PRELIMINARY

ENVIRONMENTAL IMPACT STUDY

OF THE PROPOSED

HAT CREEK DEVELOPMENT

Prepared for

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

by

B.C. RESEARCH, and
DOLMAGE CAMPBELL & ASSOCIATES LTD.

Vancouver, B.C. August, 1975

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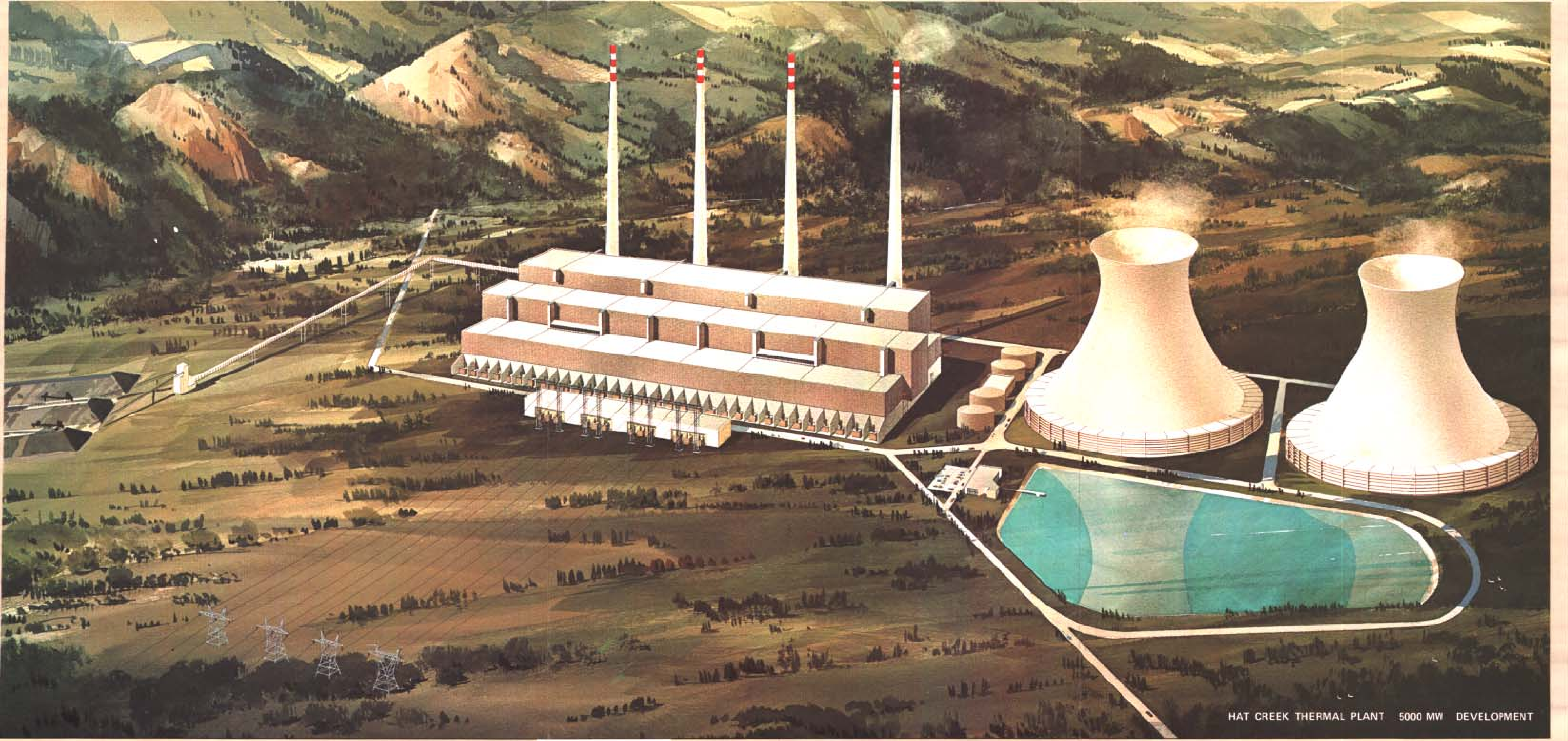
HAT CREEK THERMAL PLANT 5000 MW DEVELOPMENT

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August 18, 1975

Dr. H. M. Ellis, Manager
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700 West Pender Street
Vancouver, B. C.

Dear Dr. Ellis:

RE: ENVIRONMENTAL IMPACT STUDY, PROPOSED HAT CREEK DEVELOPMENT

We are pleased to submit our report covering the preliminary investigations pertaining to the proposed Hat Creek coal mine and thermal generating station as authorized in your letter to us dated July 26, 1974.

Respectfully submitted,

B. C. RESEARCH

Dr. A. D. McIntyre, Head
Division of Applied Chemistry
Project Director

DOLMAGE, CAMPBELL & ASSOCIATES LTD.

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Vice President

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PREFACE

(by B.C. Hydro)

1. *ELECTRIC LOAD FORECAST*

Historically, the annual electric energy load on the B.C. Hydro system has grown at an average rate of 11 percent per annum over the 20-year period 1953 to 1973. The most recent load forecast prepared by B.C. Hydro has indicated that the annual electric energy load will continue to grow at an average growth rate of 8.6 percent per annum during the 16-year period 1974 to 1990. The historic and forecast electric loads for the period 1953 to 1990 are shown graphically in Figure 1.

This forecast is developed on the basis of the following general assumptions:

(a) That the economic growth will be generally consistent with that experienced over the 20-year period 1953 to 1973.

(b) That there will be a marginal but progressive decline in the proportion of Provincial Product contributed by the primary extraction and manufacturing industries which will be largely offset by a progressive increase in the proportion contributed by the secondary manufacturing and service industries.

(c) Energy price considerations in conjunction with programs implemented to encourage the wise use of energy will effect a marginal but progressive decline in total energy and electric energy required per unit of economic output independent of other factors. However, recent price increases for oil and gas have exceeded the change in the general price level, while the price increases for electrical energy have been less than the increases in the general price level. This is likely to result in a shift in energy demand from oil and gas to electrical energy.

The forecast reflects an assumed slower than normal economic growth through 1975 based on the present outlook for world economic conditions and the probable effect of these conditions on markets for products produced locally. Beginning in 1976, a return to more normal world economy is implied coupled with a rapid recovery of production levels in British Columbia. This would be followed in turn by average economic growth through the period to 1990.

For planning purposes, it is necessary to separate the electric load into two components: the integrated system load and the isolated system loads. The generating stations and load centres on the integrated system are all interconnected by means of transmission lines, whereas the generating station(s) and load centre(s) for each isolated system are not interconnected to other systems. The integrated system load is the major portion (about 96%) of the total electric load served by B.C. Hydro, and future load growth on the integrated system would be handled by major generating stations such as the Hat Creek project.

The annual demand for electric energy in the B.C. Hydro integrated system is expected to grow by 70,000 million kwh from 22,000 million kwh in 1974 to 92,000 million kwh in 1990. In order to meet this anticipated load growth, B.C. Hydro must develop a number of new major generating stations.

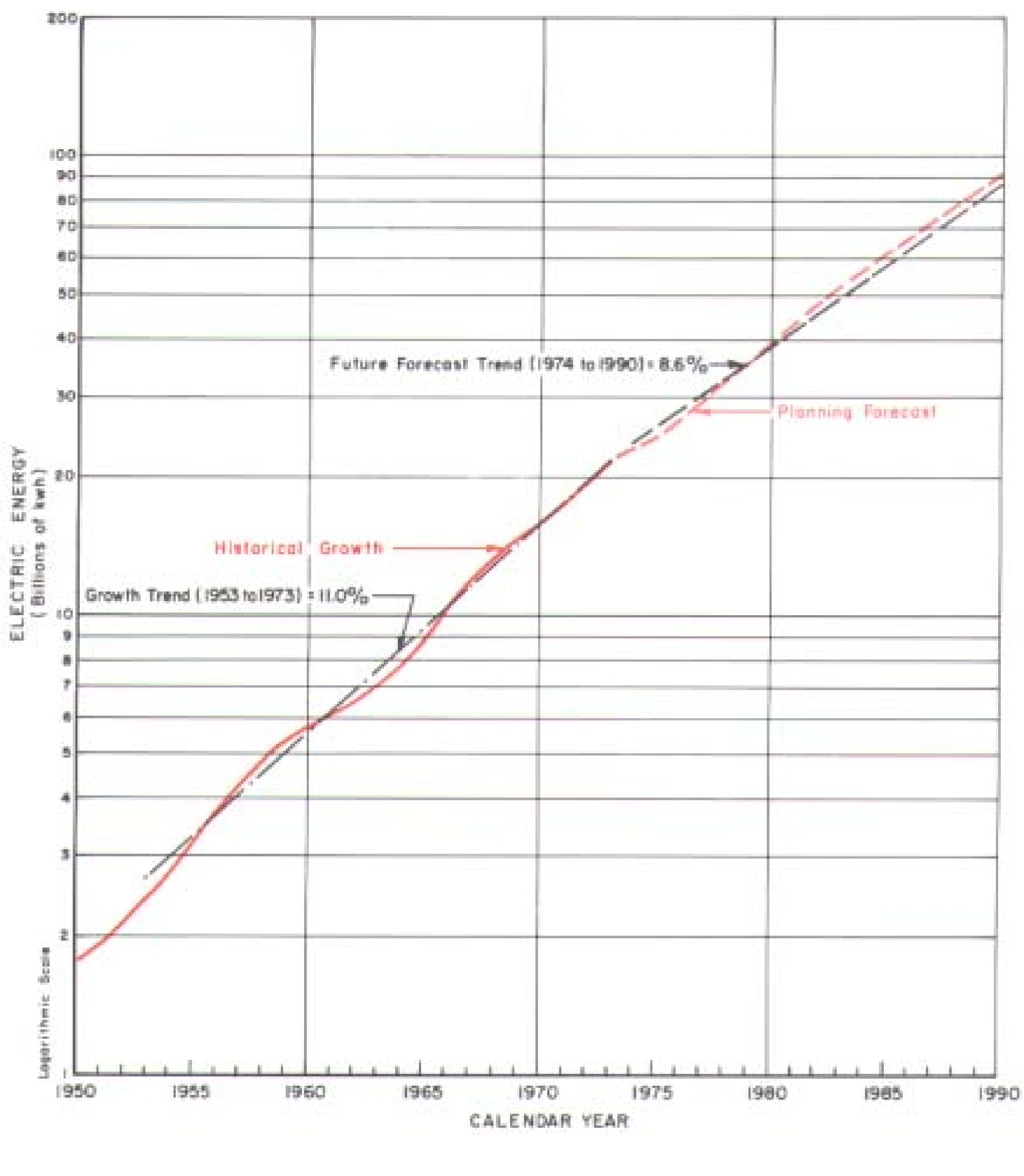


FIGURE 1

B.C. HYDRO AND POWER AUTHORITY

HISTORICAL AND FORECAST ELECTRIC ENERGY DEMAND (1950-1990)

2. EXISTING GENERATING SYSTEMS AND PROJECTS UNDER CONSTRUCTION

The existing B.C. Hydro integrated system generating facilities as of 1974 have a capacity of 4916 megawatts (Mw) and an annual firm energy capability of 24,927 million kwh. Generating projects which are currently under construction to meet the load through 1980 include the Kootenay Canal and Mica Creek hydroelectric plants in the Southern Interior, a sixth unit at Burrard Thermal in the Lower Mainland, and a second gas turbine unit at the Keogh plant on Vancouver Island, all of which are well-advanced; and the Site One Project on the Peace River and Seven Mile on the Pend d'Oreille River on which construction has recently started. The in-service schedule for projects developed in the period 1975-1980 is shown in Table 1, and the existing and planned future annual firm electric energy capabilities and load demand for the B.C. Hydro integrated system is shown in Figure 2.

3. GENERATION PROJECTS REQUIRED TO SERVE LOAD GROWTH BEYOND 1980

Since major generating stations require construction lead times of approximately 5 to 6 years, it is necessary that B.C. Hydro establish the program of generation additions that will be required to serve the load growth in the period 1981 to 1985. Recent studies have indicated that the Revelstoke hydroelectric project on the Columbia River and the Hat Creek coal-fired thermal plant are the two most economic projects which can be developed in the period 1981 to 1985.

The Revelstoke project is planned for service in 1981 or as early as possible thereafter to meet the load growth through 1982.

In order to allow for a normal program of field investigations, engineering and environmental studies, the earliest recommended in-service date for the first unit of the Hat Creek project is 1983. The proven and probable reserves of Hat Creek coal are sufficient to support the development of a 2000 Mw thermal generating station. Indications are that the potential coal resource may be sufficient for a station of 5000 Mw capacity. Such a development would provide sufficient electrical energy to meet the load growth in the period 1983 to 1988.

TABLE 1 — IN-SERVICE SCHEDULE FOR GENERATION PROJECTS UNDER CONSTRUCTION OR APPROVED FOR CONSTRUCTION

IN-SERVICE YEAR	PROJECT NAME	CAPACITY (Mw)
1975	Burrard unit 6	150
	Kootenay Canal units 1 and 2	250
	Keogh Gas Turbine unit 2	50
1976	Kootenay Canal units 3 and 4	250
	Mica units 1 and 2	800
1977	Mica units 3 and 4	800
1979	Site One units 1 and 2	350
1980	Site One units 3 and 4	350
	Seven Mile units 1, 2 and 3	525

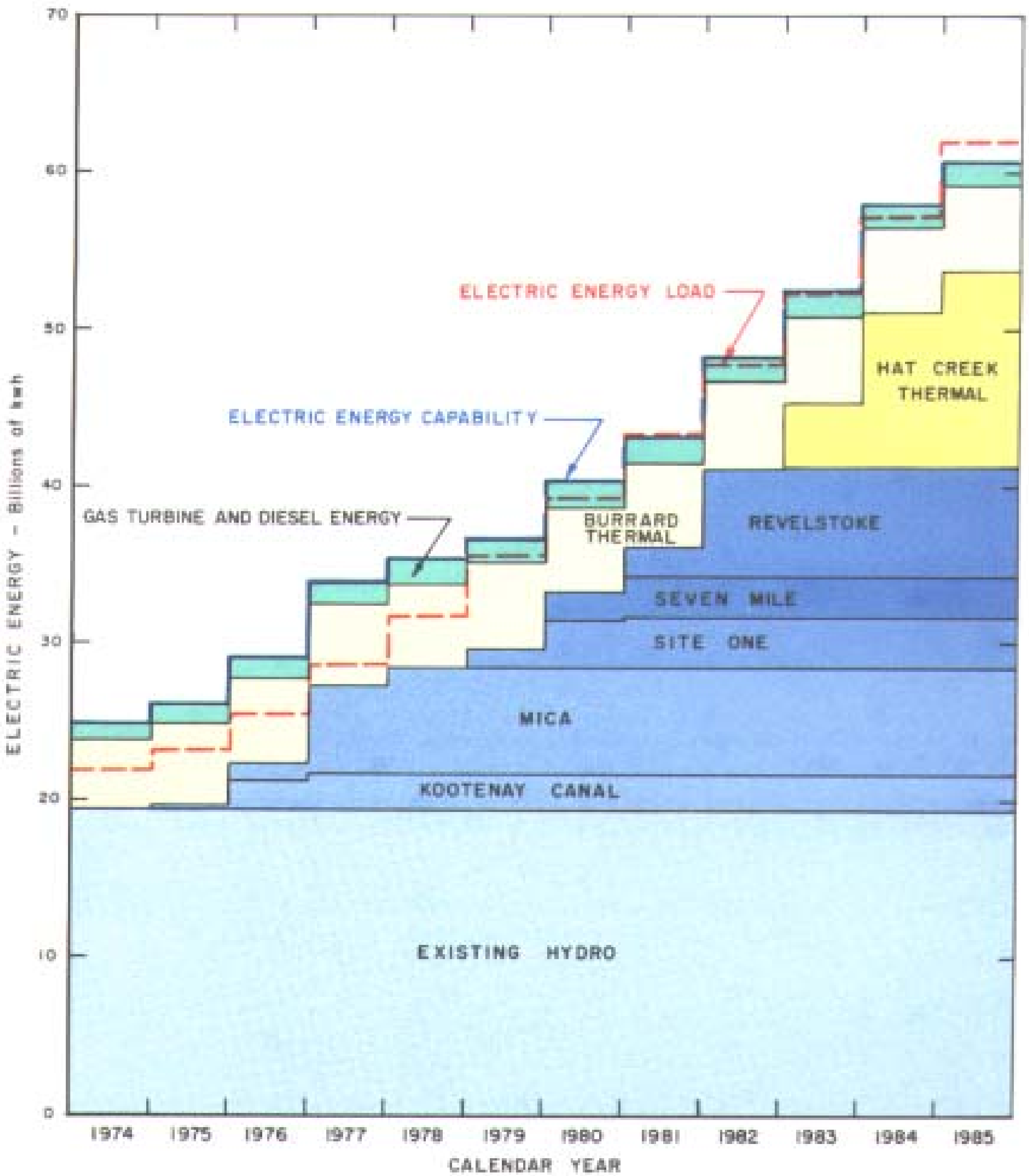


FIGURE 2

B.C. HYDRO INTEGRATED SYSTEM

ELECTRIC ENERGY LOADS AND GENERATING SYSTEM CAPABILITY

PART I

SUMMARY

PART I — SUMMARY

A. TERMS OF REFERENCE

In August, 1974, B.C. Research and Dolmage Campbell & Associates Ltd. were jointly commissioned by British Columbia Hydro and Power Authority (B.C. Hydro) to undertake a preliminary environmental impact study of the proposed Hat Creek thermal-electric power development. The terms of reference established by B.C. Hydro were, in abstract form, as follows:

> To investigate, analyze, and evaluate in a single integrated study the combined environmental (ecological, social and economic) effects of the construction and operation of a 2000 Mw conventional thermal generating plant and its associated coal mining operations located at or in the vicinity of B.C. Hydro's Hat Creek coal deposit. The earliest in-service date for a plant at this site would be early in 1983.

B. DESCRIPTION OF THE PROPOSED PROJECT

1. THE COAL DEPOSIT

The proposed Hat Creek thermal-electric development is based on a unique coal deposit situated in Upper Hat Creek Valley in south-central British Columbia. The Hat Creek coal deposit is located 120 miles northeast of Vancouver, midway between the towns of Lillooet and Ashcroft, (Figure 1-1). It was first discovered in 1877, and thereafter received sporadic exploration until mid-1974 when B.C. Hydro began definitive drilling of the deposit.

Information to date indicates the presence of at least one coal deposit, (No. 1 Openpit deposit), of sufficient size to support a 2000 megawatt (Mw) thermal-electric plant for a minimum of 35 years. As presently proposed, this openpit deposit would be mined by means of shovels, trucks and bulldozers. The quantities of material to be removed over 35 years would be approximately:

	SHORT TONS	METRIC TONS
Overburden (gravel, sand)	323,000,000	293,000,000
Waste Rock	782,000,000	710,000,000
Coal	420,000,000	381,000,000

2. THE PROPOSED GENERATING STATION

Eleven alternative locations were selected for initial consideration. Five are within or near Upper Hat Creek Valley (three termed 'mine-mouth' sites and two 'high altitude sites'), five in the general region around the valley (all 'adjacent to water supply' on the Fraser or Thompson rivers), and one at an unspecified site on the Lower Mainland ('adjacent to power demand').

SITE	LOCATION
1	North end, Upper Hat Creek Valley, Near No. 1 Openpit deposit
2	Midway in Upper Hat Creek Valley
3	South end, Upper Hat Creek Valley
4	Trachyte Hills, east of Harry Lake
5	Trachyte Hills, between Harry and McLean lakes
6	Fraser River, midway between Lytton and Lillooet
7	Fraser River, just south of Lytton
8	Fraser River, just north of Big Bar Creek
9	Thompson River, a few miles south of Ashcroft
10	Fraser River, near Lillooet
11	Lower Mainland, unspecified site

Preliminary analysis of site options incorporated the following factors: air pollution potential, transmission requirements, fuel (coal) transport, construction impact, site accessibility, water supply, flora and fauna, ash disposal, social impact, land use alternatives, and regional economic benefit. Environmentally, the mine-mouth and high altitude sites (Sites 1-5) were the most attractive, three of the sites adjacent to water were least attractive (Sites 6, 7 and 10 along the Fraser River), and the remaining three sites (8, 9 and 11), while not particularly attractive, were better than sites 6, 7 and 10.

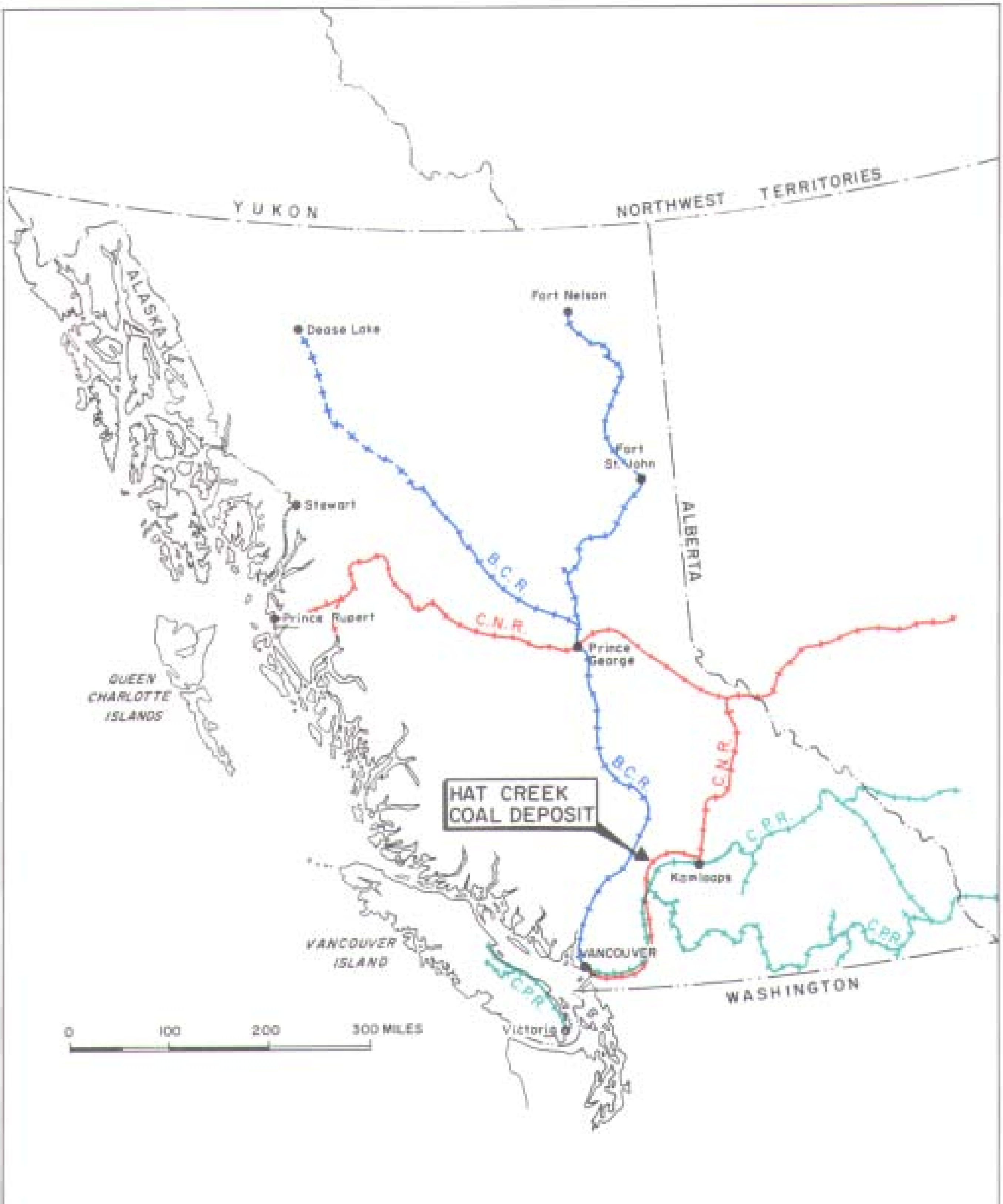


FIGURE 1-1
LOCATION OF HAT CREEK COAL DEPOSIT

In this preliminary assessment of potential environmental impacts the mine-mouth sites, and in particular site 1 which is adjacent to the No. 1 Openpit deposit, have received the greatest amount of study because:

i. they are part of the group of sites that are most environmentally attractive,
ii. they are spatially associated with the fixed location of the proposed mine and its potential impacts, and
iii. it was not possible to develop full-depth impact statements for all site options in this preliminary study.

3. THE PROPOSED FACILITIES

The proposed 2000 Mw generating station would use about 40,000 tons of coal per day. Prominent among auxiliary facilities would be a cooling tower or towers, a tall stack and possibly a water reservoir. For Sites 1 to 5 coal could be transported by conveyor from No. 1 Openpit to the generating station. Other sites would require rail service. Make-up water requirements would be about 25000 Igpm, probably conveyed by pipeline from the Thompson River. Transmission lines energized at 500,000 volts would be required to connect the station with the provincial grid.

A construction camp adequate to house perhaps 700 or more workers would be required near the site, though its population would vary with the progress of the project.

4. LAND REQUIREMENTS

The proposed project would require land use of the following proportions:

(a) UPPER HAT CREEK VALLEY SITES

	SITE				(acres)
	1	2	3	4	5
Generating Station	1570	1650	1650	1650	1650
Transport of Coal	—	19	57	23	46
Transport of Water	— Undetermined at this time —				
Transport of Electricity	10	213	519	184	306
Construction Camp	23	23	23	23	23
Sub-total	1603	1905	2249	1880	2025
Mine and Disposal Areas	3800	3800	3800	3800	3800
Total	5403	5705	6049	5680	5825

(b) OTHER SITES

	SITE					(acres)
	6	7	8	9	10	11
Generating Station	1720	1720	1720	1720	1720	1720
Transport of Coal	606	390	727	390	400	390
Transport of Water	— Undetermined at this time but probably minor —					
Transport of Electricity	—	49	1455	49	242	630
Construction Camp	24	24	24	24	24	6
Sub-total	2350	2183	3926	2183	2386	2746
Mine and Disposal Areas	3800	3800	3800	3800	3800	3800
Total	6150	5983	7726	5983	6186	6546

C. ENVIRONMENTAL IMPACTS

1. LAND FEATURES AND USES

Principal topographic impact would be the large openpit and associated disposal dump. The completed pit would cover about 1120 acres and have a maximum depth of 1400 feet. Disposal of overburden, waste and ash would require more than 2800 acres.

Most of the valley land use is for grazing. Of the alienations that would be caused by the proposed project (5370 acres total if the generating station were located at Site 1), 39% is classed as open grassland, 28% immature and 18% mature productive woodland with open grassland, and 13% non-productive woodland. The remaining 2% consists of cropland, swamp, and water surfaces. About 24% of the alienated land is deeded, and 76% leased Crown land. Six ranchers would suffer significant loss of land.

Classification and distribution of soils in the project area is detailed in the report. There appears to be considerable potential for dusting, erosion and leaching of disturbed material.

2. AIR AND WATER ENVIRONMENT

In common with much of south central British Columbia, the existing climate in Upper Hat Creek Valley is relatively dry (about 15 inches mean annual precipitation). Wind velocities appear to be low near ground level but data is inadequate and is being collected. The proposed plant would emit about 10 billion Btu/hr of heat, and 10 million lb/hr (17,000 Igpm) of water vapour, from the stack and cooling tower. Although experience elsewhere would suggest that effects on local climate would be negligible, a deep valley location would seem to increase the prospects for fog and ice formation under certain weather conditions.

The proposed development would contribute increased dust; vehicular emissions (nitrogen oxides, carbon monoxide, carbon particles); plant emissions (nitrogen, oxygen, carbon dioxide, water vapour, about 550 lb/min of sulphur dioxide, 210 lb/min of nitrogen dioxide, 2 lb/min of terpenes, 78 lb/min of particulates, and minute trace element quantities); and the cooling tower emissions noted above.

Both surface and groundwater supplies in the area are relatively modest. Preservation of Hat Creek would necessitate its diversion around the openpit and some minor streams would require protection or diversion. The probability of acid mine drainage seems remote on the basis of study to date.

Only the Fraser or Thompson rivers could provide an adequate supply of water for the proposed development at Sites 1-10, and the Thompson would be preferred because of the high sediment levels on the Fraser. Peak water requirements would not exceed 2.6% of Thompson low flow or 1% of Fraser low flow. Considerable amounts of data have been assembled on present water quality of major streams though more are required. Water licenses and flow rates are also recorded as a base line against which to note potential impacts.

