5 percent and 10 percent interest rates. The most costly site is Dunsmuir at a 5 percent interest rate whereas at a 10 percent interest rate the mostly costly site is Soda Creek.

2.4.2.2 Site Ranking

Based on the results of the engineering-economic analysis and the differential total comparative cost data presented in Tables 2-5 and 2-6, the ranking ofthe potential sites in order from most to least preferred, is as follows:

5%	10%
- Mine Mouth	Mine Mouth
- Harry Lake	Harry Lake
- Ashcroft	Ashcroft
- Big Bar Creek	Big Bar Creek
- Stave Lake	Dunsmuir
- Britannia Beach	Stave Lake
- Soda Creek	Britannia Beach
- Dunsmuir	Soda Creek

Because of the great differences in differential total comparative costs among the sites, the Mine Mouth, Harry Lake and Ashcroft sites, as a group, are greatly preferred over all remaining sites.

2.4.3 Conclusions

Based on the foregoing results of engineering and engineering-economic study, it is concluded that:

1. As a group, the Mine Mouth, Harry Lake and Ashcroft sites are far superior to all other sites when evaluated from the Total Comparative Cost viewpoint.

2. From the engineering viewpoint, the interior sites as a group offer the greatest opportunity to enhance ultimate development of a reliable, stable, secure and economic power plant site and integrated energy system. Among the interior sites, the Soda Creek, Harry Lake and Big Bar Creek sites are judged preferred over other sites in this respect.

3. The Harry Lake site is the singular site which satisfies both quantitative and qualitive criteria.

2.5 DISCUSSION

2.5.1 Introduction

This section presents a detailed discussion on a site-by-site basis of:

a) The conceptual engineering development planned for each site for 2000 MW of steam electric generating station using Hat Creek coal and the integration of the site into the overall energy delivery system.

b) The engineering aspects of each site that are judged to limit or enhance the site and its integration into the system.

c) The engineering-economic features of each site.

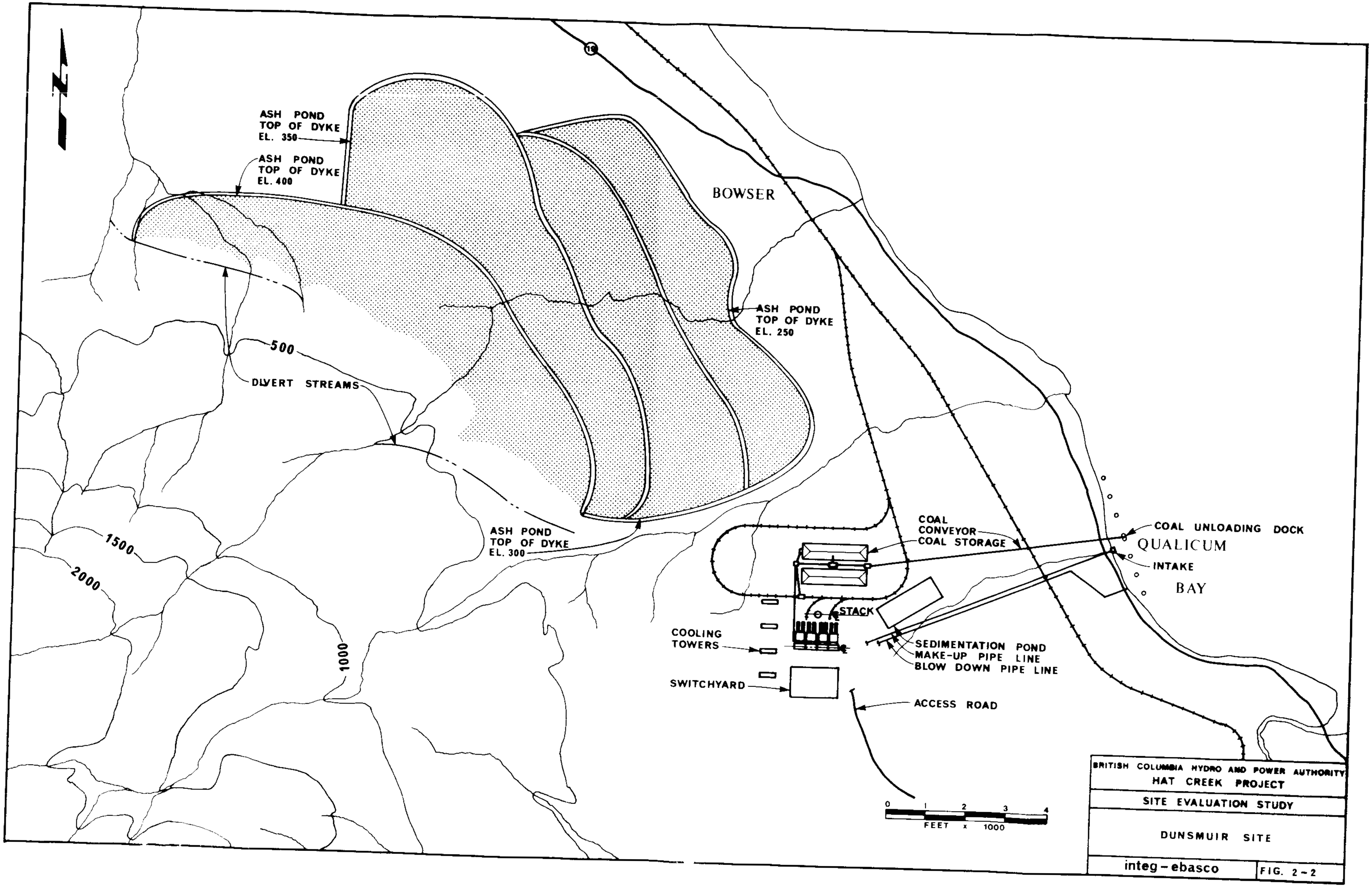
2.5.2 Dunsmuir (see Figure 2-2)

2.5.2.1 Site and Facilities Description

2.5.2.1.1 Site Location

The Dunsmuir site is located on Qualicum Bay on the east coast of Vancouver Island about 100 miles from Victoria and about 160 miles southwest of the Hat Creek Valley. The site is near the town of Bowser and about 20 miles northwest of Victoria. Vancouver is about 40 miles north-northeast of the site across the Strait of Georgia. Primary road access to the site is via Highway 19, a main highway which follows the east coast of the Island from Victoria to Kelsey Bay about 160 miles northwest of the site. The Esquimalt and Nanaimo Railroad is located near the site, roughly parallel to Highway 12 and about 1/2 mile further inland.

The site is located on a coastal plain about one mile from the shore and at an elevation of from 200 to 300 feet above sea level. The site area is presently undeveloped forest and the area between the site and the shore slopes gently downward toward the shore.


ASH POND
TOP OF DYKE
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ASH POND
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EL. 400
BOWSER
ASH POND
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EL. 250
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DIVERT STREAMS
ASH POND
TOP OF DYKE
EL. 300
1500
2000
1000
COAL
CONVEYOR
COAL STORAGE
COAL UNLOADING DOCK
QUALICUM
INTAKE
BAY
STACK
COOLING
TOWERS
SEDIMENTATION POND
MAKE-UP PIPE LINE
BLOW DOWN PIPE LINE
SWITCHYARD
ACCESS ROAD
0 1 2 3 4
FEET x 1000
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
DUNSMUIR SITE
integ-ebasco
FIG. 2-2

2.5.2.1.2 Road Access

Road access to the site is planned by connecting to a one lane loose surface road located about 2000 ft. upland of the site. The existing road connects to Highway 19 in the vicinity of the mouth of the Qualicum River about 2.2 miles east of the site. This road would have to be widened and upgraded to accommodate construction activities as well as maintenance and operating activities of the completed generating unit.

2.5.2.1.3 Coal Transportation

Coal transportation to this site would be via railroad, barge and conveyor; a total overland distance of about 160 miles and an overwater (Strait of Georgia) distance of about 40 miles. Coal would be loaded into unit train at the mine and shipped by rail to Britannia on Howe Sound. The coal would then be transferred into barges which would be towed across the Strait of Georgia to a terminal to be constructed on Qualicum Bay in the vicinity of the site. From the site terminal, coal would be unloaded and transported via a one mile long overhead conveyor system to the plant coal storage area.

. The unit train would be composed of 50 to 100 hopper cars, each with a capacity of 100 tons, and an appropriate number of locomotives depending on the size of the train and the track grades encountered. The unit train(s) would be dedicated to transporting the coal on a continuous basis between the source of the coal and its destination. The size of the unit train and the number of trains required per day would depend primarily on the amount of coal to be transported and the distance between the pickup point and the discharge point. For this site, the round trip from the mine to Britannia Beach would be about 320 miles. Assuming a unit train of ninety hundred-ton hopper cars and 9 locomotive, about 4½ train loads would be required per day. This would necessitate the operation of 4 unit trains.

In order to tie the site into existing railroad facilities, a new 16 mile spur would have to be constructed from the Hat Creek Mine to the town of Pavilion where it would be connected into the B.C. Railroad which presently serves Britannia Beach. This spur would generally follow Route 12 from the mine to Pavilion.

A railroad-to-barge transfer facility would be constructed at Britannia Beach to transfer the coal to barges for barge shipment to the site. Assuming barges with a capacity of 6000 tons are used, then 7 barge loads would be required per day. It is estimated that 7 barges would be required with an equal number of tug boats. Each barge with a loaded draft of about 17 feet would be about 230 feet long and 60 feet wide.

Coal shipped by rail to Britannia Beach would travel primarily over existing B.C. Railroad facilities. It is assumed that this service would be supplied by the railroad on the basis of a negotiated price and that this price would include provisions for new track facilities as well as rolling stock. An investigation was made to determine the prevailing tariff for the equivalent of this run and it was determined that the tariff would be about $6.50 per ton. Because the capital cost estimate for this study includes the cost of new track and rolling stock, an adjustment was made to the tariff as follows: The costs were annualized and converted to a cost per ton. This figure was then subtracted from the estimated tariff to produce a net tariff of $5.50 per ton. The net tariff was then applied as an annual cost component.

2.5.2.1.4 Condenser Cooling Water System

Condenser cooling would be provided by a closed cycle system using evaporative type mechanical draft cooling towers located as shown on Figure 2-2. Makeup would be drawn directly from Qualicum Bay and blowdown discharged back to the Bay. The intake structure would be located on the shoreline and would be equipped with travelling screen assemblies to screen out any debris. The system would be designed to supply a maximum of 30,000 gpm to the plant. The intake and discharge pipelines would be buried and would each be about 1 1/4 miles long.

2.5.2.1.5 Freshwater Makeup

Freshwater makeup for the potable water supply,steam system and sanitary uses would be drawn from the Little Qualicum River about 7 miles southeast of the plant site.

2.5.2.1.6 Ash Storage

An ash storage area of about 2500 acres would be located northwest of the plant island in an area which slopes gently downward toward the shore of the Strait of Georgia. The storage area would be developed over the plant lifetime in terraces by diking successive areas shown on Figure 2-2.

2.5.2.1.7 Transmission

The following additional transmission facilities would have to be constructed in order to integrate a plant at the Dunsmuir site into B.C. Hydro's transmission system:

a) 500 KV transmission overhead circuits from the plant to a presently existing substation located about 1 mile south of the site.

b) One 230 KV circuit between Cheekye and Sechelt (about 40 miles) and additional transformers at each station.

Development at this site would preclude the need for the presently planned submarine transmission line between Cheekye on the Mainland and Dunsmuir.

2.5.2.2 Engineering Features

Those engineering aspects which enhance this site include:

a) Site development would be relatively easy because it is flat and because of its proximity to nearby roads, rails and waterbodies. No materials delivery problems should accrue during construction.

b) The close proximity of the site to existing transmission and load center.

Limiting aspects of this site include:

a) Expansion beyond 2000 MW does not appear possible due to limited land available for ash ponds.

b) The natural site soil character indicates relatively high permeability.

c) Location in Seismic III zone.

d) The distance from the Hat Creek mine is great and the number of "linkages" in the fuel delivery system is high. This tends to reduce the reliability associated with fuel delivery.

2.5.2.3 Engineering-Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $155.5 million in 1981 at 5 percent
$ 18.8 million in 1981 at 10 percent

b) Annual Operating Cost: $ 86.9 million

c) Total Comparative Cost (1976 dollars)

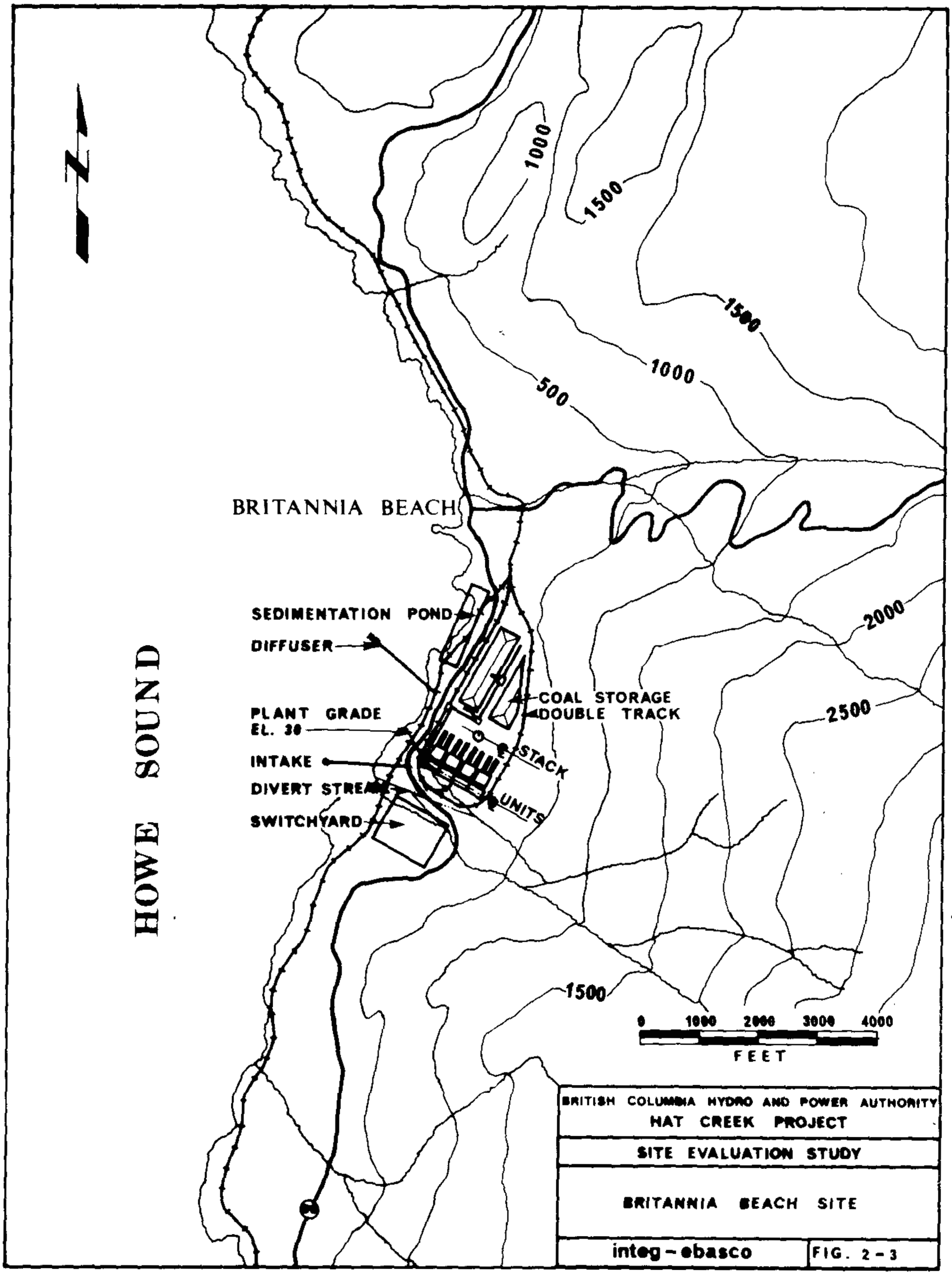
@ 5% interest rate - $1,133 million
@10% interest rate - $ 443 million

2.5.3 Britannia Beach (see Figure 2-3)

2.5.3.1 Site and Facilities Description

2.5.3.1.1 Site Location

The Britannia Beach Site is located on the eastern shore of Howe Sound, approximately 30 miles north of the City of Vancouver and 100 miles southwest (on the straight line distance) of the Hat Creek coal deposit. The site is an abandoned gravel quarry which has been extensively strip mined, leaving a relatively flat surface at about elevation 30 feet above sea level. The site is presently served by Highway 99, a hard surface road, which is routed along the shore of the Sound from Vancouver to the site. The B.C. Railroad line between Vancouver and Pavilion passes the site. Because there is no land area in the vicinity



1000
1500
1500
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500
BRITANNIA BEACH
SEDIMENTATION POND
DIFFUSER
COAL STORAGE
DOUBLE TRACK
PLANT GRADE
EL. 30
STACK
INTAKE
DIVERT STREAM
UNITS
SWITCHYARD
HOWE SOUND
2000
2500
1500
0 1000 2000 3000 4000
FEET
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
BRITANNIA BEACH SITE
integ - ebasco
FIG. 2-3

of the site which could reasonably be developed to store 35 years of ash, it has been assumed that ash would be transported back to the mine site via the unit train for disposal.

2.5.3.1.2 Road Access

Coal transportation to this site is the same as discussed for the Dunsmuir Site (i.e., a new 16 mile spur from the mine to Pavilion where a connection is made to the existing B.C. Railroad line to Britannia). It would traverse a total overland distance of 160 miles. Unit trains would be used to transport coal from the mine to the site and ash from the site to the mine.

A coal transfer facility would have to be installed at the site to transfer coal from the unit trains to the plant storage area, and because of the limited space available, a double railroad track facility would be required for unloading.

A net railroad tariff of $5.50 per ton (as discussed with the Dunsmuir Site) has been included for this site as an annual cost component.

2.5.3.1.4 Condenser Cooling Water System

The condenser cooling water system would be a once-through system that would withdraw about 750,000 gpm of water from Howe Sound and discharge the heated condenser discharge back to the Sound via a subaqueous discharge line. The discharge line would be about 1800 feet long and would be equipped with a multiport diffuser designed to promote efficient mixing of the thermal discharge with the receiving water body.

The connected pump horsepower rating of the pumps for this system is estimated at about 13,000 HP, and the electrical power requirement would be about 9.6 MW.

2.5.3.1.5 Freshwater Makeup

Freshwater makeup for the plant potable water supply system, steam system, and sanitary system would be drawn from the Mamquam River about 3 miles upstream of its confluence with the Squamish River. A surface intake would be located on the south bank of the river and water would be conveyed via pipeline following existing forest roads to the Squamish Highway and then along the B.C. Railroad right-of-way to the site. The overall pipe would be about 9 miles.

2.5.3.1.7 Transmission

In order to integrate a 2000 MW plant at Britannia Beach into B.C. Hydro's transmission network, approximately 62 miles of new 500 kV transmission facilities would be required.

2.5.3.2 Engineering Features

The singular enhancing aspect of this site from the engineering viewpoint concerns the ease of accessibility to the site.

A variety of factors appear to significantly limit the engineering desirability of this site including:

a) The "tightness" of the site limits potential for on-site systems optimization.

b) There exists no potential to expand the site beyond 2000 MW.

c) The site is located in a Seismic III zone.

d) A number of linkages are required for this site and are related to makeup water supply and rail transport of ash to the mine for disposal.

2.5.3.3 Engineering-Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $311.1 million in 1981 at 5 percent
$229 million in 1981 at 10 percent

b) Annual Operating Cost: $ 65.8 million

c) Total Comparative Cost (1976 dollars):

@ 5 percent interest rate - $1009 million
@ 10 percent interest rate - $ 468 million

2.5.4 Stave Lake (see Figure 2-4)

2.5.4.1 Site and Facilities Description

2.5.4.1.1 Site Location

The Stave Lake site is located about 40 miles east of the City of Vancouver and about 100 miles south-southeast of the Hat Creek coal deposit on the coastal side of the Lillooet Mountain range. The site is located on a peninsula which extends northward into the lake. Stave Lake is a manmade lake that was formed by daming the Stave River, a tributary of the Fraser River, about 5 miles upstream of its confluence with the Fraser River. Although a hydro-electric power plant is installed at the dam, the lake was originally dammed for flood control purposes. The site is set at an elevation of about 280 feet (MSL).

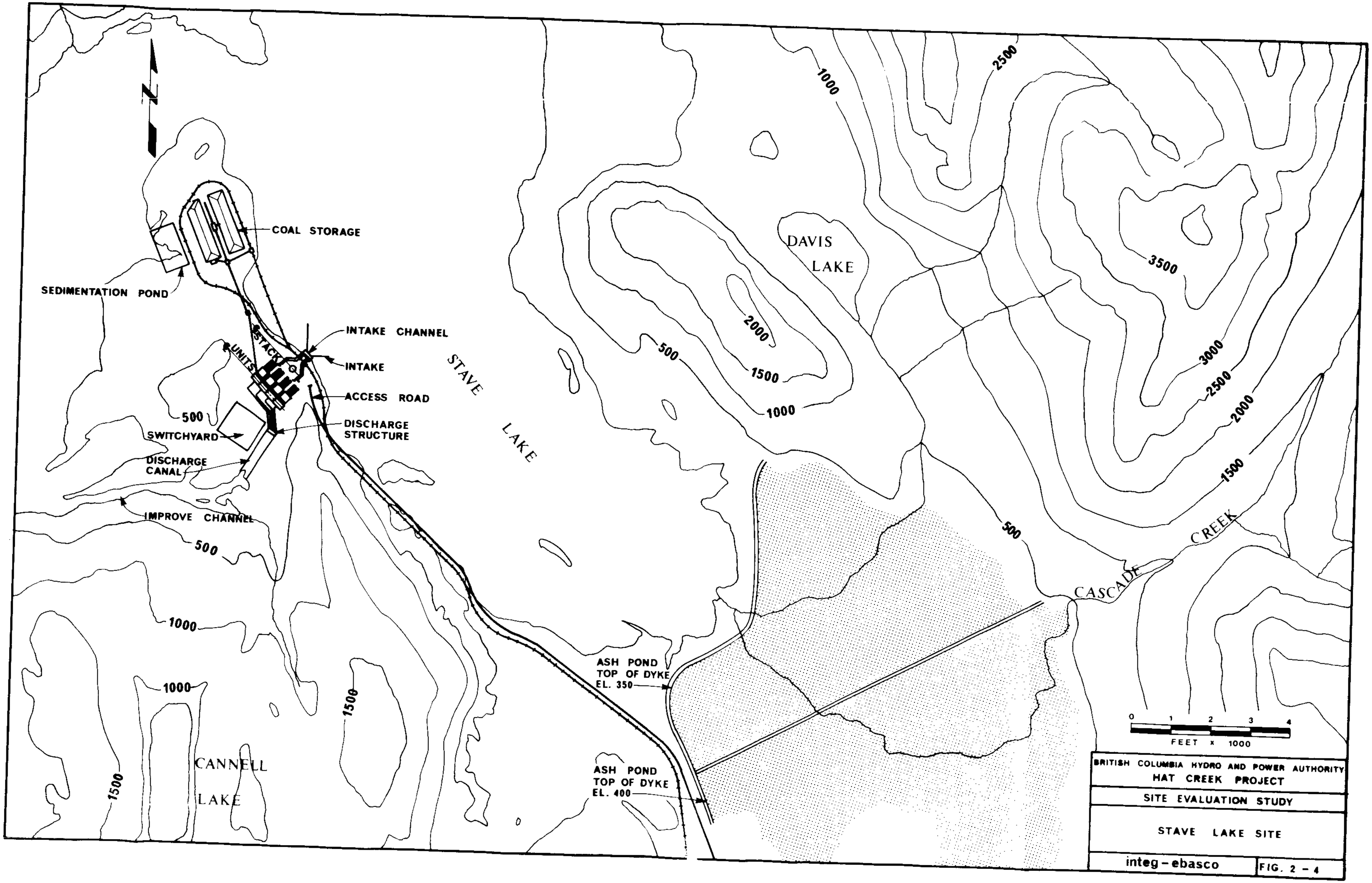
The closest road access to the site is a loose surface, all weather road located about 3 miles southeast of the site. This road is routed in a southerly direction and connects with Highway 7 in the vicinity of Dewdney. The closest railroad is the Canadian Pacific Railroad and its closest approach to the site is at Dewdney.

2.5.4.1.2 Road Access

Road access for construction and operating purposes would be provided by construction of a 9 mile long road to connect with the existing loose surface road, and in addition, upgrading about 7 miles of that loose surface road.

2.5.4.1.3 Coal Transportation

Coal would be transported to the site via unit trains over a railroad distance of about 160 miles, consisting of 28 miles of new track and 132 miles of existing line. A new 16 mile spur would be constructed from the site to Carquile following Route 12 where it would tie into the C.P. Railroad line running to Dewdney to the plant storage area. In addition, a coal car unloading facility would be constructed at the site.


COAL STORAGE
SEDIMENTATION POND
INTAKE CHANNEL
STACK
UNITS
INTAKE
ACCESS ROAD
DISCHARGE STRUCTURE
SWITCHYARD
DISCHARGE CANAL
IMPROVE CHANNEL
STAVE LAKE
DAVIS LAKE
CANNELL LAKE
CASCADE CREEK
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BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
STAVE LAKE SITE
integ - ebasco
FIG. 2 - 4

The composition of the unit trains and the number of trains required would be the same as for the Dunsmuir Site.

A net railroad tariff of $5.50 per ton (see discussion of net tariff with Dunsmuir Site) has been included for this site as an annual cost component.

2.5.4.1.4 Condenser Cooling Water System

Development at this site would use Stave Lake as a cooling lake, i.e., a heat sink for the dissipation of the waste heat produced as a consequence of power generation. The thermal load on the lake would be dissipated by two mechanisms: the forced evaporation of water at the surface of the lake; and, by dilution with the water flowing through the lake. It is estimated that the flow through the lake is about 4000 cfs on an average yearly basis. The intake would be a surface intake, located on the east leg of the lake and the discharge would be located on the west leg of the lake in the active channel.

The connected pumping horsepower rating for this system is estimated at about 13,000 HP, and the electrical power requirement would be about 9.6 MW.

2.5.4.1.5 Freshwater Makeup

Freshwater makeup for the potable water supply, steam system and sanitary uses would also be drawn directly from the lake.

2.5.4.1.6 Ash Storage

The ash storage area would be located about 2 1/2 miles southeast of the plant island area. A natural basin would be formed by diking the western perimeter of the planned storage area with about 2-1/2 miles of 60 foot high dike. The area impounded would be about 2500 acres.

2.5.4.1.7 Transmission

In order to integrate a 2000 MW plant at Stave Lake into B.C. Hydro's transmission network, approximately 56 miles of new transmission facilities would be required.

2.5.4.2 Engineering Features

There is no singular aspect of this site that is judged to enhance it for power plant development or long term operation.

Those engineering aspects which militate against this site include:

a) Site located in Seismic III zone.
b) The natural soil is quite permeable.
c) Space limitations preclude the potential for reasonable optimization of plant facilities.
d) No on-site borrow of soil appears possible.
e) Expansion beyond 2000 MW is precluded.
f) Road and rail access development would be difficult.

2.5.4.3 Engineering-Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $218.7 million in 1981 at 5 percent
$156.1 million in 1981 at 10 percent

b) Annual Operating Cost: $ 71.6 million

c) Total Comparative Cost (1976 dollars):

@ 5 percent interest rate - $1,004 million
@ 10 percent interest rate - $ 452 million

2.5.5 Ashcroft (See Figure 2-5)

2.5.5.1 Site and Facilities Description

2.5.5.1.1 Site Location

The Ashcroft site is located on the west bank of the Thompson River about 6 miles downstream of the City of Ashcroft and about 36 miles upstream of the confluence of the Thompson and Fraser Rivers. The site is about 130 miles northeast of the City of Vancouver and about 17 miles southeast of the Hat Creek coal deposit.

The proposed plant area, which would be graded to about elevation 1240 feet (MSL) is located on an almost flat tract of land east of Red Hill and would be about 400 feet above the Thompson River. Most of the site is presently under cultivation and a few small intermittent streams run through the site to the river.

The Trans Canada Highway, (Highway 1) a major north-south transportation artery, passes the site about 1 mile to the west. The Canadian Pacific Railroad passes along the east bank of the Thompson River(across the river from the site) and crosses the river to the west bank about 2 1/2 miles downstream of the site.

2.5.5.1.2 Road Access

A new road would be constructed from the site to Highway 1, a distance of about 1 mile.

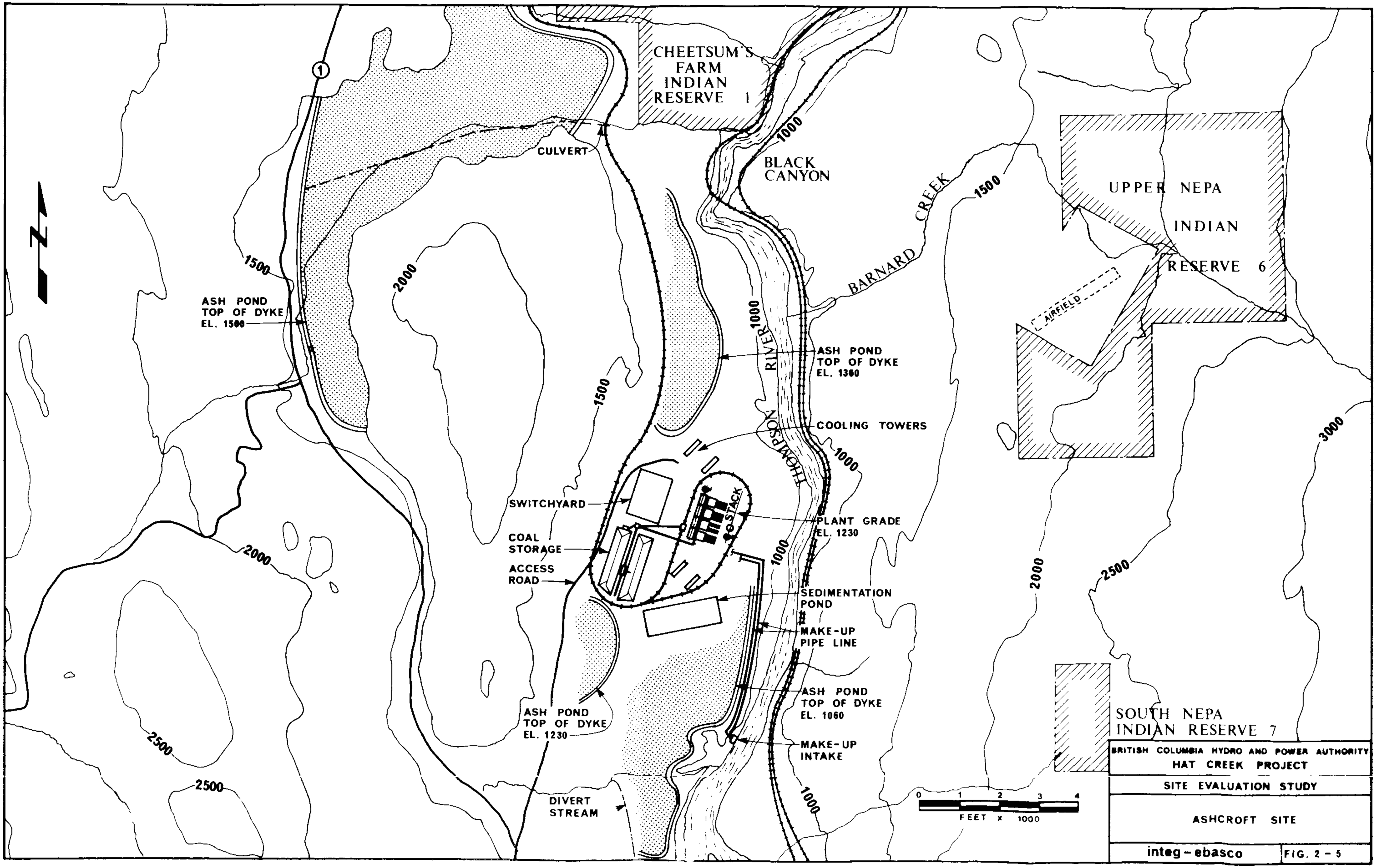
2.5.5.1.3 Coal Transportation

For coal transportation to the site, a 31 mile long private railroad from the site would be constructed. The railroad would be routed from the mine in a northeast direction along Highway 12 to Carquille and thence in a southerly direction along Highways 97 and 1 to the site. A car unloading facility would be provided at the plant.

A unit train consisting of eighty one hundred ton hopper cars and 3 locomotives would be required and it would make 5 round trips between the mine and the site per day. It has been assumed that B.C. Hydro would own and operate this railroad.

2.5.5.1.4 Condenser Cooling Water System

Condenser cooling would be provided by a closed cycle system using evaporative type machanical draft cooling towers located as shown on Figure 2-5. The connected pump horsepower for this system would be about 26,000 HP and the electrical energy requirement would be about 20 MW.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
ASHCROFT SITE
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FIG. 2 - 5

2.5.5.1.5 Makeup Water

Makeup water would be withdrawn from the Thompson River. The intake structure would be located on the west bank of the river about 1 1/2 miles downstream of the site and would be pumped to the site via a buried pipeline about 2 miles long. Because of the proximity of the site to the source of water, a water storage reservoir is not deemed required at this site.

The connected horsepower of the pumps would be about 4,500 HP and the electric power required would be about 3.4 MW.

2.5.5.1.6 Ash Storage

Storage for ash disposal would be provided by four separate ponds created by constructing earth embankments and utilizing natural contours wherever possible to minimize earthwork. The largest pond, comprising 75 percent of total storage volume would be located to the northwest of Red Hill with a crest elevation of approximately 1540 feet, MSL. The remaining three ponds, all adjacent to the plant area, would have crest elevations of approximately 1370 feet, 1310 feet, and 1110 feet, MSL. The 42,000 feet of dikes have an average height of about 70 feet.

2.5.5.1.7 Transmission

In order to integrate a 2000 MWe plant at Ashcroft into B.C. Hydro's transmission network, approximately 262 miles of new transmission facilities would be required.

2.5.5.2 Engineering Features

Except for proximity to the fuel source, ease of development, and location in Seismic Zone II, a number of factors limit the engineering opportunities and confidence at this site. These limitations include:

a) Limited site area and topographical features preclude development beyond 2000 MW and the potential for optimizing plant arrangements.

b) Because ash ponds would, of necessity, be located at a higher elevation than the plant, ash pumping problems could accrue thereby increasing the potential for plant outage time.

c) The site is located on lands that are known to be unstable at the banks due to intensive irrigation in the area. Seepage from plant facilities could exacerbate this undesirable situation.

2.5.5.3 Engineering Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $288.2 million in 1981 at 5 percent
$246.7 million in 1981 at 10 percent

b) Annual Operating Cost: $20.4 million

c) Total Comparative Cost (1976 Dollars);

@ 5% interest rate - $463 million

@ 10% interest rate - $254 million

2.5.6 Mine Mouth Site (See Figure 2-6)

2.5.6.1 Site and Facilities Description

2.5.6.1.1 Site Location

The Mine Mouth site is located approximately 130 miles north-northeast of the City of Vancouver and is about 1/2 mile NE of the Hat Creek Coal Deposit No. 1. It is situated on the east bank of Hat Creek. The south boundary of the Bonaparte Indian Reserve is approximately 1/2 mile north of the site and a second Bonaparte Indian Reserve is located about 2 miles northwest of the site. The site is located on a wooded, relatively flat terrace above the Hat Creek valley at an approximate elevation of 3100 feet (MSL). The terrain immediately east of the site rises steeply to an elevation of about 5000 feet MSL.

2.5.6.1.2 Road Access

Two alternate routes for road access have been considered. The first involves upgrading existing Highway 12 from Carquile to the mine (14 miles) and the constructing of about 5 miles of new road into the plant area The second route would branch off Highway 1 near Cornwall Creek, follow northwest along Cornwall Creek and then west along Medicine Creek to a point south of the plant site, then northwest into the plant. This alternative involves a total of 15 miles; 10 miles of which would require upgrading of an existing loose surface road and construction of 5 miles of new road. The first alternate is lower in cost, however, it passes through two Indian Reserves. Because of this, the route through the Cornwall/ Medicine Creek valleys has been selected and evaluated herein.

2.5.6.1.3 Railroad Access

The closest existing rail facilities are located at Pavilion (B.C. Railway) 16 miles northwest of the site or at Carquile (Canadian National and Canadian Pacific RR's) about 14 miles southeast of the site. Because of the long distances involved to existing rail access and because of the proximity of the site to the source of fuel, rail access to this site is deemed unnecessary.

2.5.6.1.4. Coal delivery

Coal delivery to the site would be a conveyor system directly from the mine. The length of the conveyor would be approximately 1 mile and generally located as shown on Figure 2-6. The final conveyor routing would have to be coordinated with the plans for the mine development.

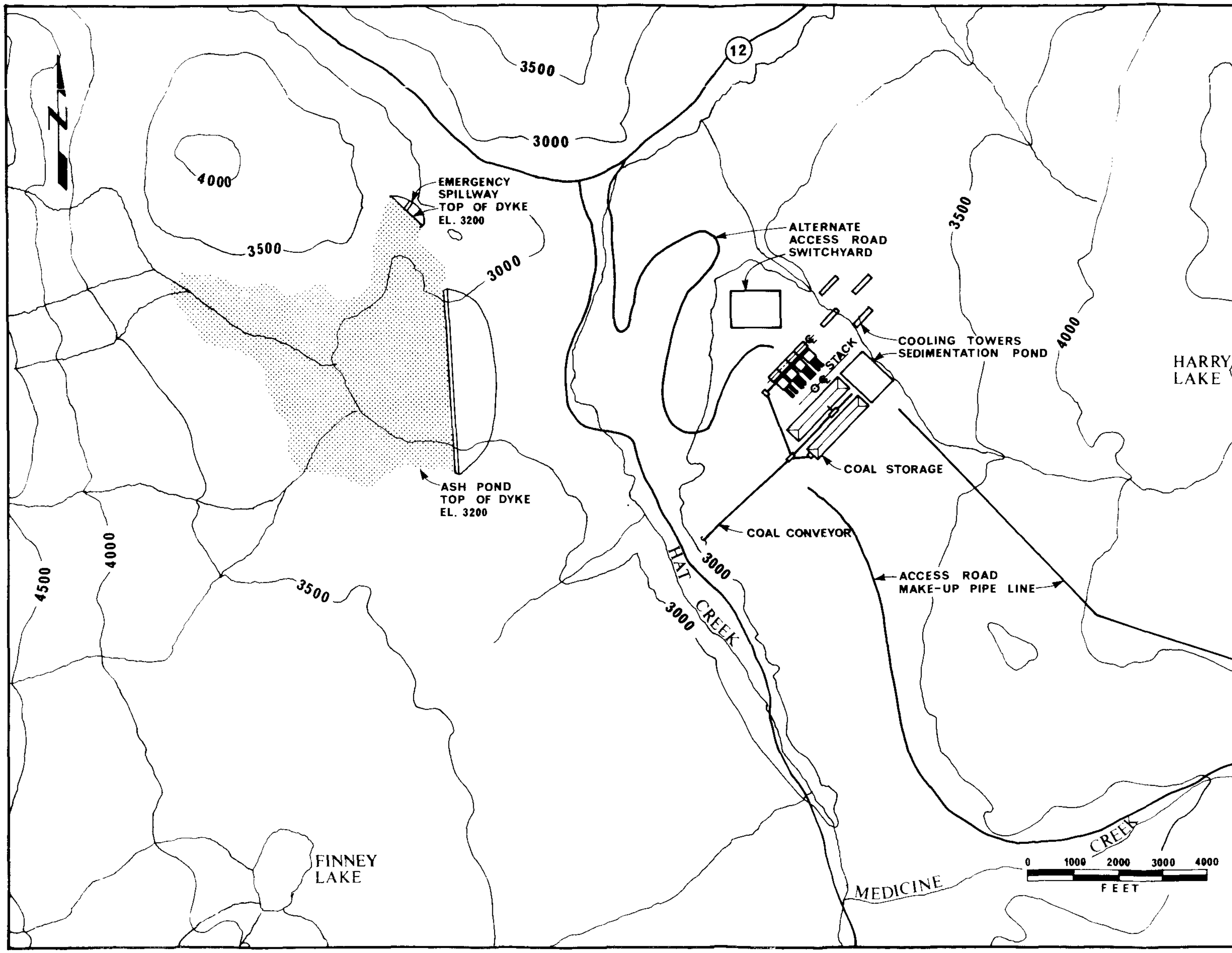
2.5.6.1.5 Condenser Cooling Water System

Condenser cooling would be provided by a closed cycle system employing evaporative type mechanical draft cooling towers.

The connected pump horsepower rating for this system would be about 26,000 HP and the electric power requirements about 20 MW.

2.5.6.1.6 Makeup Water

Makeup to the cooling water system, as well as fresh water for other plant uses, would be pumped from the Thompson River located about 14 miles to the east of the site. The water intake pump structure would



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT	
SITE EVALUATION STUDY	
MINE MOUTH SITE	
integ – ebasco	FIG. 2 – 6

be located on the west bank of the river just upstream of its confluence with the Bonaparte River and about 1-1/2 miles upstream of Ashcroft. Water would be pumped an overland distance of about 16 miles to the site. In addition to the pumps located at the intake structure, two additional booster pumping stations would be required along the 16 mile route.

The makeup water system would be designed to pump water directly to the plant or to the reservoir or to both simultaneously. An additional pumping station would be provided to convey reservoir water to the plant uses. This system would be used when the makeup system (from the Thompson River) is not operating because of either planned or forced outages.

The installed pump power on the makeup water system is estimated at 37,000 HP. Assuming a continuous makeup of 30,000 gpm, the power requirement would be about 27.6 MW.

2.5.6.1.7 Reservoir

The proposed water storage reservoir would be located about 2-1/2 miles southeast of the plant and constructed by damming Medicine Creek. The reservoir thus formed would impound about 5000 acre-feet of water, approximately 4000 feet of which would be useable with a water surface elevation of about 4030 feet MSL. The reservoir would be designed to operate with a minimum of 10 feet of freeboard to provide capacity to store flood flows. In addition, the dam would be equipped with an emergency spillway. A valved discharge pipe would be installed to discharge water downstream in a controlled manner so that the reservoir water level could be regulated.

2.5.6.1.8 Ash Storage

Ash storage would be provided by building a dike across a small unnamed stream located about two miles directly west of the generating plant.

The dike would have a crest elevation of 3200 feet (MSL). About 32 million cubic yards of fill material would be required to construct the ash pond dike including the saddle dam. The length of the main dam would be approximately 4000 feet long, and its maximum height about 330 feet. The saddle dam would be about 1000 feet along with a maximum height of 130 feet. An emergency spillway would also be provided to pass floods which could otherwise endanger the dam. Borrow for the dike construction material is assumed available either from the area to be ponded, or from the overburden at the mine area.

2.5.6.1.9 Transmission

In order to integrate a 2000 MWe generating plant at this site into B.C. Hydro's transmission network, approximately 262 miles of new transmission line would be required.

2.5.6.2 Engineering Features

The potential for expansion of the generating facility appear to be limited by a scarcity of developable land for ash disposal, however, there are two possible alternates which could be studied. It may be possible to combine the ash produced with coal mine waste for disposal. Alternately, the ash storage ponds proposed for the Harry Lake site (discussed later) could be used. This pond would be located about 3 miles southeast of the site and be generally situated at a 1500 foot higher elevation. Because of the difference in elevation, it is judged that a sluicing operation would not be appropriate. A dry ash handling system could be developed either by running closed conveyors along the path of the proposed access or by trucking the ash to the disposal area.

In general, there should be no prohibitive obstacles to construction at the Mine Mouth site. Ample area exists for construction laydown and fabrication yards. Flooding should not be a danger if proper drainage is provided. Overburden material available from mine stripping could be a close source of fill for pond embankments. However, because the mine area is so close to this site, a potential conflict may arise between the mine and plant facilities over the use of this land. Potentially the area shown for ash storage might also be utilized for mine waste and, the ultimate development of the mine might infringe on the land on which the plant facilities are planned. The plant would be located in a Seismic Zone II area. The site is relatively close to sources of fill for pond embankments.

2.5.6.3 <u>Engineering - Economic Features</u>

References to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $214.4 million in 1981 at 5 percent
$211.0 million in 1981 at 10 percent

b) Annual Operating Cost: $ 19.0 million

c) Total Comparative Cost (1976 dollars):

@ 5% interest rate - $389 million
@10% interest rate - $226 million

2.5.7 Harry Lake Site (See Figure 2-7)

2.5.7.1 Site and Facilities Description

2.5.7.1.1 Site Location

This site is located in the vicinity of the Trachyte Hills, 1/2 mile southeast of Harry Lake and approximately 3 miles east of the Hat Creek coal deposit. The site is an area of gently sloping land which is sparsely forested. The approximate elevation is above 4600 feet (MSL).

2.5.7.1.2 Road Access

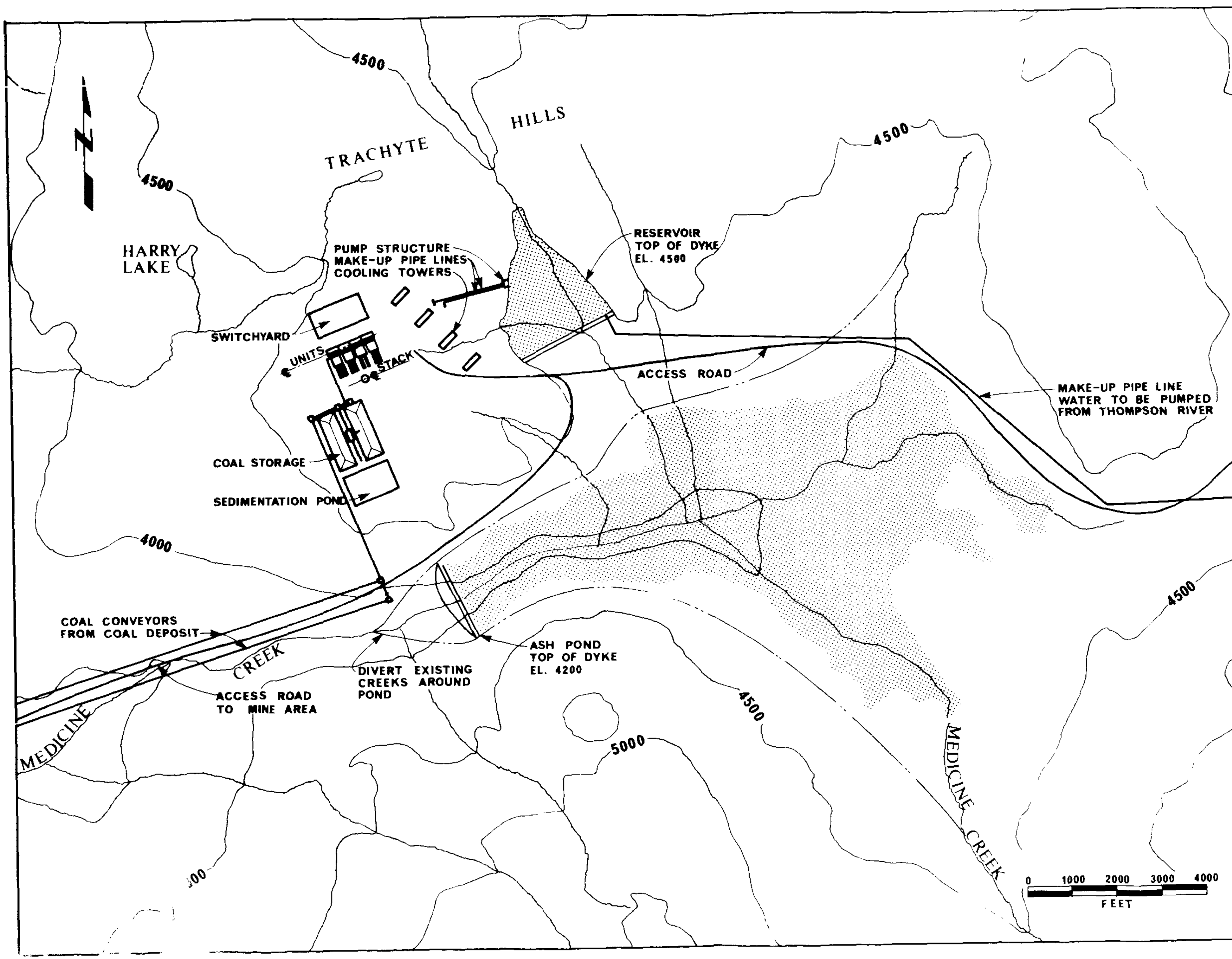
The discussion of road access for the Mine Mouth site applies here also. Road access would be from Route 1 near Ashcroft and would follow the Cornwall Creek and Medicine Creek valleys to the site. This route would involve a total of about 13 miles, 10 miles of upgrading of an existing loose surface road and construction of 3 miles of new road.

2.5.7.1.3 Railroad Access

Railroad access would not be required because of proximity to the fuel source.

2.5.7.1.4 Coal Delivery

Coal delivery from the mine to the plant would be a conveyor system about 3 miles long. The system would maintain an average slope of about 10 percent. The exact routing of the conveyor would have to be coordinated with the plans for the mine development at a later date.



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SITE EVALUATION STUDY

HARRY LAKE SITE

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FIG. 2-7

2.5.7.1.5 Condenser Cooling Water System

The discussion provided for the Mine Mouth site would apply here also. The only difference would be that: the reservoir would not be located on Medicine Creek,but in a small, natural draw located about 1 mile north of Medicine Creek; and, the overland run of the makeup water system would be about 2 miles shorter.

The installed pumping power for the closed cycle cooling water system would be about 26,000 HP. Electrical power required would be about 20 MW.

The installed pumping power for the makeup water system is established at 36,000 HP. Electrical power required would be 26.8 MW.

2.5.6.7.1.6 Reservoir

The proposed water storage reservoir would be located northeast of the plant and would be formed by damming a natural draw. The crest of the dam would be at about elevation 4500 feet (MSL) and would be about 2000 feet long at the crest and have a maximum height of 130 feet. The reservoir would impound about 4700 acre-feet of water.

2.5.6.1.7 Ash Storage

Storage for ash would be provided by constructing a dam across Medicine Creek as shown on Figure 2-7. The crest of the dam would be at about EL 4200 feet and the crest length would be about 1750 long. The dam would have a maximum height of about 300 feet. Drainage from the Medicine Creek drainage basin would be diverted around the ash storage area and discharged back into the creek downstream of the dam.

Because the pond would be located at a much lower elevation than the plant, ash could be sluiced to the pond by gravity.

2.5.7.1.8 Transmission

The additional transmission facilities required for the development of this site are the same as for the Mine Mouth site. That is, about 262 miles of new transmission line would be required.

2.5.7.2 Engineering Features

The main disadvantages of this site are its remoteness from main road and railroad transportation corridors and from a source of dependable water supply. These disadvantages are at least partially offset by the proximity to the source of fuel. Whereas the analyses presented herein assume a completely independent generating plant, it is nevertheless possible to integrate the generating plant and coal mining plant such that they can share common facilities (e.g., roads, water, supply, etc.) and in that manner reduce overall costs. In addition, it is conceivable that the ash produced as a consequence of power generation could be combined with mine waste for disposal and obviate the need for the ash pond storage area.

The site is located in a Seismic Zone II area and represents a very flexible site because of its large land area. Expansion beyond 2000 MW is deemed feasible.

2.5.7.3. Engineering - Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

a) Capital Cost: $248.5 million in 1981 at 5 percent
$238.4 million in 1981 at 10 percent

b) Annual Operating Cost: $19.7 million

c) Total Comparative Cost (1976 dollars)

@ 5% interest rate - $424 million
@ 10% interest rate - $246 million

2.5.8 Big Bar Creek Site (See Figure 2-8)

2.5.8.1 Site and Facilities Description

2.5.8.1.1 Site Location

The Big Bar Creek site is located at the confluence of Big Bar Creek and the Fraser River about 35 miles northwest of the town of Pavilion, about 150 miles northwest of Vancouver and 40 miles northwest of the Hat Creek coal deposit. The site is located in a mountainous area that is generally undeveloped with little developed road or railway access.

Located on the south edge of a plateau, the site is at an elevation of about 3600 feet MSL located between the Big Bar Mountains and Edge Hills. The drop from the plateau to the river is about 3600 feet and is quite steep.

Route 97, the Caribou Highway, runs north-south past the site about 30 miles to the east. A rail line has been proposed (unrelated to this project) between Ashcroft and Clinton. The closest approach of the railroad to the site would be at its terminus at Clinton about 41 miles east of the site.

2.5.8.1.2 Road Access

Road access to the site would be accomplished by a substantial upgrading of an existing road from its intersection with Route 97 (about 6 miles north of Clinton) to a point about 6 miles short of the plant site. From that point, a new 6 mile road would be required to the plant. The total distance of this route would be about 41 miles.

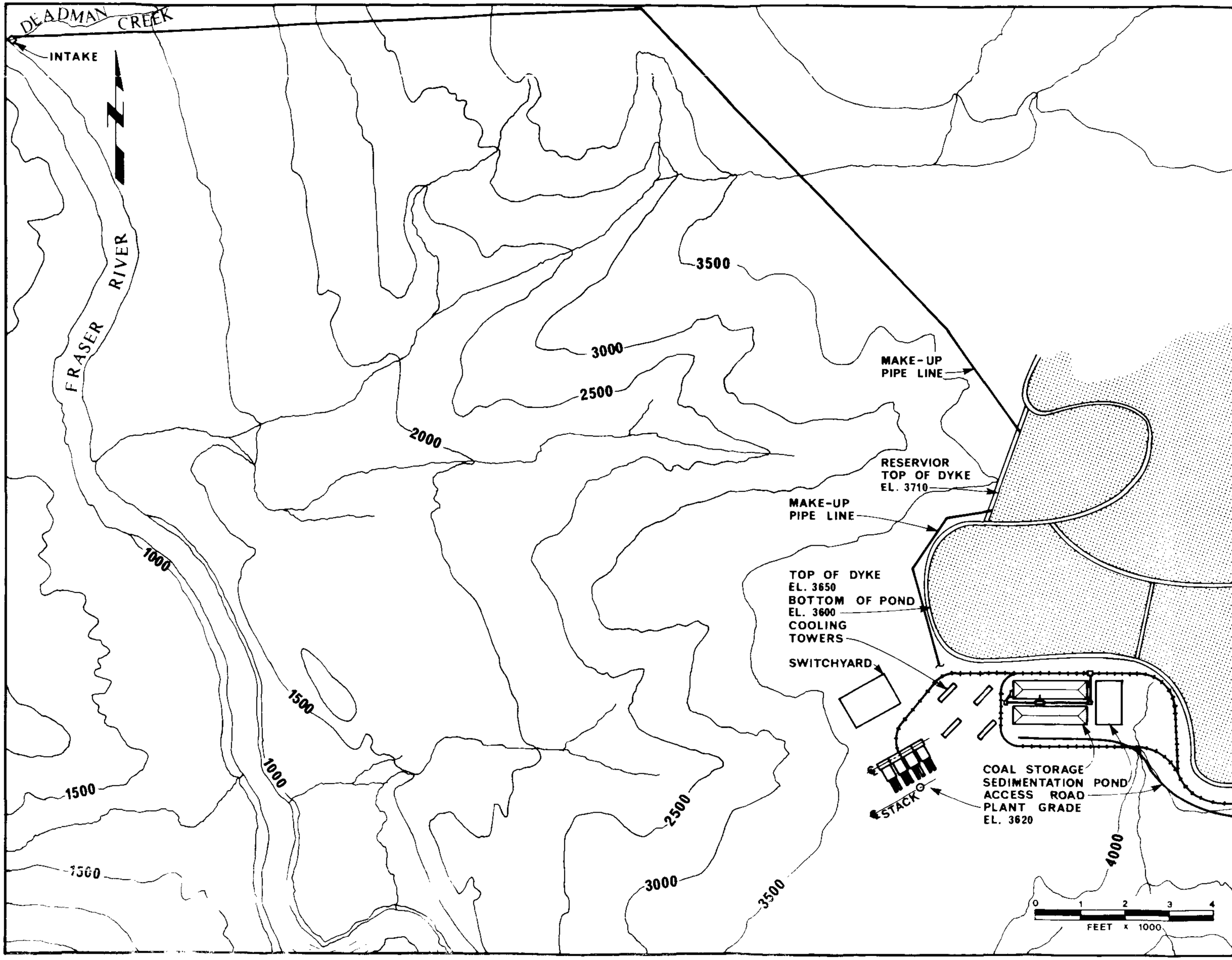
2.5.8.1.3. Coal Transportation

Coal transportation to the site would be by unit trains. The route would be from the mine to Carquile over a new 14 mile long spur from Carquile to Clinton over a currently proposed extension of the C.N. Railroad, and thence to the site via a new 41 mile long spur for a total distance of 80 miles.

The estimated unit train size for this run would consist of 50 hopper cars and 5 locomotives. Eight unit train deliveries would be required per day. In addition, a car unloading facility would be required at the plant site.

2.5.8.1.4 Condenser Cooling Water System

The condenser cooling water system would be a closed cycle system using evaporative type meachanical draft cooling towers located as shown on Figure 2-8. The connected power for the system would be about 26,000 HP and the electrical power requirement would be about 20 MW.



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HAT CREEK PROJECT

SITE EVALUATION STUDY

BIG BAR CREEK SITE

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FIG. 2 - 8

2.5.8.1.5 Makeup Water

Makeup water would be pumped from the Fraser River. The intake would be located on the east bank of the river about 9 miles upstream of its confluence with Big Bar Creek and makeup water would be pumped via pipeline for an overland distance of about 5 miles. A water storage reservoir would be constructed at the site to provide a 30 day supply of makeup water to operate the plant when the river water makeup system is inoperative.

The water reservoir and the ash storage pond would be combined. The reservoir would impound approximately 5000 acre-feet of water. The dam would be about 2300 feet long with a maximum height of about 160 feet. Water would be fed by gravity to the plant to provide makeup water to the cooling water system as well as other plant water services.

In addition to the pumps located on the intake structure, a booster pump station would be required to be installed along the pipeline. The connected power of this system would be about 29,500 HP and the electric power requirement would be about 22 MW.

2.5.8.1.6 Ash Storage

The proposed ash disposal facilities would consist of the two main adjoining ponds with a total area of about 1200 acres, the slightly larger upper pond having a crest elevation of 3710 feet and the lower pond at 3680 feet. The 41,000 feet of embankment would follow natural contours, reach a maximum height of 110 feet, average about 70 feet in height, and provide 5 feet of freeboard.

2.5.8.1.7 Transmission

In order to integrate a 2000 MW generating plant at this site into B.C. Hydro's transmission system, approximately 268 miles of new transmission lines would be required.

2.5.8.2 Engineering Features

Those aspects of the site which enhance its potential for satisfactory development include that:

- the site appears expandable beyond 2000 MW
- adequate on-site borrow material is available
- no seepage problems are expected
- the site is located in Seismic Zone II

Limiting aspects of the site include:

- its remoteness
- the potential for bank stability problems in the intake structure vicinity

2.5.8.3. Engineering-Economic Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

- Capital Cost: $380.1 million in 1981 at 5 percent
  $320.1 million in 1981 at 10 percent
- Annual Operating Cost $ 38.1 million
- Total Comparative Cost (1976 dollars):
  @ 5% interest rate - $741 million
  @10% interest rate - $388 million

2.5.9 Soda Creek Site (See Figure 2-9)

2.5.9.1 Site and Facilities Description

2.5.9.1.1 Site Location

The Soda Creek site is located on the east bank of the Fraser River about 160 miles upstream of its confluence with the Thompson River at Lytton. It is just upstream of the Soda Creek Indian Reserve and about 120 miles north-northwest of the Hat Creek coal deposit. The site is on a flat plateau at elevation 3000 feet MSL. The site is bounded on the south and west by the Fraser River (which is about 1500 feet below the plateau) and by Highway 97 (Caribou Highway) on the east and north (which runs about 700 feet below the plateau).

2.5.9.1.2 Road Access

Road access to the site for construction and operation would require construction of about 6 miles of new road connecting with Highway 97 north of the site as shown on Figure 2-9.

2.5.9.1.3 Coal Transportation

Coal transportation to the site would be by unit trains. The trains would be routed from the mine to an area south of the site, below the plateau. The coal would be unloaded and transported up to the plant coal storage area via an overhead conveyor system. The overland trip from mine to the site is about 160 miles.

The estimated size unit train for this run would consist of 50 hopper cars with 5 locomotives. Eight train loads of coal would be required per day. This would require about 6 unit trains to be in continuous operation over the transportation route.

The estimated railroad company tariff for this run is $4.30 per ton whereas the net tariff is calculated to be $3.64 per ton and has been included as an annual cost component.

2.5.9.1.4 Condenser Cooling Water System

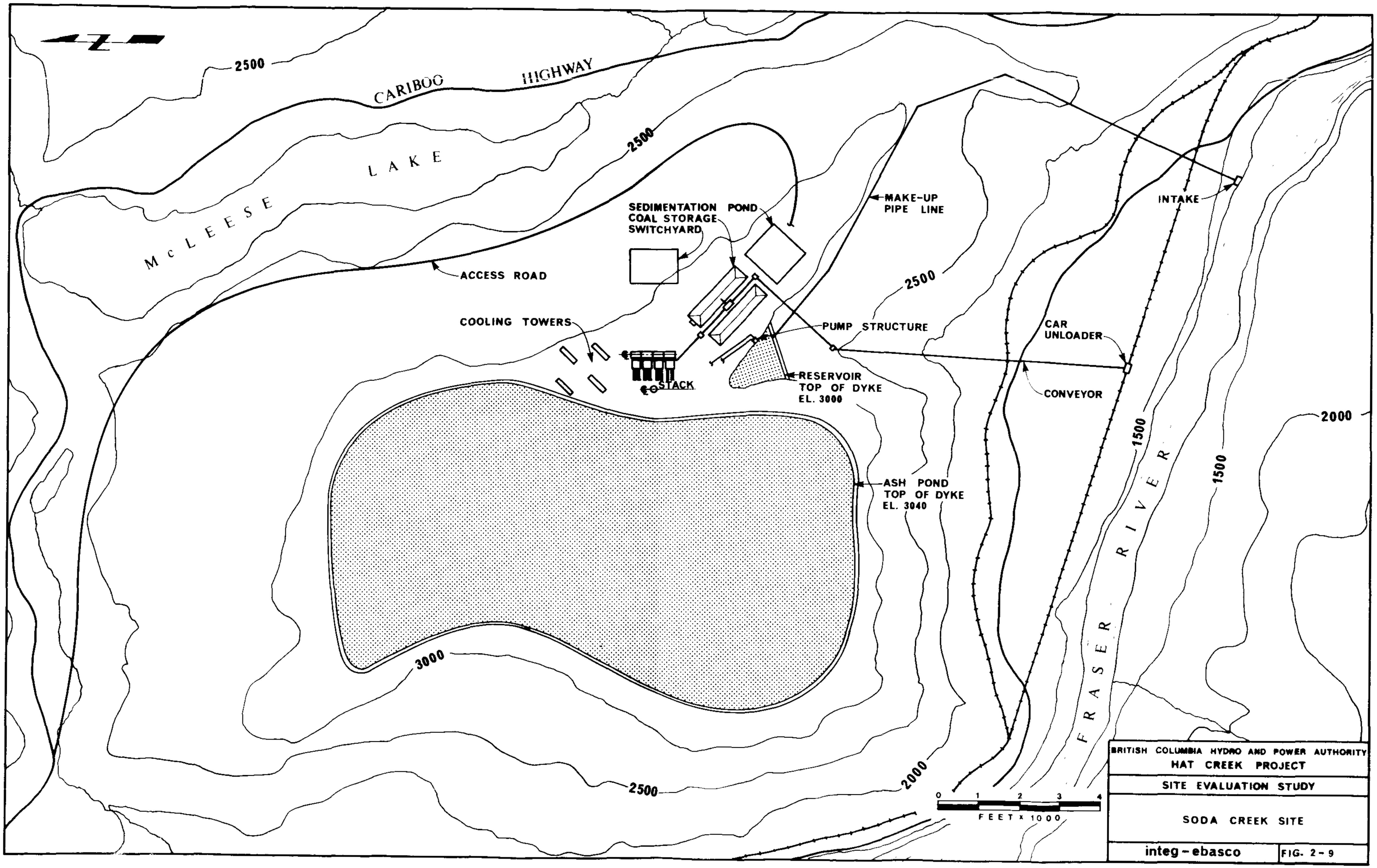
Condenser cooling would be provided by a closed cycle system employing evaporative type mechanical draft cooling towers. The location of the cooling towers would be as shown on Figure 2.9.

The connected power for this system would be about 26,000 HP and the electric power requirement would be about 20 MW.

2.5.9.1.5 Makeup Water

Makeup water for the condenser cooling water system and for other plant uses would be withdrawn from the Fraser River from an area south of the plant as shown on Figure 2-9. The intake pump structure would be located on the bank of the Fraser River. Water would be pumped via a pipeline to a reservoir on the site about 1700 feet above the river.

The reservoir would have a useable storage volume of about 4000 acre-feet and would be constructed by placing a dam across an existing drainage course. The dam would be about 1800 feet long and about 150 feet high at its highest point.



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HAT CREEK PROJECT
SITE EVALUATION STUDY
SODA CREEK SITE
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FIG. 2-9

The connected power for this system would be about 19,000 HP and the electric power requirement would be about 14 MW per hour.

2.5.9.1.6 Ash Storage

Ash storage would be in a pond about 2000 acres in area formed by enclosing the area with a 7-1/2 mile long dike about 30 feet high. Borrow for the construction of the dikes would be available from the land area enclosed.

2.5.9.1.7 Transmission

In order to integrate a 2000 MWe generating plant at this site into B.C. Hydro's transmission network, approximately 400 miles of new transmission lines would be required.

2.5.9.2 Engineering Features

The Soda Creek site is located in a Seismic Zone II area and appears limited because of its remoteness and its accessibility. The availability of onsite borrow enhances this site.

2.5.9.3 Engineering-Economics Features

Reference to Tables 2-3 through 2-6 indicates that this site would incur costs as follows:

- Capital Cost: \$420.7 million in 1981 at 5 percent
  \$354.7 million in 1981 at 10 percent
- Annual Operating Cost: \$64.3 million

- Total Comparative Cost (1976 dollars):

  @ 5% interest rate - $1,078 million

  @ 10% interest rate - $ 539 million

REFERENCES

(1) Hat Creek Project water supply study, interim report, October 1976, Sandwell & Company Limited.

(2) Proposed Hat Creek development transportation study, June 1976, Swan Wooster Engineering Co. Ltd.

APPENDIX 2-1

GEOTECHNICAL CONSIDERATIONS

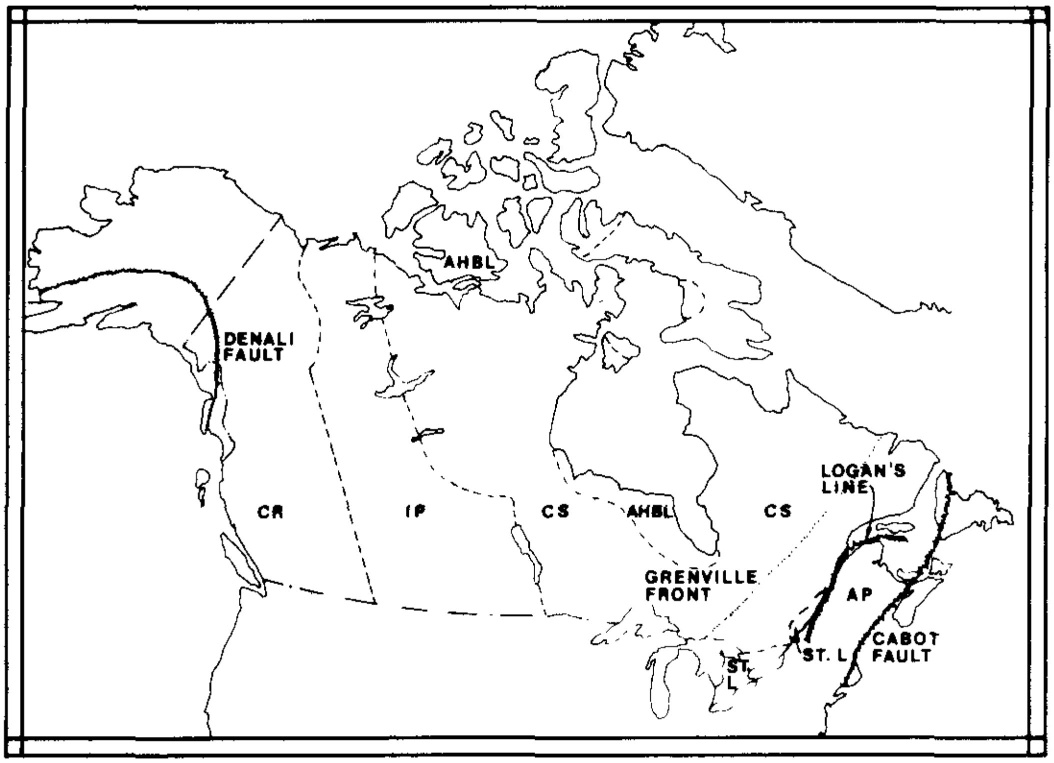
INTRODUCTION

Geotechnical factors are important in the evaluation and selection of a potential site. Major factors that have been considered are: seismic hazards, foundation conditions for the island and reservoir/pond areas, borrow areas for construction materials and related to transportation routes for water and coal to the sites.