3. SPECIES AND ECOSYSTEMS

In view of the cool and continental climate, Upper Hat Creek Valley contains two major vegetation types — a steppe zone in the valley floor below the forest and a dry forest, the lower zone of the montane forest. Plant species associations and sub-associations have been established in a preliminary manner. The proposed project would alienate 22 acres of cultivated fields, 2255 acres of Douglas fir-pinegrass, 1165 acres of upland grasses with chrysothamnus, 1070 acres of sagegrass-ponderosa pine-bunchgrass and minor amounts of other types.

There are a number of instances of existing or prospective fisheries in Hat Creek and downstream. It seems likely that the potentially hazardous impacts of the proposed project (e.g. deleterious substances entering the water such as leachates, waste materials, coal; stream modification; fry entrainment) could be circumvented by careful choice of construction and operating alternatives.

Wildlife present include deer and moose, neither in abundance. Waterfowl and smaller mammals and birds might also be affected to a minor degree by the principal impact — removal of habitat. On the basis of preliminary examination it is anticipated that habitat removal will not prove to be a severe problem. The potential effects of increased pressures from added population and activity in the area are less clear.

There are no known sites of significant archaeological value in Upper Hat Creek Valley.

D. SOCIAL AND ECONOMIC IMPACTS

Direct effects of the proposed project on people would be most noticeable to the valley ranchers, residents of the nearby Indian reserves, and residents of the towns of Ashcroft, Cache Creek, and Clinton. Lillooet seems less likely to be affected (though this depends on choice of generating station site) and Kamloops would be influenced primarily by secondary effects such as trade.

Since the population and labour force in the area is small, the influx of construction workers and subsequent permanent employees would seem relatively large. The estimates of construction and operating workforce over an 8-year period are as follows:

YEAR	CONSTRUCTION		OPERATIONS		TOTAL
	MINE	GEN. STN.	MINE	GEN. STN.	
1	50	100	—	—	150
2	190	250	—	—	440
3	150	475	—	—	625
4	150	800	—	—	950
5	150	730	120	120	1120
6	150	650	160	180	1140
7	150	300	220	250	920
8	150	—	290	250	690
n	—	—	290	250	540

Principal trades requirements for the construction force would be heavy equipment operators, boilermakers, pipefitters, and electricians. Significant work for other trades is also noted.

The payroll generated in the area by these jobs would be of the order of 120 million dollars total over the eight year development period and about 11 million dollars annually thereafter (in constant current dollars). Factors such as inflation, overtime, and engineering and other employment outside the area would add substantially to these figures.

The population increase in the general area of the project is estimated to be about 2000 unless the generating station is located outside the region, in which case it would be somewhat more than 1000.

Subsidiary economic impacts would include about 100 million dollars of project purchasing in British Columbia and several hundred million more dollars elsewhere in Canada and abroad. Local economies in the project area towns and in Kamloops would receive significant increases in trade, service, and related added business volume. This in turn would create additional jobs in these areas. Vancouver would probably benefit most from extra jobs generated by the construction phase. Corporate and personal income tax, property tax, duties, and sales taxes would generate public revenues exceeding 60 million dollars during construction.

Housing would be required for construction workers, permanent workers, and the subsidiary increase in population arising from the project. Since little excess capacity now exists in the area, housing construction would be required for nearly all of the increased population. Land supply, water and sewage systems, mobile home parks, etc. would require planning and coordination but no limiting problems are apparent. No new company town is recommended, and the required construction camp should not be a permanent establishment.

Schools would be required to absorb about a 20 percent increase over the eight-year period. This is proportionately much less than the 1966-71 increase, and would be ameliorated by presently declining enrolments.

Hospital capacity in the area would be sufficient, considering there are relatively new institutions in Ashcroft and Lillooet, both with extra space which could be equipped when required.

The recreation facilities of the area, although quite diverse, would be required to absorb a considerable increase in use. Urban facilities and programs in particular would probably require sizeable expansions and additions, and the construction camp would need special attention.

Social service case loads could be expected to increase, as would traffic and law enforcement requirements.

A number of special concerns have been noted on behalf of the Upper Hat Creek Valley ranchers (potential alteration of lifestyle, compensation, improvements to property, etc.), Indian bands (downstream air or water impacts, access routes, hunting pressures, jobs, compensation), and municipalities (economic benefits, increased service requirements, planning problems, tourism, job training).

There would likely be noticeable increases in traffic and noise in the area, but the significance of the increase has not been adequately defined.

E. CONCLUSIONS AND RECOMMENDATIONS

It should be noted that this study is preliminary in nature. It has been conducted thus far with a view to identifying the relevant factors for discussion by interested parties, but much detailed information remains to be established. The principal conclusions and recommendations presented here are supplemented in the main text of the report by a number of others of less immediate concern.

1. THERMAL PLANT SITE OPTIONS

Many plant siting impacts are similar in nature (though not necessarily in degree) for any site. The principal governing impacts would be atmospheric emissions and land alienations. At this stage of investigation it would appear that sites in Upper Hat Creek Valley (Sites 1-5) would have less impact on both counts than would the remaining alternatives.

2. ENVIRONMENTAL IMPACTS

(a) LAND FEATURES AND USES

The principal topographic changes would be caused by the coal mine openpit and waste disposal areas (3010 acres total). Suitable reclamation procedures could ultimately restore the waste areas (1890 acres) to productivity and acceptable appearance.

If the generating station were located at Site 1 total land alienation would be 5370 acres. Sizeable portions of deeded and/or leased land would be lost by six ranchers. Most valley residents would be inconvenienced to some degree.

No obvious problems are apparent with respect to trace elements, but much study remains to be done.

The fine textured soils suggest a need for caution regarding potential dusting, erosion and silting problems.

(b) AIR AND WATER ENVIRONMENT

The proposed 2000 Mw thermal generating station would discharge about 120,000 tons of water vapour, 400 tons of SO_2, 150 tons of nitrogen oxides, and 56 tons of fly ash each day. A proposed test burn of a large sample would improve understanding of the implications of these emissions. Further meterological study is also required to establish probable ground level conditions.

The generating station would have little impact on groundwater regardless of its location. The openpit would interrupt present Hat Creek flow necessitating its diversion, and would draw down subsurface water for some distance (not yet determined) around it.

A plant with a cooling tower system would require 25,000 Imperial gallons per minute (Igpm) of make-up water although, to obviate pumping during daily periods of peak power demand, the maximum pumping rate might be 40,000 Igpm. Only the Thompson or Fraser rivers could supply this quantity of water at Sites 1-10. The high suspended solids and greater hardness of the Fraser indicate that the Thompson would be a preferred source.

No conflicts with present irrigation uses of Hat Creek and Bonaparte River water are foreseen, and some augmentation might be possible.

(c) SPECIES AND ECOSYSTEMS

The most valuable land which would be alienated by the proposed project would be 22 acres of agricultural fields. Others would include 2255 acres of Douglas fir-pine grass (540 acres of which has already been logged), 1165 acres of upland grasses, and 1070 acres of sage brush-ponderosa pine-bunchgrass savannah. Increased water availability in the valley might be of some benefit to vegetation on unalienated land.

Hat Creek provides good fish habitat and spawning potential for rainbow trout. The Bonaparte River above the falls now supports some trout, and below the falls supports a small salmon population. Both the Thompson and Fraser rivers are important salmon rivers. Tests have shown that Hat Creek coal is not toxic to fish at ten percent concentration in the water, but the bedrock is very alkaline and can be lethal. Sediment loading of Hat Creek during construction could create a migration barrier.

Upper Hat Creek Valley has limited deer and moose habitat but some important winter range exists on the western valley slopes. Proposed land alienation does not appear to diminish waterfowl production potential. Increased hunting pressures might arise, but a sizeable no-shooting zone would be required in the project vicinity.

There are no known archaeological sites in the valley, but potential exists.

3. SOCIAL AND ECONOMIC IMPACTS

(a) EMPLOYMENT, INCOME AND POPULATION

The proposed project would employ more than 1100 workers at mid construction peak, and by the 8th year would provide about 540 permanent jobs. Most employees would likely have to come from outside the region, many from outside the Province.

A permanent population increase (in the area) approaching 2000 may result by the fifth year following commencement of construction. A "temporary" construction camp may have to accommodate up to 700 workers in peak years.

In terms of 1975 dollars, the construction payroll in the area could amount to $25 million per year in peak years and the permanent payroll of the order of $10-$20 million per year.

Expanding economic impacts based on mine and generating station investment and payrolls would generate secondary service jobs, increased trade, new business opportunities, and tax revenues.

Present housing stock in the communities of the project area would be totally inadequate to serve the needs of the projected population increase, but adequate land and services potential exist for new subdivision development. Planning problems would require early attention.

Currently declining school enrolments in most towns, and the availability of spare hospital capacity at Ashcroft and Lillooet taken with the experience of previous mining-related expansions suggest that increased demands for these services could be met with less major capital expenditures for new facilities than might be expected.

Other impacts that would be imposed by the project include increased traffic flows on area roads, increased law enforcement requirements, a need for enlarged and more diverse recreational facilities, and increased pressure on social services.

(b) SPECIAL SOCIAL AND LIFESTYLE CONSIDERATIONS

The Upper Hat Creek Valley ranchers would be most directly affected, and have a number of concerns regarding the alteration of the quiet rural character of their area, their future investment plans, water supplies in Hat Creek and in wells, land used or foreclosed to use by the project, and type and amount of compensation which would be provided.

The Indian bands holding reserve land in the area would not likely experience significant pressure on use of land for project purposes. However they have a number of concerns, accentuated by their perception of historical injustices and the land claims issue. These include alteration of lifestyle in the area, possible downstream water or air quality problems, access routes that might pass through reserve land, pressures on hunting by increased population, and lack of opportunity to participate in the economic benefits stemming from the proposed project.

Additional concerns of a municipal or public nature involve issues such as job training programs, financing of increased demands for services of all kinds, planning control over potential undesirable settlement patterns, and possible problems of noise, traffic, law enforcement, and public welfare.

4. RECOMMENDED REMEDIAL ACTIONS

(a) GENERAL RECOMMENDATIONS

The areas of the mine and generating station should be landscaped and converted to the best possible aesthetic state within limits of continuing work (eg. mining).

The overburden, waste rock and ash disposal areas associated with the openpit mine and thermal plant should be progressively reclaimed in order to return some of the alienated land to productive use as soon as possible and to reduce the unnatural appearance of these areas.

The proposed coal sample for test burning at an operating thermal plant should be obtained at an early date so that sufficient time would be available to conduct environmentally related studies on the sample site and attendant disposal areas.

(b) THERMAL PLANT SITE OPTIONS

To minimize alienation of Indian lands and productive bottom land resulting from the transport of coal the proposed generating station should be located near the No. 1 Openpit deposit. Any of Sites 1-5 in Upper Hat Creek Valley would be preferable to Sites 6-11 in this regard. Site 1 would be the optimum location with respect to such land alienation.

For sites not adjacent to water supply, consideration should be given to transporting water via tunnel or buried pipeline-and-tunnel if it would obviate alienations of land of significant value.

(c) LAND FEATURES AND USES

For safety purposes the boundary of the openpit, including the active buffer zone, should be fenced.

If conveyor belts were employed for the transport of coal they might require covering to prevent coal dusting and loss of product, and the land corridors they occupy would have to be fenced for safety reasons.

Provisions must be made for those ranchers whose properties would be isolated or physically reduced through development of the proposed project. It is understood that B.C. Hydro has already indicated a policy of purchasing, at current prices, any land in the Upper Hat Creek Valley offered for sale, whether directly affected or not. Lease-backs and relocations might be worth considering as added alternatives.

Provision should be made for irrigation water to improve areas surrounding both the openpit operation and the thermal plant site.

Topsoil should be progressively removed from the No. 1 Openpit and the overburden and waste rock disposal areas and preserved for future use in reclamation of the disposal dumps.

(d) AIR AND WATER ENVIRONMENT

In order to minimize the environmental impact of atmospheric emissions from the thermal generating station, a preferred location would be in a relatively high, open area where adverse meteorological conditions occur infrequently. In this regard, Sites 1-5 in Upper Hat Creek Valley would have a distinct advantage over Sites 6-11, (with the possible exception of Site 8). The optimum sites with respect to atmospheric emissions would be 4 and 5 in the Trachyte Hills.

For Sites 1-5, Thompson River water should be used as make-up water for the proposed operation, both because of better quality water and to avoid the discharge of one water system into another.

Provision should be made for the collection, storage and disposal of all effluents such as mine leachates, oil, sewage, water treatment waste, water from fly ash slurry systems, and boiler blowdown wastes.

(e) SPECIES AND ECOSYSTEMS

It would be mandatory that waste rock not be allowed to enter major water courses because of its deleterious properties for the fishery.

Discharge of physical and chemical pollutants such as dust, particulate and stack gases would have to be rigidly controlled to prevent them from being distributed on vegetation used for forage by domestic stock or wildlife. Baseline data prior to proposed development should be collected to provide a comparative base for measuring changes and indicating the need for special controls.

If the fishery in Hat Creek was disrupted by damming and/or diversion it would have to be replaced or compensated. This could be accomplished by either stocking the reservoir behind the dam or by creating spawning habitat downstream of the proposed development.

(f) SOCIAL AND ECONOMIC CONSIDERATIONS

A 'Project Impact Committee' should be established at an early date to provide a mechanism through which people can easily communicate their problems or concerns to B.C. Hydro, its contractors and appropriate agencies.

5. RECOMMENDATIONS FOR FURTHER STUDY

The following list comprises the major or more significant recommendations for further study which have become apparent during the course of this preliminary environmental evaluation of the proposed Hat Creek development. Details and reasons for them are contained in the appropriate sections of the report as are a number of less significant recommendations for further study. The purpose of these recommendations is dictated by two primary requirements: (1) the acquisition of more data, and (2) the need for more detailed evaluations. Before a final environmental study can be completed it will be necessary to establish the ultimate size of the proposed generating plant.

(a) Studies of slope stability (pit excavation, overburden and waste rock dumps). groundwater intrusion, biological angle of repose, and revegetation and other reclamation procedures. These could be accomplished on a (pilot) scale when the trenches and attendant disposal areas resulting from the mining of the burn sample are available for study and testwork.

(b) More definitive study of trace elements (research, data acquisition, testwork) as they relate to water, soil and rock, plant and animal life, and possible economic recoveries.

(c) Collection of meteorological and air quality data (on going) for the establishment of background levels before operation, and use in site evaluation with respect to atmospheric emissions of the generating plant.

(d) Studies associated with the diversion of Hat Creek around the openpit to determine the environmental effects of the various proposed methods of diversion and to select an optimum solution. Included in the study would be effects on, and required remedial actions for, fishery, water quality, irrigation, and domestic use.

(e) Determination of the groundwater regime in the pit area, the probable effect on it of the pit excavation, and suggestions for possibly required remedial action.

(f) Effects of various water intake designs as they relate to fish hazard and fry migration.

(g) Detailed vegetation survey through a minimum one-year period to determine productivity, seasonal use, potential values and timber quantities.

(h) Detailed ecological studies of the effect of the proposed development on the wildlife of the area; acquisition of baseline data and application of other data (air and water quality, greater activity, etc.) with respect to its effect on fish, animals, birds and man.

(i) Sources of project manpower; training programs.

(j) More specific and detailed study of secondary project impacts on trade, income, employment.

(k) Once a site or sites for final analysis are selected, then many factors can receive more specific local and regional analysis — housing and construction camp planning, traffic flow increases by route mode and facility, school requirements, municipal services, social services, recreational planning for the camp and principal towns.

(l) The Indian bands' situation relative to the project — more specific analysis of job opportunities, commercial or development opportunities, means to preserve traditional values and reduce potential friction.

PART II

INTRODUCTION

PART II — INTRODUCTION

A. BACKGROUND TO STUDY

British Columbia Hydro and Power Authority is charged with the responsibility for providing the needs for electricity in British Columbia at a reasonable cost to consumers. Electrical power demand has increased rapidly in recent years and, although efforts are underway to reduce this growth rate, increased generating capacity will be required even if these efforts are successful. The primary purpose of the proposed project is, therefore, to provide electricity to meet increased demand in the southwestern part of British Columbia during the 1980's.

The method of accomplishing this purpose is dictated by the energy resources of the Province and the recent changes in the energy situation worldwide. Electricity in British Columbia is now produced principally in hydro-electric stations, and additional hydro-electric capacity is planned. However, potential hydro-electric generating sites beyond those planned are increasingly remote from the large demand centres of the Lower Mainland and Vancouver Island. Combustion of fossil fuels is an alternative. The cost and availability of oil and natural gas are such that combustion of coal must be considered. Fortunately, British Columbia is richly endowed with thermal coal. The proposed course of action would result in the utilization of a large source of energy situated relatively close to the major demand centres for electric power.

Numerous factors must be considered in determining the relative merits of various sources of electric power and in determining the feasibility of any one power source. Prominent among those factors is potential environmental impact. Consequently, in August, 1974, B.C. Hydro commissioned B.C. Research and Dolmage Campbell & Associates Ltd. to jointly undertake a preliminary study of environmental impacts which might be associated with the proposed construction and operation of a thermal-electric generating station fuelled by coal obtained from one or more deposits in Upper Hat Creek Valley. This study is being conducted in conjunction with other basic studies concerning the feasibility of the proposed project and therefore will contribute to decision-making at any stage of investigation. Consequently, if the project is approved and undertaken, environmental considerations can be incorporated at the earliest possible stages.

B. TERMS OF REFERENCE

B.C. Research and Dolmage Campbell & Associates Ltd. were commissioned jointly by B.C. Hydro to undertake a preliminary environmental impact study of the proposed project. The terms of reference were established by B.C. Hydro after some preliminary discussion with the consultants.

1. ABSTRACT

To investigate, analyze, and evaluate in a single integrated study the combined environmental (ecological, social and economic) effects of the construction and operation of a 2000 megawatt (Mw) conventional thermal generating plant and its associated coal mining operations located at or in the vicinity of B.C. Hydro's Hat Creek coal deposit. The earliest in-service date for a plant at this site would be early in 1983.

2. SPECIFIC TERMS OF REFERENCE

1. The environmental study shall include identification and analysis of the construction and operational impacts of the proposed mining and power developments on existing and potential ecological, social, and economic conditions.
2. Identified impacts — beneficial and adverse — are to be evaluated both qualitatively and quantitatively wherever possible, including an assessment of the risk or probability of their occurrence, their extent (local, regional and provincial), and their duration.
3. The study shall identify and evaluate possible measures to enhance the potential benefits (apart from power production) of the developments and to avoid, reduce, or compensate for the associated losses.
4. The study shall identify the impacts of the construction phase separately from the longer term operating effects.
5. The study shall identify possible expansions and diversification of the mining and power development complex and indicate the nature of their probable impacts. This would include assessment of the impacts of expansion of the generating plant to 4000 to 5000 Mw.
6. The Regional District, municipalities, and residents of the area are to be informed of this study. Participation by local and regional governments, provincial government departments, and other public organizations, as well as from B.C. Hydro operating and construction staff, shall be sought by the consultant. Initial contact with the government agencies and liaison with the public will be coordinated by B.C. Hydro.
7. At the onset of the study, consultation will be held with the appropriate departments of B.C. Hydro responsible for planning, design and construction of the project, land acquisition, and community relations.
8. The site location for the plant will be determined upon completion of concurrent studies by B.C. Hydro (engineering), Dolmage Campbell and Associates (geological) and B.C. Research (environmental).
9. The consultant shall submit progress reports as appropriate, an interim report by October 31, 1974, and a Phase I report by December 31, 1974.
10. The study is to be controlled and coordinated on behalf of B.C. Hydro by Dr. H.M. Ellis, Manager of the System Engineering Division.

C. PURPOSE AND SCOPE OF THE STUDY

This study is a preliminary assessment of the anticipated environmental impacts resulting from the following proposed actions:

1. The mining from an openpit of approximately 12 million tons of coal per year from proven and probable reserves in Upper Hat Creek Valley, British Columbia (Figure 2-1).

2. The construction and operation of a 2000 Mw coal-fired electric generating station to supply power to the provincial grid. The generating station might be expanded subsequently to as much as 5000 Mw capacity with proportional increase in the amount of coal mined.

This preliminary report is designed to provide information about the project and its potential impacts, to define areas in which additional information and research are required, and to provide a basis for obtaining and incorporating into a final report further in-put from concerned government agencies, corporate bodies, individuals and others. The on-going nature of the study is emphasized. There has been insufficient time to collect all pertinent data, and engineering studies relating to both the proposed mine and generating station are in only preliminary stages.

The proposed coal mine would be located in Upper Hat Creek Valley but its precise location within the valley is dependent on the results of exploration in progress. For the present though, it is assumed that the No. 1 Openpit deposit, (Section III, A), would be the coal source for the generating plant. On the other hand, for the location of the generating station, eleven options have been considered. However, because it is not realistic to develop at the outset in-depth impact statements for all site options, the study has concentrated on the five potential sites within or near Upper Hat Creek Valley. The study emphasizes these sites because, regardless of the location of the proposed generating station, the mine (and its associated environmental impacts) would be located in this area. Depending on results of on-going studies it may be necessary to subsequently develop in-depth environmental statements for some of the sites away from Upper Hat Creek Valley.

It should be noted that some of the potential impacts are not confined nor directly related to the specific project sites. For example, the mine and generating station are considered as 'focal points' for a number of the potential impacts discussed in Part VII, Social and Economic Considerations. These potential impacts are regional in scope and, within limits, regardless of the site of the proposed generating station, they will still affect much the same region. Changing the location of the proposed generating station primarily would have the effect of altering the local intensity of the impacts within the region.

Part III of this report, 'Description of the Proposed Project', discusses the proposed mine and generating station, generating station site options and potential land (and other) requirements so that the proposed project and its ramifications can be better understood by all concerned. Parts IV, V, and VI are concerned with the direct environmental aspects of the proposal. In general, individual sections within these parts employ the following format: present conditions, anticipated changes due to the proposed project, recommendations for remedial action, and recommendations for further environmental study. Part VII, Social and Economic Considerations, is concerned with impacts that the proposed project may have on people. Because these impacts could affect the lifestyle and economic welfare of people in a relatively large area, they are considered to be of prime importance in this study.

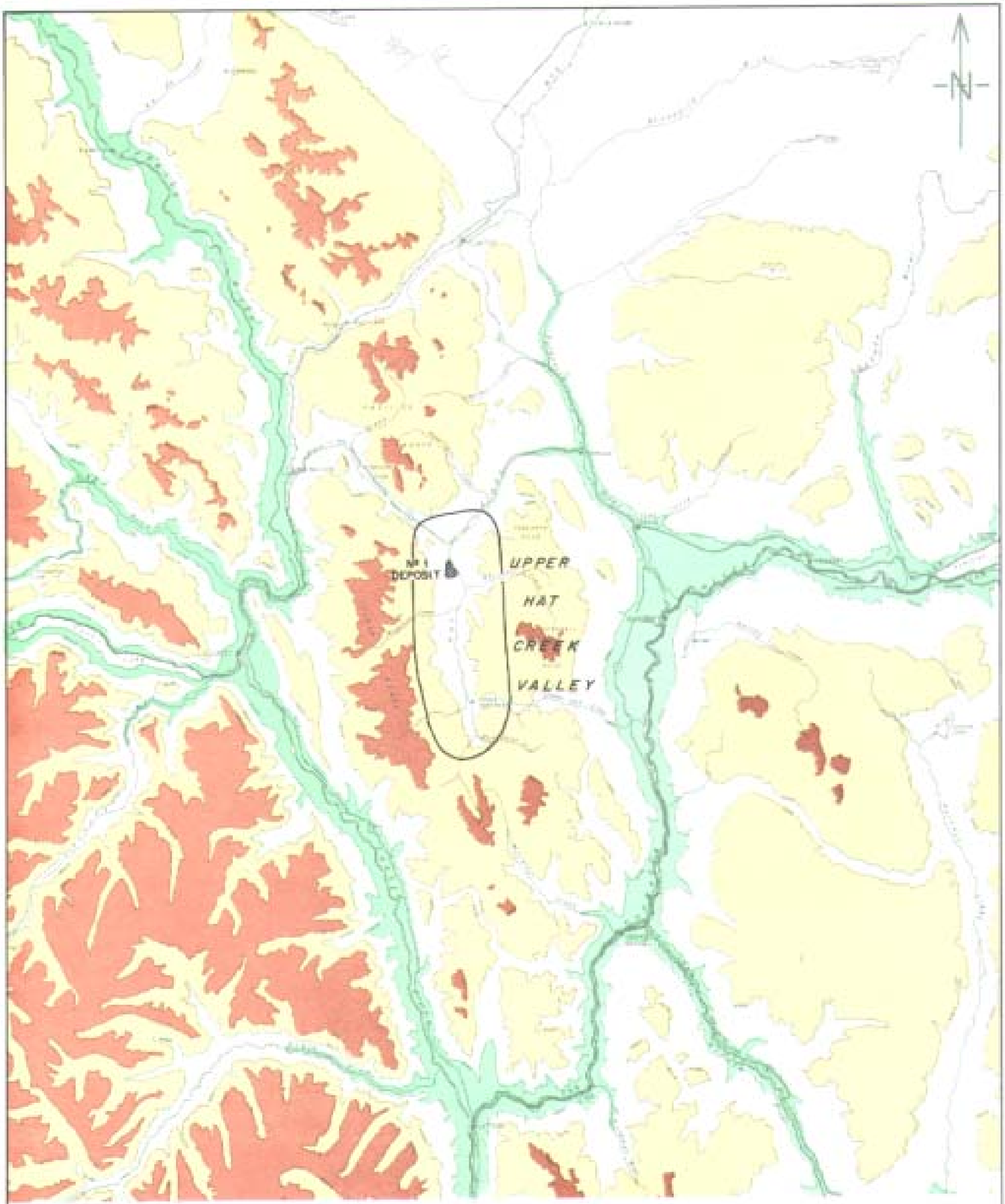


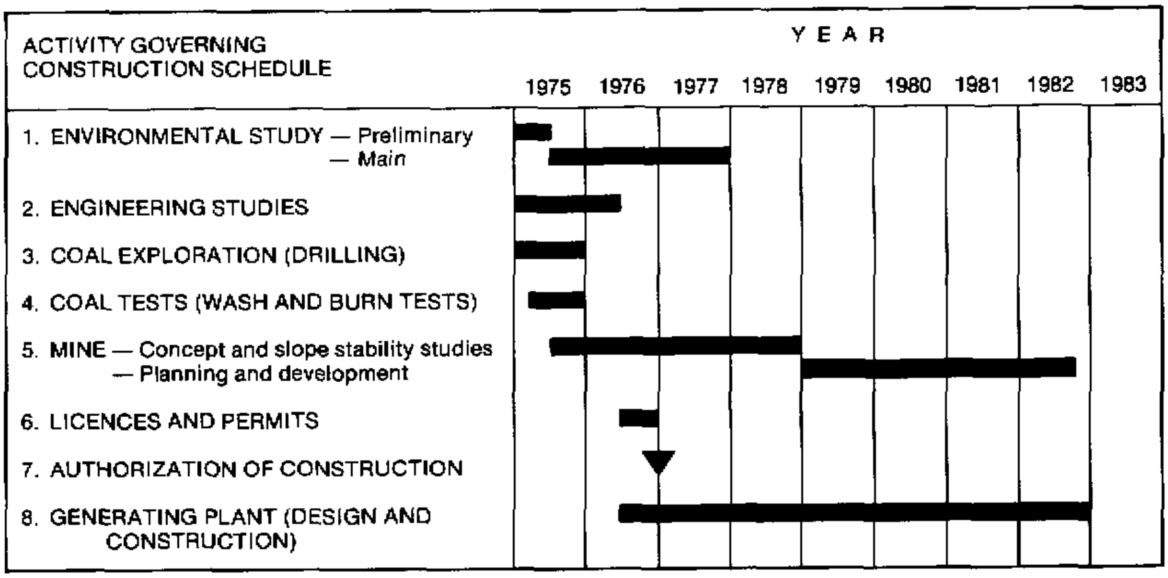
FIGURE 2-1
HAT CREEK AND ENVIRONS

D. PLANNING SCHEDULE

This preliminary environmental impact study of the proposed Hat Creek development is only one of several studies and activities concerning the proposed project. Some of the studies are presently under way and others will follow if and as the project proceeds. Many of the studies and activities are interdependent and therefore it is not always possible to employ firm data in one study if that data derives from another on-going study. The processes of proposal, study, planning and so forth are thus partly iterative with the objectives being an optimum combination of desirable factors (engineering, environmental, social and economic) in which compromise in any one area is kept to a minimum.