The following evaluation, aimed toward site-differentiating factors and feasibility, is based on literature review, aerial photos, topographic and geologic maps plus on-site geologic reconnaissance at five of the eight sites being considered. The existence of surface rock exposures and drill hole data obtained during coal exploration in the Hat Creek Valley, has precluded the need for exploration drilling for this phase of the investigation. A sub-surface exploration program, guided by present results, will be needed to better define geologic conditions for the detailed engineering phase of the project.

1.0 REGIONAL GEOLOGY-PHYSIOGRAPHY

Western Canada is considered to be within the Cordilleran Physiographic Province (Figure 2A-1). The entire region is characterized by similar structure and history of formation. The Cordilleran Province, or Belt, approximately 500 miles wide, has undergone repeated episodes of sediment accumulation and mountain building from earliest geologic time to the present. The area has undergone numerous episodes of volcanic activity, plutonism, and northerly trending faulting. Evidence for many of the geologic events in western Canada has been obscured by repetition of geologic processes and complicated sequences of mountain building.



Source: Milne & Davenport, 1969

LEGEND

AHBL	ARCTIC ARCHIPELAGO HUDSON BAY LOWLAND
CS	CANADIAN SHIELD
CR	CORDILLERAN REGION
IP	INTERIOR PLAINS
ST. L	ST. LAWRENCE LOWLAND
AP	APPALACHIAN PROVINCE

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PHYSIOGAPHIC REGIONS OF CANADA

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FIG. 2A – 1

Thick sequences of sedimentary rocks are present throughout most of the region, deposited in an elongate trough situated along the western margin of the North American continent. This trough varies in length and lateral extent.

From the Pre-Cambrian to the Mesozoic Eras, the trough underwent a complicated sequence of emergence and submergence, which resulted in layered rocks with continental and marine characteristics. This period was marked by uplift and orogeny, but the Mesozoic tectonic activity was prolonged and continued without significant break into the Tertiary. The type and intensity of deformation during the Mesozoic, expressed as regional folding, metamorphism and thrust faulting, varied widely from place to place within the Cordilleran Belt. The coastal region was only mildly affected while the interior region was intensely deformed. The area of major activity during the Tertiary was the coastal ranges and the islands off the western continental margin. The major expression of this orogeny is strike slip faulting that formed down dropped blocks (grabens) that served as basins for Tertiary sedimentary and volcanic deposits. These sediments were then uplifted, folded and intruded by granitic plutons. The Hat Creek Valley is a graben formed by a major fault system, now inactive, that corresponds in part to the Fraser River Valley.

The rock surfaces that were created by the Mesozoic to Tertiary orogenies were subsequently modified and covered by glacial deposits. Almost all of Western Canada was covered by continental ice masses, which blanketed the Tertiary rocks with drift material and till. The ice sheets, the last of which was present until approximately 12,800 years ago, tended to follow the topographic restraints of the

3.0 SITE EVALUATIONS

3.1 Ashcroft Site

The Ashcroft Site area is west of the Thompson River on two levels of alluvial terraces as shown on Figure 2A-2 and Photo 1. The topography is essentially flat-lying with several small hills in the area forming the western boundary of the site. Rock is exposed through the surficial alluvium and glacial drift along the river channel, at tops of the hills and along road cuts. The rock exposed along the river adjacent to the site is Jurassic conglomerate, shales and sandstones as described on the Ashcroft geologic map (Geologic Survey of Canada, 1951, Map 1010A). Photo 2 shows the irregular surface of the shale unit at Black Canyon where it is overlain by terrace gravels. The gravel extends to the level of the river at several points along the channel.

Surficial deposits west of the terraces in the site area consist of glacial drift which is generally dense silt or silty gravel in contrast to the cleaner reworked terrace gravels which apparently were deposited when the Thompson River was at a higher level.

3.1.1 Plant Island Area

The plant would be founded on silty gravel which overlies the irregular bedrock surface. A raft foundation would be adequate to prevent excessive settlement but the stability of the terraces is not certain. Future stability is dependent on the configuration of the underlying bedrock surface and the effects of any future saturation of the terrace materials. Terraces on the east side of the Thompson River show large areas of massive movement toward the river.

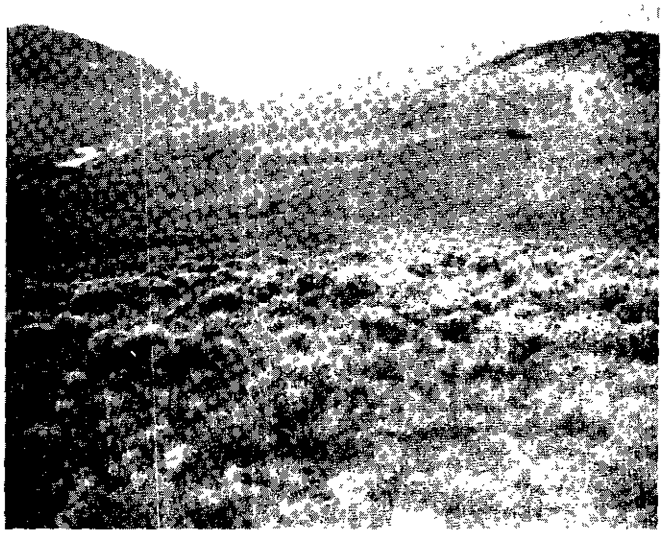


PHOTO 1

Ashcroft Plant Site, View South. Red Hill is shown in right mid-ground. Plant and ponds would be on terrace west of Thompson River.

6/13/76

PHOTO 2

Ashcroft site area. South [illegible] f Black Canyon near a pond site. Si[illegible] avel of terrace overlies black shale. [illegible]avel at right side of photo is about 50 ft. thick.

6/13/76

The terraces at the plant site on the west side appear to be stable, but cultivation may be masking cracking or other indications of movement. Note in Photo 2 the silt layer at about 10 feet depth in the gravel unit. The potential for movement along the gravel-rock interface or along a silt layer is a possibility which should be thoroughly explored.

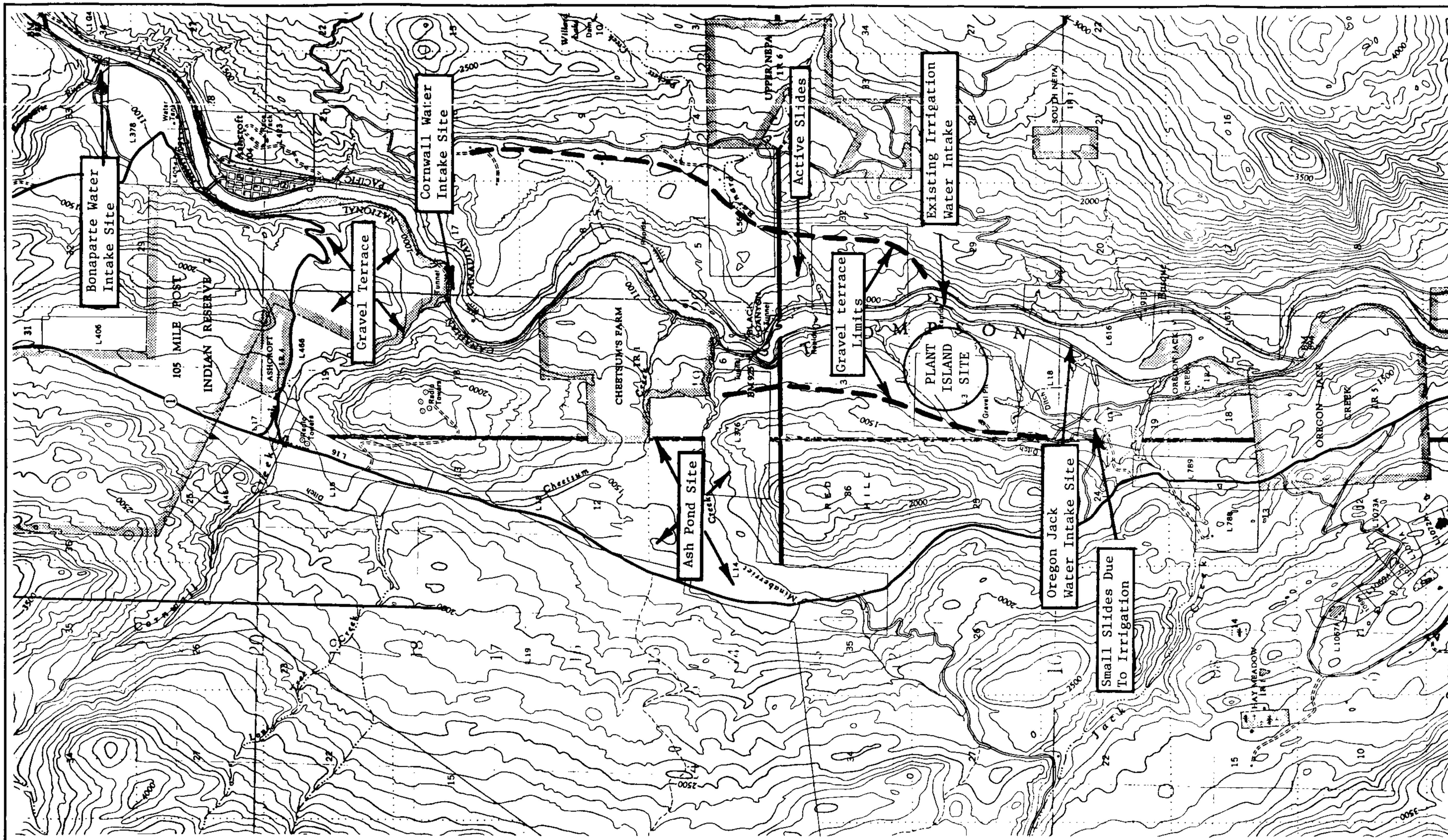
3.1.2 Disposal Pond Areas

Ponds adjacent to the rivers would be founded on the gravel terraces. Active sprinkler irrigation on the terraces is now causing seeps along a gravel-silt interface at the lower elevations and small slides are also resulting along the south side of the area as noted on Figure 2A-3. The "moderate" to "high" permeability of the terrace materials would require lining of the pond area. Any seepage escaping through a lining would migrate toward the Thompson River. Linings would be subject to cracking from minute movement of the terraces toward the river. Massive slides could result if the terrace became saturated.

The pond site at Minaberriet Creek would be on glacial drift materials which usually are more favorable in regards to stability and seepage problems. However, the drift materials are known to be variable as observed in excavations in the pond site area. Extensive drilling should be completed before concluding that the pond could be constructed.

3.1.3 Borrow Areas

Borrow material for the main bulk of the dikes is abundant



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MILES

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SITE EVALUATION STUDY

ASHCROFT AREA STRUCTURES AND GRAVEL TERRACES

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FIG. 2A-3

from the alluvium or drift but the dike core material remains to be specifically located. Glacial drift comprised of gravelly silt/clay deposits were observed along highway cuts and warrants further study as a source of core material. Saprolite from Red Hill may also provide sufficient clay for dike core and pond linings.

3.1.4 Water Intake Area

The "Oregon Jack" intake area site and pipeline would be in an area of questionable stability as noted above.

3.2 MINE MOUTH SITE

This plant site is at elevation 3100 on the east side of the Hat Creek Valley (see Figure 2A-4 and Photo 3). The proposed ash pond is on the opposite side of the valley about 2 miles away. The valley has been extensively glaciated and thick deposits of glacial materials are plastered on the valley sides. No outcrops of bedrock were observed at plant island grade or in the adjacent stream channels. Two borings, 74-29 and 74-35 which have been drilled in the area for coal exploration, show bedrock at a depth of 390 feet below the surface (Dolmage, Campbell and Associates, 19 5). Bedrock beneath the glacial drift is detrital rock of Tertiary age, consisting of siltstones and calcareous sandstones. The glacial drift in the plant island vicinity is apparently composed mostly of granular materials as observed in ravines and roadcuts (Photo 4). No sampling or detailed logs of the glacial drift interval had been completed for borings 74-29 and 74-35.

3.2.1 Plant Island Area

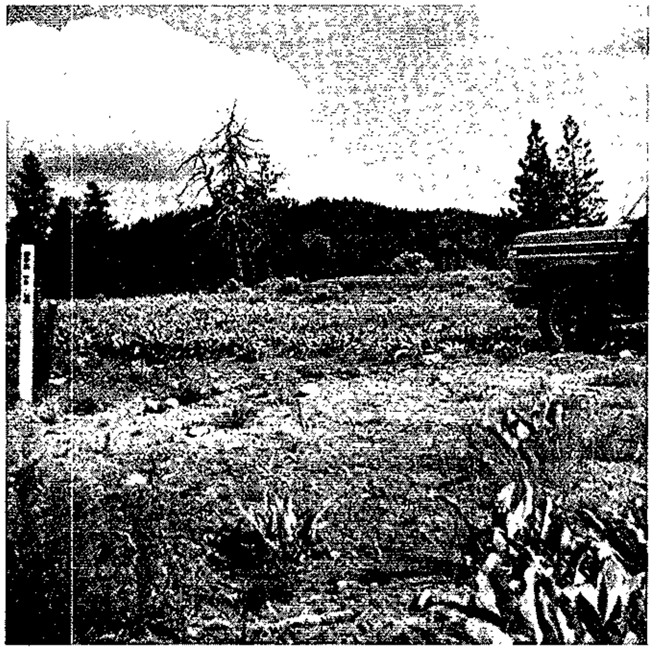
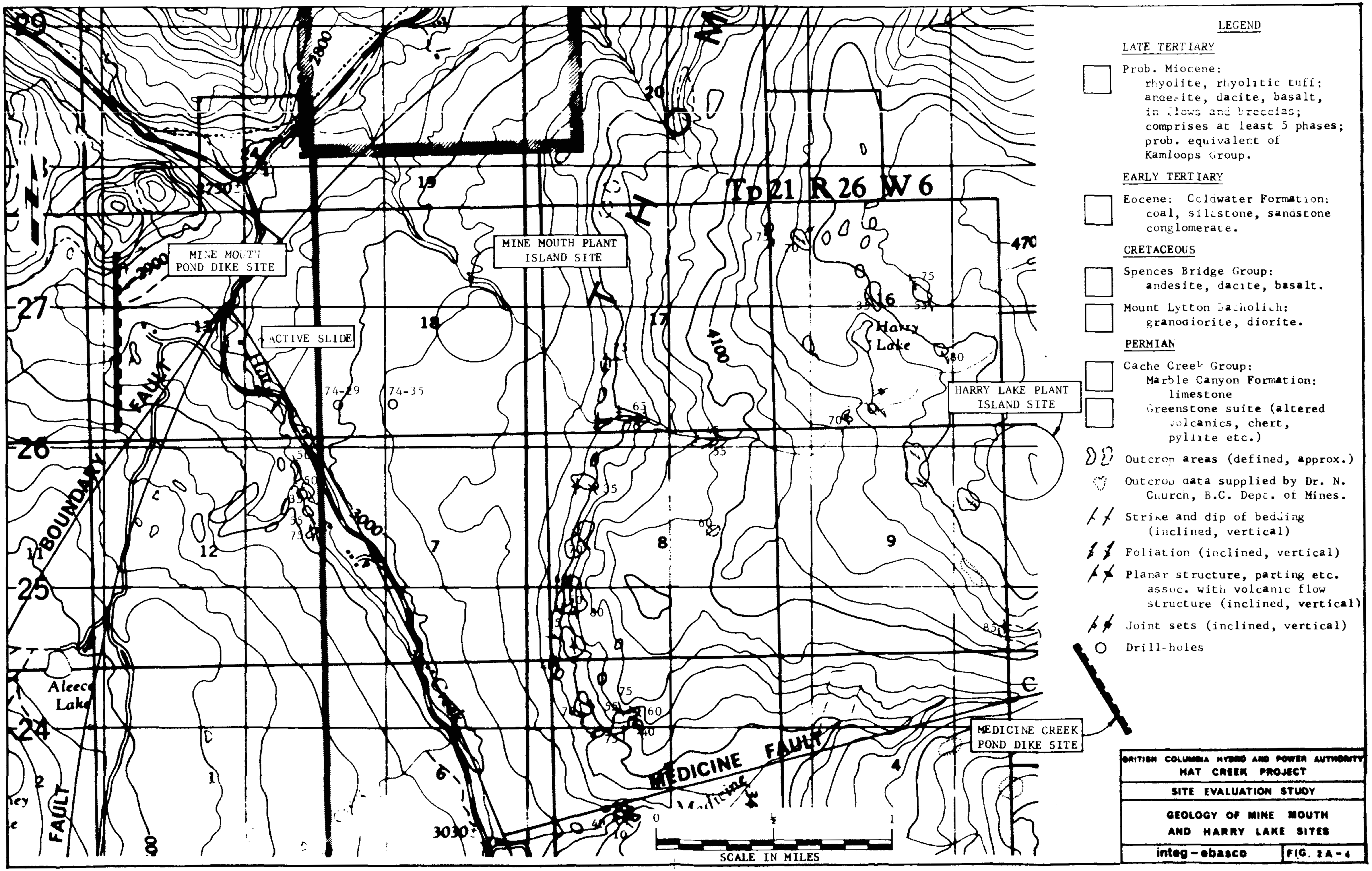


PHOTO 3
Mine Mouth Plant Site, view northeast. Note: stake marking coal exploration boring 74-35 in left of photo
6/10/76

PHOTO 4
Mine Mouth Site. Roadcut exposing granular material in site vicinity.
6/10/76



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

GEOLOGY OF MINE MOUTH AND HARRY LAKE SITES

integ - ebasco | FIG. 2A-4

Foundation conditions for the plant structures are generally favorable and would consist of a raft foundation on glacial drift.

3.2.2 Disposal Pond

The proposed disposal pond on the west side of the valley would be formed by a dike extending from the limestone ridge on the north abutment to the ridge of glacial drift to the south. (Photo 5) Depth of bedrock along the entire alignment beneath the glacial drift is unknown although limestone crops out to form a ridge along the alignment just south of the dam midpoint. See Photo 4. Numerous lakes and low swampy areas within the proposed pond area suggest relatively low permeability of the surficial deposits and therefore a low seepage rate. The active slide east of the pond area would not appear to effect the proposed pond although seepage from the new pond could further accelerate the existing slide.

The dike would block two existing streams which may require rerouting.

3.2.3 Borrow Area

Construction materials for embankments can probably be obtained from the glacial drift in the reservoir area but this would require verification by drilling and testing. An alternative source would be to select materials from the future mine overburden. Materials of low permeability appear to be scarce in the vicinity of the power plant island.

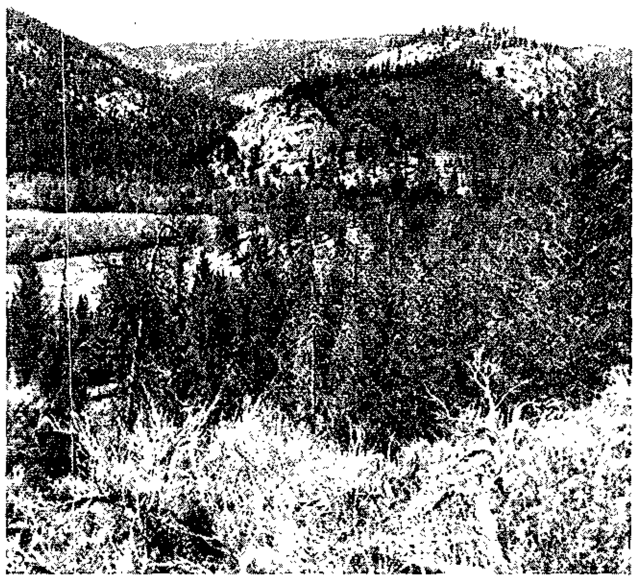


PHOTO 5
Mine Mouth Pond Site. Proposed ash pond area west of Hat Creek. View north along proposed dike alignment from elevation 3200. Emergency spillway would be in valley at left center of photo.
6/10/76

3.2.4 Coal Conveyor Route

The planned route for the coal conveyor should present little problem in that the surficial material appear stable along the route.

3.3 HARRY LAKE SITE

The Harry Lake Site is at elevation 4600 on the east side of Hat Creek Valley near the crest of the Trachyte Hills, as shown on Photo 6 and Figure 2A-4.

Geologic mapping which was previously completed for the coal development program was ended at what is now the plant island area. The reservoir area of the Medicine Creek dike are not shown. A water storage site also east of the plant island has not yet been inspected but major geologic problems are not anticipated. The "Harry Lake Pond Dike Site" is considered as a possible sludge storage area and is therefore discussed below.

Scattered outcrops of Permian chert, phyllite and volcanic greenstones extend through the overlying mantle of thin glacial drift to the west of the site and form the peaks upslope from the plant island.

3.3.1 Plant Island Area

Glacial drift is apparently thin in the plant island area judging from the outcrops in the vicinity. The plant structures would thus be founded on a mat foundation on the drift, or perhaps founded directly on bedrock if design exploration shows that the drift is shallow.

PHOTO 6
Harry Lake Plant Site, view south. Plant would be in valley at center of photo. Note Hat Creek Valley in distance.
6/11/76

3.3.2 Harry Lake Pond Dike Site

The abutments for the proposed dam would be silty, glacial drift (see Figure 2A-4 and Photo 7). Silt with some gravel and widely scattered pebbles are exposed in a ravine that approximately parallels the dike axis. Exposures of bedrock along the creek bed approximately 2000 feet upstream of the dike indicate that a cut off to bedrock may be feasible, subject to further detailed investigation. The shallow bedrock and surficial materials which are of low permeability provide desirable conditions for water or ash storage. Borrow for this dike can be obtained in the reservoir area utilizing available glacial drift.

3.3.3 Medicine Creek Dam Site

The Medicine Creek Dam axis is about one mile southeast of the plant island where the character of the stream channel changes from open channel to a steep gradient with a distinct V-shaped valley. Phyllite is exposed in the stream channel near the dam axis. The stream valley upstream is covered by glacial drift of undetermined thickness, which overlies the bedrock.

Geologic mapping for coal development has disclosed a fault, as shown on Figure 2A-4, which extends along Medicine Creek channel. The location of the fault in the site area is not yet known and is probably covered by the glacial drift. The probable age of the fault and its relationship to the dam site should be determined during early phases of any future explorations.

Glacial drift of undetermined thickness mantles the rock of the dam site abutments and the channel and valley upstream of the site.

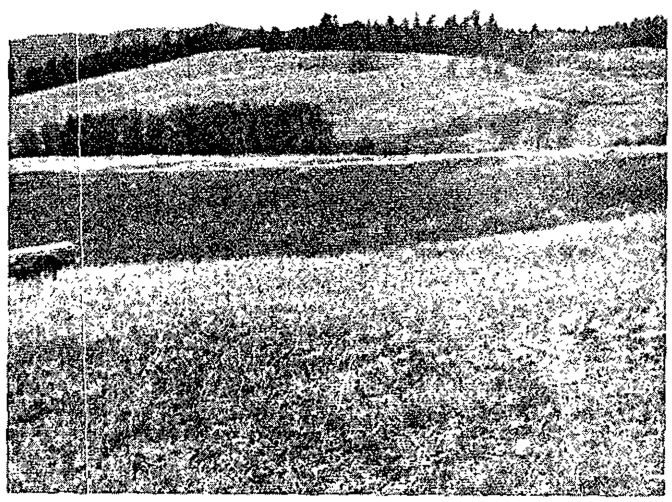


PHOTO 7
Harry Lake Site. Ravine in right background is drainage from Harry Lake.
6/11/76

Exploration drilling along the axis would be required to determine the nature of the drift and the depth and quality of the underlying bedrock.

It appears that the dam axis could be shifted upstream with little loss in reservoir volume, or increased quantity of embankment if foundation conditions should warrant such an adjustment. Seepage conditions should not be a problem at the reservoir if a safe, stable foundation is established at the dam site. Medicine Creek flow would need to be diverted if the pond is used for waste disposal. Maintenance of such a diversion against geologic/climatic hazards over the long term must be considered.

Borrow for the embankment is probably available from the broad valley which forms a saddle between Medicine Creek and MacLaren Creek. Exploratory auger holes and laboratory tests of the materials would be required.

3.4 BIG BAR SITE

This site is on a flat plateau bordered by the steep canyons of the Fraser River and Big Bar Creek. No bedrock crops out on the level area where the plant and disposal ponds will be situated but rock is exposed along the adjacent canyon walls. Bedrock, where examined, is folded chert and phyllite, apparently of the Cache Creek Group.

Surficial deposits of glacial drift of undetermined thickness mantles the bedrock. Ponds have formed in depressions on the plateau surface suggesting that the drift materials are of low permeability. See Photo 8.

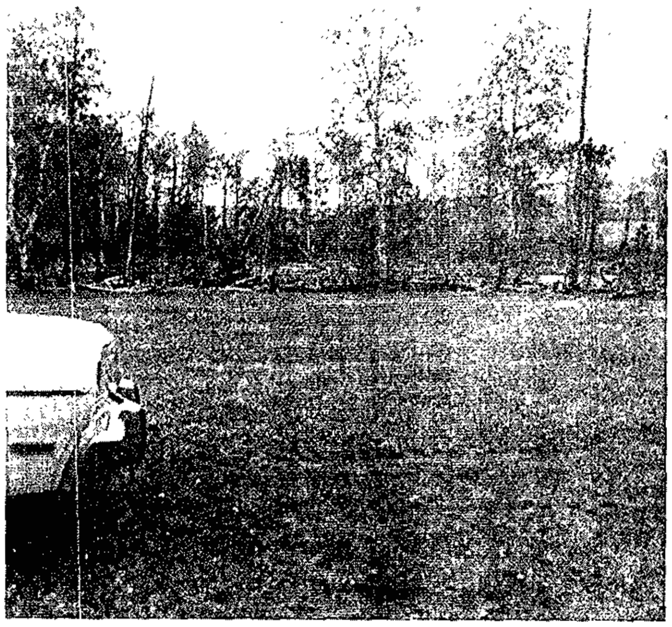


PHOTO 8
Big Bar Site, view east. One of several ponds in site vicinity.
6/11/76

3.4.1 Plant Island Area

Construction at the plant island would utilize mat foundations on the glacial drift. It would probably not be feasible to excavate to bedrock.

3.4.2 Disposal Ponds

Disposal ponds and the water reservoir would be on similar material as that of the plant. Although the drift contains abundant fine-grained material of low permeability, careful exploration will be required to avoid any sands and gravel deposits. Groundwater levels are low due to drainage to the Fraser River and Big Bar Creek. Seepage from the ash ponds would follow this general movement; however, such seepage should be low if ponds are properly designed and located.

Borrow material is available from within the reservoir and dike areas. An auger drilling exploration program at the dike site would be required to determine foundation/seepage conditions as well as to locate borrow materials.

3.4.3 Water Supply Route

Water would be carried by pipeline from an intake on the Fraser River. (See Photo 9). The gravel terraces along the river form the least stable areas through which the pipeline would pass. A route along the ridge tops, to the site, would best avoid damage due to slides within the ravines.

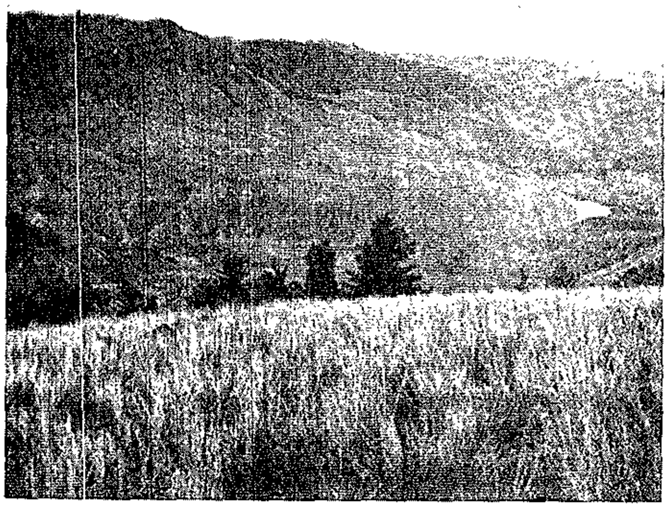


PHOTO 9
Big Bar Site, view west toward Fraser River along pipeline route. Note incised gravel terraces along river.
6/12/76

3.4.4 Railroad Route

The Big Bar Site will require a railroad from Clinton to the site area. The railroad route will generally be on flat to gently rolling topography and could be located without apparent geologic problems. Such a route would have to be more completely explored, however.

3.5 SODA CREEK SITE

The site is on a plateau along the Fraser River as is the Big Bar Site. In addition to a field reconnaissance of this site, information was obtained from the Quesnel geologic map (Geological Survey of Canada, 1959, Map 12 - 1959) and related to observations at the Big Bar site.

Geologic conditions at this site appear similar to those at the Big Bar Site. Bedrock in the area is described as basalts, andesites, and tuffs, with minor amounts of sedimentary cherts, sandstones and conglomerates. These units are underlain by more resistant sedimentary rocks. Rock outcrops are apparently scarce in this area, which is almost completely mantled with glacial drift which average 25 to 50 feet thick on a regional basis.

Sedimentary rocks in the region are folded and faulted, especially in the Fraser Valley north of the site. The plateau basalts are comparatively undeformed, and range from 500 to 1000 feet thick.

A linear feature that appears to be a zone of faults and tight folds, extends up the Fraser River Valley near Soda Creek. However, no large, single fault has been traced along it.

For the comparative purposes of this study we have assumed that the plateau at the site is mantled with glacial drift which provide borrow materials and a natural seepage barrier for disposal ponds. Actual geologic conditions will need to be determined in the field if the site is to be given further consideration.

3.6 DUNSMUIR SITE

This site is within the eastern coastal plain of Vancouver Island. These lowlands, parallel to the Strait of Georgia, form a narrow belt on the island which consists of faulted and folded sedimentary and volcanic rocks. The site was not visited for this phase of the study.

Geological conditions at this site were described by Reimchen & Bayrock (1974) in their report on nine proposed sites on Vancouver Island. Their report which shows construction on the unit of glacial till describes the till as follows:

> "Unit 12: Glacial till: consists of a heterogeneous mixture of sand, silt and clay size fragments with minor amounts of clasts; level to hummocky topography. The till is weathered in the upper 5 feet and is loose and unconsolidated. In some areas, the till has been washed by waves removing some of the silt and clay-size fragments. The unweathered portion of this till is hard and unconsolidated, and numerous fractures are present. This unit, at least in the upper portions, has moderate permeability and good drainage. The unweathered portion probably has high shear strength."

Of the units described at the site, the till would be the best foundation for the plant and ponds. The till would be the most dense and least permeable foundation material available after the upper, weathered portion had been removed by excavation.

a) Plant Island Area

For purposes of this report and based on available information, it is assumed that a plant mat foundation can be founded on the glacial till unit without serious foundation problems. As recommended in the Reichen-Bayrock report, the depth of the till unit should be determined by drilling.

b) Disposal Pond Area

The disposal ponds are planned for the area west of Bowser because of insufficient area on the glacial till near the plant island. The Reimchen-Bayrock report describes foundation materials in the vicinity as follows:

> "Unit 8: Marine Lowlands; fluvial sediments over glacial till: abandoned beaches, level to ridged topography, consists of well to poorly-sorted sand, silt and gravel-size material up to greater than 7 feet in thickness. It overlies stony till of unknown depth. The properties of this unit are similar to Unit 11."

As described, we would expect adequate foundation conditions for dikes but possible high seepage rates through sand and gravel foundation locations to possibly avoid pervious materials. However, vertical and/or clay blankets may be required to maintain low seepage rates.

Borrow materials for dikes would probably also come from the area of glacial till. Pervious material can be selected from terrace deposits or from other units.

3.7 BRITANNIA BEACH

The site is located at an abandoned gravel quarry, on Howe Sound, approximately 30 miles north of Vancouver. The gravel deposits have been extensively stripped, leaving a flat surface at Elevation 30. Mudstone forms stable, vertical walls in the quarry and apparently, lies immediately below a gravel base in the quarry, as evidenced by standing ponds in the quarry floor. Surficial deposits consist mainly of glacial gravels, overlain by a soil consisting of silts and clays.

3.7.1 Plant Island Area

All structures for the plant can be founded using a mat foundation.

3.7.2 Disposal Ponds

No ash ponds are planned for the Britannia Beach site because of the small area available for development.

3.8 STAVE LAKE SITE

The site is on the south end of Stave Lake. The lake basin was formed by glaciation of the granitic bedrock which makes up this portion of the Coast Range. Glacial and alluvial surficial debris have filled the south end of the basin and thus have formed a barrier behind which the lake formed. The site was not visited for this phase of the study. Geologic data is from the Geological Survey of Canada Map 1151A, Pitt Lake, (1965).

3.8.1 Plant Island Area

The Plant Island would be founded in an area where bedrock is listed as diorite. However, the thickness and nature of surficial materials in this area is not shown. Hopefully structure locations could be adjusted to permit mat foundations but this is not certain.

3.8.2 Disposal Pond Area

The disposal ponds would be located on the only available large flat area, which is the surficial materials at the south end of the lake. The depth and nature of these deposits is unknown and could vary considerably. Therefore many questions remain as to foundation stability of the dikes and seepage rates from the ponds. It should also be noted that Cascade Creek would need to be diverted from the pond area.

4.0 WATER INTAKE AND PIPELINE ROUTES FOR MINEMOUTH AND HARRY LAKE SITES

A geologic reconnaissance was made along the Cornwall Creek pipeline route from the Thompson River to Medicine Creek. A route should avoid the steep ravines as much as possible, where active movement of materials can be triggered by heavy rainfall.

The water intake sites at Bonaparte River and Cornwall Creek were visited and should present no special geologic problems for construction.

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3. METEOROLOGY/AIR QUALITY

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3.1 SUMMARY

A 2000 MW thermal generating station burning Hat Creek coal would introduce large quantities of contaminants into the atmosphere. These contaminants could substantially affect ambient air quality in the surrounding area. Because the extent of these effects would be influended by regional and site-specific meteorological conditions, as well as site-specific terrain features, a meteorological/air quality study was conducted to determine the differential air quality impacts at each of the eight alternative sites, to identify the most favourable site and to rank the others from an air quality standpoint.

In this study, the level of air quality impacts at each site was determined by evaluating three quantitative criteria. These criteria and their quantitative measures are as follows:

a) Standard diffusion, which is an indicator of the potential impact of the station during meteorological conditions that can be accurately modelled with standard diffusion equations. The quantitative measure of this criterion is the predicted frequency of contaminant concentrations in excess of Level A Guidelines of the Pollution Control Board of British Columbia (PCB).

b) Plume trapping, which is an indicator of the meteorological conditions at each site that would trap the power station plume in a confined valley. The quantitative measure of this criterion is the estimated frequency of occurrence of meteorological conditions which would cause plume trapping at each site.

c) Fumigation, which is an indicator of the potential for power station plumes to be carried rapidly to the ground with little dilution. The quantitative measure of this criterion is the frequency of occurrence of meteorological conditions which cause fumigation at each site.

Evaluation of the meteorological/air quality criteria for each of the sites yields the following conclusions:

a) Soda Creek is the most favourable site for development. Plume trapping and fumigation should not be problem at this site. Very few concentrations in excess of PCB Level A Guidelines were predicted by the standard diffusion model at this site.

b) Dunsmuir is the second-ranked site. Elevated terrain features at this site result in higher contaminant concentrations than are calculated for Soda Creek. A significant problem at this site is the potential for sea breeze fumigation.

c) The terrain features at Big Bar Creek and Harry Lake are more pronounced than at either Soda Creek or Dunsmuir. These terrain features have an unfavourable impact upon plume dispersion, causing higher contaminant concentrations. Therefore, these sites are ranked in a tie for third.

d) The Stave Lake, Ashcroft, Mine Mouth and Britannia Beach sites are judged to be unacceptable for development.

3.2 INTRODUCTION

3.2.1 Purpose

The operation of a 2000 MW thermal generating station burning Hat Creek coal will introduce large quantities of contaminants into the atmosphere. The Pollution Control Board of British Columbia (PCB) has established Ambient Air Quality Objectives and Guidelines for several of these contaminants. The guidelines, which were established to maintain the quality of the air environment of British Columbia at the highest possible level, will have to be considered carefully by the plant designers. Because meteorological conditions greatly influence the dilution of atmospheric contaminants and because these conditions can vary from site to site, a preliminary meteorology/air quality investigation was conducted as part of the Hat Creek Site Evaluation Study.

The purpose of this investigation is to estimate the level of air quality impacts associated with the operations of a thermal generating station, at each of the eight sites shown on Figure 3-1, and, in consideration of these impacts, to rank the sites in order of preference.

3.2.2 Scope

The scope of the meteorology/air quality investigation includes:

a) Analysis of meteorological data.
b) Identification of regional meteorological characteristics.
c) Determination of site-specific terrain features.
d) Determination of generating station emission rates.
e) Definition of the meteorological/air quality criteria to be used to evaluate each site.
f) Determination of the quantitative value for each criterion.
g) Evaluation of the relative importance of each criterion at each site.
h) Ranking each site in order of preference.

3.3 MATERIALS AND METHODS

3.3.1 Data Base

3.3.1.1 Major Stations Environment Canada

In order to evaluate the meteorological/air quality criteria presented in the following sections, site-specific frequency distributions of atmospheric stability, wind speed and wind direction are required. There are several different procedures for determining atmospheric stability. However, the only technique which can be used to differentiate among sites, utilizing the data base available for this study, is the procedure developed by D. Bruce Turner,[1] commonly referred to as the STAR program.

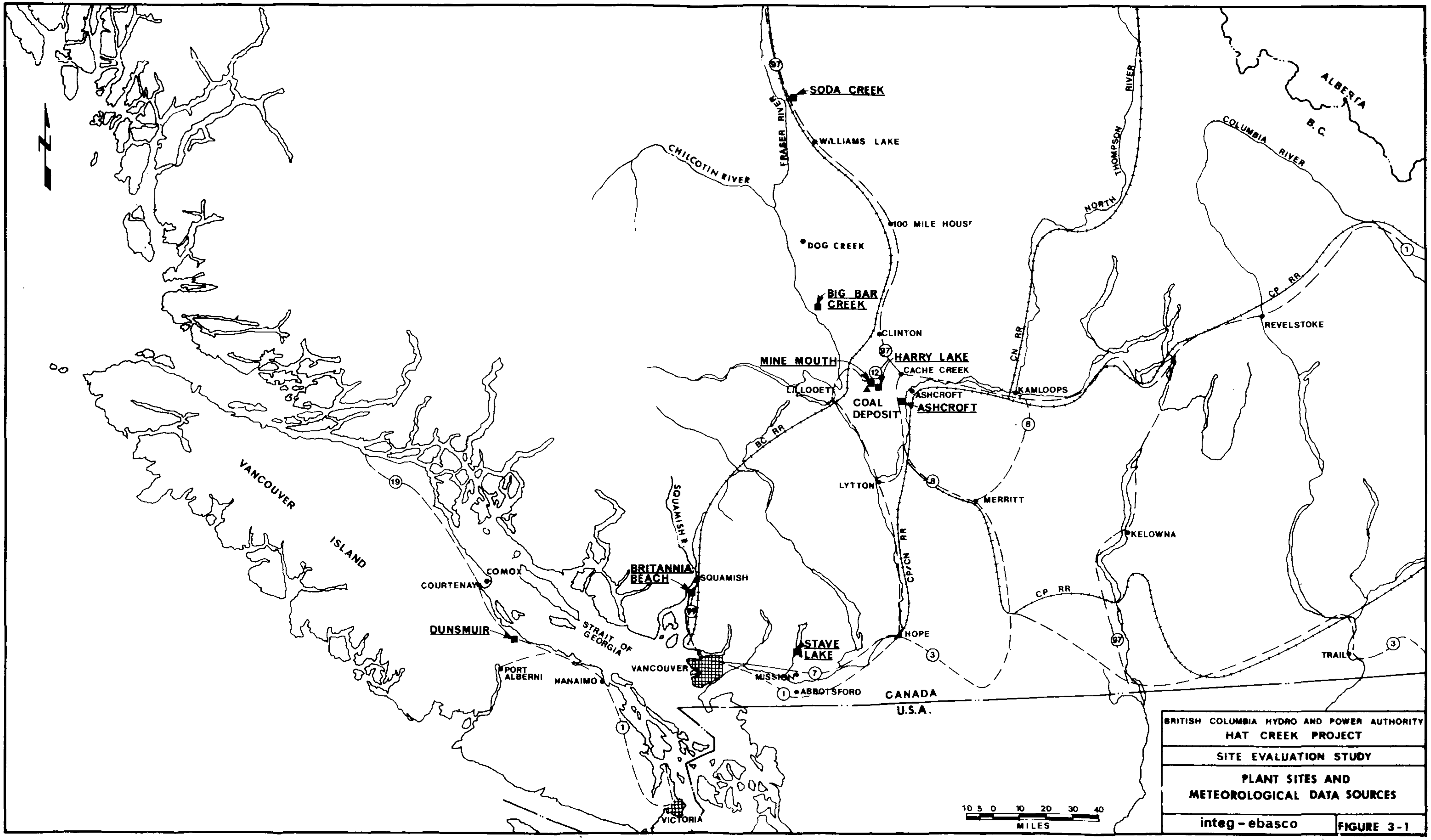
SODA CREEK
WILLIAMS LAKE
FRASER RIVER
CHILCOTIN RIVER
100 MILE HOUS
DOG CREEK
BIG BAR CREEK
CLINTON
HARRY LAKE
MINE MOUTH
CACHE CREEK
LILLOOET
COAL DEPOSIT
ASHCROFT
ASHCROFT
KAMLOOPS
NORTH THOMPSON RIVER
CN RR
ALBERTA
B.C.
COLUMBIA RIVER
CP RR
REVELSTOKE
BC RR
LYTTON
MERRITT
KELOWNA
CP/CN RR
SQUAMISH R.
BRITANNIA BEACH
SQUAMISH
VANCOUVER ISLAND
COMOX
COURTENAY
DUNSMUIR
STRAIT OF GEORGIA
PORT ALBERNI
NANAIMO
VANCOUVER
STAVE LAKE
MISSION
ABBOTSFORD
HOPE
CP RR
TRAIL
CANADA
U.S.A.
VICTORIA
10 5 0 10 20 30 40
MILES
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
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FIGURE 3-1

Use of the STAR program requires the input of long-term hourly surface meteorological data which are recorded only at major meteorological stations. Representatives of Environment Canada identified the major meteorological stations which would most closely represent conditions at each of the eight alternative plant sites. The offsite data sources recommended for each site are as follows:

Site	Data Source
Dunsmuir	Comox
Britannia Beach	Vancouver
Stave Lake	Abbotsford
Ashcroft	Ashcroft (no stability data)
Mine Mouth	B.C. Hydro Data (limited stability data)
Harry Lake	B.C. Hydro Data (limited stability data)
Big Bar Creek	Dog Creek
Soda Creek	Williams Lake

Because data for Dog Creek were not available for this study Williams Lake data were substituted. Because of the importance of stability considerations in the evaluation of alternative sites, it was necessary to supplement the B.C. Hydro and Ashcroft data with records from Lytton. The rationale for selection of Lytton data and for certain modifications to the Comox data are discussed in the following section. In all other cases the recommendations of Environment Canada are followed. Table 3-1 summarizes the offsite data sources and their application. Figure 3-1 shows the location of the data sources.

TABLE 3-1

OFFSITE DATA SOURCES

Offsite Data Source	Applicable Sites	Use
Vancouver	Britannia Beach	Wind Rose STAR Data
Comox	Dunsmuir	Wind Rose STAR Data
Abbotsford	Stave Lake	Wind Rose STAR Data
Lytton	Harry Lake Mine Mouth Ashcroft	Wind Rose STAR Data
Williams Lake	Big Bar Soda Creek	Wind Rose STAR Data
Ashcroft	Ashcroft	Wind Rose
Squamish	Britannia Beach	Wind Rose
Hat Creek	Harry Lake	Wind Rose
(B.C. Hydro)	Mine Mouth	

3.3.1.2 Supplemental Stations/Environment Canada

In some cases, the primary offsite data sources are not the best wind direction and wind speed information available for each site. Smaller Environment Canada stations provide better wind data for certain sites. Where possible, data from the smaller stations are used in conjunction with data from the larger stations in order to permit a more realistic assessment of conditions.

Vancouver is the primary offsite data source for the Britannia Beach site. Squamish wind data, however, is more representative of site conditions than Vancouver wind data. A comparison of the two sets of wind data is presented in Table 3-2. It is apparent that better agreement with Squamish wind data is obtained by rotating Vancouver wind directions 90 degrees counterclockwise. Because such an adjustment also appears realistic when topographic effects are considered, this modification to the Vancouver wind direction data was used. Modified Vancouver wind directional frequencies are also shown in Table 3-2. No attempt is made to modify stability frequencies because such information is lacking at Squamish.

Environment Canada made no recommendation regarding an offsite stability data source for the Ashcroft site. Based on proximity alone, the two possible choices are Kamloops and Lytton. Wind rose data for Kamloops, Lytton and Ashcroft are presented in Table 3-3. The Lytton data yield better correlation with Ashcroft data and accordingly are used when quantification of Ashcroft criteria is required. Table 3-1 summarizes all of the offsite data sources[3] and their uses.

TABLE 3-2

COMPARISON OF VANCOUVER AND SQUAMISH WIND ROSE DATA

Wind Direction	Percent of Time: Squamish (4/71-9/75)	Percent of Time: Vancouver (1/72-12/75)	Modified Vancouver (90 degree shift)
North	30.3	2.2	30.6
Northeast	7.5	5.1	15.6
East	3.7	30.6	7.2
Southeast	3.1	15.6	6.1
South	20.8	7.2	15.4
Southwest	18.2	6.1	9.9
West	4.4	15.4	2.2
Northwest	5.3	9.9	5.1
Calm	6.7	7.5	7.5

TABLE 3-3

WIND DATA KAMLOOPS, LYTTON, ASHCROFT

	Percent of Time		
	Ashcroft* (4/66-2/71)	Kamloops (1/74-12/74)	Lytton (1/74-12/74)
North	7.1	0.7	5.9
North-northeast		0.9	4.1
Northeast	9.7	1.7	1.6
East-northeast		5.6	0.4
East	9.7	14.3	0.3
East-southeast		19.6	0.5
Southeast	4.2	5.6	1.8
South-southeast		1.9	7.2
South	16.6	1.6	23.4
South-southwest		2.5	30.2
Southwest	27.4	3.6	1.5
West-southwest		4.9	0.7
West	10.2	10.2	0.5
West-northwest		5.7	0.4
Northwest	11.2	1.8	0.9
North-northwest		0.9	3.6
Calm	3.9	18.4	16.8

*Eight wind directions reported

3.3.1.3 B.C. Hydro Meteorological Network

B.C. Hydro operates a limited meteorological data network in the Hat Creek Valley. Two of these monitoring stations (No. 1 and No. 8) provide more realistic wind speed and direction data for the Mine Mouth and Harry Lake sites than any of the other data sources[4]. An offsite data source is necessary only because of the stability requirements discussed earlier. Kamloops and Lytton again are the most likely stability data sources and Table 3-4 presents a comparison of the wind data for the four sources. The Lytton data offer a better correlation with both B.C. Hydro data sources and accordingly are used whenever quantification of criteria is required for the Mine Mouth and Harry Lake sites. Table 3-1 summarizes the B.C. Hydro meteorological data sources and their uses.

3.3.1.4 Topographic Maps

Terrain features, which could influence atmosphere diffusion at each of the alternative sites, were interpreted from topographic maps produced by the Surveys and Mapping Branch, Department of Energy, Mines and Resources and from on-site inspection. Topographic maps, plotted to a scale of 1:50,000 were available for each of the sites.

TABLE 3-4

WIND DATA HAT CREEK, LYTTON, ASHCROFT

	Percent of Time			
	Hat Creek #1 (1/74-12/75)	Hat Creek #8 (1/74-12/75)	Kamloops (1/74-12/74)	Lytton 1/74-12/74)
North	1.2	4.9	0.7	5.9
North-northeast	1.8	7.1	0.9	4.1
Northeast	6.0	1.8	1.7	1.6
East-northeast	19.1	0.7	5.6	0.4
East	7.1	0.8	14.3	0.3
East-southeast	0.9	0.9	19.6	0.5
Southeast	0.5	1.2	5.6	1.8
South-southeast	0.4	5.3	1.9	7.2
South	1.1	6.0	1.6	23.4
South-southwest	1.3	19.5	2.5	30.2
Southwest	7.0	24.6	3.6	1.5
West-southwest	24.9	10.4	4.9	0.7
West	19.4	3.1	10.2	0.5
West-northwest	1.8	2.3	5.7	0.4
Northwest	1.3	2.4	1.8	0.9
North-northwest	1.1	8.5	0.9	3.6
Calm	4.9	0.6	18.4	16.8

3.3.2 Generating Station Characteristics

3.3.2.1 Stack Configuration and Emissions

A single 1100 foot multiple flue stack is assumed for the 2000 MW thermal generating station in the calculations associated with this study. No effort was made to optimize the stack height; however, the assumed height is believed reasonable, in view of the rugged terrain conditions surrounding many of the sites.

The emission characteristics developed for use in this study are presented in Table 3-5. Although SO_2 is considered the critical contaminant for this effort, both SO_2 and total suspended particulate (TSP) emission rates are presented. Flue gas scrubbing has not been included in the analysis work and consequently exit temperatures remain high.

The feasibility of and need for flue gas desulfurization (FGD) is not specifically addressed in this report. Some considerations regarding FGD are presented in later sections. For this analysis, however, all coal sulfur is assumed to be emitted as SO_2.

3.3.2.2 Coal Characteristics

The coal characteristics assumed for this study are presented in Table 3-5. Sulfur content of the coal is assumed to be 0.41 percent on a 20% moisture basis.

For the purpose of the study all the sulfur is assumed to be organic.

TABLE 3-5

EMISSION PARAMETERS

Station Design	
Net Generating Capacity	2000 MWe
Net Station Heat Rate	9800 Btu/kWh
Stack	1100 feet (multiple flue)
Coal Characteristics	
Heating Value	5440 Btu/lb
Ultimate Analysis	
C	33.62%
H_2	2.62%
S	0.41%
O_2	11.51%
N_2	0.82%
H_2O	20.00%
Ash	31.02%
Emissions	
Mass Release Rate of Flue Gas	22.53×10^6 lb/hr
SO_2 Release Rate	29,500 lb/hr
Particulate (TSP) Release Rate	4,300 lb/hr
Exit Temperature	280^oF (138^oC)

3.3.3 Methodology

3.3.3.1 Site Differentiating Characteristics

3.3.3.1.1 Regional Meteorological Characteristics

Meteorologically, the alternative plant sites fall into one of two categories - coastal sites or inland sites.

Those sites closer to the ocean and west of the northern extension of the Cascade Mountains experience a marine climate with relatively cool summers and mild winters. Humidities are high because of the proximity to the Pacific Ocean and substantial amounts of precipitation are recorded each year.

The inland sites, located in the higher terrain of the interior of the Province, are shielded from many of the influences of the Pacific Ocean and experience greater temperature extremes and lower humidities. Precipitation patterns vary considerably, depending on site-specific terrain features. Wind speeds are also very dependent on terrain conditions, but generally are higher than at the coastal sites because of the higher altitudes.

The regional climatological differences cited are important considerations for generating station design. For site selection purposes, however, consideration must also be given to localized meteorological phenomena. These include land/sea breezes and valley circulation patterns. Localized meteorological phenomena often limit the dispersion of contaminant plumes, causing unacceptably high ground level contaminant concentrations. In some cases these local phenomena may eliminate potential generating station sites from consideration because they cannot be mitigated by adjusting station design.

3.3.3.1.2 Site-Specific Characteristics

3.3.3.1.2.1 Background Air Quality

Little is known of the existing air quality levels at the alternative sites, although it appears likely that the PCB Guidelines are currently met at each site. (PCB Guidelines are shown on Table 3-6.) At most of the sites, the air quality should be relatively good. Significant atmospheric contaminants from residual and commercial sources are probably present only at the Dunsmuir, Britannia Beach, Ashcroft and Stave Lake sites.

Of greater concern are background air contaminant levels at Vancouver and Kamloops, locations which could be affected by the proposed generating station. Both Vancouver and Kamloops have air quality problems. The full extent of these problems remains unknown; however, both the regulatory bodies and the public at large are concerned. This study considers the impact of the development of each site on the air quality in Kamloops and Vancouver.

3.3.3.1.2.2 Terrain Characteristics

Terrain characteristics at each of the potential sites are described in this section.

TABLE 3-6

POLLUTION CONTROL BOARD

AMBIENT AIR QUALITY GUIDELINES [5] ($\mu g/m^3$)

Parameter	Averaging Period	Level A	Level B	Level C
SO_2	1 Hour	450	900	900
	24 Hours	160	260	360
	1 Year	25	50	80
Total Suspended Particulates	24 Hours	150	200	260
Total Suspended Particulates	1 Year	60	70	75

a) Dunsmuir

Plant grade at the Dunsmuir site is about 250 feet above mean sea level (MSL). The proposed generating station site is located on the southeast shore of Vancouver Island in an area where terrain heights gradually increase with increasing distance from the shore. For example, 9.5 miles inland from the site, the terrain averages 3900 feet MSL. Maximum elevations in the general site region are 5950 feet MSL and 5100 feet MSL 11.3 miles south and 12.5 miles west of the plant site, respectively.

b) Britannia Beach

Plant grade at Britannia Beach site is about 29.5 feet MSL. The site is located on the east shore of Howe Sound, about 30 miles north of Vancouver. The Sound is approximately 1.9 miles wide at the site and its main axis is oriented northeast/southwest. Terrain heights increase significantly to the east of the site, reaching a maximum elevation of 6650 feet MSL approximately 17 miles from the site. Terrain heights also increase inland from the west shore of the Sound, reaching 3050 feel MSL at a distance of 1.9 miles from the western shoreline.

c) Stave Lake

Plant grade at the Stave Lake site is 280 feet MSL. The site is located approximately 40 miles east of Vancouver on a peninsula extending into the south end of Stave Lake. Stave Lake is generally oriented north-northeast/south-southwest and has pronounced terrain features both to the east and west. Terrain heights increase to elevations in excess of 3050 feet MSL within a distance of 3.5 miles west of the site and 4.5 miles east of the site.

d) Ashcroft

Plant grade at the Ashcroft site is about 1230 feel MSL. The site is situated on a terrace above the floor of Thompson River Valley and is sheltered by steep terrain to the east and to the west. Terrain elevations exceed 4900 feet MSL within 4 miles to the east of the river and within 3.5 miles west of the river.

e) Mine Mouth

Plant grade at the Mine Mouth site is about 3100 feet MSL. The site is located in the Upper Hat Creek Valley, which has a north/south orientation and is 2-3 miles wide and 10-12 miles long. The terrain rises sharply to the east and to the west of the valley floor. Terrain elevations east of the valley are 5000 to 6500 feet MSL and west of the valley they achieve a maximum elevation of 7650 feet MSL.

f) Harry Lake

At the Harry Lake site, plant grade is about 4600 feet MSL. The site is located on elevated terrain in the Trachyte Hills area about 3 miles east of the Hat Creek Valley bottom. The terrain east of the site rises to an elevation of 6500 feet MSL. The highest terrain west of the site reaches an elevation of 7650 feet MSL.

g) Big Bar Creek

At the Big Bar Creek site, the plant grade is about 3675 feet MSL. The site is located on a plateau above the east bank of the Fraser River, which is oriented in a north-northwest to south-southwest direction. High terrain rises from both sides of the river valley and exceeds 6500 feet MSL within 9.5 miles of the plant site. Maximum terrain elevations in the general region extend to about 7400 feet MSL.

h) Soda Creek

Plant grade at the Soda Creek site is about 3010 feet MSL. The site is situated on a plateau east of the Fraser River Valley. The valley floor elevation below the site is 1375 feet MSL and the valley proper is oriented north/south. Terrain elevations increase with distance from the valley and reach 3600 feet MSL 12.5 miles to the west and 3.75 miles to the east of the valley. Maximum elevations in the region are approximately 4600 feet MSL.

3.3.3.2 Evaluation Criteria

Three quantitative criteria have been established for use in the meteorological/air quality evaluation of alternative sites. These criteria, the rationale for their selection, the analytical procedures used and their qualitative modifiers are as follows:

3.3.3.2.1 Standard Diffusion

3.3.3.2.1.1 Rationale for Criterion Selection

A Plume of contaminants released to the atmosphere by a generating station diffuses in response to a number of mechanisms. Although special meteorological conditions or terrain effects may modify this diffusion, atmospheric turbulence, a function of wind speed and atmospheric stability, is the primary diffusing mechanism. Diffusion modeling, which is based on simplified plume transport theories and determines plume diffusion by evaluating simple turbulence characteristics, is commonly referred to as standard diffusion modeling. Such modeling is applicable to almost all sites and results derived from it can be used as criteria in the site evaluation procedure.

Standard diffusion modeling is an appropriate analytical tool at all eight sites. For certain of the sites, it is possible to use this procedure to estimate most, if not all, of the ground level contaminant concentrations. For the remaining sites, where terrain effects are important, standard diffusion modeling is used to estimate contaminant concentrations when the plume escapes from the influence of localized controlling mechanisms (e.g. when the plume rises out of a steep-walled valley).

In consideration of the factors described above, standard diffusion is selected as one of the criteria for the meteorological/air quality evaluation of the alternative sites. The quantitative measure selected for this criterion is the frequency with which standard diffusion modeling forecasts hourly SO_2 concentrations in excess of the PCB Level A Guidelines.

Source terms used in the standard modeling analyses are the project generating station stack emissions presented in Table 3-5. This table indicates that, for the proposed station, SO_2 emission rates would be more than six times as great as TSP emission rates. Because the Level A 24-hour PCB Guidelines for ground level concentrations of SO_2 and TSP are nearly identical (160 ug/m^3 and 150 ug/m^3, respectively) and because background levels of both contaminants are low at all of the sites, SO_2 is used as the controlling indicator in these analyses.

Standard diffusion modeling analyses normally utilize one-hour meteorological data to calculate hourly values of ground level SO_2 concentrations. When longer time periods are examined, statistically derived constants[6] are applied to the hourly values. For example, a statistical factor of 0.21 is applied to calculated hourly SO_2 values to predict 24-hour average values. As shown on Table 3-7, this procedure would predict that an hourly SO_2 concentration equal to the PCB Guideline level of 450 ug/m^3 would be associated with a 24-hour concentration of 95 ug/m^3. The actual PCB 24-hour Guideline level is 160 ug/m^3, much higher than the 95 ug/m^3 predicted. It is apparent, then, that hourly concentrations, predicted by the standard diffusion model, are more conservation with respect to PCB Guidelines than are the 24-hour average concentrations predicted using standard statistical procedures. Therefore, predicted hourly SO_2 concentrations are used as the quantitative measure of the standard diffusion criterion.

TABLE 3-7

SO_2 CONCENTRATIONS

Hourly SO_2 PCB Guideline	450 ug/m^3
Statistical factor appropriate to convert hourly concentration to 24-hour averages	0.21
Expected 24-hour average concentration associated with hourly SO_2 PCB Guideline level	95 ug/m^3
Actual 24-hour SO_2 PCB Guideline	160 ug/m^3

3.3.3.2.1.2 Analytical Procedures

The standard diffusion model incorporates:

a) The Brigges plume rise equations[7]

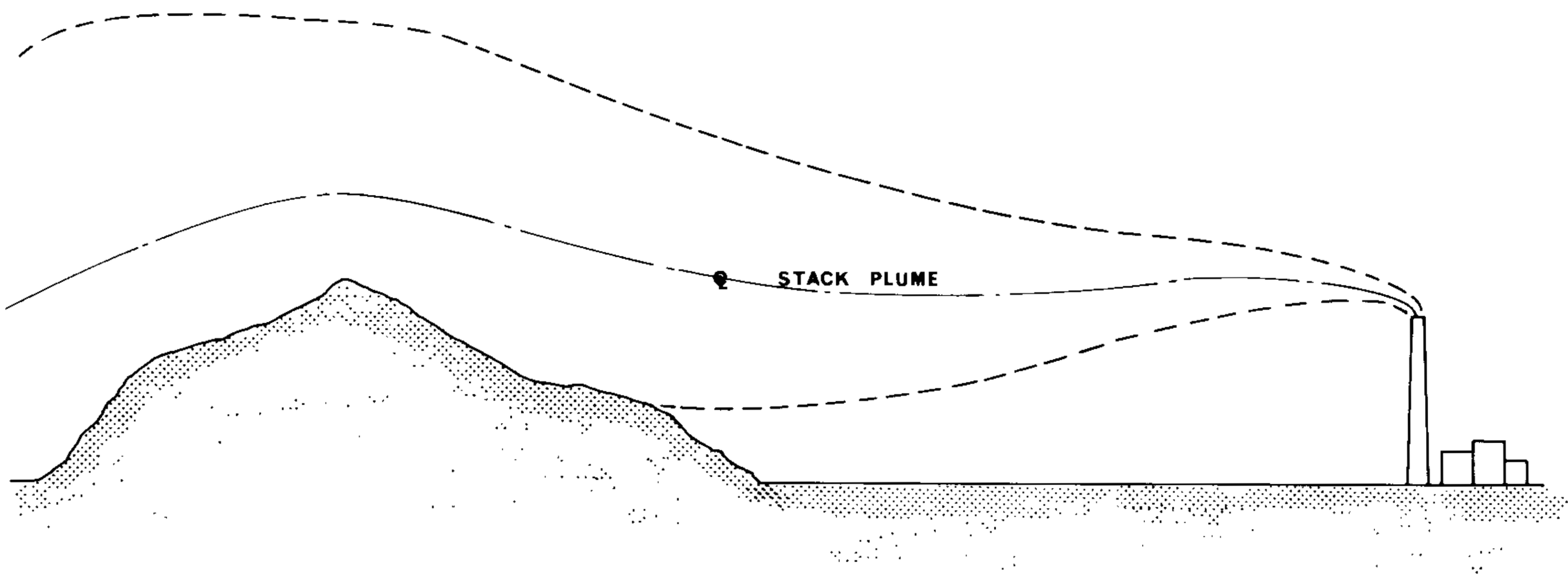
b) The standard Gaussian diffusion equations[8]

c) Diffusion coefficients reported by Turner[8]

A thorough description of the model is contained in Appendix A.

In the model used in this study, the standard Gaussian diffusion equations have been modified to permit consideration of terrain effects. During neutral and unstable atmospheric conditions, this model allows the contaminant plume to flow over elevated terrain, although the vertical distance from the terrain to the plume centerline is reduced. Figure 3-2 depicts this condition. During stable atmospheric conditions the plume is assumed to flow over terrain without changing its elevation above sea level. Thus, under stable atmospheric conditions, the model predicts close approach or direct impingement of a contaminant plume on elevated terrain. Figure 3-3 depicts the stable model situation.

The standard diffusion model predicts direct plume impingement or very high contaminant concentrations on elevated terrain under stable conditons. Recent field studies have shown that contaminant plumes are diluted by mechanical turbulence near the point of impingement and over rugged terrain. To account for this observed dilution, correction factors of 1/3 to 1/8 [9, 10] are applied to calculated ground



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

NEUTRAL AND UNSTABLE PLUME IMPACT

integ – ebasco

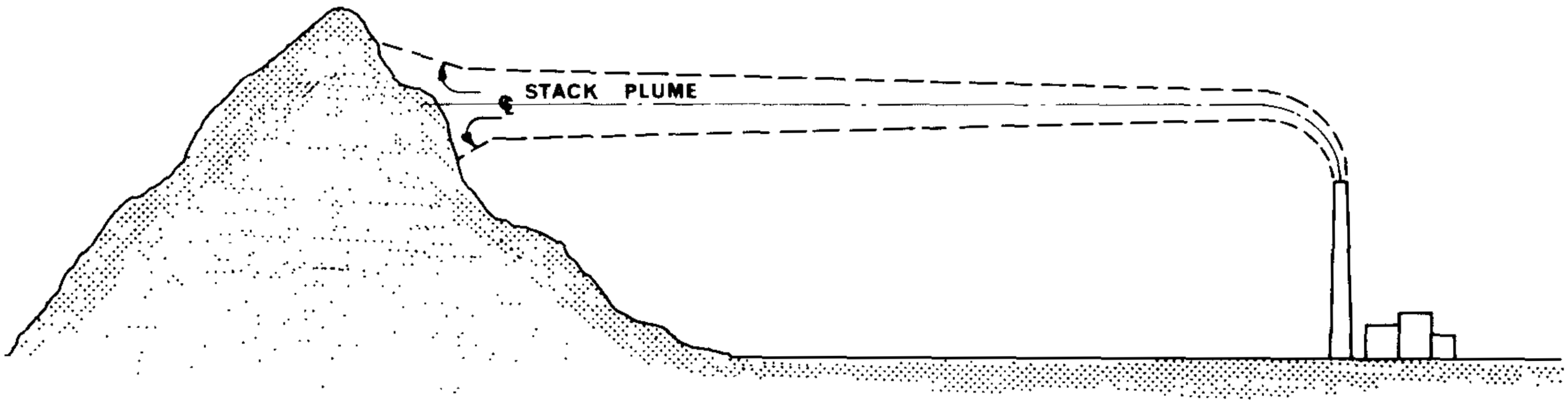
FIGURE 3-2

level concentrations. The correction factor used is dependent upon both the nature of the terrain and the proximity of the plume to the terrain.

The standard diffusion model calculates hourly SO_2 ground level concentrations for selected combinations of wind speed, wind direction, stability class, and elevated inversion heights. These concentrations are computed at grid points on the terrain out to a distance of 12.5 miles from each of the sites. Calculated concentrations in excess of those outlined in the Level A PCB Guidelines are identified and the frequency of occurrence of these excessive concentrations is estimated at each site using the STAR joint frequency data. The total frequency in excess of the Guidelines' suggested concentrations is the quantitative measure of the standard diffusion criterion.

3.3.3.2.1.3 Qualitative Aspects of Criterion

Although the standard diffusion criterion can be applied quantitatively, several site evaluation factors can be applied only qualitatively. These factors, designated qualitative modifiers, include ambient air quality, the location of population centers and model availability/data needs. The standard diffusion criterion takes on added significance in areas where existing concentrations of air contaminants are high and in the vicinity of population centers. Qualitative judgement must also be applied to the standard diffusion criterion when data sources are remote from the modelled site and when significant terrain features must be considered.