Figure 2-2 is a chart depicting the relationship of the environmental studies to other studies and activities comprising the proposed project.

FIGURE 2-2
HAT CREEK THERMAL GENERATING STATION
PLANNING SCHEDULE TO JANUARY 1983 — FIRST UNIT IN SERVICE



E. GLOSSARY OF TECHNICAL TERMS

alluvial — deposit of clay, silt, sand and gravel formed by flowing water.

ambient — surrounding on all sides; the environment surrounding a body but undisturbed by it.

ash — the incombustible material in coal; the residue remaining after ignition of combustible substances.

barren — lacking in valuable components re coal.

biocide — a substance which is toxic to life, i.e. insecticide, pesticide.

British thermal unit — (Btu); the heat required to raise one pound of water one degree Farenheit; a measure of the heating value of coal.

brunisol — a dark brown soil which develops under forest grassland associations.

calorific value — a measure of the heating value of coal; generally expressed as British thermal units per pound (Btu/lb).

chernozem — black soil derived from alluvial parent material.

coal measure — strata (layered rocks) containing coal beds or seams.

colluvial — consisting of alluvium but containing angular fragments of the original rocks (slide and talus material); usually loose and incoherent deposits.

diurnal — variations occuring within a 24 hour period; recurring every day; having a daily cycle.

fry — recently hatched or very young fish.

glacial till — material deposited by glaciation, usually composed of a wide range of particle sizes with little or no size sorting.

glacio-fluvial — material produced or deposited by combined glacier and stream action.

indurated — hardened; applied to rocks hardened by heat, pressure or the addition of a cementing ingredient.

inversion — an increase of air temperature with increased altitude rather than the usual decrease; a warm air layer overlying cooler air.

Kjeldahl nitrogen — nitrogen content determined by the Kjeldahl procedure; total nitrogen content except for nitrite and nitrate nitrogen.

latent heat — thermal energy absorbed in a process not resulting in a change in temperature.

limnology — the scientific study of physical, chemical, meteorological and biological conditions of fresh waters.

luvisol — a soil of alluvial origin which develops in the forest grassland transition zone in moderate and cool climates.

microclimate — the essentially uniform local climate of a small site or habitat.

overburden — loose material such as clay, sand or gravel that lies above the bedrock.

pH — denotes the degree of acidity or basicity. Pure water has a pH of 7.

raptors — birds of prey.

sensible heat — thermal energy, the transfer of which results in a change of temperature.

smolt — a salmon or sea trout when it is about one year old and first descends to the sea.

steppe — an area of subdued topography generally lacking in forest cover.

stratigraphy — the study of layered rocks.

subcrop — the rock surface covered by overburden.

synergistic — the ability for cooperative action of discrete agencies such that the total effect is greater than the sum of the effects taken independently.

synoptic — relating to or displaying atmospheric and weather conditions as they exist simultaneously over a broad area.

tertiary — a period of geologic age extending back approximately 1 to 70 million years from the present; a relatively young and short geologic period.

tons — *all tons quoted in this report, unless otherwise noted, are short tons of 2000 pounds.*

turbidity — measure of all transparency or translucency of water.

terpene — an aromatic hydrocarbon produced by vegetation.

ungulate — hoofed animal.

vegetation association — an aggregation of plants common to a defined area.

vesicular — having a cellular structure.

waste — waste rock; the barren rock which must be removed from an openpit in order to obtain the valuable material (coal).

ABBREVIATIONS

ac ft	— acre feet
AUM	— animal unit month
Btu/hr	— British thermal units per hour
cfm	— cubic feet per minute
cfs	— cubic feet per second
$CaCO_3$	— calcium carbonate
CO_2	— carbon dioxide
ESP	— electrostatic precipitator
gpd	— gallons per day
grn/sdcf	— grains per standard dry cubic foot
Igpm	— Imperial gallons per minute
Kw	— kilowatts
kwh	— kilowatt hours
lb/hr	— pounds per hour
m^3	— cubic metres
m/s	— metres per second
mg/l	— milligrams per litre
mg/m^3	— milligrams per cubic metre
mph	— miles per hour
Mw	— megawatts
ppm	— parts per million
rpm	— revolutions per minute
SO_2	— sulphur dioxide
SO_3	— sulphur trioxide
tpd, tpy	— tons per day, tons per year
Tp. 21, R. 27	— Township 21, Range 27
TVA	— Tennessee Valley Authority
wt	— weight
ΔT	— temperature change
$\mu g/m^3$	— micrograms per cubic metre
μmhos/cm	— micro-mhos per centimeter

F. ACKNOWLEDGEMENTS

The terms of reference were arrived at on the basis of previous experience of B.C. Hydro and its consultants, consideration of the obvious and potentially related factors, and preliminary discussions with the Secretariat of the Environment and Land Use Committee of the Government of British Columbia.

The study has been a joint project of B.C. Research and Dolmage Campbell and Associates Ltd. with B.C. Research acting as prime contractor. Both the principal consultants have been assisted by other professional specialists in various phases of the investigation.

The authors are indebted to a wide variety of public agency officials, municipal administrators, industrial executives, ranchers, and members of Indian bands for their advice and assistance in the course of compiling this report. Wider involvement of other parties and the general public is anticipated in subsequent stages following circulation and study of these preliminary findings. To attempt to name the individuals consulted thus far would be to risk omitting many, but readers should be advised of the nature and breadth of participation in arriving at this first stage in the study of such a major proposed project. Sincere appreciation is expressed for the cooperation of the numerous parties interviewed. These have included:

B.C. Department of Agriculture
B.C. Department of Economic Development
B.C. Department of Mines and Petroleum Resources
B.C. Department of Highways
B.C. Department of Human Resources
B.C. Department of Land, Forests and Water Resources
B.C. Department of Recreation and Conservation
B.C. Environment and Land Use Committee Secretariat
B.C. Provincial Archaeologist
Environment Canada
Canada Department of Indian and Northern Affairs
Canada Department of Manpower and Immigration
Royal Canadian Mounted Police

The Ashcroft, Bonaparte, Oregon Jack and Pavilion Indian Bands
Residents of Upper Hat Creek Valley
Regional District of Thompson-Nicola
Regional District of Squamish-Lillooet
Town Councils of Ashcroft, Cache Creek, Clinton and Lillooet

Bethlehem Copper Corporation Ltd.
Lornex Mining Corporation Ltd.
Calgary Power Ltd.
Alberta Department of Environment
The Saskatchewan Power Corporation
The Hydro-Electric Power Commission of Ontario
Ontario Department of Environment

PART III

DESCRIPTION OF THE PROPOSED PROJECT

PART III — DESCRIPTION OF THE PROPOSED PROJECT

A. THE PROPOSED MINE

1. HAT CREEK NO. 1 COAL DEPOSIT

Diamond drill exploration has outlined a surface-mineable coal deposit at the north end of Upper Hat Creek Valley in south-central British Columbia. This deposit, the No. 1 Openpit, has sufficient proven and probable coal reserves to sustain the proposed thermal generating plant for at least 35 years. Drill exploration of the remainder of Upper Hat Creek Valley is continuing and, although other coal deposits may be found elsewhere in the valley, it is assumed for the purpose of the present study that the proposed thermal plant would be fed from coal mined from the No. 1 Openpit deposit.

(a) SITE DESCRIPTION

LOCATION

The Hat Creek coal deposit is located 120 miles northeast of Vancouver, B.C., midway between the towns of Lillooet and Ashcroft, (Lat. 50° 45'N, Long. 121° 35'W), (Figure 3-1) Railheads can be reached at Pavilion, on the BC Railway, 15 miles to the northwest, and at Ashcroft, on the CP and CN railways, 24 road miles to the east. Easiest access to the property is from the Trans Canada Highway at Cache Creek, 19 miles to the east, via the paved secondary highway between Cache Creek and Pavilion. The closest regularly serviced airport is at Kamloops, 68 miles to the east.

The short access distance to existing first-class highways and railroads of the Hat Creek deposit, together with its location well-removed from any major towns or cities upon which its operation might infringe, would appear to be important advantages for the development of a major mine at this coal resource.

PHYSIOGRAPHY

The explored portion of the Hat Creek coal deposit underlies approximately one square mile of the north end of the broad, north-trending, grassland valley, about 15 miles in length, through which flows the upstream portion of Hat Creek, (Figure 3-2). From the north end of this valley Hat Creek flows northeastward and eastward through a relatively narrow valley into the Bonaparte River, which flows south to join the Thompson River near Ashcroft.

Upper Hat Creek Valley lies within the Interior Dry Belt of British Columbia at a mean elevation of about 3500 feet. The No. 1 coal deposit is located at an elevation of about 2900

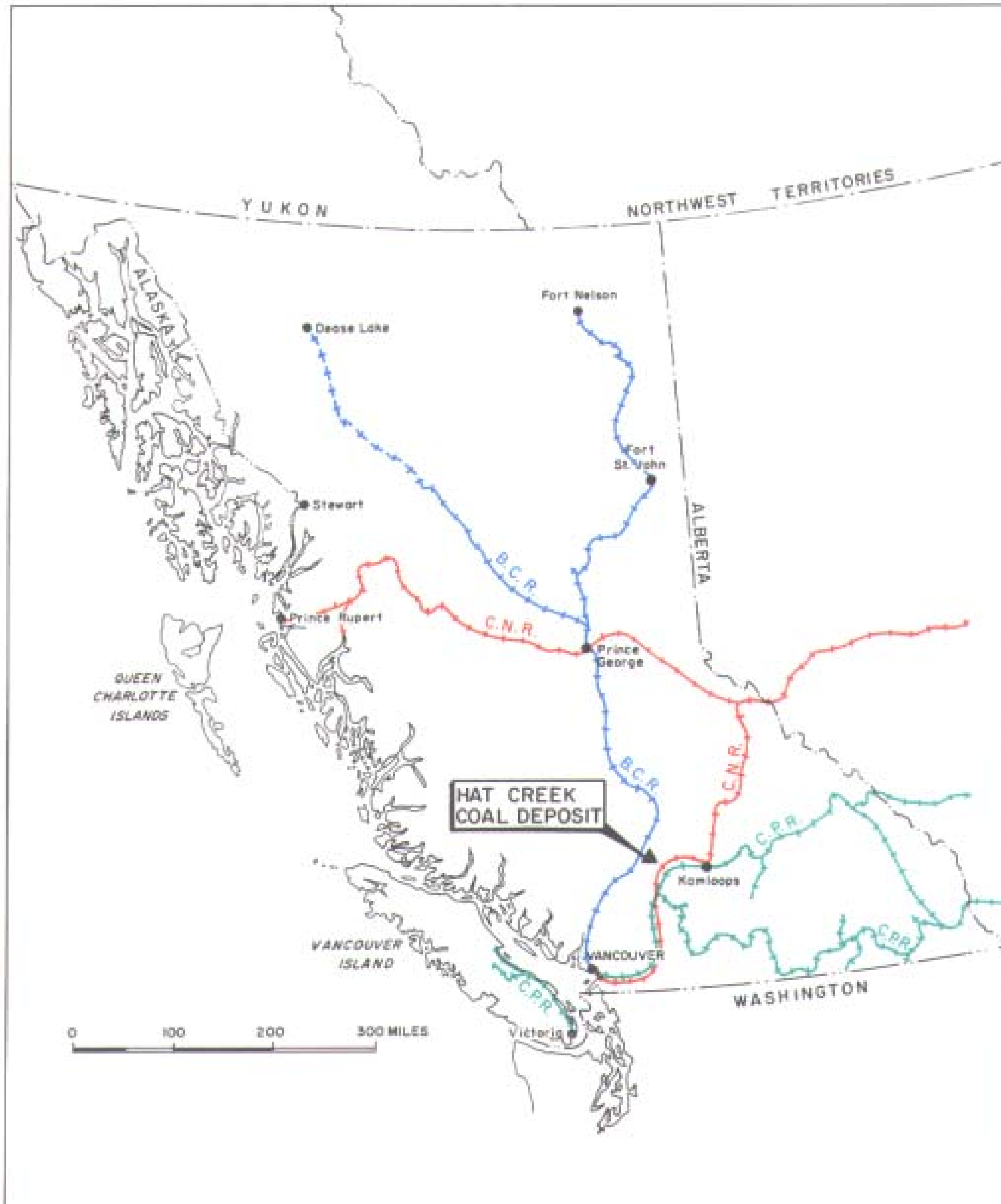


FIGURE 3-1

LOCATION OF HAT CREEK COAL DEPOSIT

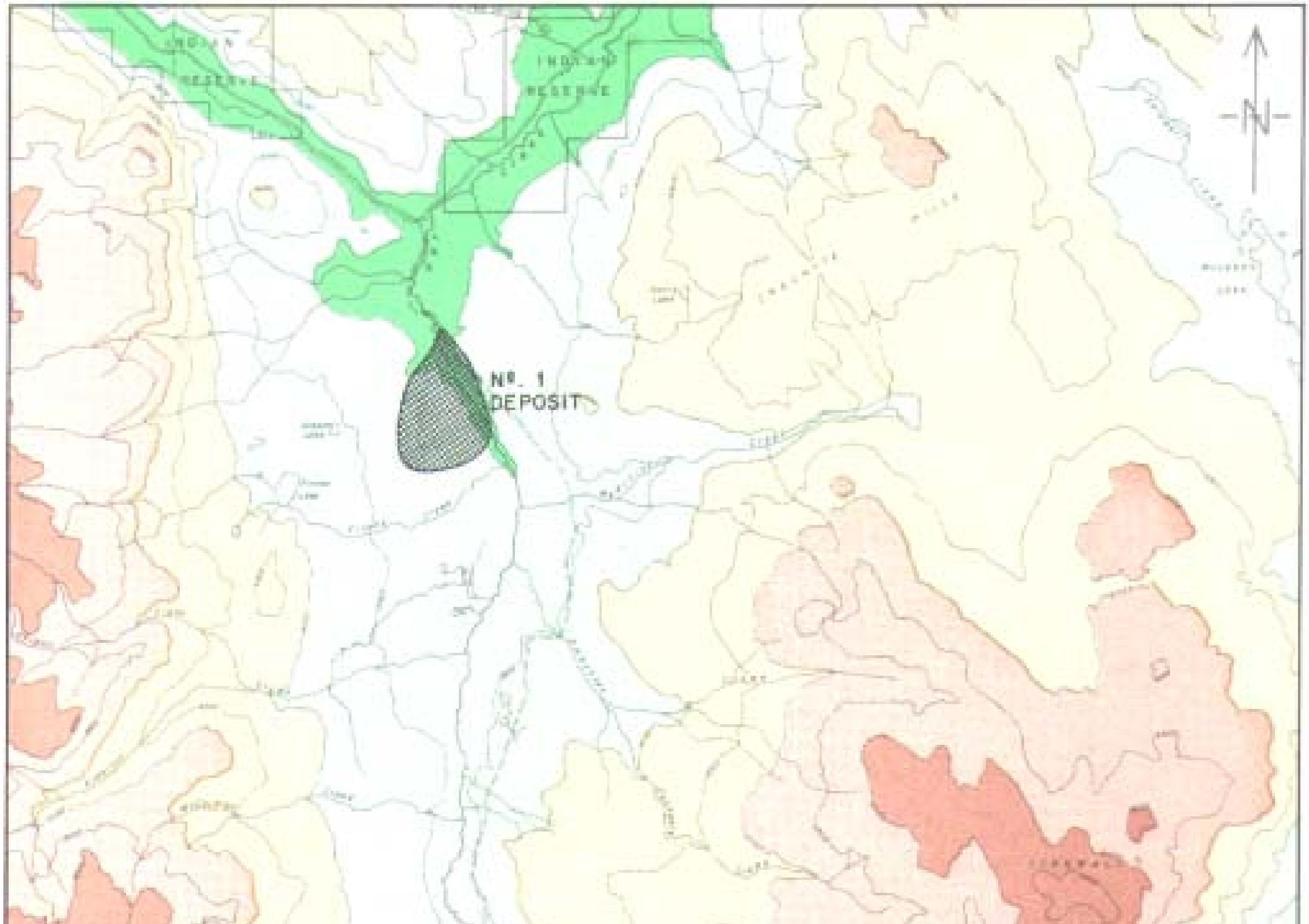


FIGURE 3-2
PHYSIOGRAPHY OF UPPER HAT CREEK VALLEY

feet. The valley is flanked by somewhat subdued mountains that rise to elevations of 6000-7000 feet four miles west of Hat Creek and to elevations of 5000-6000 feet six miles to the east. The uplands are covered with thin forests and the valleys are sparsely-treed open ranges of grass and sage.

Rock outcrops are sparse in the floor of the valley. Overburden, consisting of loosely compacted sand and gravel, ranges in depth from 10 to 300 feet in the vicinity of the coal deposit.

HISTORY

The No. 1 Hat Creek coal deposit was reported by Dr. G.M. Dawson of the Geological Survey of Canada in 1877 and 1894. The only coal exposures were along the banks of Hat Creek, where the overburden cover had been removed by creek erosion. By 1925 three shallow shafts and two short adits had been driven into the coal along the creek and seven holes had been bored into it. No further work was done on the deposit until 1933.

From 1933 until 1942 a few hundred tons of coal a year were produced from the property and sold in the nearby towns and villages. No work was done from 1942 to 1957. In 1957 the property was optioned by Western Development and Power Ltd., a subsidiary of B.C. Electric Co. Ltd., at which time one Crown Grant claim was extensively explored by surface diamond drilling.

Following the acquisition of B.C. Electric by the Government of British Columbia, the ownership of the one explored Crown Grant claim and two coal licenses comprising the Hat Creek coal property passed to British Columbia Hydro and Power Authority. No further exploration was done on the property until mid-1974, when B.C. Hydro began definitive drilling of the deposit. In 1974 B.C. Hydro acquired coal licenses covering most of Upper Hat Creek Valley, (Figure 3-3).

(b) GEOLOGICAL SETTING

The valley of Upper Hat Creek is largely underlain by Tertiary strata that form a basin-like structure whose boundaries conform to the valley walls, at elevations of 1000 feet or more above the valley floor. The basin lies northsouth along the valley of Upper Hat Creek for a length of about fifteen miles and an average width of about three miles, (Figure 3-4). The valley sides at higher elevations are underlain by terraces of volcanic rocks that apparently represent erosional remnants of volcanic deposits that once covered the valley.

The bedrock geology of the valley is known only from the few surface outcrops and from diamond drill cores. Consequently, pending further drilling, the interpretation of the stratigraphy and structure of the Tertiary formations is subject to some variation.

Most of the sedimentary rocks are poorly indurated and generally poorly cemented; therefore, they are incompetent and have low compressive strengths. Technically many of them are better described as semi-consolidated sands, silts, and clays. (This general weak nature of the rocks indicates that the waste rock that would be mined from the proposed openpit would disintegrate to rubble and fines by the time it was deposited and compacted on the dumps and thus should be in a condition more physically amenable to cultivation than normal mine waste dumps.)

A prominent feature of the Tertiary bedrock underlying Upper Hat Creek Valley is the presence of major, regional, steeply-dipping block faults. The principal known faults cross the north end of the valley in an east-northeast direction and are spaced about one mile apart. The coal deposit is known to be located between block faults in the north end of the valley. Preliminary evidence suggests that the faults comprise bedrock groundwater conduits within rocks that are otherwise dry and impermeable.

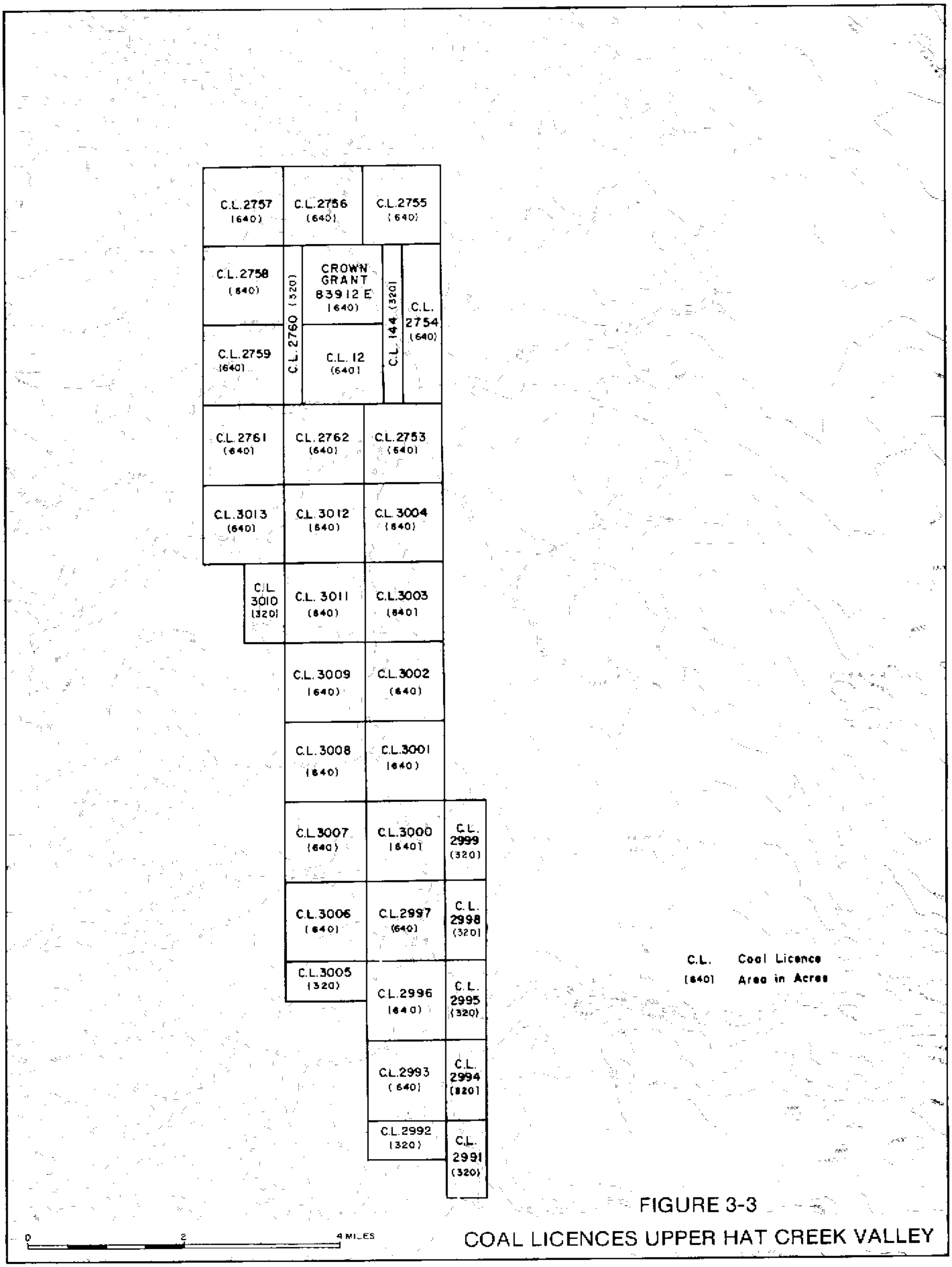


FIGURE 3-3

COAL LICENCES UPPER HAT CREEK VALLEY

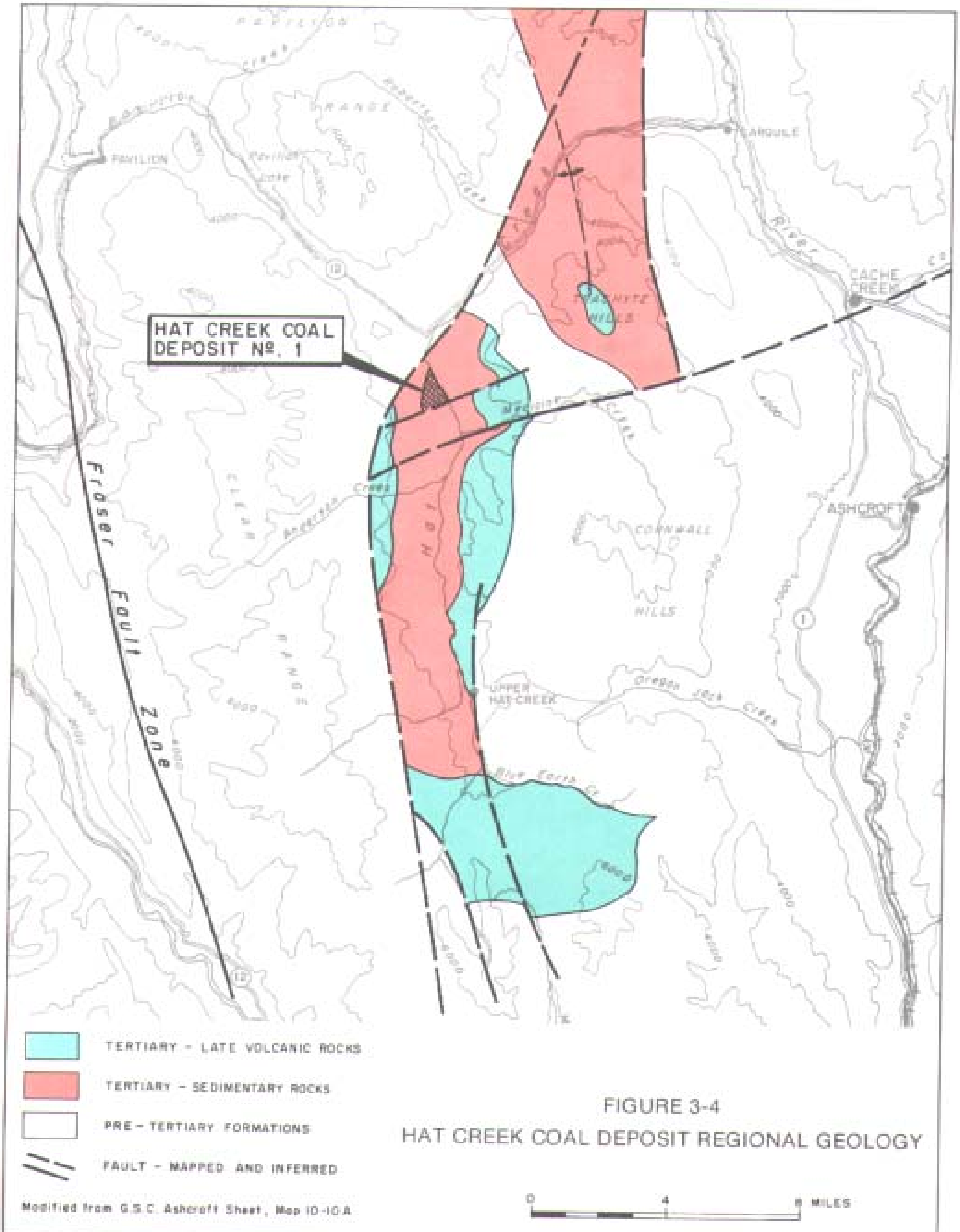


FIGURE 3-4
HAT CREEK COAL DEPOSIT REGIONAL GEOLOGY

The general area around Upper Hat Creek Valley including the region encompassing all potential generating station sites except Site 11 lies within Zone 1 of the Seismic Zoning Map for Canada. This is a zone not particularly susceptible to damaging earthquakes. Since 1899, when records were first kept, there have been no damaging effects in the Hat Creek area from any earthquakes regardless of their intensity or location.

(c) NO. 1 COAL DEPOSIT AND COAL RESERVES

The coal measure in the No. 1 deposit contains two major coal layers; No. 1 Seam, 400 to 600 feet in thickness, and No. 2 Seam, about 1600 feet in thickness. At least three major, steeply-dipping normal faults have dislocated the coal-bearing strata into several blocks which have yet to be positively correlated stratigraphically with one another.

The No. 1 Openpit deposit consists principally of a one-mile north-trending length of No. 2 Seam which is dipping steeply westward, flattening in dip at a depth of about 1600 feet. The deposit is terminated on the south and east by block faults and rises gradually to the surface to the north and west (as No. 1 Seam). The main body of the coal deposit, represented by No. 2 Seam, is approximately 5000 feet in length and 3000 feet in width at the surface and reaches its maximum depth below surface of about 1600 feet at its south end.