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HAT CREEK PROJECT

SITE EVALUATION STUDY

STABLE PLUME IMPINGEMENT

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FIGURE 3-3

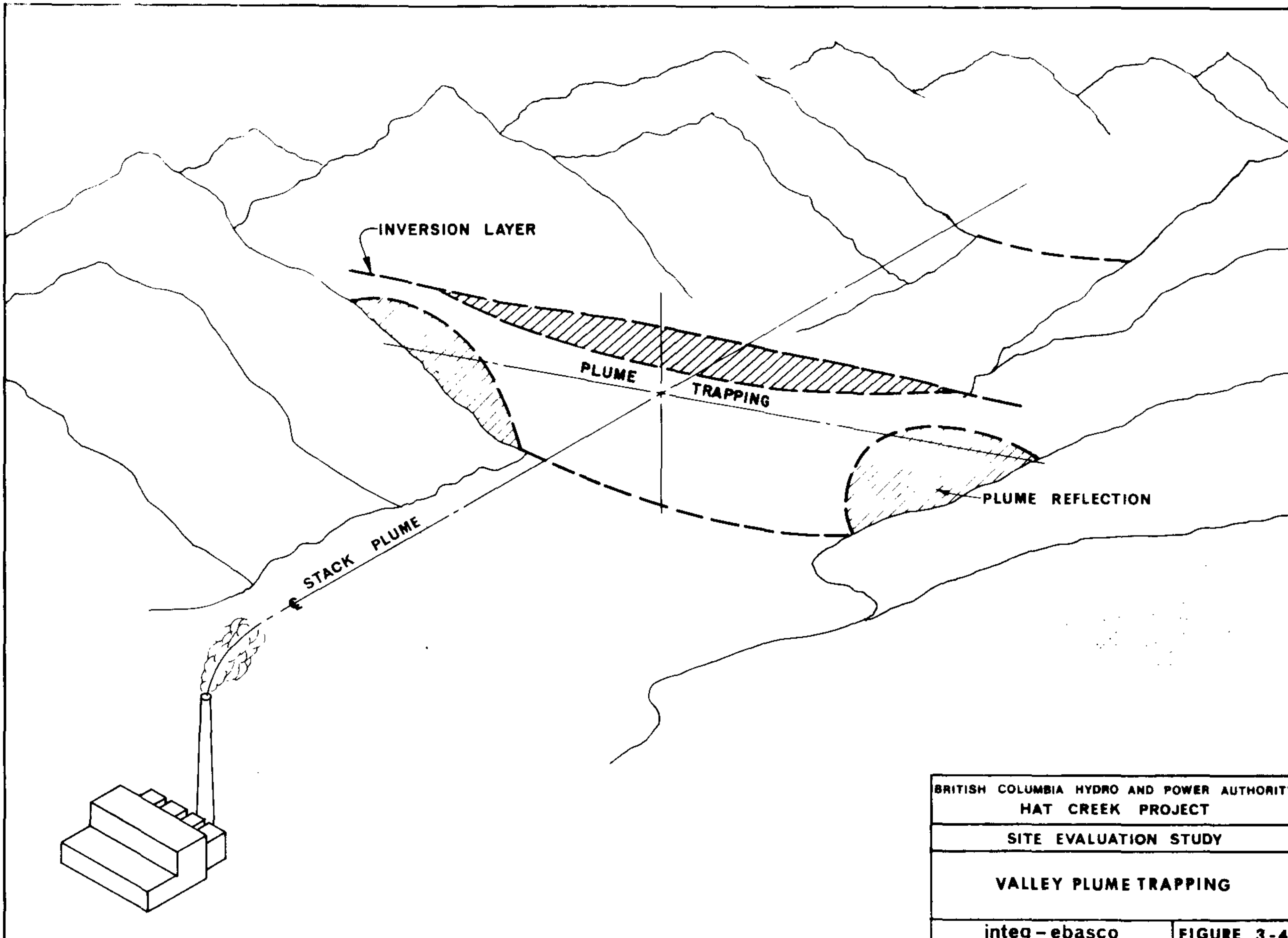
3.3.3.2.2 Plume Trapping

3.3.3.2.2.1 Rationale for Criterion Selection

Generating station siting in rugged terrain can be limited by contaminant dispersion. One limitation occurs when a contaminant plume is unable to rise out of a valley. In such a case, horizontal plume dispersion is limited by the valley walls and the result may be ground level contaminant concentrations in excess of those which would occur on flat terrain.[8] This problem may be further aggravated when atmospheric conditions limit vertical plume dispersion and trap contaminants within the valley. Plume trapping is depicted in Figure 3-4.

Atmospheric conditions conducive to plume trapping incidents are likely at all of the sites. Most of the sites also have terrain features which could contribute to plume trapping. In view of the likelihood that plume trapping will occur at some of the sites, and that standard diffusion modeling will not identify the problem, plume trapping was selected as the second meteorological/air quality criterion for the site evaluation process.

The quantitative measure of the plume trapping criterion is the estimated frequency with which such events could occur. Not all plume trapping incidents would result in ground level contaminant concentrations above PCB Guideline levels. Data limitations and the scope of this study do not permit an accurate estimate of the frequency of such excessive concentrations. Trapping incidents can be serious, however, and the frequency of such incidents is a good measure of the suitability of a potential site.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

VALLEY PLUME TRAPPING

integ – ebasco | FIGURE 3-4

3.3.3.2.2.2 Analytical Procedures

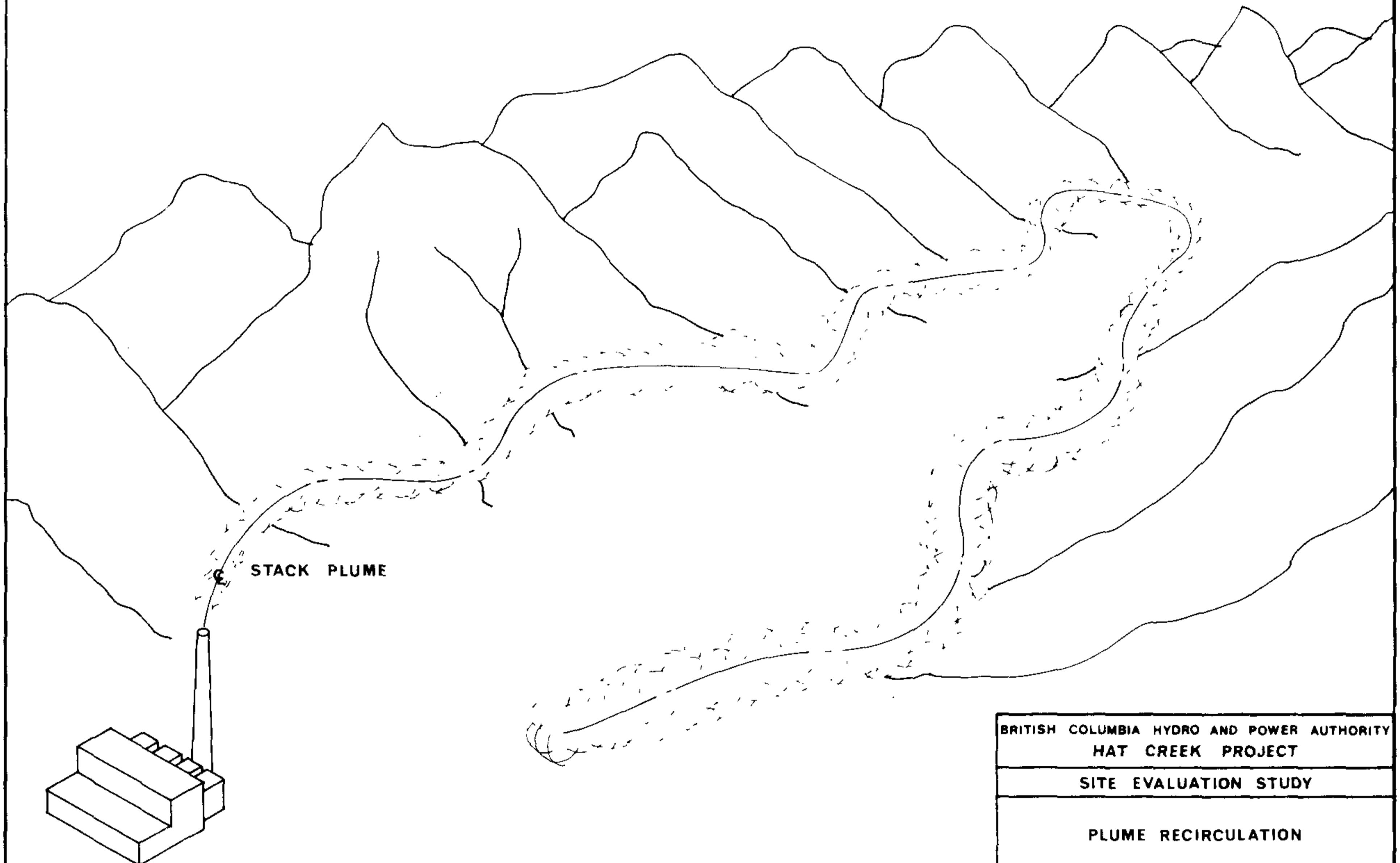
Plume trapping incidents are generally associated with neutral or near-neutral stability conditions (STAR Program Classes 3 and 4). Very high wind speeds inhibit the formation of elevated temperature inversions and are not associated with plume trapping incidents.

The frequency of plume trapping events is estimated using STAR data appropriate for each of the alternative sites. The terrain features of each site are examined to determine the wind direction which could be associated with plume trapping. STAR data are then used to develop joint frequencies of these critical wind directions, stability classes 3 and 4, and wind speeds of less than 12 miles per hour. These joint frequencies are the quantitative measures of the plume trapping criterion.

3.3.3.2.2.3 Qualitative Aspects of Criterion

The qualitative modifiers (ambient air quality, population centers and model accuracy/data needs) are applicable to the plume trapping criterion. One additional modifier, plume recirculation potential, is also used.

Plume trapping events can be aggravated if atmospheric and terrain conditions cause a contaminant plume to recirculate up and down a valley. Under such circumstances, contaminant concentrations in the valley would be high. Figure 3-5 depicts the plume recirculation phenomenon. Steep-walled valleys with pronounced drainage wind flows have a high potential for plume recirculation. Whenever the potential for plume recirculation exists at a site, it is used to accentuate the plume trapping criterion.



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HAT CREEK PROJECT

SITE EVALUATION STUDY

PLUME RECIRCULATION

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FIGURE 3 - 5

3.3.3.2.3 Fumigation

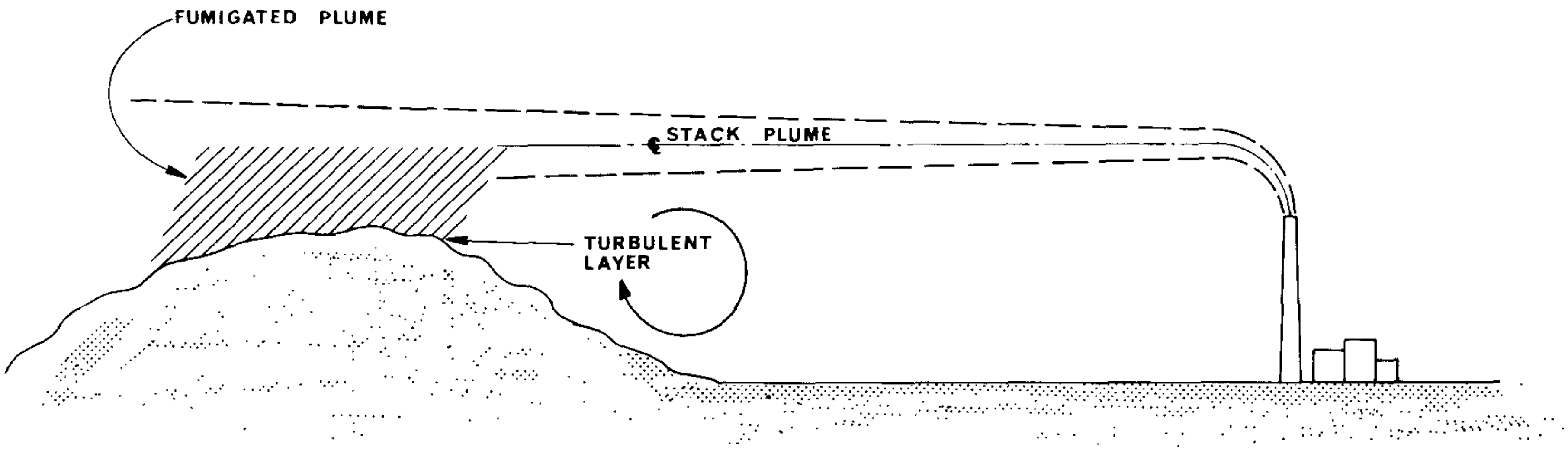
3.3.3.2.3.1 Rationale for Criterion Selection

As the ground heats in response to the sun, air currents form and grow in the vertical direction. These currents can interact with a contaminant plume and bring it to the ground with little dilution. Resultant ground level contaminant concentrations are often high, although generally of short duration.[8] This phenomenon, known as fumigation, is illustrated in Figure 3-6.

Fumigation is aggravated by local high terrain, which facilitates interception of the plume by vertical air currents. Fumigation also occurs where air currents, established in response to the temperature difference between the cool air in the center of a valley and the warm air adjacent to the valley wall, intercept a contaminant plume and bring it against the walls.

A sea or lake breeze can create a relatively constant boundary between stable and unstable air with the result that a fumigation incident may persist at one location for several hours.[11] Sea or lake breeze fumigation problems are the most serious of all fumigation concerns because of their persistence.

Meteorological conditions which could assure fumigation incidents are experienced at all of the sites. Because this impact is not included in the standard diffusion and plume trapping criteria, fumigation is used as the third meteorological/air quality criterion.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT
SITE EVALUATION STUDY
PLUME FUMIGATION ON HIGH TERRAIN
integ – ebasco — FIGURE 3-6

The quantitative measure of plume trapping is the estimated frequency with which such events could occur. Not all fumigation incidents result in contamination levels above PCB Guidelines. Data limitations and the scope of the study do not permit the frequencies of such excessive concentrations to be calculated. The frequency of fumigation incidents, however, is a good indicator of site suitability and is used for that purpose.

3.3.3.2.3.2. Analytical Procedures

The frequency of fumigation events is estimated using the STAR program data appropriate for each of the sites. Terrain features of each site are examined to determine wind direction which could be associated with fumigation incidents on high terrain. Fumigation of a plume onto flat terrain could occur at any site and is, therefore, not a site-differentiating feature. In considering the atmospheric conditions likely to be associated with fumigation, the STAR data are used to develop joint frequencies of stability classes 1 and 2 and the critical wind directions. The total of these joint frequencies is the quantitative measure of the fumigation criterion.

For the Dunsmuir site additional consideration is given to sea breeze fumigation incidents. Frequencies of occurrence of stability classes 1 and 2, concurrent with onshore winds, are calculated and are included in the total frequency values for this site.

a) Qualitative Aspects of Criterion

The qualitative modifiers, exclusive of plume recirculation, are applicable to fumigation. No additional modifiers are necessary or appropriate.

3.4 RESULTS

3.4.1 Application of Criteria to Sites

The quantitative measures of criteria for each site is presented in Table 3-8. All values are presented as percent frequency of occurrence. The plume trapping and fumigation values are the frequencies of occurrence of specified meteorological conditions, whereas the standard diffusion values are frequencies of calculated SO_2 concentrations in excess of one-hour PCB Guidelines.

Based on application of the standard diffusion criterion, Soda Creek and Dunsmuir are the most favorable sites. This is because the terrain surrounding these sites is not as high as that near the other sites. Big Bar Creek and Harry Lake are the next most favourable sites. The calculated tandard diffusion criterion frequencies for the Britannia Beach, Stave Lake, and Mine Mouth sites are high enough to raise questions concerning their viability as sites for a 2000 MW thermal generating station burning Hat Creek coal. Ashcroft is regarded as a marginal site based on its high standard diffusion criterion value.

From a plume-trapping standpoint, Soda Creek is the most favorable site. Harry Lake and Dunsmuir rate equally as the next most favourable sites, followed by Big Bar Creek. The Britannia Beach, Mine Mouth, Stave Lake and Ashcroft sites all exhibit serious plume trapping problems.

The fumigation results are similar to those for the plume trapping criterion except that the Dunsmuir site ranks last in terms of fumigation potential. The change in the relative ordering of the Dunsmuir site results from sea breeze fumigation problems.

TABLE 3-8

QUANTITATIVE MEASURES OF CRITERIA

Frequency of Occurrence - Percent

	Standard Diffusion	Plume Trapping	Fumigation
Dunsmuir	0.36	4.70	6.62
Britannia Beach	14.56	33.60	4.65
Stave Lake	9.09	28.43	4.80
Ashcroft	6.43	23.80	4.32
Mine Mouth	9.16	17.51	4.00
Harry Lake	4.51	1.62	1.34
Big Bar Creek	3.49	9.69	2.20
Soda Creek	0.26	0.00	0.00

3.4.2 Ranking of Criteria at each Site

Table 3-9 ranks the three criteria at each site on the basis of their importance at that site. The qualitative modifiers, discussed previously, were considered in the ranking process. The criteria listed with the value 1 are most important at a given site, whereas those with value 3 are least important. No forced decision matrix was necessary, because only three criteria are involved.

3.4.3 Relative Importance of each Criterion at each Site

Table 3-10 presents an assessment of the relative importance of each criterion at each site. This assessment considers both quantitative factors and qualitative modifiers. This assessment is used implicitly in the site ranking process.

3.4.4 Site Ranking

In ranking the sites in order of preference, from a meteorological/air quality standpoint, careful consideration was given to the criteria rankings and relative criteria importance discussed above and illustrated in Tables 3-8, 3-9 and 3-10. This ranking process yields the following order of site preference:

a) Soda Creek
b) Dunsmuir
c) Big Bar Creek/Harry Lake
d) Ashcroft
e) Stave Lake/Mine Mouth
f) Britannia Beach

TABLE 3-9

RANKING OF CRITERIA

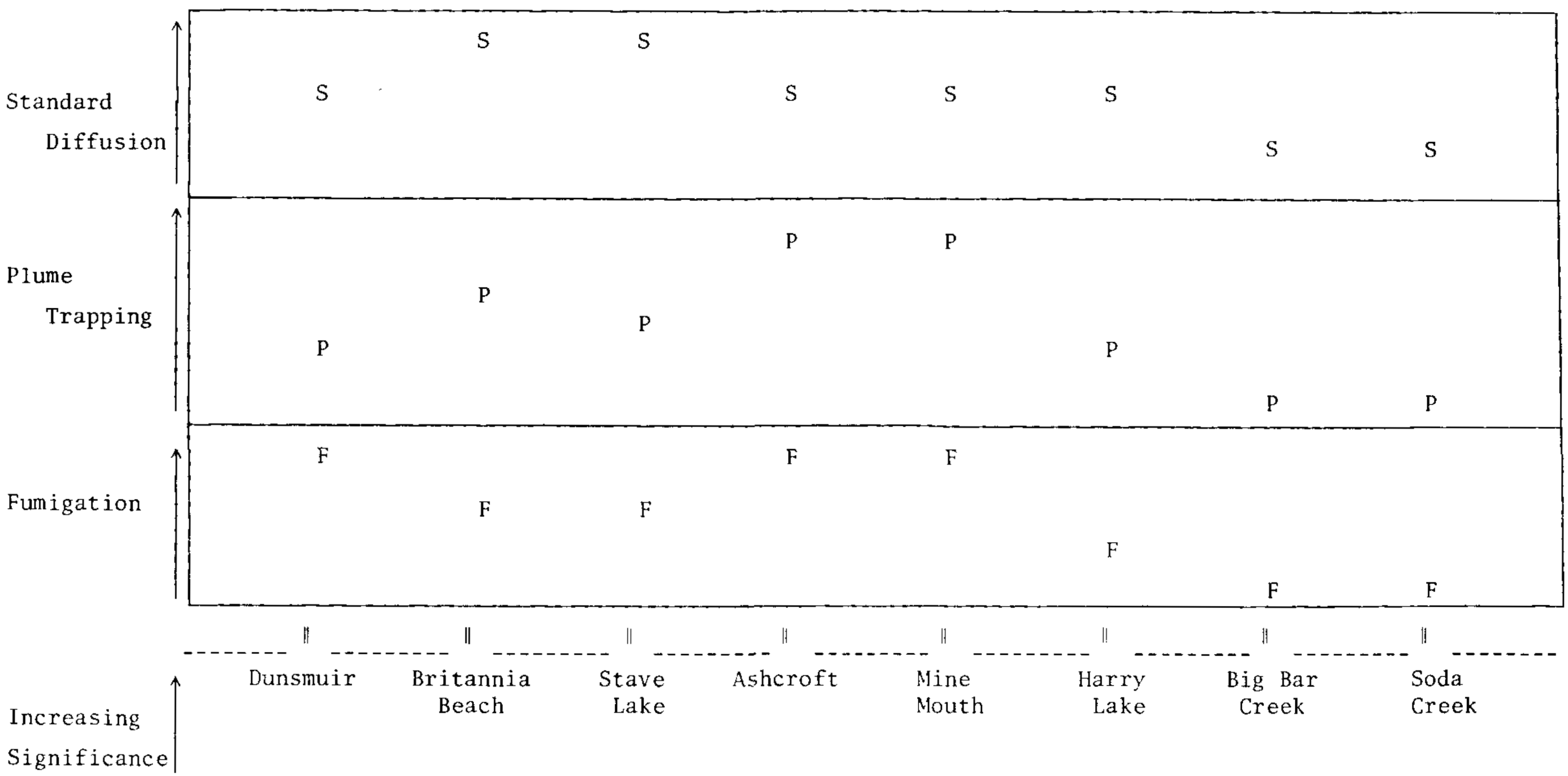
	Standard Diffusion	Plume Trapping	Fumigation
Dunsmuir	1	3	2
Britannia Beach	1	2	3
Stave Lake	1	2	3
Ashcroft	2	1	3
Mine Mouth	2	1	3
Harry Lake	1	2	3
Big Bar Creek	1	2	3
Soda Creek	1	2	3

1 = Most important

3 = Least important

TABLE 3-10

IMPORTANCE OF CRITERIA AMONG SITES



3.5 DISCUSSION AND CONCLUSION

3.5.1 Site Evaluation Criteria

3.5.1.1 Dunsmuir

The most important criterion for this site is standard diffusion. A generating station at this location could have a substantial effect on the air quality of several population centers, including the City of Vancouver. The atmospheric conditions contributing to those effects can be accurately determined using a standard Gaussian approach.

Although standard diffusion is the most important criterion for this site, on a relative basis it is not as important here as it is at some of the other sites. In the vicinity of the site, the population centers which would be affected by contaminant emissions are not large. Additionally Vancouver is a substantial distance from Dunsmuir (40-50 miles) and this distance would mitigate the predicted effects of the generating station.

The analyses performed for the study, using the standard diffusion model, predicted few air quality problems. Those problems occurred primarily under stable atmospheric conditions on high terrain inland from the site. No serious problems were encountered under neutral and unstable conditions.

The second most important criterion for this site is fumigation. When fumigation conditions occur, a generating station at this site could cause high ground level contaminant concentrations at locations a few miles inland from the Strait of Georgia. The affected area would include both recreation and population centers. Sea breeze fumigation models exist, although they are largely unproven. Therefore, fumigation problems are difficult to quantify accurately at this site. Potential sea breeze fumigation conditions are important. Although the frequency of winds toward high terrain, concurrent with very unstable atmospheric conditions (stability classes 1 and 2), is quite low, sea breeze conditions increase the potential fumigation frequency to over 6 percent. This is the highest fumigation value calculated for any of the sites.

Plume trapping is a minor concern at Dunsmuir. A few small valleys exist in the high terrain inland from the site, but few people would be exposed to increased contaminant concentrations if plume trapping occurred in these valleys. Moreover, the incidence of wind blowing toward this terrain in quite low (4.7 percent), confirming the low importance of this criterion at Dunsmuir. Several of the alternative sites have more serious plume trapping problems than Dunsmuir.

3.5.1.2 Britannia Beach

Standard diffusion is the most important criterion for this site because it could indicate potential plant impacts on many population centers including the City of Vancouver and its suburbs 20 miles south of the site. Concern would undoubtedly focus on potential impacts in the City of Vancouver because of its large population and existing air quality problems.

The standard diffusion criterion is more important at Britannia Beach than at any other site except Stave Lake, which is considered equal in this regard. The importance of this criterion reflects the proximity of Vancouver and the problems that could be associated with satisfying PCB Guidelines.

Standard diffusion modeling analyses emphasize the importance of this criterion at Britannia Beach and indicate the magnitude of the potential problems. Not only does Britannia Beach have the highest frequency of standard diffusion problems,but it also is the only site with high predicted ground level concentrations under neutral and unstable conditions.

Plume trapping also is a potentially serious problem for this site. Plumes trapped in the broad valley, which contains the site, would combine with emissions from other industrial sources and affect a significant number of people. Terrain analysis indicates trapping problems could occur through a number of different wind directions and the frequency value of this criterion is quite high (33.6 percent).

The plume trapping potential at this site is also important when all of the sites are compared on a relative basis in regard to this criterion. Although the site is not as confined by terrain as the Mine Mouth and Ashcroft sites, there are several population centers near the site,

Fumigation is the least important criterion for the Britannia Beach site. Some population centers could be affected if such events occurred, but problems would be of short duration. Howe Sound is not large enough to create sea breeze fumigation incidents.

Although sea breeze fumigation is not a concern at Britannia Beach, the frequency of potential fumigation problems is still high in comparison to many of the other sites. Plume fumigation onto high terrain is a possibility with almost all wind directions except those toward the southwest, which would carry any plumes down the sound toward Vancouver.

On a relative basis, fumigation is more important at this site than at others where fumigation problems would affect fewer people. However, this criterion is much less important at Britannia Beach than at Dunsmuir, which is exposed to sea breeze fumigation problems.

3.5.1.3 Stave Lake

Standard diffusion is the most important criterion for this site. The potential impacts of a generating station at Stave Lake on the nearby Vancouver population center would likely be of great concern.

Terrain around Stave Lake is not quite as precipitous as it is at Britannia Beach, and the standard diffusion modeling results show a lower frequency of potential problems. Contaminant concentrations under neutral and unstable conditions are not as significant at this site as at Britannia Beach.

Plume trapping is of secondary importance for this site. Plume trapping incidents could impact some of the high terrain in the area but the areas that would experience these problems are sparsely populated. On a relative basis, plume trapping is not as important at this site as it is at Britannia Beach, because fewer people and fewer industrial air contaminant sources are located in the area. Analysis of potential trapping incidents indicates that problems could occur with 10 of the 16 possible wind directions. The high frequency which results (28.4 per cent) is expected.

Fumigation problems although possible at Stave Lake, would be of limited importance. Although the high terrain surrounding the site could result in a great frequency of fumigation incidents, few people would be affected and the incidents would be short-lived.

3.5.1.4 Ashcroft

Plume trapping is the most important criterion for the Ashcroft site. The station would be located deep in the Thompson River Valley and the potential for air pollution problems would be high. Because the Thompson River Valley contains several localized population centers, the effects of this phenonemon would cause concern.

Plume trapping is not only the most important criterion at Ashcroft but, relatively speaking, it is more important at this site than at any other site, except Mine Mouth. The difficulty of modeling this phenomenom, coupled with the extensive needs required to support a licensing effort and the potential for high contaminations in the valley, emphasize the importance of this criterion at Ashcroft.

An analysis of terrain around the Ashcroft site indicates that plume trapping conditions are possible with all 16 wind directions. The trapping frequency for this site is lower than at Britannia Beach and Stave Lake, only because the frequency of stability classes 3 and 4 was projected to be somewhat lower for this site than for the others.

When standard diffusion modeling is considered at this site, some recognition must be taken of the small population centers in the general vicinity of the site. Attention must also be focused on the potential effects of station emissions on Kamloops, approximately 40 miles away. Because of these population concerns, the standard diffusion criterion at this site has a relative importance similar to that of Dunsmuir, Harry Lake and Mine Mouth.

Standard diffusion modeling analyses indicate potential air quality problems for this site. The calculated frequency (6.43 percent) for this criterion is probably somewhat low since many of the grid points are located at elevations well above the zone of maximum predicted plume impacts and concentrations calculated for these grid points do not reflect the maximum impact of the plume.

Fumigation on high terrain is a concern at this site because of its pronounced valley features and the proximity of population centers. This phenomenon is less significant, however, than the other two criteria. Because of the nature of the terrain around the site, fumigation could take place with almost any wind direction. This is reflected in the relatively high value for the fumigation criterion.

3.5.1.5 Mine Mouth

Relative ranking of the three criteria for the Mine Mouth site and the importance of each criterion at this site are identical to those of the Ashcroft site. Both sites are located in deep valleys where plume trapping could result in high ground level contaminant concentrations, emphasizing the importance of this criterion. The primary qualitative difference between the Ashcroft and Mine Mouth sites is the lack of population centres in the valley containing the Mine Mouth site. Both sites would require extensive diffusion monitoring and modeling if they were selected as generating station sites.

The quantitative ranking of the criteria for the Mine Mouth site also indicated general similarity to the situation at Ashcroft. The plume trapping and fumigation frequencies are a little lower at Mine Mouth than at Ashcroft, primarily because the terrain around Mine Mouth offers some relief, primarily to the southeast. The standard diffusion value is somewhat higher at Mine Mouth than at Ashcroft, but, as indicated earlier, the Ashcroft values are unrealistically low and the two sites should probably be much closer in numerical value with respect to this criterion.

3.5.1.6 Harry Lake

Standard diffusion is the most significant criterion at this site. The potential effect on air quality outside the Hat Creek Valley is of primary concern. Plumes escaping the valley could have a potential impact upon Kamloops which already has air quality problems. Any further studies performed regarding this site should carefully investigate the possibility of plant effects at Kamloops. The standard diffusion criterion at this site is similar in importance to that at the Dunsmuir, Mine Mouth and Ashcroft sites.

Plume trapping is of some importance because of plume effects in high terrain locations distant from the site. Fumigation is the least important of the three criteria due to the low frequency of occurance and low population density.

All three criteria are less critical at this site than at the Mine Mouth site. The basic reason is the higher plant grade at Harry Lake. Releases from a station at this site would have a greater probability of traveling over high surrounding terrain than would those from the Mine Mouth site. Additionally plumes from a plant at Harry Lake would be less likely to incur the problems associated with plume trapping and fumigation because they would be released outside the deeper parts of the Hat Creek valley.

3.5.1.7 Big Bar Creek

Standard diffusion is the most important criterion for Big Bar Creek since it measures those atmospheric conditions most likely to result in an impact on populated area. On a relative basis this criterion is less important at this site than at several of the other alternative sites. Because of the sparse population possibly experiencing the effects of plume trapping and fumigation, other criteria are ranked of higher importance.

The quantitative values developed for Big Bar Creek indicate that terrain and diffusion problems are not as severe at this site as they are at some of the other station locations. As with Harry Lake, many of the problems identified are associated with terrain located a substantial distance from the site. Because modelling uncertainties increase with travel distance, the estimated effects of the generating station at these distances are less certain than for sites like Ashcroft and Mine Mouth where Terrain problems occur very close to the plant site.

3.5.1.8 Soda Creek

The criteria ranking for the Soda Creek site is identical to that for Big Bar Creek. The standard diffusion criterion is again most important. The greatest impact on populated areas would be best measured by standard diffusion considerations, while short-lived fumigation incidents are likely to have few noticeable effects.

Analysis of the Soda Creek site provides little material for discussion. No terrain features were found which could be associated with fumigation and plume trapping. In addition, the standard diffusion modelling for this site yielded the fewest predicted values in excess of PCB Guidelines.

3.5.2 Favoured Site on the Basis of Meteorological/Air Quality Considerations

A review of the quantitative measure of each criterion indicates that Soda Creek is the favored site from a meteorological/air quality standpoint. Dunsmuir is second in rank and Big Bar Creek and Harry Lake are considered equal in third position. Because greater importance is attached to the standard diffusion criterion than to the plume trapping and fumigation criteria, the Dunsmuir site is rated above the Big Bar Creek and Harry Lake sites even though it has a greater potential for fumigation problems.

The Britannia Beach, Stave Lake, Mine Mouth and Ashcroft sites all have the potential for serious air quality problems. They should not be considered as viable sites.

3.5.3 Flue Gas Desulfurization

Flue gas desulfurization (FGD) is not assumed for the base case station considered in this study. It is unlikely that inclusion of FGD would have a significant impact on the ranking of sites in the meteorological/air quality studies. Soda Creek is the best site from a meteorological/air quality standpoint and would remain so even if FGD were included in the analyses. Britannia Beach, Stave Lake, Mine Mouth and Ashcroft all have serious air quality problems which FGD alone could not overcome. Consideration of FGD at the three remaining sites might cause some changes in the numerical measures and might adjust their relative ranking. However, rough approximations indicate that Dunsmuir would remain number two and Big Bar and Harry Lake would still tie for third.

Based on studies performed to date, it is not possible to assume that the Dunsmuir, Soda Creek, Harry Lake, or Big Bar sites would meet the PCB guidelines without a Supplemental Control System (SCS) or FGD. As a consequence of this uncertainty it is recommended that:

a) In the early stages of the Environmental Report effort detailed studies be undertaken at the preferred site to determine if either FGD or SCS will be required to control ground level contaminant concentrations.

b) If it is determined that FGD is required to control ground level concentrations at the preferred site, consideration should be given to the economics of FGD versus the economics and environmental compatibility of alternative site or sites.

The above course of action is a reasonable one and is consistent with the Terms of Reference for both the Site Evaluation Study and the Environmental Report.

3.5.4 Recommended Studies

Regardless of the site chosen, site-specific meteorological and air quality monitoring programs should be initiated in the near future in order to develop the data base necessary to support a site licensing effort. Sites located in complex terrain will obviously require more extensive and more sophisticated monitoring efforts while less complex sites, such as Soda Creek or Big Bar Creek, would require more standardized monitoring programs.

This study recognises that a potential problem of acid rain formation and transport may exist but does not investigate it. A more detailed investigation may be necessary to supplement the work in the Environmental Report (ER) presently in preparation. It is also noted that a committee has been established to study the problems.

If the Dunsmuir site were selected two additional research needs can be identified. First, sea breeze fumigation model verification studies are needed. Some calibration of this model has been done, using actual background contaminant measurements. However, a thorough monitoring program should be implemented to calibrate the model.

A second area of potential concern at the Dunsmuir site is the potential for salt deposition. Salt deposition predictive models are plentiful, but little meaningful model calibration has been done. Unless the area around the Dunsmuir plant has salt resistant plant species, salt deposition concerns could be important. Such concerns could be more properly addressed by a monitoring program designed to define the problem and identify mitigative measures.

GLOSSARY

Atmospheric Stability - A measure of the atmospheric ability to inhibit or accentuate air motion in the vertical plane.

Diffusion - Dilution of a contaminant plume by the turbulent forces of the atmosphere.

Fumigation - The rapid bringing to the ground of an elevated contaminant plume by vertical air currents resulting from an unstable atmosphere.

Gaussian Diffusion Model - A statistical, calculational model that treats diffusion as a function of wind speed and atmospheric stability and assumes that a contaminant plume is normally distributed in the vertical and the horizontal.

Impingement - The striking of the centerline of a contaminant plume on an elevated terrain feature.

Inversion - A layer of the atmosphere in which temperatures increase with height and which acts as a lid upon the vertical diffusion of a contaminant plume.

Neutral Conditions - The stability condition of the atmosphere which has no positive or negative effect upon vertical air motions.

Plume Trapping - An atmospheric condition which limits the upward diffusion of a contaminant plume and which may be made more serious if topography concurrently limits horizontal plume diffusion.

Sea Breeze - Onshore wind flow caused by the fact that land surfaces warm more rapidly than the surfaces of water bodies.

Stable Conditions - The stability condition of the atmosphere which inhibits vertical motions.

Unstable Conditions - The stability condition of the atmosphere which accentuates vertical motions.

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APPENDIX 3-1

STANDARD DIFFUSION MODEL CALCULATIONS

STANDARD DIFFUSION MODEL CALCULATIONS

The following is a discussion of the sequence of calculations performed for each stable condition evaluated:

a) Surface or low level wind speeds are adjusted to stack top wind speeds using the relationship [12]

$$u = u_1 \left(\frac{h_s}{h_i}\right)^{\frac{1}{10-S}}$$

where:

u = wind speed at stack top, m/sec

u_1 = surface or low level wind speed, m/sec

h_s = height of the top of the stack above ground level, m.

h_i = height of low level or surface wind speed sensor above ground level, m.

S = stability class number

b) The heat emission rate is calculated using the following equation:

$H = 252\ M\ Cp\ (T_s - T_A)$

M = flue gas mass release rate, lb/sec

C_p = flue gas mean specific heat, $\frac{\text{Btu}}{\text{lb-}^{\circ}\text{R}}$

T_s = stack exit temperature, $^{\circ}$R

T_A = ambient temperature, $^{\circ}$R

c) Using the heat emission rate calculated in Step (c) and an approximation suggested by Briggs [13] the buoyancy flux parameter is calculated:

$F = 3.7 \times 10^{-5}\ H$

where:

F = buoyancy flux parameter, m^4/sec^3

c) The buoyancy flux parameter is used to define the downwind distance at which atmospheric turbulence begins to dominate entrainment. This distance is expressed by the following dimensionless equation [7] :

$x^* = 14\ F^{5/8}$ if $F \leq 55\ m^4/sec^3$

$x^* = 34\ F^{2/5}$ if $F > 55\ m4/sec^3$

where:

x^* = downwind distance to point at which turbulence begins to dominate entrainment, m.

e) The horizontal distance to the point of final rise is defined by the following relationship:

$$x_{fs} = \frac{3.14\ u}{s^{1/2}}$$

where:

x_{fs} = downwind distance to point of final rise, m

u = wind speed at stack top, m/sec

s = stability parameter = $\frac{g\Delta\Theta}{T\Delta z}$, sec^{-2}

g = acceleration of gravity, m/sec^2

T = ambient air temperature, ^oK

$\frac{\Delta\Theta}{\Delta z}$ = potential temperature gradient of environment, $^oK/m$, a stability class function = 0.0155 - 0.055 (S as defined in Step (a) above)

f) For points closer than x_{fs} the plume rise equation used is [7] :

$$\Delta h = \frac{1.6\ F^{1/3}\ x^{2/3}}{u}$$

For points further from the stack than x_{fs}, the following Briggs stable formula is used [9] :

$$\Delta h = 2.4 \left(\frac{F}{us}\right)^{1/3}$$

where:

Δh = plume rise, m

u = wind speed at stack top, m/sec

F = buoyancy flux parameter, m^4/sec^3

s is defined in (e) above.

g) A final adjustment is made to the plume rise model to account for the effects of terrain. This final adjustment is incorporated by the following equation:

$$h = h_s + \Delta h - (h_t - h_b)$$

where:

h = effective height of plume, m

h_s = stack height, m

Δh = plume rise, m

h_t = height of terrain above mean level, m

h_b = height of base of stack above mean sea level, m

(h) Once the effective height of the plume has been determined, the computer program calculates ground level pollutant concentrations for each stack/grid point combination and all meteorological conditions considered, using the basic Gaussian diffusion equation modified to account for plume dilution at the point of impact [8]:

$$X = \frac{KQ}{\pi \sigma_z \sigma_y u} \exp\left[-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\tfrac{1}{2}\left(\frac{h}{\sigma_z}\right)^2\right]$$

where:

X = ground level concentration of pollutant, ug/m^3

Q = contaminant release rate, ug/sec

σ_y = horizontal dispersion coefficient, m

σ_z = vertical dispersion coefficient, m

u = stack top wind speed, m/sec

h = effective plume height, m

y = crosswind distance between plume centerline and grid point, m

K = 1/3 corrects for additional dispersion of the plume at the point of impaction.

(i) The horizontal and tertical dispersion coefficients are calculated by the computer subroutine POLYN developed by J. F. Sagendorf.[14] The σ_y and σ_z values generated by this subroutine approximate those presented by Turner.[8]

(j) Predicted stable plume impacts were further reduced by a factor of 1/6 when the travel path of the plume would require its passage over underlying rugged terrain. This correction factor was based upon the results of tracer studies conducted in rugged terrain in the United States.[9,10]

The following sequence of calculations was performed for each neutral and unstable condition examined.

(a) Surface or low-level wind speeds are adjusted to stack top wind speeds using the relationship[12] :

$$u = u_1 \left(\frac{h_s}{h_i} \right)^{\frac{1}{10-S}}$$

where:

u = wind speed at stack top, m/sec

u_1 = surface or low level wind speed, m/sec

h_s = height of the top of the stack above ground level, m

h_i = height of low level or surface wind speed sensor above ground level, m

S = stability class number

(b) The heat emission rate is calculated using the following equation:

H = $252\ M\ Cp\ (T_s - T_A)$

M = flue gas mass release rate, lb/sec

C_p = flue gas mean specific heat, $\frac{\text{Btu}}{\text{lb-}^{\circ}\text{R}}$

T_s = stack exit temperature, $^{\circ}$R

T_A = ambient temperature, ^{o}R

(c) Using the heat emission rate calculated in Step (b) and an approximation suggested by Briggs [12] the buoyancy flux parameter is calculated:

$$F = 3.7 \times 10^{-5} H$$

where:

F = buoyancy flux parameter, m^4/sec^3

(d) The buoyancy flux parameter is used to define the downwind distance at which atmospheric turbulence begins to dominate entrainment. This distance is expressed by the following dimensional equation:

$$x^* = 14 F^{5/8} \quad \text{if } F \leq 55 \ m^4/sec^3$$

$$x^* = 34 F^{2/5} \quad \text{if } F > 55 \ m^4/sec^3$$

where:

x^* = downwind distance to point at which turbulence begins to dominate entrainment, m

(e) x^* is then used to calculate the downwind distance to the final rise point of the plume by the equation [7] :

$$x_f = 3.5\ x^*$$

where:

x^* is defined in (4) above

x_f = downwind distance to point of final rise, m

(f) When a given grid point is closer to the stack than the distance x_f, the plume is predicted to rise according to the following relationships as reported by Briggs [7] :

$$\Delta h = \frac{1.6\ F^{1/3}\ \ x^{2/3}}{u}$$

where:

Δh = plume rise, m

f = buoyancy flux parameter, m^4/sec^3

x = downwind distance from source, m

u = wind speed at stack top, m/sec

(g) When a given grid point is farther from the stack than the distance of x_f the plume is considered to reach a final height as given by the following Briggs [7] formula:

$$h_f = \frac{1.6F^{1/3}x_f^{2/3}}{u}$$

(h) To account for the downwash under high wind conditions, a procedure suggested by Briggs is utilized. Whenever the plume exit velocity is less than 1.5 times the stack top wind speed, the correction term described below is subtracted from the plume rise calculated in Steps (f) and (g). This downwash correction term is calculated as follows[15]:

$$h_d = 3(1.5) - w_o/u)\ D$$

where:

h_d = downwash correction, m

w_o = plume exit velocity, m/sec

u = stack-top wind speed, m/sec

D = outer diameter of stack top, m

(i) A final adjustment is made to the plume rise model to account for the effects of terrain. This final adjustment is incorporated into the following equation:

$$h = h_s + \Delta h - h_d - \tfrac{1}{2}(h_t - h_b)$$

where:

h = effective height of plume, m

h_s = stack height, m

Δh = plume rise, m

h_t = height of terrain above mean sea level, m

h_b = height of stack base above mean sea level, m

(j) Once the effective height of the contaiminant plume has been determined, the computer program calculates ground level pollutant concentrations for each stack/grid point combination and all meteorological conditions considered using the basic Gaussian diffusion equation:

$$X = \frac{Q}{\pi \sigma_z \sigma_y} \exp\left[-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\tfrac{1}{2}\left(\frac{h}{\sigma_z}\right)^2\right]$$

where:

X = ground level concentration of pollutant, ug/m^3

Q = contaminant release rate, ug/sec

σ_y = horizontal dispersion coefficient, m

σ_z = vertical dispersion coefficient, m

u = stock top wind speed, m/sec

h = effective plume height, m

y = crosswind distance between plume centerline and grid point, m

(k) The horizontal and vertical dispersion coefficients are calculated by the computer subroutine POLYN developed by J. F. Sagendorf.[14] The σ_y and σ_z values generated by this subroutine approximate those presented by Turner.[8]

(l) For neutral and unstable conditions a check of limited mixing conditions was also performed. The model tests to determine if an elevated inversion will impact upon the dispersion of the plume. If that test is answered affirmatively, the model then tests to determine what portion, if any, of the pollutant plume is trapped beneath the inversion. If the top of the stack is below the inversion base, the portion of the plume which is trapped below the inversion (Tr) is determined using the following, which was suggested by Briggs.[16]

$$T_r = 1.5 - \frac{h}{(L-h_s)}$$

where:

$0 \leq T_r < 0.5$

and:

$T_r = 1$ for $\Delta h < (L-h_s)$

Note that when the plume centerline is not predicted to rise above the inversion base, it is assumed that the entire plume is trapped below the inversion.

(m) When the plume is trapped by an elevated inversion, the impact of the inversion on ground level concentrations will not be felt until it is some distance downwind from the reliable point. Turner[8] has indicated that the downwind distance associated with high limited mixing concentrations can be approximated by the following relationship:

$$d = 2x$$

where:

d = downwind distance for high concentrations, m

x = downwind distance at which $\sigma_z(x) = 0.47$ L, m

L = height of inversion, m

(n) Even under limited mixing conditions, the model calculates ground level concentration contaminants according to the standard Gaussian equation until the distance from the plant specified in Step (m) is reached. At that point, the limited mixing diffusion equation [8] shown below is substituted for the standard diffusion equation.

$$X = \frac{T_r Q}{\sqrt{2\pi}\,\sigma_y L u} \exp\left[-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]$$

where:

X = ground level concentration of pollutant, ug/m^3

Q = pollutant release rate, ug/sec

σ_y = horizontal dispersion coefficient, m

u = stack top wind speed, mps

L = height of trapping inversion, m

y = crosswind distance plume centerline and grid point, m

(o) Ground level concentrations obtained either from the limited mixing equation or the normal diffusion equation are treated identically by the model.

4. WATER RESOURCES

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4.1 SUMMARY

A 2000 MW Thermal Generating Station burning Hat Creek coal is proposed for British Columbia. There are eight alternative sites under consideration in two distinct areas of the Province: the Pacific Coast and the Fraser River Watershed. An investigation of these water resources has been performed and water management plans conceptualized for the thermal generating station. Each site-specific plan minimizes process water withdrawal and maximizes water reuse wherever possible. Based upon these analyses, six site-differentiating criteria have been generated. These criteria are measures of 1) the effect of the thermal generating station on water resources and 2) the effect of the water resources on the thermal generating station.

Numerical values for each criterion have been applied to each site; they indicate from a water resources standpoint that the order of site preference is:

Site	Rank
Harry Lake	1
Mine Mouth	2
Ashcroft	3
Big Bar Creek	4
Soda Creek	5
Dunsmuir	6
Britannia Beach	7
Stave Lake	8

The Harry Lake site is preferred for the following reasons:

a) No liquid chemical and thermal wastes would be discharged to natural water bodies.

b) In-water construction would be limited to an intake structure.

c) The quality of the water would require less chemical additions and treatment.

Stave Lake is the least acceptable site. This conclusion is based on the following:

a) The once-through condenser cooling water system would discharge 9.45×10^9 Btu/hr of heat to the lake.

b) Treated chemical effluents would affect the water quality of the lake.

c) Significant dredging volumes would be required for large intake and discharge structures.

4.2 INTRODUCTION

Thermal generating stations require water for virtually all plant processes. Water withdrawal and wastewater discharge could cause environmental impacts in an aquatic ecosystem or affect subsequent use of a water resource. The purpose of water resources management is to develop a water use plan that ensures efficient plant operation and minimizes adverse environmental effects.

4.2.1 Purpose

The purpose of this chapter is to evaluate the alternative sites for a 2000 MW Thermal Generating Station development, in consideration of provincial water resource impacts.

The specific objectives of this report on water resources evaluation are:

a) To characterize the surface water resources in the study area regarding quantity, quality and availability.

b) To identify the water supply requirements of the proposed thermal generating station development on a generic and site-specific basis.

c) To identify the wastes-generating potential of the proposed thermal generating station development on a generic and site-specific basis.

d) To identify those regulatory agency guidelines and limitations that pertain to water withdrawals, water use, and wastes disposal.

e) To identify the potential and reasonably expected effects of the thermal generating station development on the water resources of the study area and alternative sites.

f) To develop and justify criteria relevant to the water resource factors of concern herein; to allow for relative site evaluation on both a regional and site-specific basis.

g) To apply the criteria to the alternative sites on both a regional and site-specific basis.

h) To identify a preferred site(s) from the water resources viewpoint based on the results of the Hat Creek Site Evaluation Study.

i) To recommend any additional investigations, evaluations or analyses that are believed warranted from the water resources viewpoint in connection with the Hat Creek Site Evaluation Study.

4.2.2 Scope

The scope of the comparative water resources impact evaluation includes field identification and data analysis. All relevant data and information were obtained from literature, personal communications and conferences with representatives of participating disciplines. The following specific activities were carried out:

a) Establishing, with the cooperation of engineering specialists, the conceptual water supply, water use and wastes discharge characteristics of the proposed development.

b) Consulting with and securing data and information from various governmental agencies concerning the water resources of the study area and alternative sites, and the regulatory limitations pertaining thereto.

c) Reviewing, analyzing and evaluating the publications relevant to the overall site evaluation effort.

d) Establishing, justifying and applying site evaluation criteria.

e) Co-ordination with other project personnel of all disciplines.

f) Evaluating the alternative sites based on the established criteria and selecting a preferred site(s).

The water and wastes systems described and evaluated herein are conceptual in nature, reflecting current state-of-the-art engineering practice. During the final engineering and design effort, the concepts would be optimized for the preferred site, upon the availability of more detailed and extensive site-specific engineering, economic and environmental information. The conceptual nature of these systems does not preclude preferred site selection, as the effects defined are representative of "extreme case" situations that would be further minimized (if adverse in nature) or maximized (if beneficial in nature) during final project design.

4.3 MATERIALS AND METHODS

4.3.1 Data and Information Sources

The water resources study utilized data on:

a) Water Resources

- Water quantity
- Water availability
- Water quality
- Water use and discharge regulations

b) Plant Water Use and Waste Generation

c) Climate

- Evaporation rates
- Precipitation rates.

Water resources data were obtained from the Inland Waters Directorate, Environment Canada and the Pollution Control Branch of the Province of British Columbia (PCB), Water Resources Service. Water use and rights records were obtained from the PCB, Water Rights Branch. Water quality data were obtained from the National Water Quality Data Bank (NAQUADAT). The Canadian Weather Service provided meteorological data and regional climatic characteristics.

4.3.2 Methodology

In order to differentiate between the eight alternative sites, water management plans were developed for each site by utilizing site-specific thermal generating station conceptual designs. These plans defined water supply requirements and wastewater characteristics. To assist the reader, generic descriptions of the major thermal generating station systems, associated water use and wastewater discharges are given in Appendix 4-1. Subsequently, the following effects were considered:

a) The effects of construction and operation on the water resource;

b) The effects of the water resource upon thermal generating station operation.

Construction effects on water quality include increased turbidity and suspended solids from rainfall runoff. Turbidity and suspended solids also increase during dredging operations. Although the former effects can be minimized by proper construction techniques, dredging, and the attendant loss of benthic habitat, represents an irretrievable commitment of resources. Dredging can thus be considered a site differentiating factor.

Operational effects stem from make-up water withdrawal and wastewater discharges. Water withdrawal reduces stream flow, and wastewater discharges can degrade water quality. Because water availability in the study area is not limiting, the effect of stream flow reduction would be minimal and not differentiating. Wastewater discharge characteristics vary because of site-specific conceptual design.

The addition of chemicals and heat to receiving water bodies permit sites to be differentiated.

Make-up water quality dictates the extent of treatment required to assure proper plant operation. Plant-related water quality problems include scaling, corrosion, solids deposition, condenser tube plugging, and biofouling. Because the quality of the site water resources varies, it can be used to differentiate between sites.

4.3.3 Site Evaluation Criteria

The comparative site evaluations utilized six water resource related criteria. Three criteria measure thermal generating station effects on water resources. The remainder relate to water resource effects on thermal generating station operation. These criteria are defined in the following paragraphs:

4.3.3.1 Thermal Generating Station Effects on Water Resources

a) Dredging - an indirect measure of dradging effects was used as an index of this criterion. The numerical value is the sum of the make-up and discharge rates in cubic feet per second, which is used to represent the relative area required for intake and discharge structures.

b) Chemical discharge - the amount of total dissolved solids in pounds per day added by a plant to a receiving water body. This criterion estimates the potential chemical contamination at a site.

c) Thermal Discharge - the heat contained in the discharge of the condenser cooling water system, measured in British Thermal Units (BTU) per hour. This criterion measures the potential thermal pollution at a site.

4.3.3.2 Water Resource Effects on the Thermal Generating Station

a) Total Dissolved Solids (TDS) - the make-up water TDS concentration, measured in milligrams per litre (mg/l). This criterion is a measure of the potential scaling/ corrosion problems in condenser cooling water systems.

b) Suspended Solids (SS) - the make-up water SS concentration, measured in mg/l. SS estimates the potential abrasion and blockage problems in piping and pumping systems.

c) Chlorine demand - the chlorine demand of the make-up water measured in mg/l. This criterion estimates biofouling potential and biocide requirements.

4.3.4 Evaluation Procedure

The procedure used to compare sites is shown below:

a) Criteria were applied to each site and their numerical values computed. The results were displayed in a matrix format (sites vs criterion).

b) The forced-decision technique was used to make pair-wise comparisons between criteria for each site. The resultant ordering ranked the criteria by their importance at each site. Importance is defined as the relative potential impact of a criterion at a site.

c) The forced-decision technique was also applied to determine the relative signifance of each criterion among the eight alternative sites.

d) Site ordering and the identification of a preferred site from a water resources viewpoint were accomplished by data interpretation and professional judgement.

4.4 RESULTS

4.4.1 Water Resource Quantity, Quality and Availability

Table 4-1 presents the volume or the minimum flow of the makeup supply source, the general water quality of the supply source as typified by the TDS concentration and the anticipated constraints associated with the withdrawal of water to satisfy thermal generating station requirements.

4.4.2 Site-Specific Makeup, Consumption Use and Discharge Flows

Table 4-2 presents the results of applying state-of-the-art water management techniques to each site in the formulation of a preliminary conceptual plant water balance. Characteristics at the five interior sites permit the operation of a no liquid discharge system.

4.4.3 Numerical Criteria

TABLE 4-1

SUMMARY OF SITE SPECIFIC WATER QUANTITY, QUALITY AND AVAILABILITY

Site	Volume or Minimum Flow of Supply Source	Average TDS Concentration of Supply Source (mg/l)	Anticipated Constraints Which Would Preclude Water Withdrawal
Dunsmuir	-----	22,000	NONE
Britannia Beach	3×10^{11} cf	21,500	NONE
Stave Lake	2.13×10^{10} cf	70	NONE
Ashcroft	5300 cfs	70	NONE
Mine Mouth	5300 cfs	55	NONE
Harry Lake	5300 cfs	55	NONE
Big Bar Creek	7000 cfs	96	NONE
Soda Creek	7000 cfs	90	NONE

TABLE 4-2

TOTAL MAKEUP, CONSUMPTIVE AND DISCHARGE FLOWS

Process Flows	Ashcroft	Big Bar Creek	Britannia Beach	Dunsmuir	Harry Lake	Mine Mouth	Soda Creek	Stave Lake
Makeup Flows								
1) Cooling Water System	20,572	19,992	750,000	27,900	20,195	19,674	20,233	750,000
2) Plant Processes	810	810	1,140	810	810	810	810	810
3) Offsetting Reservoir Evaporation	-	46	-	-	90	146	11	-
Total Makeup from Supply Source	21,382	20,848	751,140	28,710	21,095	20,630	21,054	750,810
Consumptive Flows								
1) Cooling Tower Evaporation	18,600	18,600	-	18,600	18,600	18,600	18,600	-
2) Cooling Tower Drift	70	70	-	70	70	70	70	-
3) Water Consumed by Plant Processes	240	240	240	240	240	240	240	240
4) Reservoir Evaporation	-	46	-	-	90	146	11	-
5) Water Consumed by Ash	1,250	1,250	330	1,250	1,250	1,250	1,250	1,250
6) Ash Pond Evaporation	1,222	642	-	-	845	324	883	-
Total	21,382	20,848	570	20,790	21,095	20,630	21,054	1,490
Process Discharge Flows								
1) Cooling Water System	1,902	1,322	750,000	8,600	1,525	1,004	1,563	750,000
2) Other Plant Processes	570	570	570	570	570	570	570	570
Total	2,472	1,892	750,570	9,170	2,095	1,574	2,133	750,570
Recycle Flow	2,472	1,892	0	1,250	2,095	1,574	2,133	1,250
Net Accumulated Precipitation	-	-	-	2,895	-	-	-	2,989
Total Plant Discharge to Receiving Water Body	0	0	750,570	10,815	0	0	0	752,309

[1] All Flows presented in Gallons Per Minute (GPM)

The results of applying the numerical criteria to the various sites are identified in Table 4-3. These results indicate the following:

a) A significant difference exists between interior and coastal sites. This is primarily due to the fact that no discharge of chemical and thermal contaminants would result at interior sites whereas, relatively significant discharges would occur at the coastal sites.

b) The effects of dredging at the Britannia Beach and Stave Lake sites would be far greater than such effects at all other sites.

c) In terms of effects of the environment on the plant, the Dunsmuir and Britannia Beach sites would be more significantly affected than all remaining sites. Among the interior sites, the Mine Mouth and Harry Lake sites are expected to experience the least adverse effects.

4.4.4 Relative Importance of Each Criterion at East Site

A subjective forced-decision process was performed on the evaluation criteria at each site to determine the relative importance, or ranking of each criterion at a specific site. Site-specific criteria rankings are presented in Table 4-4 and indicate:

a) Those criteria reflecting the effects of the plant on the environment are more important than the criteria

TABLE 4-3

SITE EVALUATION CRITERIA AND NUMERICAL VALUES

Criteria	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
The Effects of the Plant on the Environment								
1. Chemical Addition (lbs/day)	43,150	6,550	8,900	0	0	0	0	0
2. Thermal Addition (Btu/hr)	9.45×10^7	9.45×10^9	9.45×10^9	0	0	0	0	0
3. Dredging Quantities (cfs)	86	3,340	3,340	50	46	47	46	47
The Effects of the Environment on the Plant								
1. Total Dissolved Solids (mg/l)	22,000	21,500	30	70	55	55	96	90
2. Suspended Solids (mg/l)	10	10	10	19	10	10	70	105
3. Biofouling (mg/l Chlorine Demand)	5	5	1	1	1	1	1	1

TABLE 4-4

SITE SPECIFIC CRITERIA RANKING[1]

Criteria	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
The Effects of the Plant on the Environment								
1. Chemical Addition	1	2	2	1	1	1	1	1
2. Thermal Addition	2	1	1	2	2	2	2	2
3. Dredging Quantities	3	3	3	3	3	3	3	3
The Effects of the Environment on the Plant								
1. Total Dissolved Solids	5	5	5	4	4	4	4	4
2. Suspended Solids	6	6	6	5	5	5	5	5
3. Biofouling	4	4	4	6	6	6	6	6

[1] Figures shown represent the relative importance of the criteria at each site. A value of 1 indicates the most important; a value of 6 indicates the least important.

that reflect the effects of the environment on the plant.

b) At all sites where recirculating condenser cooling water systems would be employed, the most important criterion is chemical addition to the receiving water body. The next most important criterion reflects the degree of heat rejection to the receiving water body.

c) At sites where once-through condenser cooling water systems would be employed, the criterion reflective of heat rejection is deemed most important, followed by the criterion reflective of chemical addition to the receiving water body.

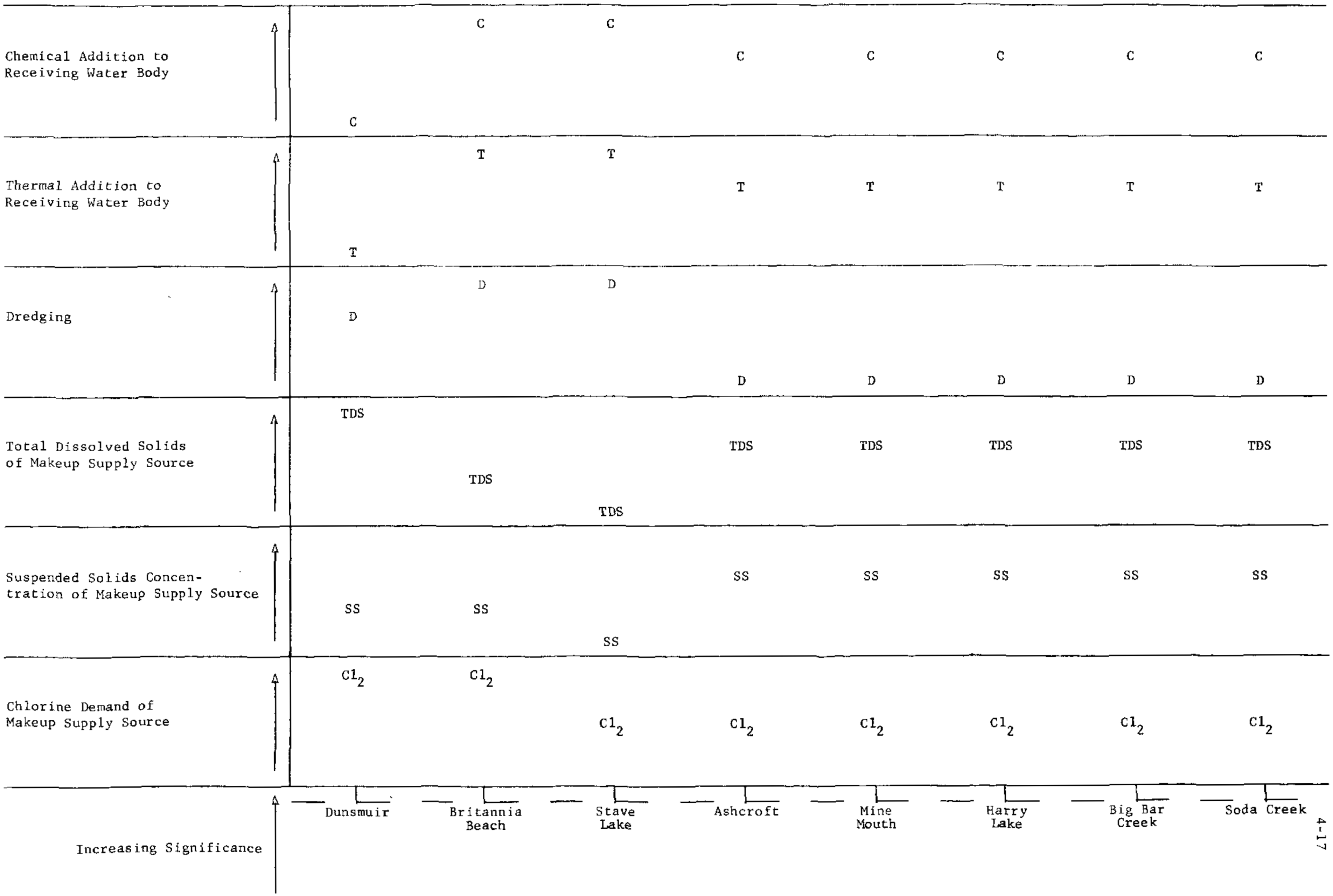
4.4.5 Significance of Criteria Among Sites

Table 4-5 presents the relative significance of each criterion among the eight alternative sites. This significance table was required to place appropriate weights for each criterion in the multidisciplinary quantitative site selection analysis. The relative ranking of the criteria are a subjective measure of qualitative site-specific information that influenced the site ranking. In order to facilitate interpretation of this table the following example is given:

As seen in Table 4-4, the criterion "Chemical Addition" is considered the most important for the Dunsmuir site. Table 4-5 states, however, that significance of the chemical addition criterion at the Dunsmuir site is the least in comparison to the other sites under consideration. This is due to the fact that the receiving

TABLE 4 - 5

SIGNIFICANCE OF CRITERIA AMONG SITES



water body at Dunsmuir (the Strait of Georgia) has naturally occurring high TDS and is also subject to wide TDS variations. Therefore, while being the most important effect on the water body, the characteristics of the strait lessen the environmental impact of this discharge.

4.4.6 Site Ranking

Based on the foregoing results, the following site ranking has been determined from a water resources standpoint:

1. Harry Lake
2. Mine Mouth
3. Ashcroft
4. Big Bar Creek
5. Soda Creek
6. Dunsmuir
7. Britannia Beach
8. Stave Lake

The ranking considered the following:

a) Interior sites are preferred over coastal sites because of the better choice of system for the disposal of chemical and thermal discharges.

b) Among the interior sites, the Mine Mouth and Harry Lake sites would experience the least potential for impact on thermal generating station reliability, and availability, and are preferred over other interior sites.

This is indicative of the superior water quality of the Thompson River.

4.5 DISCUSSION AND CONCLUSIONS

The purpose of this section is to present, in detail, that data and information used in selecting a preferred site for thermal generating station development from consideration of the water resources. Each of the following subsections represents a major area of the water quality discipline and are used to develop specific information concerning site-differentiating criteria. The major topics of the section are as follows:

a) Surface Water Resources (4.5.1)

b) Project Water Requirements and Waste Discharges (4.5.2)

c) Water Quality Regulations and Other Legal Constraints (4.5.3)

d) Site Specific Criteria Application (4.5.4)

e) Conclusions (4.5.5)

f) Recommendations (4.5.6)

4.5.1 Surface Water Resources

This section characterizes the water resources of the study area on a regional and site-specific basis to permit an evaluation of the proposed plant's water requirements and potential water resource impacts.

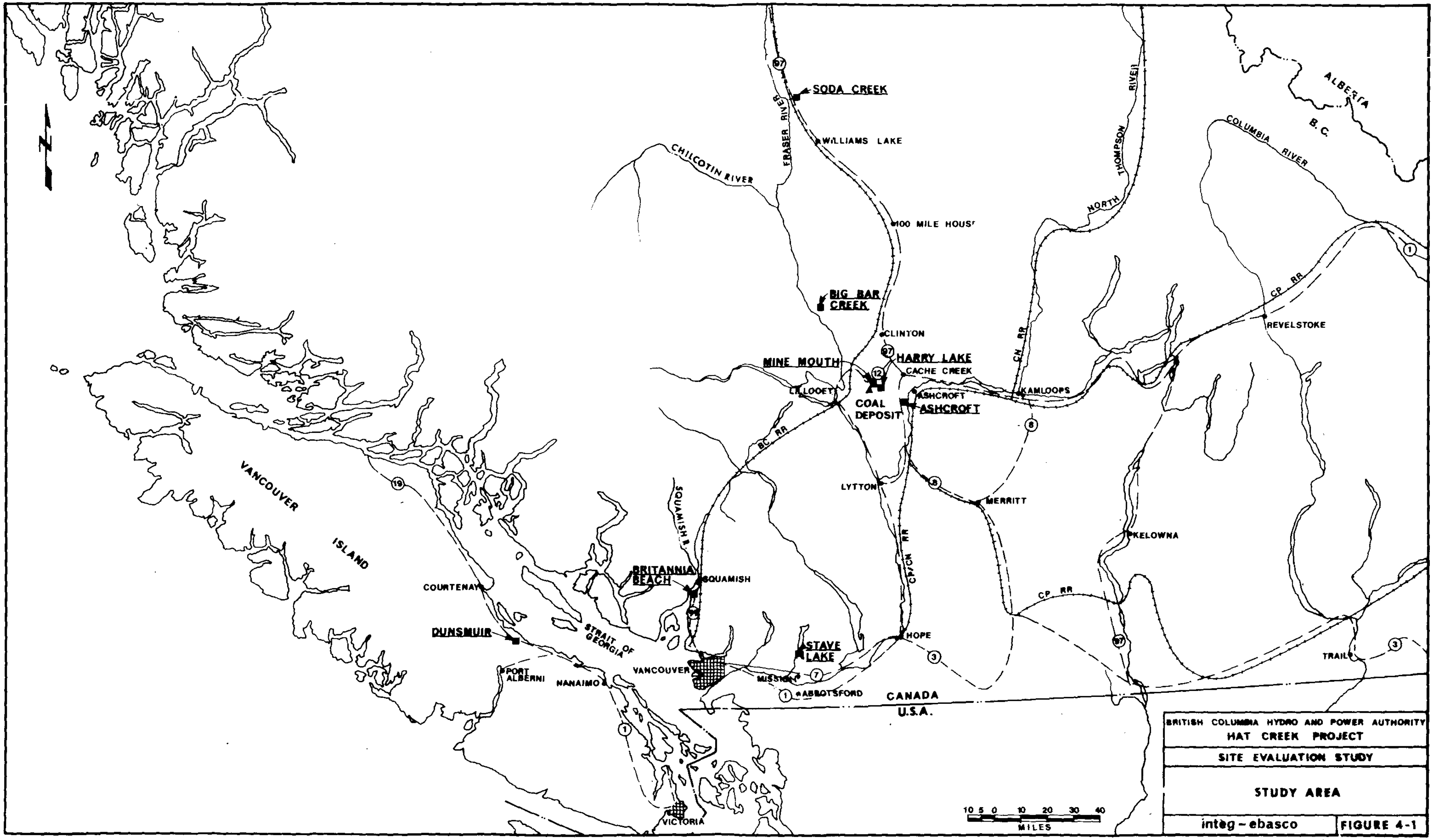
4.5.1.1 Regional Water Resources

A map of the study area depicting alternative site locations and major surface water resources is presented as Figure 4-1. As can be seen, site locations can generally be grouped into two categories: interior sites and coastal sites. The interior sites under consideration consist of Ashcroft, Mine Mouth, Harry Lake, Big Bar Creek and Soda Creek whereas, the coastal sites include Dunsmuir, Britannia Beach and Stave Lake.

4.5.1.2 Interior Sites

The hydrology of the interior region of the study area is dominated by two extensive river systems, the Fraser River and Thompson River. The Thompson River (see Figure 4-2) is a primary tributary of the Fraser River with their confluence occurring at Lytton. The Thompson River can be characterized as a narrow, quick-moving water body with a mean flow of approximately 26,000 cfs and a total drainage area of approximately 22,000 sq. miles.

The Fraser River is a much larger system (see Figure 4-1) originating in the Rocky Mountains and flowing south until the river becomes a large estuary system and discharges into the Strait of Georgia. The total drainage basin of the river system encompasses approximately 90,000 sq. miles and the mean annual flow of the river is approximately 96,000 cfs.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
STUDY AREA
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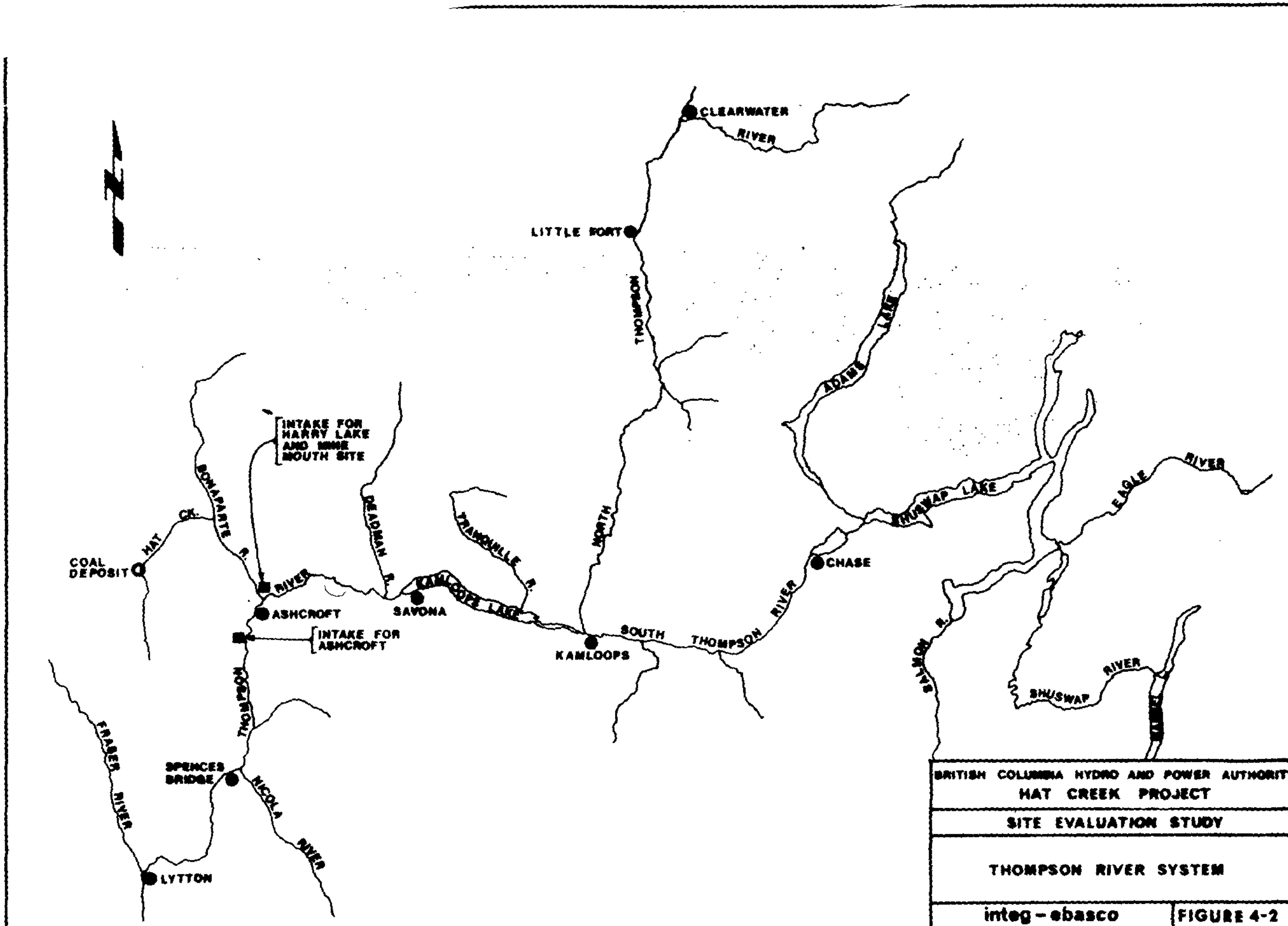
FIGURE 4-1



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

THOMPSON RIVER SYSTEM

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FIGURE 4-2

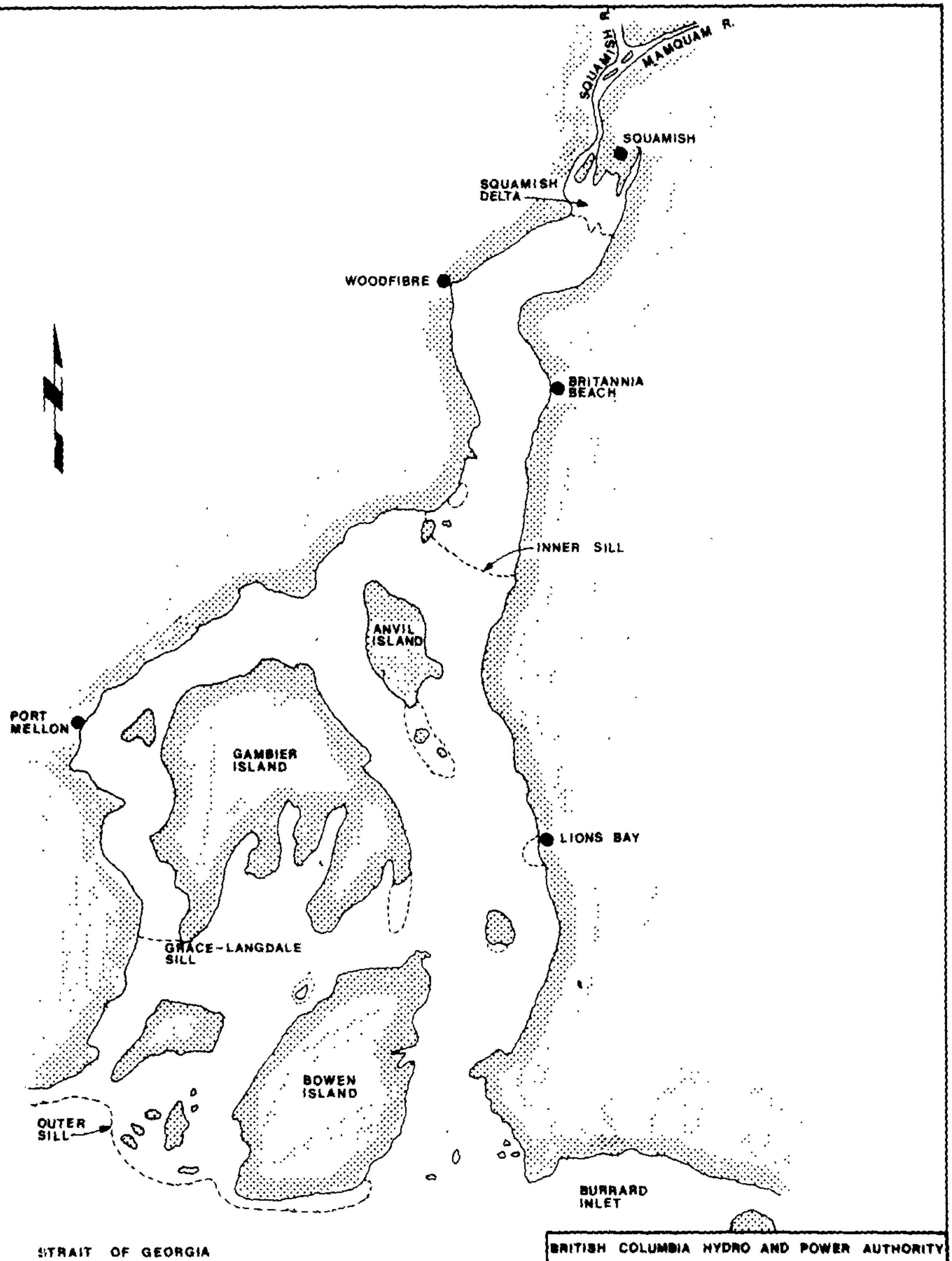
4.5.1.3 Coastal Sites

a) Strait of Georgia

The Strait of Georgia, Greater Puget Sound and Juan de Fuca Strait (see Figure 4-1) form an inland sea with an immediate drainage basin of approximately 30,000 sq. miles. This estuarine water body is basically a two-layer oceanographic system: a surface layer containing freshwater at various chloride concentrations moving seaward and a more saline "underlayer" of ocean water moving shoreward. Ocean inflow mainly occurs through Juan de Fuca Strait with a small inflow taking place through the northern channels of Johnstone Strait and Discovery Passage.[1] The two layers are subject to varying degrees of intermixing which is influenced by surface meteorological conditions, river discharges, tides and the bathymetry of the strait.

b) Howe Sound

Howe Sound is one of the many coastal fjord that exist on the northeastern shore of the Strait of Georgia. The sound as depicted in Figure 4-3 is 30.5 miles long, with a mean width of 5.0 miles and a mean depth of 740 ft. Two sills, one at the mouth and another north of Anvil Island, serve to divide the sound into inner and outer sections. The inner section or northern reach of the sound, is a typical British Columbia coastal fjord with a steep mountainous shore, a deepwater channel and a river system (the Squamish River) at its head.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

HOWE SOUND

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FIGURE 4-3

c) Stave Lake

This lake is one of a number of lakes which drain the mountain region directly North of the westward flowing segment of the Fraser River (see Figure 4-1). The flow out of the 16 sq.miles lake is governed by the operation of dams for the generation of hydroelectric power. The sources of lake water are chiefly the inflow of the Stave River and other smaller streams and surface overland runoff.

4.5.1.4 Water Quantity Information

Water quantity and water quality data were available from the stations noted on Table 4-6 and Figure 4-4.

a) Fraser River

The Fraser River is the presently planned makeup water supply source for the proposed Big Bar Creek and Soda Creek Sites. The mean annual flow of the river at Big Bar Creek is 53,900 cfs. Peak flows generally occur during late spring, early summer (May to June) and have been recorded as high as 289,000 cfs while low flows are typical of the winter months (December to March). Figure 4-5 presents low flow data reported by the Inland Waters Directorate in graphical form. From the graph the flow representing the annual 7-day average low flow with a recurrence interval of 10 years is 7,000 cfs. The maximum water withdrawal of a thermal generating station for either of these sites would be 67 cfs corresponding to less than 1.0 percent of this flow.

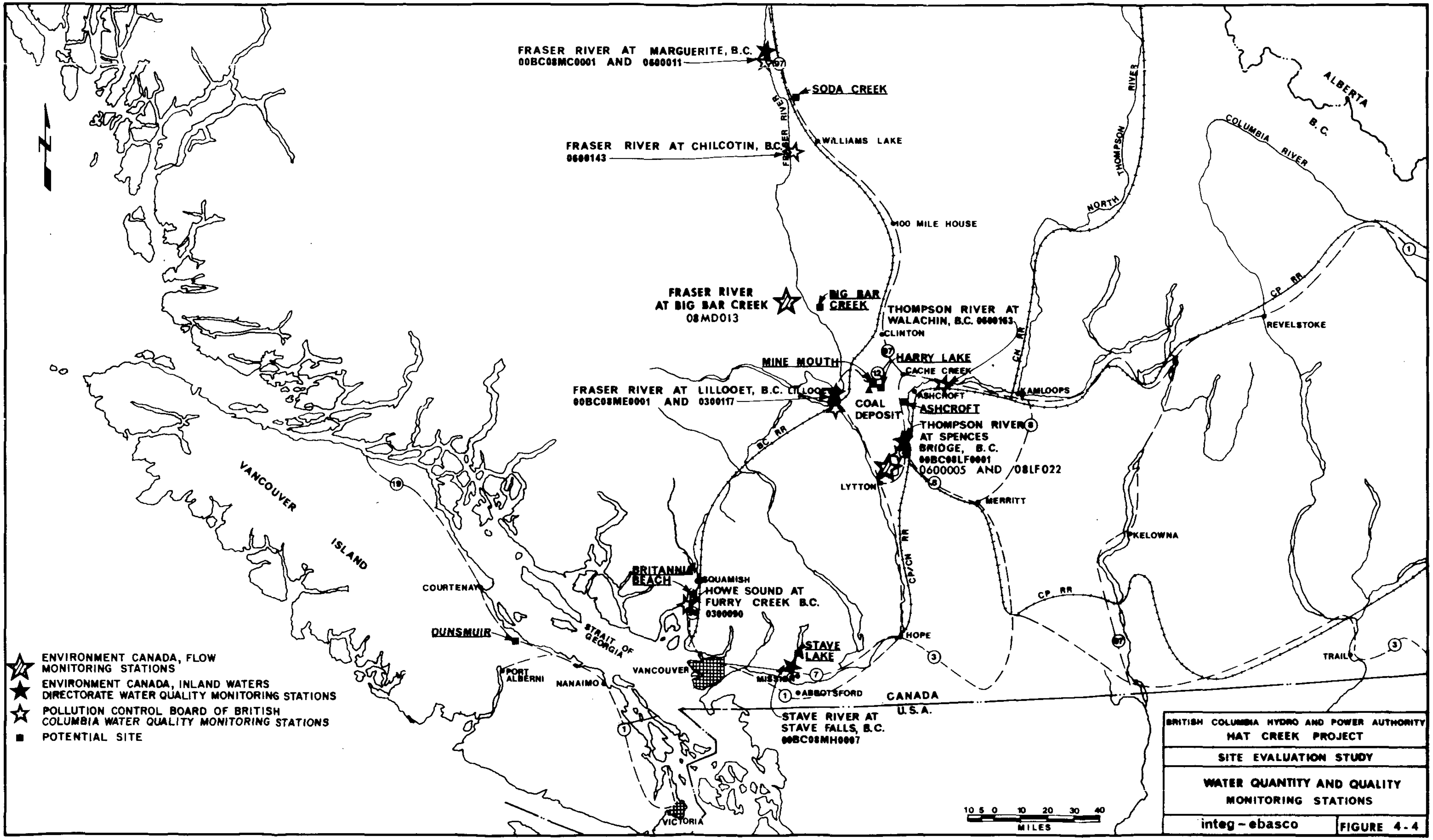
FRASER RIVER AT MARGUERITE, B.C.
00BC08MC0001 AND 0600011
SODA CREEK
FRASER RIVER
WILLIAMS LAKE
FRASER RIVER AT CHILCOTIN, B.C.
0600143
100 MILE HOUSE
NORTH THOMPSON RIVER
COLUMBIA RIVER
ALBERTA
B.C.
FRASER RIVER
AT BIG BAR CREEK
08MD013
BIG BAR
CREEK
THOMPSON RIVER AT
WALACHIN, B.C. 0600163
CLINTON
CN RR
REVELSTOKE
CP RR
MINE MOUTH
HARRY LAKE
CACHE CREEK
KAMLOOPS
FRASER RIVER AT LILLOOET, B.C.
00BC08ME0001 AND 0300117
LILLOOET
COAL
DEPOSIT
ASHCROFT
ASHCROFT
THOMPSON RIVER
AT SPENCES
BRIDGE, B.C.
00BC08LF0001
0600005 AND 08LF022
B.C. RR
LYTTON
MERRITT
VANCOUVER
ISLAND
KELOWNA
CP/CN RR
BRITANNIA
BEACH
SQUAMISH
HOWE SOUND AT
FURRY CREEK B.C.
0300090
COURTENAY
CP RR
DUNSMUIR
STRAIT OF GEORGIA
HOPE
STAVE
LAKE
TRAIL
PORT
ALBERNI
NANAIMO
VANCOUVER
MISSION
ABBOTSFORD
CANADA
U.S.A.
STAVE RIVER AT
STAVE FALLS, B.C.
00BC08MH0007
VICTORIA
ENVIRONMENT CANADA, FLOW
MONITORING STATIONS
ENVIRONMENT CANADA, INLAND WATERS
DIRECTORATE WATER QUALITY MONITORING STATIONS
POLLUTION CONTROL BOARD OF BRITISH
COLUMBIA WATER QUALITY MONITORING STATIONS
POTENTIAL SITE
10 5 0 10 20 30 40
MILES
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
WATER QUANTITY AND QUALITY
MONITORING STATIONS
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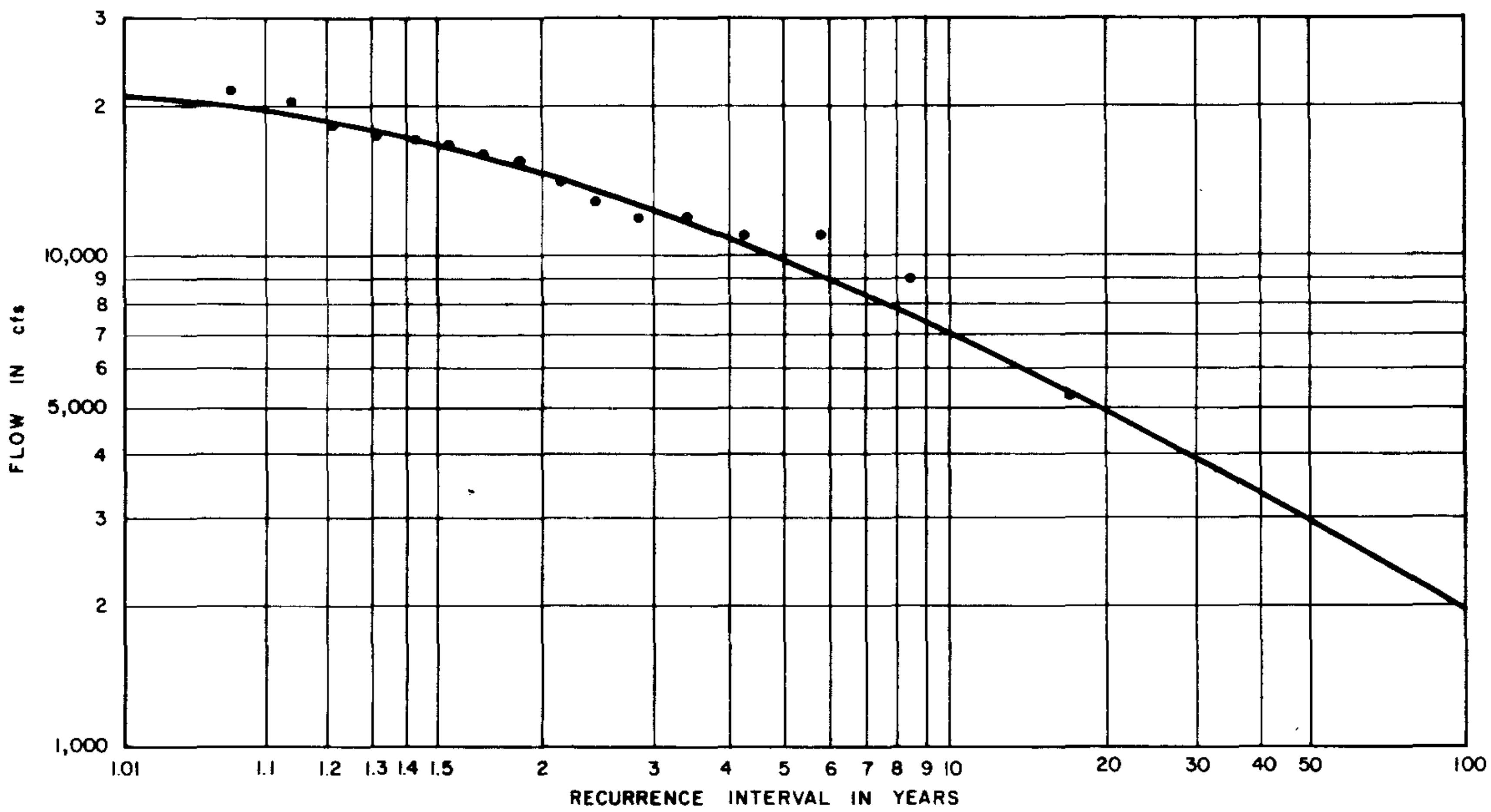
FIGURE 4-4



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

ANNUAL 7-DAY AVERAGE LOW FLOWS
FRASER RIVER AT BIG BAR CREEK

integ – ebasco | FIGURE 4-5

TABLE 4-6

WATER QUALITY AND QUANTITY MONITORING STATIONS

Agency	Station Number	Location	Type of Data	Years of Available Data
Environment Canada	00BC08ME0001	Fraser River at Highway Bridge, north of Lillooet, B C	Detailed and summary water quality data	1961-1976
Pollution Control Board	0300117	Fraser River, 100 feet downstream of Highway Bridge, Lillooet, B C, access via road off southwest side	Detailed and summary water quality data	1970-1976
Environment Canada	00BC08MC0001	Fraser River at ferry crossing, 2 miles north of Marguerite, B C	Detailed and summary water quality data	1961-1976
Pollution Control Board	0600011	Fraser River from Marguerite ferry at midstream	Detailed and summary water quality data	1970-1976
Pollution Control Board	0600143	Fraser River at Chilcotin Bridge, 15 miles west of Williams Lake on Highway 20 bridge	Detailed and summary water quality data	1970-1976
Environment Canada	08MD013	Fraser River at Big Bar Creek	Monthly and annual mean flow discharges and low flows	1935-1972
Environment Canada	00BC08LF0001	Thompson River at Highway 1 bridge, Spences bridge, B C	Detailed and summary water quality data	1961-1976
Pollution Control Board	0600005	Thompson River, midstream from Highway 1 bridge, Spences bridge	Detailed and summary water quality data	1970-1976
Pollution Control Board	0600163	Thompson River at Walachin, B C, sample from bridge on road to Walachin, about 10 miles west of Savona	Detailed and summary water quality data	1970-1976
Environment Canada	08LF022	Thompson River at Spences bridge	Monthly and annual mean flow discharges and low flows	1911-1951, 1952-1972
Pollution Control Board	0300090	Howe Sound, mid-channel directly off Furry Creek	Detailed and summary water quality data	1970-1976
Environment Canada	00BC08MH0007	Stave River at Stave Falls, B C	Student water quality data	Two sampling dates

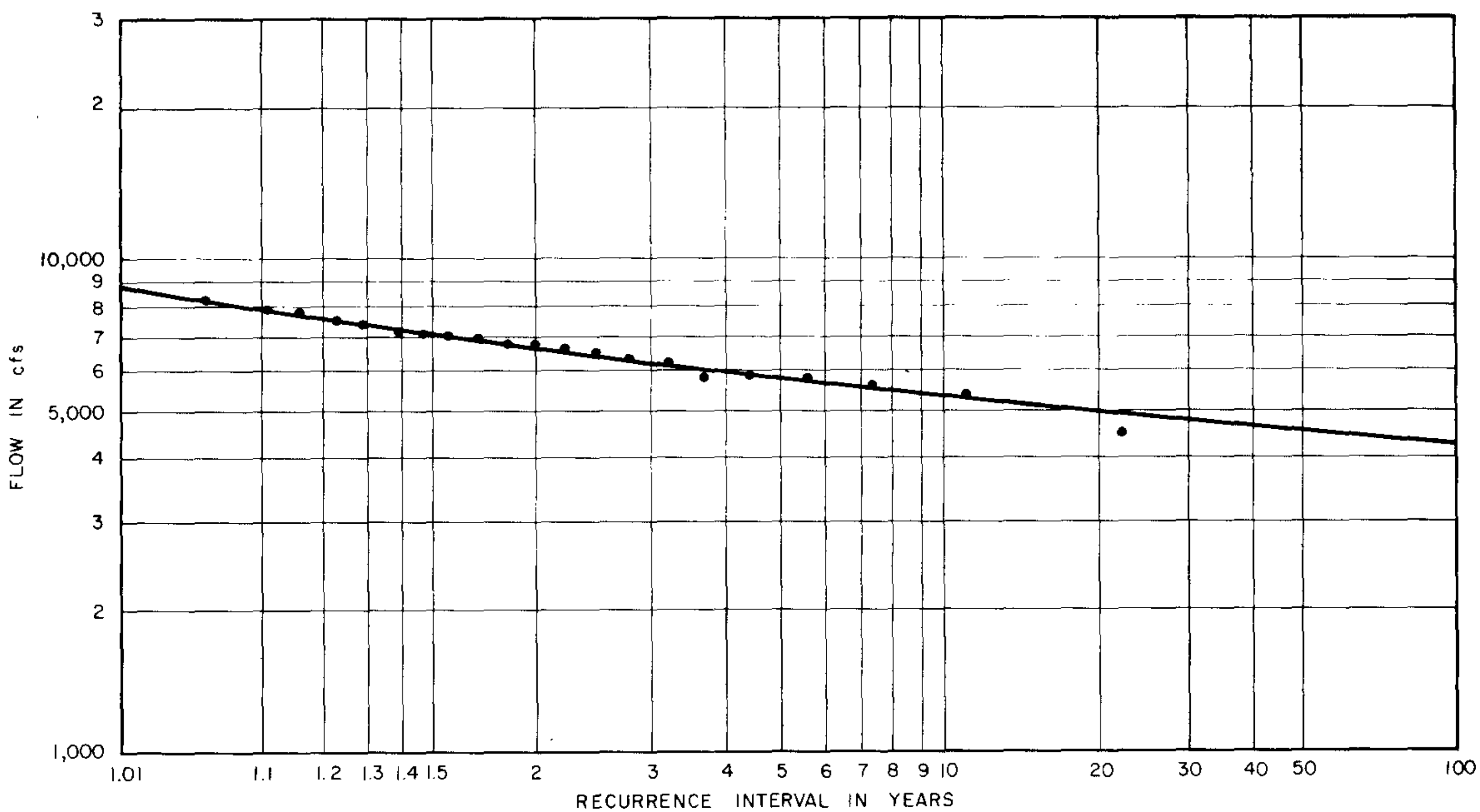
b) *Thompson River*

Use of the Thompson River as a makeup water supply source is presently planned for the proposed Mine Mouth, Harry Lake and Ashcroft sites. Based on flow data reported at the Spences Bridge monitoring station, the mean annual flow for this river is 26,300 cfs. Similar to the Fraser River, high flows generally occur from May to June while low flows are characteristic of the December to March period. From the graphical presentation of the Inland Waters Directorate low flow data (Figure 4-6), it can be seen that the annual 7-day average low flow with a recurrence interval of 10 years is approximately 5,300 cfs. A maximum plant withdrawal rate of 67 cfs would correspond to less than 1.3 percent of this low flow.

c) Strait of Georgia, Qualicum Bay

The Dunsmuir site is located on the east coast of Vancouver Island in the central portion of the Strait of Georgia. Surface drift currents in the area of the site are generally to the southeast as is characteristic of the entire Steven's Passage area due to the prevailing wind direction.

The tidal range in this area of the strait is approximately 10.5 feet but the magnitude of any specific tidal current in this area is not known. Deep oceanic water is believed to exchange once a year between the Pacific Ocean and the Strait of Georgia, but the brackish surface layer may flush through more frequently.[1]



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

ANNUAL 7-DAY AVERAGE LOW FLOWS
THOMPSON RIVER AT SPENCES BRIDGE

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FIGURE 4-6

d) Howe Sound

The major source of freshwater inflow into Howe Sound is the Squamish River System which consists of the Cheakamus, Mamquam and Stawamus Rivers. This system drains a watershed of approximately 900 sq mi and exhibits a mean monthly discharge of 8,600 cfs as measured at Brackendale. Other minor freshwater flow components to the sound include Furry Creek, Britannia Creek, Shannon Creek, Woodfibre Creek and Mashiter Creek.

The inner basin of the sound, where the Britannia Beach site is located is a typical coastal fjord. The volume of this basin is approximately 3×10^{11} cfs but the quantity of displaced water due to seasonal flushing is not known at this time.

The tidal range in the Strait of Georgia adjacent to the mouth of Howe Sound is approximately 10 feet, but the effect this has on water levels within the sound is unknown due to a lack of detailed information concerning sill configuration.

e) Stave Lake

Stave Lake is an enclosed freshwater basin artificially created by the existence of a hydroelectric dam. The volume of the lake is approximately 2.13×10^{10} cfs with a surface area of approximately 10,240 acres.

The major water source of the lake is the Stave River which enters the lake at its most northern point. Numerous other small creeks including Tingle Creek, Weatherhead Creek, Glacier Creek, Roaring Creek and Salsbury Creek drain into the lake. The average annual flow discharged from the lake as measured at the dam at Stave Falls is 4,027 cfs.

4.5.1.5 Water Availability

This section highlights the constraints, both legal and committed water supply, that would affect the actual availability of water for withdrawal and use for the proposed thermal generating station.

Pursuant to the Federal Water Act, a "water license" is required for the diversion or use of any freshwater source within the confines of Canada. The license entitles the holder to: 1) divert and utilize water beneficially, 2) store water, 3) construct authorized works in a freshwater body, 4) alter or improve stream conditions and 5) construct fences, screens and fish or game guards to conserve fish or game. Discussion with the licensing agency, the Water Rights Branch of the Pollution Control Board of British Columbia, has indicated that the total of all water licenses on a specific freshwater body must be less than the "low flow in an average dry year". The use of saline water is not governed in regard to the quantity of water available for withdrawal. A "foreshore lease" must be obtained from the Land Management Department of British Columbia to develop or place any structure on the Province's shoreline. This would be applicable to two of the proposed coastal sites' intake and discharge structures.

The following subsections identify the existing and committed water uses on the various water bodies of concern in this study.

a) Fraser River

Water licenses have been issued for the Fraser River between Soda Creek and Lytton by the Province of British Columbia Water Rights Branch for domestic, irrigation and mining uses. These licenses are identified in Table 4-7 and total approximately 35 cfs if it is conservatively assumed that all irrigation occurs in a two-month period. Because, as presented in Figure 4-5, the average 7-day flow (with a recurrence interval of 10 years) of the Fraser River is estimated to be 7,000 cfs at Big Bar Creek then the total demand on this water resource (including a maximum plant requirement of 67 cfs) would be approximately 102 cfs or 1.5 percent of this low flow.

b) Thompson River

Water licenses for the Thompson River between Wallachin and Lytton have been issued for domestic, irrigation, mining and other industrial uses. These licenses are presented in Table 4-8 and total approximately 65 cfs. Because the average 7-day low flow with a recurrence interval of 10 years of the Thompson River is estimated to be 5300 cfs (see Figure 4-6) at Spences Bridge then the total demand on the water resource (including a maximum plant need of 67 cfs) would be approximately 131.5 cfs or 2.5 percent of this low flow.

TABLE 4-7

WATER LICENSES AND APPLICATIONS
ON THE FRASER RIVER
BETWEEN SODA CREEK AND LYTTON, BC

Location	Date	Volume	Purpose
K 1054	June 19, 1974	1.18×10^6 cf (1)	Irrigation
J 1052	March 22, 1976	104.5×10^6 cf	Irrigation (2)
T 256	June 25, 1974	0.5 cfs	Mining (2)
T 256	July 19, 1974	0.5 cfs	Mining (2)
P 253	July 9, 1975	0.04 cfs	Mining (2)
L 443	June 25, 1973	0.5 cfs	Mining (2)
U4 102A	May 5, 1954	9.1×10^6 cfs	Irrigation
U4 102A	May 5, 1954	28.8×10^6 cfs	Irrigation
E5 102A	December 23, 1970	0.65×10^6 cfs	Irrigation
C5 102A	September 16, 1966	0.98×10^6 cfs	Irrigation
D5 102A	September 16, 1966	0.001 cfs	Domestic
Z4 102C	January 13, 1971	1.3×10^6 cf	Irrigation
F5 102A	February 9, 1971	2.0×10^6 cf	Irrigation
F5 102C	June 10, 1974	1.3×10^6 cf	Irrigation
FF 103	April 7, 1975	0.01 cfs	Mining (2)
GG 103	July 29, 1975	0.02 cfs	Mining (2)
U4 102A	December 18, 1975	23×10^6 cf	Irrigation
	TOTAL (3)	34.4 cfs	

(1) The volume of water allocated for irrigation purposes covers the entire growing season.

(2) Denotes Water Application only, not a license.

(3) Conservatively Assuming Irrigation occurs for only a two-month period.

TABLE 4-8

WATER LICENSES AND APPLICATIONS
ON THE THOMPSON RIVER
BETWEEN WALLACHIN AND LYTTON, BC

Location	Date	Volume	Purpose
H 502	February 3, 1975	0.65×10^6 cf (1)	Irrigation (2)
H 501	March 7, 1975	2.6×10^6 cf	Irrigation (2)
J 502	April 21, 1975	0.65×10^6 cf	Industrial (2)
J 502	April 21, 1975	0.03 cfs	Industrial (2)
C 381	March 21, 1960	13.1×10^6 cf	Irrigation
E 380	May 2, 1964	0.004 cfs	Domestic
FH 380	March 8, 1968	34.9×10^6 cf	Irrigation
FH 380	March 8, 1968	0.001 cfs	Domestic
E 381	April 10, 1968	7.0×10^6 cf	Irrigation (2)
P 363	July 17, 1915	0.019 cfs	Industrial
NN 362	April 2, 1968	78.4×10^6 cf	Irrigation
L 304	April 20, 1898	0.19 cfs	Domestic
T 304	February 13, 1932	8.9×10^6 cf	Irrigation
L 304	July 3, 1962	0.74 cfs	Domestic
CC 305	May 25, 1964	33.7×10^6 cf	Irrigation
U 301	August 9, 1967	7.8×10^6 cf	Irrigation
Y 301	August 13, 1968	27.9 cfs	Mining
Y 301	November 18, 1968	- - -	Mining (2)
Y 301	September 21, 1970	0.04 cfs	Mining (2)
HH 348	January 4, 1974	9.1×10^6 cf	Irrigation
	TOTAL (3)	64.5 cfs	

(1) The volume of water allocated for irrigation purposes covers the entire growing season.

(2) Denotes Water Application only, not a license.

(3) Conservatively Assuming Irrigation Occurs for only a two-month period.

c) Strait of Georgia

The extent of water use in the vicinity of the Dunsmuir site is not known. Due to the large size of the Strait, however, a problem concerning water availability is not anticipated.

d) Howe Sound

The extent of Howe Sound water use is not known. From Foreshore leases, log storage and marina areas appear to be the main water use functions in the interior basin. Water availability is not anticipated to pose a problem.

e) Stave Lake

The major existing water user of Stave Lake is the BC Hydro and Power Authority which operates two hydroelectric power generating stations between the proposed plant site and the confluence of the Stave River and Fraser River. These stations utilize the entire flow from the lake which has been estimated at 4027 cfs on an average annual basis. The consumptive water use of the proposed thermal generating station at this location would be approximately 35 cfs. This consumptive use is 0.9 percent of the lake's average annual discharge and should not preclude the lake's use.

4.5.1.6 <u>Water Quality Information</u>

The water quality information presented in this section has been developed from data and statistical summaries of the data when available from the source enumerated in Table 4-6.

a) Fraser River

The three Fraser River monitoring stations encompass a reach of the river approximately 140 miles in length. The data are representative of the water quality for the Big Bar Creek site and for the Soda Creek site (see Figure 4-4).

The total dissolved solids (TDS) concentration in this reach of the river is relatively constant averaging approximately 96 mg/l. Fraser River water can be considered "moderately hard"[2] with hardness values ranging from approximately 50 to 100 mg $CaCO_3$/l. These parameters are important as they influence the amount of water recycle and reuse within the plant by limiting the degree of recirculation possible in a condenser cooling water system. They also determine to a large extent the degree of treatment for steam generator makeup, which must be very low in TDS levels to prevent scaling and corrosion. Fraser River water contains high concentrations of suspended solids averaging approximately 80 mg/l (ranging from 5 to 537 mg/l) and turbidity values recorded up to 95 Jackson Turbidity Units (JTU). Suspended material is important as excessive quantities can cause extensive wear on piping and equipment and solids deposition in the condenser cooling tubes can decrease heat transfer efficiency.

General indicators of water quality include: total organic carbon (TOC), ammonia, nitrate, total and dissolved phosphorous, fecal and total coliform, and heavy metals (arsenic, copper lead, mercury, nickel and zinc). There is no indication of any municipal and/or industrial waste source influence on overall river water quality as these indicator parameter concentrations are all extremely low, in many cases below the detection limit of the analytic test procedure. This fact is also reflected in the reported dissolved oxygen concentrations which were typically 90-100 percent of the saturation value during the warmer months. Winter dissolved oxygen concentrations are, as expected, typically lower, 70-90 percent of saturation, as ice cover inhibits the aeration process.

A statistical comparison of the TDS values for each of the three monitoring stations indicates that river water quality remains relatively constant in this 140 mile reach. A similar comparison of the 1961-1971 summaries at both Marguerite and Lillooet, with the more recent data (1970-1975) suggests that the concentration of chemical water quality parameters have not changed significantly over the entire monitoring period. The constitutent concentrations reported by the two monitoring agencies, the Inland Waters Directorate and the Pollution Control Board, compare very well yielding a high degree of reliability to the data.

b) Thompson River

The water quality data reported for this river have been utilized for the Mine Mouth site, Harry Lake site, and the Ashcroft site. The intake structures for the Mine Mouth and Harry Lake sites would be located upstream of the confluence of the Bonaparte River and the Thompson River. The Ashcroft site intake structure would be located below this confluence.

Statistical comparison of the data reported for the Walachin Station with that from Spences Bridge indicates, as previously reported,[3] that total dissolved solids concentrations generally increase as the Thompson River proceeds downstream. The increase is not the result of an increase in one particular parameter but rather all TDS components exhibit slight numerical increases. At Walachin, TDS levels vary between 40 and 66 mg/l with an average value of approximately 55 mg/l whereas, the average hardness value is 36.7 mg $CaCO_3$/l. This reach of the river can, therefore, be considered as "soft". Downstream, at Spences Bridge, the river can be characterized as "moderately hard" with an average hardness concentration of approximately 43 mg $CaCO_3$/l. The TDS concentration at this station ranges from 40 to 80 mg/l while averaging approximately 70 mg/l. It should be noted that both the TDS and hardness values for both Thompson River stations are considerably lower than that reported for the Fraser River. Also in contrast to the Fraser River are the suspended solids (SS) and turbidity levels in the Thompson River, SS concentrations generally range from 0.7 to 36 mg/l while turbidity values range from 0.1 to 47 JTU's.

Examination of the raw data reported for these monitoring stations indicate that there appears to be very little variation in TDS component concentrations due to flow variations. Suspended solids and turbidity values do however appear to vary with flow changes, and higher concentrations of these constituents can be expected during high flow periods occurring during late spring and early summer.

Similar to the Fraser River, nutrient, chloride, sulfate, metal and TOC concentrations are extremely low thus giving no indication of any water quality deterioration due to a municipal and/or industrial discharge. The Inland Waters Directorate performed a series of 14 pesticide tests on one sampling date at Spences Bridge, and did not detect any trace pesticides. Three statistical summaries are available for Spences Bridge data. They compare very favorably, indicating a high degree of reliability, and suggesting that the water quality at Spences Bridge has not changed significantly over the entire monitoring period.

c) Strait of Georgia, Qualicum Bay

Specific water quality data for this water body which would be representative of the water supply for the Dunsmuir site was not available at the time of this writing. TDS typically vary between 5 parts per thousand (ppt) and 32 ppt[1], which is characteristic of estuarine waters. The concentration of TDS components can be expected to occur in the same ratio of the total dissolved solids as that normally found in typical sea-water.

d) Howe Sound

The water quality monitoring station, located mid-channel in Howe Sound off Furry Creek provides reasonable estimates of the water quality for the Britannia Beach site. The TDS level averages 21,500 mg/l (21.5 ppt), typical of semi-isolated water bodies being influenced by tidal saltwater inflows and fresh water runoff. At the station the concentrations of all major water quality constituents including chloride, sodium, sulfate, magnesium, calcium and potassium approximate to the same percentage of the TDS concentration that is found in typical seawater.

Discharges due to polluting sources do not appear to have affected the water quality as dissolved oxygen concentrations in the surface strata are typically above 80 percent of saturation values and total coliform measurements are very low.

e) Stave Lake

Water quality data was only available for two sampling dates during July, 1971 at the Stave River monitoring station, therefore, the data are not sufficient to adequately quantify the water quality of the area. The reported specific conductance value, an indication of the TDS concentration and the hardness concentration were both extremely low with values of 8 MHO/cm and 5 mg/1 respectively.

f) Summary

A summary of the values of water quality parameters which were utilized to develop the conceptual site specific water management plans described in subsequent sections are presented in Table 4-9.

TABLE 4-9

WATER QUALITY CONCENTRATIONS UTILIZED FOR COOLING WATER SYSTEM DESIGN

Parameter	Sites(1)					
	Ashcroft	Big Bar Creek	Dunsmuir	Harry Lake	Mine Mouth	Soda Creek
Total Dissolved Solids	70	96	22,000	55	55	90
Suspended Solids	19	70	10	10	10	105
pH	7.6	7.7	8.3	7.4	7.4	7.8
Calcium	13.5	20.0	290	11.7	11.7	20.0
Sulfate	9.3	10.0	1,900	6.9	6.9	8.0
Magnesium	2.5	4.7	900	1.5	1.5	3.9
Silica (SiO_2)	5.5	5.3	- - -	4.3	4.3	3.7
Chloride	0.9	2.1	13,560	1.3	1.3	1.1
Alkalinity as $CaCO_3$	39	65	100	34	34	55
Chlorine Demand	1.0	1.0	5.0	1.0	1.0	1.0

(1) Only sites utilizing a recirculating cooling system are presented.

(2) All parameters expressed as mg/l except pH which is in units.

4.5.2 Project Water Requirements and Wastes Discharges

The purpose of this section is to describe the major water requirements and wastes discharges of a thermal generating station burning Hat Creek Coal. Appendix 4-1 presents a detailed generic description of a power plant and associated systems whereas, the following subsections present site specific estimates of water demand and wastewater character.

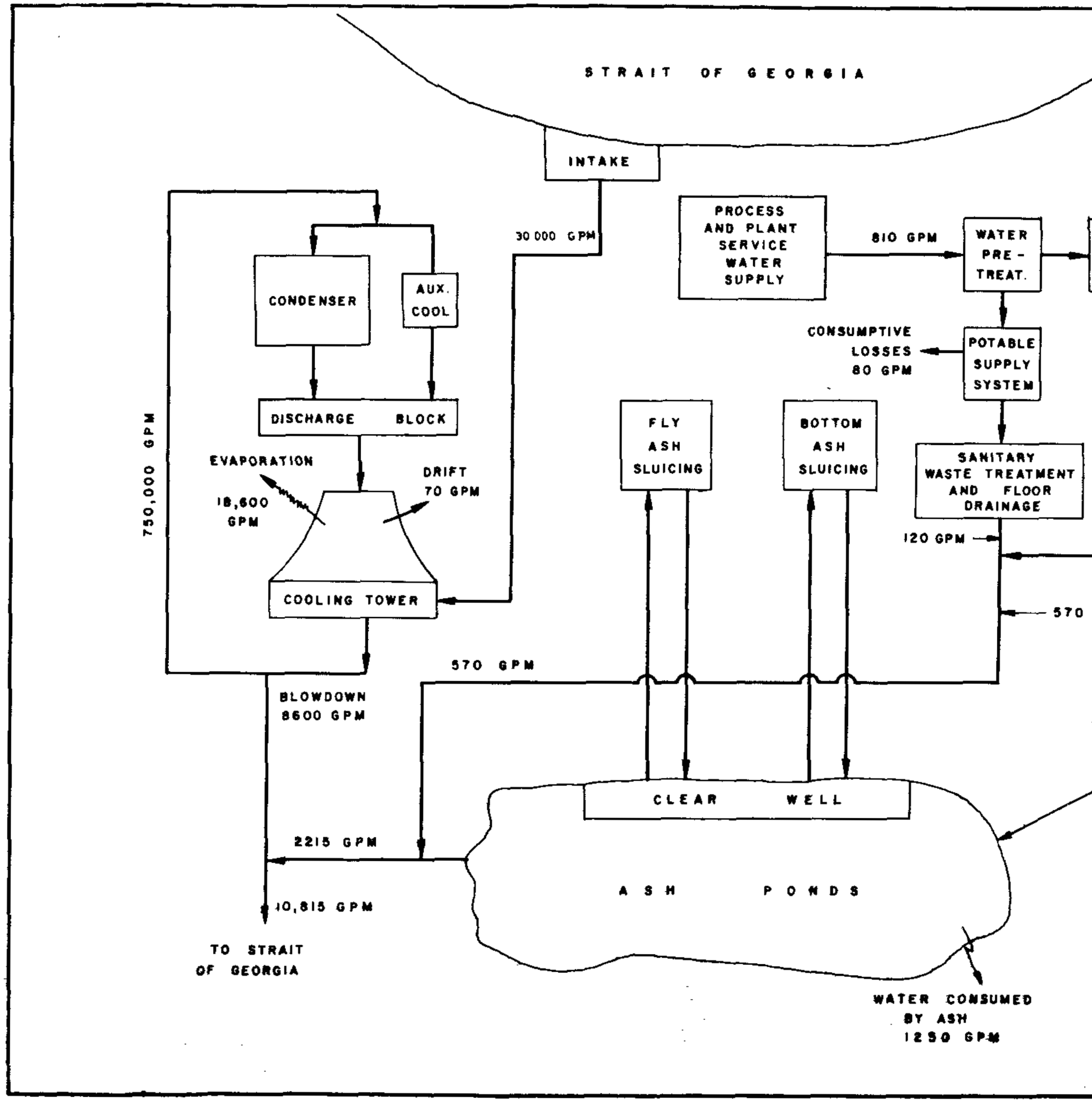
A conceptual water management system for each of the alternative sites has been prepared to provide a basis for site differentiation. Comprising each site specific water management system are estimates of required plant makeup water, identification of site related limitations on unit processes and operations, and identification and estimates of project wastewater discharges. The formulation of the water management systems were subject to a number of constraints and generalizations. Plant makeup water requirements and subsequent waste discharges were minimized in response to legal regulations presented in Section 4.5.3 of this chapter. Reuse of plant process waters was incorporated whenever possible. Specific thermal generating station design at each site was kept similar when feasible so that an adequate evaluation and site differentiation could be made.

Based on the foregoing and technical information supplied by other disciplinary groups, the major plant water/wastewater systems presented in Table 4-10 were chosen for site evaluation. Schematic diagrams of the conceptual water management plans for each site appear in Figures 4-7 through 4-10. These systems do not necessarily represent a final design, but are reasonable assumptions based on state-of-the-art technology and specific site constraints. Final design will only be developed after detailed system and economic comparisons are performed

Table 4-10

Site Specific Process Design Alternates

Site	Condenser Cooling Water System	Ash Transport System	Facility Discharge
Ashcroft	Recirculating	Closed-Loop Sluicing	Absent
Big Bar Creek	Recirculating	Closed-Loop Sluicing	Absent
Britannia Beach	Once-Through	Dry, Transported Off-Site	Present
Dunsmuir	Recirculating	Open-Loop Sluicing	Present
Harry Lake	Recirculating	Closed-Loop Sluicing	Absent
Mine Mouth	Recirculating	Closed-Loop Sluicing	Absent
Soda Creek	Recirculating	Closed-Loop Sluicing	Absent
Stave Lake	Once-Through	Open-Loop Sluicing	Present



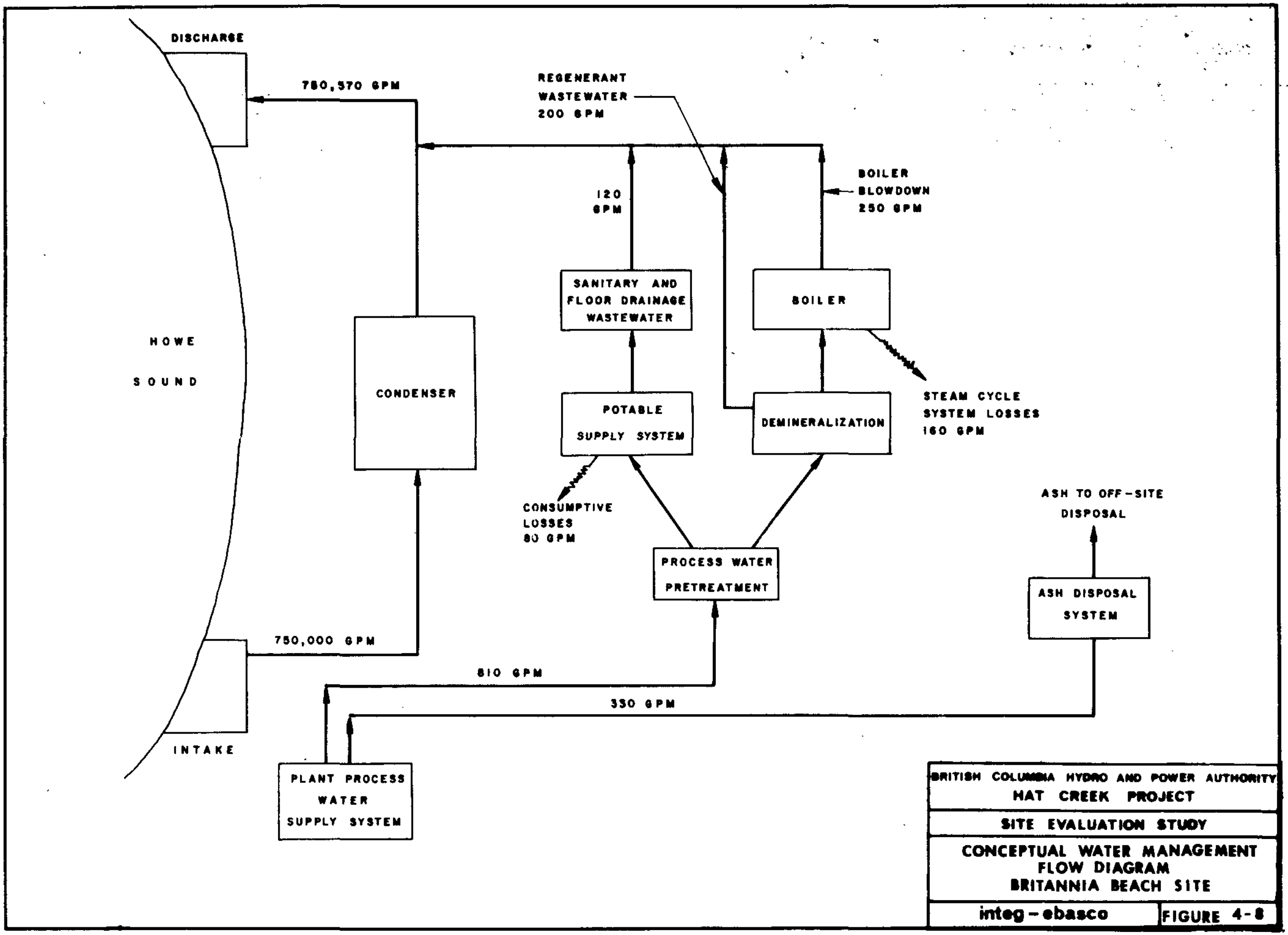
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

CONCEPTUAL WATER MANAGEMENT FLOW DIAGRAM DUNSMUIR SITE

integ – ebasco

FIGURE 4.7



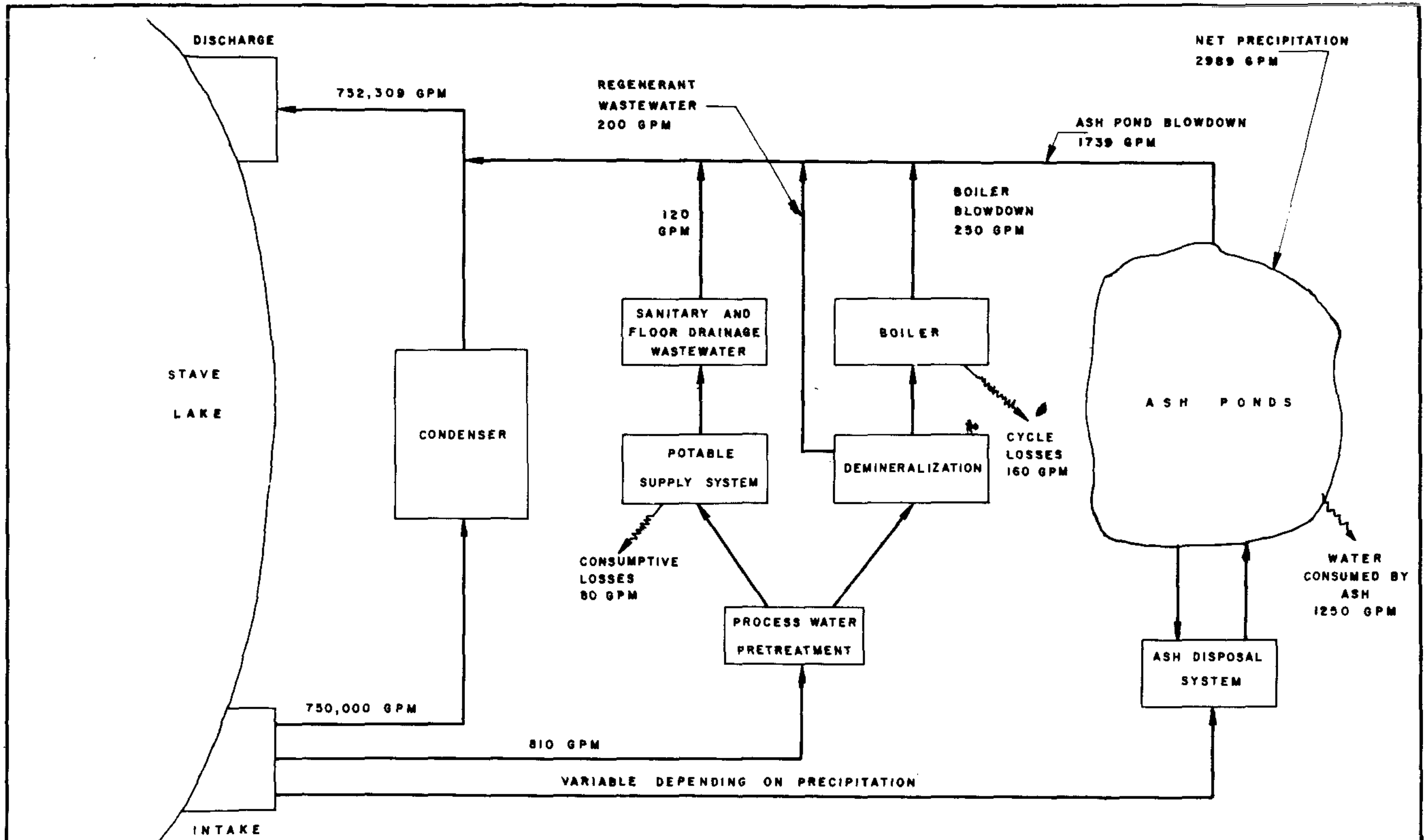
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

CONCEPTUAL WATER MANAGEMENT
FLOW DIAGRAM
BRITANNIA BEACH SITE

integ-ebasco

FIGURE 4-8

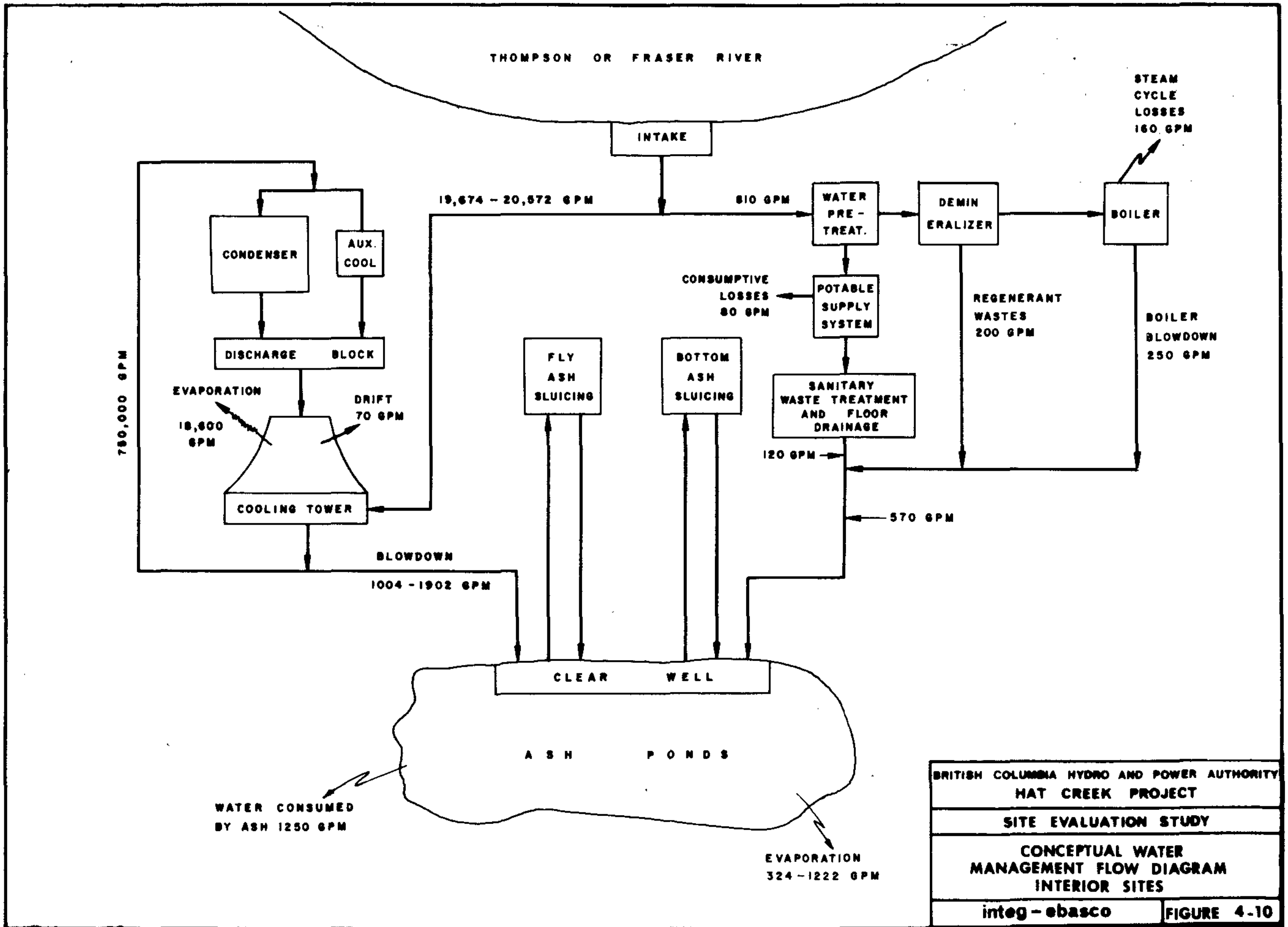


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

CONCEPTUAL WATER MANAGEMENT
FLOW DIAGRAM
STAVE LAKE

integ – ebasco | FIGURE 4-9



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

CONCEPTUAL WATER MANAGEMENT FLOW DIAGRAM INTERIOR SITES

integ - ebasco

FIGURE 4-10

during the design engineering phase of work.

4.5.2.1 Condenser Cooling Water Systems

It is estimated that the condenser cooling water flow required for this 2000 MW Thermal Generating Station will be approximately 750,000 gpm (0.84 cfs/MW) based on a heat rejection requirement of approximately 9.45 x 10^9 Btu/hr. For once-through condenser cooling water system operation, which is proposed for the Britannia Beach and Stave Lake sites (See Figures 4-8 and 4-9 respectively) this quantity of water would be continually withdrawn from the supply source, intermittently chlorinated to prevent biofouling, passed through the condenser tubing and then discharged to the receiving water body. For this cooling system mode, makeup flow and discharge flow are equivalent and the entire amount of heat transferred across the condenser to the cooling water is discharged to the receiving water body (Refer to Table 4-2 for a complete listing of site specific makeup, consumptive use and discharge flows). The amount of chlorine required for these once-through systems has been estimated at 2250 lbs/day and 1000 lbs/day for the Britannia Beach and Stave Lake sites respectively. These quantities have been developed utilizing seasonal average chlorine demand values of 5 mg/l and 1 mg/l for typical estuarine and freshwater systems respectively and prior experience with chlorine application feed rates. Refer to Table 4-11 for a complete listing of site specific chemical and thermal discharge quantities.

To minimize the amount of water required for cooling purposes and to maximize reuse of this water, Dunsmuir and the five interior sites will utilize a recirculating condenser cooling water system employing "wet type" cooling towers.

TABLE 4-11

SITE SPECIFIC CHEMICAL AND THERMAL INCREMENTAL PROCESS DISCHARGE QUANTITIES[1]

Site	Cooling Water System		Ash Sluicing Supernatant	Demineralizer Regeneration	Potable and Miscellaneous	Coal Pile Runoff	Total Discharged to Receiving Water Body	
	(lbs/day)	(Btu/hr)					(lbs/day)	(Btu/hr)
Dunsmuir	35,750	9.45×10^7	3,500	1,000	300	2,600	43,150	9.45×10^7
Britannia Beach	2,250	9.45×10^9	0	1,000	300	3,000	6,550	9.45×10^9
Stave Lake	1,000	9.45×10^9	3,600	1,000	300	3,000	8,900	9.45×10^9
Ashcroft	2,100	9.45×10^7	0	1,000	300	600	0[2]	0[2]
Mine Mouth	2,100	9.45×10^7	0	1,000	300	0	0[2]	0[2]
Harry Lake	2,100	9.45×10^7	0	1,000	300	0	0[2]	0[2]
Big Bar Creek	3,500	9.45×10^7	0	1,000	300	600	0[2]	0[2]
Soda Creek	2,300	9.45×10^7	0	1,000	300	600	0[2]	0[2]

(1) Chemical discharges measured as pounds per day (lbs/day) of incremental total dissolved solids, thermal discharges measured as Btu/hr.

(2) All waste discharges are maintained at the site.

Cooling tower evaporation has been estimated at 18,600 gpm, with drift estimated at approximately 70 gpm. These estimates result in the makeup and blowdown flow requirements presented in Table 4-13 and Figure 4-11 at various cycles of concentration.

The cycles of concentration chosen for use at a specific site are dependent upon and limited by the water quality of the makeup water source, associated costs of chemical treatment and the resultant quality of the blowdown. Blowdown quality can limit the extent of water reuse within the plant and greatly affect the impact on the receiving water body's water quality.

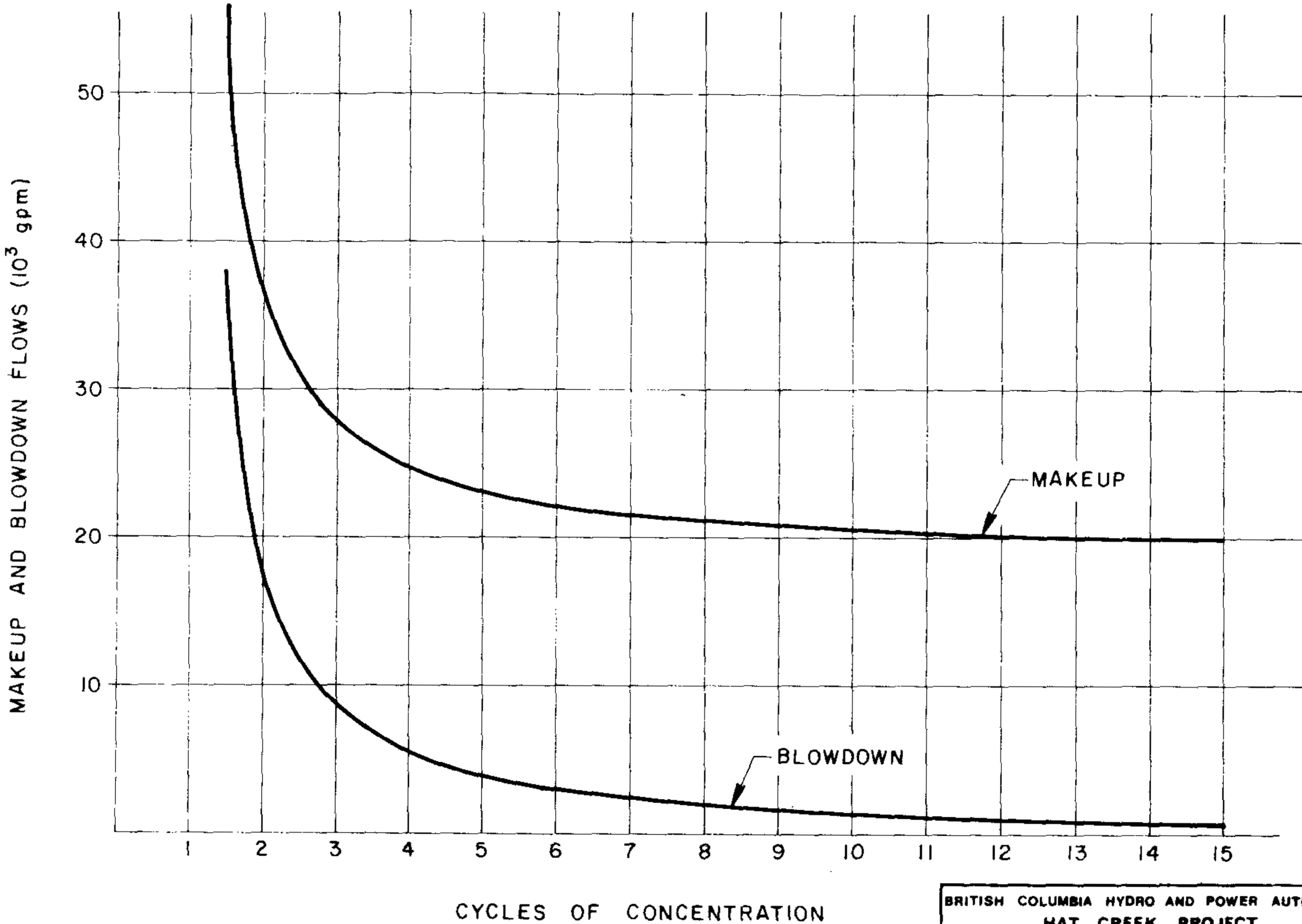
The Dunsmuir Site will utilize brackish water for cooling purposes. This limits the maximum attainable cycles of concentration to approximately 3.0 because calcium sulfate will precipitate at higher levels[5]. As shown in Table 4-13 and Figure 4-11, the quantity of makeup water is not significantly reduced beyond three or four cycles of concentration, whereas the cooling system water quality deteriorates steadily.

Makeup water to the recirculating condenser cooling system will require chemical treatment to prevent scaling of calcium carbonate ($CaCO_3$) and to control biofouling of the makeup water supply line, condenser surfaces and cooling tower surfaces. It is estimated that approximately 33,500 lbs/day of 100 percent sulfuric acid and 2250 lbs/day of chlorine will have to be added to the cooling water system to control these problems. The blowdown water quality of the system which will be discharged to the Strait will essentially be the makeup water quality multiplied by a factor of 3 (the cycle of concentration maintained in the system). Total dissolved solids concentrations can be expected to vary from 15,000 to 96,000 mg/l depending on normal seasonal salinity fluctuations.

TABLE 4-12

RECIRCULATING CONDENSER COOLING WATER SYSTEM FLOW REQUIREMENTS AT VARIOUS CYCLES OF CONCENTRATION

Cycles	Makeup (gpm)	Blowdown (gpm)	Percent Savings
1.5	55,800	37,130	Base
2	37,200	18,530	33.3
3	27,900	9,230	50.0
4	24,800	6,130	55.6
5	23,250	4,580	58.3
6	22,320	3,650	60.0
7	21,700	3,030	61.1
8	21,257	2,587	62.0
9	20,925	2,255	62.5
10	20,667	1,997	63.0
11	20,460	1,790	63.3
12	20,291	1,621	63.6
13	20,150	1,480	63.9
14	20,031	1,361	64.1
15	19,928	1,259	64.3
16	19,840	1,170	64.4
17	19,763	1,093	64.6
18	19,694	1,024	64.7
19	19,633	963	64.8
20	19,579	909	64.9



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY HAT CREEK PROJECT
SITE EVALUATION STUDY
MAKE-UP & BLOWDOWN FLOWS AT VARIOUS CYCLES OF CONCENTRATION
integ-ebasco — FIGURE 4-11

Also associated with the blowdown will be a heat load discharge which will vary throughout the year depending on ambient climatic conditions. A conservative average annual value would be approximately 0-2 percent of the total heat rejection rate or approximately 9.45 x 10^7 Btu/hr.