The total amount of proven and probable coal deliverable to a thermal plant is indicated by drilling to be 480 million tons with an average ash content of approximately 28 percent at 20 percent moisture and an average calorific value of 6000 Btu per pound. (Careful selective mining could reduce the average ash content somewhat and thereby result in a corresponding increase in average calorific value.)

The Hat Creek coal is categorized, on an average, as subbituminous B, with an average sulphur content (mostly organic) of less than 0.5 percent.

(d) OVERBURDEN AND WASTE ROCK

The gravel and sand overburden which would have to be removed in order to mine the openpit amounts to 323 million tons. This material constitutes a potential source of aggregate or construction material.

Waste rock which would be produced from the mining of No. 1 Openpit amounts to 782 million tons, consisting principally of siltstone and shale with minor sandstone.

2. PROPOSED OPENPIT MINE

(a) DESCRIPTION OF THE OPENPIT AND MINING METHOD

The No. 1 Coal deposit would be excavated as an openpit. The ultimate surface area of the opening, after 35 years of mining, would be approximately 1120 acres, shaped as shown on Figure 3-5. Maximum pit dimensions would be 8000 feet in length, 7000 feet in width and 1400 feet in depth (near the southwestern side). A buffer zone, approximately 1000 feet in width, should be maintained around the periphery of the pit for safety purposes. When mining from the pit was completed, most of the buffer zone, (740 acres at ultimate pit size), would still be in its original form.

Initial engineering studies indicate that the most economic and dependable method of mining this openpit would be by means of shovels, trucks and bulldozers, with or without auxiliary conveyor belt haulage. Drilling and blasting would probably be minimal because most of the rock and all of the coal are soft enough to be either directly excavated by shovels or ripped by bulldozers.

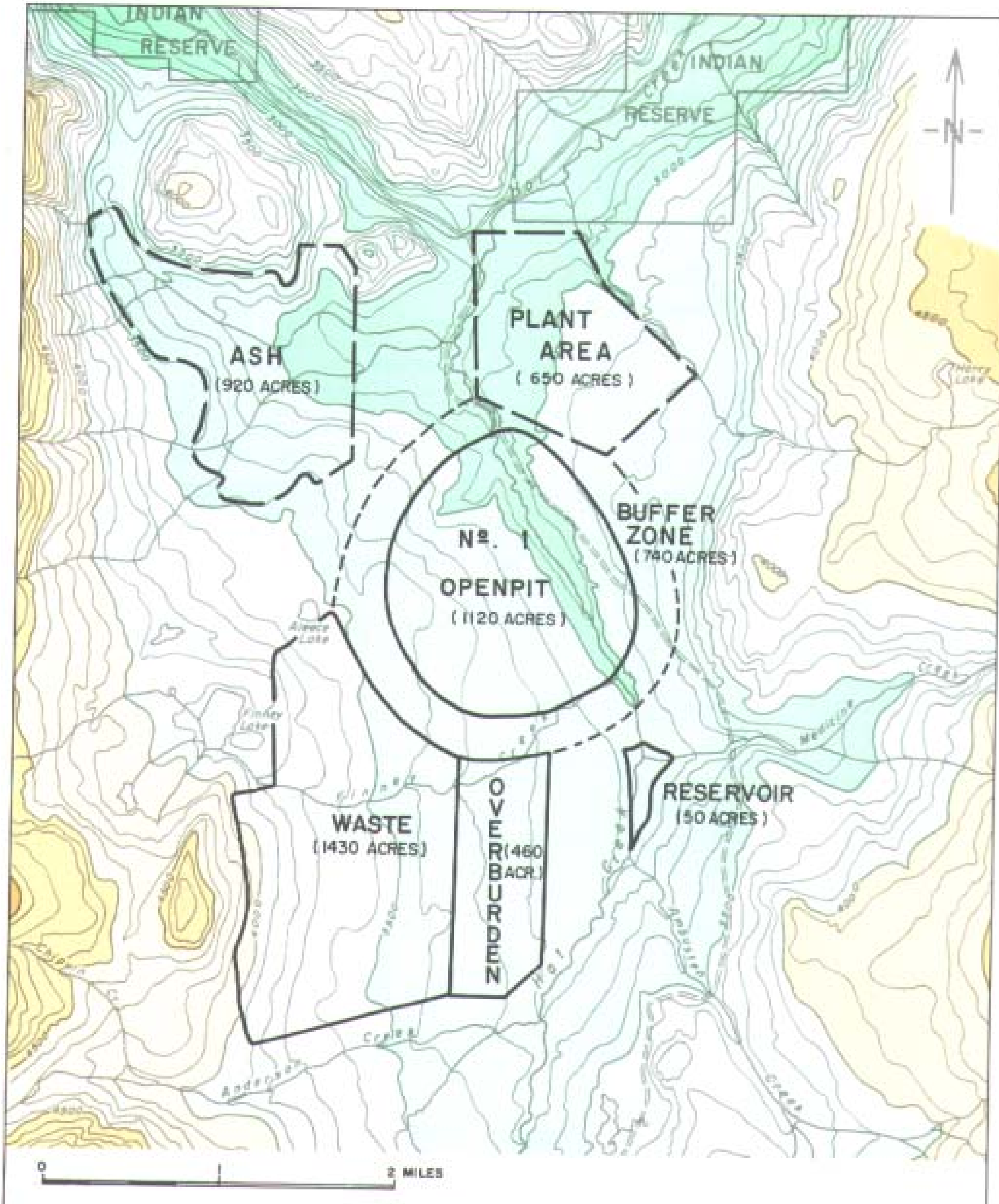


FIGURE 3-5

AREAS ALIENATED BY THE PROPOSED PROJECT

The total amounts of overburden and waste rock which would be removed from the pit are based on the requirement to supply approximately 12,000,000 tons per year of 6000 Btu coal to a thermal generating plant for 35 years. The extreme case for maximum pit size has been employed: pit wall slopes for the entire circumference of the pit would be at an angle of 25 degrees. Under these conditions the amounts of overburden and waste rock to be removed and placed in disposal areas would be:

Overburden	323,000,000 tons
Waste Rock	782,000,000 tons

Figure 3-5 indicates the approximate area of the proposed openpit, as well as the areas which would be required for overburden and waste rock disposal.

(b) DISPOSAL OF OVERBURDEN AND WASTE ROCK

It is assumed for the purposes of this study that no significant amounts of the sand and gravel overburden which blankets the No. 1 Openpit area nor of the waste rock derived from mining the openpit would be transported out of Upper Hat Creek Valley for use elsewhere; therefore space provision would be required for the disposal of these materials. It is of primary importance that the overburden and waste rock not be stacked on areas underlain by minable coal. Based on information to date and allowing for the possibility that the generating station (and attendant ash disposal area) would be close to the mine, the choice of disposal areas is limited and, although the areas are large enough, there are virtually no optional disposal areas in the near vicinity of the openpit. If the generating station were constructed at a site other than near the mine, then a major proportion of those areas shown on Figure 3-5 as 'plant' and 'ash' could be available for overburden and waste rock disposal.

OVERBURDEN

To minimize the space covered it is proposed that the overburden be stacked and compacted to a height of 300 feet with the peripheral edges sloping at 25 degrees. This mound would merge with the waste rock on the west side and the north side would slope at an angle of 25 degrees towards the pit with the toe of the slope being maintained at a distance of 1000 feet from the rim of the pit. Because the sand and gravel are a potential resource they would not be covered with waste rock. Employing the above proposal the 323,000,000 tons of overburden would cover a total of 460 acres by the end of the eighteen years required to remove all of it from the pit area.

A 25° slope angle for the sides of the dump is considered to be an absolute minimum that would be required for slope stability. More probably, a slope angle in the order of 35° would be adequate. A steeper angle would also result in slightly smaller dump areas and thus less land alienation for an equivalent volume of overburden (as well as waste and ash).

If further study indicates that the topsoil in the pit area is useful for reclamation of disposal areas, it would be removed ahead of the overburden mining and stacked in a temporary holding area. Topsoil in the overburden and waste rock disposal areas (and in the plant site and ash disposal areas as well) could be handled in the same manner.

WASTE ROCK

Approximately 782 million tons of waste rock would be derived from the openpit over the full life of the mine. This material would consist largely of very weakly cemented, fine-to-medium grained siltstone and shale. It would break down easily on handling and dumping, so that when it was compacted in the disposal area it would be in a state more physically amenable to reclamation. As samples become available, studies must continue on the characteristics of the waste rock, to assist in determining the procedures of reclamation and the plant species most adaptable for landscaping of the waste disposal area. It is planned to generally conform to the existing ground which is at an average slope of 5 to 6 degrees in most of the dump area. The waste would be produced at an average rate of 22 million tons per year and would ultimately, at the end of 35 years, cover an area of 1430 acres.

It is apparent from Figure 3-5 that it would be necessary to install a culvert under the waste dump to divert the water flow of Finney Creek into Anderson Creek, and thence into Hat Creek. Records should be obtained of seasonal flows in Finney Creek to assist in design of the culvert.

Again, because of limited space for dumping, it is proposed that the waste rock dumps be built to a height of 300 feet with peripheral slopes at 25°.

A study should be undertaken to determine the practical advantages and advisability of disposing of the pit waste in specific areas that could be completed and reclaimed separately as mining proceeds, so that the "live dump" area would be relatively small.

It is recommended, therefore, that once stripping and mining of the deposit begins, a test dump area be constructed wherein different methods of compaction, drainage, watering, sodding and seeding could be employed to determine optimum reclamation methods for the final disposal areas.

(c) DESCRIPTION OF MINING EQUIPMENT

The types of equipment proposed for mining the No. 1 Openpit deposit are discussed below, with general comments regarding their noise level and their influence on the project environment.

The number of personnel required to operate and maintain the equipment and do other mine-related work would rise from about 50 in the first pre-production year to a maximum of about 440 during the years when overburden removal and full-scale mining were both in operation (Table 3-1). When overburden removal had been completed the mine work-force would be stabilized at approximately 290 personnel.

TABLE 3-1
MINING — OPERATING CRAFTS AND NUMBERS — TIMETABLE

Year	1				2		3	4	5		6		7		8		'n'
Operation	Erection of site offices shops, warehouse, camp	Power facilities to pit area	Assemble and erect shovels and trucks	Construct roads	Overburden Removal	Hat Creek Diversion	Overburden Removal	Overburden Removal	Overburden Removal	Pit Operation	Overburden Removal	Pit Operation	Overburden Removal	Pit Operation	Overburden Removal	Pit Operation	Pit Operation
Heavy Equipment Operators	8		2	1	101	12	101	101	101	60	101	84	101	129	101	180	180
Supervision, Eng. Clerical	4				20	6	20	20	20	25	20	26	20	27	20	29	29
Tradesmen	18	6	6		18	15	18	18	18	21	18	34	18	45	18	57	57
Labourers	4				8	6	8	8	8	12	8	16	8	18	8	20	20
Sub-totals	34	6	8	1	147	39	147	147	147	118	147	160	147	219	147	286	286
Total	49				186		147	147	265		307		366		443		286
Total (Rounded-off)	50				190		150	150	270		310		370		440		290

DRILLS

It is anticipated that drills would be few and used sparingly. They would be electrically powered and would not be a major contributor to noise in the pit.

SHOVELS

These would be electrically powered and therefore the noise from them would not be great. In any case, all of them would be below pit rim level and thus not seen or heard except from within the pit or directly above it.

TRUCKS

As presently proposed, the haulage trucks employed in the mine would be powered by diesel engines of about 850 horsepower. They would comprise the principal noise source in the mining operation since they would come above the pit rim to haul coal to the plant or stockpile and to haul waste to disposal areas. For the first three years there would be in the order of ten 85-ton trucks hauling overburden. With the pit in operation, (in addition to the overburden haul), the number of trucks operating would increase over the life of the pit to a total of 50.

Significant changes in plant location or dump site locations could change the above numbers but the changes should not greatly affect the significance of this present study. Information has not been obtainable to date on decibel ratings outside the trucks; however inside the driver's cab they are in the 80 to 85 range which is within the Mining Act requirements. Enquiries have been made to determine exhaust emission analyses.

Main service and haul roads around the openpit would be paved to obviate dust generation and to provide the optimum operating conditions. However, haulage and shovelling within the pit would generate dust, particularly in the dry climate of Hat Creek, and thus would require suppression by constant sprinkling throughout the operation. Similarly, the loads would be sprayed if the coal were found to form serious dust during truck haulage.

TRACTORS

There would be six to twelve D-9 size tractors operating on the property from the start of overburden removal to the completion of the pit. They would be employed in road building, overburden removal, overburden and waste spreading and packing, and possibly coal stockpile spreading and packing. They would probably be the noisiest equipment operating on the mine site; however, they would be few in number and would only be onerous to those working nearby.

LOADERS

Provision has been made for two front-end loaders. These would be employed in the overburden removal operation and subsequently in the pit. The diesel engines have ratings in the order of 550 flywheel horsepower and are relatively noisy in operation; however they will normally be working below the pit rim and should not constitute a noise problem beyond the pit.

In addition to the above heavy equipment there would be pick-up trucks, graders, water trucks, personnel buses, a lubetruck, an ambulance and mobile welders. Once the equipment was operating below rim level in the pit, there would be no significantly audible noise beyond the pit. However, it is recommended that decibel rating studies be conducted at operating pits in order to determine the noise levels of the various pieces of equipment used.

(d) TRENCHING FOR TEST BURN SAMPLE

It is not possible to predict from the results of laboratory-scale tests on coal samples all of the aspects of the performance of a full-scale generating station. It is generally desirable to carry out a full-scale test on the efficiency of ash removal from the flue gases by electrostatic precipitators since the results of such testing can provide the manufacturer of the precipitators with information to ensure a proper design for acceptable performance.

It is proposed that a test burn be carried out at a coal-fired generating station yet to be selected. For a two-week test at a station consuming about 4,000 tons of coal per day, some 50,000 tons of Hat Creek coal would be required. To obtain this coal it would be necessary to excavate surface trenches across the No. 1 Openpit deposit in locations which would provide representative samples of the ultimate coal feed to the plant. The size of the coal sample would actually be about 75,000 tons to allow for the discarding of weathered coal.

The required trenches would be up to 1000 feet in individual length and 20 to 70 feet in depth in overburden. Assuming 35° wall slopes, these trenches would range from 135 to 270 feet in width. Some 600,000 tons of overburden would have to be removed, requiring about two acres of ground for disposal. This material could be used as the preliminary layer in the ultimate main disposal area thus allowing experimentation in such disposal. The trenches would also provide good information on the study of soil profiles, ground water action, slope stability, excavation characteristics, etc.

If results of the burn test were quite unacceptable or if the proposed project did not proceed for other reasons after the sample trenches had been excavated, the trenches would be refilled and the surface area reclaimed.

B. THE PROPOSED GENERATING STATION

1. SELECTION OF POTENTIAL SITES

It is proposed to mine from an openpit a coal deposit located in the Upper Hat Creek Valley as described in Section A preceding, and to utilize the coal for the generation of electricity. Some 12 million tons per year of coal would be mined to supply a generating station of 2000 Mw capacity. Present proposals are to have the first generating unit in operation early in 1983, to be followed with additional units at approximately annual intervals up to 2000 Mw rating. In the event that the coal deposit is as large as is currently indicated, it is further proposed to increase the generating capacity to 4000-5000 Mw at a later date, with a corresponding increase in the coal mined per year.

(a) MAJOR FACTORS IN CHOICE OF SITE

Important overall considerations in regard to the location of the generating station include the following:

1. Cost and impact of transporting coal from mine to the plant;
2. Cost and impact of transporting process water from an acceptable source to the plant;
3. Cost and impact of transporting electricity from the plant to the load centre;
4. Impact on the local environment of the construction and operation of the plant.

Because the principal load centre for electricity in British Columbia is the Lower Mainland and the coal under consideration is at Hat Creek, no generating site can be chosen which will minimize the cost and impact of more than two of the first three factors, above. But with all four factors in mind, eleven potential generating station sites which met other qualifications were selected and appraised. The other qualifications were: (a) reasonable proximity to the Hat Creek coalfield, (except for Site 11) and (b) the availability of land where a 650-acre plant site could be located without extensive topographic modifications.

The eleven sites are discussed below. The list of sites is not exhaustive of all possible sites where a coal-fired generating station could be constructed.

(b) SUMMARY LIST OF LOCATIONS CONSIDERED

The sites selected (except for Site 11) are shown on Figure 3-6 and are as follows:

1. North end of Upper Hat Creek Valley near B.C. Highway 12; site elevation approximately 2750 feet.
2. Midway in Upper Hat Creek Valley; site elevation approximately 3200 feet.
3. South end of Upper Hat Creek Valley; site elevation approximately 3650 feet.
4. The flat land east of Harry Lake; site elevation approximately 4300 feet.
5. The flat land south of the Trachyte Hills (about half way between Harry Lake and MacLean Lake); site elevation approximately 4000 feet.
6. On the east side of the Fraser River, on a bench roughly half way between Lytton and Lillooet; site elevation approximately 1000 feet.
7. South of the confluence of the Fraser and Thompson rivers near Lytton; site elevation approximately 750 feet.
8. On the east side of the Fraser River just north of Big Bar Creek; site elevation approximately 3500 feet.
9. On the Thompson River within roughly five miles of Ashcroft; site elevation 1000 to 2000 feet.

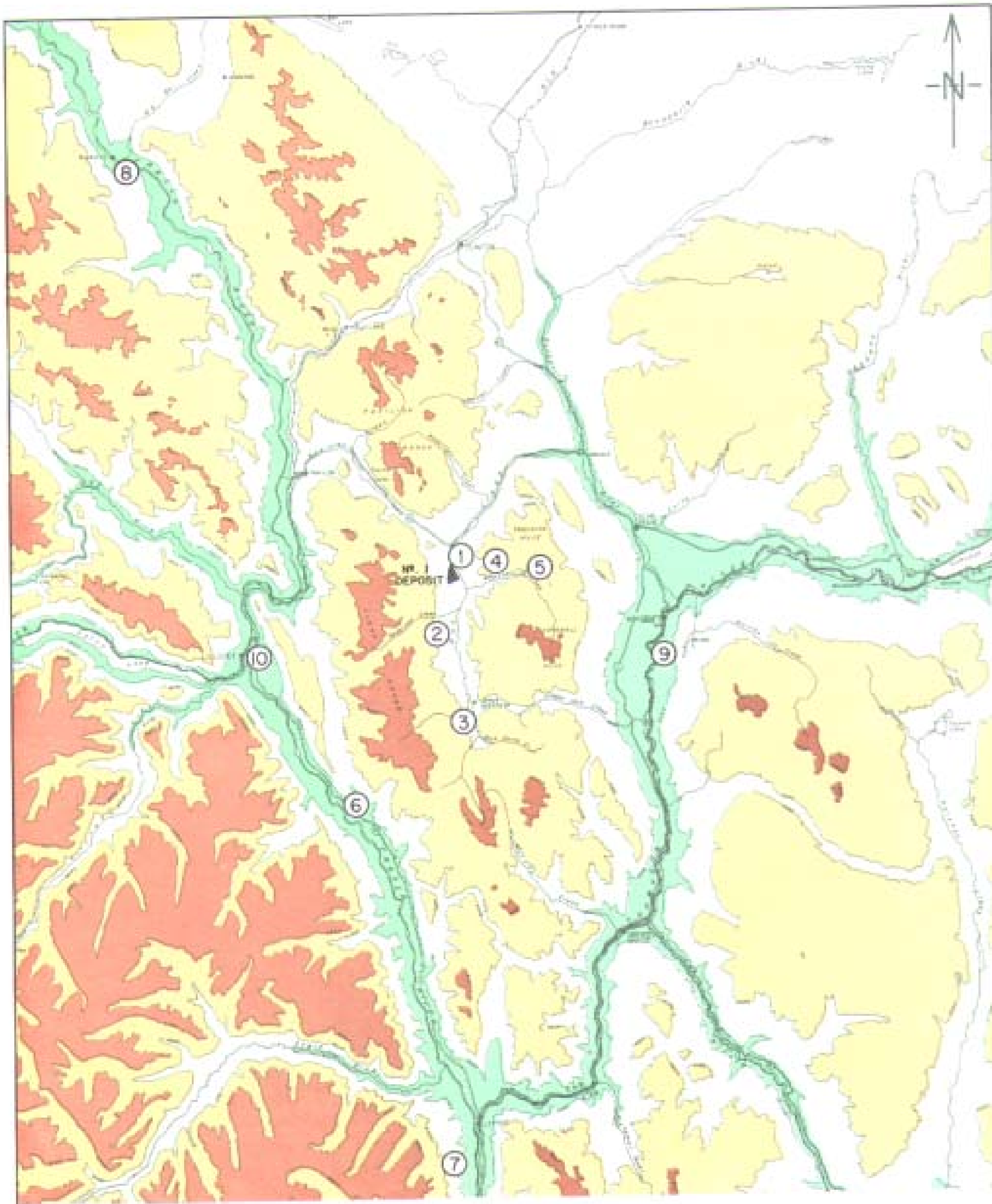


FIGURE 3-6

GENERATING STATION SITE OPTIONS

10. On the bench land east of Lillooet on the east side of the Fraser River; site elevation 1000 to 1500 feet.
11. Somewhere on the Lower Mainland.

These eleven sites can be divided into four categories, namely: 1. Mine mouth (1, 2 and 3); 2. High altitude (4 and 5); 3. Adjacent to water supply (6, 7, 8, 9 and 10); and 4. Adjacent to power demand (11).

(c) MINE MOUTH LOCATIONS

It has been shown at several locations in North America that the installation of a thermal-electric generating station next to the coal deposit results in significant savings in the cost of electricity, mainly because the cost of fuel transport to a distant location is more than that of transporting electricity. The table below exemplifies this:

GENERATING STATION LOCATION	DISTANCE MINE TO GENERATING STATION: MILES	CAPITAL COST		COAL TRANSPORT OPERATING COST	
		Power Line	Coal Transport	Per Ton Mile	Per Year
Mine Mouth Sites					
(1)	1.3	$128M	$ 3.9M	4.1¢	$ 0.6M
(2)	3.1	$128M	$ 9.7M	4.3¢	$ 1.6M
(3)	9.5	$128M	$29 M	4.3¢	$ 4.7M
Distant Site					
(11)	230	$ 28M*	$27 M	1.0¢	$29 M

* For overhead line; however, Site 11 is likely to require an underground line at several times higher cost per mile, ($208M total).

It should be noted that while, for the distant site the annual operating cost ($29M) alone substantiates the statement, the figure only includes 32 miles of new railroad construction. The remainder of the transport would occur over existing track.

Three sites within Upper Hat Creek Valley have been considered.

The No. 1 site is at the north end of the valley, close to B.C. Highway 12 and about one mile north of the proposed No. 1 Openpit. Adequate space for the generating plant and its auxiliary equipment, (about 650 acres), exists at this location. Although further exploration is required, present indications are that the likelihood of minable coal occuring here is remote.

No. 2 or 3 sites, in Upper Hat Creek Valley, five and twelve miles respectively south of the No. 1 site, would be a viable option to the No. 1 site if the exploration drilling in progress confirms a superior coal deposit near one of them and if it is found that the site itself is not underlain by an economic deposit of coal.

(d) HIGH ALTITUDE LOCATIONS

Even with the best available control technology, some discharges to the atmosphere from combustion processes cannot be eliminated. One approach to lessen air quality deterioration is to locate the emission source at a high altitude where deep ground-based inversions seldom occur and where prevailing winds tend to be stronger and more persistent than at lower altitudes and in valley locations. Emissions at high altitudes are thus more readily diluted and dispersed. The meteorological phenomena involved are in fact more complex than indicated here and are discussed in more detail in Part V, A. Two tentative high altitude sites of sufficient area of level ground were selected near the Hat Creek coal deposit. Site 4 is near Harry Lake (elevation 4300 feet) and Site 5 just south of the Trachyte Hills (elevation 4000 feet). These sites are some 500 to 1600 feet higher than the mine mouth sites described above. A more complete discussion of the atmospheric impact of a power plant located at these sites, or at the other sites considered, is given in Part V.

(e) LOCATIONS ADJACENT TO WATER SUPPLY

The proposed generating station would require an estimated 25,000 Igpm of make-up process water and the only potential sources of this quantity of water would be the Fraser River or the Thompson River. For the sites discussed above water would have to be transported by pipeline approximately fifteen miles from either of these rivers. An alternative would be to locate the power station near one of the rivers and transport the coal from the mine to the station.

Five sites were located (Figure 3-6), subject to the constraints of proximity to one of the major rivers, the availability of about 650 acres of flat land and reasonable proximity to the coal deposit. The last of these constraints was imposed by the economics of coal transport and their effects on the cost of electricity. The potential sites considered are:

No. 6 On the Fraser River about half-way between Lytton and Lillooet.
No. 7 Near Lytton, just below the confluence of the Fraser and Thompson rivers.
No. 8 Northwest of Clinton near where Big Bar Creek enters the Fraser River.
No. 9 On the Thompson River south of Ashcroft.
No. 10 On the bench land east of Lillooet on the Fraser River.

(f) LOCATIONS ADJACENT TO POWER DEMAND

Because the demand center is in or close to the Lower Mainland, the location of a generating station there (at an unspecified site) has been considered in the present study. The site is listed as No. 11.

2. PRELIMINARY SITE EVALUATION

The eleven generating station site options described above were subjected to a preliminary analysis incorporating 11 rating factors as follows:

1. Air pollution potential
2. Transmission requirements
3. Fuel (coal) transport
4. Construction impact
5. Site accessibility
6. Water supply
7. Flora and fauna
8. Ash disposal
9. Social impact
10. Land use alternatives
11. Regional economic benefit

The analysis was based on the anticipated environmental impact of all factors and, for factors 2, 3 and 6, on general economic and engineering considerations as well. Because of individual opinion, emphasis or bias it was not possible to absolutely quantify the anticipated environmental impacts and thus establish a preference rating for the eleven potential sites. However, the analysis did indicate three categories of sites. Environmentally, the mine-mouth and high altitude sites were clearly the most attractive (Sites 1 to 5); three of the sites adjacent to water supply were the least attractive (Sites 6, 7 and 10 along the Fraser River); and the remaining three Sites (8, 9 and 11), while not particularly attractive, were better than Sites 6, 7 and 10.

The reason Sites 6, 7 and 10 are so environmentally unattractive is because of the high air pollution potential due to their low elevation in deep, confined valleys. It is because of this serious potential air quality problem that these three sites receive only cursory discussion in the environmental parts of this preliminary report; further analysis will be conducted as a part of the ongoing study. On the other hand the sites in and near Upper Hat Creek Valley have received the greatest amount of study at this preliminary stage because: (1) they are the most environmentally attractive sites, (2) they are near the fixed location of the proposed mine (and its potential impacts), and (3) since it was not considered realistic to undertake detailed studies for all sites at this time, effort was concentrated on the most environmentally acceptable sites.

3. PROPOSED FACILITIES, UPPER HAT CREEK VALLEY SITES

(a) GENERATING STATION

According to the preliminary design study for the proposed generating station the first stage (2000 Mw) would feature some combination of turbine generators such as: a) 2 x 375 Mw, 2 x 750 Mw, b) 4 x 560 Mw or c) 3 x 750 Mw. (Although the installed generating capacity might be about 10 percent more than 2000 Mw, station power requirement would be such that line output would be approximately 2000 Mw. All references are to 2000 Mw station capacity in this report, but where calculated data are employed the installed capacity has been taken into account.) The generators would be served by coal-fired boilers of as yet undetermined numbers and sizes. The station would use a maximum of about 40,000 tons of coal per day for 2000 Mw output. Auxiliary equipment would include coal and ash handling systems, transformers and switchyard, fuel oil storage (required for boiler start-up), a water cooling system, a water treatment plant, a sanitary sewage system and required structures which, in addition to the turbine and boiler buildings, would include such items as maintenance shops, warehouse and parts storage, an office building and a kitchen for serving hot meals to the employees. Building sizes have not yet been specified.

Roads, sidewalks and parking lots would be paved and the area around the plant would be landscaped.

It is hoped that the source of the work force for the construction of the generating station would be principally British Columbia, insofar as the necessary skills are available, but the contributions from different areas are not known.

The most visible construction activities would involve the site preparation, turbine hall, coal-fired boilers, stack, cooling tower(s) and pipeline.

Pollution can result from the stack emissions, from coal dust, and from the various aqueous effluent streams. The extent of such pollution and the effect of proposed abatement measures is discussed in Parts IV, V and VI.