At the five interior sites, where no condenser cooling water discharge is proposed, high cycles of concentration and subsequent low blowdown flows are required to maintain each plant's water balance. The results of these water balances have resulted in the average cooling system makeup and blowdown presented in Table 4-11 and the following cycles of concentration:

Site	Average Cycle of Concentration
Ashcroft	10.4
Big Bar Creek	14.3
Harry Lake	12.7
Mine Mouth	18.3
Soda Creek	12.4

Based on the water quality evaluations for the Thompson and Fraser Rivers previously presented, these water sources will permit the operation of each site's recirculating condenser cooling water system at the necessary cycle of concentration. Chemical treatment required would include sulfuric acid addition to control carbonate scaling, corrosion inhibitors and possibly a buffering agent to aid in maintaining cooling water pH. Chlorine will also be added intermittently to control biological growth on heat exchanger surfaces. This should only be a seasonal problem as algal reproductive rates and densities in freshwater rivers are very dependent upon the temperature regime and nutrient supply which are most favorable for these organisms during the late spring and summer.

4.5.2.2 Ash Sluicing Systems

The second largest water user at a thermal generating station is the fly ash and bottom ash sluicing systems. Based on an ash production rate of 10,000 tons per day of which 80 percent is fly ash and 20 percent bottom ash, and a sluicing solids content of 10 percent, approximately 12,000 gpm will be required for fly ash transport on an averaged daily basis and 3,000 gpm will be required for bottom ash transport on an averaged daily basis. Actual flows will be higher as sluicing is not performed continuously.

The Britannia Beach site does not have land available for ash ponds. Ash would be transported dry to a designated disposal area in the Hat Creek Valley. Approximately 330 gpm will be required to wet the ash to prevent dusting problems during both transport and storage. The seven remaining sites would utilize a wet sluicing system with on-site storage of the ash in ponds.

Ash sluicing systems whether closed-loop (no blowdown) or open-loop are responsible for two other water budget flows; namely water lost to the solids during sluicing and net ash pond evaporation or rainfall accummulation. The first item was estimated at 1,250 gpm by utilizing a bulk density of 50 pounds per cubic foot for both fly ash and bottom ash. The second component is site specific depending upon the local meteoroligical conditions at each site and the ash pond surface area available at each site for evaporation. Table 4-14 presents average annual lake evaporation and precipitation rates obtained from the Canadian Weather Service. These rates are based on measured pan evaporation rates for the ten-year period from 1957 to 1966 and corrected to lake evaporation

TABLE 4-13

EVAPORATION AND PRECIPITATION RATES

Site	Lake Evaporation	Precipitation	Net Evaporation	Evaporation per Unit Surface Area	Ash Pond Surface Area	Total Evaporative Flow
	Inches per yr.	Inches per yr	Inches per yr	gpm/acre	acres	gpm
Ashcroft	28.0	8.85	19.15	0.99	1,236	1,222
Big Bar Creek	25.0	15.5	9.5	0.49	1,308	642
Dunsmuir	25.0	52.7	-27.7	-1.43	2,025	-2,895
Harry Lake	27.5	12.5	15.0	0.77	1,091	845
Mine Mouth	27.5	12.5	15.0	0.77	418	324
Soda Creek	25.0	15.8	9.2	0.475	1,860	883
Stave Lake	29.0	61.9	-32.9	-1.69	1,760	-2,989

NOTE:

Negative value indicates net precipitation rates reflecting local climatological conditions. Precipitation rates are based on thirty years of record from 1941 to 1970. The table also presents net evaporation rates (a negative value indicates net precipitation), ash pond surface area and the resulting evaporative or accumulative flow.

This information dictates that the Dunsmuir and Stave Lake sites must operate their ash sluicing systems in an open-loop mode due to the excess of precipitation over evaporation. However, evaporation can be utilized at the interior sites to obviate the need for a liquid discharge.

Alternative ash disposal schemes for the inland sites, such as a dry ash transport system in conjunction with evaporation ponds to consume excess plant process water could also obviate the need for a liquid discharge. The final choice will be the result of a detailed economic comparison and land availability.

Wastewater flow from ash sluice systems is comprised of blowdown to maintain pond water quality and net precipitation accummulation. The discharge flows anticipated from the proposed sites are presented in Table 4-11. The interior sites will not incorporate a blowdown. Combined bottom ash and fly ash sluicewater can be expected to contain a TDS concentration of approximately 1,000 mg/l and a SS concentration of 30 mg/l. The TDS are comprised of calcium and sulfate ions with minor contributions due to a variety of heavy metals.

4.5.2.3 Process and Plant Service Water

The remaining plant water uses have been estimated as follows:

System	Makeup (gpm)	Blowdown (gpm)
Steam Generation System	610	450
Potable Demand	100	20
Miscellaneous	100	100
Total	810	570

The steam generation system is comprised of boiler makeup and demineralizer regeneration requirements and has been conservatively estimated as 2 percent of the unit's design steam output. The treatment requirements necessary to produce a boiler feedwater compatible with system specifications will vary between sites depending upon various water quality parameters of the supply source, e.g., TDS, SS, calcium, magnesium, silica, sulfate, TOC, alkalinity, etc. The major wastewater produced by these processes is demineralizer regenerate and will contain approximately 4,000 mg/l of TDS with sodium and sulfate ions being the major constitutents. Potable demand and miscellaneous plant water uses include water utilized for sanitary and kitchen purposes, floor and equipment washdowns, makeup to the heating, ventilating and air conditioning (HVAC) system, and laboratory water requirements. The total blowdown flow of these systems after individual process treatment would exhibit TDS concentrations of approximately 200 mg/l, SS concentrations of 30 mg/l and oil/grease concentrations of 10 mg/l. Following treatment interior sites would reuse and/or evaporate these wastewater discharges while the coastal sites would discharge these wastewater to the receiving water body.

Another wastewater discharge which would be important for all but the interior sites, where evaporation exceeds precipitation, is coal pile runoff. This wastewater can be generally characterized after appropriate treatment by a TDS concentration of 4,000 mg/l comprised mainly of sulfate ions, and a SS concentration of 50 mg/l.

4.5.3 Water Quality and Solid Waste Management Regulations

In December, 1973 and January, 1975, the Pollution Control Board of British Columbia promulgated recommended guidelines and objectives for waste discharges to land and water for various specific industries operating in the Province of British Columbia. On the same dates the Pollution Control Board also issued receiving water quality guidelines in order to preserve and enhance the quality of provincial water consistent with their intended use. These recommended guidelines were issued pursuant to section 14 of the British Columbia Pollution Control Act of 1967. The effluent guidelines and objectives set forth three levels of compliance which are indicative of the attainment of high, intermediate and low order discharge quality and are termed Level A, Level B and Level C, respectively. The guidelines recommend that generally all new or proposed discharges meet Level A objectives.

Specific guidelines for the industry of concern in this report, namely a Thermal Generating Station, have not been detailed at this time. However, the Pollution Control Board has made provision for the application of existing guidelines from closely applicable industrial processes. There are two general industrial categories with waste discharges that may be considered similar to those usually experienced with a Thermal Generating Station. These are Milne, Mine Milling and Smelting Industries and Industries Discharging Heavy Metals. The objectives for these industries as well as receiving water guidelines are presented in Tables 4-15, 4-16 and 4-17. The receiving water guidelines presented herein are applicable after an "initial dilution zone" which has been defined by the Pollution

Table 4-14—*Objectives for Effluent Discharges*

Characteristics	Description	Unit of Measurement	Marine-water Discharge			Fresh-water Discharge		
			Level A	Level B	Level C	Level A	Level B	Level C
Total suspended solids (non-filterable residue)	That portion of the effluent, as discharged which is retained by an approved filter	mg/1	50[1]	150[1]	(2)	50[1]	150[1]	(2)
Total dissolved solids (filterable residue)	That portion of the effluent as discharged which passes through an approved 0.45-micron pore-sized filter	mg/1	....	....	....	<2,500	<3,500	<5,000
Colour[3]	Colour of the effluent, at the point of discharge	Approved units	....	....	....	....	....	....
pH[2]	The pH of the effluent at the point of discharge	pH units	6.5–8.5[4]	6.5–9.5	6.0–10	6.5–8.5[4]	6.5–9.5	6.0–10
Specific elements and compounds[1]	Material contained in the effluent, at the point of discharge, which passes an approved 0.45-micron pore-sized filter (except where total values are required)	....	....	....	....	....	....	....
Aluminum (Al)	Dissolved in the effluent	mg/1	0.50	1.00	10.00	0.50	1.00	10.00
Ammonia (as N)	Dissolved in the effluent	mg/1	0.50[4]	1.00	10.00	0.50[4]	1.00	10.00
Antimony (Sb)	Dissolved in the effluent	mg/1	0.05	0.25	1.00	0.05	0.25	1.00
Arsenic (As)	Dissolved in the effluent	mg/1	0.05	0.25	1.00	0.05	0.25	1.00
Cadmium (Cd)[5]	Dissolved in the effluent	mg/1	0.005	0.01	0.02	0.005	0.01	0.02
Chromium (Cr)	Dissolved in the effluent	mg/1	0.05	0.30	0.50	0.05	0.30	0.50
Cobalt (Co)	Dissolved in the effluent	mg/1	0.10	0.50	1.00	0.10	0.50	1.00
Copper (Cu)	Dissolved in the effluent	mg/1	0.05	0.30	1.00	0.05	0.30	1.00
Cyanide (CN)	Total cyanide in the effluent	mg/1	0.10	0.50	2.00	0.10	0.50	2.00
Fluoride (F)	Dissolved in the effluent	mg/1	2.50	5.00	15.00	2.50	5.00	15.00
Iron (Fe)	Dissolved in the effluent	mg/1	0.30	1.00	5.00	0.30	1.00	5.00
Lead (Pb)	Dissolved in the effluent	mg/1	0.05	0.10	0.50	0.05	0.10	0.50
Manganese (Mn)	Dissolved in the effluent	mg/1	0.05	0.50	1.50	0.05	0.50	1.50
Magnesium (Mg)	Dissolved in the effluent	mg/1	....	....	....	150	300	500
Mercury (Hg)	Total in the effluent	mg/1	0.001[4]	0.003	0.01	0.001[4]	0.003	0.01
Molybdenum (Mo)	Dissolved in the effluent	mg/1	0.50[4]	1.00	10.0	0.50[4]	1.00	10.00
Nickel (Ni)	Dissolved in the effluent	mg/1	0.30	0.50	1.00	0.30	0.50	1.00
Nitrates/Nitrites (as N)	Dissolved in the effluent	mg/1	10.00	25.00	50.00	10.00	25.00	50.00
Phosphate (as P)	Total in the effluent	mg/1	2.00	5.00	10.00	2.00	5.00	10.00
Selenium (Se)	Dissolved in the effluent	mg/1	0.05	0.10	1.00	0.05	0.10	1.00
Silver (Ag)	Dissolved in the effluent	mg/1	0.10	0.50	1.00	0.10	0.50	1.00
Sulphate (SO_4)	Dissolved in the effluent	mg/1	....	....	....	50[4]	250	1,000
Uranyl (UO_2)	Dissolved in the effluent	mg/1	2.00	5.00	10.00	2.00	5.00	10.00
Zinc (Zn)	Dissolved in the effluent	mg/1	0.50	5.00	10.00	0.50	5.00	10.00
Oil and Grease	Total in the effluent	mg/1	15.00	15.00	15.00	15.00	15.00	15.00

NOTE—Acceptable concentrations for characteristics not appearing in this list are to be determined as required. When all liquids are totally recycled, the applicability of the above objectives will be assessed.

1 Initially, semiquarterly sampling on effluents and at control and test stations in receiving-waters; quarterly sampling on effluent discharged to closed systems.
2 Daily sampling.
3 To be reviewed.
4 Tentative, subject to review.
5 Subject to review where applied to smelters.

Table 4-15

Objectives for the Discharge of Effluent to Marine and Fresh Waters From Metal-finishing Plants and Industries Discharging Heavy Metals

Level / Parameter		A	B[1]	C	Monitoring Frequency
Aluminum	Dissolved mg/l Al	0.2	....	0.50	Twice a month.
Ammonia	Dissolved mg/l N	1.0	....	2.0	Twice a month.
Antimony	Dissolved mg/l Sb	5.0	....	5.0	Twice a month.
Arsenic	Dissolved mg/l As	1.0	....	1.0	Twice a month.
Cadmium	Dissolved mg/l Cd	0.02	....	0.10	Twice a month.
Chromium, hexavalent and trivalent	Dissolved mg/l Cr	0.15	....	0.60	Twice a month.
Cobalt	Dissolved mg/l Co	1.0	....	2.0	Twice a month.
Copper	Dissolved mg/l Cu	0.10	....	1.0	Twice a month.
Cyanide	Total mg/l CN	0.50	....	1.0	Twice a month.
Fluoride	Dissolved mg/l F	5.0	....	15.0	Twice a month.
Iron	Dissolved mg/l Fe	0.5	....	1.0	Twice a month.
Lead	Dissolved mg/l Pb	0.20	....	0.50	Twice a month.
Manganese	Dissolved mg/l Mn	1.0	....	1.0	Twice a month.
Mercury	Dissolved mg/l Hg	0.005	....	0.005	Twice a month.
Molybdenum	Dissolved mg/l Mo	10.0	....	10.0	Twice a month.
Nickel	Dissolved mg/l Ni	1.0	....	2.0	Twice a month.
Nitrate and nitrite	Dissolved mg/l N	10.0	....	25.0	Twice a month.
Oil and grease	Total mg/l	10.0	....	15.0	Twice a month.
Phenols	Dissolved mg/l phenol	0.20	....	0.50	Twice a month.
pH range		6.5–8.5	....	6.5–8.5	Twice a month.
Phosphate	Total mg/l P	2.0	....	5.0	Twice a month.
Selenium	Dissolved mg/l Se	0.20	....	1.0	Twice a month.
Silver	Dissolved mg/l Ag	0.05	....	0.10	Twice a month.
Sulphate[2]	Dissolved mg/l SO_4	100.0	....	250.0	Twice a month.
Nonfilterable residue	mg/l	50.0	....	100.0	Twice a month.
Tin	Dissolved mg/l Sn	2.0	....	4.0	Twice a month.
Zinc	Dissolved mg/l Zn	0.3	....	1.0	Twice a month.

[1] No intermediate level of treatment is suggested.
[2] Objectives for sulphate are not applicable to discharges to marine waters.

TABLE 4-16

OBJECTIVES FOR RECEIVING-WATER QUALITY[1]

Parameter	Marine Water	Fresh Water
Dissolved Oxygen............mg/l	90% seasonal natural value	90% seasonal natural value[2]
pH[3]..................... pH units	$\pm$ 0.2	$\pm$ 0.2
Turbidity[3]............APHA units	+5	+5
Color[3]................APHA units	NO APPRECIABLE CHANGE[4]	NO APPRECIABLE CHANGE[4]
Floatable solids............mg/l	NONE	NONE
Toxicity........................	BELOW DETECTABLE LIMIT	BELOW DETECTABLE LIMIT
Aesthetic.......................	NO DECREASE	NO DECREASE
Temperature[3]..................$^{\circ}$C	$+1^{\circ}$	$+1^{\circ}$
Alkalinity[3].....mg/l equiv. $CaCO_3$	....	-20%
Chloride[3]...................mg/l	....	+25
Faecal coliforms[4]......mpn/100 ml	....	....
Chlorine Residual...........mg/l	BELOW DETECTABLE LIMITS	BELOW DETECTABLE LIMITS

1 This table is a composite of the Objectives presented in the November, 1973 and the March, 1975 Pollution Control Objectives. Where values were inconsistent the more stringent value was assumed to apply.

2 Excluding lake stations, which should be assessed individually.

3 Variations in water quality, due to the discharge of waste, should not exceed the numerical increments listed.

4 To be reviewed

NOTE - Parameters as determined at the limit of the initial dilution zone.

Control Board as follows:

> Initial dilution zone - (a) For marine waters and lakes: Waters contained within an area extending 300 feet in all directions from a point of discharge. (b) For rivers or streams: Waters contained within an area extending 300 feet downcurrent from a point of discharge, and within a lateral distance not exceeding one-half the width of a river or stream at the point of discharge.

The Pollution Control Objectives strongly emphasize in-plant control of process water losses and the volumetric reduction of waste streams and desire that no discernible change in environmental characteristics from background or natural levels be incurred due to a waste discharge. A liquid discharge permit issued by the Pollution Control Board is necessary before liquid wastes may be discharged to a water body.

The Pollution Control Objectives recommend that any solid waste disposal location be such that surface drainage or runoff can be diverted around the area; that adequate drainage from the site is ensured and that groundwater will not become contaminated as a result of the location and/or the operation of the disposal area. Similar to a liquid effluent, a permit issued by the Pollution Control Board is necessary for the operation of a solid waste disposal area.

4.5.4 Site Specific Criteria Application

This section presents and discusses the subjective site-specific conditions which led to the criteria ranking at each site and across all the sites. The criteria category "The Thermal Generating

Station Effects on Water Resources" was always considered more important than "Water Resource Effects on the Thermal Generating Station".

4.5.4.1 Dunsmuir

a) Water Resource Effects on the Thermal Generating Station

The operation of a salt water recirculating condenser cooling water system utilizing makeup water with an average TDS of approximately 22,000 mg/l will require large acid additions to prevent calcium carbonate scaling and pH increases. A more expensive means of treatment utilizing hydrochloric acid could be substituted for this purpose, since sulfuric acid will increase calcium sulfate precipitation potential and possibly lower the operating cycles of concentration. The SS concentrations of approximately 10 mg/l in the Strait of Georgia in the vicinity of the plant site are relatively low and should not require treatment for their removal.

Because the plant is located in brackish, estuarine waters where biological productivity is high, (chlorine demand approximately 5 mg/l), biofouling of the condenser tubes and cooling towers will be a serious problem. Biocide treatment and/or mechanical treatment costs associated with maintaining high heat transfer efficiencies will be much more extensive than at the interior sites with a fresh water supply.

b) Thermal Generating Station Effects on Water Resources

The total discharge from this plant to the receiving water body will be approximately 10,815 gpm with the majority of this flow, 8,600 gpm, being cooling tower blowdown. This will result in a thermal addition to the strait of approximately 9.45×10^7 Btu/hr. The chemical quality of this discharge will be ambient TDS concentrations multiplied by a factor of three, resulting in a plume area of increased TDS levels in the receiving water surrounding the discharge diffuser. The combination of other process wastewater effluents such as demineralizer regenerant, ash pond blowdown and coal pile runoff, with cooling tower blowdown will not change any effluent concentrations significantly due to the high TDS concentrations of the makeup water. Naturally occurring TDS concentrations of the strait vary considerably and flushing occurs frequently. Long-term effects on the water quality regime of the area are not anticipated even though the total quantity of chemical addition to the strait has been estimated at 43,150 lbs/day.

The use of a recirculating condenser cooling water system with a "wet" cooling tower minimizes heat loadings to the strait as well as system makeup and blowdown flows (approximately 86 cfs). This latter point reduces the quantity of dredging required for the intake and discharge structures.

4.5.4.2 Britannia Beach

a) Water Resource Effects on the Thermal Generating Station

This plant would utilize a once-through condenser cooling water system and subsequently, chemical and/or physical treatment to maintain cooling water quality would not be required. Because of the estuarine environment, biofouling will pose a significant problem and costly biocidal and/or mechanical treatment would be necessary to maintain condenser tube cleanliness. The chlorine demand of this water body has been estimated at 5 mg/l.

b) Thermal Generating Station Effects on Water Resources

A once-through condenser cooling water system would result in the discharge of 9.45 x 10^9 Btu/hr to Howe Sound. This heat discharge may have a significant effect on the circulation patterns of the sound due to their density dependence. Other process wastewaters such as boiler blowdown, demineralizer regenerant wastewater, sanitary wastewater and coal pile run-off would also be discharged to the Sound following treatment (6,550 lbs/day of TDS). These discharges should not produce a significant impact on ambient water quality after an initial mixing zone, due to the naturally high TDS concentrations of this water body. A once-through condenser cooling water system sized for approximately 1,670 cfs would also require extensive in-water construction and dredging.

4.5.4.3 Stave Lake

a) Water Resource Effects on the Thermal Generating Station

This plant would utilize a once-through condenser cooling water system and chemical and/or physical treatment to maintain cooling water quality would not be required. Biofouling is not anticipated to present a major problem as the estimated chlorine demand of this freshwater source is low (1 mg/l) and high algal densities should only occur during the late spring and summer months.

b) Thermal Generating Station Effects on Water Resources

Due to the large amounts of cooling water required to dissipate 9.45×10^9 Btu/hr, Stave Lake should experience a significant amount of recirculation. Other process wastewaters including boiler blowdown, demineralizer regenerant wastewater, sanitary wastewater and coal pile runoff containing about 8,900 lbs of TDS/day will also be discharged to the lake following treatment. Since the lake would be recirculating to various degrees, concentration increases for most dissolved chemical constituents can be anticipated. Extensive dredging of the lake's marshland would also be necessary for the construction of intake and discharge canals sized for approximately 1,670 cfs.

4.5.4.4 Ashcroft

a) Water Resource Effects on the Thermal Generating Station

A Thompson River water supply should not require treatment of cooling tower makeup for the removal of approximately 19 mg/l SS. Thompson River water is moderately soft in this area with low TDS concentrations (70 mg/l). This lessens the extent and the cost of maintaining the recirculating condenser cooling water pH to prevent scaling and corrosion.

Biocide additions to the condenser cooling water system are expected to be minimal. In studies conducted for BC Hydro during 1974 and 1975, the chlorine demand value of Thompson River water was found to be less than 1 mg/l. While these same studies indicated that algae are present, it is not anticipated that a significant biofouling problem would result, due to the temperature regime of the river.

b) Thermal Generating Station Effects on Water Resources

The characteristics of this site permit the maximum reuse of plant process waters and a liquid discharge to a natural water body can be obviated. This eliminates adverse environmental impacts due to chemical and thermal discharges. The effects of dredging are minimized in that only an intake structure sized for 50 cfs is required.

4.5.4.5 Mine Mouth

a) Water Resource Effects on the Thermal Generating Station

The use of Thompson River water containing about 10 mg/l SS and 55 mg/l TDS minimizes the extent and the cost of maintaining condenser cooling water system quality. This site exhibits the lowest pond evaporation rate of the interior sites and therefore requires the highest cycles of concentration to equalize the plant water balance. This may result in increased cooling tower chemical treatment.

As previously stated, Thompson River water would require minimal biocidal additions to prevent biofouling (chlorine demand is less than 1 mg/l).

b) Thermal Generating Station Effects on Water Resources

The characteristics of this site permit the maximum reuse of plant process waters resulting in a no liquid discharge to a natural water body. This eliminates adverse environmental impacts due to chemical and thermal discharges. The effects of dredging are minimized because only an intake structure sized for 46 cfs is required.

4.5.4.6 Harry Lake

a) Water Resource Effects on the Thermal Generating Station

Similar to the Mine Mouth Site, the Thompson River water supply for this site minimizes condenser cooling water system's chemical, physical and biocidal treatment requirements.

b) Thermal Generating Station Effects on Water Resources

Since this site permits the maximum reuse of plant process waters and no discharge of liquid wastewater, adverse environmental effects to a receiving water body are eliminated. Dredging effects are also minimized because only an intake structure sized for 47 cfs is required.

4.5.4.7 Big Bar Creek

a) Water Resource Effects on the Thermal Generating Station

Fraser River water quality is such that condenser cooling water system makeup would have to undergo treatment for the removal of suspended solids with concentrations averaging approximately 70 mg/l. The high hardness and TDS levels (96 mg/l) of this river water would require greater acid addition rates to maintain the condenser cooling water system as compared to Thompson River water.

Biocide addition to the cooling water system would be minimal. Similar to Thompson River water, Fraser River water exhibits low chlorine demand, values of less than 1 mg/l, and algae density may be lower than that experienced in the Thompson River due to the much higher sediment load.

b) Thermal Generating Station Effects on Water Resources

Similar to the other interior sites, maximum reuse of plant process waters is affected and a liquid waste discharge to a natural water body is obviated. The effects due to dredging operations are minimized as the intake structure sized for 46 cfs would be the only in-water construction.

4.5.4.8 Soda Creek

a) Water Resource Effects on the Thermal Generating Station

Similar to the Big Bar Creek Site, all makeup water would require treatment to remove an average concentration of 105 mg/l SS. Condenser cooling water system treatment requirements are more extensive for Fraser River water with a TDS concentration of approximately 90 mg/l in this area than for a similar system using Thompson River water.

Similar to the other Fraser River alternative sites, biocide additions to maintain the condenser tubes and cooling tower system should be minimal as the chlorine demand is approximately 1 mg/l.

b) Thermal Generating Station Effects on Water Resources

Because a thermal generating station at this site would have no wastewater discharge, there would be no adverse environmental impact on the water bodies in the vicinity of the plant. Dredging effects are minimized because only an intake structure sized for 47 cfs is necessary.

4.5.5 Conclusions

Based on the foregoing site specific investigation and discussion, it is concluded that:

a) Each of the alternative sites is located on a water body that has sufficient quantity of water to satisfy all thermal generating station requirements.

b) The quantity of water present at each of the alternative sites is legally available to satisfy thermal generating station water requirements and would not affect existing water uses.

c) Water quality does not preclude the use of any water body in regard to condenser cooling water requirements, but would necessitate the development of other water sources for the proposed Dunsmuir and Britannia Beach sites for other uses.

Based on the application of site evaluation criteria, numerical values and ranking, it is concluded that:

a) Interior sites are more acceptable than Coastal sites from a water resource viewpoint.

b) Regarding the Interior sites, those utilizing the Thompson River as a makeup supply source are preferred over those sites using the Fraser River.

c) Of the Interior sites, the Harry Lake and Mine Mouth sites are preferred over all others.

d) As between these two sites, the Harry Lake site is preferred as evaporation rates are higher.

e) Regarding the Coastal sites, the Dunsmuir site is preferred because of the use of a recirculating condenser cooling water system which lessens water withdrawal and discharge quantities and subsequent thermal effects.

f) The Stave Lake site is the least acceptable due to the significant impact on the lake created by the proposed thermal generating station's chemical and thermal discharges.

4.5.6 Recommendations

Based on the information presented in this report, it is recommended that:

a) The Harry Lake site be selected for the development of a 2000 MW Thermal Generating Station.

b) A water quality monitoring program be instituted at the proposed intake location for the Harry Lake site to determine the specific treatment requirement necessary to ensure reliable thermal generating station operation.

c) A meteorological monitoring program be instituted at location of the proposed Harry Lake ash ponds and at various other potential pond sites, to determine the extent of evaporation and precipitation and adequately develop a water management programme.

d) A detailed water and wastewater management study and solid waste management study be performed to determine an optimal and cost effective means of maintaining the proposed system, in which no liquid waste would be discharged.

GLOSSARY

Bathymetry - The measurement of water depth.

Biofouling - The formation and attachment of aquatic and marine organisms (bacteria, algae, mollusks, etc.) to various water transport and water use systems. These organisms decrease system efficiency by physically blocking water flow and lessening heat transfer ability.

Blowdown - The quantity of liquid discharged from a specific process, e.g. cooling tower blowdown, or from an entire thermal generating station, e.g. plant blowdown.

Chemical Discharge - A process or plant liquid discharge which contains dissolved chemicals.

Chlorine Demand - The amount of chlorine (mg/l) required to be added to a water (sample) before any stable residual chlorine is formed. Organic substances and reducing agents in the water cause this demand.

Closed-Loop Ash Sluicing System - An operational process of a thermal generating station, which continually reuses water to transport ash to disposal ponds. An ash pond blowdown is not required as chemical treatment makes the water suitable for reuse.

Consumptive Water Use - That portion of the water withdrawn from the supply source that is not directly discharged from a thermal generating station to a receiving water body. Major consumptive water uses include evaporation, retention of water in ash and ash pond seepage.

Cycle of Concentration - The number of times a water quality parameter is concentrated. This value is equal to the makeup flow divided by the blowdown flow and is usually associated with recirculating condenser cooling water systems.

Dissolved Oxygen Saturation Value - The maximum concentration of dissolved oxygen in a water (sample) at a specific temperature, pressure and chloride concentration.

Drainage Basin (Watershed) - The area drained by a river system.

Dredging - A process by which sediments are removed from water bodies, transported via ship, barge or pipeline and disposed of as spoil to land or water.

Drift - Water droplets resulting from the turbulent contact zones inside a cooling tower and emitted to the atmosphere in the cooling tower air stream.

Fjord - A semi-isolated coastal basin characterized by considerable freshwater drainage, a shallow sill and a steep mountainous shoreline.

Makeup - The quantity of water withdrawn from the supply source to satisfy either a specific process water requirement, e.g. cooling tower makeup, or the entire thermal generating station water requirement, e.g. plant makeup.

Once-Through Condenser Cooling Water System - A condenser cooling water system in which total water requirement for steam condensation is pumped from the supply source through the condenser on a single pass basis and then discharged into the receiving water body.

Open-Loop Ash Sluicing System - A thermal generating station operational process in which water is reused to varying degrees for the transportation of ash to disposal ponds. A blowdown is incorporated to maintain water quality parameters within certain limits.

Recirculating Condenser Cooling Water System - A condenser cooling water system which utilizes a heat dissipation system, e.g. cooling tower, spray canal, to lower the condenser cooling water's elevated temperatures and permit the reuse of this water.

Suspended Solids - The residue or solid material present in a water (sample) and capable of being retained by a filter.

Thermal Discharge - A process or plant discharge which contains quantities of waste heat.

Tidal Range - The height differential of a water body's surface caused by solar and lunar attractive forces.

Total Dissolved Solids - The residue of a water (sample) which passes through a filter. It is generally comprised of chemical ions and soluble organic compounds.

Turbidity - An expression of the optical property of a water (sample) which causes light to be scattered and absorbed rather than transmitted in straight lines through the water.

Water Consumed by Ash - Water bound in the void volume of bottom ash and fly ash and unable to be recycled or discharged.

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APPENDIX 4-1

GENERIC COAL-FIRED THERMAL GENERATING STATION DESCRIPTION

A4. GENERIC COAL-FIRED THERMAL GENERATING STATION DESCRIPTION

A4-1.1 Major Components of a Generic Coal-Fired Thermal Generating Station

A coal-fired thermal generating station converts coal, the fuel (or energy source), into electrical energy. To accomplish this, several major plant components are required as described in the following paragraphs and noted on Figure 4-A-1.

A4-1.1.1 Fuel Delivery and On-Site Storage System

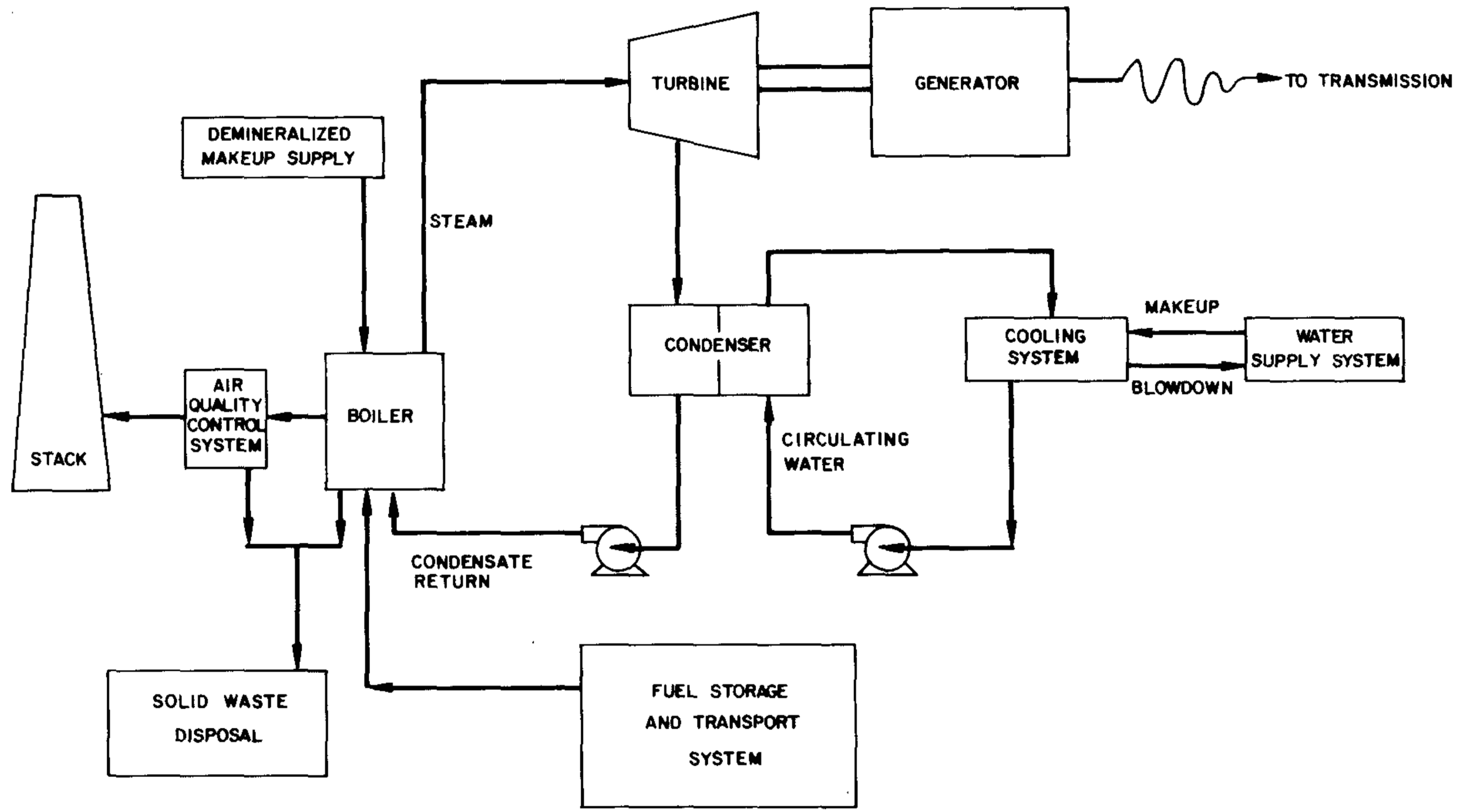
Fuel, typically delivered to the plant from the mine by rail, must be stored on-site in an open pile. The usual storage capacity equals approximately 90 days of coal demand.

A4-1.1.2 Boiler

The energy in the coal must be converted to high temperature and pressure steam in order to produce useful work. This process takes place in the boiler via coal combustion.

A4-1.1.3 Turbine-Generator

The steam produced in the steam generator is conveyed to the turbine where the steam's energy is converted to mechanical energy (i.e., the steam, under differential pressure, rotates the turbine). The turbine rotor is connected to a generator which, when rotated, produces electricity.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

GENERIC FEATURES OF A FOSSIL FUELED POWER PLANT

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FIGURE 4-A-1

A4-1.1.4 Switchyard and Transmission Facilities

The electricity produced in the generator must then be transmitted to the distribution system. This process takes place in the switching yard, where voltage is regulated and the electricity is then transmitted to the distribution system in a high voltage transmission line.

A4-1.1.5 Condenser and Cooling Facility

The steam exiting the turbine is cooled to increase the pressure differential across the turbine which subsequently causes the turbine to spin.

In the cooling process, the steam is condensed and returned to the boiler for reuse. The cooling is effected in a heat exchanger (i.e., condenser) where an "outside" coolant (i.e., circulating cooling water) is used to cool the steam. In a fossil fuel power plant, the typical heat rejection rate across the condenser is 4.5×10^6 Btu/MW-hr. The cooling water can, in turn, be cooled to allow for reuse or it can be discharged. A heat dissipation system, such as a pond or tower (wet or dry type), is used to convey the rejected heat back to the air or water environment in recirculating systems.

A4-1.1.6 Air Quality Control System (AQCS)

The combustion of coal produces an inorganic residue called ash and causes the oxidation of sulfur in the coal to sulfur dioxide (SO_2) gas. Ash is of two types: bottom ash which is collected in the bottom of the boiler (usually 20% of the total); and, fly ash which exits the boiler with the flue gas (usually 80% of the total). To meet stack emission regulations that govern the amount of particulates and SO_2 emitted from the stack and ambient air quality regulations that govern the ambient concentrations resulting from these emissions, major air quality control equipment is required. Fly ash is collected with either an electrostatic precipitator or a particulate scrubber and SO_2, if required to be removed, is removed from the flue gas by an SO_2 absorber.

A4-1.1.7 Solid Waste Disposal Facilities

The large amounts of bottom ash, fly ash and, if pertinent, SO_2 absorber solids are usually disposed of on-site, in waste disposal ponds. Because the amounts of solid waste produced are so large, these disposal ponds usually require large tracts of land.

A4-1.2 Major Water Use and Wastewater Generation Locations

The key water use and subsequent wastewater generation locations associated with a typical coal-fired power plant include the following: process water, cooling water and potable/plant service water.

A4-1.2.1 Process Water

a) Boiler Makeup and Blowdown

Makeup water to the boiler is required to maintain various water quality parameters within desirable limits. Blowdown is also required for water quality purposes and to offset steam cycle losses. The quantity of makeup is generally 1.0 to 1.5 percent of the circulating steam flow rate.

b) Ash Sluicing

Ash produced as a product of combustion is collected in bottom ash hoppers (bottom ash) and the hoppers of the electrostatic precipitators (fly ash). The sluicing operation is highly variable in water demand depending on the coal type and ash content, ash accumulation rate in the hoppers, frequency of sluicing and duration of each sluicing event. Typically, the sluicing operation is designed to produce a 5 to 10 percent (by weight) ash slurry. Ash sluicing wastes are normally disposed of on-site and pond supernatant, the wastewater associated with this process, can be reused to varying degrees within the plant depending on supernatant water quality and subsequent treatment needs.

c) Sulfur Dioxide Scrubber System

When flue gas desulfurization is required, major water use, wastewater and solid waste sources are created. Typically, lime or limestone based slurry systems are utilized. A 5 to 10 percent calcium sulfate/sulfite sludge is produced that is then thickened to about 40 percent solids and subsequently disposed of in an off-site pond. Similar to ash sluicing, the pond supernatant can be reused to varying degrees depending on system operations.

A4.1.2.2 Cooling Water

Cooling water is required to condense the spent steam for increased pressure differential and to cool auxiliary system equipment such as seals, bearings and pumps. Typically, the quantity of condenser cooling water is approximately 1 cfs per MW of capability while auxiliary cooling systems require from 0.01 to 0.1 cfs/MW. Blowdown is required from recirculating systems to maintain water quality parameters within desirable limits. Blowdown quantity is equal to the makeup quantity minus evaporation and drift losses.

A4.1.2.3 Potable/Plant Service Water

This category of water use is generally comprised of potable water for sanitary and kitchen uses, equipment and floor washdowns, fire protection and heating, ventilating and air conditioning (HVAC). The quantity of water required by these processes is highly variable and dependent on specific plant processes. In general potable demand varies from 30-60 gallons per capita per day. Major wastewater discharges from these processes include sanitary wastes and floor drainage.

A4-1.3 Detailed Systems Description

The primary water and wastewater flows in a fossil fuel thermal generating station are presented in Table 4-A-1.

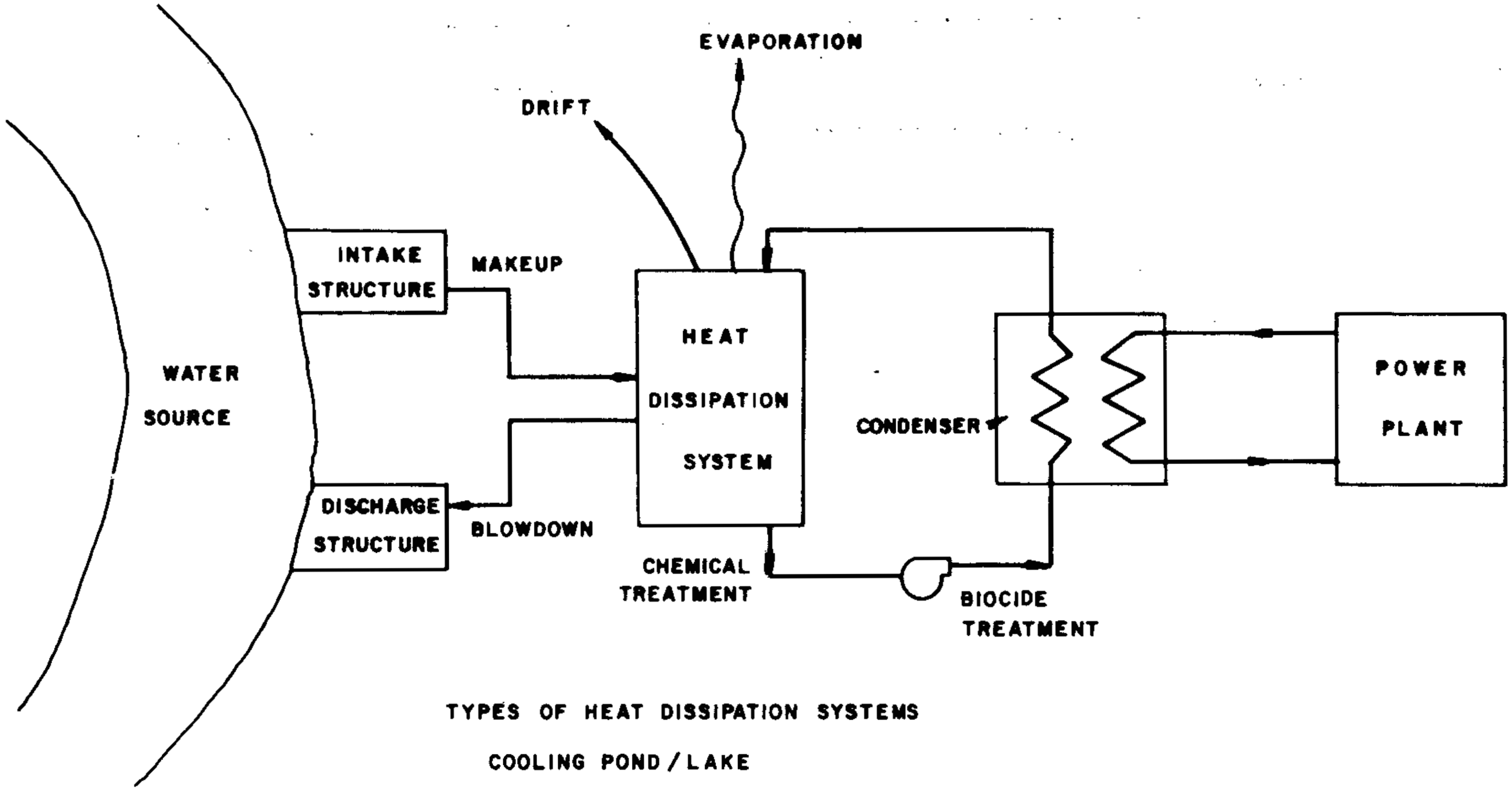
A4-1.3.1 Cooling Systems

Figure 4-A-2 presents a schematic diagram of the typical features of a condenser cooling water system. In general, cooling systems

TABLE 4-A-1

PRIMARY WATER USES AND WASTEWATER FLOWS
IN A COAL-FIRED
THERMAL GENERATING STATION

Process Phenomenon	Impact On Plant-Control	Impact On Environment-Use Increment	Wastewater Stream
Construction			
1. Material Preparation	-	Suspended Solids (SS)	Construction Wastes
2. Potable Water Supply	Treatment by SS Removal and Chlorination	Organics, Bacteria, SS	Sanitary Wastes
3. Rainfall	Drainage System	Soil Sediment	Construction Runoff
Operation			
1. Condenser Cooling Water System	Treatment by Chemical Addition and SS Removal	Heat, Chlorine, Corrosion Inhibitors, Sulfates	Cooling System Blowdown
2. Boiler Makeup	Treatment by Chemical Addition	Metals, Chemicals, TDS, Sulfates, Sodium	Boiler Blowdown Regeneration Wastes
3. Bottom Ash/Fly Ash Transport	-	Metals, TDS	Ash Sluicing Supernatant
4. Flue Gas Desulfurization	Chemical Addition	TDS, Metals, SS	Scrubber Waste Supernatant
5. Floor and Equipment Washdown	Drainage System	Oil/Grease and SS	Drainage Wastes
6. Potable Water Supply	Treatment	Organics, Bacteria, SS	Sanitary Wastes
7. Rainfall on Coal Pile	Drainage System	Sulfates, Metals, TDS, SS	Coal Pile Runoff



TYPES OF HEAT DISSIPATION SYSTEMS

- COOLING POND / LAKE
- SPRAY POND
- MECHANICAL DRAFT TOWER
- NATURAL DRAFT TOWER
- DRY TOWER
- WET / DRY TOWER

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SITE EVALUATION STUDY

RECIRCULATING CONDENSER COOLING WATER SYSTEM

integ – ebasco | FIGURE 4-A-2

can be characterized as either recirculating or once-through. A once through system is one in which the total water requirement for the condenser is pumped from the supply source through the condenser on a single pass basis and then discharged into the receiving water body. The heat sink for this type system is the receiving water body. In a recirculating cooling water system, an additional heat sink is utilized to lower the spent condenser cooling water's elevated temperatures to permit the reuse of the condenser cooling water. Recirculation can be accomplished by utilizing various heat dissipating systems which transfer the absorbed heat to the atmosphere primarily by evaporation. The heat dissipation systems usually considered for a recirculating cooling water system include: cooling ponds/lakes, spray ponds, and cooling towers.

a) Cooling Pond or lake is a reservoir of water having a sufficient surface area to permit natural heat dissipative mechanisms, (e.g., evaporation, wind induced conductive cooling, etc), to remove the heat loads imposed on the reservoir, from natural sources (solar radiation, infrared radiation from warmed air, etc.) and the power plant steam generator. The cooling of heated effluent in the pond usually results in an evaporative water loss of approximately 4.0 to 8.0 gpm/MW.

b) Spray Canal

In a spray canal, waste heat is dissipated to the atmosphere by sensible and latent (evaporative) heat transfer. The circulating water is cooled by spraying it into the ambient air via floating spray modules. The modules which are secured to concrete anchors alongside the canal generally consist of flat mounted pumps connected to spray heads. Design criteria for these systems vary considerably depending on spray head design and local meteorology.

c) Cooling Towers

Cooling Towers can be divided into two broad categories, wet cooling towers which effect cooling primarily by the direct evaporation of heated effluent, and dry cooling towers which effect cooling through the principle of sensible heat transfer, using air as the sole medium for heat dissipation.

All cooling towers depend on a continuous flow of air through or across a heat exchange device. In wet towers, the exchange device is the cooling tower packing and there is direct water-to-air heat exchange. In dry towers, the heat exchange device is a set of cooling coils over which the cooling air flow passes. The operation of the dry tower (referred to as an Air Cooled Heat Exchanger or ACHE) is analogous to the operation of an automobile radiator. In dry towers, the cooled water does not come into contact with the air.

Wet cooling towers can be also divided into two general categories; mechanical draft towers and natural draft towers. In a mechanical draft tower, the condenser discharge is pumped to the inlet distribution system at the top of the tower. The water cascades over the tower fill where the flow is broken up into smaller droplets, which come into contact with the cool ambient air flow. Evaporative heat loss (approximately 80%) and some sensible heat transfer (approximately 20%) occurs, thus cooling the water. The air flowing through the towers, due to the pressure differential caused by the induced draft fans, ultimately exhausts the heat and moisture-laden air to the atmosphere.

Mechanical draft cooling towers evaporate approximately 8.0 gpm (fossil) per megawatt (gross). Other water losses from a mechanical draft cooling tower include blowdown and drift. Drift is composed of water droplets carried over in the air stream from the turbulent contact zones inside the tower and is equal to approximately 0.005% of the circulating water flow. Blowdown will be discussed in a subsequent section.

For natural draft wet cooling towers, the basic principle of heat rejection is the same as for mechanical draft (wet) towers. The difference between the two is that instead of fans, the natural draft tower exploits the buoyancy difference between the cool outside ambient air and the warm, moist air within the tower to provide the "draft" or air flow. A typical natural draft tower measures approximately 400 ft. in diameter and 400-500 ft. in height. The great height of the tower is necessary in order to utilize the buoyancy difference and thus induce the "draft".

Natural draft wet cooling towers dissipate approximately 80 percent of the heat load via evaporation and 20 percent via sensible heat transfer. The typical evaporative water loss for natural draft towers similar to mechanical towers is approximately 8 gpm per megawatt of fossil capacity. Drift losses from natural draft towers are negligible, usually 0.001 percent of the circulating water flow. Blowdown losses constitute the only other water loss.

Dry cooling towers dissipate waste heat to the atmosphere by convection. There is no contact between the water to be cooled and the ambient air, thus, no evaporative water losses occur.

There are two alternative dry systems: direct and indirect types.

In the direct-type system, the turbine exhaust steam is carried away from the turbine in large ducts and distributed to cooling coil bundles, where it is condensed directly on the inside of air-cooled tubes. In the indirect-type system, the turbine exhaust steam is condensed directly under the turbine outlet. Recirculating water is sprayed into the condenser where it mixes with, and absorbs heat from, the exhaust steam as condensation occurs. Circulating water pumps recycle most of the heated condensate to the dry cooling tower and return the remaining condensate to the feed-water cycle.

d) Cooling System Blowdown

All of the "wet" recirculating condenser cooling water systems previously described require continuous blowdown to offset dederiorating water quality resulting from system evaporation.

A water quality parameter with considerable significance is total dissolved solids (TDS). As the TDS increases through recirculation and evaporation, the alkalinity also increases resulting in a pH increase of the recirculating cooling water. Precipitation and subsequent scaling of those chemical species (mainly calcium and magnesium), whose solubility product decreases with increasing pH and temperature, can occur.

Scaling of calcium and to a lesser degree magnesium is a problem in condenser cooling water system operation as it can cause deposition on the condenser tubes and decrease the heat transfer efficiency. To offset the problem, recirculating condenser cooling water is maintained at a constant pH (calculated from Langelier's Saturation Index) usually by the addition of sulfuric acid.

There are two general equations which describe the relationship and, therefore, the quantity of blowdown and consequently the makeup required in a recirculating condenser cooling water system once the evaporation is known. These are:

$$M = \frac{N}{N-1} (E - P - R) \quad \text{and}$$

$$\frac{M}{B} = N$$

where:

B = Blowdown Rate

M = Makeup Rate

E = Evaporation Rate

P = Precipitation

R = Rainfall Runoff

N = The number of cycles of concentration; the number of times a water quality parameter is concentrated.

It should be noted that precipitation and rainfall runoff only pertain to cooling ponds and spray canals where these values can present a significant input into the water balance.

Based on this discussion, recirculating condenser cooling water system blowdown water quality will essentially be makeup water quality concentrated a specific number of times. The exact value of N will depend on regulatory and operational considerations. Exceptions to this include pH, alkalinity, sulfates and chlorides whose concentrations are also governed by the addition of sulfuric acid and chlorine.

As previously stated, sulfuric acid is added to prevent scaling and/or corrosion in the system by maintaining recirculating condenser cooling water pH.

Chlorine is usually applied to the condenser inlet of all condenser cooling water systems and occasionally to the hot side of a cooling tower and to the intake structure and makeup supply line. This chemical addition is necessary to protect the condenser, makeup system and the tower distribution system and surfaces against excessive biological fouling (the increased temperatures of a condenser cooling water system and ample supply of nutrients increase biological reproduction rates). The exact quantity of both of these chemical additions is a function of the makeup supply source and site specific operational mode.

It should also be noted that the above discussion concerning blowdown does not apply to a dry cooling tower because no significant volumes of water are transferred between a dry tower and the environment.

A4-1.3.2 Solid Waste Disposal Systems

a) Fly Ash Systems

Combustion of coal in the furnace produces ash that can be divided into two fractions: fly ash and bottom ash. Fly ash constitutes that portion (usually 80 percent) of the total ash which exits the boiler combined with the flue gas.

In general there are two basic fly ash handling systems.

One is a pressurized pneumatic (dry) system and the other a hydraulic pneumatic (wet) system. The pressurized pneumatic system takes the fly ash from the precipitator hoppers into the pneumatic conveyor system via pressure feeders. The conveyor then transports the fly ash in an air stream to a storage silo adjacent to the disposal area. At the storage silo the fly ash is separated from the air. The silo is emptied by a dustless unloader before being loaded into carryalls. Water is used to prevent dusting during the unloading operation. The carryalls then transport the mixture to the storage area for disposal. Bulldozers are used to distribute the ash over the area. To minimize dust problems a rather elaborate water spray system is required.

The hydraulic-pneumatic fly ash handling system combines a vacuum system with a hydraulic sluicing system. The vacuum pneumatic system transports fly ash from the precipitator hoppers to the inlet of a water-jet exhauster. A vacuum is developed by the exhauster. The fly ash and conveying air mix with water in the inlet section of the exhauster and then this mixture enters an air separator. The air is separated from the mixture at this point. The ash slurry (usually 5 to 10 percent solids by weight) is then pumped on an intermittent basis from the separator to the disposal area. The water serves three functions in this system: transporting the ash to the pond, distributing the ash in the pond, and keeping the ash wet to prevent dusting.

b) Bottom Ash System

Bottom ash constitutes that portion (usually 20 percent) of the coal combustion products (solid inorganic residue) that falls to the lower section of the furnace and is collected in bottom ash hoppers located below the boiler.

Once in the hoppers the ash is quenched and then undergoes mechanical grinding to produce particles small enough for water sluicing. The ash is then hydraulically sluiced, usually at a 5 to 10 percent solids content, to an on-site disposal pond. While some modifications to the basic system exist, the process outlined above is generally utilized at all coal-fired thermal generating stations.

c) Ash Sluicing Wastewater

In both bottom ash and fly ash hydraulic disposal, on-site ponding and sluicing system operation can occur in three general modes: a once-through system, an open loop system and a closed loop system. These techniques refer to various degrees of ash pond supernatant reuse. In a once-through system, water is withdrawn from the makeup supply source as needed for a sluicing event, discharged with the ash to a pond and the subsequent supernatant is then allowed to overflow from the pond to the receiving water body without any reuse. In an open loop system, pond supernatant is reused for sluicing in various degrees depending upon supernatant water quality. This type of operation incorporates a makeup to offset system losses such as pond evaporation, seepage, and water lost to the solids, i.e., water bound in the void volume of the ash and unable to be recycled. A blowdown to maintain recirculating water quality is also used similar to a recirculating condenser cooling water system.

In a closed loop operation, substantial chemical treatment of sluicewater is employed to eliminate the need of a blowdown. Makeup, however, is still required to offset system losses.

Deterioration of sluicewater quality is due to the fact that hydraulic sluicing of both bottom and fly ash causes a fraction of the chemical constituents of the ash to dissolve into solution and increase sluice water TDS. In general, fly ash chemical constituents dissolve more readily than that of bottom ash due to the physical characteristics of the ash itself. Therefore, the actual amount of sluicewater reuse is dependent upon the chemical composition of the ash and the amount of chemical leaching. Blowdown water quality is usually typified by high TDS concentrations and in particular, metal ions which naturally occur in the coal and suspended solids due to unsettleable ash particles.

It should be noted that the use of a pressurized pneumatic (dry) ash transport system does not eliminate a wastewater discharge. Water utilized for ash wetting to prevent dusting problems, precipitation and rainfall runoff contribute to seepage and overland drainage discharges with similar water quality characteristics as actual sluicewater.

A4-1.3.3 Process and Plant Service Water

Other plant water users such as potable water, boiler makeup, heating, ventilating and air conditioning, etc., require a water quality exceeding that of the water supply source and must, therefore, undergo treatment prior to use (see Figure 4-A-3).

a) Pretreatment

These waters are usually subject to pretreatment consisting of coagulation-sedimentation and gravity filtration for the removal of suspended solids and organics. Coagulation, usually the addition of aluminum sulfate and/or lime, and sedimentation can be combined in a single coagulator/clarifier. Effluent from this clarifier then undergoes gravity filtration (sand filters usually followed in series by carbon filters). The effluent from these processes is then separated into steam cycle supply and potable water. Potable water undergoes chlorination before entering the plant's distribution system.

b) Ion Exchange

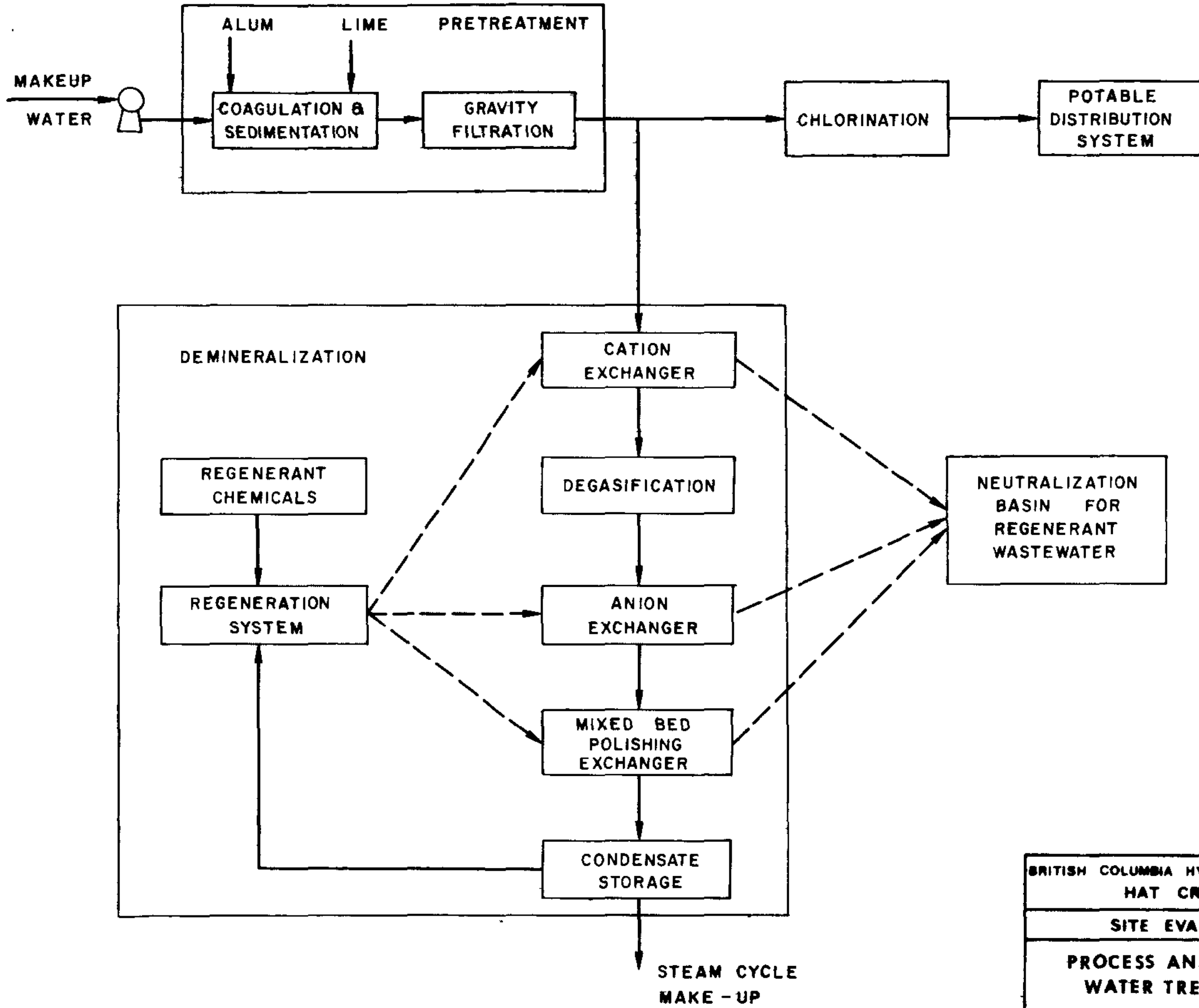
Following pretreatment, steam cycle makeup undergoes demineralization for dissolved solids removal. The demineralization process usually consists of cation exchange, degasification, anion exchange, and polishing demineralization. In these processes, hydrogen ions (H^+) and hydroxide ions (OH^-) are exchanged with the naturally occurring cations and anions of the makeup water. This water is then stored for subsequent steam generation (see Figures 4-A-1 and 4-A-3).

c) Major Wastewater Components

Process and plant service waters generate the following major wastewater discharges: demineralizer regeneration, boiler blowdown, sanitary wastewater and plant and floor drainage. Demineralizer regeneration is usually accomplished by the application of sulfuric acid and sodium hydroxide solutions to the demineralizer beds which liberates the cations and anions originally removed from the process water. Wastewater quality can, therefore, be characterized as makeup water concentrated 3 to 10 times (N = M/B) depending on makeup water quality and subsequent bed regeneration requirements.

Boiler blowdown is characteristically alkaline in nature with the pH ranging from 8.8 to 10.0. TDS concentrations are generally low, less than 100 mg/l for high pressure boilers. Parameters of concern include phosphates which are used as a buffering system (5-50 mg/l) and heavy metals which result from boiler corrosion. The quantity of blowdown generally ranges from 0 to 4 gallons per 1000 pounds of steam produced.

The main contaminants of untreated sewage generated from the use of potable water include: suspended solids (300 mg/l), biochemical oxygen demand (200 mg/l), ammonia-nitrogen (25 mg/l) and phosphorus (10 mg/l). The flow of this wastewater is generally estimated at 50 gallons per capita per day.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

PROCESS AND PLANT SERVICES WATER TREATMENT SYSTEM

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FIGURE 4-A-3

Each thermal generating station is designed with a floor drainage system which receives plant washdown, i.e., housekeeping wastewaters.

The main contaminants that can be expected in floor drainage are suspended solids and oil and grease. Floor drainage will typically have a pH of approximately 6 to 8, a suspended solids concentration ranging from 200 to 400 ppm and oil and grease concentrations ranging from 100 to 500 ppm. Total average daily flow from these drains and sumps is usually estimated to be 100 gpm.

Another potential major wastewater source that is, however, not directly related to a plant water user is coal pile runoff.

Rain falling on a coal storage area will cause coal fines to be washed out with the runoff and will result in the leaching of coal constituents, mainly metals, into solution.

Runoff pH can be expected to be acidic due to the formation of sulfuric acid (H_2SO_4) which results from the biological oxidation of sulfide to sulfite and sulfate, the pH depression from the accompanying hydrogen ion release. The amount of leaching is extremely variable and is dependent upon rainfall intensity duration and sulfur content of the coal. The expected pH depression will not persist beyond the initial phase of runoff through the pile as most of the fines and solids which readily dissolve into solution will be quickly removed.

5. TERRESTRIAL ECOLOGY

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5.1 SUMMARY

A 2,000 MW Thermal-Electric Generating Station burning Hat Creek coal is proposed for southwestern British Columbia. The purpose of this study is to assess the potential effects of this plant on the terrestrial ecology of eight alternative sites, and to select a preferred site for the development of the plant.

The terrestrial ecology of the selected sites was evaluated in terms of four criteria, habitat diversity, breeding birds and mammals, land capability for waterfowl production, and land capability for ungulate production. Quantitative values for each of these criteria were determined, and each site ranked according to the importance of each criterion. In addition, the criteria were ranked for each site according to their relative importance. A concensus decision analysis methodology was utilized to develop a composite ranking of sites according to the importance of terrestrial ecology considerations. It was assumed that the greater the importance of a criterion for a site, the greater would be the impact from the development of a power generating station. Therefore, the most preferred site(s) for the development of such a plant were those site(s) where terrestrial ecology was least important. Ashcroft, Britannia Beach, and Stave Lake were selected as the most preferred sites for the development of a power plant, while Big Bar Creek and Soda Creek were selected as the least preferred. The remaining sites, Harry Lake, Dunsmuir and Mine Mouth were intermediate between these two groups.

5.2 INTRODUCTION

Construction and operation of a thermal generating station could affect the terrestrial ecology of an area in various ways (including changes in land use, increased human activity and stack gas emissions). This chapter presents the results of investigations and analyses conducted on eight sites in southwestern British Columbia, which are under consideration for location of a 2000 MW Thermal Generating Station. In addition, a preliminary assessment of the potential effects on the terrestrial ecology of the area is presented.

5.2.1 Purpose

This study compares important terrestrial ecology features of eight sites in terms of their potential compatibility or conflict with a thermal generating station. These concerns are utilized to establish a ranking of the sites in order of preference, and to select a preferred site, from the viewpoint of the terrestrial ecology discipline. The results of this study are used in the overall multidisciplinary Site Evaluation Study.

5.2.2 Scope

In order to evaluate terrestrial ecology considerations and to make recommendations as to which site development would have the least impact from this disciplinary viewpoint, information was gathered on a regional and site specific basis.

The scope of work includes:

a) Identification of the location, composition and structure of habitats and wildlife resources of each site.

b) Definition and selection of terrestrial considerations to be used as quantitative and qualitative criteria in evaluating each site.

c) Determination of quantitative values for each criterion at each site.

d) Evaluation of the relative importance of each criterion at each site.

e) Qualitative ranking of sites by each criterion.

f) Utilization of all of these factors to determine site ranking and selection of a preferred site from a terrestrial ecology standpoint.

g) Utilization of all of these factors as input into the multidisciplinary site evaluation study.

5.3 MATERIALS AND METHODS

5.3.1 Data Base

The data used in the evaluation of the terrestrial ecology of the study sites were obtained from the available literature; primarily publications by Banfield[1] and Goldfrey[2], and appropriate Canada Land Inventory maps[3]. Information was also extracted from reports submitted to the B. C. Hydro and Power Authority by Sandwell and Company Limited[4], and B. C. Research, Dolmage Campbell and Associates Ltd.[5] Additional information was obtained during a field reconnaissance of each site and from discussions with knowledgeable professionals of the Canadian Wildlife Service of Environment Canada, and the Fish and Wildlife Branch of the Recreation Department of British Columbia. The physical characteristics of a thermal generating station conceptually designed for each site were also used in the evaluation.

5.3.2 Methodology

In order to differentiate between the eight alternative sites, the terrestrial ecology considerations were translated into quantitative criteria which are described in Section 5.3.3. Aspects which account for nonquantifiable regional and site specific considerations, modified each criterion. These criteria were applied to every site, and ranked according to their relative importance at each site. A similar evaluation, or ordering, by criteria across the sites was then performed using the "forced decision method". This resulted in an ordering of "most preferred" to "least preferred" sites for each criterion. An examination of these two orderings, the quantitative values for the evaluation criteria at each site and input from the overall site-selection analysis described in Chapter One, led to the final ranking of sites based upon terrestrial ecology preferences.

5.3.3 Site Evaluation Criteria

5.3.3.1 Selection of Site Evaluation Criteria

Various impacts on the terrestrial ecology of a site occur during the development of a power plant. The source of these impacts include stack gas emissions, increased noise and human activity, and the loss or change of habitat. However, the importance of the impacts depends on the receptors (that is, the resources at the site). Impacts may be of two types, near-field and far-field. Near-field impacts are the more site specific (thus, site-differentiating) because they occur in the vicinity of the plant island. Near-field impacts are more concentrated, and are more easily quantified in terms of the resources affected. Far-field impacts are less site specific (therefore, less differentiating) because they occur away from the vicinity of the plant island. Far-field effects are less concentrated, and are less easily quantified in terms of resources affected.

In this study, selected criteria were evaluated both quantitatively and qualitatively. These evaluations were used to differentiate one site from another.

Site differentiation criteria selected for use in this study were habitat diversity, breeding birds and mammal diversity, land capability for the production of waterfowl, and land capability for the production of ungulates.

The two indicators of diversity (breeding birds and mammals) are important because diversity has been shown to be a measure of perturbational effects (such as pollution or single-component management by man). For example, one population may respond positively to a perturbation, while others may not. Thus, some populations are selectively removed and the diversity is reduced. Diversity is also an accepted indicator of ecosystem organization and the capacity of an ecosystem to support life. The diversity criteria used in this study in a broad way, assess the diversity of the plants and animals at each site. The importance of habitat and the number of unique or threatened species at each site are also considered in these criteria.

The two land capability criteria were selected because of the importance of hunting and nature tourism in British Columbia.

5.3.3.2 Habitat Diversity

This criterion is used to evaluate the diversity at each of the sites with regards to habitat. The type of habitat, as well as the diversity within different habitats are of equal importance. For example, an area with trees, understory vegetation and cultivated crops is considered to be more valuable than an area with any one of the three alone.

Data concerning relative habitat abundance were obtained from land use maps for each of the sites. A radial distance of one mile from the boundary of the plant island and ash ponds was used as a limit.