The effect on pollution of maintenance procedures during operation of the generating station can range from considerable (in the case of an electrostatic precipitator malfunction or failure of an effluent containment pond) to minor (in the case of in-plant coal transport duct leakage).

There would be at least one annual shutdown per unit, by government regulation, for planned routine inspection and maintenance. This would probably last one month but could be longer or shorter depending on the power demand and the maintenance staff available. The schedule for such shutdowns would be determined by the operating personnel and would be devised to best suit the anticipated power load.

The maximum estimated generating station work force would be:

YEAR (FROM DECISION TO GO AHEAD)	CONSTRUCTION CREW	OPERATING PERSONNEL
1	100	0
2	250	0
3	475	0
4	800	0
5	730	120
6	650	180
7	300	250
8	0	250

For purposes of this study it is assumed that major overhauls to the steam generators, turbo-generators and other major pieces of equipment should be done by outside contractor — preferably by staff from the equipment manufacturers. The maintenance staff would have to be increased substantially above that shown in the table above if the proposed generating station were to be completely maintained on an in-house basis.

(b) TRANSPORT OF COAL, WATER AND ELECTRICITY

For Sites 1 to 5, located in or near Upper Hat Creek Valley, it is proposed to use belt conveyors to transport the coal from No. 1 Openpit to the generating station.

The right-of-way for the conveyor, 50 feet wide for the valley sites and 75 feet wide for the high altitude sites, would be fenced for safety reasons and would be unavailable for domestic or wild animal grazing. Cattle and vehicular crossings would be provided at gullies and/or creeks. Operating conveyors are not noisy but a long conveyor probably would have to be covered to prevent a dust problem.

The cost of coal transport by conveyor has been estimated for Sites 1 to 5. In conveyor operation the cost is related to distance and to the elevation above (or below) the mine site. Cost estimates (in 1974 dollars) are as follows:

SITE	DISTANCE (feet)	ELEVATION (feet)	OPERATING COST ($/ton)	OPERATING COST (1) ($/yr.)	OPERATING COST (2) COVERED CONVEYOR ($/ton)
1	6,700	-100	0.054	637,000	0.01
2	16,500	+350	0.135	1,578,000	0.02
3	50,000	+800	0.404	4,728,000	0.07
4	13,400	+1,350	0.131	1,533,000	0.02
5	26,500	+1,150	0.223	2,605,000	0.04

Notes:
(1) For supply of 11.7 million tons of coal per year to the generating station.
(2) This would be the estimated extra operating cost should the conveyor have to be covered.

An estimated 25,000 Igpm of make-up water would be required for the power station. For plant sites in or near Upper Hat Creek Valley, water would probably be obtained from the Thompson River near Ashcroft and conveyed by pipeline or tunnel to the plant. This aspect of the project is presently under study.

Any surface or subsurface pipeline would require a right-of-way of about 40 to 60 feet for the life of the project. The right-of-way would accommodate the pipeline itself and an access road for maintenance. A tunnel does not require right-of-way but the construction spoil would have to be transported to an acceptable location. Depending on the location, the surface of the spoil pile may have to be reclaimed.

The proposed locations of transmission lines are described under Section III, C, 5.

(c) CONSTRUCTION CAMP

On large construction projects in rural areas, it has proven impractical not to house personnel in camps close to the site. During the peak construction period at an Upper Hat Creek Valley site, a maximum work force of 1140 including miners, could be anticipated. To provide space for accommodation and recreation facilities, approximately 23 acres of land would be required.

By the end of the fourth pre-production year, it is expected that the majority of the miners would be accommodated in permanent housing in neighbouring communities. During the subsequent three-year period, a construction work force tapering off from about 730 to 300 would be required for installation of the additional generating units.

4. PROPOSED FACILITIES, OTHER SITES

The site locations are as follows:

Site 6	Fraser River, roughly halfway between Lytton and Lillooet
Site 7	South of the confluence of the Fraser and Thompson rivers near Lytton
Site 8	Fraser River, northwest of Clinton (near Big Bar Creek)
Site 9	Thompson River, south of Ashcroft
Site 10	Fraser River east of Lillooet
Site 11	Somewhere on the Lower Mainland

(a) GENERATING STATION

A generating station constructed at one of Sites 6 to 11 would be basically the same as the one discussed in Section B.3(a). The height of the exhaust stack would be tailored to the atmospheric conditions at the site where it was constructed. Likewise, the procedure used for cooling the process water would be tailored to the site conditions.

(b) TRANSPORT OF COAL, WATER AND ELECTRICITY

The transport of coal to the generating station would be the major difference resulting from the construction of the plant at any site removed from the Upper Hat Creek Valley area. For this report, it is assumed that the coal would be transported by unit train. However, transportation by pipeline should be investigated if serious consideration is given to construction of a plant at a distant site.

Shown on Figure 3-7 and discussed below are existing and new railroads which would be required for coal transportation to each of Sites 6-11. Detailed studies of these transportation routes have not been made.

The most practical rail route for the transport of coal from the No. 1 Openpit in Upper Hat Creek Valley to *Site 6* (east side of the Fraser River approximately halfway between Lytton and Lillooet) appears to be as follows:

1. New trackage from the mine site to Anglesey on the CNR, a distance of 32 miles. The route would follow Hat Creek Valley (lower) and the Bonaparte River Valley to the community of Cache Creek and thence along the Thompson River Valley to Anglesey. (This section of the railroad would go through five Indian Reservations, cross ten to fifteen major access roads, conceivably cross Highway 97 more than once and go through the municipality of Cache Creek.)

2. Travel on CNR line 60 miles to a switch-off point north of Lytton.

3. New trackage up the east side of the Fraser River Canyon to Site 6, a distance of 18 miles.

The total distance is 110 miles of which 50 miles would require new railbed construction. An alternative route via Clinton and Lillooet was discarded because of generally adverse grades and anticipated construction problems along the Fraser canyon section of the route (south of Lillooet). Assuming a 100 foot right-of-way, the 50 miles of new railroad along the proposed route would require 606 acres of land.

Transportation of coal to *Site 7* (south of Lytton) would require the 32 miles of new trackage from the mine site to Anglesey described for Site 6. From Anglesey the coal would be transported an additional 62 miles on the CNR to the generating station. The total distance would be 94 miles; the 32 miles of new railbed would require 390 acres of land.

From Upper Hat Creek Valley to *Site 8* (near Big Bar Creek on the Fraser River) the most practical rail route appears to be as follows:

1. New trackage roughly paralleling Highway 12 to the junction with Highway 97 and then paralleling Highway 97 to Clinton,

2. Existing BCR trackage from Clinton to Kelly Lake,

3. New trackage up the Porcupine Creek Valley to Big Bar Creek.

The total distance is 70 miles of which 60 miles would require new railbed construction. The alternative of constructing the railroad through Marble Canyon to connect with the BCR at Pavilion was considered but was discarded because the Canyon in many places is too

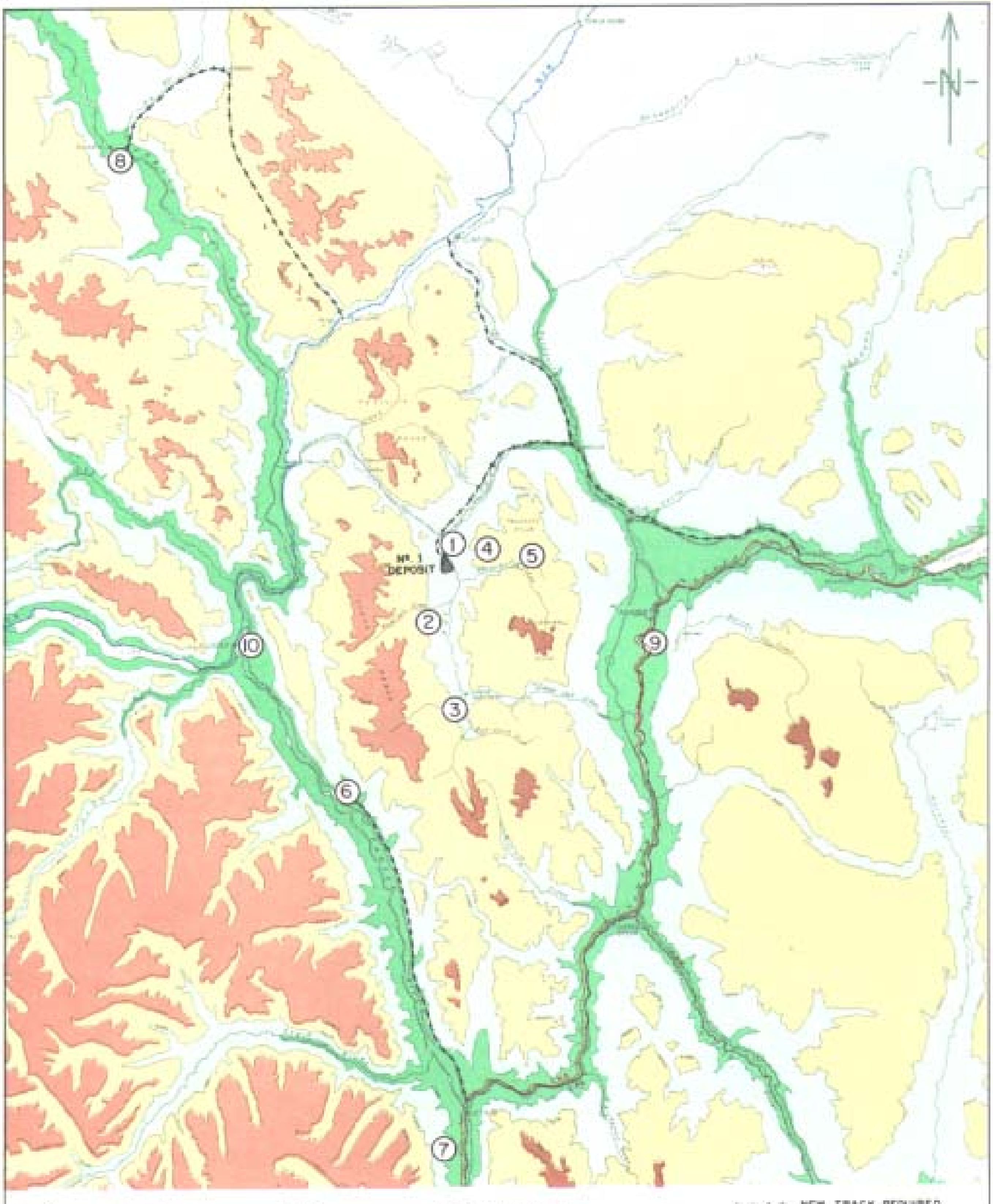


FIGURE 3-7

EXISTING AND NEW RAIL LINES REQUIRED FOR TRANSPORT OF COAL TO SITES 6-11 narrow to accommodate both the highway and a railroad, and because of steep grades at the Pavilion end of the canyon. Construction of the new railroad would require 727 acres of land, assuming a right-of-way 100 feet wide.

To reach *Site 9*, (on the east side of the Thompson River) is difficult with unit trains. A new railroad would have to be constructed from the Hat Creek coal deposit to connect with the CNR near Anglesey (as with Site 6), a distance of 32 miles. The unit train would travel on the CNR line twelve miles to where it crosses to the south side of the Thompson River and, if practical, connect with the CPR and travel six miles on that line to the plant site. This transportation route is basically impractical but if it could be used it would require the same construction and land as for Site 7; that is 32 miles of new railbed and 390 acres of land.

To transport the coal from the No. 1 Openpit deposit to *Site 10* (the benches east of Lillooet on the Fraser River) would require the construction of 30 miles of new railroad to Clinton to connect with the BCR, (the same route proposed to Site 8), and three miles from the BCR near the Fraser River bridge crossing just north of Lillooet to the plant site. The total distance is 77 miles of which 44 miles would be over the BCR and 33 miles would be newly constructed. Assuming a 100 foot right-of-way, the newly constructed portion would require 400 acres of land.

The possibility of constructing a railroad from the No. 1 Openpit site to connect with the BCR at Pavilion was investigated. This route to Site 10 would have the advantage of being much shorter than that through Clinton, being approximately 37 miles as compared to 77 miles. However such a railroad would have to traverse some very confined and precipitous sections, particularly through Marble Canyon Park and along Pavilion Lake. These sections would in all likelihood entail extensive rock excavation and/or tunnel construction.

The most practical route from the proposed No. 1 Openpit to *Site 11* (Lower Mainland) is from Hat Creek to Anglesey, connect with the CNR and travel over it to Port Mann and then to the as yet unspecified site in the Lower Mainland area. The round trip distance would be in the order of 460 miles and would involve the same new railroad construction at its northern end as for Site 9. The same land alienation would also be involved (390 acres).

An alternative route to the Lower Mainland was considered, viz., construct a new railroad to Clinton, as for Site 8, and transport the coal via the BCR to Vancouver. This was rejected on the basis of the existing overload at the Second Narrows rail bridge which would have to be used.

In addition to rail facilities for transport of coal to Sites 6 to 11, equipment would be needed at the mine to stockpile coal and load it on unit trains. At the generating station equipment would be needed to unload the unit trains, stockpile the coal and reclaim it for firing to the boilers. Space would be required for these operations.

Operating costs for transport and handling of coal for Sites 6 to 11 have been estimated as follows (1974 dollars):

SITE	COST, $/ton		
	TRANSPORT	HANDLING	TOTAL
6	1.40	0.10	1.50
7	1.15	0.10	1.25
8	1.00	0.10	1.10
9	0.65	0.10	0.75
10	0.95	0.10	1.05
11	2.50	0.10	2.60

For Sites 6 to 10, transport of water is not a major factor because they were selected on the basis of proximity to water. In the case of the Lower Mainland (Site 11), ocean water could be used for cooling purposes if the generating station were located on tidewater.

The reader is referred to Section III, C, 5 for a discussion of the proposed locations of transmission lines.

(c) CONSTRUCTION CAMP

In the event that one of Sites 6-10 were selected for the generating station, two construction camps would be required — one in Upper Hat Creek Valley for mine construction workers engaged in overburden removal and one near the selected site for generating station workers. Only about three acres would be required at Hat Creek. Because the overburden removal crews could become the permanent crews engaged in coal mining, the miners should be encouraged to settle in neighboring communities at an early date.

At Sites 6 to 10, about 21 acres would be required for a construction camp.

For the Lower Mainland option (Site 11) all the work force would come from the area and would not require housing; therefore, no construction camp is considered necessary at this site.

No consideration has been given to the provision of a construction camp for railroad construction workers required for Site options 6 to 11. Such workers would be supplied by the railroad company and normally would be housed in railroad mobile units.

C. POTENTIAL LAND REQUIREMENTS OF THE PROJECT

The land required for the proposed project will be governed by six factors:

1. the mining operation
2. the power station and its auxiliaries
3. transport of coal to the power station
4. transport of water to the power station
5. transport of electricity from the power station to an existing transmission network
6. housing for construction employees

1. MINING OPERATION

Land requirements for the proposed mining operation include areas for the openpit, overburden disposal, waste rock disposal and a reservoir on Hat Creek as surge capacity above the Hat Creek diversion. The areas shown in the Table below and in Figure 3-5 are ultimate sizes after 35 years of operation for a mine supplying a 2000 Mw thermal plant. They would be much smaller initially but would become progressively larger over the life of the operation until they reached these ultimate sizes. However, progressive reclamation and rehabilitation of the overburden and waste rock disposal areas (leaving relatively small 'live-dump' areas) may be a means of returning some of the lands to agricultural production during the life of the operation. During the openpit operational life, a buffer zone approximately 1000 feet in width would be required around the pit for safety purposes. However, except for roads, much of this land would remain in its original state.

The land requirements (ultimate) for the mining operation would be:

Overburden disposal	460 acres
Openpit mine	1120 acres
Waste rock disposal	1430 acres
Hat Creek Reservoir	50 acres
	3060 acres
Buffer zone	740 acres
	3800 acres

In the event that the generating station were expanded to 4000-5000 Mw the required acreages, except for the Hat Creek Reservoir, would increase about proportionally to the increase in plant output.

2. GENERATING STATION

Land requirements for the proposed 2000 Mw generating station comprise the generating plant (and ancillary installations) and an ash disposal area. For the potential sites near the No. 1 Openpit deposit (Sites 1 to 5), the area of the generating plant, including room for possible expansion, would be 650 acres. For the other Sites (6 to 11), which are relatively remote from the proposed mine, additional land would be required for coal storage to ensure continuity of supply to the plant. A three month inventory has been assumed which would require about 70 additional acres.

The area required for ash disposal would vary somewhat depending on the topography of the particular site but would probably not be more than 1000 acres. (920 acres for Site 1, Figure 3-5), for a 2000 Mw station.

For a 4000-5000 Mw station the plant area would remain at about 650 acres but the ash disposal area would increase proportionally with the increase in generating plant size.

The land acreage which would be required for a 2000 Mw generating station is summarized as follows:

	SITE 1	SITES 2 to 5	SITE 6 to 11
Generating plant	650	650	650
Ash disposal	920	1000 (max.)	1000 (max.)
Additional coal storage	—	—	70
TOTALS	1570 acres	1650 acres	1720 acres

3. TRANSPORT OF COAL

For Site 1 the coal could be transported from the openpit to the plant stockpile directly from the pit by trucks or by conveyor from the pit rim to the plant. Regardless of the method employed, the land which would be required for coal transportation lies within those areas included with the generating station and mine land requirements (plant area, openpit, buffer zone). No additional land would be required for coal transport.

For Sites 2 to 5 it is proposed that the coal be transported from the openpit to the generating station by conveyor. The land which would be required for conveying to each potential site, assuming a 50 foot right-of-way to the sites in the valley (2 and 3) and a 75 foot right of way for the more rugged routes to the high altitude sites (4 and 5), would be:

SITE	AREA (acres)
2. Midway along Upper Hat Creek Valley	19
3. South end of Upper Hat Creek Valley	57
4. Near Harry Lake in the Trachyte Hills	23
5. Near the head of Medicine Creek in the Trachyte Hills	46

For Sites 6 to 11 transport of coal would best be accomplished via unit trains. Land which would be required for new trackage (Figure 3-7), assuming a 100 foot right-of-way, would be:

	LAND AREA (acres)			
SITE	CROWN	ALIENATED	TOTAL	I.R.*
6. Fraser River between Lytton and Lillooet	126	480	606	160
7. Fraser River south of Lytton	—	390	390	100
8. Fraser River north of Big Bar Creek	327	400	727	87
9. Thompson River south of Ashcroft	—	390	390	100
10. Fraser River near Lillooet	—	400	400	87
11. Unspecified site on Lower Mainland	—	390	390	100

* Area of alienated land in Indian Reserves

4. TRANSPORT OF WATER

The land required for water transport has not yet been determined for Sites 1 to 5. For the other sites the land required would be minimal.

For Sites 1 to 5 water requirements of the generating station could be obtained from either the Fraser or Thompson rivers, but there are environmental and technical factors which indicate the Thompson River to be the better choice. In any event, land requirements for water transport can be assumed to be similar for both water sources since the valley is roughly midway between the two rivers. The mechanism for water transport has not yet been determined, but will probably involve a combination of surface pipe, buried pipe and tunnel. The latter would inflict less permanent alienation of land because no right-of-way is required for later access and maintenance.

5. TRANSPORT OF ELECTRICITY

Transmission lines out of a Hat Creek generating station would be energized at 500,000 volts and would each require a 200 foot wide corridor or 24.2 acres per mile. Such corridors do not completely alienate the land, however, since they can be used for crops or grazing except where transmission towers are erected. There are about 3.5 towers per mile of corridor for a single line and, with about 1000 square feet per tower base, the land alienated is approximately 0.08 acres per mile per line.

Existing and future main transmission lines are shown in Figure 3-8.

One 500,000 volt transmission line connecting the substation at Kelly Lake to that between Douglas and Nicola lakes (Nicola Substation) will be required quite independently of the Hat Creek project. If Hat Creek generating station were located at any one of *Sites 1 to 5* then a second Kelly Lake-Nicola line and a second Nicola-Meridian line would be required. (Meridian is a substation in Coquitlam on the Lower Mainland.) One of the Kelly Lake-Nicola lines would be looped into the Hat Creek generating station. For this loop, land would be required for a two-circuit corridor 400 feet wide; the length would depend on the site chosen and the routing of the Kelly Lake-Nicola lines. Typical values are shown in the table below:

SITE NO.	DISTANCE, (mi.)	ACREAGE, 400' CORRIDOR	ACREAGE, TOWER BASES ONLY
1	0.2	10	0.03
2	4.4	213	0.70
3	10.7	519	1.71
4	3.8	184	0.61
5	6.3	306	1.01

Site 6 requires essentially no connecting lines because the 500,000 volt Kelly Lake-Ingledow transmission line passes over or very near the proposed generating station site. However, a second 500,000 volt transmission line from Kelly Lake to Ingledow would be required. (Ingledow substation is in the Lower Mainland.)

Site 7 (south of Lytton) is similar to Site 6 except that an additional one mile line would be required to loop into the Kelly Lake-Ingledow line. The 400 foot wide corridor would occupy 49 acres of which 0.16 acres would be alienated for tower bases.

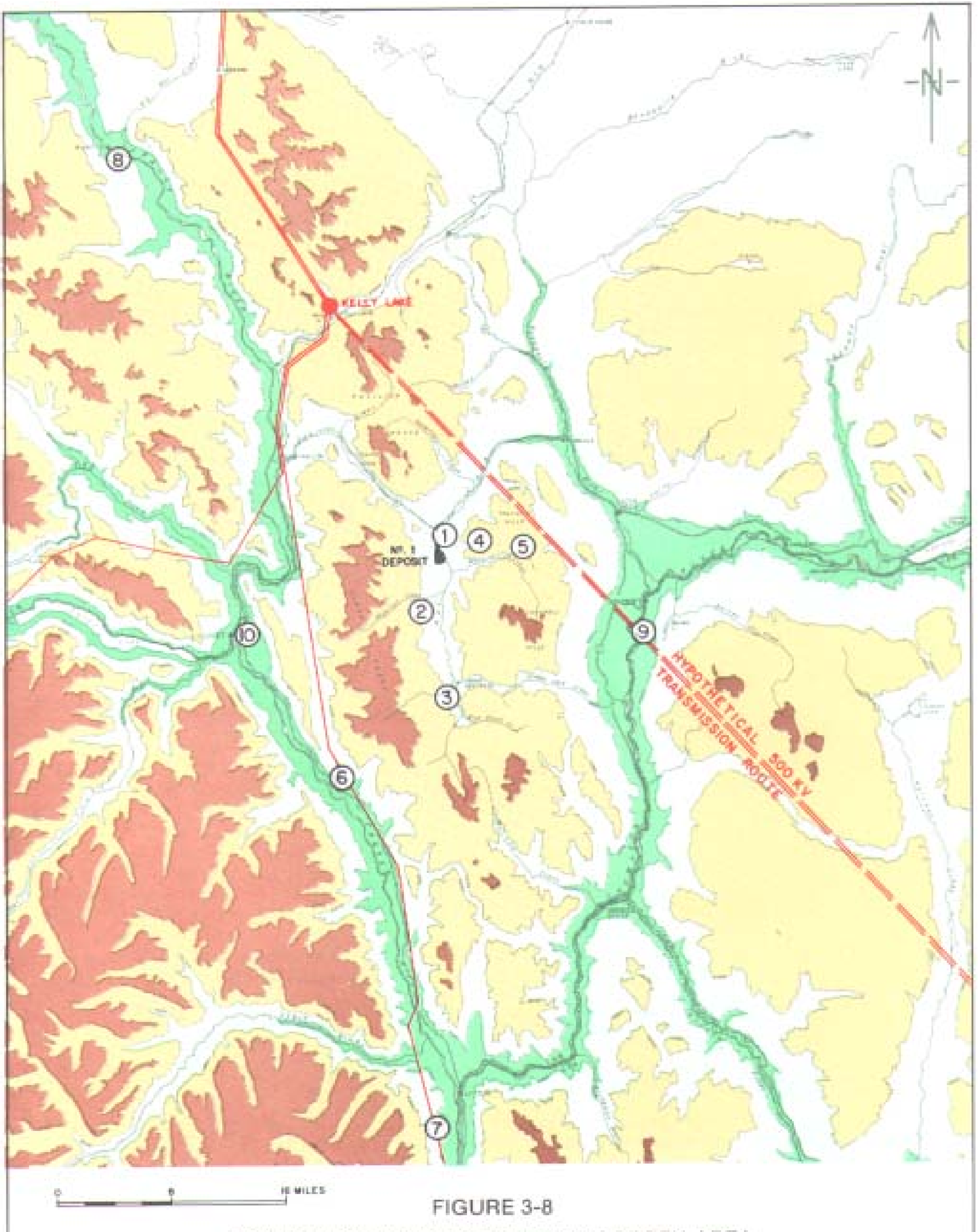


FIGURE 3-8

TRANSMISSION LINES IN THE HAT CREEK AREA

For *Site 8* (Fraser, northwest of Clinton) it is assumed that two 500,000 volt transmission lines would be constructed to connect to the Kelly Lake Substation, about 30 miles to the southeast. This 400 foot wide corridor would occupy 1455 acres of which 4.8 acres would be required for the tower bases. A second 500,000 volt transmission line would be required between Kelly Lake and Nicola and also between Nicola and Meridian.

If *Site 9* (Ashcroft) were selected for the generating station it is assumed that one of the two Kelly Lake-Nicola transmission lines would be routed to pass near Ashcroft. An additional estimated one mile corridor 400 feet wide would be necessary to loop into the generating station resulting in 49 acres of which 0.16 acres would be alienated for the tower bases.

Site 10 (Lillooet) is approximately equidistant from the Kelly Lake-Ingledow 500,000 volt transmission line and the Kelly Lake-Walters 230,000 volt transmission line. (Walters substation is on the north shore in the Vancouver area.) The length of the tie-in loop would be approximately five miles. The land required for a 400 foot wide corridor would be 242 acres of which 0.8 acres would be alienated by tower footings. A second Kelly Lake-Ingledow 500,000 volt line would also be required as for Sites 6 and 7.

If it is assumed that *Site 11* (Lower Mainland) is located in the vicinity of the Roberts Bank Development area, two 500,000 volt transmission lines would be required, resulting in a 400 foot wide corridor about 13 miles long and leading to the Ingledow substation in Surrey (88th Avenue and Sandell). The corridor would require 630 acres of which 2.1 acres would be alienated for the tower bases. The power lines would cross three major highways (10, 17 and 99), two railways (Roberts Bank and Burlington Northern) and three major blocks of residential and commercial areas in Surrey.

The following table summarizes the land requirements for the transport of electricity for those sites not in Upper Hat Creek Valley.

SITE NO.	DISTANCE, (mi.)	ACREAGE, 400' CORRIDOR	ACREAGE, TOWER BASES ONLY
6	—	—	—
7	1	49	0.16
8	30	1455	4.8
9	1	49	0.16
10	5	242	0.8
11	13	630	2.1

The foregoing land requirements for 500,000 volt transmission lines presuppose that the Hat Creek plant capacity will be 2000 Mw. If the plant were developed to an ultimate 4000-5000 Mw stage, then the land requirements given in the above two tables would double for all sites except 8 and 10. For Sites 8 and 10, the requirements would increase by 50 percent.

6. CONSTRUCTION CAMP

During the peak of construction activity about 1120 workers (including 320 operating personnel) would be employed and, if the majority of these were housed in a construction camp, some 23 acres of land would be required at the Upper Hat Creek Valley sites. If the generating station were located elsewhere, (Sites 6 to 11), the land required in Upper Hat Creek Valley would be reduced to 3 acres, with 21 acres needed at Sites 6 to 10 and 3 acres needed for Site 11.