The index of habitat diversity (H) used in this study was the Shannon Index[6], where $H = -\sum P_i \log_e P_i$. The probability function (P_i) is the ratio for each of the parts to the whole. An increase in the value of H, is indicative of greater habitat diversity, or a reduction in the domination by one or a few kinds of habitat.

The sites were qualitatively ranked for habitat diversity using the following categories: the presence or absence of signficant amounts of built-up areas at each site, a high or low number of breeding birds and mammals potentially occurring at each site, and the potential diversity (low, medium or high) of plant species for the predominant vegetational types (grassland, forest or mixed grassland-forest).

5.3.3.3 Breeding Birds and Mammals

This criterion was used to evaluate the potential occurrence of breeding birds and mammals at each of the sites. An index of the potential occurrence of breeding birds and mammals at each site was calculated on the basis of the best available range maps of bird species[3] and mammals[2] of British Columbia. Information was also recorded during field reconnaissance of each site and in meetings with Fish and Wildlife Branch employees. Residents in the vicinity of each site provided useful information on the occurrence and estimated abundance of important game species.

The breeding bird and mammal index was calculated by first assigning each species the value of 1.0. This value was then distributed equally among the sites at which the range maps indicated the species might occur. Finally, the values were summed for each site. This technique produced an index such that a higher value indicates the presence of more unique species and/or a larger total species count.

The sites were ranked qualitatively for this criterion by considering the presence or absence of a selected group of species of interest. Currently, there is no officially recognized list of rare or endangered species. Thus, a working list of such species was compiled from the literature and conversations with officials of the Canadian Wildlife Service and the Fish and Wildlife Branch.

5.3.3.4 Land Capability for Waterfowl

This criterion was used in the evaluation of land capability for waterfowl production at each site. It was based on the Canada Land Inventory system. Physiographic characteristics important to waterfowl populations were used to divide the land into seven classes. Lands in Class 1 have no substantial limitations to the production of waterfowl, while lands in Class 7 have such severe limitations that waterfowl production is minimal.

The appropriate map for each of the sites was examined, and the percentage of each class of land within a one mile radial distance of each site was calculated.

Two important qualitative modifiers of this criterion were the best capability class represented and the location of migratory routes.

5.3.3.5 Land Capability for Ungulates

This criterion was utilized to evaluate the land capability for wild ungulate production at each site. It was based on the Canada Land Inventory system. Physiographic characteristics important to wild ungulate populations were used to divide the land into seven classes. Lands in Class 1 have no significant limitations to the production of ungulates, while lands in Class 7 have such severe limitations that there is no ungulate production.

The appropriate map for each of the sites was examined and the percentage of each class of land within a one mile radial distance of each site was calculated.

The sites were ranked qualitatively for this criterion by considering the best capability class represented, the use of land for winter range, and the presence of unique ungulate species.

5.4 RESULTS

5.4.1 Results of Quantitative Criteria Value Determinations

The results of the quantification of values for the four evaluation criteria are presented in Tables 5-1 through 5-4. The land use within a radial distance of one mile from the plant island and ash ponds of each site is summarized in Table 5-1. The table also presents the habitat diversity index (H) for each site. As indicated, the Soda Creek site has the highest habitat diversity and the Ashcroft site has the lowest habitat diversity.

The values for the breeding birds and mammal index at each site are listed in Table 5-2. It is evident that the Soda Creek site has the highest potential for breeding birds and mammals, while the Dunsmuir site has the lowest.

The results of the quantitative site evaluation of land capability for waterfowl are presented in Table 5-3. The sites at Dunsmuir, Mine Mouth and Harry Lake have capability Class 3 lands which is the best capability class found at any of the sites. All other sites have capability classes ranging from 4 to 7 lands, and are not considered to be as important for the production of waterfowl.

TABLE 5-1

SUMMARY OF LAND USE WITHIN ONE MILE OF PLANT ISLAND AT EACH SITE

Site	CLI Category	Approximate Acres	Percent of Total	Habitat Diversity
Dunsmuir	T_1	1,170	14.3	
	T_2	6,526	79.7	
	P_1	26	.2	
	B	234	2.9	
	Other	234	2.9	
	Total	8,190	100.0	0.6768
Britannia Beach	T_1	260	12.4	
	T_2	1,352	64.2	
	B	182	8.6	
	Other	312	14.8	
	Total	2,106	100.0	1.0371
Stave Lake	T_1	2,106	24.0	
	T_2	4,446	50.4	
	P_1	26	.3	
	B	52	.6	
	Other	2,184	24.7	
	Total	8,814	100.0	1.0813
Ashcroft	T_1K	0	.0	
	T_2K	572	5.6	
	P_1	754	7.4	
	Other	8,814	87.0	
	Total	10,140	100.0	0.4753
Mine Mouth	T_1K	832	13.1	
	T_2K	3,588	56.7	
	Other	1,910	30.2	
	Total	6,330	100.0	0.9496

.../

TABLE 5-1 (Continued)

SUMMARY OF LAND USE WITHIN ONE MILE OF PLANT ISLAND AT EACH SITE

Site	CLI Category	Approximate Acres	Percent of Total	Habitat Diversity
Harry Lake	T_1K	1,196	12.1	
	T_2K**	3,900	39.5	
	Other	4,786	48.4	
	Total	9,882	100.0	0.9736
Big Bar Creek	T_1K	2,444	27.2	
	T_2K	624	7.0	
	P_1	26	.3	
	B	26	.3	
	Other	5,850	65.2	
	Total	8,970	100.0	0.8539
Soda Creek	T_1K	3,978	42.7	
	T_2K	2,106	22.6	
	P_1	52	.6	
	B	52	.6	
	Other	3,120	33.5	
	Total	9,308	100.0	1.1273

Key: T_1 = Mature productive woodland

T_2 = Immature productive woodland

T_1K = Mature productive woodland and open grassland

T_2K = Immature productive woodland and open grassland

P_1 = 75.0 - 94.9% improved pasture and forage crops

B = Built-up areas

Other = Open grassland, non-productive woodland, sandflats, swamp, rock, water.

** Primarily Open Grassland

TABLE 5-2

BREEDING BIRD AND MAMMAL INDEX

Site	Bird	Mammal	Total
Dunsmuir	23.3	4.5	27.8
Britannia Beach	22.7	13.9	36.6
Stave Lake	22.4	16.6	39.0
Ashcroft	23.0	7.3	30.3
Mine Mouth	23.0	7.3	30.3
Harry Lake	23.0	7.3	30.3
Big Bar Creek	23.3	7.1	30.4
Soda Creek	30.3	10.1	40.4

TABLE 5-3

LAND CAPABILITY FOR WATERFOWL

Site	Capability Class	Percentage
Dunsmuir	7	63.46
	3 M*	36.54
Britannia Beach	7	100.00
Stave Lake	7	50.00
	6	50.00
Ashcroft	7	100.00
Mine Mouth	7	90.38
	4	5.77
	3	3.85
Harry Lake	7	90.40
	3	9.60
Big Bar Creek	7	100.00
Soda Creek	7	88.46
	6	7.70
	5	3.84

M* - Lands used as wintering areas or migratory routes.

The results of the quantitative site evaluation of land capability for ungulates is presented in Table 5-4. The Soda Creek site has capability Class 2 land and is considered to be the most important, while Dunsmuir, Ashcroft, Mine Mouth, and Big Bar Creek sites have capability Class 3 lands. The remaining sites have capability classes ranging from 4 to 7 lands.

5.4.2 Qualitative Ranking of Sites by Criterion

The qualitative ranking of the sites for each criterion is presented in Table 5-5. The "forced decision" methodology was utilized to rank each site on the basis of impact importance for each criterion.

Qualitatively, there is no significant difference in habitat diversity among the Mine Mouth, Harry Lake, Big Bar Creek and Soda Creek sites. These sites are considered to have the greatest habitat diversity, while the site at Dunsmuir is considered to have the poorest habitat diversity.

The importance of breeding birds and mammals is considered to be highest at the Soda Creek and Big Bar Creek sites, and to be lowest at Dunsmuir.

As indicated in Table 5-5, the land capability for ungulates is most important at the Soda Creek site, and least important at the Britannia Beach and Stave Lake sites.

TABLE 5-4

LAND CAPABILITY FOR UNGULATES

Site	Capability Class	Percentage
Dunsmuir	3	100.00
Britannia Beach	4	73.40
	5	26.60
Stave Lake	4	88.64
	7	11.36
Ashcroft	6	57.69
	3	36.54
	4	5.77
Mine Mouth	4	50.00
	4,3W*	32.69
	3	17.31
Harry Lake	4	100.00
Big Bar Creek	4	50.00
	3W*	50.00
Soda Creek	3	73.08
	2W*	15.38
	4	7.69
	3W*	3.85

W* - Lands that are winter ranges on which animals from surrounding areas depend.

TABLE 5-5

IMPORTANCE OF CRITERIA AMONG SITES

Criteria	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
↑ Habitat Diversity	HD	HD	HD	HD	HD	HD	HD	HD
↑ Breeding Birds and Mammals	BB	BB	BB	BB	BB	BB	BB	BB
↑ Land Capability for Waterfowl	WF	WF	WF	WF	WF	WF	WF	WF
↑ Land Capability for Ungulates	U	U	U	U	U	U	U	U

Arrow indicates increasing importance.

5.4.3 Qualitative Ranking of Criteria at Each Site

The "forced decision" methodology was used to identify the relative importance of the four evaluation criteria at a particular site. The results of the application of this methodology are summarized in Table 5-6 and have been used in the concensus decision analysis discussed in Chapter 1. In the table, the most important criterion has been assigned a value of 1 and the least important a value of 4.

In order to facilitate interpretation of the data presented in Table 5-6, the following examples are given:

> Example 1: At Dunsmuir, breeding birds and mammals has been determined to be the most important criterion from the terrestrial ecology viewpoint, whereas habitat diversity has been determined to be least important.
>
> Example 2: At Soda Creek, breeding birds and mammals has been determined to be the most important criterion whereas land capability for waterfowl has been determined to be the least important terrestrial ecology criterion.

5.4.4 Composite Ranking

The results obtained when the quantitative values for each criterion, the ranking of criteria by site, and the ranking of sites by criterion are combined using the consensus decision analysis are presented in Table 5-7. The sites with the most potential importance from the terrestrial ecology viewpoint are Soda Creek and Big Bar Creek; while the sites with the least terrestrial ecology importance are Ashcroft, Britannia Beach and Stave Lake.

TABLE 5-6

RELATIVE IMPORTANCE OF EVALUATION CRITERIA AT EACH SITE

Criteria/Site	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Breeding Birds and Mammals	1	1	1	1	1	1	1	1
Habitat Diversity	4	2	2	3	2	2	2	2
Land Capabilities for Waterfowl	2	3	3	4	4	3	4	4
Land Capabilities for Ungulates	3	3	3	2	3	4	3	3

Key - 1 = most important
5 = least important

TABLE 5-7

COMPOSITE RANKING OF TERRESTRIAL ECOLOGY IMPORTANCE BY SITE

Importance	Site
Most:	Soda Creek
	Big Bar Creek
Intermediate:	Mine Mouth
	Dunsmuir
	Harry Lake
Least:	Stave Lake
	Britannia Beach
	Ashcroft

5.5 DISCUSSION AND CONCLUSIONS

5.5.1 Ecosystem Analysis

In general, it is necessary to obtain information about the structure, function and evolution of an ecosystem to completely understand it. However, first-order conclusions may usually be formulated from information on the structural attributes of the ecosystem. These attributes include the location of the ecosystem, its components and diversity. Since these attributes would be impacted by the development of a thermal generating station, evaluation criteria were selected which would facilitate the retrieval and review of information regarding these attributes at the alternative sites.

5.5.2 Study Area

The eight sites selected for study are located in the southwestern part of British Columbia (Figure 5-1). Krojina[8] and others have described the ecology of this part of British Columbia. The study area contains the province's largest city, Vancouver, where about one-half of the provincial population lives. Each of the sites is located in one of the three vegetation regions of Canada (Figure 5-1) as defined by Rowe[9]. It is convenient to discuss the regional terrestrial ecology characteristics of the study area using these vegetation regions.

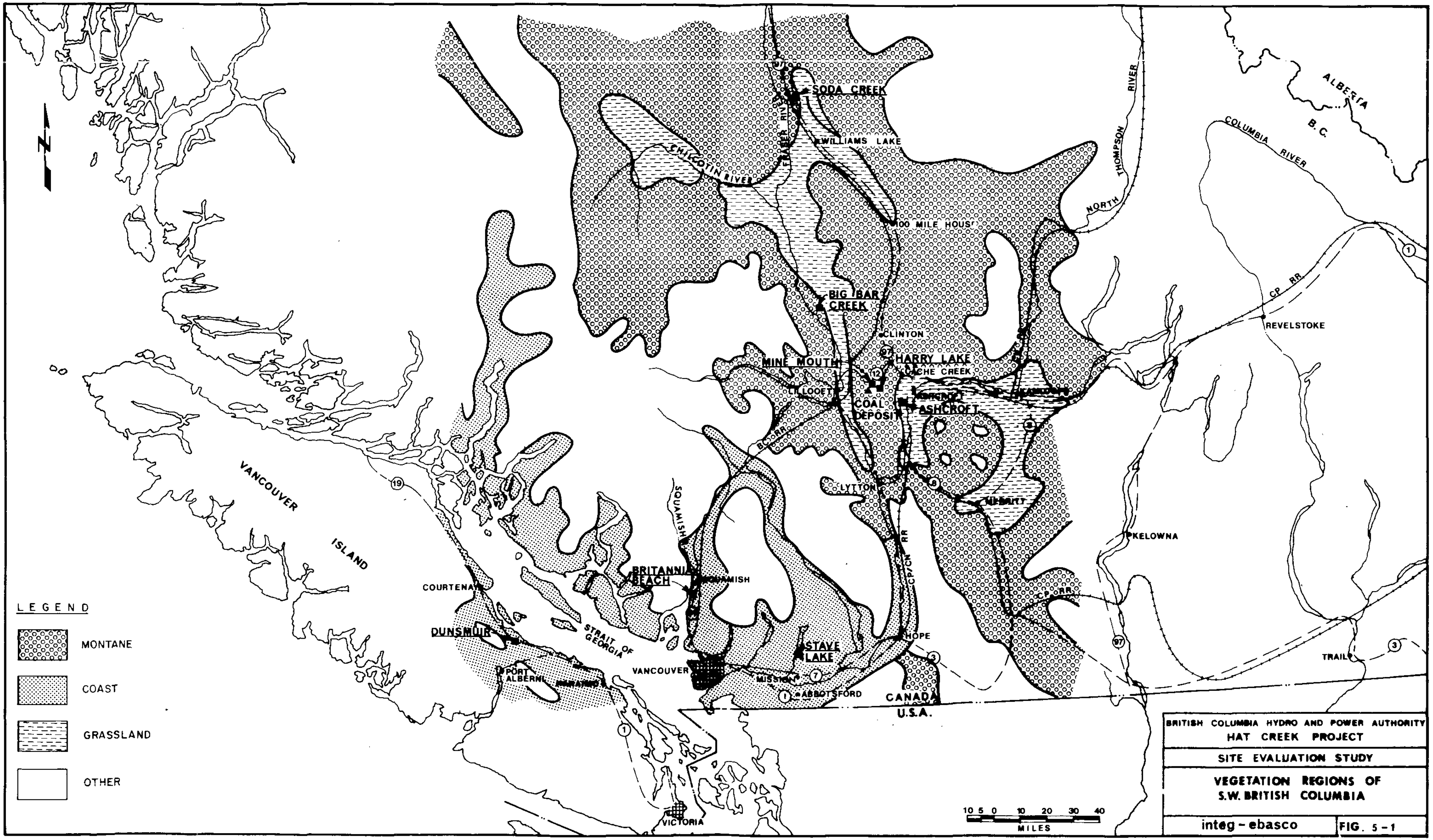
5.5.2.1 Coast Forest Region

The sites at Dunsmuir, Britannia Beach, and Stave Lake are located within this region. An excellent review of the ecology of this region is presented by Shefford[10]. Coast Douglas fir (Pseudotsuga menziesii) is the dominant tree at the Dunsmuir site. Two tree species not found elsewhere in Canada occur in this region. These are the arbutus (Arbutus menziesii) and the garry oak (Quercus garriyana). Other common species of trees found in the region are western hemlock (Tsuga heterophylla), western cedar (Thuja plicata), black cottonwood (Populus trichocarpa), red alder (Alnus rubra) and bigleaf maple (Acer macrophyllum). The climate of the region is summer-dry maritime, but considerable local variation occurs in response to altitudinal effects.

Waterbirds are numerous in this region and many mammalian species are represented by distinctive subspecies[11].

5.5.2.2 Montane Forest Region

Four of the eight sites, Mine Mouth, Harry Lake, Big Bar Creek, and Soda Creek, occur within the montane forest region. Douglas fir (Psendotsuga menziesii var. glanca) is the characteristic tree of this zone. This variety is different from that found growing along the coast, and is often referred to as the variety glanca. Other tree species, such as lodgepole pine (Pinus contorta), ponderosa pine (Pinus ponderosa), and trembling aspen (Populus tremuloides), have increased in abundance within this zone, primarily from disturbances associated with fire and logging.


LEGEND
MONTANE
COAST
GRASSLAND
OTHER
SODA CREEK
WILLIAMS LAKE
CHILCOTIN RIVER
FRASER RIVER
100 MILE HOUSE
BIG BAR CREEK
CLINTON
HARRY LAKE
MINE MOUTH
CACHE CREEK
LILLOOET
COAL DEPOSIT
ASHCROFT
LYTTON
MERRITT
NORTH THOMPSON RIVER
COLUMBIA RIVER
ALBERTA
B.C.
CP RR
CP/CN RR
REVELSTOKE
KELOWNA
TRAIL
VANCOUVER ISLAND
STRAIT OF GEORGIA
COURTENAY
DUNSMUIR
PORT ALBERNI
NANAIMO
BRITANNIA BEACH
SQUAMISH
VANCOUVER
STAVE LAKE
MISSION
ABBOTSFORD
HOPE
CANADA
U.S.A.
VICTORIA
MILES
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
VEGETATION REGIONS OF S.W. BRITISH COLUMBIA
integ - ebasco
FIG. 5-1

Vertical gradients in precipitation and temperature have resulted in a distinct altitudinal zonation of vegetation in this region[12]. A steppe vegetation zone which is dominated by bluebunch wheat-grass (Agropyron spicatum) can be found along the lower slopes and at the lowest levels in the river valleys. A zone of open parkland, where Pinus ponderosa and ground cover typical of steppe vegetation predominate, is found further up the slopes. This parkland grades into the Douglas fir zone at higher levels. The climax forest at these higher levels is characterized by a moderately closed canopy of Douglas fir. The ground cover of this zone is dominated by typical forest species. The cooler and wetter ridges of the Douglas fir zone are commonly invaded by species from the sub-alpine forest region, including Engelman spruce (Picea engelmannii), white spruce (Picea glanca) and alpine fir (Abies lasiocarpa).

5.5.2.3 Grassland

The Ashcroft site is located within the grassland region of British Columbia. The climatic conditions of this region are too warm and dry to support coniferous forests. The ecology of this region has been thoroughly studied and reported in the literature[13, 14]. The region is characterized and dominated by Agropyron spicatum. Sagebrush (Artemisia tridentata) and other species of semi-desert shrubs are common, especially in areas which have been overgrazed.

5.5.3 Site Descriptions

5.5.3.1 Dunsmuir

The Dunsmuir site is located on the eastern coast of Vancouver Island, approximately 15 miles northeast of Port Alberni. The site is relatively flat with a slight east-facing slope. The vegetation consists primarily of second growth Douglas fir (Pseudotsuga menziesii) forest. The Douglas fir stands are evenly aged and continuous throughout the site. The forest canopy is well developed and as a result, the undergrowth remains sparse. Red alder (Alnus rubra), salal (Gaultheria shallon), Oregon grape (Mahonia nervosa) and sword fern (Polystrichum munitum) are some other plant species characteristic to the area.

5.5.3.2 Britannia Beach

The Britannia Beach site is located about 25 miles north of Vancouver on Howe Sound. The elevation of the site is near sea level and the topography relatively flat. However, the terrain behind the site rises steeply into the Coast Range. Much of the land within the site area is part of an abandoned rock and gravel quarry. The area is barren of vegetation as a result of the quarrying activities. Forests surrounding the site are relatively young and predominately second growth, due to past logging activities. The common plant species found in the vegetated areas surrounding the site include: Douglas fir (Pseudotsuga menziesii), western red cedar (Thuja plicata), red alder (Alnus rubra), salmonberry (Rubus spectabilis) and salal (Gaultheria shallon).

5.5.3.3 Stave Lake

Stave Lake is a hydroelectric impoundment operated by B. C. Hydro and Power Authority. The site is located about 35 miles east of Vancouver near the Fraser River Valley. The site is relatively flat except in the southern sector where the land rises steeply. The shoreline around the lake is characterized by a steep rise in elevation.

The prominant features of the site include: coniferous forest, the lake, and surrounding hills. The area has been logged in the past and the second growth forest is nearing harvestable size.

The dominant vegetational type is coniferous forest, although patches of deciduous forest are found along the lake shoreline. The common species include Douglas fir (*Pseudotsuga menziesii*), red cedar (*Thuja plicata*), red alder (*Alnus rubra*), broadleaf maple (*Acer macrophyllum*) and willows (*Salix spp*).

5.5.3.4 Ashcroft

The Ashcroft site is located on the west bank of the Thompson River about six miles south of Ashcroft. The site is located on a bench above the river. The bench is relatively flat with a gentle slope towards the river. A portion of the site area is presently being used for cattle grazing. Alfalfa is also grown in irrigated portions of the site. The vegetation of the area is characteristic of open grasslands. The dominant species include: bluebunch wheatgrass (*Agropyron spicatum*), Kentucky bluegrass (*Poa pratensis*), and needle-and-thread (*Stipa comata*). Sagebrush (*Artemisia tridentata*) and downey brome (*Bromus tectorum*) are abundant in overgrazed areas. Ponderosa pine (*Pinus ponderosa*) occurs on the site, but the individuals are widely scattered and not of harvestable size.

5.5.3.5 Mine Mouth

The Mine Mouth site is located approximately 13 miles west of Cache Creek, near the mouth of the Hat Creek Valley. The site is relatively flat. The vegetation of this site is characterized as a mixture of second-growth coniferous forest and open rangeland. Deciduous species are found along the banks of Hat Creek and several of the smaller tributary creeks. Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), willows (Salix spp.), trembling aspen (Populus tremuloides), black cottonwood (Populus trichocarpa), bluebunch wheatgrass (Agropyron spicatum) and sagebrush (Artemisia tridentata) are the plant species common to the site. The Douglas fir and ponderosa pine trees are currently being harvested via selective logging techniques.

5.5.3.6 Harry Lake

The Harry Lake site is located on a bench above the east side of Hat Creek Valley. The vegetation is principally composed of Douglas fir and ponderosa pine associated with bunchgrass. Several large meadow areas are present on the site. In addition, slash and other remnants of selective logging operations are evident. Patches of trembling aspen are found along small drainages and on moist slopes. Trembling aspen (Populus tremuloides), willow (Salix spp.) and black cottonwood (Populus triehocarpa) are found in isolated patches along Medicine Creek, which drains the southern portion of the site.

5.5.3.7 Big Bar Creek

The Big Bar Creek site is located on the east bank of the Fraser River about 25 miles northwest of Clinton. The site is situated on a plateau above the river, and has a slight southern exposure. The vegetation is composed primarily of Douglas fir (Pseudotsuga menziesii) and bluebunch wheatgrass (Agropyron spicatum). The other plant species which are commonly found in the area are june grass (Kolleria cristata), ponderosa pine (Pinus ponderosa), lodgepole pine (Pinus contorta var.

latifolia) and trembling aspen (Populus tremuloides). Extensive upland meadows are also found within the borders of the site. The meadows are primarily used to graze cattle. The timber found on the site is of commercial size and some has been removed recently by selective logging. The area is reported to be utilized as habitat by mule deer and California bighorn sheep.

5.5.3.8 Soda Creek

The Soda Creek site is located approximately 20 miles north of Williams Lake on a plateau adjacent to the east bank of the Fraser River. The site has been logged in the past and is presently being selectively logged. A small amount of irrigated cropland exists along the lower terraces west of the Fraser River. The forested land is also used to graze cattle.

Two types of vegetational associations, a second growth forest-grassland and a closed canopy Douglas fir (Pseudotsuga menziesii) forest are found on this site. Lodgepole pine (Pinus contorta var. latifolia) is abundant in the second growth forest-grassland association. The grassland is composed primarily of bluebunch wheatgrass (Agropyron spicatum).

5.5.4 Evaluation Criteria

5.5.4.1 Habitat Diversity

This criterion was chosen because it gives an indication of the stability of the terrestrial ecosystem at each site. In general, a high diversity value is indicative of greater stability.

Since the major impact of a thermal generating station on the terrestrial ecology would result in the removal or alteration of habitat, it was concluded that the greatest impact would occur at those sites with the highest habitat diversity. It was also concluded that the greatest impact would occur at those sites where the habitat diversity was of significant importance.

The importance of habitat diversity at each site was determined by considering three factors: potential plant diversity, potential breeding bird and mammal diversity, and amount of existing built-up areas. Potential plant diversity of the predominant vegetation at each site was rated as low, medium or high for grassland, forest, mixed forest-grassland, or respectively. Breeding birds and mammal diversity was determined by the potential number of species occurring at each site. The extent of built-up areas at each site was evaluated as high, if greater than 1 per cent, or low if less than 1 per cent.

The qualitative ratings for these factors at each site are listed in Table 5-8. These data were used to determine the relative importance of habitat diversity, as well as the relative importance of this criterion at each site.

5.5.4.2 Breeding Birds and Mammals

An index of breeding birds and mammals potentially occurring at each of the sites was determined as discussed in Section 5.3.3.2. A high index value for a particular site is indicative that significant impacts would occur should a thermal generating station be developed on that site. The importance of this criterion at each site was evaluated by summing the number of "species of interest" that can potentially

TABLE 5-8

IMPORTANCE OF HABITAT DIVERSITY

Site	Potential Plant Diversity	Potential Breeding Birds and Mammals Diversity	Built-Up Area
Dunsmuir	Medium	Low	Low
Britannia Beach	Medium	High	Low
Stave Lake	Medium	High	High
Ashcroft	Low	High	High
Mine Mouth	High	High	High
Harry Lake	High	High	High
Big Bar Creek	High	High	High
Soda Creek	High	High	High

occur at each site (the higher the number, the greater the importance). A list of these species and the numbers potentially occurring at each site is listed in Table 5-9. There is presently no official list of rare or endangered species for British Columbia. The species listed in Table 5-9 were tentatively identified as rare or endangered from literature references and conversations with the Canadian Wildlife Federation.

5.5.4.3 Land Capability for Waterfowl

Sites were evaluated quantitatively for this criterion by first determining which site had the most land in capability classes 1 to 3. The land capability for each of the other sites was then expressed as a percentage of this amount (Table 5-3). The importance of this criterion was evaluated on the basis of (1) the presence or absence of capability Class 3 lands (the lowest class found at any of the eight sites), and (2) whether or not the site was located along a migratory route. Dunsmuir, Harry Lake, and Mine Mouth were the only sites with capability Class 3 land, and Dunsmuir was the only site found to be along a migratory route. Thus, Dunsmuir was rated qualitatively as having the greatest capability for waterfowl, followed by Harry Lake and Mine Mouth. This criterion proved to be of little importance at the other five sites.

5.5.4.4 Land Capability for Ungulates

Sites were evaluated quantitatively for this criterion by first determining which site had the most land in capability Classes 1 to 3. The land capability for each of the other sites was then expressed as a percentage of this amount (Table 5-4). The importance of this criterion was evaluated first on the basis of the

TABLE 5-9

SPECIES OF INTEREST

Species	Site							
	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Prairie falcon				x	x	x	x	x
Bald eagle	x	x	x	x	x	x	x	x
Osprey	x	x	x	x	x	x	x	x
Sharptailed grouse				x	x	x	x	x
Lewis's woodpecker	x	x	x	x	x	x	x	x
Western bluebird	x	x	x	x	x	x	x	x
Purple martin	x	x	x					
Goshawk	x	x	x	x	x	x	x	x
California bighorn sheep							x	x
Northern Rocky Mountain cougar	x	x	x	x	x	x	x	x
Grizzly bear		x	x	x	x	x	x	x
Wolf	x	x	x	x	x	x	x	x
TOTAL	8	9	9	10	10	10	11	11

"x" denotes potential occurrence

presence or absence of land in capability Classes 2 or 3 (the lowest classes found at the eight sites). Next, the site(s) with Class 2 land were differentiated from those with Class 3. The Class 3 sites were then differentiated on the basis of capability as a wintering area. Finally, the last differentiation was made on the basis of the number of ungulate game species potentially occurring at the sites. Since Soda Creek was the only site with land in capability Class 2, it was judged to be the site of highest quality. As with the other criteria, the site with the highest is also the site which would suffer the greatest impact from the development.

5.5.5 *Importance of Criteria at Each Site*

It is possible to rank the four evaluation criteria at each site according to the relative importance of each criterion. This ranking is presented in Table 5-6. Factors which enter into determination of this relative importance are such things as present land uses, ecosystem relationships, regulatory limitations, local and regional plans and public concern.

Once these various factors were taken into consideration, several assumptions were made in order to achieve the ranking presented in Table 5-6. First, it was established that the criterion breeding birds and mammals was the most important of the criteria at each site. This was based on the fact that the species list, which served as an indication of the importance of this criterion, contains species which may be described as "sensitive" or "threatened". This is indicative that these species would be especially vulnerable to impacts associated with the development.

Since the possibility exists that one or more of these species will be displaced from the ecosystem at the sites, it was concluded that this criterion deserved special consideration.

Habitat plays an important role in determining ecosystem composition. Therefore, high habitat diversity was considered next in the ordering of criteria at each site. High habitat diversity was found to exist at the Mine Mouth, Harry Lake, Big Bar Creek and Soda Creek sites.

Aspects of best land capability class for waterfowl and ungulates were the next factors considered in ranking the evaluation criteria at each site. These aspects included the best class of land found at each site, and whether or not the site was located along a migratory route or used as a wintering range.

Finally, medium habitat diversity was recognized as being important. After these factors were applied to the four evaluation criteria at each site, any remaining criteria were considered to be the least significant and thus were placed last in the ranking.

5.5.6 Conclusions and Recommendations

The results presented in Table 5-7 represent the conclusions of this study. The concensus decision methodology utilized the various criteria to determine which sites were the most important from a terrestrial ecology viewpoint and which sites were of least importance. It was concluded that those sites of most importance would suffer the greatest impact from the generating station. Thus, these sites were least preferred for development. Those sites of least terrestrial ecology importance were considered to suffer the least impact, and were the most preferred sites for the development. Table 8-10 presents the status of preference from a terrestrial ecology viewpoint for the development of each site.

TABLE 5-10

SITE PREFERENCE FOR DEVELOPMENT OF POWER PLANT

Site	Preference
Ashcroft	Most
Britannia Beach	Most
Stave Lake	Most
Harry Lake	Intermediate
Dunsmuir	Intermediate
Mine Mouth	Intermediate
Big Bar Creek	Least
Soda Creek	Least

GLOSSARY

Forest-grassland association - vegetation region where dominant vegetation is composed of tree and grass species

Habitat diversity - an indication of the number and kinds of habitats at a site

Land capability class - The degree of limitation associated with each unit of land. Reflects the unit's ability to meet the needs of the species or group under consideration.

Species of interest - species which have been identified by various agencies as potential candidates for an official list of rare and endangered species, when such a list is prepared

Ungulates - animals belonging to the Ungulata comprising hoofed mammals. Example - California bighorn sheep.

Waterfowl - swimming game birds. Example - ducks and geese

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6. AQUATIC ECOLOGY

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6.1 SUMMARY

A 2,000 MW thermal generating station burning Hat Creek Coal is proposed for British Columbia. The effects of the proposed generating facility on the important fishery resources of British Columbia have been evaluated for eight alternative sites. These sites are located in two regions of the Province: the coastal region and the inland region of the Fraser River watershed.

Plant construction effects on important provincial fishery resources were assumed equal at all sites. This analysis evaluates the effects of plant operation on anadromous salmonids.

The following assumptions have been used to estimate the effects of generating station operation on aquatic fauna:

a) Anadromous salmonids are the most valuable British Columbian fishery resource and must be protected.

b) Impacts on anadromous salmonids are proportional to the quantity of water withdrawn and discharged by the generating station.

c) Generating station impacts on the fishery resource are a function of the estimated average annual escapement of anadromous salmonids which pass each site.

The quantity of water that would be withdrawn and discharged by the station at each alternative site, and the number of anadromous salmonids which yearly pass each site were used to determine impacts of station operation on aquatic fauna. In addition, qualitative information, such as: presence or absence of salmonid spawning grounds; potential for discharge of heated water and biocides to receiving water bodies; and possible obstructions to salmonid migration were considered for each site.

Analysis of available quantitative and qualitative site-specific data indicates that the order of site preference is:

1. Soda Creek
2. Big Bar Creek
3. Mine Mouth
   Harry Lake
   Ashcroft
   Dunsmuir
4. Stave Lake
5. Britannia Beach

The Soda Creek site, which is adjacent to the east bank of the Fraser River, is favored for the following reasons:

a) Relatively few anadromous salmonids pass this site (250,000 sockeye per year).

b) The proposed generating station would withdraw a small volume of water (approximately 21,000 US gpm).

c) No effluents would be discharged to natural bodies of water.

These factors indicate that a 2000 MW generating station located at Soda Creek would cause fewer adverse effects on aquatic fauna than at any of the seven remaining sites.

Britannia Beach is the least acceptable site. This conclusion is based on the following facts:

a) A generating station located at Britannia Beach would withdraw 750,000 US gpm of condenser cooling water.

b) The station would discharge 750,000 US gpm of water, heated 25°F above ambient water temperature, into Howe Sound.

c) The average annual escapement of salmonids to the Squamish River system approximates 275,000 fish, all of which would pass the plant.

Generating station operation at Britannia Beach would adversely affect salmonids which spawn in the Squamish River system. These impacts would include impingement, entrapment and entrainment of juvenile salmonids by water withdrawal, and potential obstruction of migratory routes due to the discharge of heated water.

Evaluation of alternative intake and discharge structure designs is required to select designs which would least affect all life stages of anadromous salmonids. Intake and discharge structures which would protect anadromous salmonids would also protect other aquatic fauna.

6.2 INTRODUCTION

This report presents the rationale and results of an aquatic ecological evaluation of eight sites being considered by B. C. Hydro and Power Authority for the construction of a 2000 MW thermal generating station burning Hat Creek coal. Aquatic ecological considerations are important factors in siting studies because the construction and operation of such a facility frequently cause major impacts on the aquatic environment.

These impacts, which are primarily caused by water withdrawal and discharge during plant operation, include: potential for entrainment, impingement and entrapment of aquatic organisms; barriers or obstacles to migratory routes of important aquatic species; loss of important aquatic habitats (including spawning areas and nursery zones); and thermal and biocide (discharge) effects. These impacts result in direct mortality of organisms and in habitat alteration, but can be minimized through the choice of a suitable site, the selection of appropriate condenser cooling systems and careful design and placement of intake and discharge structures.

6.2.1 Purpose

The purpose of this portion of the Hat Creek Site Evaluation Study is to estimate the effects of power plant operation on the aquatic resources of eight sites. This estimate of impacts is then used to select a site where the total unavoidable aquatic ecological impacts are as low as possible. The preferred site is then identified, and the remaining seven sites ordered in terms of increasing impact on aquatic resources.

6.2.2 Scope

The scope of work developed for the site evaluation study includes the following tasks:

a) Review of existing data on regional and site specific aquatic ecological resources.

b) Reconnaissance of each site to determine additional aquatic ecological factors and information which should be incorporated into the evaluation.

c) Identification of specific aquatic ecological parameters for comparative impact analysis.

d) Utilization of site- and station-specific design variables for comparative impact analysis.

e) Selection of site evaluation criteria based on aquatic resources and thermal generating station water requirements.

f) Assembly and ranking of site-specific criteria values into impact assessment matrices.

g) Ranking the sites by comparing total unavoidable impacts on aquatic resources at each alternative site.

h) Identification of the preferred site.

The site evaluation does not consider the aquatic ecological effects of coal mine operation in Hat Creek Valley, the impacts produced by the diversion/impoundment of Hat Creek and its tributaries, the potential effects of acid rain precipitation, and construction activities. The latter are assumed to be similar at all sites.

6.3 MATERIALS AND METHODS

6.3.1 Data Sources

The fishery data used in this evaluation were obtained from the available literature, primarily reports from the International Pacific Salmon Fisheries Commission, the Canadian Department of Environment and the Fisheries Research Board of Canada, and from discussions with knowledgeable professionals of those agencies. Information was also gathered from reports submitted to the B. C. Hydro and Power Authority by the consulting firms of Sandwell and Company Limited and B. C. Research, Dolmage Campbell & Associates Ltd. In addition, a field reconnaissance was performed at each site to identify additional aquatic factors which should be considered.

6.3.2 Generating Station Characteristics

Eight alternative sites suitable for a 2,000 MW generating station burning Hat Creek coal were identified in a preliminary site screening phase. Conceptual design features varied considerably among those sites. The major conceptual design variable among the sites is the condenser cooling system design, which includes open-cycle, closed-cycle with blowdown and closed-cycle with no discharge to natural waterbodies. These differences in cooling system designs result from site-specific engineering factors as well as differences in water availability and salmonid fisheries' considerations.

The alternative sites are located on both the coast of British Columbia and in the Fraser River watershed. Coastal sites are situated on the Strait of Georgia and Howe Sound. Closed-cycle and once-through condenser cooling systems, utilizing seawater, are proposed for stations at these sites. Condenser cooling systems, proposed for stations on the Fraser River sites, include both closed and open-cycle designs.

Table 6-1 presents the type of condenser cooling system proposed for each site. Table 6-2 presents the estimated intake and discharge water quantities associated with the condenser cooling systems proposed for each site.

6.3.3 Methodology

6.3.3.1 Site Differentiating Characteristics

6.3.3.1.1 Regional Characteristics

6.3.3.1.1.1 Coastal

Howe Sound connects the Strait of Georgia with the Squamish River, 10 miles northwest of Vancouver. The Strait of Georgia is approximately 120 miles long and extends from the San Juan Islands in the south to the Campbell River on Vancouver Island in the north. The Strait provides important habitat and a passage for rearing and feeding anadromous salmonids.

TABLE 6-1

PROPOSED GENERATING STATION CONDENSER COOLING SYSTEMS

Site Location	Site	Condenser Cooling System
Coastal	Dunsmuir	Closed-Cycle
	Britannia Beach	Once-Through
Lake	Stave Lake	Once-Through
Fraser River System	Ashcroft	Closed-Cycle
	Mine Mouth	Closed-Cycle
	Harry Lake	Closed-Cycle
	Big Bar Creek	Closed-Cycle
	Soda Creek	Closed-Cycle

TABLE 6-2

PROPOSED GENERATING STATION WATER REQUIREMENTS

Site	Intake Water Volume, U S gpm	Discharge Water Volume, U S gpm
Dunsmuir	28,710	10,815
Britannia Beach	751,140	750,570
Stave Lake	750,810	752,309
Ashcroft	21,382	0
Mine Mouth	20,630	0
Harry Lake	21,095	0
Big Bar Creek	20,848	0
Soda Creek	21,054	0

Commercially important marine fishes and invertebrates are distributed throughout the Strait. These include herring and demersal fishes, such as rockfish, cod, flounder, and the Dungeness crab.

6.3.3.1.1.2 Interior

The Fraser River watershed encompasses approximately 90,000 square miles of British Columbia. It is one of the major river systems in North America and produces abundant populations of anadromous salmonids. Five species of Pacific salmon, including sockeye (Oncorhynchus nerka), pink (O. gorbuscha), chinook (O. tshawytscha), coho (O. kisutch), and chum (O. keta), comprise the dominant species. Steelhead trout (Salmo gairdneri) are also abundant. These species form the basis of a valuable commercial and sport fishing industry.

Table 6-3 gives the number of Fraser River sockeye salmon in the runs from 1970 to 1975. Table 6-4 gives the number of pink salmon in the run over the same period. These data include fish caught by both the commercial and Indian fisheries. The escapement and spawning runs to the four major drainages of the Fraser River system are also included. Approximately 75 percent of the returning sockeye and pink salmon are caught by the commercial fisheries. The majority of the sockeye salmon originate in the upper Fraser River and in the Thompson River. The majority of the pink salmon are from the lower Fraser River.[1-6]

In addition to salmon and steelhead trout, substantial, although as yet unassessed, populations of game fish, such as rainbow (S. gairdneri), cutthroat (S. clarki), and lake trout (Salvelinus namaycush), Dolly Varden char (Salvelinus malma), whitefish and sturgeon (Acipenser sp), are supported by the Fraser River system.[7]

TABLE 6-3

FRASER RIVER SOCKEYE SALMON RUNS 1970 THROUGH 1975[a,b]
(Numbers in 1000)

	1975		1974		1973		1972		1971		1970		Average	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catch														
Commercial	3678	73.5	6677	76.4	5570	79.0	2737	72.4	6709	87.9	4071	65.3	4907	76.6
Indian	253	5.1	222	2.5	163	2.3	134	3.5	153	2.0	151	2.4	179	2.8
Escapement	1076	21.5	1840	21.1	1317	18.7	911	24.1	772	10.1	2014	32.3	1322	20.6
TOTAL RUN:	5007	100.1	8739	100.0	7050	100.0	3782	100.0	7634	100.0	6236	100.0	6408	100.0
Escapement														
Lower Fraser[c]	217	20.2	348	18.9	290	22.0	228	25.0	75	9.7	163	8.1	220	16.6
Thompson[d]	214	19.9	1214	66.0	104	7.9	21	2.3	312	40.4	1590	78.9	576	43.5
Seton[e]	11	1.0	13	0.7	6	0.5	12	1.3	4	0.5	5	0.2	9	0.7
Upper Fraser[f]	634	58.9	265	14.4	917	69.6	650	71.4	381	49.4	256	12.7	517	39.0
TOTAL:	1076	100.0	1840	100.0	1317	100.0	911	100.0	772	100.0	2014	99.9	1322	100.0

a Tabulated from References 1 through 6

b Includes jacks

c Total of early runs of Lower Fraser, Harrison, Fraser Canyon and late runs of Harrison and Chilliwack-Vedder

d Thompson River and tributaries

e Seton River and Anderson Creek runs

f Runs above the Seton River

TABLE 6-4

FRASER RIVER PINK SALMON RUNS 1969 THROUGH 1975[a]
(Numbers in 1000)

	1975		1973		1971		1969		Average	
	No.	%	No.	%	No.	%	No.	%	No.	%
Catch	2523	64.9	3718	67.9	4949	73.3	8186	84.3	4844	75.0
Escapement	1367	35.1	1754	32.1	1804	26.7	1529	15.7	1613	25.0
TOTAL:	3890	100.0	5472	100.0	6753	100.0	9715	100.0	6457	100.0
Escapement										
Lower Fraser[b]	606	44.3	1222	69.7	1238	68.6	1058	69.2	1031	63.9
Thompson[c]	480	35.1	283	16.1	258	14.3	248	16.2	317	19.6
Seton[d]	281	20.6	249	14.2	308	17.1	223	14.6	265	16.4
Upper Fraser[e]	P		P		P		P		P	
TOTAL:	1367	100.0	1754	100.0	1804	100.0	1529	100.0	1613	99.9

[a] Tabulated from References 1 through 6.

[b] Total of early runs of Lower Fraser, Harrison, Fraser Canyon and late runs of Harrison and Chilliwack-Vedder

[c] Thompson River and tributaries

[d] Seton River and Anderson Creek runs

[e] Runs above the Seton River

P: Present in small number.

These species are taken by sport fishermen throughout the watershed.

The stretch of the Fraser River above Lillooet is of concern because of the potential water intake sites located there. At Lillooet, the Fraser River intercepts approximately 57,000 square miles, or 63 percent, of the watershed drainage area. Sockeye salmon is the dominant species. Spawning occurs in Chilko River, Taseko Lake as well as in the Horsefly. Mitchell and Brown Rivers, tributaries of the Stuart Lake system, the Stellako River and tributaries of Francois Lake. Upstream migrants average over half a million per year, about 40 percent of the total Fraser sockeye escapement in the years 1970 through 1975.[1-6]

Historical reports suggest that as many as 750,000 sockeye salmon spawners pass upstream through this reach of the Fraser in a single day.[8] The seaward migration of the fry and smolt of salmon and steelhead trout occurs between April and July. As many as 180 million sockeye smolt pass Lillooet in a single day during the peak migration.

Chinook salmon spawn in the Nechako, Chilcotin. Stuart, Salmon, McGregar, Torpy, Morkill, Holmes, McLennan, Goat, Bowron and Willow Rivers and their tributaries. About 160,000 fish, or one-third of the annual Fraser River chinook catch can be attributed to the stock spawned above Lillooet.

The Thompson River system is one of the major tributaries of the Fraser River. It enters the Fraser at Lytton and divides to form the North Thompson River and South Thompson River at Kamloops. The mean annual river flow at Spences Bridge approximates 27,000 cfs. The Thompson River drains approximately 22,000 square miles of southern British Columbia.

Four species of salmon sockeye, pink, chinook and coho are found in the Thompson River. In addition, steelhead, rainbow trout, whitefish and Dolly Varden char inhabit the river, tributaries and lakes.[1-6,8] These species are the object of relatively intensive sport fisheries.

The number of sockeye salmon returning to spawn in the Thompson River system fluctuates widely but averages about 576,000 per year (Table 6-3). This is 43.5 percent of the total Fraser River escapement. Pink salmon return to the Thompson River to spawn in odd years, with escapement averaging 317,000 fish, or about 20 percent of the total pink salmon escapement to the total Fraser River System (Table 6-4). The average number of chinook and coho salmon spawners are 24,000 and 17,000 fish, respectively. Steelhead and rainbow trout also spawn in the river, but no estimates of their numbers are available.

The Thompson River, between Ashcroft and its confluence with the Bonaparte River, is of interest to this study because proposed water intakes for the Ashcroft, Mine Mouth and Harry Lake sites would be located in this river reach.[9] This reach of the Thompson River is prime spawning ground for pink, chinook and coho salmon as well as steelhead and rainbow trout.[10] Sockeye salmon spawn farther upstream, primarily in the tributaries of Adam and Shuswap Lakes.

6.3.3.1.2 Site Specific Characteristics

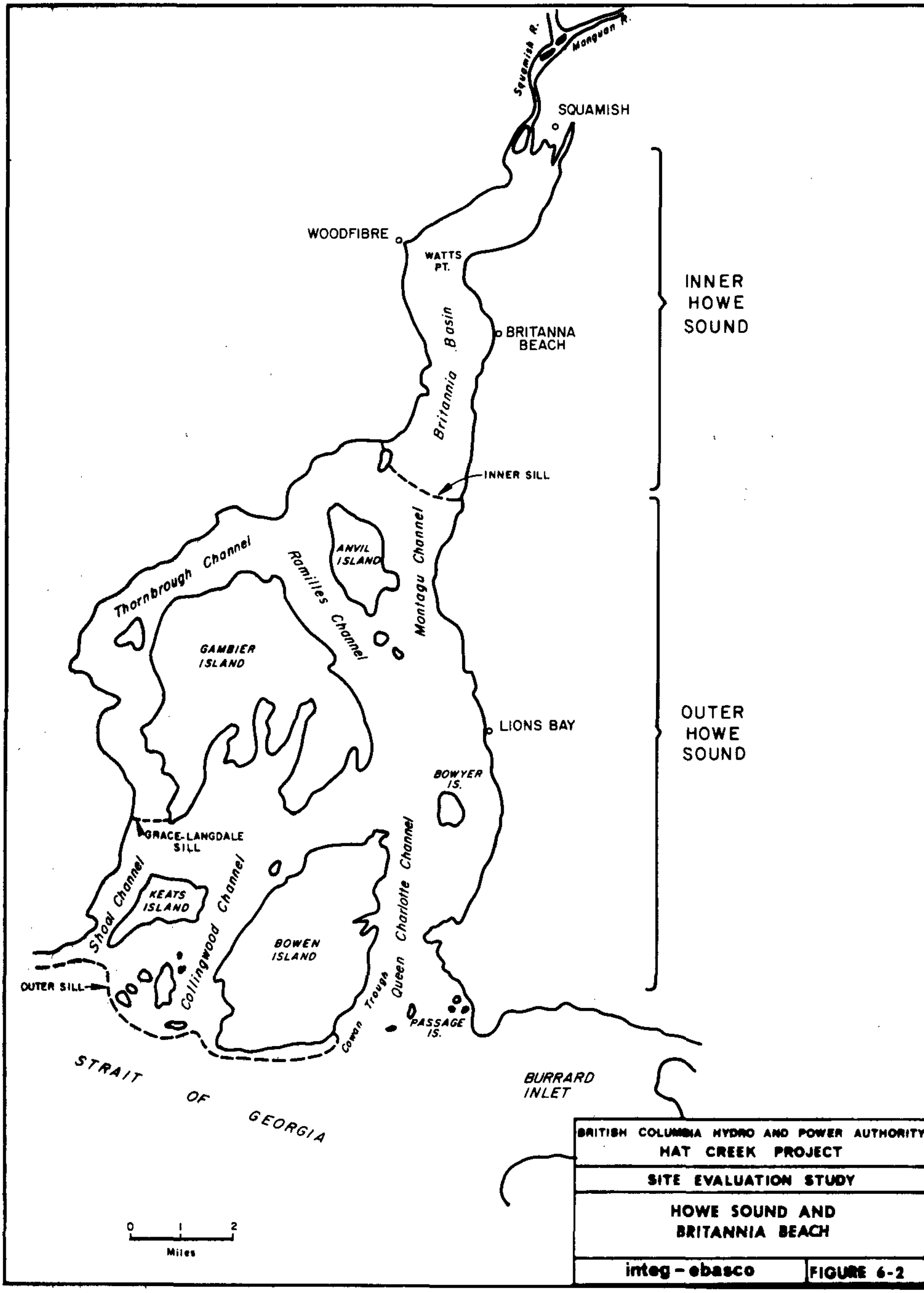
6.3.3.1.2.1 Dunsmuir

The Dunsmuir site is located on Vancouver Island near Qualicum Bay, off the Strait of Georgia, about 15 miles northeast of Port Alberni (Figure 6-1). Salmon are the most important commercial fishes in this area. Chum, chinook, coho and some pink salmon are produced in the Qualicum River system. Coho, chinook, some pink salmon, steelhead, rainbow, cutthroat and brown trout are taken by anglers in the Qualicum Bay and River systems. Pacific herring spawn in the waters of the Bay. Oyster and clam beds occur along the shore, and are harvested by commercial and sport fishermen. Some benthic fish, such as sole and cod, are taken by trawl in the Strait near the Bay.

6.3.3.1.2.2 Britannia Beach

The Britannia Beach site is located on the eastern shore of Howe Sound, approximately 4 miles south of Squamish. Howe Sound (Figure 6-2) is an inlet about 30.5 miles long, with a mean width of 5 miles and a mean depth of 738 feet. Two sills, one at the mouth and another north of Anvil Island, divide the Sound into inner and outer sections. The inner, or northern reach of the Sound, is a typical British Columbia coastal fjord with a steep mountainous shore, a deep-water channel at the middle, and a river, the Squamish, as its head.

The Squamish River system includes the Cheakamus, Mamquam and Stawamus Rivers and drains a 900 square mile watershed. A mean monthly discharge of 8,600 cfs has been measured in the Squamish River at Brackendale. The Squamish River drainage exerts a profound influence on the ecology of the northern reach of Howe Sound.



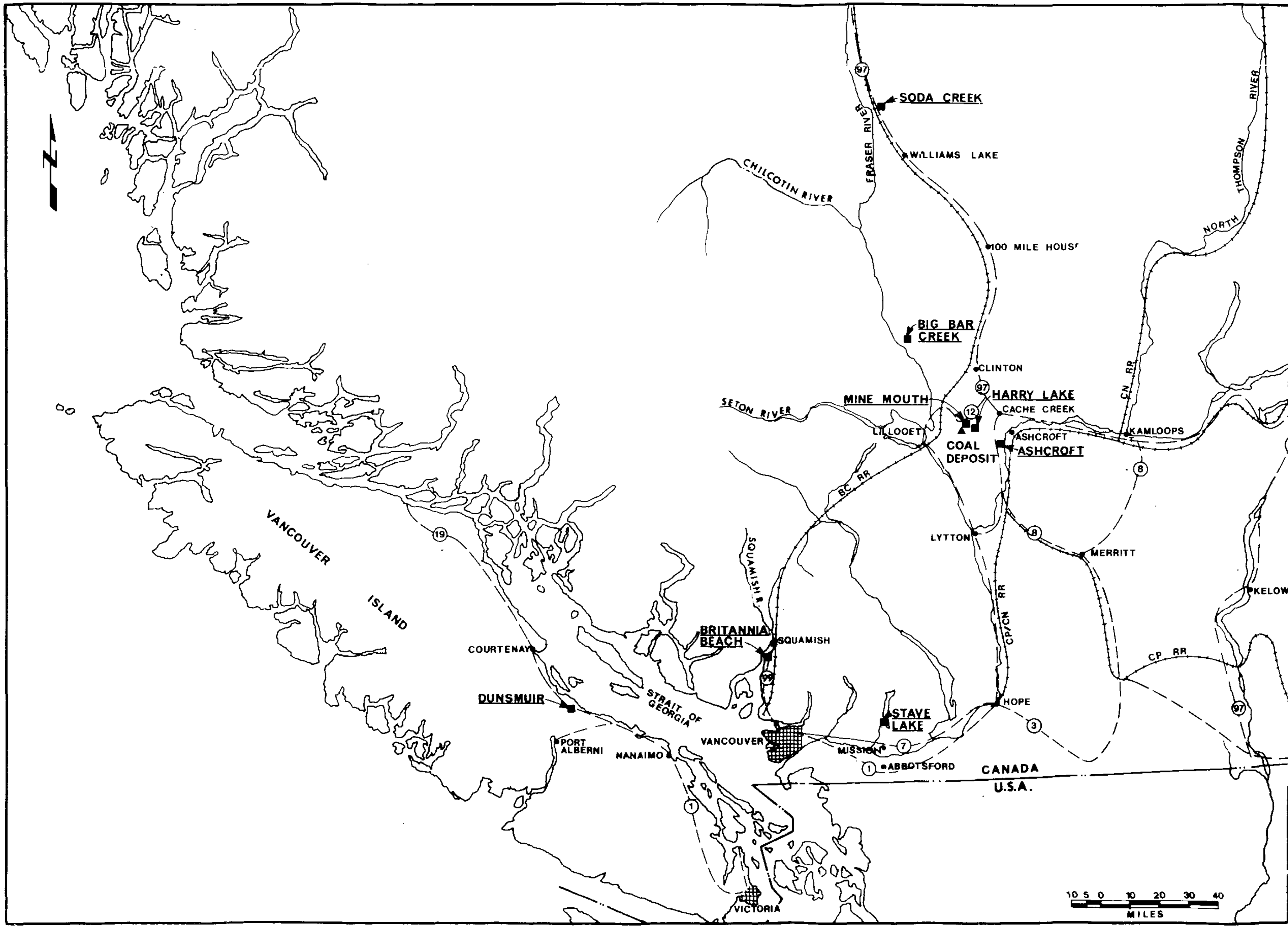
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

HOWE SOUND AND BRITANNIA BEACH

integ - ebasco

FIGURE 6-2



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
SITE EVALUATION STUDY
LOCATION OF EIGHT ALTERNATIVE SITES
integ – ebasco — FIGURE 6-1

Howe Sound is an important habitat for large numbers of marine species.[11,12] It also serves as a passage zone and temporary rearing area for anadromous salmonids from the Squamish River system. Chinook, coho, pink and chum salmon and some steelhead trout are taken by the commercial fisheries outside Howe Sound and by the sport fisheries both inside and outside the Sound.[11] The average escapement and commercial catch of Squamish River system salmonids is shown in Table 6-5 for the years 1962 to 1970.

Herring of all ages are present throughout the year in Howe Sound. Data on spawning in the years 1960 through 1970 indicate an average annual deposition of 387 tons of eggs and a peak deposition of 2,331 tons of eggs in 1962. Spawning occurs on eelgrass and roots of other aquatic plants near Mamquam Channel. Since 1969, no spawning has been observed. This is due, preumably, to the loss of spawning habitat from landfill and log storage activities. Periodically, large schools of juvenile herring are observed in the Sound, suggesting that Howe Sound is a good nursery area. Herring is a commercially important species in British Columbia and are also an important food source for salmonids.[11,12]

6.3.3.1.2.3 Stave Lake

Stave Lake, an impoundment of the Stave River, is located in southern British Columbia. Two dams, located between the lake and the Fraser River, obstruct migrating fish. The Stave River joins the Fraser River near the town of Mission (Figure 6-1).

TABLE 6-5

AVERAGE ANNUAL ESCAPEMENT OF ANADROMOUS SALMONIDS TO THE SQUAMISH RIVER SYSTEM (1962-1971)[a]

Species	Squamish R.	Cheakamus R.	Mamquam R.	Ashlu Cr.	Total
Chinook	14,200	2,040	475	665	17,380
Coho	11,200	5,050	2,230	720	19,200
Pink[b]	28,000	123,840	21,200	4,900	177,940
Chum	21,600	23,750	4,855	400	50,605
Steelhead Trout	9,550	1,210	270	120	11,150
TOTAL	84,550	155,890	29,030	6,805	276,275

[a] From Reference 11, pg 89

[b] Odd years only

Little biological information is available on Stave Lake. Limited sport fishing occurs because of poor accessibility, but the magnitude of catches has never been documented. Rainbow and cutthroat trout, kokanee, Dolly Varden char and Rocky Mountain whitefish are taken from the lake. Squawfish, large-scale sucker, peamouth, stickleback and other coarse fish also are prevalent.

6.3.3.1.2.4 Ashcroft, Mine Mouth and Harry Lake

Two areas of the Thompson River, one near its confluence with the Bonaparte River and the other approximately 2 miles downstream of Ashcroft, have been selected as potential intake locations for the Ashcroft, Mine Mouth and Harry Lake sites. The Ashcroft intake site is located on the right bank (descending) of the Thompson River, about 2 miles downstream from the town of Ashcroft (Figure 6-1).

The Thompson River, between Lytton and Kamloops Lake, is a major spawning ground for the Thompson River pink salmon population.[1-6,9] Small numbers of chinook and coho salmon also spawn in the Thompson River and its tributaries (Table 6-6).

Makeup water for a thermal generating plant located at either the Mine Mouth or Harry Lake site would be withdrawn from the Thompson River. The intake for either site would be located on the north bank of the Thompson River, just upstream of its confluence with the Bonaparte River.

TABLE 6-6

ESTIMATED AVERAGE ANNUAL ESCAPEMENT
OF CHINOOK AND COHO SALMON
TO THE THOMPSON RIVER AND ITS TRIBUTARIES
BETWEEN LYTTON AND KAMLOOPS (1969-1974)[a]

	Chinook Salmon	Coho Salmon
Nicola River	2833	1200
Bonaparte River	67	38
Deadman River	75	50
Little River	308	0
Thompson River	2667	200

Total estimated average annual escapement minus Nicola River chinook and coho = 3405

[a] From Reference 10

6.3.3.1.2.5 Big Bar Creek

Few, if any, anadromous salmonids spawn in the Fraser River at Big Bar Creek, which is located about 50 river miles upstream from Lillooet (Figure 6-1). However, for the years 1970 to 1975, an average of 517,000 sockeye salmon, or 39 percent of the Fraser River system escapement, spawned upstream of the Seton River at Lillooet (Table 6-3). Few pink salmon occur in the Fraser River upstream of Lillooet.[1-6]

6.3.3.1.2.6 Soda Creek

Soda Creek is located about 100 river miles upstream of the Big Bar Creek site (Figure 6-1). No specific intake site has been identified, but the ecology of this reach of river is similar to that of the Big Bar Creek site. However, fewer sockeye salmon migrate upstream of Soda Creek than at Big Bar Creek because of the number of sockeye which spawn in the Chilcotin River and its tributaries, downstream of Soda Creek. Between 1963 and 1970, sockeye escapement to the Chilcotin River averaged 270,500 fish.

6.3.3.2 Site Evaluation Criteria

Because of the recreational and commercial value of the salmon stocks, the site evaluation criteria are based on the operational effects of the proposed plant on anadromous salmonid fishes. These effects can be grouped into intake and nearfield discharge effects, and those far-field effects which are ecosystem oriented. Two quantitative criteria have been selected for the aquatic ecological evaluation of the alternative sites. These criteria, the rationale for their selection and their quantitative measures are described in the following sections. In addition, three qualitative modifers are identified and their use discussed.

6.3.3.2.1 Intake Effects Criterion

6.3.3.2.1.1 Rationale for Criterion Selection

6.3.3.2.1.1.1 Entrainment of Aquatic Organisms

The circulating water systems of thermal generating stations directly influence plankton, including eggs, larvae and juvenile fish. Because of their microscopic size and weak swimming ability, plankton contained in the intake water are subject to the vagaries of a station induced environment. Plankton entrained into closed-cycle condenser cooling systems are killed because of prolonged exposure to high temperature. Plankton entrained in once-through cooling water are subject to abrupt temperature changes, chemical additives, pressure changes, shear and turbulence while passing through the condenser. These stresses may be lethal or sublethal. Plankton may survive passage, but their ability to develop, grow, reproduce or adapt to environmental variables may be impaired.

The extent to which plankton populations are affected by once-through condenser cooling systems is exceedingly difficult to quantify. Nevertheless, because of the large volumes of water utilized by once-through cooling systems, the potential impact on planktonic components of aquatic ecosystems must be evaluated.

6.3.3.2.1.1.2 Impingement of Aquatic Organisms

Nekton, actively swimming aquatic organisms such as fish, can be impinged or trapped against the intake screens by velocity forces. Prolonged exposure to the resulting physical abrasion can lead to injury and mortality.

The effects of impingement are highly site-dependent and related to the distribution, composition and abundance of important species in the cooling water source, as well as the water volume required by station operation and the velocity of this water at the intake and screens. Juvenile forms are generally more vunerable than are adults.

6.3.3.2.1.1.3 Entrapment of Aquatic Organisms

Entrapment of aquatic organisms is defined as the attraction, diversion or retention of aquatic organisms near intake or discharge structures. Faulty design, construction and location of intake structures can induce entrapment of fish.

Organisms are susceptible to entrapment because of their behavior, swimming orientation and ability, thermal preference, seasonal occurrence as migrants, or residency throughout the year. Migratory species are more vulnerable to entrapment than residents, particularly during juvenile stages. Organisms near cooling system structures are also subject to additional mortalities because of their vulnerability to impingement and entrainment.

6.3.3.2.1.2 Measure of Intake Effects Criterion

With the data presently available, the intake effects of power plant operation on anadromous salmonid fishes cannot be precisely quantified. However, if the effects of entrainment, impingement, and entrapment are assumed to be related to intake water velocity, then water withdrawal rate can be used as a criterion for site-specific impacts.

The conceptual condenser cooling water system designs proposed for the alternative sites require different volumes of water. The analysis of ecological impacts in based upon the assumption that entrainment, impingement and entrapment of aquatic organisms are proportional to plant water requirements. Proposed intake water quantities for each site are given in Table 6-2.

6.3.3.2.2 Discharge Effects Criterion

6.3.3.2.2.1 Rationale for Criterion Selection

As with intake effects, if the effects of station effluents can be assumed to be related to the quantity of water discharged to a receiving water body, then the discharge quantity can be used as a criterion for determining site-specific impacts. Proposed station effluent quantities are given in Table 6-2.

6.3.3.2.3 Qualitative Aspects which Modify Station Intake and Discharge Effects

Three additional ecological considerations, (1) obstruction to migration, (2) loss of important habitat, and (3) estimated average annual escapement of anadromous salmonids past each site, can be utilized as qualitative modifiers to evaluate the effects of station operation at a given site. While these concerns cannot be estimated quantitatively, information in these areas can be used to identify sites with high ecological risks.

6.3.3.2.3.1 Obstruction to Migratory Routes of Important Fauna

Heated effluent, discharged from a generating station, can interrupt or block seasonal and daily migratory patterns of aquatic organisms. A thermal block could impair reproduction of important fishes, such as salmon and trout. To prevent these problems, information on zones of passage, migration periods coincident with maximum ambient temperatures, potential current modifications, siltation, entrapment, impingement and entrainment must be evaluated.

6.3.3.2.3.2 Loss of Important Habitat

Important habitats are areas essential for the maintenance of populations of important biological species. Such habitats include nesting and spawning areas; nursery, feeding and resting areas; and areas of seasonally high populations.

In the aquatic environment, loss of habitat can occur with the alteration of benthic communities. Habitat loss may occur during construction, or during operation due to physical changes in essential habitat characteristics. Scouring and siltation of the substrate, and thermal or chemical stresses on aquatic biota from the discharge can cause profound changes in habitat or patterns of habitat utilization.

With information on habitat diversity and species composition, relative assessments can be made of the status of communities at different sites and their susceptibility to station induced changes. For example, heated water discharged from a once-through condenser cooling system can cover a large area, altering the temperature regime and rendering that area uninhabitable for many species.

6.3.3.2.3.3 Estimated Average Annual Escapement of Anadromous Salmonids

The average number of spawning salmon estimated to pass each site annually are given in Table 6-7. Sites cannot be differentiated solely on the basis of estimated escapement, but these data are used to modify, semi-quantitatively, the impacts of station operation at each site.

Approximately 250,000 salmonids pass the Soda Creek site each year. About 276,000 anadromous salmonids spawn in the Squamish River system each year and all are assumed to pass the Britannia Beach site. More than 500,000 sockeye salmon annually pass upstream of the Big Bar Creek site. The largest average annual salmonid escapement, approximately 900,000 fish, passes the Thompson River sites, Ashcroft, Mine Mouth and Harry Lake. No anadromous salmonids spawn in Stave Lake and no data on salmonid escapement to the Qualicum River, near Dunsmuir, are available.

6.3.3.3 Application of Site Evaluation Criteria

The site evaluation and ranking procedure comprises six steps:

TABLE 6-7

AVERAGE ANNUAL ESCAPEMENT OF ANADROMOUS SALMONIDS WHICH PASS EACH SITE[a]

Site	Pink Salmon	Sockeye Salmon	Others[b]	Total
Dunsmuir[c]	-	-	-	-
Britannia Beach	177,940	0	98,335	276,275
Stave Lake	0	0	0	0
Ashcroft Mine Mouth Harry Lake	317,000	576,000	3,405	896,405
Big Bar Creek	Present in small numbers	517,000	c	517,000
Soda Creek	Present in small numbers	246,500	c	246,500

[a] Data from Tables 3, 4, 5 and 6.

[b] Chinook, coho, chum salmon and steelhead trout.

[c] No data available

a) Quantifying the amount of water withdrawn and discharged at each site.

b) Estimating the escapement of anadromous salmonids which pass each site.

c) Identifying the qualitative factors that are important at each site.

d) Determining the relative importance of the criteria at each site.

e) Ranking the sites for each criterion.

f) Ranking the sites based on relative impacts on the aquatic environment at each site.

6.3.3.3.1 Importance of Criteria at Each Site

The importance of each criterion, intake effects and discharge-effects, was determined by the quantity of water that would be withdrawn or discharged at any site. For example, at sites which would withdraw larger quantities of water than would be discharged, the importance of the intake-effects criterion is ranked higher than the discharge-effects criterion.

6.3.3.3.2 Significance of Criteria Among Sites

The significance of each criterion among the eight alternative sites was estimated by considering water intake and discharge quantities and the effects of water withdrawal and discharge on important aquatic resources.

In the case of a station at which no effluent would be discharged, the significance of the discharge effects criterion on aquatic fauna is zero.

6.4 RESULTS

6.4.1 Ranking of Criteria at Each Site

Table 6-8 summarizes the ranking of criteria at each site. The following discussion briefly describes the rationale for the assigned ranks.

6.4.1.1 Dunsmuir

The closed-cycle condenser cooling system proposed for the Dunsmuir site would require approximately 30,000 US gpm of water and would discharge nearly 11,000 US gpm into Qualicum Bay. The intake flow would be 4 percent of that required by a once-through cooling system. The criterion, intake effects, is considered more important than potential effluent effects because a greater volume of water will be withdrawn at Dunsmuir than will be discharged.

6.4.1.2 Britannia Beach

The two criteria used to evaluate the potential effects of a Britannia Beach generating station on aquatic ecosystems are considered equally important. Approximately 750,000 US gpm of water would be pumped from Howe Sound, passed through the condensers, heated and discharged into Howe Sound.

TABLE 6-8

RANKING OF INTAKE AND DISCHARGE CRITERIA AT EACH SITE

Site	Intake Effects	Discharge Effects
Dunsmuir	1	2
Britannia Beach	Both of equal importance	
Stave Lake	2	1
Ashcroft	1	2[a]
Mine Mouth	1	2[a]
Harry Lake	1	2[a]
Big Bar Creek	1	2[a]
Soda Creek	1	2[a]

[a] Zero discharge

6.4.1.3 Stave Lake

Discharge effects are considered more important than intake effects because greater quantities of water would be discharged than withdrawn.

6.4.1.4 Ashcroft, Mine Mouth, and Harry Lake

Intake effect is the only criterion of concern at these sites. No effluents would be discharged from a station located at any of the three Thompson River sites.

6.4.1.5 Big Bar Creek and Soda Creek

For both sites, intake effect is the only criterion of importance. No discharges would occur if a station were located at either site.

6.4.2 Ranking Criteria by Significance Among Sites

Both criteria were ranked by significance of potential impact on aquatic resources among sites. Table 6-9 presents the results of this ranking process, which reflect the effects of the qualitative modifiers. The rationale for site/criterion significance is given below:

TABLE 6-9

SIGNIFICANCE OF CRITERIA AMONG SITES[a]

Criteria / Sites	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Intake Effects ↑	I	I	I	I	I	I	I	I
Discharge Effects ↑	D	D	D	D	D	D	D	D

[a] Increasing Significance ↑

6.4.2.1 Dunsmuir

The eggs and larvae of oysters and clams are planktonic and would be entrained in the cooling water. Hyper-saline station effluents may adversely affect bivalve molluscs and may interfere with migration routes used by Qualicum River salmonids.

6.4.2.2 Britannia Beach

Chinook, coho, chum and pink salmon and steelhead trout returning to the Squamish River system pass through the waters off Britannia Beach. The progeny of these salmon also pass this site on their seaward migration. Thermal effluent discharged from a station located at Britannia Beach would alter or effectively block the migration of anadromous fish. Oceanographic data indicate that water in the vicinity of Britannia Beach is comparatively stagnant. Because of the postulated stagnant condition, it is expected that heat exchange between the thermal plume from a generating station and surrounding water would be slow and the mixing zone would be widespread. Such conditions would affect fauna over a large area. Entrainment, entrapment and impingement of juvenile salmon, herring and other species of fish and invertebrates would occur at the intake.

6.4.2.3 Stave Lake

The use of Stave Lake water for condenser cooling would cause impingement and entrapment of fish. Intake of cooling water would entrain large numbers of plankton which may be killed by heat, pressure changes and abrasion as they pass through the condensers.

Heated effluent from the proposed station would elevate lake water temperature and might result in an increase of undesirable species, such as sucker, carp and squawfish. Plant discharges might also increase water temperature in the Stave River below the impounding dams. Higher water temperatures in the lower reaches of the Stave River might adversely affect those chum, pink and coho salmon and steelhead trout which spawn below the dams. In addition, the heated plant effluent would increase the potential for gas supersaturation, and hence "gas bubble" disease, both above and below the dams.

6.4.2.4 Ashcroft, Mine Mouth and Harry Lake

Thompson River ichthyofauna include pink salmon fry and sockeye salmon smolts. Pink salmon are more likely to be affected by water withdrawal because of their small size and because both proposed intakes are situated in the major pink salmon spawning ground of the Thompson River. The fry of pink salmon may be trapped by or impinged on the intake screens once they are entrained in the intake current, if approach velocities are high. However, fry of pink salmon migrate downstream at night. These juveniles remain on the bottom near rocks and gravel during the daytime. Pink fry migrate anytime of day if the water is turbid. They are found in all sections across the river, but tend to concentrate in the center of the river where the current is swiftest. Pink fry are distributed at all depths during migration.

Impingement and entrapment of sockeye smolt on intake screens would not be a serious problem, because sockeye smolts can usually swim away when they sense intake currents. The fry of chinook salmon, steelhead and rainbow trout, spawned in the river, may be entrapped or impinged by the intake structure.

As noted in Table 6-2, water requirements for a plant located at any of the three sites (Ashcroft, Mine Mouth, Harry Lake) differ only slightly in volume. Because the small difference in water volume does not differentiate among sites, impact of plant operation on anadromous salmonids is considered equal at the three Thompson River sites.

6.4.2.5 Big Bar Creek

An estimated 517,000 sockeye salmon annually pass the Big Bar Creek Site. The major impact on salmonids would be the entrapment and impingement of sockeye smolts during their seaward migration.

6.4.2.6 Soda Creek

At Soda Creek, anadromous salmonids would be affected by the use of Fraser River water for plant makeup. Impingement and entrapment of young salmonids would occur. However, the small volume of water required and the relatively small number of fish in the area suggest that the severity of intake effects would be low.

6.4.3 Site Ranking

Total impacts of proposed power plant operation at each site were projected from intake and discharge effects and site specific qualitative data such as presence of important habitat, migratory routes and presence of vulnerable life stages of salmonids. The sites were ranked in order of increasing impact on aquatic resources. Table 6-10 presents the ordering of the eight alternative sites.

TABLE 6-10

RANKING OF ALTERNATIVE SITES

Site	Rank
Soda Creek	1
Big Bar Creek	2
Mine Mouth	3
Harry Lake	3
Ashcroft	3
Dunsmuir	3
Stave Lake	4
Britannia Beach	5

Soda Creek is the preferred site for the following reasons:

a) Relatively few anadromous salmonids pass this site (250,000 sockeye per year).

b) Small volume of water required by the proposed power plant (21,054 US gpm).

c) No effluents discharged to natural bodies of water.

Britannia Beach is the least acceptable site for the following reasons:

a) A generating station located at Britannia Beach would withdraw 750,000 US gpm of condenser cooling water.

b) The station would discharge 750,000 US gpm of water, heated 25°F above ambient, into Howe Sound.

c) The average annual escapement of salmonids to the Squamish River system approximates 275,000 fish, all of which would pass the site.

6.5 DISCUSSION AND CONCLUSIONS

6.5.1 Introduction

Site evaluation and ranking was based primarily on potential impacts of power plant operation on populations of anadromous salmonids in the vicinity of each site.

The following assumptions were used to estimate the effects of plant operation on this important fishery resource: 1) anadromous salmonids are the most important fisheries resource in British Columbia; 2) impacts on anadromous salmonids are proportional to the volume of water withdrawn and discharged by the generating station; 3) the potential for station impacts on fisheries resources is a function of the average annual escapement of anadromous salmonids which pass each site.

6.5.2 Importance of Anadromous Salmonid Fisheries

That anadromous salmonid fishes form the most important fisheries in British Columbia is undisputed. The five species of Pacific salmon form the basis of a commercial fishing industry with a yearly revenue of more than $45,000,000, based on the 1972 wholesale value [15]. Fishing is vital to the economy of British Columbia and also influences the economy of the State of Washington. In addition, both migratory and non-migratory Fraser River salmonids support sport fisheries worth more than $185,000,000 in 1972 [15]. Sport fisheries, in turn, support large recreational and resort industries. In recent years, increasing numbers of the salmonids have been taken by the Native Indian population for their subsistence. This use accounts for about 3 percent of the total run.

The sockeye salmon is the most valuable commercial species and provides approximately 46 percent of the total annual British Columbia salmon production. During the years 1970 to 1975, the average catch was 5,000,000 fish. Pink salmon, which spawn only in odd years, provide 16 percent (all-year average or 36 percent odd-year average), of the total production.

In the odd years from 1969 to 1975, the number of pink salmon taken averaged approximately 5,000,000 fish. It is estimated that 480,000 chinook, 500,000 coho, and 571,000 chum salmon from the Fraser River system are caught annually by commercial and sport fisheries [1-6].

6.5.3 Intake and Discharge Effects

A 2,000 MW thermal generating station at Britannia Beach would utilize a once-through or open-cycle condenser cooling system. The ecological concerns at this site are twofold, and are associated with the intake and discharge of large quantities of water and the location of the site on an estuary.

The water requirements would be about 750,000 US gpm of sea water. Because of the large quantities of water involved, the potential for entrainment, impingement, and entrapment of aquatic biota, especially anadromous salmonids is great.

Heated water discharged directly into the environment could alter the hydrography of the receiving water body. The heated discharge water raises the receiving water temperature in a mixing zone that would cover a large area. Alteration of the temperature regime of an ecosystem could cause serious undesirable effects on organisms, because many metabolic functions, such as feeding efficiency, spawning, embryonic development, and swimming ability are controlled by temperature. Heated discharge water is subject to nitrogen supersaturation because of reduced gas solubilities at elevated temperature. Nitrogen supersaturation could produce embolisms in aquatic fauna, a condition known as "gas bubble" disease.

At Dunsmuir, approximately 30,000 US gpm of seawater would be withdrawn from the Strait of Georgia and nearly 11,000 US gpm of hypersaline located effluent would be discharged.

Organisms occurring in the Strait of Georgia and susceptible to entrainment are similar qualitatively to those at Britannia Beach. Loss of entrained organisms from the Dunsmuir areas would have less impact than at Britannia Beach because of the smaller quantities of intake water involved.

The open seacoast generally experiences considerable variation in currents but relatively little change in salinity. Numbers of planktonic larval stages susceptible to impingement/entrainment at Dunsmuir would be usually less than at Britannia Beach, but may be greater than those at river and lake sites.

A generating station at Stave Lake would utilize an open-cycle condenser cooling system which would withdraw about 750,000 US gpm and discharge about the same quantity to Stave Lake.

Most lakes (or reservoirs) used for generating station cooling are selected for efficient dissipation of waste heat to the atmosphere. The discharge normally forms a surface layer of warmed water but may form a submerged mid-layer, if substantial density differences occur between surface and discharge water. Benthic organisms are not directly affected by such stratification. Because lakes usually do not have strong, undirectional currents, pelagic organisms are less commonly carried into a mixing zone than in rivers. However, such organisms as phytoplankton, zooplankton, fish eggs and larvae and insect larvae may enter zones of heated water in shifts because of currents and changes of wind direction and intensity occur.

The data presented in Table 6-2 show that power plants located at five interior sites (Ashcroft, Mine Mouth, Harry Lake, Big Bar Creek and Soda Creek) would require small quantities of water for cooling tower makeup (about 21,000 US gpm) and would discharge no effluent to natural waterbodies. Fraser and Thompson River organisms are adapted to life in areas of moderate to high currents as adults, but some have temporary planktonic larval stages susceptible to entrainment. Juveniles and fry of Pacific salmon may be susceptible to impingement. Rivers generally contain small populations of planktonic organisms and floating fish eggs. However, because of the small quantities of water required for cooling tower makeup, impacts on aquatic organisms at interior sites would be low. The absence of any discharge to natural waterbodies would preclude any discharge effects.

6.5.4 Conclusions

Soda Creek is the most desirable generating station site from the standpoint of aquatic ecology. The Soda Creek selection is due primarily to its location upstream from other intake sites. A smaller number of salmonids pass this point compared with intake sites located further downstream. The possibility for impingement and entrapment of sockeye smolt or the fry of chinook and pink salmon, steelhead and rainbow trout and other game fish is less here than at the other sites considered. The upper Fraser River is ecologically more favorable for intake siting than the Thompson River because no significant spawning occurs in the main stem of the Fraser, whereas extensive spawning of pink salmon occurs in the Thompson River. Impingement or entrapment of newly hatched pink salmon fry on intake screens could be a problem in the Thompson River.

The Britannia Beach Site is least preferred, because of the potential for adverse impacts on the Squamish River system salmon population. A station equipped with an open-cycle condenser cooling system at this site is incompatible with the fisheries resources of the Squamish River - Howe Sound area.

6.6 RECOMMENDATIONS

The generating station will affect aquatic fauna at all of the eight sites evaluated in this study. Although adverse impacts on salmonids will be relatively low at those interior sites for which closed-cooling cycle systems have been proposed, alternative intake structures should be evaluated, regardless of the site selected. Intake designs considered for Fraser River system sites should include those which utilize groundwater, such as the Ranney Radial Collector System. For the coastal and lake sites, intakes which reduce fish entrapment, such as the velocity cap intake, should be evaluated as well as conventional designs. In addition, diffuser discharge systems, which provide rapid dilution of plant effluents, should be evaluated for those site-plant combinations which discharge condenser water to natural waterbodies.

GLOSSARY

Anadromous - Fish which reproduce in fresh water but mature in the sea, such as salmon.

Benthic - Organisms which live at the bottom of the sea or other body of water.

Demersal - Fish which live on or near the floor of seas or lakes, such as flounder and cod.

Escapement - Those adult fish in a specific salmon run which are not harvested and then spawn.

Invertebrate - Animals which lack a spinal column or backbone.

Nekton - Swimming organisms able to move at will against currents, such as fish, squids and whales.

Plankton - Aquatic organisms of fresh, estuarine or marine environments which float passively or exhibit limited locomotor activity.

Salmonid - A fish of the family Salmonidae, which includes salmon, trout and char.

Smolt - Young salmon, one or more years old, as they first migrate downstream to salt water.

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7. LAND USE

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7.1 SUMMARY

The construction and operation of a 2000 MW Thermal Generating Station requires the use of a large tract of land and represents an intrusion upon surrounding landscape and land uses. This study evaluates the nature and extent of the effects of such development on the land use resources of southwest British Columbia and specifically at the area of the generating station. The impacts upon land use resources of concern in this investigation include:

a) Impact on aesthetics
b) Impact on forestry
c) Impact on agriculture capability
d) Impact on recreation capability
e) Impact on Native Indian Reserves

These concerns were translated into quantitive criteria which were used to evaluate eight alternative sites. These criteria are identified on Table 7-1, along with their numerical values at every site. The relative importance of each criterion at a given site was determined through use of the forced decision method. The results are presented in Table 7-2 of this report.

An examination of these criteria and the qualitative aspects associated with them has led to the following conclusions:

a) In terms of aesthetics, interior sites would have less conflict with a thermal generating station primarily because of less extensive viewshed.

b) Forest was found to be more abundant and dense at the coastal sites than in the interior.

c) Impact on Native Indians would be more serious at the Interior sites, especially at the Mine Mouth, Harry Lake and Ashcroft sites, because there are more Indian Reserves in the interior.

The Soda Creek site is considered to be the most suitable location for a large thermal generating station because the overall land use impact would be moderate, with no major land use conflict at this site. The Harry Lake site is the next alternative site because there is only one significant land use conflict at this site, the potential impact on Native Indian Reserves.

Of the remaining six alternative sites, the coastal sites are generally considered to be the least preferred because of aesthetic, forestry, and recreation considerations.

7.2 INTRODUCTION

Construction and operation of a 2000 MW Thermal Generating Station can affect man's quality of life by visually intruding on the surrounding landscape, land alienation, and conflicting with land use patterns and practices. These effects may be far-reaching and long-term and deserve careful consideration in the siting of a thermal generating station.

7.2.1 Purpose

This study compares the relative aesthetic and land use characteristics of eight alternative sites in terms of their potential compatibility or conflict with a thermal generating station.

These concerns are then utilized to develop a ranking of the alternative sites in order of preference for the land use discipline, and a a preferred site selected.

7.2.2 Scope

This chapter includes a discussion, analysis and evaluation of both aesthetic and land use considerations for eight alternative thermal generating station sites in southwest British Columbia. The location of these sites is shown on Figure 7-1. The scope of work includes:

a) Descriptions and site-specific land use and aesthetic factors.
b) Definitions of quantitative land use criteria used to evaluate each site.
c) Determination of quantitative values for each criterion at every site.
d) Evaluation of the relative importance of each criterion at a given site (for use in the overall, multi-disciplinary evaluation).

Because land use at both the coastal and inland sites is primarily resource-based (that is, forestry, agriculture, and recreation), the land use evaluation is limited to consideration of these activities. In light of unique cultural, provincial, and national considerations, the potential impact of the generating station on Native Indians has been given special attention in the evaluation process. The interests of other groups such as ranchers, farmers, and city dwellers have also been included in the overall site evaluation study.

7.3 MATERIALS AND METHODS

7.3.1 Data Base

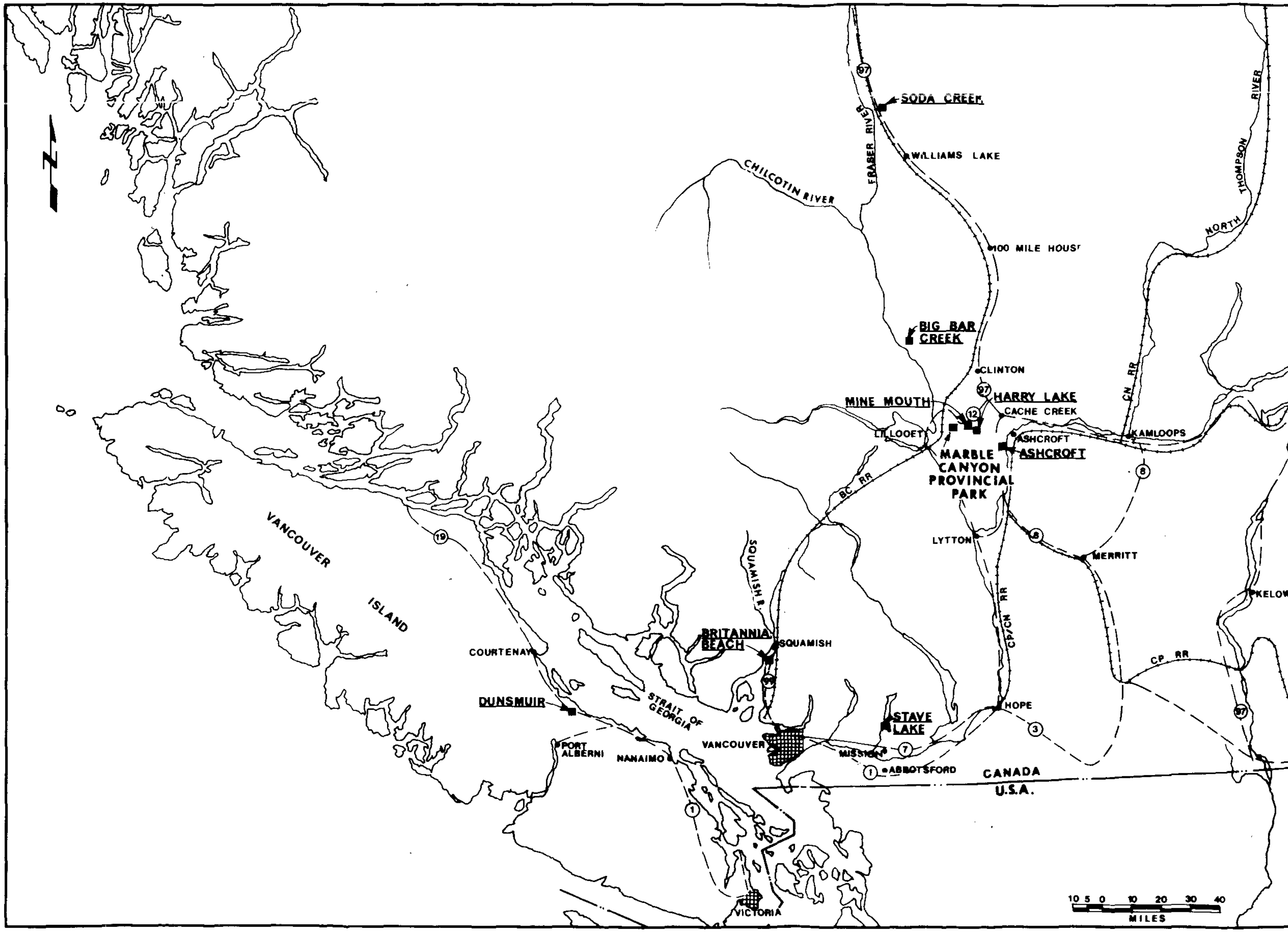
Land use was determined from Canada Land Inventory[1] (CLI) maps, aerial photography, topographic maps, and site reconnaissance.

Agriculture and recreation capability information for each site was derived from Land Use Capability Maps[2]. Information regarding forestry capability was obtained from CLI Present Land Use maps. The categories "Immature productive forest" and "Mature productive forest" were taken to be reasonable indicators of the capability of a site for future forestry. A radial distance of one mile from the plant island and ash ponds delineated the study area for these land uses. This area defines the zone of potential plant influence on land use in the form of noise, ice, fog, and salt deposition.

Current information on the population of Indian Reserves in the study area was provided by B.C. Hydro.

7.3.2 Methodology

In order to differentiate between the eight sites, the land use concerns under study were translated into quantitative criteria which are described below. Each criterion also has associated with it qualitative aspects which took into account unquantifiable regional and site specific considerations. These criteria were applied to every site, as discussed in detail in Section 7.4 of this chapter. The relative importance of each criterion at a given site was then evaluated (using the "forced decision method") for use in the overall, multi-disciplinary site selection analysis.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

SITE EVALUATION STUDY

ALTERNATIVE SITE LOCATIONS

integ - ebasco

FIGURE 7-1

A similar evaluation, or ordering, by criteria across the sites was then performed. This resulted in an ordering of "most preferred" to "least preferred" site for each criterion. An examination of these two orderings, along with input from the overall site-selection analysis described in Chapter One, led to the final selection of sites based only on the concerns of the land use discipline.

7.3.3 Site Evaluation Criteria

7.3.3.1 Viewshed

Spectacular scenery represents an important asset of the Province of British Columbia. The existence of these aesthetic values contributes heavily to the well-being of the Province, both in terms of tourism and immigration. Therefore, the potential for interruption of aesthetically pleasing scenery by a large industrial facility is a mater of major concern.

"Viewshed" is used in this study as a quantative measure of aesthetic considerations. This term is a measure of the size of the area from which a power plant can be seen. The viewshed has been calculated for each site using small-scale topographic maps (1:50,000 - 1:250,000). Given the elevation of the plant island at each site, the viewshed was established in consideration of the surrounding contour elevations. The viewshed was then modified by eliminating forested areas which would provide screening. Other things being equal, the potential adverse aesthetic impact of a plant site will vary with the size of the viewshed.

Qualitative factors considered in rating the alternative sites for their aesthetic compatibility with a thermal generating station were as follows:

a) The physical quality of the scenery at the site and in the surrounding areas as judged by the study participants. This is the most subjective factor within this category and is based upon such elements as unique, pleasing, and unusual features.

b) The aesthetic character of the existing or anticipated development in the area. An extremely scenic area, which is at the same time heavily industrialized, would not necessarily be incompatible with a thermal generating station.

c) The number of people who would view and take advantage of the aesthetic character of the area, from highways, parks, or other developed areas.

7.3.3.2 Acres of Productive Forest

The preemption of forested land was chosen as a criterion because timber is an important resource in British Columbia. CLI classifies standing forest by maturity and productivity. For the one-mile study area,a measure was taken of the acreage classified on the CLI Land Use Maps as mature and immature productive forest (T_1 and T_2). At those sites where the CLI classification is productive forest interspersed with grassland (T_1K and T_2K), the quantative measure was reduced by 25 percent, based upon an analysis of aerial photographs and site reconnaissance.

The single qualitative factor used for determining the importance of this criterion at each site was whether logging had taken place or is still taking place. This was determined by site reconnaissance, and was considered to be an indicator of current commercial production.

7.3.3.3 Acres in Agriculture Capability Classes 1 - 4

The CLI identifies agriculture capability classes which are determined by the relative range of crops the land can produce. There are seven capability classes, with 1 representing the highest class, or widest range of crops, and 7 representing the lowest. For the purposes of this study, only lands in Classes 1 through 4 were considered to be of significant agricultural capability. The criterion was a measure of this acreage within the land-use study area.

Qualitative factors used for judging the importance of this criterion at each site were: the existence of current agricultural uses within the study area, the types of crops grown, and the relative value of agriculture in each site area.

7.3.3.4 Acres in Recreation Capability Classes 1 - 4

A thermal generating station could have direct impacts upon recreational resources by preempting land which might otherwise be used for recreation. Indirect impacts on the recreational use of adjacent areas may occur because of noise, increased traffic congestion, and the aesthetic impacts associated with the construction and operation of the facility.

There are seven recreation capability classes identified by the CLI. Class 1 represents the highest capability for outdoor recreation while Class 7 represents the lowest capability. Sub-classes, or features, include a wide spectrum of activities such as angling, organized camping, viewing, and family boating. The recreation capability criterion is a measure of the approximate acreage within the one mile distance that is designated by the CLI to be in the first four capability classes. This criterion took into account both the value of the area for recreation and the amount of land to be affected at each of the proposed sites.

Qualitative factors,which were used for determining the importance of this criterion at each site,included the presence of any organized recreational areas (parks) within ten miles of the site and the acreages and user numbers associated with these areas. Site reconnaissance also revealed that some areas deemed by the CLI as having low recreational potential, possibly due to poor existing access, appeared to have high value for future recreational development because of unique aesthetic features.

7.3.3.5 Native Indians

Native Indians have been a primary concern in the site evaluation study because of their special and long-standing regard for the land. Although a large number of Native Indians in the study area have chosen to live away from Reserve land, they are eager to maintain the land as part of their heritage.

A criterion concerning Native Indians within 10 miles of the plant site has been established in quantitative form. This is the sum of the reciprocals of the distance in miles of each reserve from the plant site.

Qualitative factors associated with this criterion include the population on the Reserves under consideration and whether there is a need to pass through or immediately adjacent to Native Indian lands for ancillary services such as access roads and railroads.

7.3.3.6 Other Considerations

There are land uses in addition to those described above that ultimately require consideration but have not been included in the site evaluation stage of effort because of the limited data availability, or characteristics which were of a non site-differentiating nature.

In this category are included:

a) Archeological considerations

b) "Built-up Area" designations defined by the CLI, which include marginal industrial/residential development.

These were examined during the study and are described in a later section of this report.

7.4 RESULTS

7.4.1 Results of Quantitative Criteria Application

The specific criteria previously developed were applied in quantitive form to each of the sites, and the results are given in Table 7-1.

The data on Table 7-1 indicate the following with respect to each criterion:

a) Viewshed: the coastal sites have a greater viewshed than the interior sites, with Dunsmuir yielding the greatest viewshed, 168.3 square miles. Of the interior sites, Harry Lake yields the smallest viewshed.

b) Productive Forest: the Dunsmuir and Stave Lake site areas affect the greatest areas of productive forest (greater than 6500 acres),whereas the Ashcroft site area represents only about 430 acres as measured by this criterion. The Mine Mouth, Harry Lake, Big Bar and Soda Creek sites affect essentially equivalent amounts of productive forest, between 2300 and 4600 acres.

TABLE 7 - 1

LAND USE CRITERIA

NUMERICAL VALUES

Criterion	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar	Soda Creek
1. Viewshed (sq miles)	168.30	78.00	44.66	31.14	12.46	8.87	49.98	13.10
2. Productive Forest* (acres)	7,696	1,612	6,552	429***	3,315***	3,822***	2,301***	4,563***
3. Native Indians (populated reserves/ miles from site)	.5	0	0	.55	2.65	1.13	.25	.25
4. Acres in Agriculture Capability Classes* (1-4)	4,914	0**	3,526	7,605	1,266	0	4,934	6,981
5. Acres in Recreation Capability Classes* (1-4)	1,229	842	441	10,140	317	0	0	465

*For area within a one-mile distance around the site boundaries (plant island and ash ponds).
**Unsurveyed by C L I; judged to be unsuitable for agriculture because of topographic restraints and current developments.
***Forest interspersed with open grassland (T_1K and T_2K) assigned a value of 75% pure forest (T_1 - T_2).

c) Native Indians: the numerical index reflective of this criterion is greater at the Mine Mouth and Harry Lake site areas and least at the Stave Lake and Britannia Beach site areas.

d) Agriculture Capability Class: whereas the Harry Lake and Britannia Beach site areas incorporate no areas designated in Agriculture Capability Classes of concern, all other site areas include from about 1300 to 7000 acres of such lands.

e) Recreation Capability Class: whereas the Harry Lake and Big Bar site areas affect no lands considered in this criterion, the Ashcroft site area affects over 10,000 acres of potential recreational lands. Other site areas affect between about 300 and 1229 acres of potential recreational lands.

7.4.2 Ordering of Criteria By Sites

In order to identify the relative importance of the various criteria at a particular site, a "forced decision" methodology was used as described in Chapter One of the report. The results of these evaluations are presented on Table 7-2 in summary form and have been used in the concensus decision analysis discussed in Chapter One of the report.

In order to facilitate interpretation of the data presented in Table 7-2, the following examples are given.

TABLE 7 - 2

LAND USE

ORDERING OF CRITERIA AT EACH SITE

Criterion	Dunsmuir	Britannia Beach	Stave Lake	Asncroft	Mine Mouth	Harry Lake	Big Bar	Soda Creek
Viewshed	1	1	1	4	2	2	1	1
Productive Forest	4	3	3	5	4	4	3	4
Agriculture Capability	5	5	5	3	5	5	5	5
Recreation Capability	2	4	2	2	3	3	4	3
Native Indians	3	2	4	1	1	1	2	2

Key

1 = Most Important

5 = Least Important

Example 1: At Stave Lake, viewshed has been determined to be the most important criterion from the land use viewpoint, whereas agricultural capability has been determined to be least important.

Example 2: At Ashcroft, productive forest has been determined to be the least important criterion whereas Native Reserves has been determined to be the most important land use criterion.

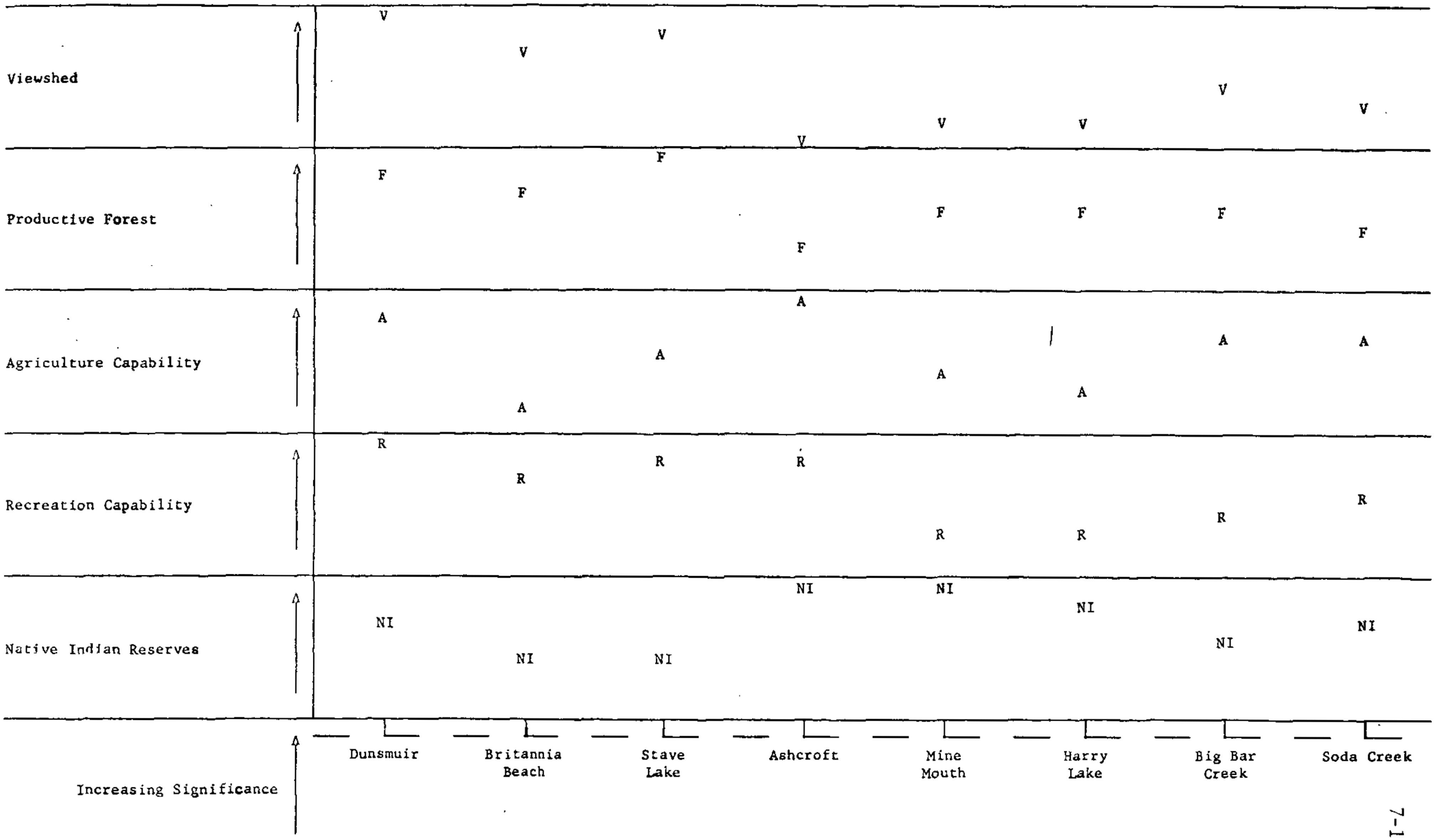
7.4.3 Ordering Of Sites By Criteria

The "forced decision" methodology was also applied to determine an ordering from the site with the most significant impact to the site with the least significant impact for each criterion. The results of these evaluations are shown in Table 7-3. In brief, the results are as follows:

a) Viewshed: This criterion was judged to be most important at the Dunsmuir site because of the extensive area from which the plant would probably be seen; the number of viewers who would see it from the Strait of Georgia; and the largely unspoiled, scenic character of the site location. Conflict with viewshed is least important at Ashcroft because the viewshed itself is not extensive, it would not be viewed by many people, and the site itself is not considered to have any significant intrinsic scenic quality. The impact on aesthetics is generally more significant at the coastal sites than at the inland sites because the cost is a more populated area and more highly recreation-oriented.

TABLE 7 - 3

SIGNIFICANCE OF CRITERIA AMONG SITES



b) Productive Forest: This criterion was judged to be most important at the Stave Lake site largely because of the extent of productive, commercially significant forest which may be affected by the construction and operation of a thermal generating station. Coastal sites generally had more extensive and denser growths of timber than the inland sites. The Ashcroft site had the least amount of forested land.

c) Agriculture Capability: Agriculture capability was judged to be most important at the Ashcroft site primarily because it had the largest acreage of all the sites in current agricultural production. This criterion is least important at the Britannia Beach site because of the industrial uses already present there, and the constraints of slope. Agriculture capability at all other sites is generally judged to be insignificant.

d) Recreation Capability: The Dunsmuir site was judged to have the most conflict with recreation because of the large construction of organized recreation areas within ten miles of the site, and the overall "recreation character" of Vancouver Island. Recreation capability is least important at Harry Lake and Mine Mouth because of the remoteness of these sites from users, and the fact that the presence of a mine would inherently curtail the capability for outdoor recreation in the area.

e) Native Indian Reserves: This criterion was judged to be most important at the Ashcroft and Mine Mouth sites because of the close proximity of these sites and ancillary services (access roads) to populated Reserves. The Stave Lake and Britannia Beach sites were judged to have the least impact on Native Indians, although all of the sites may have some impact on Reserves because of the coal railroad to be constructed in the vicinity of Reserves in the Hat Creek Valley.

7.4.4 Site Ranking

The order of sites from most to least preferred is as follows:

1. Soda Creek
2. Harry Lake
3. Ashcroft
4. Mine Mouth
5. Big Bar Creek
6. Britannia Beach
7. Stave Lake
8. Dunsmuir

7.5 DISCUSSION AND CONCLUSIONS

7.5.1 Regional Aspects

The following is a brief overview of land uses on a regional level.

7.5.1.1 Aesthetics

Scenery varies considerably within British Columbia. The coastal areas are characterized by high jagged, tree-covered mountains rising above the waters of the Strait of Georgia. Within the Strait, vistas are easily accessible to viewers from ferries, steamers, and several coastal highways.

Heavily forested, mountainous terrain is also characteristic of the area surrounding the lower Fraser Valley. The scenery at the edges of the Valley is comparable to that in the immediate coastal areas, especially along the shores of lakes.

In the Interior, where rainfall is sparse, the land cover varies from grasslands to large open areas with scrubby vegetation and exposed soil. Tree cover is dense only in the higher altitudes. Fraser Canyon forms a spectacular, if barren and rocky, drop to the Fraser River. To the north, at Soda Creek, rainfall is greater, resulting in a denser growth of trees. Numerous lakes and rivers add to the scenic quality of the terrain near Soda Creek.

7.5.1.2 Forestry

British Columbia's extensive forest resources have been a significant factor in the economic growth of the Province. The primary and secondary forest industries form the most important provincial industrial sector. In 1973, nine percent of the employed labor force in the Province was utilized in the forestry industries, and the exports of British Columbia forest products were valued at $2.29 billion.[3] The British Columbia Forest Service estimates that provincial forest land amounts to 134.1 million acres, or 58 percent of British Columbia's total area of approximately 230 million acres.[3] Mature forest comprises 47 percent of this forest land, of which approximately 97 percent is softwood. Ninety-five percent of the forest land is publicly owned and managed by the British Columbia Forest Service. Private interests own four percent of the forest land and federal interests control the balance.[3] Practically the entire interior forest is publicly owned, with a large portion of the privately leased or licensed forests being concentrated on the coast.[4]

In 1973, the interior forest accounted for the larger portion of the Province's annual forest harvest,(53.3 percent from the Interior compared to 46.7 percent from the coast).[4]

For provincial administration and management purposes, the Province has been divided into six forest districts, and the study area falls within three of these districts. The coastal sites are within the Vancouver Forest District and the interior sites are within the Cariboo and Kamloops Forest Districts.

7.5.1.3 Agriculture

Agricultural development in British Columbia has been restricted by the physical and climatic characteristics of the Province, with crop cultivation limited to arable lands along the river valleys. The Lower Mainland-Vancouver Island area yields the bulk of provincial output of dairy products, berry crops, vegetables, poultry and eggs. The three coastal sites under consideration in this study, however, do not include agricultural lands. The Central Interior design is the centre of the beef industry, with portions of the Hat Creek Valley being devoted to pasture and grazing land.

Hay farms or ranches are located in the vicinity of Ashcroft, Cache Creek, and eastward along the Thompson River through Kamloops. These farms produce hay and alfalfa almost exclusively and ship large quantities to the coast for sale. The Thompson Valley near Ashcroft is also a producer of potato crops, although in general, cattle ranching is the predominant agricultural use in the area.[5]

7.5.1.4 Recreation

British Columbia is renowned for its spectacular scenery and plentiful stocks of fish and game. Among the more popular activities in the Province are boating, camping, hunting, fishing and skiing. In general, and in terms of relative usage the coastal region is more popular from the recreational standpoint than the inland region. Vancouver Island alone has 43 provincial parks. Whereas the availability of salt water fishing and boating add to the popularily of the coastal region, an important factor limiting the recreational potential of the inland region is the poor accessibility to forested areas and lakes.

7.5.1.5 Native Indians

The 1971 Census of Canada shows a total of 295,215 Native Indians in Canada, including both registered* (231,000) and non-registered (64,000) people. The combination of Native Indians and Eskimos (Inuit peoples) represents almost two percent of Canada's population.[4] The Canadian Native Indian population is comprised of 565 Bands that occupy or have access to some 2,200 reserves having a combined area of about 6.3 million acres.[4]

In British Columbia, there are a total of 192 Indian Bands with a total population of 50,973.[4] In 1973, 33,339 members of bands lived on reserves, 17,200 lived off reserves, and 434 lived on Crown land.

In the Central Region of British Columbia, there were approximately 5,400 registered Native Indians on reserves in 1971, comprising about 2.6 percent of the regional population, and a substantial number (unknown) off reserves. It is estimated that there are equivalent numbers of non-registered Native Indians in the region. About 60 percent of the registered Native Indians live in the southern part of the region, particularly near Kamloops, Merritt, Ashcroft, and Lytton. Less than 4 percent of the registered Native Indians on reserves live in the northern part of the region, and the remaining 36 percent live in the Cariboo-Chilcotin area.[6]

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* Persons registered as Indians by the Department of Indian Affairs and Northern Development. These are persons who are entitled to be so registered in accordance with the terms of the Indian Act.[4]

7.5.2 Site Specific Aspects

This section is a discussion of each site based on consideration of the land use criteria. Separate sections dealing with archeological and other concerns are also included.

Table 7-4 presents a summary of the CLI present land use categories for the study area at each site.

7.5.2.1 Dunsmuir

7.5.2.1.1 Viewshed

The Dunsmuir site is situated in a low-lying coastal area which is essentially rural in character. Vancouver Island proper has experienced intensive recreational development and attracts many tourists because of its unique scenery. The viewshed at the Dunsmuir site is quite extensive. The plant would be visible from the Strait of Georgia, particularly from the Strait of Georgia Steamer and the Nanaimo ferries, which carry large numbers of tourists. However, because of the dense forest inland, a plant would probably not be visible from Route 19, which is approximately 0.6 miles to the east of the site. The annual average daily traffic count (AADT) on this road in 1973 was 8200 at Qualicum River.

A secondary aesthetic impact associated with development of any of the coastal sites would be the coal transport railroad to be constructed through Marble Canyon Provincial Park. This highly scenic park had a recorded user figure of 8692 camper nights in 1974.

TABLE 7 - 4

Summary of Land Use within One Mile of All Sites

Site	CLI Category	Approx. Acres*	Percent of Total
Dunsmuir	T_1	1,170	14.3
	T_2	6,526	79.7
	P_1	26	.2
	B	234	2.9
	Other	234	2.9
	Total	8,190	100.0%
Britannia Beach	T_1	260	12.4
	T_2	1,352	64.2
	B	182	8.6
	Other	312	14.8
	Total	2,106	100.0
Stave Lake	T_1	2,106	24.0
	T_2	4,446	50.4
	P_1	26	.3
	B	52	0.6
	Other	2,184	24.7
	Total	8,814	100.0
Ashcroft	T_1K	0	0.0
	T_2K	572	5.6
	P_1	754	7.4
	Other**	8,814	87.0
	Total	10,140	100.0
Mine Mouth	T_1K	832	13.1
	T_2K	3,588	56.7
	Other	1,910	30.2
	Total	6,330	100.0

(continued on next page)

TABLE 7-4 (Cont'd)

Summary of Land Use Within One Mile of All Sites

Site	CLI Category	Approx. Acres*	Percent of Total
Harry Lake	T_1K	1,196	12.1
	T_2K	3,900	39.5
	Other**	4,786	48.4
	Total	9,882	100.0
Big Bar Cr.	T_1K	2,444	27.2
	T_2K	624	7.0
	P_1	26	.3
	B	26	.3
	Other**	5,850	65.2
	Total	8,970	100.00
Soda Cr.	T_1K	3,978	42.7
	T_2K	2,106	22.6
	P_1	52	.6
	B	52	.6
	Other	3,120	33.5
	Total	9,308	100.00

Key: T_1 = Mature productive woodland
T_2 = Immature productive woodland
T_1K= Mature productive woodland and open grassland
T_2K= Immature productive woodland and open grassland
P_1 = 75.0 - 94.9% improved posture and forage crops
B = Built-up areas
Other = Open grassland, non-productive woodland, sandflats, swamp, rock, water.

*Based on one mile radius around sites
**Primarily open grassland

Construction and operation of this rail line would present an adverse impact on the aesthetic resources of the Canyon.

7.5.2.1.2 Productive Forest

The majority of the land within one mile of the Dunsmuir site is heavily forested. About 14.3 percent, or approximately 1,170 acres, is mature productive forest. About 80 percent, or approximately 6,526 acres, is immature productive forest, which translates into a high forestry capability. The forest is primarily second growth Douglas fir near harvestable size, and would therefore have significant commercial value. In terms of forestry, the Dunsmuir Site has a low compatibility with a power plant.

7.5.2.1.3 Agriculture Capability

Approximately 4,914 acres, or 60 percent of the study area falls within agriculture capability Classes 1 through 4. The highest class at this site is 2, but this encompasses only 5 percent of the area. In general, agricultural capability at this site is reduced due to soil characteristics. Approximately 27 acres, or 0.2 percent of the area considered by this criterion are classified by the CLI Land Use map as being in current agricultural use, and approximately 30 percent of the site proper is within the Agricultural Land Reserve. Neither of these aspects was judged to add particular significance to the agriculture capability at this site. A thermal generating station would pose few conflicts with agricultural land use at the Dunsmuir site.

7.5.2.1.4 Recreation Capability

Approximately 1,229 acres, or 15 percent of the area within a one mile distance of the Dunsmuir site boundaries are categorized by the CLK as being in the four highest recreation capability classes. Ten percent of this area is designated Class 2, with the main recreational features being beach and boating use. In addition, four provincial parks are located within ten miles of the Dunsmuir site. Little Qualicum Falls is approximately four miles distant, and Cameron Lake, Beaufort, and Macmillan are, respectively, five, seven and nine miles distant. The combination of Little Qualicum Falls, Cameron Lake and Beaufort represents 1,098 acres whereas, MacMillan Park consists of 337 acres. These parks offer camping, picnicking and scenic trails. In 1975 there were 20,520 day visits to MacMillan Park, 42,698 visits to Cameron Lake, 2,184 visits to Beaufort.[8]

A secondary impact on recreation would be associated with the coal railroad line in the vicinity of Marble Canyon Provincial Park, near the Hat Creek coal deposits. Coal trains passing through this area would have significant detrimental impact on use of this park.

7.5.2.1.5 Native Indians

The Qualicum Indian Reserve is located within approximately two miles of the Dunsmuir site at the mouth of the Qualicum River. Latest population estimates indicate that there are 38 Indians living on this Reserve.[9]

A thermal generating station at this location would also require construction of a railroad in the vicinity of Hat Creek to connect the mine with the British Columbia Railroad. This line would pass near, and possibly through, Indian Reserve land. Due to the proximity of the generating station and the proposed railroad line to populated Reserve land, this site is considered to have a moderately low compatibility with generating station development.

7.5.2.2. Britannia Beach

7.5.2.2.1 Viewshed

The Britannia Beach site has a moderately extensive viewshed of 78 square miles. The thermal generating plant facilities (stack and associated plume) would be visible from upper Howe Sound, which is surrounded by high mountains and is considered to be a scenic area. However, nearby industrial uses such as the pulp plant in Woodfibre reduce the intrinsically scenic value of the area. Plant facilities would not be visible from the exceptionally scenic lower Howe Sound.

Travelers on nearby Route 99 would be able to observe the plant, but only for a short distance because of the curvature of the coastline. The 1973 AADT count for this highway is 4,500.

Although the aesthetic impact of a thermal generating station at this site would be modified by the existing industrial uses cited above, impact would still be significant because of the intrinsic scenic quality of the area.

7.5.2.2.2 Productive Forest

About 77 percent of the land area within one mile of the Britannia Beach site is forested. According to CLI maps, approximately 260 acres, or 12.4 percent of the total, consist of mature productive forest; and about 1,352 acres, or 64.2 percent of the total, consist of immature productive forest. This is predominantly second growth forest of Red Alder, Douglas fir, and Western Hemlock. In terms of forestry resources, the Britannia Beach site is considered to be of moderately low compatibility with a power plant development.

7.5.2.2.3 Agriculture Capability

Agriculture capability of the area around the Britannia Beach site was not surveyed by the CLI. Because the site area has been used as a gravel pit and most of the adjacent land is excessively steep, agriculture capability is judged to be poor. There is no existing agricultural use within one mile of the site. Compatibility with a power plant, in terms of agriculture, is therefore high.

7.5.2.2.4 Recreation Capability

Approximately 40 percent, or 842 acres, of the recreation study area falls within recreation capability Class 4. The majority of the area is in Class 6, which is low capability for outdoor recreation. In addition, there are no known organized recreation areas within ten miles of the Britannia Beach site. A thermal generating station at this site would have a secondary impact on recreation in the form of a new railroad line for coal deliveries that would pass through Marble Canyon Provincial Park. A thermal generating station at this site is judged to be moderately compatible with recreation capability.

7.5.2.2.5 Native Indian Reserves

There are no Indian Reserves within ten miles of the Britannia Beach site. However, additional railroad lines and roads would have to be constructed in proximity to or through Reserves near Hat Creek in order to transport coal to and fly ash from the station this site is considered to be only moderately compatible with thermal generating station development.

7.5.2.3 Stave Lake

7.5.2.3.1 Viewshed

The viewshed at Stave Lake totals 44.7 square miles. In terms of viewers, the site proper is relatively inaccessible. Roads in the immediate area of the site are unpaved and are used primarily by local traffic. The nearest major highway is Route 7 approximately 12 miles distant. Davis Lake Park, a 474 acre recreation area, is one mile away, but is largely undeveloped and inaccessible to users. Visibility of the thermal generating station facilities from the park would be limited due to screening by extensive tree cover.

There is one important qualitative factor which greatly adds to the significance of an aesthetic impact at this site - the exceptional physical beauty of the site area. High mountains encircle Stave Lake, and the nearby areas are heavily forested. A thermal generating station at this site would constitute a major intrusion upon uniquely scenic, undeveloped surroundings.

7.5.2.3.2 . Productive Forest

Approximately 74 percent of the land area within one mile of the Stave Lake Site is forested. The area has been logged in the past and the second growth forest is nearing harvestable size. According to the CLI maps, approximately 2,106 acres, or 24 percent of the area within one mile of the site is mature productive forest. Approximately 4,446 acres, or 50 percent, is immature productive forest. This largely coniferous forest is composed of Douglas fir, western hemlock, and occasional western cedar. In terms of forest resources, therefore, the Stave Lake site is considered to be relatively incompatible with a thermal generating station.

7.5.2.3.3 Agriculture Capability

Approximately 3,526 acres, or 40 percent, of the agriculture study area fall within the first four agriculture capability classes. Approximately 15 percent is in Class 3 and 25 percent is in Class 4. In general, agriculture capability at this site is in the Agricultural Land Reserve, existing agricultural use (approximately 25 acres) is not considered to be significant. A thermal generating station would not pose significant conflicts with agricultural land use.

7.5.2.3.4 Recreation Capability

Five percent, or approximately 441 acres, of the recreation study area is in recreation capability Class 3. The majority of the site is considered by the CLI to have poor capability for outdoor recreation, possibly due to the poor accessibility. This area was judged to have good recreational potential because of its unique, scenic character. Also, Davis Lake Park is located within one mile of the site. At the present time, this 474 acre park has limited facilities, but could be developed in the future. A thermal generating station at the Stave Lake site was judged to be somewhat incompatible with the recreation capability of the area.

7.5.2.3.5 Native Indians

Although there are no Native Indian Reserves within ten miles of the site, thermal generating station development at this site would entail construction of railroad lines adjacent to or through Reserves in the Hat Creek Valley. The potential for impact on Native Indians would exist.

7.5.2.4. Ashcroft

7.5.2.4.1 Viewshed

The viewshed at the Ashcroft site (31.14 square miles) is moderately extensive. Plant facilities would be largely hidden from view from Highway 1, which is approximately one mile distant. Because this is the only major highway in the area, conflict would be minimal. The plant may be visible from a local road east of the Thompson River, but AADT's on this road are low and would not result in serious aesthetic conflicts.

The intrinsic visual value of the site area is not considered to be high because it is in a barren, dry portion of the Thompson River Valley. Industrial uses are already present in nearby Ashcroft. For these reasons, this site is considered to be aesthetically compatible with thermal generating station development.

7.5.2.4.2 Productive Forest

Only 5.6 percent, or approximately 572 acres, of the area within one mile of the Ashcroft site falls within the CLI category of T_2K, or immature productive woodland interspersed with open grassland. The Ponderosa Pine forest in the area is sparse, relatively small, and not commercially significant.

In terms of forestry, this site is considered to be highly compatible with a thermal generating station.

7.5.2.4.3 Agriculture Capability

Approximately 7605 acres, or 40 percent, of the agriculture study area at the Ashcroft site are within the first four CLI agriculture capability classes. Twenty-five percent is in Class 1, 10 percent is in Class 2, and 5 percent is in Class 3. In addition, approximately 7.4 percent, or 754 acres, of this area is classified on the CLI mpa as being used for improved pasture and forage crops. Site reconnaissance has revealed that range land and alfalfa occupy nearly all of the level land at the Ashcroft site. All of the plant site is located on Agricultural Reserve Land. In terms of agriculture, this site was judged to have only a moderately low compatibility with a thermal generating station.

7.5.2.4.4 Recreation Capability

This site was rated by the CLI as having a moderately high recreation capability. One hundred percent, or approximately 10,140 acres, within the one-mile study distance is within recreation capability Classes 3 and 4. Eighty-five percent is in Class 3, and 15 percent in

Class 4. This rating can be attributed primarily to good fishing potential in the nearby Thompson River. However, there are no organized recreation areas of more than local significance within ten miles of the Ashcroft site. Due to the high CLI rating, a thermal generating station at this site was judged to be incompatible with recreational uses.

7.5.2.4.5 Native Indians

There are two Indian Bands occupying a total of 12 separate Indian Reserves within 10 miles of the Ashcroft site. Only three of these Reserves are known to be populated, with a total of approximately 50 inhabitants.[9] In addition to the number and proximity of these reserves to the site, the use of adjacent roads for the transport of materials and labor increases the likelihood of an adverse impact on the Indian Bands. Another consideration is the required coal railroad from the mine which would affect the Indian Reserves in the Hat Creek area.

7.5.2.5 Mine Mouth

7.5.2.5.1 Viewshed

The viewshed at the Mine Mouth site (12.5 square miles) is not extensive. Station facilities would probably be seen from Highway 12, which leads to Marble Canyon Provincial Park. However, the 1973 AADT count for this road was only 560 vehicles.[7] The scenery in the Hat Creek Valley is pleasant, but is expected to be heavily impacted by the presence of the mine. A thermal generating station at this site would not have a significant adverse aesthetic impact.

7.5.2.5.2 Productive Forest

The Mine Mouth site has been logged in the past and second growth Douglas fir and ponderosa pine is being selectively cut. According to the CLI map, approximately 832 acres, or 13.1 percent, of the area within one mile of the site is mature productive woodland, interspersed with open grassland. An additional 3,588 acres, or 56.7 percent, of this area is in the category of immature productive woodland interspersed with grassland. In terms of forestry, this site is judged to be moderately compatible with a thermal generating station.

7.5.2.5.3 Agriculture Capability

Agriculture capability at the Mine Mouth site is moderately low, primarily due to the lack of moisture, the length of the growing season, and the constraints of slope. Twenty percent of the agriculture study area, or approximately 1,266 acres, are within capability Classes 3 and 4. According to the CLI land use map, there is no existing agricultural use (improved pasture) within one mile of the site, although there may be cattle grazing in grasslands near the site. Approximately 70 percent of the plant site is located within the Agricultural Land Reserve. Because a mine will constitute the primary future land use in the immediate area, there should be no significant conflicts with potential agricultural uses.

7.5.2.5.4 Recreation

Five percent, or approximately 317 acres, of the area defined by the recreation criterion is categorized by the CLI as Class 4 capability for outdoor recreation. In general, recreational capability at this site is moderately low. This capability is further reduced by the anticipated presence of the coal mine. A qualifying factor, however, is the presence of Marble Canyon Provincial Park 5 miles to the northwest of the proposed site. The park encompasses 827 acres. In 1974 it had a recorded use of 8,692 camper nights.[8] Although the park is outside of the viewshed for a thermal generating station at this site, increased traffic congestion associated with construction may result in an indirect impact on the use of the park. In addition, the influx of construction workers and their families to the region may place greater pressure on park facilities. A thermal generating station at this site is judged to be moderately compatible with recreation in the area.

7.5.2.5.5 Native Indians

There are eight Native Indian Reserves within 10 miles of the Mine Mouth site. They are occupied by the Pavilion or Bonaparte Indian Bands. The population of these Reserves is slightly over 200.[9] The nearest populated Reserve is one mile distant. Roads that may be used for access of construction workers and materials to the site are also adjacent to several of these Reserves. The compatibility of a thermal generating station with Native Indian Reserves is moderately low. Alternative access through Medicine Creek Valley would make this site more compatible.

7.5.2.6 Harry Lake

7.5.2.6.1 Viewshed

The viewshed at Harry Lake is 8.87 square miles. The plant facilities would probably be seen from Highway 12 by tourists on their way to Marble Canyon Provincial Park. The 1973 AADT count for this road was only 560 vehicles. The pleasant scenery at this site will not be as heavily affected by the presence of the mine as will the Mine Mouth site. Because of poor access to the area and its remoteness from populated areas, a thermal generating station at this site would not have a adverse aesthetic impact.

7.5.2.6.2 Productive Forest

Approximately 56 percent of the area within a one mile distance of the Harry Lake site is classified on the CLI map as woodland interspersed with open grassland. Of this, approximately 1,196 acres or 12 percent, is mature productive woodland. 3,900 acres, or 39.5 percent, is immature productive woodland. The woodland consists principally of douglas fir and ponderosa pine, with patches of aspen and cottonwood. Selective logging operations in the vicinity of the site indicate the commercial viability of forestry in the area. A thermal generating station is judged to be moderately compatible with forestry at this site.

7.5.2.6.3 Agriculture Capability

The agriculture capability of this site was the lowest of all the sites, due to slope and moisture constraints. No area within a one-mile distance falls within the first four CLI agriculture capability classes. In fact, approximately 70 percent of this area is in Class 7, which is the lowest capability. According to the CLI land use map, there is no existing agriculture (improved pastureland) within one mile of the site, although there may be cattle grazing in the grasslands area. Approximately 27 percent of the total site area is Agricultural Reserve land. A thermal generating station at this site would not pose conflicts with agricultural use.

7.5.2.6.4 Recreation Capability

In general, this area has a moderately low capability for outdoor recreation. No area within a one mile radius of the Harry Lake site falls within the first four CLI recreation capability classes. Marble Canyon Provincial Park is located approximately six miles to the northwest of the site.

7.5.2.6.5 Native Indians

A Reserve of the Bonaparte Band is approximately 3.5 miles distant. There are seven other Indian Reserves within 10 miles of the site, with a total population of approximately 200. The compatability of a thermal generating station with these reserves is judged to be moderately low, although it is somewhat better than at the Mine Mouth site.

7.5.2.7 Big Bar Creek

7.5.2.7.1 Viewshed

The Big Bar site has a fairly extensive viewshed (49.98 square miles). There are two opposing aesthetic concerns at this site. One factor which is valuable for the siting of a power plant, is the fact that the area is quite inaccessible. The nearest major highway is Route 97, about 25 miles away. The other factor, which is unfavorable, is that the site is situated in an area of unique landforms. It is poised high above Fraser River Canyon, a spectacular, if dry and barren, gorge. The area has a significant aesthetic value because of the unique and breathtaking scale of the Fraser Canyon. This factor took precedence in rating the compatibility of a power plant at this site, which is judged to be low.

7.5.2.7.2 Productive Forest

Approximately 2,444 acres, or 27.2 percent, of the area within a one mile radius of the Big Bar Creek site are classified by the CLI land use map as mature productive woodland interspersed with open grassland. About 624 acres, or approximately 7 percent of this area are classified as immature productive woodland interspersed with grassland. The forest is primarily Douglas fir of commerical size. Some selective logging has occurred. The forestry compatibility of this site with a thermal generating station is moderate.

7.5.2.7.3 Agriculture Capability

The capability for agriculture at the Big Bar Creek site is limited due to the constraints of slope and moisture and the rocky nature of the soil. Fifty-five percent, or 4934 acres, of the area within one mile of the site is Agriculture Capabiltiy Class 4. According to the CLI land use map, approximately 0.3 percent, or 26 acres, of this area is devoted to agriculture in the form of pasture and forage crops. All of the plant site itself is located on Agricultural Reserve Land. A thermal generating station at this site would not conflict with agricultural uses at this site because agriculture capability is of no great significance.

7.5.2.7.4 Recreation Capability

Although it has a uniquely scenic character, the area within one mile of the site was given a moderately low recreation capability rating by CLI, probably due to poor access to the area. None of the area falls within the first four recreation capability classes. There are no organized recreational areas within 10 miles of the Big Bar Creek site. A thermal generating station at this site therefore would pose no conflicts with recreation capability at this site.

7.5.2.7.5 Native Indians

The High Bar Indian Band occupies one of four reserves located eight miles from the proposed Big Bar Creek site. A 1976 population survey estimated that a total of 3 Indians live on these reserves.[9] A new railroad line required to supply coal to the proposed station would be situated adjacent to or through Indian Reserves east of Hat Creek. This would constitute the only significant impact on Native Indians. The compatability of a thermal generating station at this site with Native Indian Reserves is judged to be moderate.

7.5.2.8 Soda Creek

7.5.2.8.1 Viewshed

The viewshed at the Soda Creek site is 13.10 square miles. The site is situated on a plateau overlooking the Fraser River, with a surrounding area that is hilly and rural in character. The site was judged to have good scenic value. Due to its elevation, the Soda Creek site would be highly visible from Route 97, the major access road for tourists traveling north. The 1973 AADT count for Route 97 was 380.[7] In addition, the site would probably be visible from across McLeese Lake, a pleasant visual attribute adjacent to Route 97, northeast of the site. Several nearby residences also fall within the viewshed. These dwellings are located in the Fraser River Valley below the plateau on which the thermal generating station would be located. A station at this site is judged to have a moderately low aesthetic compatibility.

7.5.2.8.2 Productive Forest

According to the CLI land use maps, approximately 3,978 acres, or 42.7 percent of the area within one mile of the Soda Creek site, are classified as mature productive woodland interspersed with open grassland. Another 2,106 acres, or approximately 22.6 percent of this area, are classified as immature productive woodland interspersed with grassland. The forest is predominantly second growth Douglas fir, which has been logged in the past and is presently being selectively logged. In terms of forestry, this site was judged to be only moderately compatible with a thermal generating station.

7.5.2.8.3 Agriculture Capability

Approximately 6,981 acres, or 75 percent, of the area within one mile of the Soda Creek site are in CLI agriculture capability Class 4. According to the CLI land use map, approximately 0.6 percent of the area, or 52 acres, is devoted to pasture and forage crops. All of the site proper is located on Agricultural Reserve Land. In general, agricultural capability is limited by topography and the rocky nature of the soil. A thermal generating station should pose no major conflicts with agricultural use of this site.

7.5,2.8.4 Recreation Capability

Recreation capability at this site is rated by the CLI as being moderately low. Only five percent of the site, or 465 acres, is in Class 4 capability for outdoor recreation. There is a potential for sportfishing at nearby McLeese Lake and in the Fraser River, although it is not exceptionally high. There are no organized recreational areas within a ten mile distance of the site. In general, a thermal generating station at this site will not result in any significant conflicts with recreational use in the area.

7.5.2.8.5 Native Indians

The Soda Creek Indian Band inhabits one Reserve that is located approximately four miles south of the Soda Creek site, within viewing distance. The 1976 population estimate for this Reserve is 75.[9] The construction of a railroad line to transport coal from the mine is expected to affect the Reserves to the east of Hat Creek. For these reasons, as well as the proximity of Reserve land to possible access routes (Route 97), this site has a moderately low compatibility for a thermal generating station with regard to effects on Native Indians.

7.5.3 Other considerations

In addition to the land uses previously described, certain other land uses within a one mile radius of each site were examined. The results of this examination are as follows:

Based upon the generalized one mile distance survey, residential uses at the Dunsmuir site comprise approximately 234 acres, or 3 percent of total land use. These consist primarily of residences and cottages along the coast. This site has the largest concentration of adjacent "Built-up-Area" (residential) of all the sites.

At Britannia Beach, industrial use of the site and adjacent areas is already taking place. The site is located on a gravel pit. A semi-active mine is nearby, and a pulp mill is located across Howe Sound. Due to the presence of these industrial uses, it is believed that a thermal generating station at this site would be relatively compatible with existing land use.

According to the CLI land use map, approximately 0.3 percent of the study area at the Big Bar Creek site is classified as a "Built-up-Area" and contains several ranch homes and farm houses. Approximately 0.6 per cent of the study area at the Soda Creek site is also classified as "Built-up-Area" and is known to include individual farm residences. There are no known residential uses on the site proper. A thermal generating station should not result in a significant conflict with these land uses.

7.5.4 Archaeological Considerations

Human occupation of British Columbia for a period in excess of 12,000 years has resulted in the occurrence of remains of settlement and activity. These remains are not expected to be located randomly within the Province but would be located in respect to evolving patterns of economic and social adaptation. Since the time of initial settlement, and in congruence with the evolving climate and landscape, the inhabitants adapted to coastal and interior cycles of resource availability.

Although no detailed archaeological analysis has been performed for this study, preliminary investigations indicate that any of the alternate sites under consideration could be potential locations of archaeological finds. However, no site exclusionary information has been identified. Therefore, it is recommended that an archaeological survey be undertaken at the site selected from the multidisciplinary study in order to assure proper management of the archaeological resources of the Province.

7.5.5 Conclusions

Based on the results of the land use study, it is concluded that:

a) The Soda Creek site be considered as the preferred site for development of a thermal generating station. The overall land use impacts would be moderate, with no major land use conflict.

b) Other considerations such as archeology, marginal industrial and residential development, etc., as studied thus far, do not indicate that development at any of the sites is precluded.

Based on these conclusions, it is recommended that:

a) The Soda Creek site be adopted as the preferred site from the land use viewpoint and that,

b) the site selected as preferred from the multidisciplinary evaluation be subjected to detailed archeological evaluation during the site specific environmental assessment phase.

CLI = Canada Land Inventory

The CLI was undertaken by the Evaluation and Mapping Branch of the Lands Directorate of the Department of the Environment. Under federal-provincial agreement, all settled lands of Canada have been classified according to their existing land uses, as well as their capabilities for agriculture, forestry, recreation and wildlife. These data are used for land-use planning by the Province at the regional level.

B = CLI land use classification meaning "Built-up-Areaa" - residential and/or industrial.

T_1 = CLI land use classification meaning mature productive forest.

T_2 = CLI land use classification meaning immature productive forest.

T_1K = CLI land use classification meaning mature productive forest interspersed with open grassland.

T_2K = CLI land use classification meaning immature productive forest interspersed with open grassland.

Viewshed = "Viewshed" is used in this study as a quantitative measure of aesthetic considerations. This term is a measure of the size of the area from which a power plant can be seen.

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8. SOCIOECONOMICS

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8.1 SUMMARY

The development of a 2,000 MW thermal generating station burning Hat Creek coal would significantly affect the socioeconomy of the population in the site vicinity. The magnitude of these effects was evaluated qualitatively and quantitatively in regional and site-specific analyses. Both beneficial and adverse factors were used to establish the preferred site order.

On the basis of socioeconomic criteria, Mine Mouth, Harry Lake and Ashcroft were preferred sites. Advantages associated with these sites include: the large labor pool, minimal impact on the human population, adequate housing (assuming a construction camp and reasonable dispersion of the plant workers among residential areas), and a strong fiscal base in the regional district.

The mining of Hat Creek coal and the construction and operation of a thermal generating plant would benefit economic development of the interior region of British Columbia. Stimulation of local income, employment and industrial diversification would attract secondary industry to the area. The project would provide tax benefits, add to the existing regional infrastructure, and promote economic linkages between the lower mainland and the interior of the Province.

8.2 INTRODUCTION

8.2.1 Purpose

The construction and operation of 2,000 MW thermal generating station burning Hat Creek coal would have significant effects on the social and economic well being of the people located in the vicinity of the project. The primary effects would include income/tax benefits, and costs to the potential infrastructure and lifestyle dislocation associated with construction and operation of the project. The purpose of this study is to evaluate and rank alternative generating station sites, based on the evaluation of explicit social and economic variables.

8.2.2 Scope

The study considers eight alternative generating station sites located in southwestern British Columbia. It consists of a regional overview and site specific application of quantitative and qualitative criteria, which aid in the determination of a preferential ordering of the eight sites. The evaluation process takes into consideration both beneficial and adverse factors as integral parts.

The thermal generating station was considered as an economic unit utilizing labor, capital and materials to produce electricity. Thus, the ranking of alternative sites, from a socio-economic standpoint, was based on an evaluation of the beneficial and adverse impacts associated with this development process. The four criteria used in the evaluation procedure were: impacts on housing, impacts on local population, impacts on municipal government structures and availability of a local labor force. The quantitative measures used to evaluate these criteria at each site included: the number of housing units in the regional district, the population density in the vicinity of the site, the ratio of total debenture debt to total taxable assessment in the regional district and the number of construction workers in the vicinity of each site.

8.3 METHODS AND MATERIALS

8.3.1 Data Base

Relevant departmental agencies from both the B. C. Provincial and Federal Governments were contacted for information. Many of the agencies were able to provide studies complete with statistical analyses. A complete list of those agencies contacted for information is provided in an appendix to this section.