7. SUMMARY OF LAND REQUIREMENTS

(a) UPPER HAT CREEK VALLEY SITES

	SITE				(acres)
	1	2	3	4	5
Generating Station	1570	1650	1650	1650	1650
Transport of Coal	—	19	57	23	46
Transport of Water	— Undetermined at this time —				
Transport of Electricity	10	213	519	184	306
Construction Camp	23	23	23	23	23
Sub-total	1603	1905	2249	1880	2025
Mine and Disposal Areas	3800	3800	3800	3800	3800
Total	5403	5705	6049	5680	5825

(b) OTHER SITES

	SITE					(acres)
	6	7	8	9	10	11
Generating Station	1720	1720	1720	1720	1720	1720
Transport of Coal	606	390	727	390	400	390
Transport of Water	— Undetermined at this time but probably minor —					
Transport of Electricity	—	49	1455	49	242	630
Construction Camp	24	24	24	24	24	6
Sub-total	2350	2183	3926	2183	2386	2746
Mine and Disposal Areas	3800	3800	3800	3800	3800	3800
Total	6150	5983	7726	5983	6186	6546

PART IV

LAND FEATURES AND USES

PART IV — LAND FEATURES AND USES

A. UPPER HAT CREEK VALLEY SITES

1. TOPOGRAPHY

(a) EXISTING

A model of the eastern edge of the Thompson Plateau is shown in Figure 4-1. The vertical and horizontal scales are not the same in the model; consequently, the elevations shown are accentuated giving the impression of more rugged terrain than actually exists.

The Coast Range and the deeply incised Fraser River Valley form the western boundary of the Plateau. Upper Hat Creek Valley, which is located just left of the center of the model, has a north-south orientation and lies between the Clear Range with peaks of 6000 - 7000 feet elevation on the west and the Trachyte and Cornwall Hills with peaks of 5000 - 6000 feet on the east. The valley has an elevation of about 2800 feet at its northern end and about 4000 feet at its southern end. Ashcroft, at an elevation of about 1000 feet lies in the Thompson River Valley which turns easterly toward Kamloops Lake just north of Ashcroft.

(b) IMPACT OF THE PROPOSED PROJECT

Topographical changes would result mainly from the excavation of the pit, the construction of disposal dumps, and the building of roads.

The land area of the completed pit is calculated to be in the order of 1120 acres; maximum pit depth would be 1400 feet. It is not practical to backfill the pit with waste from the pit, either during the mining period or after completion. However, if additional mineable coal deposits are located in the valley the waste from these deposits could be dumped into the original pit. If not, the upper slopes of the excavation could be seeded and ultimately the pit would fill with water to form a lake.

The impact of changed topography on animal movements is not known at this time, but warrants further investigation.

The waste dumps would be constructed in gently sloping terraces of varying heights depending on the underlying topography, with the peripheral slopes at a proposed 25 degrees. The completed dumps would be covered with topsoil that had been recovered and stacked during the first stages of overburden-removal from the pit area. The terraces would be planted with suitable vegetation.

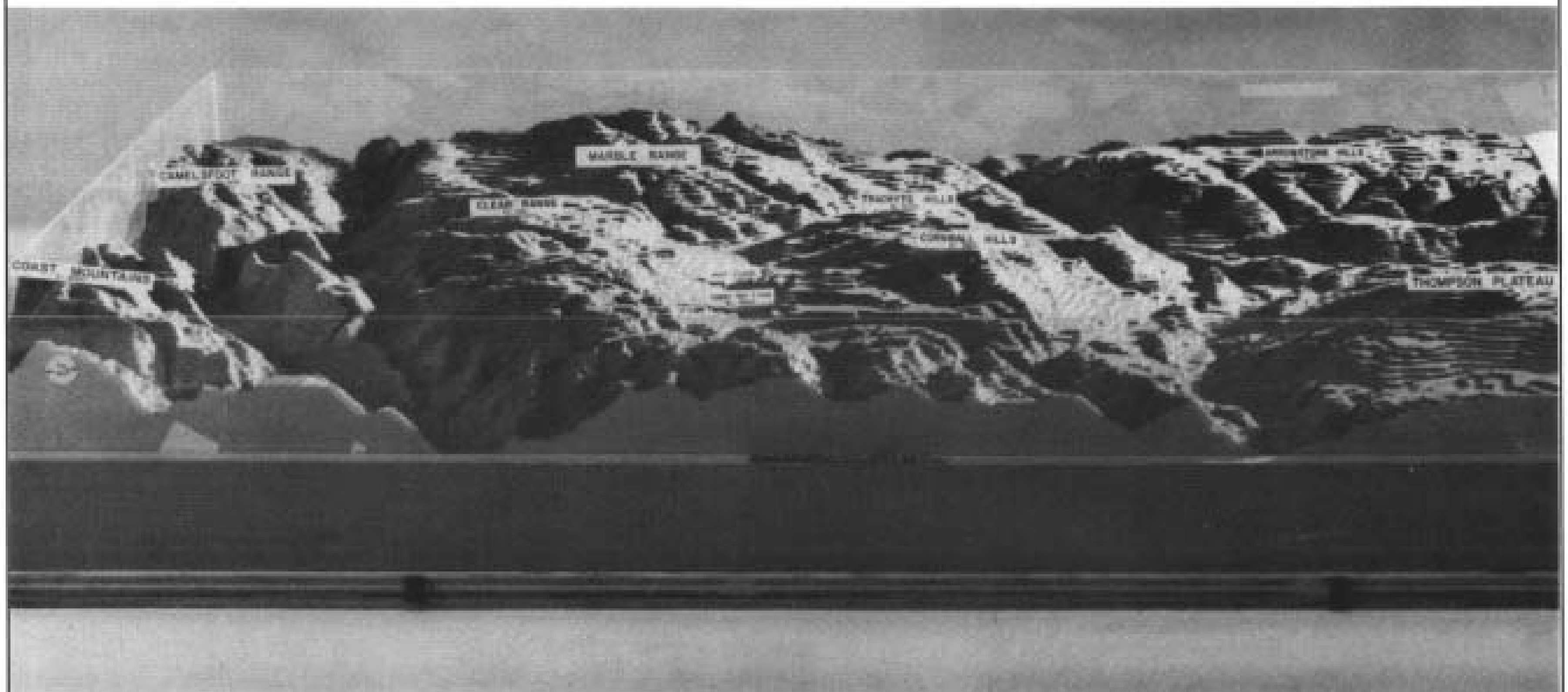


FIGURE 4-1

MODEL OF EASTERN EDGE OF THOMPSON PLATEAU

(SHOWING UPPER HAT CREEK VALLEY)

2. LAND

(a) LAND HOLDINGS

Information compiled from several sources indicates that thirteen individuals or companies hold almost the entire Upper Hat Creek Valley. Holdings are identified in Figure 4-2 by the letters A to N. Three small parcels of land shown as "C" in Figure 4-2 have not been identified. (As more definitive information becomes available, minor alterations will be required on Figure 4-2.)

Roughly 35,055 acres of land lie between the heights of land from Upper Hat Creek north almost to the boundaries of IR No. 1 (Table 4A-1, Appendix IV-1). Of the total acreage, 7085 acres (20%) are deeded, 27,880 acres, (79%) are leased agricultural land, and 110 acres (1%) unidentified at this time.

(b) PRESENT LAND USE

Land use in Upper Hat Creek Valley in 1967 (the latest data available), is summarized in Canada Land Inventory (CLI) *Present Land Use* mapping. Land use can be divided among the categories shown in Table 4-1 in order of decreasing area occupied by each category.

TABLE 4-1
LAND INVENTORY — UPPER HAT CREEK VALLEY

Map Symbol	
T_2K	Immature productive woodland with open grassland grazing areas.
K	Open grassland (probably used for domestic grazing).
T_1K	Mature productive woodland with open grassland grazing areas.
U_1K	Non-productive woodland on a productive site with grazing areas.
P_1	Cropland and pasture, (75% - 95% improved pasture and forage crops).
M	Swamp, marsh, or bog.
X	Water surfaces.
U_2K	Non-productive woodlands on a non-productive site with some grassland for grazing.

Over 95% of the valley within the area of proposed development is used as grazing land divided among the first four categories shown in Table 4-1. Small areas of cultivated pastureland exist along the valley bottoms and are located south of the proposed development.

The grazing lease permits issued for Upper Hat Creek Valley (Table 4A-2, Appendix IV-1) indicate that a maximum of 820 cattle can graze for a total of 3196 Animal Unit Months (AUM). (An AUM is defined as one cow and calf or one 1000-lb steer grazing for one month). A conservative estimate by provincial authorities of spring and fall grazing in the agricultural or grazing leased land in Upper Hat Creek Valley is 3000 Animal Unit Months. At this level the area supporting an AUM is 9.3 acres.

About one third of the deeded land in Upper Hat Creek Valley is licensed for irrigation by 11 landowners (See Table 5A-9, Appendix V-3). As stated by the Department of Agriculture:

> "Much of the cultivated land lies along the creek bottom and is subject to high water levels during the run-off period, while benefiting from irrigation later in the season. These lands are not suitable to alfalfa production but are producing hay

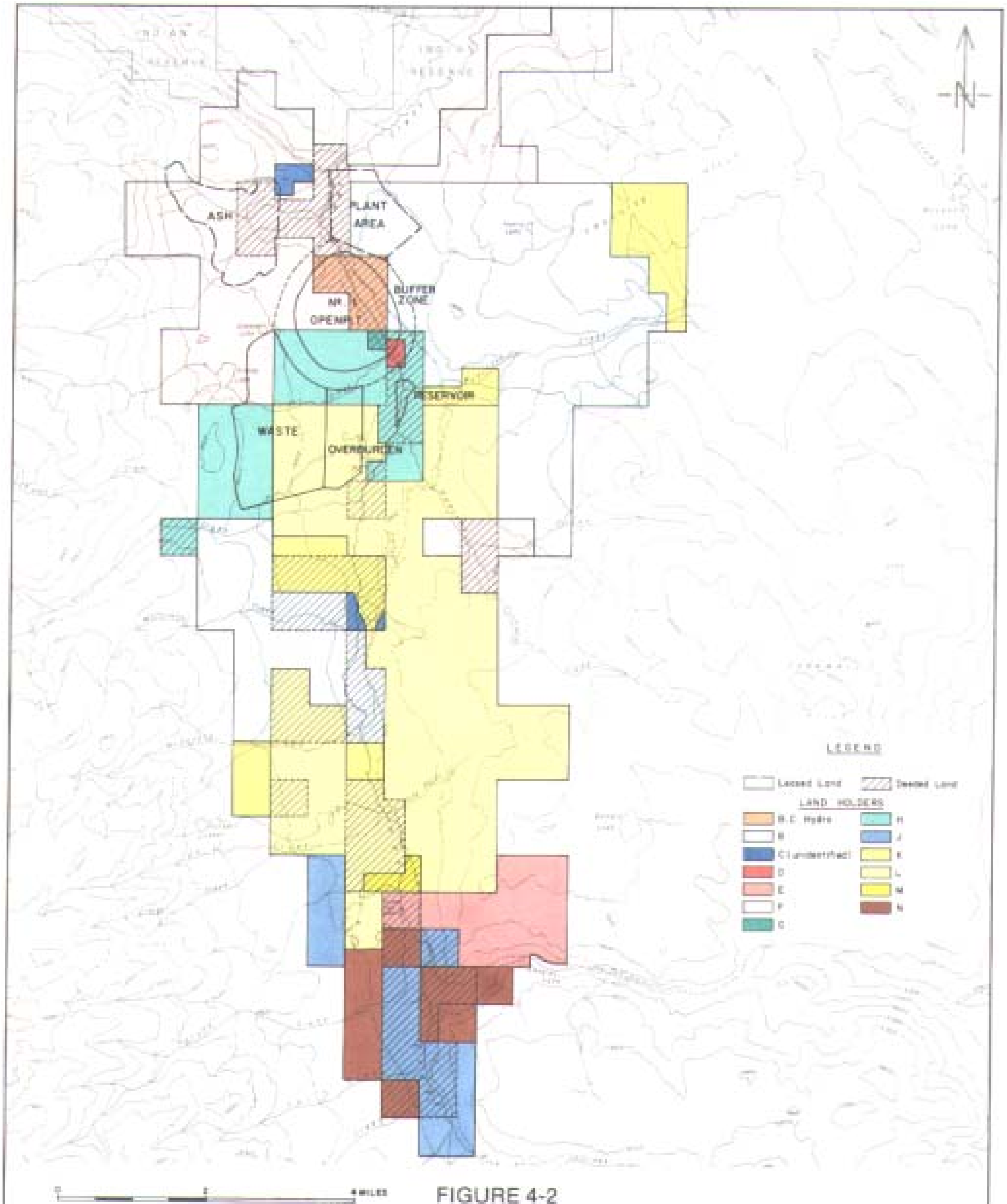


FIGURE 4-2

LAND HOLDINGS IN UPPER HAT CREEK VALLEY

(BASED ON BEST AVAILABLE INFORMATION TO JUNE 30, 1975) and pasture from such species as timothy, alsike, red clover and various indigenous grasses and sedges. Total hay production at present is grossly estimated at 3000 tons, but could be increased through more intensive management. Alfalfa is grown on the better-drained soils."

From CLI *Agriculture Capability* mapping, capability of the land in the general area of the proposed mine-plant sites is virtually all classes 5 and 6 (permanent pasture (forage) and natural grazing, respectively).

(c) ALIENATION OF LAND AND LAND USE BY THE PROPOSED PROJECT

The land which would be alienated by the proposed action is shown in Figure 4-2. In the following discussion all acreages are approximate.

NO. 1 OPEN PIT

CLI *Present Land Use* mapping shows that of the 1120 acres a pit might occupy, 530 acres are a combination of mature productive woodland (land bearing a productive forest type with at least one tree per acre greater than 11.1" diameter) and open grassland, 480 acres are open grassland, and 88 acres are non-productive woodland on a productive site (logged, burned or diseased forest land) combined with grassland. Swamp, marsh, or bog (12 acres) and water surfaces (10 acres) occupy the remainder (Table 4A-3, Appendix IV-1).

Approximately 420 acres of the maximum pit are held by B.C. Hydro, owners "H" and "G" hold 30 and 40 acres of deeded land respectively, and owners "D" and "F" each hold 15 acres. The remaining acreage is primarily leased land held by owners "F" (270 acres) and "H" (330 acres), (Table 4A-4, Appendix IV-1).

CLI *Agricultural Capability* mapping shows that 378 acres of the area which might be occupied by a maximum-size pit are comprised of 60% topography limited natural grazing land (Class 6) and 40% permanent pasture (Class 5) limited by climate. Irrigation might be expected to improve the pastureland but stoniness would be a limitation.

An additional 544 acres are climate-limited Class 5 land. Through irrigation, 102 acres could be improved to a 70-30 ratio Class 3 and 4 limited by low fertility, moisture deficiency and stoniness, and 160 acres to Class 4 limited by stoniness and moisture deficiency. The remaining 282 acres are Class 5 land limited by low fertility (60%), flooding and excess water (40%), and would not be improved by additional irrigation water.

198 acres of Class 6 land cannot be improved because of adverse topography.

BUFFER ZONE

CLI *Present Land Use* mapping shows that the proposed 740 acre buffer zone surrounding the No. 1 pit consists of 280 acres of grassland, 200 acres of immature productive woodland with open grassland, 170 acres of mature woodland, 77 acres of unproductive woodland on a productive site, 10 acres of swamp, marsh or bog and 3 acres of water surfaces.

B.C. Hydro and owner "F" each hold 60 acres of deeded land; 40 acres belong to owner "D" and 35 acres to owner "H". The remaining land is leased by owners "H" (285 acres), and owners "B" and "F", each with 130 acres.

CLI *Agricultural Capability* mapping shows that 170 acres of the proposed area is Class 6 land limited by topography. It cannot be improved by irrigation. About 256 acres are Class 6 and 5 (60-40 ratio) limited by topography and climate. The Class 5 portion of this land can be improved by irrigation to Class 3 limited by stoniness. The remaining land is Class 5 limited by climate except for 13 acres limited by topography and fertility. About 218 acres of the Class 5 land can be improved by irrigation to Class 3 - 4 (70-30 ratio) limited by fertility, stoniness and moisture. An additional 38 acres can be improved to Class 4 limited by stoniness and moisture, whereas 58 acres cannot be improved.

WASTE DUMP

CLI *Present Land Use* mapping shows that 697 acres of the 1430 acres which might be occupied by the waste dump are immature productive woodland with open grassland. About 672 acres are open grassland, 45 acres are non-productive woodland on a productive site, 13 acres are swamp, marsh or bog and 4 acres are water surfaces.

All the land is leased Crown land. Owner "F" leases 205 acres, owner "H" 690 acres and owner "L" 535 acres.

CLI *Agricultural Capability* mapping shows that most of the land (1014 acres) is Class 6 limited by topography and bedrock near the surface, or poorer. About 326 acres is Class 5 and 6 (60-40 ratio) limited by topography and low fertility and it cannot be improved by irrigation. The remaining 90 acres is Class 6 and 5 (80-20 ratio) limited by topography and moisture deficiency. Irrigation would not improve it.

OVERBURDEN STOCKPILE

CLI *Present Land Use* mapping shows that 420 of the 460 acres which might be used for the overburden stockpile are grasslands and the remaining 40 acres are water surfaces. About 375 acres of the area are leased by owner "L" and 85 acres by owner "H".

CLI *Agricultural Capability* mapping shows that 370 acres are classed as Class 5 and 6 (60-40 ratio) limited by topography and fertility. Irrigation would not improve this land. The remaining 90 acres is Class 6 and 5 land (80-20 ratio) limited by topography and climate. About 20% of the land could be improved by irrigation to Class 3 limited by fertility.

PLANT AREA

CLI *Present Land Use* indicates that of the 650 acres involved, about half (336 acres) are classified as non-productive woodland on a productive site (logged, burnt, diseased), 237 acres as mature productive woodland and open grassland, and 77 acres as open grassland.

Much of the plant area falls on Crown land under lease to holder "B" (420 acres). A lesser area (50 acres) falls on leased land held by rancher "F". Approximately 180 acres of deeded land belonging to owner "F" could be occupied by the plant site.

The CLI *Agriculture Capability* for Site 1 is primarily Class 5 (only permanent pasture or forage). The capability for the largest unit (445 acres) without irrigation is Class 5 limited by climate. With irrigation, the capability increases to Class 4 representing a reduced range of crops with the limiting factors of stoniness and moisture deficiency. An additional 179 acres of climate restricted Class 5 land could be capable of meeting Classes 3 - 4 (70-30 ratio) limited by low fertility, moisture deficiency, and stoniness. Only 26 acres, which do not appear capable of irrigation-improvement are classified as permanent pasture or forage (Class 5), modified by low fertility (60%), flooding and excess water (40%).

ASH DUMP

CLI *Present Land Use* classifies 600 acres (of the 920 acres involved) as immature productive woodland with open grassland. Another 179 acres are open grassland, while the remaining 141 acres are non-productive woodland on a productive site (logged, burnt, or diseased timber).

Rancher "F" might ultimately lose approximately a half section (336 acres) of deeded land to possible ash disposal. The remaining 584 acres are leased Crown land of which 568 acres are held by rancher "F". The holder of the remaining 16 acres is unidentified.

The potential of the ash disposal area as outlined by the CLI *Agriculture Capability* mapping, comprises four units for which irrigation is not warranted. The largest area (225 acres) is Class 6 land limited by topography and bedrock near the surface. An additional 118 acres, Class 6 land, is limited by topography. About 190 acres are Class 6 and 5 land (80-20 ratio) limited by topography and moisture, and 109 acres are Class 5 land limited by climate.

The two areas which could be improved by irrigation comprise 80 acres of 80% Class 5 and 20% Class 6 lands currently limited by climate, topography and bedrock near the surface. These lands, with irrigation, might provide an improvement to 80% Class 3 with limitations of topography and moisture deficiency. The remaining 198 acres consist of Classes 6 and 5 (60-40 ratio) with topographic and climate limitations. About 40% of this might be improved to Class 3 limited by stoniness.

HAT CREEK RESERVOIR

CLI *Present Land Use* data indicates that a 50-acre Hat Creek reservoir would occupy 32 acres of improved pasture and forage crops, 13 acres of non-productive woodland on a productive site combined with open woodland and forest range, and 5 acres of immature woodland. All of the 50-acre area lies within deeded land held by owner "H". The entire 50 acres are classified by CLI *Agriculture Capability* mapping as capable of only permanent pasture or forage modified by climate, low fertility, flooding, and excess water.

SUMMARY OF OPENPIT AND SITE 1 ALIENATIONS

The current land usage is summarized in Table 4A-3 of Appendix IV-1. About 2100 acres or 39% of the total land which might be alienated is classed as open grassland, and 1500 acres or 28% is classed as immature productive woodland with open grassland. About 940 acres or 18% is mature productive woodland with open grassland and 700 acres or 13% is non-productive woodland on a productive site. The remainder is made up of 32 acres of cropland (all in the potential reservoir site), 35 acres of swamp, marsh or bog, and 57 acres of water surfaces.

The ownership of the land which would be alienated by the proposed project is summarized in Table 4A-4 of Appendix IV-1. About 0.3% of the land expected to be used if this project proceeds belongs to unidentified owners, whereas 23.9% or about 1281 acres are deeded land and the remaining 4073 acres (75.8%) are leased Crown land. Owner "F" has control over about 34% of the land, owner "H" over 28%, owner "L" over 17%, owner "B" over 10%, owner "A" 9%, and owners "D" and "G" about 1% each.

OTHER LAND ALIENATIONS

The transport of coal to the generating plant would also involve land alienation. To protect cattle and wildlife the conveyor corridors would be fenced; the conveyors would be covered, if necessary, to eliminate coal dusting.

Transport of electricity from sites 1 to 5 would also result in land alienations but the completeness of alienation is less than that associated with other aspects of the proposed action, since much of the land remains available for cattle or wildlife grazing. Furthermore, evidence has been developed in other studies carried out by B.C. Research that ungulate populations in particular, which tend to inhabit the interface between forested land and grassed land, increase as a result of the installation of power line transmission corridors.

Although transmission lines are esthetically displeasing (to some), the proposed action for sites 1 to 5 would involve installation of transmission corridors that would be seen by few people and which could result in an increase in ungulate population.

Land alienation for a construction camp would also be involved if the proposed action is carried through. The duration would, however, be short relative to the time period of the proposed mining operation — about eight years as compared to a 35 year life of the mining and generating operations. After the eight year construction period the land occupied by the camp would be essentially returned to its original condition. However, if Site 1 were chosen for the generating station it is proposed that the camp area would become part of the ash disposal site and land reclamation would not be necessary.

If it is decided to proceed with the test burn program, the resulting sample trenches (2000 feet long in total and up to 270 feet wide) could be reclaimed readily. It is recommended, however, that the trenches not be reclaimed but that engineering studies be carried out to examine wall slope stability and surface and groundwater intrusion. These studies would provide information of great importance to the subsequent mining of No. 1 Open Pit. If a decision is made not to proceed with the proposed action after completing the test burn, the trenches would have to be reclaimed.

If the water for the generating station is obtained from the Fraser River rather than the Thompson River, additional land would be required, either at the intake point on the Fraser River or at the generating station site, for a water treatment system to remove suspended solids that occur during the freshet period. It is assumed the silt would be disposed of on the waste or overburden dumps if the treatment system was in Hat Creek Valley.

(d) IMPACT OF THE PROPOSED PROJECT

The major land use impacts of the project would result from not only reduction of leased grazing lands available to rancher "H", but from both reduction and isolation of his deeded land which, conceivably, might seriously reduce the viability of his Hat Creek operation (Figure 4-2 and Table 4A-4, Appendix IV-1). His total losses would be approximately 1500 acres. The operation of rancher "F" would be reduced also through both deeded and leased land losses totalling some 1800 acres. Rancher "L" would lose 900 acres of leased land, whereas rancher "B", with the loss of only 550 acres of his leased land, would likely experience proportionately less impact. Ranchers "D" and "G" would lose virtually all of their deeded small holdings.

Increased industrial activity and attendant tourist activity could adversely affect cattle operations in the valley. Such problems as harassment, reduced access, movement of cattle and rustling could, unless carefully controlled, reduce the effectiveness of current cattle operations.

Within a presently unknown zone surrounding the proposed plant and cooling tower, the possibility exists for a combination of heat and water vapour emissions which could combine to provide a change in micro-climate affecting vegetation. This could result in an improvement of the present plant communities.

(e) REMEDIAL ACTION

Consideration should be given to direct compensation, or alternatively, relocation of those ranchers whose properties will be isolated or physically reduced through development of the proposed project.

Provision of excess water might improve qualified areas surrounding the project. The use of irrigation water combined with range improvement practice (such as the use of a range drill) should be investigated in a separate study. Considerable expertise in this area is available through specialists from the Canada Department of Agriculture Research Station and the Provincial Department of Agriculture.

Reject heat in cooling water systems has been used elsewhere in year-round greenhouses to produce specialty crops. This desirable positive impact of the development of the Hat Creek coal deposit should be investigated.

3. SOILS

(a) CLASSIFICATION AND DISTRIBUTION OF SOILS

Topsoil is a generalized term used to describe the surface material which has developed according to soil forming processes. It differs from the underlying or parent material in that the upper soil layers usually have high organic matter content and fewer salts. The major advantage of conserving topsoil is the preservation of organic matter.

Soils of Upper Hat Creek Valley were mapped in 1974 by the Soils Branch, B.C. Department of Agriculture, Kelowna, They classified them on the basis of the parent material, vegetation and landform. A summary is given in Tables 4A-5 to 4A-8 of Appendix IV-1.

The soil types on the upland areas are largely derived from glacial till (Table 4A-5) and colluvial material (Table 4A-6), whereas alluvial (Table 4A-7) and glacio-fluvial (Table 4A-8) parent materials are present along the valley bottoms. Soils under grasslands are chernozems, while those formed under forest cover are brunisols or luvisols. Many of the soils are effervescent or saline to varying extents.

In the pit area, the following soil types are present: Medicine, Maiden, Glossey, Francis and Crown. The Medicine and Maiden soils are derived from glacial till (Table 4A-5). Both are moderately to strongly effervescent and moderately to strongly saline. They will provide topsoil down to the calcareous parent material only, a depth ranging from 8 to 18 inches. These depths will have to be assessed in some detail before stockpiling. The Glossey soil type is derived from glacio-fluvial deposits (Table 4A-8) and is moderately effervescent and weakly saline. It is expected that the top few inches will be suitable for use in reclamation. The Francis soil type (Table 4A-7) is strongly effervescent and moderately saline and its suitability for reclamation is probably restricted to the surface few inches only. The Crown soil type derived from colluvium (Table 4A-6) will provide topsoil to a depth of 8 to 18 inches.

It appears that topsoil from the pit area would be insufficient to satisfy subsequent reclamation requirements. Therefore consideration should be given to removing and storing soil from areas selected for waste dumps. Soil types in the waste areas are: Medicine, Maiden, Minnie, MacLaren, Glossey, Francis, Gisborne, Community and Crown. The suitability of the Medicine, Maiden, Glossey, Francis and Crown soil types have been discussed above. The Minnie soil type (Table 4A-5) should be an excellent source of topsoil. The top 37 inches can be utilized although the surface 17 inches would be the best material. The MacLaren soil type (Table 4A-5) will provide 7 or 8 inches of suitable topsoil material. The Gisborne and Community soils are not expected to provide more than a few inches of suitable topsoil.

The potential reservoir site is underlain by soil of the Franics - Glossey type. Because of the limited depth of these soils which would be useful for reclamation, no effort should be expended to recover and stockpile them.

(b) CHARACTERISTICS OF OVERBURDEN AND BEDROCK

Since waste materials from the proposed mining operation will be produced in large quantities, it is necessary to determine if physical or chemical barriers exist to their abilities to support vegetation. Accordingly, eight samples of overburden from depths ranging from 2 to 90 feet below the ground surface and three samples of bedrock (drill cores) 640 to 920 feet below ground level and a potting soil control were subjected to preliminary growth tests following methods outlined by Hodder[1]. Barley, grown under a controlled environment, was used as a test crop. Duplicates of fertilized and unfertilized samples were used.

The experimental details and results are given in Appendix IV-2. The tests indicate a good deal of variation in the growth response of barley on overburden materials. Fertilizer improved growth in most of the overburden samples; some beyond that achieved with the controls. Potential alkalinity problems may exist.

The unfertilized bedrock samples usually underperformed the controls and the addition of fertilizer caused no marked improvement. It would appear that the physical structure of the bedrock material limits growth no matter what the chemical characteristics. Revegetation of bedrock will be a problem because of its fine texture and high pH.

(c) TRACE ELEMENTS

Hat Creek coal (like all coals) contains, in addition to its major chemical constituents, traces of various elements which could cause environmental effects, if introduced in sufficient quantity, to man, animals or plants. These effects could be beneficial or detrimental depending, for each individual element, primarily on the extent to which it is concentrated, its chemical form, and even, in the case of certain elements, on its concentration relative to certain other trace elements or major chemical constituents.

The effects of trace elements on life forms is a very complex and little-known subject. Certain trace elements are essential for certain life forms yet not essential or even harmful for others. Some trace elements can be benign or beneficial for a given life form in very small concentrations yet destructive in excessive concentrations. Other trace elements may be benign, beneficial or detrimental depending on whether certain other elements or chemical compounds are present or absent. This is supported by the knowledge that an individual trace element may appear to be detrimental at relatively low concentration in one locality yet be apparently innocuous at much higher concentration in another locality.

At present very little definite information is available on the numbers and quantities of trace elements in the water, soil and rock of Upper Hat Creek Valley or in the tissues of plants and animals living in the Hat Creek area. Similarly, the present knowledge of trace elements in Hat Creek coal is scanty, preliminary in nature and not quantitatively reliable.

Table 4-2 lists the quantities of some trace elements present in various coals of the world along with comparative results for several samples of Hat Creek coal obtained from drill cores. Table 4-3 lists trace element contents of several samples of coal ash and waste rock from Hat Creek. All these results are fragmentary and should be regarded at best as only indicative of trace element content. In addition not all elements of interest were determined. The results presented by two different laboratories differ significantly. Whether these differences are due to variation in the samples or the quality of analytical work is yet to be determined.

TABLE 4-2
TRACE ELEMENTS IN HAT CREEK COAL RELATIVE TO SOME OTHER COALS
(In Parts Per Million)

	COAL							SOIL	HAT CREEK COAL								
	(A) Nova Scotia		(A) Germany		(B) U.S. Rocky	(C) USA	(D) World	(E) World	DDH 74-23(1)			DDH 74-26(1)		RH 75-4(2)	DDH 75-50(2)	DDH 75-52(2)	DDH 75-52(2)
	Range	Avg.	Avg.	Max.	Mtn's	Range	Avg.		#402	#403	#406	#403	#405	#7	#10	#8	#11
Arsenic (As)	33-270	100	100	500	4-5	3.6	5	5	4	20	7	3	7	nd	nd	nd	nd
Barium (Ba)	2-257	35	*	100	—	—	500	500	150	150	52	120	130	nd	nd	nd	nd
Beryllium (Be)	1-2	2	13	40	.3-.8	.1-8	3	6	.9	19	1	.7	.6	nd	nd	nd	nd
Boron (B)	6-25	17	—	10	—	2-2.5	75	10	13	5	76	7	15	30	30	nd	30
Cadmium (Cd)	—	—	—	—	.1-.3	0.06	—	.5	—	—	—	—	—	nd	nd	nd	nd
Cerium (Ce)	—	—	—	—	—	—	11.5	50	62	110	13	63	10	—	—	—	—
Chlorine (Cl)	—	—	—	—	—	—	1000	1000	23	54	14	7	5	—	—	—	—
Chromium (Cr)	2-9	5	*	*	3-4	4.5	10	200	73	150	28	56	80	nd	nd	50	nd
Cobalt (Co)	3-34	10	14	30	—	—	5	8	10	18	6	8	16	nd	nd	nd	nd
Copper (Cu)	—	—	25	10,-000	—	—	15	20	72	24	18	28	59	10	10	70	10
Fluorine (F)	—	—	—	—	—	10-220	—	100-290	1000	1000	570	1000	250	—	—	—	—
Germanium (Ge)	—	—	30	100	—	—	5	10	.5	.5	.3	.5	—	—	—	—	—
Lead (Pb)	25-120	66	140	3000	4-6	4-14	25	10	4	4	1	2	2	nd	nd	nd	nd
Lithium (Li)	—	—	—	—	—	—	65	30	1000	1000	91	45	37	—	—	—	—
Mercury (Hg)	—	—	—	—	.2	.01-.5	.012	.01	.15	.06	.07	.3	.13	—	—	—	—
Molybdenum (Mo)	2-12	7	21	200	—	0-9	5	2	11	16	16	8	26	nd	nd	nd	nd
Selenium (Se)	—	—	—	—	1.5	.5-4	3	.01	.3	.3	.4	.1	—	—	—	—	—
Strontium (Sr)	76-87	65	*	100	—	—	500	300	230	340	35	170	170	100	50	100	30
Thorium (Th)	—	—	—	—	—	—	—	6	4	2	3	3	—	nd	nd	nd	nd
Uranium (U)	—	—	—	—	—	—	1	1	2	2	3	2	—	nd	nd	nd	nd
Vanadium (V)	7-28	14	18	100	—	2-67	25	100	76	76	92	150	99	30	30	70	30
Zinc (Zn)	13-64	25	170	2000	—	0-53	50	50	13	52	8	10	9	nd	nd	nd	nd

* ....Not Significant
nd .....Not Detected
— ......Not Determined
(1) .....Sample analyzed in laboratory No. 1.
(2) .....Sample analyzed in laboratory No. 2.

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E. Vinogradov, A.P. 1959, "The Geochemistry of Rare and Preferred Elements in Soils". Translated from the Russian.

To date there is little known of the mineralogical form and manner of occurrence of individual elements in Hat Creek Coal. It is also unknown if combustion will cause each element to be retained in the ash or emitted in a gaseous or particulate form in the stack emissions. This effect may also depend on the design of the furnaces and the combustion regime, particularly combustion temperatures and draft air arrangements.

On the basis of the trace element information presently available, the elements barium, chlorine, chromium, cobalt, copper, germanium, lead, molybdenum, strontium, thorium, uranium, and zinc all occur in concentrations which would seem to pose no environmental hazards.

TABLE 4-3
SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSES
OF HAT CREEK COAL ASH, WASTE ROCK AND COALY ROCK
(In Parts Per Million)

DD Hole No.		Sample No.	Matter	As	Be	Ba	B	Cr	Co	Cu	Pb	V	Zn
74-23	(1)	402	Coal Ash	nd	5	500	50	100	20	100	20	200	200
"	(1)	403	"	nd	5	500	50	100	20	100	20	20	50
"	(1)	406	"	nd	5	500	500	100	20	100	20	200	100
74-37A	(1)	37	Waste Rock	50	nd	500	nd	200	20	50	100	100	500
"	(1)	38	"	50	nd	1000	nd	200	20	100	50	100	1000
"	(1)	53	"	50	nd	500	nd	200	20	500	500	200	2000
"	(1)	69	"	50	nd	500	nd	200	10	50	50	100	500
"	(1)	70	"	nd	5	200	50	100	20	500	100	100	200
"	(1)	71	"	nd	5	200	50	100	10	100	20	100	100
"	(1)	72	"	nd	5	200	50	200	20	100	20	100	200
74-43	(1)	1	Waste Rock	50	nd	500	nd	200	20	100	50	200	2000
"	(1)	6	"	50	nd	500	nd	200	20	100	20	200	1000
"	(1)	18	"	50	nd	500	nd	100	10	50	20	100	500
74-44	(1)	1	Waste Rock	nd	nd	500	nd	100	20	100	100	100	200
"	(1)	5	"	50	nd	1000	nd	100	10	50	50	100	1000
"	(1)	23	"	50	nd	500	nd	200	20	50	20	200	500
"	(1)	27	"	50	nd	500	nd	200	20	100	20	200	500
"	(1)	34	"	100	nd	500	nd	100	10	50	200	100	5000
"	(2)	35	"	Tr	Tr	50	Tr	100	Tr	100	nd	400	nd
"	(2)	44	"	Tr	Tr	50	10	150	30	60	nd	300	nd
74-46	(2)	12	Coaly Rock	Tr	Tr	50	Tr	70	Tr	70	Tr	300	nd
"	(2)	36	"	Tr	Tr	30	10	80	Tr	100	nd	400	nd
"	(2)	37	Waste Rock	50	nd	500	nd	100	20	50	200	100	5000
"	(1)	38	"	50	nd	500	nd	100	20	50	200	100	200

nd — Not Detected.
Tr — Trace.
(1) — Sample analyzed in laboratory No. 1.
(2) — Sample analyzed in laboratory No. 2.

Technical problems may arise from the higher than normal concentrations of fluorine and lithium reported in the preliminary analyses. These elements may also cause environmental problems.

Environmental hazards could possibly arise from the seemingly high concentrations of arsenic, boron, and cadmium. Although there is no direct evidence that there are high concentrations of cadmium in any of the Hat Creek samples, cadmium normally is associated with zinc; the relatively high concentrations of zinc reported in the coal ash and waste rock indicate the possibility of cadmium concentrations which might be detrimental. Data on beryllium, selenium and mercury are too sparse to justify drawing any conclusions as to whether or not they pose a potential danger. However they must be determined because of their highly toxic nature.

The information now at hand is not sufficiently extensive or definitive to draw any conclusions regarding either specific potential impacts or remedial measures.

More extensive investigation of trace elements will be required. A literature search should provide a basis for determining potential impacts and remedies once there are sufficient reliable trace element analyses of Hat Creek coal and coal ash, and the combustion regime is known. Large scale test burns contemplated for 1976 would yield much more reliable information on which to draw conclusions than will laboratory analyses on coal and ash. It is recommended that an immediate start be made on collecting trace element data in the existing Hat Creek environment so that pre-operational conditions will be known and available for comparison with conditions after operations commence.

Economic possibilities may lie in the potential recovery of cerium and vanadium which appear in some samples to be anomalously high. However, until it is know where, how and in what quantities these elements will occur after combustion, no economic assessment is possible.

(d) CHARACTERISTICS OF PULVERIZED FUEL ASH

The disposal of ash into tailings impoundments results in flat surfaces for reclamation. The reclamation of pulverized fuel ash has been studied elsewhere and a number of problems have been found which restrict plant growth. Plant nutrients, especially nitrogen and phosphorus, must be added through fertilizer treatment to establish vegetation[2]. Elements in over-abundance have proven toxic to plants in several instances. Rees and Sidrak[3] found manganese and aluminum toxicities, whereas Hodgson and Townsend[2] found boron in lethal concentrations. They also cited salinity, compaction and wind erosion as major problems.

(e) IMPACT OF THE PROPOSED PROJECT

The soils are all fine textured (silt to silty clay loams) and their potential for dusting is high. Dust problems would be expected to be considerable owing to the hot dry summer characteristic of Upper Hat Creek Valley. Thus, the extensive areas of disturbance, the fine textured soil, and the dry summers could combine to make dust control a major problem.

The potential for soil erosion would also be high. Erosion would occur most frequently during spring runoff and during summer-fall storms. Most of the moisture would discharge through the surface flow because the fine textured soils are not expected to be permeable to water. Suitable engineering procedure would have to be followed to prevent large quantities of silt from reaching water courses.

The potential for leaching of salts would also be high owing to the saline nature of many of the soils. This leaching would not be through a downward percolation of water but rather a lateral transport over the soil surface. Measures used to control erosion would also prevent salt discharge into water courses.

A summary of the soils which might be disturbed and their potential for dusting, leaching and erosion is presented in Table 4-4.

TABLE 4-4
DUSTING, LEACHING AND EROSION POTENTIAL OF UPPER HAT CREEK VALLEY SOILS

SOIL NAME	ACREAGE TO BE DISTURBED	POTENTIAL FOR DUSTING	POTENTIAL FOR LEACHING	POTENTIAL FOR EROSION
Community	53	Moderate	Low	Moderate
Crown	215	Moderate	Moderate	Moderate
Gisborne	47	Moderate	Low	Moderate
Glossey	235	Moderate	Moderate	Moderate
MacLaren	809	High	Low	High
Maiden	440	High	High	High
Medicine	641	High	Moderate	High
Minnie	266	High	Low	High
Francis-Glossey	418	High	Moderate	High
Maiden-Crown	606	High	High	High
Medicine-Glossey	755	High	High	High
Minnie-Clapperton	15	Moderate	Low	Moderate
Minnie-Clemes	80	High	Low	High

(f) RECLAMATION, REMEDIAL ACTION AND RECOMMENDATIONS FOR FURTHER STUDIES

SOILS

Soils data are important for reclamation planning. The knowledge of soil and vegetation relationships under pre-mining conditions is useful as a baseline toward which reclamation plans should be aimed. Soils data are especially useful in assessing topsoil availability for use in reclamation treatments.

Not all soils will provide material which would be suitable for reclamation. The major problem centers around excessive calcium or sodium salts. The upper layers of several soils have lower salt levels and would be useful for reclamation purposes. Also, soils derived from volcanic parent material would contain less salt than those from limestone and metamorphic rocks.

In general, many of the soils would provide suitable topsoil for use in reclamation. Further soils evaluation should be carried out to more closely delineate the boundaries and depths of useful materials in relation to potential reclamation requirements.

OVERBURDEN AND BEDROCK

Further study is essential if development goes ahead. Overburden and bedrock should be documented as to type and quantity and each further screened for its suitability for reclamation. The physical and chemical characteristics, weatherability, compactability, permeability and potential for leaching of toxic materials should be assessed. Plant species selection should be determined in a later phase.

Should trenching be carried out to provide large-scale coal sampling, overburden and other waste materials would probably be exposed which would provide excellent opportunities for on-site evaluation and testing.

PULVERIZED FUEL ASH

Further investigation should be made into the reclamation potential of Hat Creek coal ash. A preliminary examination of potential uses for the ash is included as Appendix IV-3.

WASTE DISPOSAL

For the present preliminary study it is suggested that waste dumps be designed to have a maximum slope angle of 25°, a maximum slope height of 100 feet between benches and a maximum dump height of 300 feet. Further study may suggest that some change in these parameters is desirable or acceptable (such as a steeper slope angle). The ultimate waste dump configuration would depend upon land use goals and plant growth characteristics.

The major factors limiting plant growth should be assessed and the waste disposal procedures designed to modify these factors. At present, one of the major limiting factors is moisture because of the relatively arid nature of Upper Hat Creek Valley (mean annual precipitation 15 inches.) Parameters which affect moisture status of waste material (slope, aspect, color, texture, organic matter content) should be investigated in some detail. The major emphasis should be on determining the effect of slope and aspect (direction in which slope faces) on plant growth. Steep south-facing slopes should be avoided in the design of waste dumps whenever possible. The maximum angle at which plants can be established has been called the "biological angle of repose" which is often a much flatter slope than the "natural angle of repose".

(g) REFERENCES

1. Hodder, R.L., B.W. Sindelar. 1972. Coal Mine Land Reclamation Research Located at Decker, Montana. Research Report No. 21, 1971 Progress Report, Montana Agric. Eng. Stn.

2. Hodgson, D.R. and W.N. Townsend. 1973. The amelioration and revegetation of pulverized fuel ash. In Ecology and Reclamation of Devastated Land **2**:247-271.

3. Rees, W.J. and G.H. Sidrak. 1956. Plant Nutrition of Fly-Ash. Plant and Soil **8**(2): 141-159.

B. OTHER SITES

The only component of the proposed project which could be sited elsewhere than Upper Hat Creek Valley is the power plant and its associated ash dumps. The topographical changes associated with the power plant are minor compared with those associated with the mining operation. The major impact on land would be alienation resulting from ash disposal. This would require detailed investigation if a site outside Upper Hat Creek Valley were selected.

The effects of the proposed power plant on land and soils are not expected to be major factors in siting the plant, although further study would be required. All Interior sites (1-10) have similar land use and climatic limitations; Site 11 (Lower Mainland) presents an entirely different environment.

If the power plant were located at one of Sites 6-11, there would be an increase in the overall land use requirement of the project. This would include additional land for railways to transport the coal (a requirement exceeding that of the conveyor belts proposed to supply Upper Hat Creek Valley sites) and coal storage facilities at both the mine site and the power plant site. In addition, the construction camp site in Upper Hat Creek Valley might have to be reclaimed as it would not be used as part of the ash disposal site (although it might be used for overburden or waste disposal).

PART V

AIR AND WATER ENVIRONMENT

PART V — AIR AND WATER ENVIRONMENT

A. UPPER HAT CREEK VALLEY SITES

1. CLIMATE

(a) EXISTING CLIMATE

The climate in the Hat Creek area is to a large extent dominated by the large scale weather patterns over south central British Columbia. This region, lying in the rain-shadow of the Coastal Mountains, experiences little precipitation. Extreme temperatures, particularly in the winter, are common and depend largely on whether Pacific air passes from the west across the Coast Range or more frigid Arctic air passes from the north and east. Upper level winds are generally from the southwest in all months, being more southerly in colder months and more westerly in warmer months. Mean wind speeds are quite light, especially in the summer and fall.

These large scale (synoptic) climatic features are, on a local scale, modified by the topography and by the elevation. A simplified explanation of how topographic features affect local atmospheric conditions, and hence the dispersion of gaseous effluents, is presented in Appendix V-1.

Very little meteorological data is available for Hat Creek Valley. Limited weather observations (temperature, humidity, and precipitation) carried out at the Lehman Ranch in Upper Hat Creek Valley are summarized in Table 5-1. While there is some concern as to the reliability of these data they are reasonably consistent with those recorded at the nearby town of Ashcroft when allowances are made for the differences in elevation.

The town of Ashcroft lies in a narrow valley which veers from north to northeast as it follows the Thompson River. The predominant wind reflects the orientation of this valley, blowing from the southwest at an annual average velocity of 4.8 mph. In this location calms occur 40 percent of the time. This figure is probably strongly influenced by the high frequency of inversions which occur over the lower Interior valleys.

Upper wind data obtained from radiosonde flights over Vernon, 115 miles away, indicate that calms are infrequent at higher altitudes. Hence it is expected that the winds will be brisker and the calms less frequent in the Upper Hat Creek Valley area than in Ashcroft. This conclusion is substantiated by some recent wind data obtained in this area which show a correlation between higher altitudes and stronger winds. The data, while as yet very limited, also show how wind direction is strongly influenced by local topography.

TABLE 5-1
LEHMAN RANCH WEATHER OBSERVATIONS (1961-1974)

MONTH	AVERAGE TEMPERATURE (°F) MEAN	AVERAGE TEMPERATURE (°F) MINIMUM	AVERAGE RELATIVE HUMIDITY (%)	AVERAGE DEW POINT (°F)	AVERAGE TOTAL PRECIPITATION (inches)
Jan.	13	−24	84	10	1.6
Feb	24	− 3	85	18	0.6
Mar	30	− 2	79	23	0.5
Apr	39	15	66	28	0.6
May	48	22	58	34	0.9
Jun	55	31	59	42	1.0
Jul	59	33	60	46	1.2
Aug	58	32	64	46	1.1
Sep	50	24	75	40	0.9
Oct	39	15	83	32	0.8
Nov	26	− 3	89	23	1.1
Dec	15	−18	87	13	1.6

(b) ACQUISITION OF ADDITIONAL DATA

As discussed in Appendix V-1, local meteorologic conditions play an extremely important role in the dispersion of gaseous emissions. In complex terrain it is difficult to reliably estimate the extent of this dispersion, but if given adequate data on wind trajectories, inversions, and on diurnal effects, some useful approximations can be made. Consequently an extensive program for collection of weather data was initiated by B.C. Hydro with the assistance of Atmospheric Environment Canada. Eight weather stations have been set up to measure precipitation, wind direction and wind velocity (Figure 5-1). Five of these (1, 2, 3, 4, 5) are located at low elevations in Hat Creek Valley and Marble Canyon. Existing data indicate low wind velocities which might transport air pollutants emitted near ground level. The winds are largely related to air drainage along the valleys. The low-level sites will provide the data to resolve this possibility and provide specific data at some possible low-level plant sites. Three stations (6, 7 and 8) are located at high elevations to provide data on upper-level wind conditions and specific data at possible high level plant sites. Weather station 5 is mounted on a wooden pole so that it can be readily dismantled and moved to other sites where data might be required.

A series of four hygrothermographs have been installed along a line extending from an elevation near the valley floor to a high elevation in the Trachyte Hills. These units provide data on temperature and relative humidity, the former to provide information on the existence of atmospheric inversions and the latter to provide information on fog or ice formation, which are possible results from cooling ponds or towers. In addition to these continuous monitors, minisonde devices will be used periodically to measure upper atmospheric conditions. These devices consist of helium-filled balloons which are released at ground level and transport temperature sensing instruments aloft. The presence or absence of temperature inversions and their persistence is determined. In addition, the horizontal motion of the balloons provides information on upper-level winds.

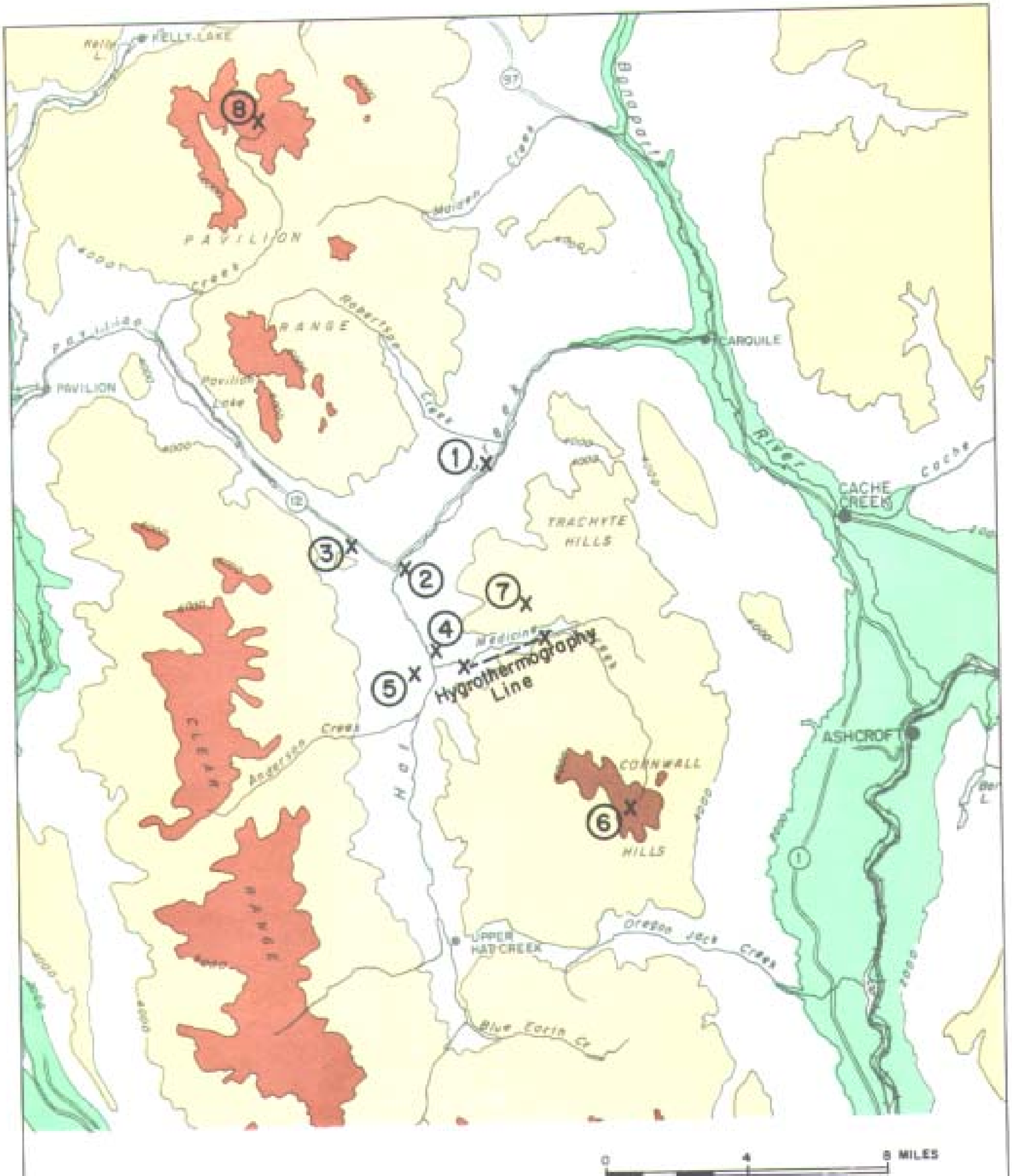

FIGURE 5-1

WEATHER AND HYGROTHERMOGRAPH MONITORING STATIONS

(c) POTENTIAL IMPACTS OF THERMAL PLANT EMISSIONS

In accordance with the laws of thermodynamics a conventional thermal power plant loses the majority of the energy potential of the consumed fuel. In the case of a coal-fired station located in Upper Hat Creek Valley this energy loss would mainly be via one or more large natural draft cooling towers. In addition, some heat would be lost through discharge of the combustion gases from the powerhouse. For a 2000 Mw plant burning 40,000 tons of coal per day the combined energy rejected to the environment would be around 10 billion Btu/hr. The associated water vapour release from the cooling towers would be about 10 million lb/hr (equivalent to 17,000 Igpm). The question naturally arises as to the environmental impact of these discharges.

It is known that large localized releases of heat can, in certain instances, lead to the formation of intense vortices. Briggs[1] has concluded that while such phenomena could occur in the case of a power park (e.g. a large number of nuclear power plants situated close together so as to share certain facilities) it is very unlikely to be a concern in the case of a more conventional sized plant. This is mainly due to the fact that vortex generation is caused by thermal buoyancy and hence by the sensible heat contained in the gaseous emissions. The energy contained in cooling tower emissions is, on the other hand, largely in the form of latent heat which does not contribute directly to buoyancy unless gross condensation occurs. This condensation cannot occur to an appreciable extent because of plume dilution by ambient air.

It is expected, however, that a power plant located in Upper Hat Creek Valley would have some mild influence upon the local weather, especially during the cold winter months. Generally this would take the form of an increase in the incidence of fog and perhaps of precipitation. Existing mathematical models available to predict the behavior of cooling tower plumes have had little field validation and are mainly based on limited observations made on relatively small mechanical draft units. The operating experience of the British Central Electricity Generating Board which has in the order of 300 natural draft cooling towers, is pertinent to this discussion. Since the British climate is relatively cool and humid it is obvious that most environmental problems inherent in the use of towers there will be magnified. They have found[2] that provided the towers are properly designed and maintained they have negligible effect on the local climate.

Plume persistence and hence visual impact were found[3] to be strongly correlated to ambient relative humidity. This study also concluded that wind speed and station load are relatively unimportant parameters. At no time during the one year of observations was the plume envelope seen to touch the ground. If we use the Lehman Ranch humidity data (Table 5-1) with the correlation observed in the above study we find that during the summer months (April to August) the plume would generally be less than 1000 feet long, and that during the balance of the year the plume would generally be less than 3000 feet long.

The above estimates should be viewed with caution, because in a valley location the plume could easily become trapped below an inversion lid and result in an increase in fog. Normally this would not be serious but during extremely cold weather a dense ice fog could result. This phenomena occurs during inversion conditions in Fairbanks, Alaska when the temperature drops below about -40°F. At this temperature the supercooled water droplets spontaneously freeze and result in a rapid and widespread formation of ice fog[4]. During the Lehman Ranch observations (1961-1974) this critical temperature was reached only twice. Therefore it is unlikely that dense ice fog would be a problem, especially when the greenhouse effect of the large carbon dioxide emission is considered.

Icing could occur either by cooling tower plume impingement against a mountain side or, on a very localized scale, by surface freezing of carryover (tower entrainment of water droplets). The former mechanism should not be serious unless the tower is located adjacent to a large hill. Localized icing depends upon the amount of carryover and hence upon the efficiency of the tower's droplet eliminators. Proper design can minimize this effect.

(d) REMEDIAL ACTION

A more thorough investigation of the impact of the plant upon local climate is not warranted until more data are available on local weather and on proposed plant design.

If further study indicates that conventional natural draft cooling towers could lead to a strong negative impact due to extensive valley fogging, then consideration could be given to the use of combination wet/dry towers. Such towers may be justified in cool climates where make-up water is scarce. In any event it is recommended that the cooling towers should not be located close to hills where winter icing would be a problem. The power plant stack should be located far enough away from the cooling towers such that its plume is not affected by these structures. A wind tunnel can be used to help determine optimum spacing.

(e) REFERENCES

1. Briggs, G.A., "Plume Rise from Multiple Sources", in *Cooling Tower Environment — 1974*, AEC Symposium Series (CONF — 74302 from Clearinghouse for Fed. Scient. and Tech. Inf., U.S. Dept. of Com. Springfield, Va. 22151).
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2. AIR QUALITY

(a) PRESENT STATUS

Air quality has not yet been studied for the sites in Hat Creek Valley and vicinity. Because of the rural nature of the area and its low population it is likely that air pollution is minimal. Visibility during clear weather is generally several tens of miles, except when slash burning or forest fires occur. This suggests that suspended particulates are at a level well below the Federal Ambient Air Quality objective of $60 \mu g/m^3$. However, dustfall arising from natural sources can be high because of the semi-arid nature of the region.