In addition, responsible officials from agencies within the Department of Municipal Affairs, and from the local municipal governments of Clinton, Cache Creek and Ashcroft were interviewed. Site visits were also made to obtain firsthand, site-specific information

8.3.2 Criteria Evaluation

The thermal generating station was considered as an economic unit utilizing labor, capital and materials to produce electricity. Adverse impacts were considered to be by-products of this transformation process. The criteria used in evaluation of the sites were derived from the external effects associated with project activities. The four criteria utilized include: housing, population, municipal government structures, and the availability of a local labor force.

The quantitative measures used to evaluate each site in regard to the four criteria were population density (number of people per square mile in an electoral area), the absolute number of dwelling units in a regional district, the number of local construction workers in the local Canada Manpower Centre (CMC), and the ratio of total debenture debt to the total taxable assessment in a regional district.

The measures described above do not adequately represent the broad spectrum of socioeconomic concerns, or, for that matter, the full significance of these concerns. Consequently, the importance of these measures was described through the use of other site-related data.

8.3.2.1 Effects on the Human Population

Local population density is used to measure the degree of impact on the human population that results from the construction and operation of the generating station. A basic assumption utilized in this evaluation is that the population density in the vicinity of a site is inversely proportional to desirability of a site for the location of a generating station.

The quotient obtained, when the population living within the relevant region is divided by the land area, was used to describe the criterion. The data, needed to calculate this quotient, were obtained from the Census of Canada (1971) and the Department of Municipal Affairs, British Columbia.

The importance of this criterion depends upon the absolute level of the population, the population growth rate, and the age and sex distributions of the population. The absolute level of population is important because it quantifies the number if people that might be impacted directly by station activities. In addition, it aids in the identification of bias in the density figure due to the heterogeneity of electoral areas. The population growth rate affects future levels of the population in the vicinity of each site. However, the relative order of population diversities associated with each of the alternative sites could change prior to operation of the facility. The age and sex distributions often reflect the population's work character as well as the relative number of productive individuals.

8.3.2.2 Housing

The rationale for considering housing as a criterion was two-fold: to avoid or minimize adverse impact on the housing markets and to provide an adequate supply of dwelling units for workers during the construction and operation of the station. The absolute number of dwelling units provides an index of the probable availability of housing required during the construction and operation of the generating station.

This criterion was evaluated by first calculating the absolute number of dwelling units. The 1971 Census of Canada statistics for each regional district was the source of the information needed in the calculations. It was assumed that the present number of dwellings in a regional district is inversely related to the impact on the housing market. This assumption includes the potential use of temporary housing facilities during the construction period.

The importance of this criterion at each site is estimated by determining the number of mobile, over-crowded, and owned dwelling units, as a percentage of the total number of dwelling units. Each of these factors were calculated from the Census of Canada Housing Data (1971). The greater percentage of mobile homes in an area was considered to indicate a favorable rating for that area, since many workers and their dependants desire relatively short-term housing. The per cent of crowded dwellings denotes overall housing conditions and potential deficiencies in the existing housing market. A high percentage of crowded housing indicated that an area should be down-rated for siting purposes. Similarily, a high percentage of private ownership indicates a shortage of rental or other temporary housing.

8.3.2.3 Labor Force

The construction of the generating station will require a sizeable work force and many construction trade skills. The extent of local labor used, is directly related to the employment and income benefits shared by individuals and the local community as a whole.

This criterion was evaluated by listing the number of construction trade workers in the CMC closest to each site. The number of local construction workers is positively related to site suitability.

A greater understanding of the criterion was achieved by examining the absolute number of the labor force, the unemployment and participation rates, and the potential stimulous to employment and income outside the lower Vancouver mainland area. These qualitative factors are positively associated with the suitability of a particular site. The last factor reflects the stated, although not manifested, policy of the Provincial Government to stimulate development in areas other than the already well-developed and economically vigorous Greater Vancouver area.[1]

8.3.2.4 Municipal Affairs

Although local governmental units will sustain project related impacts, it is important that the burden borne by local communities be offset by adequate compensatory measures (taxes and grants in aid). For siting purposes, the existing debt of municipalities is examined in conjunction with its ability to generate funds for public purposes. The greater the fiscal capacity of the governmental unit, relative to its financial commitments, the more able will that governmental unit be to absorb all resource impacts.

This criterion was evaluated at each site by computing the ratio of taxable assessment (mil rate for general purposes) to the total debenture debt (computed on a regional district basis). If the ratio of potential revenues to debt is small, then a great strain is placed upon the municipal system's capacity to service the outstanding indebtedness.

The following measures provide additional insight and significance to the overall quantitative criterion: total debenture debt per capita, assessment taxables for school purposes per head, assessment taxables for general purposes per head, student-teacher ratios, and the number of hospital beds. The first item is an estimate of debt burden, the second and third items are estimates of fiscal capacity, and the last two items are indices of the adequacy of social services.

8.4 RESULTS

8.4.1 Application of Criteria

Quantitative values of socioeconomic criteria are presented in Table 8-1. The least significant impact upon human population would, as indicated in Table 8-1, occur at the Ashcroft, Mine Mouth, Harry Lake, and Big Bar Creek sites, while the greatest impact would occur at the Dunsmuir site. The quantity of dwelling units is greatest in the Thompson-Nicola region (Hat Creek sites), and smallest in the Squamish-Lillooet region (Britannia Beach site) (Table 8-1). The size of the local labor force is largest at the Britannia Beach site and smallest at Dunsmuir. The least impact on municipal affairs would occur at the Hat Creek area sites, and the greatest at Dunsmuir or Britannia Beach (Table 8-1).

8.4.2 Ranking of Criteria

8.4.2.1 Within Sites

The criteria, in order of importance for each site, are listed in Table 8-2. The impact on the human population was minor for the interior sites, but major for the Britannia Beach, Stave Lake and Dunsmuir sites. Housing was determined to be a critical factor at the interior sites, less critical at the Dunsmuir and Britannia Beach sites, and least critical at the Stave Lake site. The labor force criterion is most significant at the Britannia Beach and Stave Lake sites, while the impact on municipal affairs is most significant for the lower mainland sites.

TABLE 8-1

SOCIO ECONOMIC CRITERIA

NUMERICAL VALUES

	Site							
Criteria	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Human Population (Number of People per Square Mile)	7.3	0.98	4.9	0.53	0.53	0.53	0.47	2.47
Housing (Number of Dwelling Units)$^{-1}$	6.55×10^{-5}	2.89×10^{-4}	8.36×10^{-5}	4.97×10^{-5}	4.97×10^{-5}	4.97×10^{-5}	4.97×10^{-5}	9.58×10^{-5}
Labor Force (Number of Construction Workers)$^{-1}$	3.8×10^{-4}	3.28×10^{-5}	2.64×10^{-4}	2.91×10^{-4}	2.91×10^{-4}	2.91×10^{-4}	2.91×10^{-4}	2.41×10^{-4}
Municipal Affairs (Debt - \$ - per Tax Income - \$)	0.17	0.17	0.13	0.09	0.09	0.09	0.09	0.16

TABLE 8-2

IMPORTANCE OF CRITERIA AT EACH SITE

Criteria	Site: Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Human Population	1	3	2	4	4	4	4	4
Housing	2	2	3	1	1	1	1	1
Labor Force	4	1	1	3	3	3	3	3
Municipal Affairs	3	4	2	2	2	2	2	2

1 = Most Important

4 = Least Important

8.4.2.2 Across Sites

The ranking of sites by criterion, is presented in Table 8-3. In relation to all of the other sites, Britannia Beach has the highest level of importance for each criterion, with the exception of municipal affairs. The interior sites are less important, in terms of human population and labor force, than the coastal sites. However, municipal affairs was found to be more important at the interior sites than at the coastal sites. The housing criterion was found to be important at the Britannia Beach and interior sites.

8.4.3 Ranking of Sites

The preferential ordering of sites from a socioeconomic viewpoint are listed in Table 8-4. Once all quantitative and qualitative criteria have been considered, the Hat Creek sites were judged to be the preferred site, followed by Soda Creek, Stave Lake, Dunsmuir and Britannia Beach, in that order. The interior sites were preferable to the lower mainland coastal sites, in terms of income and employment benefits, and minimization of population impact. This preferance was not offset by the probable impacts on housing and municipal affairs.

8.5 DISCUSSION

8.5.1 Regional Socioeconomic Overview

8.5.1.1 Population

The most important asset of British Columbia is the population. Between 1963 and 1973, British Columbia recorded a population growth

TABLE 8-3

SIGNIFICANCE OF CRITERIA AMONG SITES

Criteria	Sites							
	Dunsmuir	Britannia Beach	Stave Lake	Ashcroft	Mine Mouth	Harry Lake	Big Bar Creek	Soda Creek
Human Population	HP	HP	HP	HP	HP	HP	HP	HP
Housing	H	H	H	H	H	H	H	H
Labor Force	LF	LF	LF	LF	LF	LF	LF	LF
Municipal Affairs	MA	MA	MA	MA	MA	MA	MA	MA

(Increasing Significance)

TABLE 8-4

SITE PREFERENCE ORDER

Site	Rank
Harry Lake	1
Mine Mouth	1
Big Bar Creek	1
Ashcroft	1
Soda Creek	2
Stave Lake	3
Dunsmuir	4
Britannia Beach	5

which exceeded that of all the other Canadian Provinces. The average rate of population growth in the Province, over the past two decades (1951 to 1970) was approximately 37 per cent.[2]

The population growth and its spatial distribution within the Province has not been uniform. The greatest population concentration occurs in the Greater Vancouver area. In 1971, the percentages of total Provincial population in selected regional districts were as follows: Greater Vancouver 47%; Nanaimo 2%; Squamish-Lillooet 0.6%; Dewdney-Alouette 1.8%; Thompson-Nicola 3.4%; and the Cariboo 1.9%.

Immigration, especially into the Greater Vancouver area, explains much of the Provincial population growth. Interior regions, such as Thompson-Nicola, have experienced vigorous population growth rates relative to the lower mainland such as Squamish-Lillooet and Dewdney-Alouette. Thus, to minimize the impact upon the human population, from a regional perspective, an appropriate site should be chosen from the areas outside the lower mainland.

8.5.1.2 Housing

The housing sector is a major part of the social infrastructure of a community. The influx of personnel and their dependants into communities surrounding the selected site will increase the demand for housing facilities. The existing stock of dwelling units and their physical characteristics are crucial in assessing probable impact, since housing units are not readily constructed.[3]

A suitable site, from a locational point of view, should have a sufficient number of housing units for both plant construction and plant operation personnel. The erection of a construction camp would provide housing primarily for single workers. However, married workers with dependents would likely try to obtain accommodations within adjacent communities. If the number of housing units is large, particularly in categories such as mobile dwelling units, and there is a reasonable vacancy rate; then, it is probable that incremental housing demands can be satisfied by the existing stock.

The housing sector of a community should be protected from the construction of permanent dwellings for individuals and their families who will not be permanent members of that community. It should be noted that, on a local level, people invest a large proportion of their savings in their homes.

8.5.1.3 Labor Force

The labor force, which is an important part of the total population, includes economically active persons, whether employed or not. The labor force is a component in the total population, and as a result, it grows with it. The labor force in British Columbia has grown faster over the recent past than in any of the other Canadian Provinces. For example, the British Columbia total labor force was 575,000 persons in 1961, and increased to 878,000 persons by 1970. This represents a growth rate of about 52 per cent. Two major reasons for this high rate of growth are the influx of workers drawn to the Province by attractive wage rates and the increasing participation of females in the labor force.

The distribution of the labor force throughout the Province corresponds with the distribution of the total population. Thus, the major labor market in British Columbia is found in the Greater Vancouver area. Important labor centers relevant to the study are also located at Prince George, Kamloops, and Nanaimo.

8.5.1.4 Municipal Affairs

In British Columbia, the local governmental system is made up of incorporated municipalities, school districts, regional districts, improvement districts, and special purpose districts. Incorporated municipalities include: cities, towns, villages, and districts. There are more school districts than regional districts. Thus, a few regional districts include two or more school districts. These larger governmental units encompass the municipalities and nonmunicipal regions of British Columbia.[4]

An important concern in the evaluation of alternative sites is the fiscal impact of the generating station on municipal governments. The term fiscal impact refers to the net budgetary position resulting from incremental costs incurred and revenues realized to provide the municipal services required by station construction and operation. The proposed station would require the services provided by relevant municipalities and at the same time would be a major source of tax revenues or grants in aid (in lieu of taxes). In a similar manner, new plant personnel and their dependents would utilize local services (such as health care, recreation facilities and transportation). However, the tax revenues of municipal governments would also increase.

8.5.2 Application of Criteria to Sites

8.5.2.1 Dunsmuir

8.5.2.1.1 Population

Table 8-5 contains population figures and population densities for municipalities in the Nanaimo Regional District. The

TABLE 8-5

NANAIMO REGIONAL DISTRICT 1971 POPULATION CENSUS

Location	Area[a]	Population	Density
City: Nanaimo	31,101.2	44,403[b]	1.42/acre
Villages:			
Parksville	1,671.9	2,169	1.30/acre
Qualicum Beach	2,563.0	1,245	.49/acre
Electoral Areas:			
A	19.6	3,137[b]	160.1 /sq mile
B	23.5	687	29.2 /sq mile
C	416.4	350[b]	0.84/sq mile
D	20.1	2,408[b]	119.8 /sq mile
E	29.3	1,085[b]	37.0 /sq mile
F	101.1	1,266[b]	12.5 /sq mile
G	27.2	1,689	62.1 /sq mile
H	110.4	801	7.3 /sq mile
		59,837	

(a) Area shown for incorporated municipalities in acres; for electoral areas in square miles.

(b) Boundary changes subsequent to 1971 Census. Population as certified by Minister of Municipal Affairs.

Source: Department of Municipal Affairs, Statistics relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p 49; density calculations by the Envirosphere Company.

Dunsmuir site is located within an area which had a 1971 population density of approximately 7.3 individuals per square mile. This relatively high density is undesirable from a siting viewpoint, since the area is well known for its recreational resources and the tourist trade introduces additional people into the locality.

Population growth in the Nanaimo Regional District exhibited an average decade rate of around 41 per cent over the 1951 - 1971 period.[6] This growth rate is slightly greater than the rate reported for the Province as a whole. The male component of the population in the Nanaimo Regional District slightly exceeds 50 per cent of the total population.[7] Approximately 62 per cent of the 1971 population in the Nanaimo Regional District were in the fifteen to sixty-five year age group.[8]

The Dunsmuir site is, in terms of impact upon the human population, the least preferred (with the exception of the Britannia Beach site). This conclusion is supported by population, the relatively high population density and the potential impact from tourists in the general area.

8.5.2.1.2 Housing

Housing statistics for 1971 relative to the Nanaimo Regional District as well as other districts are presented in Table 8-6. There were 15,260 dwellings in the Nanaimo Regional District in 1971. The city of Nanaimo had approximately one-third of the total with 5,030 dwellings. Mobile dwellings were 3.8 per cent of the total, and crowded and owned dwellings 6.13 and 74.54 per cent respectively. Port Alberni, a city within communicating distance of the Dunsmuir site, had a total of 5,684 dwellings in 1971. Approximately one per cent of these dwellings were mobile, 7 per cent crowded and 68 per cent owned.

TABLE 8-6

HOUSING STATISTICS
(1971)

Location	Number of Dwellings	Percent of Mobile Dwellings	Percent of Crowded Dwellings	Percent of Owned Dwellings
Regional District				
Alberni-Clayoquot	8,660	2.83	9.87	70.61
Cariboo	10,435	9.49	19.55	66.70
Dewdney-Alouette	11,965	2.21	8.15	75.22
Greater Vancouver	329,790	4.25	4.34	58.00
Nanaimo	15,260	3.80	6.13	74.54
Squamish-Lillooet	3,465	6.93	15.15	57.86
Thompson-Nicola	20,115	9.15	11.81	66.02
Cities				
Nanaimo	5,030	0.19	5.17	35.3
Port Alberni	5,685	0.97	7.39	67.9
Kamloops	7,485	2.81	7.15	56.7

Source:
Statistics Canada, advance bulletin, 1971 Census of Canada, Ottawa, Canada, December, 1972, p 8, 10, 11; percent calculations by the Envirosphere Company.

Vacancy rates for employees during project construction and operation phases could not be estimated with the available information. It is assumed that a construction camp would provide housing for a high population of the unmarried men who desire such accommodations. It is expected that most of the married workers and their families would desire residences within the Nanaimo District or in relatively nearby muncipalities, such as Port Alberni. The impact upon housing would decrease as a function of the percentage of construction and operating personnel currently residing in the Dunsmuir area.

Housing impact is expected to be minimal around the Dunsmuir site. In fact, relative to the other sites, Stave Lake is the only site, other than Dunsmuir, where less significant impact is expected.

8.5.2.1.3 Labor Force

The potential for local employment benefits depends upon the quantity, the skill classifications, and the extent of unemployment that characterize the local labor force. Based on Nanaimo CMC data, shown in Table 8-7, there were 2,635 experienced construction laborers in the regional district in 1971. Construction labor in the experienced labor force by occupation represented 7.9 per cent of the total force of over 33,350 persons. Although unemployment rates by job classification are not available, the unemployment and participation rates of the labor force by economic region are available for May 1976. The participation rate was 57.8 per cent and the unemployment rate was 8.5 per cent for the economic region, which includes Dunsmuir.[9] The unemployed comprised 6.5 per cent of the labor force of the Province where the labor force participation rates were approximately 78 and 39 per cent for males and females, respectively.[10]

TABLE 8-7

LABOR FORCE STATISTICS
(1971)

Canada Manpower Centre	Experienced Labor Force Numbers: Construction Occupation	Construction Industry	All Occupations
Nanaimo	2,635	2,220	33,390
Vancouver	30,515	30,215	457,465
Abbottsford	3,795	3,825	37,395
Kamloops	3,435	3,205	32,160
Williams Lake	735	555	9,485

Source:
Department of Manpower and Immigration, Canada Manpower Centre Area Profiles fpr Nanaimo CMC, Vancouver CMC, and Williams Lake CMC, 1975.

Income and employment benefits in the local vicinity are not anticipated to be large, due to the residential dispersion of the work force. Many of the workers are likely to come from Port Alberni, Nanaimo and other outlying areas. Therefore, a high proportion of their wages and salaries would be spent in those areas. Although the economic development of Vancouver Island is viewed favorably, a thermal generating station would not be too compatible with a major recreational area. Therefore, from a labor force viewpoint, the Dunsmuir site is considered the best of the sites near Vancouver, but inferior to the interior sites.

8.5.2.1.4 Municipal Affairs

Statistics relating to the local government finances within the Nanaimo regional district are included in Tables 8-8 and 8-9.

The Nanaimo regional district ranks second to the Thompson-Nicola regional district regarding total taxable assessment for school and general purposes. However, the taxable assessment per capita for the regional district is lower than the Squamish-Lillooet, Cariboo, and the Thompson-Nicola districts.

A breakdown of debenture debt and per capita debt for the Nanaimo regional district is presented in Table 8-10. The total debenture debt exceeds 38 million dollars, the second highest debt level (the Thompson-Nicola district has the highest). However, a large tax base enables Nanaimo to support this debt level. The total debenture debt per capita in the Nanaimo district is less than the debenture debt per capita in the Thompson-Nicola, Cariboo, and Squamish-Lillooet regional districts.

TABLE 8-8

SCHEDULE OF ASSESSMENTS TAXABLE
Nanaimo Regional District
1975 Taxation Year

Community	Assessment Taxable for School Purposes[a]	Assessment Taxable by Mill Rate for General Purposes
City: Nanaimo	$138,318,540	$110,151,252
Villages:		
Parkville	9,150,053	8,830,202
Qualicum Beach	7,276,302	7,023,629

[a] excluding property taxable only by special act.

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., 1975, p 49.

TABLE 8-9

TAXABLE ASSESSMENTS PER CAPITA
Nanaimo Regional District
1975 Taxation Year

Community	1971 Population	Purpose	
		Schools	General
City: Nanaimo	44,403[a]	$3,115.07	$2,479.91
Villages:			
Parksville	2,169	4,218.56	4,071.09
Qualicum Beach	1,245	5,844.42	5,641.47

[a]Boundary changes subsequent to 1971 census. Population as certified by Minister of Municipal Affairs.

Source: Population figures from Statistics Relating to Regional and Municipal Governments in British Columbia, Department of Municipal Affairs, Victoria, B.C., 1975, p 49; calculations by Envirosphere Company.

TABLE 8-10

ANALYSIS OF NANAIMO DEBENTURE DEBT

(Year Ending December 31, 1974)

Community	General Fixed Assets ($)	School ($)	Hospital ($)	Utilities ($)	Unissued ($)	Total ($)	Total Dept per Capita ($)
City: Nanaimo	2,566,976	-	286,00	2,400	256,961	3,112,337	70.09
Villages:							
Parkville	183,667	-	-	199,189	117,800	500,656	230.82
Qualicum Beach	-	-	-	61,000	-	61,000	48.99
School Districts		11,952,000	-	-	-	11,952,000	-
Regional Hospital District	-	-	5,455,000	-	-	5,455,000	-
Regional District	584,226	-	-	-	12,513,401	13,097,627	-
Water and Sewerage District	2,642,313	-	-	1,981,858	-	4,624,171	-
Totals	5,977,182	11,952,000	5,741,000	2,244,447	12,888,162	38,802,791	-

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria B.C., 1975, p 49.

The following discussion considers schools and medical services as representative elements of the social infrastructure which could be affected by the influx of workers and their families. The discussion considers each element separately.

Schools. The numbers of full-time equivalent teachers and pupils, and the student-teacher ratio for the Nanaimo School District are presented in Table 8-11. The pupil to teacher ratio declined from 21.94 to 20.88 over a one year period (October 1973 to October 1974). Assuming the quality of staff and facilities have been maintained, this decline would be a favorable factor in regard to the Dunsmuir site.

The existing facilities are listed in Table 8-12. The teaching staff appear adequate for the level of expected enrollment. Education experts have forecasted no growth in net enrollment.[11] Although planned expansion of school facilities through capital spending will not be large, assuming the forecast is correct, the activities associated with the construction and operation of a generating station at the Dunsmuir site would not significantly impact the local schools. This follows because it is expected that only a few school age dependents of the workers would be located in the Dunsmuir area.

Medical and Health Services. A generating station at Dunsmuir would have no significant impact on medical facilities in Nanaimo. The Nanaimo Regional General Hospital has a rated capacity of 359 beds, cribs and 43 bassinets.[12] Once again, minimal migration to the Nanaimo area would be expected. Moreover, the supply of health care facilities in the immediate area (i.e., Vancouver Island and the City of Vancouver) is such that the incremental demands placed upon them by the proposed station would not be significant.

TABLE 8-11

NANAIMO PUBLIC SCHOOL PUPIL/TEACHER RATIOS

Full Time Equivalent	October 31, 1973	October 31, 1974
Pupils	11,954	11,987
Teachers	544.80	574.1
Ratio	21.94	20.88

Source: Department of Education, Report on Education, '74-'75, Victoria, B.C., 1975, p. F 137.

TABLE 8-12

NANAIMO PUBLIC SCHOOL FACILITIES

Category	Number of Rooms	Maximum Pupil Capacity	Special Education Approv. Number	Special Education Approv. Reduction in Pupil Capacity	Pupil Operating Capacity
All schools	550.5	14,454	20.5	340	12,628
Elementary	322	8,464	13.5	270	7,320
Jr. Secondary	157	4,056	7	70	3,568
Sr. Secondary	71.5	1,934	-	-	1,740

Source: Deparment of Education, 1974-75 B.C. Public School Facilities by School District, Number of Rooms and Pupil Capacity, Victoria, B.C., June 1975, pp. 3-6, 11-12, 15-16.

An examination of the services and infrastructure data leads to the conclusion that from a socioeconomic standpoint, Dunsmuir is a suitable site, although not without drawbacks. For example, if a large influx of construction workers and their dependents were concentrated in Nanaimo or Port Alberni, an adverse impact on educational facilities could occur.

8.5.2.2 Britannia Beach

8.5.2.2.1 Population

Britannia Beach is situated within the Squamish-Lillooet Regional District. The appropriate population density was 0.98 persons per square mile, based on a population of 874 persons distributed over an area of 894.2 square miles. A more detailed description of municipal population statistics in the regional district is presented in Table 8-13.

The population of the Squamish-Lillooet Regional District increased by 18.35 per cent from 1951 to 1961 and by 31.34 per cent from 1961 to 1971. This represents an average population growth rate of approximately 24 per cent over these two decades. The growth rate for British Columbia over the same period was 37 per cent. Thus, it is apparent that the Squamish-Lillooet District is not a significant growth area.[13] In 1971, 54 per cent of the population in the district were male and 61 per cent were in 15 to 65 year age group.[14]

It is anticipated that the impact upon the human population would be significant in the vicinity of the generating station. The population tends to concentrate in relatively narrow zones which could not be avoided by project related activities.

TABLE 8-13

SQUAMISH-LILLOOET REGIONAL DISTRICT 1971 POPULATION CENSUS

Location	Area[a]	Population	Density
District:			
Squamish	26,816.0	6,121	0.23/acre
Villages:			
Lillooet	748.8	1,514	2.02/acre
Pemberton	301.1	157	0.52/acre
Electoral areas:			
A	1,470.9	514	0.35/sq mile
B	1,434.3	979	0.68/sq mile
C	1,996.6	795	0.40/sq mile
D	894.2	874	0.98/sq mile
E	605.0	414	0.68/sq mile
		11,368	

(a) Area shown for incorporated municipalities in acres; for electoral areas in square miles.

Source: Department of Municipal Affairs, Statistics relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p 61; density calculations by the Envirosphere Company.

8.5.2.2.2 Housing

There were 3,465 dwellings in the district in 1971. Mobile dwellings represented nearly 7 per cent of the total. Owned dwellings accounted for about 58 per cent of the total, with more than 15 per cent considered crowded. The housing statistics are presented in Table 8-6.

The majority of workers would be expected to come from the Vancouver labor market and most would reside in the local Vancouver area, since Britannia Beach is located within reasonable traveling time (approximately 45 minutes) from the Greater Vancouver area. Thus, housing facilities in the Greater Vancouver area, particularly in West Vancouver and North Vancouver, might be sought after by workers and their families.

In spite of the attractive Vancouver housing market, the data suggest that the impact upon local housing could be substantial. The basic reasons of the substantial impact are the relatively small number of dwelling units in the district, and the high percentage of crowded dwellings. If it is assumed that a construction camp would be erected near the Britannia Beach site to house a high proportion of unmarried construction workers as well as some of the married men, the impact on housing would be less severe.

8.5.2.2.3 Labor Force

The labor force statistics for the Vancouver CMC are listed in Table 8-7. There were 30,575 construction laborers listed in the construction trades by occupational category in 1971. The unemployment rate for the various job classifications are not available. However, in May 1976, the participation rate was 66.6 per cent[15] and the unemployment rate was 8.1 per cent.[16]

The large supply of construction labor as well as other job skills lead to the conclusion that there is an ample labor force for plant construction and operation requirements nearby. However, income and employment benefits in the Squamish-Lillooet region would not be significant. The proposed participation rate would tend to minimize the concentration of economic activity in the greater Vancouver area and would not provide much of a stimulus to the economic development of the Squamish-Lillooet region.

8.5.2.2.4 Municipal Affairs

Local financial statistics are provided in Tables 8-14 and 8-15 for the municipalities in the Squamish-Lillooet Regional District. On a regional district basis, Squamish-Lillooet has a smaller total taxable assessment for schools and general purposes than the regional districts of Thompson-Nicola, Cariboo, Dewdney-Alouette and Nanaimo. Taxable assessment per capita for school purposes is the largest of all the regional districts considered, while the assessment for general purposes is the second largest.

A breakdown of the debenture debt by function and debenture debt per capita for the Squamish-Lillooet Regional District is presented in Table 8-16. A total debenture debt of slightly over $10 million is shown for the district. This debenture debt total is lower than the debenture debt in the Thompson-Nicola, Dewdney-Alouette, Nanaimo, and the Cariboo regional districts. Squamish-Lillooet is the one district of all those considered which has the greatest inability to raise capital through property assessments. This would limit its ability to provide for capital expansion, without the aid of government loans. The per capita debt figures for Squamish-Lillooet are the highest of any of the other regional districts covered.

TABLE 8-14

SCHEDULE OF ASSESSMENTS TAXABLE
Squamish-Lillooet Regional District
1975 Taxation Year

Community	Assessment Taxable for School Purposes[a]	Assessment Taxable by Mill Rate for General Purposes
District: Squamish	$42,623,120	$27,971,440
Villages:		
Lillooet	3,258,226	3,075,812
Pemberton	971,070	906,422
Totals[b]	73,125,750	58,227,008

[a] excluding property taxable only by special act.

[b] includes municipalities listed and electoral areas.

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., June 1975, P 61.

TABLE 8-15

TAXABLE ASSESSMENTS PER CAPITA
Squamish-Lillooet Regional District
1975 Taxation Year

Community	1971 Population	Purpose	
		Schools	General
District Squamish	6,121	$6,963.42	$4,569.75
Villages:			
Lillooet	1,514	2,152.06	2,031.58
Pemberton	157	6,185.16	5,773.39
Totals[a]	11,368	6,432.60	5,122.01

[a] includes municipalities listed and electoral areas

Source: Population figures from Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., 1975, p. 61; calculations by Envirosphere Company.

TABLE 8-16

ANALYSIS OF SQUAMISH-LILLOOET DEBENTURE DEBT
(Year Ending December 31, 1974)

Community	General Fixed Assets ($)	School ($)	Hospital ($)	Utilities ($)	Unissued ($)	Total ($)	Total Dept per Capita ($)
District Squamish	3,308,730			772,378	528,832	4,609,940	753.14
Villages:							
Lilloort	149,663			101,746	26,590	277,999	183.62
Pemberton	-			2,500	60,000	62,500	398.09
School Districts	-	4,140,300				4,140,300	-
Regional Hospital District	-		769,000				
Regional District	18,400				52,000	70,400	-
Totals	3,476,798	4,140,300	769,000	876,624	667,422	9,930,139	-

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., 1975, p. 61.

Schools. Statistics for the Howe Sound School District on the full-time equivalent teachers and pupils are provided in Table 8-17. The pupil-teacher ratio was 21.61 on October 31, 1973, and 20.47 one year later. Based on the data of public school facilities listed in Table 8-18, the educational system in the Howe Sound area appears to be adequate. The planned expansion of school facilities to meet enrolment forecasts should be sufficient to accommodate the school-age dependents of those plant workers located in the Squamish-Lillooet District. The size of the Vancouver educational system is more than adequate to absorb any incremental demands placed upon it, should a generating station be built and operated at Britannia Beach.

Medical and Health Services. The local supply of medical facilities and services are adequate to meet any incremental demands placed upon them as a result of the construction and operation of a generating station at Britannia Beach. The Squamish General Hospital has a rated capacity of twenty-one beds and cribs and four bassinets.[17] The proximity of the proposed site to the Greater Vancouver area with its abundant medical facilities and services supports this conclusion.

Municipal affairs are a major concern for the Britannia Beach site. The general economic conditions in Squamish-Lillooet are not prosperous and the fiscal status of the municipalities is limited.

8.5.2.3 Stave Lake

8.5.2.3.1 Population

The Stave Lake site is located in the Dewdney-Alouette region, which is north-east of the Greater Vancouver area. The physical setting is rural but its proximity to Vancouver results in an urban population profile.

TABLE 8-17

HOWE SOUND PUBLIC SCHOOL PUPIL/TEACHER RATIOS

Full Time Equivalent	October 31, 1973	October 31, 1974
Pupils	2,680	2,767
Teachers	124.00	135.20
Ratio	21.61	20.47

Source: Department of Education, Report on Education, '74-'75, Victoria, B.C., 1975, p. F 137.

TABLE 8-18

HOWE SOUND PUBLIC SCHOOL FACILITIES

Category	Number of Rooms	Maximum Pupil Capacity	Special Education Approv. Number	Special Education Approv. Reduction in Pupil Capacity	Pupil Operating Capacity
All schools	130	3,426	10	160	2,930
Elementary	79	2,196	6	120	1,859
Secondary	51	1,230	4	40	1,071

Source: Department of Education, 1974-75 B.C. Public School Facilities by School District, Number of Rooms and Pupil Capacity, Victoria, B.C., June 1975, pp. 3-6, 13-14.

The population density of the Stave Lake site is 4.9 persons per square mile. The population and population density figures for various municipalities in the regional district are listed in Table 8-19.

Population growth in the Dewdney-Alouette Regional District was 46 per cent from 1951 to 1961 and 34.39 per cent from 1961 to 1971. The average growth rate over the two decades was 39.79 per cent, which is slightly greater than the Provincial average.[18] In 1971, 51 per cent of the population were males and 60 per cent were in the 15 to 65 year age group.[19]

The impact upon the human population is considerably more significant at Stave Lake than the interior sites, but less significant with respect to Dunsmuir and Britannia Beach.

8.5.2.3.2 Housing

The statistics on local housing are summarized in Table 8-6. The total number of dwelling units within the Dewdney-Alouette District was 11,965 in 1971. The number of mobile units was less than 2.25 per cent of the total. More than 75 per cent of the dwellings were owned, and approximately 8 per cent were considered to be crowded.

The statistics suggest stability in the housing sector with a high percentage of ownership and a low percentage of mobile dwellings. Since vacancy rates were not available, impact of the station construction and operation on local housing can not be adequately assessed. However, given the total number of dwellings in Dewdney-Alouette and the expectation that a large proportion of workers will come from the Vancouver labor market, it can be concluded that no significant impact on the local housing sector would occur. The potential impact on local housing would be deminished further if a construction camp was established. The housing impact is anticipated to be the least significant of all the other sites.

TABLE 8-19

DEWDNEY-ALOUETTE REGIONAL DISTRICT 1971 POPULATION CENSUS

Location	Area[a]	Population	Density
Districts:			
Maple Ridge	66,000.0	24,476	0.37/acre
Mission	62,600.0	10,220	0.16/acre
Pitt Meadows	12,366.0	2,771	0.22/acre
Electoral Areas:			
A	689.0	113	0.16/sq mile
B	13.9	790[b]	56.8 /sq mile
C	20.3	715[b]	35.2 /sq mile
D	21.9	168[b]	7.7 /sq mile
E	139.2	688[b]	4.9/ sq mile
		39,941	

[a] Area shown for incorporated municipalities in acres; for electoral areas in square miles.

[b] Boundary changes subsequent to 1971 Census. Population as certified by Minister of Municipal Affairs.

Source: Department of Municipal Affairs, Statistics relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p 33; density calculations by the Envirosphere Company.

8.5.2.3.3 Labor Force

The likelihood for local employment benefits resulting from development of the Stave Lake site depends upon the quantity, skill, and degree of employment of the local labor force. Labor force statistics for the Abbotsford CMC are presented in Table 8-7.

The CMC area profile lists 3,795 experienced construction laborers in the 1971 labor force by occupation group.[20] The unemployment rate for the economic region was relatively high at 9.7 per cent with a participation rate of 63.6 per cent for May, 1976.[21]

The data suggest that there is a sufficient supply of labor for plant construction and operation. In addition, the local employment benefits would appear to be greater than that which could be expected at the proposed Britannia Beach site. However, as in the case of the Britannia Beach site, economic activity would tend to be concentrated in the Greater Vancouver area.

8.5.2.3.4 Municipal Affairs

Financial statistics for local municipal and regional governments are given in Tables 8-20 and 8-21. Dewdney-Alouette has the second smallest total taxable assessment for both school and general purposes of the regional districts considered. The Dewdney-Alouette District with a population of 40,000 has the lowest taxable assessment per capita of all of the regional districts considered.

An analysis of the debenture debt and debt per capita for the Dewdney-Alouette regional district is presented in Table 8-22. The total debenture debt (less than 18 million dollars) is the second

TABLE 8-20

DEWDNEY-ALOUETTE REGIONAL DISTRICT
Schedule of Assessments Taxable
1975 Taxation Year

Community	Assessment Taxable for School Purposes[a]	Assessment Taxable by Mill Rate for General Purposes
Districts:		
Maple Ridge	$82,196,850	$77,206,638
Mission	34,847,706	33,944,019
Pitt Meadows	13,675,020	13,119,877
Totals[b]	141,067,878	134,618,236

[a] excluding property taxable only by special act.

[b] includes municipalities listed and electrical areas.

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., June 1975, p. 33.

TABLE 8-21

DEWDNEY-ALOUETTE REGIONAL DISTRICT
Taxable Assessments per Capita
1975 Taxation Year

Community	1971 Population	Purpose	
		Schools	General
Districts:			
Maple Ridge	24,476	$3,358.26	$3,154.36
Mission	10,220	3,409.96	3,321.33
Pitt Meadows	2,771	4,935.05	4,734.71
Totals[a]	39,941	3,532.00	3,370.51

[a]includes municipalities listed and electoral areas.

Source: Population figures from Statistics Relating to Regional and Municipal Governments in British Columbia, Department of Municipal Affairs, Victoria, B.C., 1975, p. 73.

TABLE 8-22

ANALYSIS OF DEWDNEY-ALOUETTE DEBENTURE DEBT
(Year Ending December 31, 1974)

Community	General Fixed Assets ($)	School ($)	Hospital ($)	Utilities ($)	Unissued ($)	Total ($)	Total Dept per Capita ($)
Districts:							
Maple Ridge	1,929,464	-	293,000	148,894	257,750	2,629,108	107.42
Mission	770,808	-	431,000	777,432	1,132,000	3,111,240	304.43
Pitt Meadows	-	-	-	-	935,000	935,000	337.42
School Districts	-	9,608,500	-	-	-	9,608,500	-
Regional Hospital District	-	-	1,550,000	-	-	1,550,000	-
Regional District	15,000	-		-	-	15,000	-
Totals	2,715,272	9,608,500	2,274,000	926,326	2,324,750	17,848,848	-

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., 1975, p. 32.

lowest of all the regional districts compared. The relatively low fiscal capacity of Dewdney-Alouette affects the ability of the government to support debt. The school district debt constitutes more than 50 per cent of the total debenture debt. The total debenture debt per capita for the Dewdney-Alouette regional district is less than $450 per person. This is the lowest overall debt per capita of all of the districts considered. The debenture debt per capita for the district of Maple Ridge, Mission and Pitt Meadows are all lower than the overall per capita debt for the Dewdney-Alouette Regional District.

Schools. The Stave Lake site is found within the Mission School District. School-age dependents of construction workers, residing in the Dewdney-Alouette region near the site, would likely attend schools in the Mission District. Table 8-23 lists the full-time teachers and pupils. It is interesting to note that the pupil-teacher ratio did not change from October 1973 to October 1974. This is indicative of a proportional growth in pupils as well as teachers over the time span.

The facilities of the Mission Public School District are listed in Table 8-24. The existing school system in the Mission District appears adequate. The pupil to teacher ratio meets generally accepted standards. The expansion of school facilities to satisfy expected growth in enrollment to 1986 should be more than adequate to provide for the anticipated minimal number of school-age dependents of construction workers residing in Dewdney-Alouette.[22] The size of the Vancouver educational system is easily capable of meeting any incremental demands placed upon it as a result of the proposed plant site at Stave Lake.

TABLE 8-23

MISSION SCHOOL PUPIL/TEACHER RATIOS

Full Time Equivalent	October 31, 1973	October 31, 1974
Pupils	3,874	3,981
Teachers	190.10	195.3
Ratio	20.38	20.38

Source: Department of Education, Report on Education, '74-'75, Victoria, B.C., 1975, p. F137.

TABLE 8-24

MISSION PUBLIC SCHOOL FACILITIES

Category	Number of Rooms	Maximum Pupil Capacity	Special Education Number	Special Education Approv. Reduction in Pupil Capacity	Pupil Operating Capacity
All Schools	205	5,272	9	150	4,711
Elementary	128	3,294	6	120	2,905
Jr. Secondary	44	1,140	3	30	1,052
Secondary	33	838	-	-	754

Source: Deparment of Education, 1974-75 B.C. Public School Facilities by School District, Number of Rooms and Pupil Capacity, Victoria, B.C. June 1975, pp. 3-6, 11-14.

Medical and Health Services. The Stave Lake site is located in a region with medical facilities sufficient to meet the additional demand for health care[23] which may result from development of the generating facility at this site. Mission Memorial Hospital, located in Mission City, has a rated capacity of 54 beds and cribs and 16 bassinets. The Matsqui-Sumas-Abbotsford General Hospital, located in Abbotsford, has a rated capacity of 123 beds and cribs and 18 bassinets. These hospitals, as well as the ample medical facilities and services provided throughout the Greater Vancouver area, should satisfy any incremental demands placed upon them should the Stave Lake site be developed.

No significant impact on local housing, medical facilities, and schools is expected from the proposed construction and operation of the plant at Stave Lake. On an overall basis, the impact on municipal affairs is expected to be least significant with the Stave Lake site. The relatively low per capita debt, the existing social infrastructure, and the nearby Vancouver facilities support this conclusion.

8.5.2.4 Ashcroft, Mine Mouth, Harry Lake, Big Bar Creek - Thompson-Nicola Regional District

8.5.2.4.1 Population

Ashcroft, Mine Mouth, Harry Lake and Big Bar Creek are located in the Thompson-Nicola Regional District. The population density of the district is estimated to be 0.53 people per square mile. This low density reflects both the intensive ranching and the physical geography of the region. Population statistics for municipalities in the regional district are provided in Table 8-25. The nearest villages to the site are Ashcroft and Cache Creek. The nearest city is Kamloops with a

TABLE 8-25

THOMPSON-NICOLA REGIONAL DISTRICT 1971 POPULATION CENSUS

Location	Area[(a)]	Population	Density
City: Kamloops	88,448	55,090	0.62/acre
Town: Merritt	2,151.4	5,289	2.46/acre
Villages:			
Ashcroft	2,052.3	1,916	0.93/acre
Cache Creek	477.8	1,019[(b)]	2.11/acre
Chase	919.0	1,212	1.32/acre
Clinton	225.3	905	4.02/acre
Logan Lake	397.7	3	0.01/acre
Lytton	537.2	494	0.92/acre
Electoral Areas:			
A	2,833.8	2,606	.92/sq mile
B	2,033.6	811	.40/sq mile
C	1,264.2	821[(b)]	.65/sq mile
D	1,098.6	1,667[(b)]	1.52/sq mile
E	2,464.1	1,149	.47/sq mile
I	2,534.9	1,344	.53/sq mile
J	1,377.3	1,008[(b)]	.73/sq mile
L	1,252.2	2,331[(b)]	1.86/sq mile
M	1,588.8	1,499	.94/sq mile
N	922.1	1,264	1.37/sq mile
		80,428	

(a) Area shown for incorporated municipalities in acres; for electoral areas in square miles.

(b) Boundary changes subsequent to 1971 Census. Population as certified by Minister of Municipal Affairs.

Source: Department of Municipal Affairs, Statistics relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p 67; density calculations by the Envirosphere Company.

1971 population of over 55,000. However, Kamloops covers such a wide area that its population density of 0.62 persons per acre is less than that at Ashcroft and Cache Creek. The driving time from the site to Kamloops is more than one hour. The low population density throughout this general area makes it a desirable generating station site from a socioeconomic viewpoint.

Population growth in the Thompson-Nicola Regional District has been vigorous, averaging 66.9 per cent from 1951 to 1971. The growth rate from 1951 to 1961 was 65 per cent, and approximately 69 per cent from 1961 to 1971.[24] Fifty-two per cent of the 1971 population were males and 62 per cent were in the 15 to 65 year age group.[25]

Ashcroft, Mine Mouth, Harry Lake and Big Bar Creek are preferred over the coastal sites in terms of minimizing impact on the human population. However, the location of the Ashcroft site near the village of Ashcroft is a disadvantage. The other interior sites are expected to have slightly less effect upon the human population.

8.5.2.4.2 Housing

The housing characteristics of the regional district and the city of Kamloops are presented in Table 8-6. A total of 20,115 dwelling units were available in the Thompson-Nicola Regional District in 1971. Mobile dwellings accounted for over 9 per cent of the total. Approximately 12 per cent of the total units were crowded, and 66 per cent of the total dwellings were privately owned. The city of Kamloops had 7,485 dwelling units in 1971, or slightly more than 37 per cent of all the dwelling units in the regional district. Housing statistics were not available for Cache Creek, the nearest village to Hat Creek Valley.

A construction camp would be established if the site were located in the Thompson-Nicola Regional District. This camp would provide housing facilities for construction workers. The camp would be used chiefly by single workers, although married individuals from outside a convenient commuting distance might also be housed in the facilities. Therefore, it is reasonable to assume that most of the workers who would try to obtain housing in the local towns would be married with dependents and/or expect employment of some duration during the construction phase. The towns, which are within a convenient commuting distance of the site are Cache Creek, Ashcroft, Kamloops, Clinton and Lillooet. Selection of the Ashcroft or Big Bar Creek site would likely accentuate the impact on the housing facilities in Ashcroft or Clinton, respectively.

On the basis of the current housing statistics, the proposed plant would increase the housing requirements at Ashcroft and Cache Creek, as well as the other small towns in close proximity to the site. The present availability of housing for sale or rent is limited, although some development is possible in suitable areas or subdivisions. There is limited mobile home space but future planning could remedy this deficiency.

The Thompson-Nicola sites would have a similar effect on housing. The Ashcroft site would have a greater impact on housing than the Dunsmuir, Stave Lake or Soda Creek sites. Mine Mouth would have less impact on housing than Ashcroft, but a greater effect than the coastal sites.

8.5.2.4.3 Labor Force

The labor force statistics, applicable for the site were taken from the Kamloops CMC. A total of 3,435 construction workers are listed in the 1971 experienced labor force by occupation classification. This represents 10.7 per cent of the total occupations.[26] The statistics on the labor force are presented in Table 8-7.

Local employment benefits from the proposed site are related to the quantity of labor, expertise of workers, and level of unemployment. In the absence of unemployment rates by job classification, the regional unemployment rate for the labor force as a whole was used to estimate unemployment conditions. In May, 1976, the participation rate was 66.6 per cent and the unemployment rate was 8.1 per cent.[27]

Labor force statistics from the Kamloops CMC suggest a sufficient supply of local labor for plant construction and operation. The proposed site would provide employment benefits as well as augmenting the economic base of the local region through the employment and income generation process. The proposed site and use of Hat Creek coal would contribute to the development of the British Columbia interior.

8.5.2.4.4 Municipal Affairs

Statistics relating to the financial status of the local governments within the Thompson-Nicola Regional District are included in Tables 8-26 and 8-27. The Thompson-Nicola Regional District had the largest taxable assessment for school and general purposes. The total taxable assessment for general purposes per capita ($7,500), was due in part to a regional district population of 80,428 in 1971.

TABLE 8-26

THOMPSON-NICOLA REGIONAL DISTRICT
Schedule of Assessments Taxable
1975 Taxation Year

Community	Assessment Taxable for School Purposes[a]	Assessment Taxable by Mill Rate for General Purposes
City: Kamloops	$233,302,976	$459,177,708[b]
Town: Merritt	14,276,672	12,039,000
Villages:		
Ashcroft	4,883,590	4,718,864
Cache Creek	4,481,742	4,130,647
Chase	3,581,975	3,422,589
Clinton	1,725,877	1,614,367
Logan Lake	2,701,364	2,549,839
Lytton	826,273	775,801

[a]exluding property taxable only by special act.

[b]assessment based on 100 percent of market value and includes conversion of former municipalities of Brocklehurst and Valleyview.

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B.C., June 1975, p. 67.

TABLE 8-27

THOMPSON-NICOLA REGIONAL DISTRICT
Taxable Assessments per Capita
1975 Taxation Year

Community	1971 Population	Purpose: Schools	Purpose: General
City: Kamloops	55,090[a]	$4,234.17	$8,333.54
Town: Merritt	5,289	2,693.77	2,271.51
Villages:			
Ashcroft	1,916	2,543.75	2,457.81
Cache Creek	1,019[a]	4,393.86	4,049.66
Chase	1,212	2,960.31	2,845.12
Clinton	905	1,907.04	1,783.83
Lytton	494	1,672.61	1,570.45

[a]Boundary changes subsequent to 1971 census. Population as certified by Minister of Municipal Affairs.

Source: Population figures from Statistics Relating to Regional and Municipal Governments in British Columbia, Department of Economic Development, Victoria, B C, June 1975, p 67; Envirosphere Company.

The City of Kamloops had a per capita tax assessment for general purposes of over $8,000, and for school purposes over $4,000. The village of Cache Creek had the highest tax assessment per capita (more than $4,000 for both school and general purposes). The village of Clinton had a lower taxable assessment per capita than either Cache Creek or Ashcroft.

Table 8-28 presents a breakdown of debenture debt and per capita debt for the Thompson-Nicola Regional District. The total debenture debt exceeds $57 million. The large tax base for Thompson-Nicola allows for the support of a debt of this amount. The total debenture debt per capita for Thompson-Nicola is approximately $700. The per capita debenture debt for Cache Creek is approximately $643.

The following discussion considers social infrastructure which would be affected by the influx of workers and their families.

Schools. The South Cariboo School District would be the only school district likely to be impacted by the Hat Creek Project. Other school districts such as Lillooet No. 29 might encounter additional demand for education facilities and services, but not to any appreciable extent.

The full-time equivalent teachers and pupils are listed in Table 8-29 for the South Cariboo School District. The pupil-teacher ratio declined from 20.9 to 19.28 from 1973 to 1974. This decline is favorable from an educational point of view. The public school facilities in the South Cariboo School District for 1974 - 1975 are presented in Table 8-30.

TABLE 8-28

ANALYSIS OF THOMPSON-NICOLA REGIONAL DISTRICT DEBENTURE DEBT
(Year Ending December 31, 1974)

Community	General Fixed Assets	School	Hospital	Utilities	Unissued	Total	Total Dept per Capita
City: Kamloops	$8,837,914	$ -	$ 453,000	$6,520,712	$2,247,325	$18,058,951	$ 327.75
Town: Merrit	438,650	-	-	241,552	19,971	700,173	132.11
Villages:							
Ashcroft	361,981	-	-	109,246	182,916	654,143	341.41
Cache Creek	402,779	-	-	152,789	100,452	656,020	643.79
Chase	14,400	-	-	100,000	49,000	163,400	134.82
Clinton	207,348	-	-	44,324	56,000	307,672	339.97
Lytton	24,778	-	-	-	70,000	94,778	191.84
School Districts	-	30,868,800	-	-	-	30,868,800	-
Regional Hospital District	-	-	4,437,900	-	-	4,437,900	-
Regional District	-	-	-	-	1,300,000	1,300,000	-
Totals	$10,287,850	$30,868,800	$4,890,900	$7,168,623	$4,025,644	$57,241,837	-

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B C, June 1975, p 67; Envirosphere Company.

TABLE 8-29

SOUTH CARIBOO PUBLIC SCHOOL PUPIL/TEACHER RATIOS

Full Time Equivalent	Time Period October 31, 1973	Time Period October 31, 1974
Pupils	2,278	2,227
Teachers	109.02	115.5
Ratio	20.90	19.28

Source: Department of Education, Report on Education, '74-'75, Victoria, B.C., 1975, p. F137.

TABLE 8-30

SOUTH CARIBOO PUBLIC SCHOOL FACILITIES

Category	Number of Rooms	Maximum Pupil Capacity (not mcl. kgn)	Special Education Approv. Number	Special Education Approv. Reduction in Pupil Capacity	Pupil Operating Capacity
All schools	124	3195	8	140	2728
Elementary	75	1995	6	120	1692
Jr. Secondary	10	254	-	-	202
Secondary	39	946	2	20	834

Source: Deparment of Education, 1974-75 B.C. Public School Facilities by School District, Number of Rooms and Pupil Capacity, Victoria, British Columbia, June, 1975, pp 3-6, 11-14.

In spite of these statistics, it appears that the existing school facilities and staff will have to be augmented. This expansion will be necessary even if the proposed generating station and Hat Creek coal development is not undertaken. The expanding population of school age dependents related to the operation of the mine and the thermal plant would increase the total demand for educational services.[28]

Medical and Health Services. The major medical center in Ashcroft and the nearby villages of Cache Creek and Clinton is the Ashcroft and District Hospital. This public hospital provided general care facilities in 1975 with 41 beds and cribs, and 8 bassinets. The Royal Island Hospital in Kamloops had 343 beds and cribs, and 45 bassinets.[29] These facilities are sufficient for present community requirements.

Any of the interior thermal generating station sites would have significant impacts on municipal services and infrastucture. Municipal budgets are limited in the central region of British Columbia and significant financial burden would occur, should additional water and sewer services be required.[30] The coastal sites are preferred in terms of minimizing impact upon municipal systems.

8.5.2.5 Soda Creek - Cariboo Regional District

8.5.2.5.1 Population

The Soda Creek site is located within the Cariboo Regional District. The 1971 population density estimate is 2.47 per square mile, based on the population of electoral areas A, D and C. The town of Williams Lake is the closest town with a population density of 1.09 persons per acre in 1971. The 1971 population statistics for municipalities in the regional district are listed in Table 8-31.

TABLE 8-31

CARIBOO REGIONAL DISTRICT 1971 POPULATION CENSUS

Location	Area[a]	Population	Density
Towns:			
Quesnel	3,763.8	6,442[b]	1.71/acre
Williams Lake	3,771.6	4,104[b]	1.09/acre
Villages:			
100 Mile House	322.5	1,120	3.47/acre
Electoral Areas:			
A	45.6	3,205[b]	70.3 /sq mile
B	558.6	3,240[b]	5.8 /sq mile
C	3,281.8	2,804	0.9 /sq mile
D	258.9	2,850	11.0 /sq mile
E	658.4	4,063	6.2 /sq mile
F	4,038.9	1,513	0.4 /sq mile
G	1,762.5	3,682	2.1 /sq mile
H	865.8	1,718	2.0 /sq mile
I	5,787.2	1,225[b]	0.2 /sq mile
J	14,611.7	1,506	0.1 /sq mile
		37,472	

[a] Area shown for incorporated municipalities in acres; for electoral areas in square miles.

[b] Boundary changes subsequent to 1971 Census. Population as certified by Minister of Municipal Affairs.

Source: Department of Municipal Affairs, Statistics relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p 17; density calculations by the Enviro-sphere Company.

The town of Quesnel and the village of 100 Mile House had 1971 population densities of 1.71 and 3.47 persons per acre, respectively. The overall regional population density is low and therefore from a population standpoint the proposed site is suitable.

Population growth in the Cariboo Regional District has been greater than that of the Regional District of Nanaimo, Squamish-Lillooet, Dewdney-Alouette, and Thompson-Nicola. Over the two decades from 1951 to 1971, population growth has averaged 69.62 per cent per decade.[31]

Males represent about 53 per cent of the 1971 population of the Williams Lake area; of that, 60.5 per cent were in the 15 to 65 age group.[32]

The Soda Creek site is preferred to the Ashcroft and coastal sites in regard to minimizing impact upon the human population. The proposed sites at Harry Lake, Mine Mouth and Big Bar Creek would be equivalent to the Soda Creek site.

8.5.2.5.2 Housing

Table 8-6 presents the housing statistics relevant for the Soda Creek site. A total of 10,430 dwelling units was available in 1971. Mobile dwellings represented approximately 9.5 per cent of the total number of dwellings. The per cent of crowded and owned dwellings in 1971 were 20 and 67, respectively. The total number of housing units in the Cariboo Regional District is a little more than half the number of units in the Thompson-Nicola Regional District.

The location of the Soda Creek site will probably require a construction camp to provide housing for workers during the construction period. The distance of the site from the more populated areas of the interior would prevent commutation. However, married workers with dependents would probably seek residency in nearby communities. The town of Williams Lake, Quesnel and the village of 100 Mile House are areas that would likely be impacted in the region. The impact upon housing is anticipated to be slightly less at the Soda Creek site than at the Hat Creek sites because of the proximity of Quesnel and Williams Lake to the Soda Creek site.

8.5.2.5.3 Labor Force

The Williams Lake, Quesnel and Prince George CMC are relevant to the proposed site at Soda Creek. In 1971, the Census data revealed that nearly 4,150 construction workers were listed in the experienced labor force by occupation classification.[33] All labor force statistics are listed in Table 8-7.

The absolute number of laborers, the degree of worker skill, and the extent of unemployment have an effect on the local employment benefits derived from site development. Since unemployment rates by job classification are unobtainable, the unemployment rate for the total labor force on a regional basis was used as a rough estimate of unemployment conditions. The unemployment rate in May, 1976 was 8.1 per cent and the participation rate was 66.6 per cent.[34]

The labor force statistics suggest that the manpower available in the Williams Lake CMC is limited. If construction projects become more numerous in that region in the near future, the supply of local labor is questionable. However, the force is augmented considerably by the mobility of workers from Quesnel and Prince George. Employment and income benefits would accrue to the interior regions as additional workers would most likely come from the Prince George and Quesnel areas as well as Williams Lake. The Soda Creek site is equivalent to the Big Bar Creek site in that income and employment benefits would tend to be more widely dispersed at the Hat Creek sites. The Hat Creek sites would tend to concentrate economic benefits in the local area.

8.5.2.5.4 Municipal Affairs

The financial statistics associated with the functions and services provided by the local governments in the Cariboo Regional District are summarized in Tables 8-32 and 8-33.

The total taxable assessment of the Cariboo district is smaller than that of the City of Kamloops (Table 8-32). However, the town of Quesnel and Williams Lake have larger absolute taxable assessments than Merritt. The towns and village of 100 Mile House have larger assessment values than any of the villages listed for the Thompson-Nicola Regional District.

An analysis of debenture debt and various debt per capita for the Cariboo Regional District is presented in Table 8-34. The total debenture debt per capita in the Cariboo Regional District was around $765 for the 1974 calendar year. Quesnel and Williams Lake had a larger total debenture debt and a higher per capita debt than any of the towns and villages mentioned in the Thompson-Nicola District.

Schools. The Cariboo-Chilcoton District is the only school district likely to receive any significant impact due to the siting of the thermal plant at Soda Creek.

TABLE 8-32

CARIBOO REGIONAL DISTRICT
Schedule of Assessments Taxable
1975 Taxation Year

Community	Assessment Taxable for School Purposes[a]	Assessment Taxable by Mill Rate for General Purposes
Towns:		
Quesnel	$54,319,520	$33,847,883
Williams Lake	29,919,787	23,444,392
Village:		
100 Mile House	6,142,942	5,711,762
Totals[b]	206,976,597	179,598,385

[a]excluding property taxable only by special act.

[b]includes municipalities and electoral areas.

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B C, June 1975, p. 17.

TABLE 8-33

CARIBOO REGIONAL DISTRICT
Taxable Assessments per Capita
1975 Taxation Year

Community	1971 Population	Purpose: Schools	Purpose: General
Towns:			
Quesnel	6,442	$8,432.09	$5,254.25
Williams Lake	4,104	7,290.40	5,712.57
Village:			
100 Mile House	1,120[a]	5,484.77	5,099.79

[a]Boundary charges subsequent to 1971 census. Population as certified by Minister of Municipal Affairs.

Source: Population and taxable assessment figures taken from Statistics Relating to Regional and Municipal Governments in British Columbia, Department of Municipal Affairs, Victoria, B.C., 1975, p. 17; calculations compiled by Envirosphere Company.

TABLE 8-34

ANALYSIS OF CARIBOO DISTRICT DEBENTURE DEBT
(Year Ending December 31, 1974)

Community	General Fixed Assets ($)	School ($)	Hospital ($)	Utilities ($)	Unissued ($)	Total ($)	Total Dept per Capita ($)
Towns:							
Quesnel	489,681			508,955	1,901,000	2,899,636	450.11
Williams Lake	1,747,615			858,422	1,565,000	4,171,037	1,016.33
Village:							
100 Mile House	96,670			-	23,896	120,566	107.65
School District	-	18,243,400		-	-	18,243,400	-
Regional Hospital District			2,493,800	-	-	2,493,800	-
Regional District	150,000				585,000	735,000	-
Totals	2,483,966	18,243,400	2,493,800	1,367,377	4,074,896	28,663,439	-

Source: Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, B C June 1975, p 17; computations by Envirosphere Company.

Full time pupils and teachers are given in Table 8-35. In comparison with the South Cariboo School District, the Cariboo-Chilcotin District has over three times as many pupils and teachers, with no significant change in ratio. Details on the number of rooms and pupil occupancy by type of school for the Cariboo-Chilcotin School District is presented in Table 8-36.

The Cariboo-Chilcotin School District was larger than the South Cariboo District in terms of number of schools, pupils, and teachers in 1975. However, the pupil-teacher ratio was approximately the same. The absolute totals of the Cariboo-Chilcotin School District were directly related to the large area encompassed by the district. The school facts for Williams Lake, Quesnel, 100 Mile House and nearby villages to the site are more relevant to the suitability of the site. Assuming the growth of net enrollment to be uniformly distributed throughout the district, the relatively rapid increase in enrollment forecasted would result in a need for additional facilities and teachers.[35] The development of a thermal site at Soda Creek and the consequent socioeconomic activities would likely add to the expected increased educational demands in the region.

Medical and Health Services. In the general region of the Soda Creek site, the most important medical center would be the Cariboo Memorial Hospital and the 100 Mile House District General Hospital. Another hospital, located in Quesnel, would also provide medical care facilities. The rated capacity of these hospitals was 255 beds and cribs, and 47 bassinets in 1975.[36]

The available data on medical facilities would seem to indicate that there is adequate medical coverage for the present and near future. Additional analysis is required for determining when medical facilities will have to be expanded or upgraded.

On an overall basis, municipal finance and infrastructure considerations are significant with respect to the Soda Creek site. The municipalities near the Soda Creek site are representative of other governmental units in the central region. Prince George, Quesnel, and Willimas Lake will incur backlog costs for water and sewer services.[37] The general financial ability of the municipalities to provide services is limited.

TABLE 8-35

CARIBOO-CHILCOTIN PUBLIC SCHOOL PUPIL/TEACHER RATIOS

Full Time Equivalent	October 31, 1973	October 31, 1974
Pupils	7,520	7,839
Teachers	329.4	387.3
Ratio	22.83	20.24

Source: Department of Education, Report on Education, '74-'75, Victoria, B.C., 1975, p. F 137.

TABLE 8-36

CARIBOO-CHILCOTIN PUBLIC SCHOOL FACILITIES

			Special Education Approv.		
Category	Number of Rooms	Maximum Pupil Capacity	Number	Reduction in Pupil Capacity	Pupil Operating Capacity
All Schools	370.5	10,316	16	260	8,904
Elementary	213.5	5,920	10	200	5,031
Elem.-Jr. Secondary	26	852	-	-	738
Jr. Secondary	57.5	2,294	5	50	2,019
Secondary	25	642	-	-	578
Sr. Secondary	22	608	1	10	538

Source: Department of Education, 1974-75 B.C. Public School Facilities by School District, Number of Rooms and Pupil Capacity, Victoria, B.C., June 1975, pp. 3-16.

GLOSSARY

Fiscal Capacity	- a quantitative measure, reflecting the resources over which a governmental unit can tax for generating revenue for public purposes.
Participation rate	- represents the labor force as a percentage of the population 15 years of age and over.
Population density	- given a geographical unit, the total number of individuals divided by the total area of that geographical unit.
Population growth	- the per cent change in the population of an area over a definite period of time.
Social infrastructure	- consists of local municipal goods and services such as schools, water and sewage systems, health care facilities, secretarial facilities, law and fire protection.
Unemployment rate	- represents the number of unemployed persons as a per cent of the labor force
Crowded dwelling	- for census purposes, any dwelling in which the number of persons exceeds the number of rooms occupied

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(2) Department of Economic Development, The Manual of Resources, Victoria, British Columbia, November 1974, p. 53.

(3) Statistics Canada, Advance Bulletin, 1971 Census of Canada, December 1972.

(4) Op. cit., The Manual of Resources, p. 54

(5) Department of Municipal Affairs, Statistics Relating to Regional and Municipal Governments in British Columbia, Victoria, British Columbia, June 1975, p. 7.

(6) Calculated from information in The Manual of Resources, Department of Economic Development, Victoria, British Columbia, November 1974, p. 53.

(7) Department of Manpower and Immigration, Nanaimo Canada Manpower Centre Area Profile, February 1975, p. 13.

(8) Ibid., p. 14

(9) Statistics Canada, The Labor Force, May 1976, p. 39.

(10) Op. cit., The Manual of Resources, p. 54.

(11) Department of Education, British Columbia Public School September Enrollment Projections, 1976 - 1986, Victoria, British Columbia, 1976, p. 122.

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(12) Statistics Canada, Canadian Hospitals, and Related Facilities, 1975, Ottawa, Canada, March, 1975, p. 54.

(13) Same as reference six.

(14) Department of Manpower and Immigration, Vancouver, Canada Manpower Centre Area Profile, February 1975, p. 24.

(15) Ibid., p. 25.

(16) Op. cit., The Labor Force, p. 39.

(17) Op. cit., Canadian Hospitals and Related Facilities, 1975, p. 55.

(18) Op. cit., The Manual of Resources, p. 53.

(19) Department of Manpower and Immigration, Abbotsford Manpower Centre Area Profile, February 1975, p. 10.

(20) Ibid., p. 11

(21) Op. cit., The Labour Force, p. 39.

(22) Op. cit., British Columbia Public School September Enrollment Projections, 1976 - 1986, p. 132.

(23) Op. cit., Canadian Hospitals and Related Facilities, 1975, p. 53.

(24) Op. cit., The Manual of Resources, p. 53.

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(25) Department of Manpower and Immigration, Kamloops Manpower Centre Area Profile, February, 1975, p. 14.

(26) Ibid., p. 15.

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(28) Strong, Hall & Associates Ltd., Hat Creek Regional Economic Impacts, Vancouver, British Columbia, March 1976, pp. 3-47.

(29) Op. cit., Canadian Hospitals and Related Facilities, 1975, pp. 53-54.

(30) Department of Economic Development, The Central Report 76, Victoria, British Columbia, 1976, pp. 128-132.

(31) Op. cit., The Manual of Resources, p. 53.

(32) Department of Manpower and Immigration, Williams Lake Manpower Centre Area Profile, February, 1975, p. 11.

(33) Ibid., p. 12; Canada Manpower and Immigration, Quesnel Manpower Centre Area Profile, p. 12; Canada Manpower and Immigration, Prince George Manpower Centre Area Profile, p. 15.

(34) Op. Cit., The Labor Force, p. 39.

(35) Op. Cit., British Columbia Public School September Enrollment Projection, 1976 - 1986, p. 50.

(36) Op. cit., Canadian Hospitals and Related Facilities, 1975, pp. 54-56.

(37) Op. cit., The Central Region 76, p. 129.

APPENDIX 8-1

SOCIOECONOMICS

AGENCIES CONTACTED

(1) Department of Recreation and Conservation, Provincial Parks Branch, Victoria, British Columbia.

(2) Department of Environment, Lands Service, Victoria, British Columbia.

(3) Department of Transport and Communications, Victoria, British Columbia.

(4) Environment and Land Use Committee SECRETARIAT,

a) Geographic Division, Resource Analyser Unit

b) Economist, Special Projects Unit

c) Planner, Special Projects Unit

(5) Department of Economic Development, Victoria, British Columbia.

(6) British Columbia Department of Highways, Victoria, British Columbia.

(7) Department of Indian Affairs and Northern Development, Vancouver, British Columbia.

(8) Inland Waters Directorate, Vancouver, British Columbia.

(9) Lands Directorate, Vancouver, British Columbia.

(10) British Columbia Energy Commission, Vancouver, British Columbia.

(11) Statistics Canada, Ottawa, Ontario and Vancouver, British Columbia.

(12) Department of Municipal Affairs, Victoria, British Columbia.

(13) Department of Education, Victoria, British Columbia.

(14) British Columbia Aviation, Vancouver, British Columbia.

(15) Unemployment Insurance Commission, Vancouver, British Columbia.

(16) Vancouver Board of Trade, Vancouver, British Columbia.

(17) Greater Vancouver Regional District Office, Vancouver, British Columbia.

(18) Agriculture Canada, Vancouver, British Columbia.

(19) Thompson-Nicola Regional District, Planning Department, Kamloops, British Columbia.

(20) Recreational and Travel Industry, Vancouver, British Columbia.

(21) Department of Health, Victoria, British Columbia.

(22) British Columbia Lands Commission, Burnaby, British Columbia.

(23) Manpower and Immigration, Regional Economic Service Branch, Kamloops, British Columbia.

(24) Village of Ashcroft, Ashcroft, British Columbia.

(25) Village of Clinton, Clinton, British Columbia.

(26) Village of Cache Creek, Cache Creek, British Columbia.