To establish the background level of atmospheric contaminants, an air quality study should be instigated prior to station operation. Of major interest is the ambient level of suspended particulate and the concentration of potentially toxic trace elements contained in this particulate. Of secondary interest is background dustfall and nitrogen oxide concentration (produced to some extent by plant foliage). The background level of sulfur dioxide in this area is expected to be negligible.

(b) POTENTIAL CONTAMINANTS AND THEIR ENVIRONMENTAL EFFECTS

A large coal mine/power plant would result in certain atmospheric emissions. Dust would be generated during the mining operation. Vehicular activity would result in the release of hydrocarbons, nitrogen oxides, and carbon monoxide. Fuel combustion in the power plant would result in the formation of sulphur oxides, nitrogen oxides, and particulates (fly ash). The natural draft cooling towers could release small amounts of cooling water treatment chemicals. The following sections will examine these emissions in more detail.

DUSTS

The proposed construction, mining and coal handling operations at Hat Creek would all create some quantities of dusts. Plant construction would not contribute heavily to dust problems; however road construction, overburden stripping and stockpiling and particularly transport of overburden, pit waste and coal by trucks would tend to generate large amounts of dusts.

Winds blowing over roads, overburden dumps, waste dumps, ash disposal dumps, coal stockpiles and the openpit would tend to produce dust. The problem would require continued attention to a well planned dust-abatement program.

The frequency of calm weather in the Hat Creek area is not yet known but it is probably relatively high, therefore the dust control measures that would be needed both in the mine and at the plant would have to be particularly stringent in order to prevent the build-up of a dust pall in the valley during both construction and operation. In the course of overburden removal from the openpit, the operation would require greater than normal sprinkling by tank trucks in order to avoid build-up of dust in Upper Hat Creek Valley. Mining in bedrock in the openpit would not generate as much dust as construction and stripping in overburden.

The thermal plant operation would produce no significant dusts except from coal and ash handling. Coal stockpiles could be sprayed with chemicals or special petroleum products to control dusts, while ash would likely be handled in the form of a wet slurry. If a coal cleaning plant were built it would also produce dusts from coal handling and the same abatement measures would be required. Within the plants, dust collection machinery would be employed.

VEHICULAR EMISSIONS

Some of the large excavating machines to be employed in the mine could be diesel powered. The smaller excavators, such as scrapers, loaders, tractors and pit trucks would also be diesel powered and would produce normal exhaust pollutants, (principally nitrogen oxides, carbon particulates and less troublesome amounts of carbon monoxide). All of these pollutants could be reduced to very low and acceptable levels through the use of hot catalytic scrubbers of the types employed on diesel engines in underground applications. Use of catalytic scrubbers on all diesel engines should be considered.

Many cars, light trucks and buses employ gasoline engines, and catalytic scrubbers for these have still not been perfected. Carbon monoxide and nitrogen oxides are the principal pollutants along with a little particulate matter.

It is probable that vehicular emissions would be relatively insignificant.

POWER PLANT EMISSIONS

The major source of atmospheric contaminants would be the power plant. For a nominal 2000 Mw plant burning 40,000 tons of coal per day the stack discharge would be about 4.7 million cfm of combustion gases. This gas stream would mainly consist of nitrogen, oxygen, carbon dioxide, and water vapour. In addition there would be lesser amounts of sulphur oxides, nitrogen oxides and particulate (fly ash).

The sulphur oxides originate from the combustion of the sulphur contained in the fuel. For a nominal sulphur concentration in coal of 0.5 per cent the resulting uncontrolled emission of sulphur oxides would be about 550 lb/min. These oxides would be mainly in the form of sulphur dioxide (SO_2). The small amount of sulphur trioxide (SO_3) formed would be almost entirely removed by the electrostatic precipitators.

The major environmental effect of SO_2 would be damage to vegetation as described in Appendix V-2.

Nitrogen oxides are created during the coal combustion process; their formation is favoured by high temperatures and excess oxygen. Flue gas from a typical lignite fired power plant contains about 400 parts per million (ppm) of nitrogen oxides[1]. For a 2000 Mw plant this is equivalent to about 210 lb/min of nitrogen dioxide. The major environmental effect of this contaminant is its photochemical reaction with hydrocarbons to produce smog. Since a properly fired power boiler emits negligible quantities of hydrocarbons, this effect may not be important in this case. A natural source of volatile organic material is that emitted by plant foliage; this material is mainly in the form of monoterpenes. Using the method of Rasmussen[2] it can be shown that the maximum terpene emissions in Upper Hat Creek Valley would be in the order of 2 lb/min. This is not considered to be significant.

Particulate emissions derive mainly from the inorganic ash contained in the coal. For a 2000 Mw plant burning 40,000 tpd coal containing 28 percent ash the uncontrolled emissions would be about 12,000 lb/min[3]. Most of these emissions could be removed by a mechanical collector backed up with a high efficiency electrostatic precipitator (ESP).

If it is assumed that the collection system would be designed to limit particulate emissions to the present B.C. standard (for forest industry power boilers) of 0.1 grains per standard dry cubic foot (0.1 grn/sdcf) at 12 percent carbon dioxide (CO_2), for 20 percent excess air, then the equivalent emissions would be 78 lb/min. If the mechanical collection has an efficiency of 60 percent, then the ESP must have a minimum efficiency of 98.4 percent. A study[4] done by the TVA on a large number of steam power plants showed that in general the operating efficiency of an ESP was less than the design efficiency. Hence it is probable that the final particulate collector for the Hat Creek plant would have to be designed with an efficiency in excess of 99 percent in order to continuously meet the above standard. Efficiency of an ESP is strongly correlated with fly ash resistivity, which in turn is affected by such variables as fly ash chemical composition and flue gas temperature, humidity, and SO_3 concentration. By properly controlling these parameters, efficiencies exceeding 99 percent can be achieved even with low-sulphur coal[2].

As shown in Table 5-2, the major constituents in the fly ash of the Hat Creek coal would be silica and complex aluminum silicates which are also the primary components of clay. On cursory examination it would appear that these particulate emissions are relatively innocuous and would lead only to a slight reduction in atmospheric visibility. But perhaps more important is the synergistic effect between particulate and SO_2 as discussed in Appendix V-2.

Associated with the above fly ash emission would be a minute quantity of trace elements. Sixty-element spectrographic analyses have been carried out on five samples of Hat Creek coal. The reported concentration of those trace elements which show in

TABLE 5-2
TYPICAL MINERAL ANALYSIS OF ASH OF HAT CREEK COAL

MINERAL	KNOWN RANGE (wt %)	NORMAL RANGE (wt %)
Phosphorus, P_2O_5	0.1 - 0.5	0.2 - 0.3
Silica, SiO_2	48.0 - 60.0	50.0 - 55.0
Iron, Fe_2O_3	3.7 - 12.6	5.0 - 8.0
Alumina, Al_2O_3	19.0 - 33.0	27.0 - 33.0
Titania, TiO_2	0.6 - 1.5	0.6 - 0.8
Lime, CaO	0.8 - 8.6	2.0 - 5.0
Magnesia, MgO	0.5 - 1.6	0.8 - 1.3
Sulphur, SO_3	0.8 - 3.6	1.0 - 3.0
Potassium, K_2O	0.05 - 1.5	0.1 - 0.4
Sodium, Na_2O	0.4 - 3.8	0.5 - 2.0
Undetermined	0.1 - 2.0	0.5 - 1.0

appreciable amounts and those trace elements generally regarded as of environmental importance are shown in Part IV, Tables 4-2 and 4-3. Also shown are ranges and averages of trace element contents for other coals occurring throughout the world.

Two of the elements determined, chromium and fluorine, are regarded as beneficial to human life and occur in Hat Creek coal in higher than normal amounts. Three elements, lithium, mercury and strontium can be harmful to human life and occur in higher than normal, or at least questionable, amounts. Cadmium and iodine can have harmful and beneficial effects, respectively, but neither has so far been analyzed. Five elements, cerium, cesium, gallium, thorium and zirconium, occur in appreciable amounts in Hat Creek coal but their effects on human health have not been determined to date.

Some trace elements will have to be subjected to more sensitive analytical techniques, as some were not detected using spectrographic analysis. It should be noted that trace elements bound into the fly ash would, if present at the one ppm level, be emitted at the rate of 40 lb per year assuming total emissions of 78 lb per min. On the other hand those trace elements which are volatile and which are present at the one ppm level in the coal could be emitted at the rate of 1800 lb per year.

COOLING TOWER EMISSIONS

The major atmospheric emission from cooling towers is water vapour. The climatic effects of this emission were discussed earlier.

A secondary emission arises from entrainment, in the tower's vapour plume, of cooling water droplets. This droplet carryover, or drift, is controlled by mechanical separators (drift eliminators) which are now being designed to reduce drift to 0.008 percent of the circulating flow[6]. Besides the previously discussed potential for localized icing during the winter, this drift could also lead to a local deposition of cooling water chemicals. These chemicals take the form of concentrated salts which were originally present in the cooling water make-up, and on cooling water additives such as corrosion inhibitors, antifoulants, and biocides. Whether these materials have a noticeable environmental effect depends upon the specific additives used and upon their emission rates.

(c) FEDERAL AMBIENT AIR QUALITY OBJECTIVES

The Clean Air Act of 1974 presented ambient air quality objectives that are guidelines for maximum ambient pollutant concentrations which are biologically acceptable. Those pertinent to a power plant are presented in Table 5-3.

TABLE 5-3
AMBIENT AIR QUALITY OBJECTIVES

POLLUTANT	AVERAGING TIME	DESIRABLE RANGE ($\mu g/m^3$)	ACCEPTABLE RANGE ($\mu g/m^3$)
Sulfur	Annual Average	0 - 30	30 - 60
Dioxide	24 hour	0 - 150	150 - 300
	1 hour	0 - 450	450 - 900
Suspended	Annual Geometric	0 - 60	60 - 70
Particulate	Mean		
Matter	24 hour	-	0 - 120
Nitrogen	Annual Average	0 - 60	60 - 100
Oxides	24 hour	-	0 - 200
as NO^2	1 hour	-	0 - 400

Whether a power plant in the Hat Creek area could meet these objectives is dependent upon the rate of pollutant emissions, the effective stack height (stack height plus plume rise), and the dispersion capabilities of the atmosphere. These factors will be discussed in the following section.

(d) ESTIMATED EXTENT OF IMPACT OF PROPOSED PROJECT

The environmental impact of atmospheric contaminants is mainly dependent upon their ambient concentrations and hence upon the process of atmospheric dispersion. This will be illustrated by two examples.

Around 1930 extensive crop damage occurred in the State of Washington as a result of SO_2 emissions from the Trail smelter[7]. Prior to emission control measures this smelter, situated in a deep narrow valley with sides 2500 feet high, discharged 650 tons per day (900 lb/min) of SO_2. During a diurnal inversion the plume rose about 500 feet and then spread laterally to form a concentrated layer which subsequently drifted down the Columbia River valley to Washington. Differential heating of the valley sides by morning sunlight caused this concentrated plume to be circulated against the valley sides and hence fumigate the vegetation. This condition was ameliorated when the smelter utilized the majority of the waste SO_2 to produce sulphur and sulphuric acid. The residual SO_2 emissions were rigidly limited according to the dispersive capabilities of the meteorological measurements.

If the plume had risen above the ground-based inversion it is certain that the environmental impact of the original emissions would have been far less severe.

The second example is the Fort Nelson gas treatment plant which emitted 600 tpd of SO_2 at 1000°F from a 350-foot stack. The considerable buoyancy of this hot plume and the flatness of the surrounding terrain resulted in relatively low ground level concentrations under all but the most adverse meteorological conditions. A study of aerial infra-red photographs of this area failed to reveal any appreciable vegetation damage attributable to the stack discharge[8].

The two examples above show that two different plants, each emitting approximately the same quantity of SO_2, had profoundly different impacts upon their environments.

The impact of a 2000 Mw coal-fired generating station situated in Upper Hat Creek Valley cannot be accurately assessed at this time due to a lack of meteorological data. As is pointed out in Appendix V-1, dispersion estimates are difficult for mountainous terrain. The situation is complicated by topographically-induced localized circulation patterns such as valley channeling, drainage winds and lee-side rotational flow. Mechanically-induced turbulence will generally tend to augment plume dispersion, hence rendering the common plume dispersion models (empirically derived for flat terrain regions) invalid. There exists the possibility of a plume impinging against the side of a mountain and thus giving rise to high localized concentrations provided that the atmosphere is stable.

Some preliminary estimates on plume dispersion indicate that the limiting case may be that of plume impingement. Whether this impingement occurs will depend upon stack height, plume rise, height of the surrounding hills, and the wind flow pattern around and over these hills. Due to the tremendous heat energy emitted from the stack of a 2000 Mw power plant the plume rise can be considerable, even when emitted into a stable layer of air. It was assumed that a single stack 50 feet in diameter and 1000 feet high would emit 300°F flue gas into 60°F ambient air. Plume rise was calculated using the methods of Moses-Carson[9], TVA[10], and Briggs[11]. A comparison is presented in Table 5-4.

TABLE 5-4
PRELIMINARY PLUME RISE ESTIMATE

METHOD OF ESTIMATION	ATMOSPHERIC CONDITION			
	UNSTABLE, 2m/s WIND	NEUTRAL, 8m/s WIND	STABLE, 2m/s WIND	STABLE, CALM
1. Moses-Carson	2070 m	220 m	550 m	
2. TVA	1470 m	330 m	870 m	
3. Briggs	2030 m		500 m	780 m

It can be seen that there is considerable variation between the results of the different estimation methods. The formulae used in these methods are based on observations which were limited to a plume rise of around 500 metres (1600 ft). This occurred at the TVA Paradise plant when the atmosphere was stable and a 2.1 m/s wind was blowing. Hence the very high plume rises estimated for an unstable atmosphere and a light (2 m/s) wind which are shown in the first column of Table 5-4 should be viewed with caution.

If it is arbitrarily assumed that the plume is emitted into a deep, stable layer aloft where the wind velocity is about 2 m/s, then the plume rise would be in the order of 600 metres (2000 ft). For a 1000 foot stack this puts the plume axis on a level with many of the surrounding mountain peaks in the case of a plant located in the north end of Upper Hat Creek Valley. It is not yet known what the plume trajectory would be in this case but if it is assumed that it impinges against the Marble Range to the north then the maximum SO_2 calculated concentration at ground level would be in the order of 8 ppm (21,000 ug/m^3). The other contaminant concentrations would be similarily high. The above estimate is based on the dispersion methods of Turner[12] which are reliable only for flat terrain. Mechanically induced turbulence caused by mountainous terrain would enhance atmospheric dispersion and hence reduce the above concentrations. It is obvious though, that considerable reduction would be required to prevent vegetation damage as described in Appendix V-2.

Two other meteorological conditions could conceivably lead to high ambient pollutant concentrations. These are a deep ground based nocturnal inversion with subsequent morning fumigation such as occurs at Trail, and an elevated inversion lid which has been shown[10] to be the limited case for large power plants located on flat terrain.

The former condition is not considered to be a serious problem in Upper Hat Creek Valley. Stable air draining down the flanks of this valley during the evening would tend to flow north and to follow Hat Creek down and out of the valley. Hence the stable layer would not be expected to accumulate to a depth so great that a large buoyant plume would not be able to penetrate it.

The second condition, that of an inversion lid capping the valley, is more difficult to assess. Generally these elevated inversions are a result of atmospheric subsidence due to a near-stationary high pressure system. Pollutants unable to penetrate such an inversion would tend to accumulate below to an environmentally unacceptable level. Whether this could happen depends upon the elevation and the thickness of the inversion layer, and upon the wind patterns beneath this layer. The subject definitely warrants further investigation.

(e) REMEDIAL ACTION AND RECOMMENDATIONS FOR FURTHER STUDY

The previous sections attempted to focus on some of the more important environmental considerations involved in situating a power plant in Upper Hat Creek Valley. It was emphasized that an accurate knowledge of meteorological conditions within and above the valley is required before a proper assessment of potential impact can be conducted. Air flow patterns through the valley and over the hills must be defined and the question of possible plume impingement should be resolved. The frequency and characteristics of inversions must be known.

When such knowledge is available it should be possible to estimate whether a tall stack would result in sufficient dispersion to prevent a negative impact, or whether even with a tall stack the plume rise would be inadequate to penetrate an inversion lid. If the latter case could lead to an environmentally unacceptable condition but would occur only infrequently, then the possibility of temporarily curtailing power generation or of switching to a low sulphur fuel during such episodes should be considered. Otherwise the alternatives of flue gas scrubbing versus locating the plant at a site with more favourable dispersion characteristics should also be investigated.

While technology exists for scrubbing the majority of the SO_2 out of the stack gas, it is expensive and could lead to secondary problems. Capital cost for a limestone based process is quoted[13] to be $50 to $60 per kw ($100-$120 million for a 2000 Mw station). Operating costs would be high because of limestone requirements and because of potentially severe problems with scaling and corrosion. The cool wet plume emitted from such a process would have lost much of its thermal buoyancy and hence could easily become trapped by an inversion condition. To prevent this the gas would have to be reheated. This process requires considerable energy and could lead to severe corrosion problems[14].

It is apparent from the above discussion that flue gas scrubbing is a difficult and expensive process — one that should be only considered if no other environmentally acceptable method of operating a coal-fired thermal plant is available.

All major permanent roads should be paved during construction, both to reduce wear on equipment and to reduce the dust problem. Sprinkling or application of mulch could be used for other roads.

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3. GROUNDWATER

(a) PRESENT STATUS

SURFACE

Figure 5-2 depicts the principal features of present surface water distribution in Upper Hat Creek Valley.

Hat Creek and three main tributaries in the north half of Upper Hat Creek Valley flow continuously throughout the year. The three tributaries are Medicine Creek, Ambusten (or Boyles) Creek and Anderson Creek. At the height of the spring run-off, in mid-June, Hat Creek is 1½ to 2 feet higher than in late summer.

In addition, two small unnamed creeks that drain the Houth Ranch (northwest of No. 1 Open Pit area) maintain a meagre flow throughout the summer, fed partly from the mountain

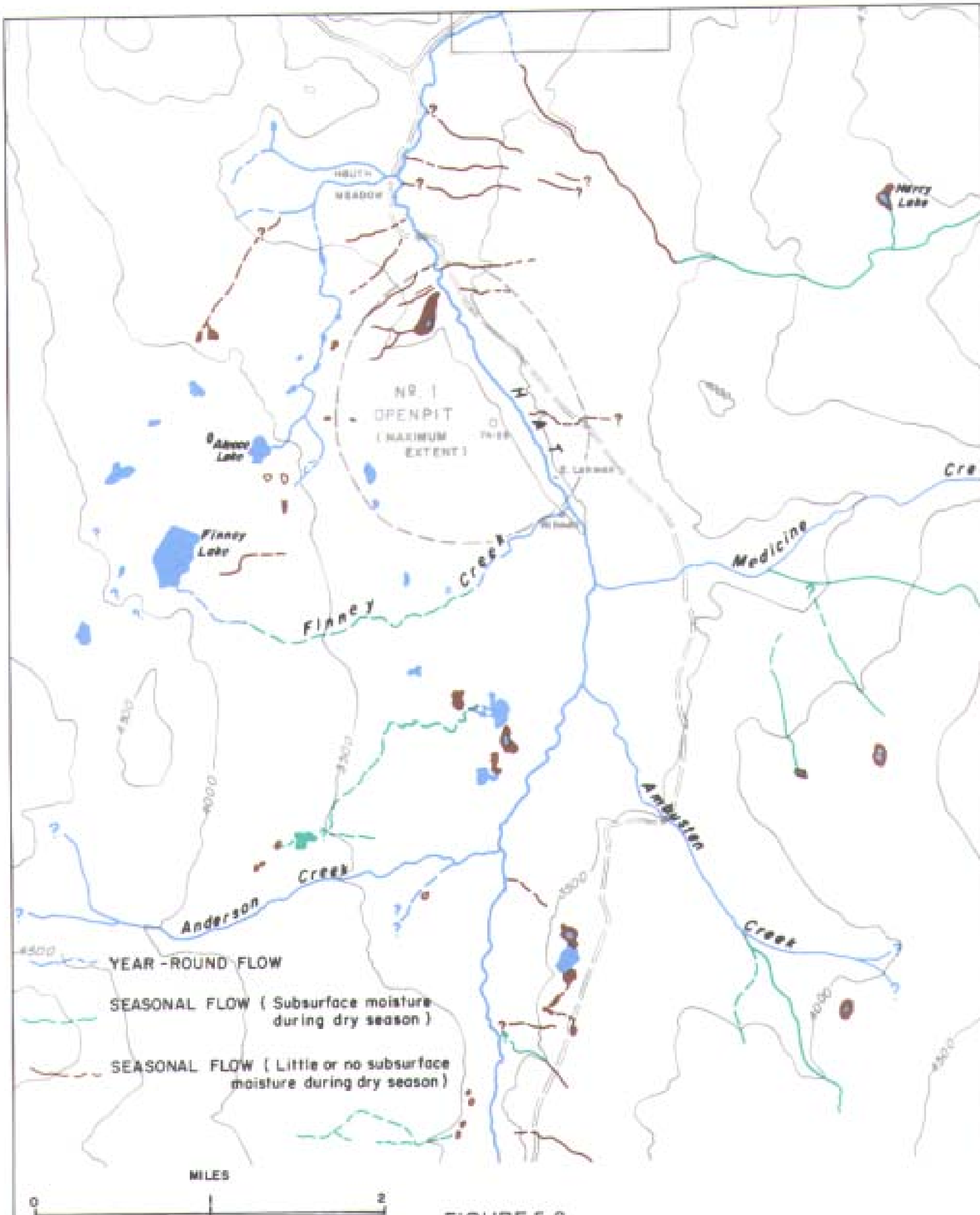


FIGURE 5-2

SURFACE WATER DISTRIBUTION IN UPPER HAT CREEK VALLEY slopes to the west and partly by a slight but steady contribution from the Aleece Lake-Finney Lake area. The Houth meadows remain moderately green during the summer, suggesting that the water table is probably not more than 3-4 feet below the ground surface. The northwest corner of these meadows tends to be swampy because the more northerly of the two creeks has been dammed by beavers.

It is likely that at least McDonald, Pocock, Colley and Yet creeks, entering Hat Creek from the west in the south half of the valley (see Figure 3-2), also flow throughout the year, but this has not been fully checked. They are all marked by an abundant growth of trees, and have moderately incised channels.

In the northern half of the valley, the east bench is conspicuously drier than the west bench. North of Medicine Creek, a major channel drains the upland on which Harry Lake is situated, but is dry in the fall except for traces of moisture in its lowermost portion, (within 2,000 feet of Hat Creek) and possible subsurface moisture above 3,500 feet elevation. Except for about a mile where it crosses the flatter part of the bench, this creek is well incised. Several minor but well-incised channels notch the edge of the bench between Hat Creek road junction (with Highway 12) and Medicine Creek, but all are dry except for a brief period during the spring run-off. They are likely to have been cut by seasonal, semi-torrential creek flow.

SUBSURFACE

The east bench at the north end of Upper Hat Creek Valley may be unique, as it appears to be underlain mostly by gravelly sands, grading into gravels, with interbeds of (probably) lakesilts and sands, i.e. it is generally pervious and well-drained. Subsurface flow is thus likely to be dispersed and the water table low; there is no perched groundwater in the form of sloughs.

By contrast, the east bench south of Ambusten Creek, and most of the west bench, have a scattering of small depressions, some of them holding water in June and July, drying out later, and others retaining water throughout the summer and fall.

On the flatter parts of the benches, a notable feature is that some depressions maintain a steady water level while others, nearby and at the same general elevation, go dry. This suggests that the overburden here lacks the general permeability that results in the uniform dryness of the northeast bench area, and is variably permeable, possibly having a system of seepage channels that keeps some sloughs supplied with water. (An example is one slough about 1,000 feet north of Finney Creek, from which water was pumped for drilling in 1974. The water level remained constant despite several weeks pumping.) Large sloughs on the west bench opposite the mouth of Ambusten Creek and on the east bench south of the same creek also retain water in August and September. Water flow in Finney Creek disappears within 3,000 feet down-stream of the outlet from Finney Lake, and reappears as a spring 600 feet upstream from the Hillman house. A few years ago the flow from this spring declined suddenly and at the same time the yield from a spring on the west bank of Hat Creek, about 1,500 feet north of Finney Creek, markedly increased. The E. Lehman household obtains its water supply from this latter spring.

A system of seepage channels appears to connect several lakes and sloughs in the Finney-Aleece Lakes area. The subcrop within most of this area probably consists of Kamloops basalts, commonly vesicular and porous, and probably with fair permeability. In particular, a small group of lakes lying between 3,500 and 3,600 feet elevation, including Aleece Lake, appears to maintain a steady water level, and only Aleece Lake has a visible outlet. Local opinion is that three small lakes within 2,000 feet southeast of Aleece Lake drain underground, feeding a swampy slough by the forestry trail in the northeast corner of Section 1 (Tp. 21, R. 27) and draining northwards from there into the chain of creeks and sloughs that discharge into the Houth Meadows.

Much of the bottom land along Hat Creek in the No. 1 Openpit area is underlain by stream gravels that are highly pervious. However, the water table in these gravels is at least several feet below the level of Hat Creek itself. Test pumping in 1974 indicates that stream silts and possibly some mineral precipitates from the water of Hat Creek have effectively sealed off the creek from the enclosing highly pervious gravels. Ranchers digging wells near Hat Creek have experienced this problem. Although details are lacking at present, it appears that when they do obtain a flow from wells near the creek, they consider that this flow is independent of the creek itself.

There are reports of several small holes on the west bench which open into cavities large enough to trap cattle and horses. These holes are evidently the result of piping and subsidence associated with subsurface drainage.

The only instance of artesian flow known to date occurred in 1974 in drill hole 74-25 (Figure 5-2) when water flowed from the hole in gradually diminishing volume for several days after drilling had stopped.

(b) POTENTIAL IMPACTS OF THE PROPOSED PROJECT

The openpit would have two major influences on the water regime in the north end of Upper Hat Creek Valley; (i) Hat Creek itself would have to be diverted around the pit for about two miles, and (ii) drainage of groundwater into the pit could be significant and would have to be disposed of, and of course, the drawdown area surrounding the pit might have to be replenished.

HAT CREEK DIVERSION

Hat Creek would have to be diverted around the proposed open pit. The method of diversion is not certain at present but some possibilities are:

1. Pump and siphon through a pipeline (requires a lift in the order of 150 feet).
2. Flume around the eastern side of the openpit but well above the pit rim. The flume would have to start several miles south of the openpit and would thus not be of any use for drainage from the western slopes (eg: Anderson Creek).
3. Trench and tunnel around the eastern side of the openpit. This would have the advantage of no lift and result in a natural, although partially underground (two miles?), water course. However, at present it is not known if the rock east of the pit is suitable for tunneling.
4. Construction of a dam above the pit and use of Hat Creek water for dust suppression in and about the pit area. Hat Creek flow below the development would then have to be restored by Thompson River water.

The diversion of the creek might require a dam and a small reservoir of about 50 acres. If required the dam would be located just downstream of the confluence of Medicine Creek and Hat Creek, approximately 1/2 mile upstream of the ultimate periphery of the pit (Figure 3-5).

If a pipeline is used, the reservoir would function as a forebay. However, it is unlikely that fish would be able to migrate upstream through the pipeline. Compensation for this lost fishery could be achieved by stocking the reservoir. Additional compensation could be attained by providing an artificial spawning channel in Hat Creek downstream of the openpit, possibly using high quality Thompson River water from the plant. This action could also be taken if Hat Creek were dammed and the water used for irrigation, dust suppression, or other purposes around the pit.

In any situation involving a dam and reservoir the water flow rate would have to be controlled to ensure that the seasonal variations in the flow rate of Hat Creek were maintained.

Other creeks passing through the proposed development, particularly Finney Creek, may have to be diverted. In addition, drainage channels and/or culverts would have to be built and maintained.

OPENPIT WATER

Extensive tests to determine the groundwater conditions in the vicinity of the openpit would be required. Finney Creek which runs through the proposed pit area would have to be diverted. Water pumped out of the openpit would have to be treated before disposal into Hat Creek.

An additional potential problem is the formation of acidic drainage water arising from the oxidation of any metallic sulphides associated with the coal or waste rock. The analytical data available concerning Hat Creek coal indicate that it contains from 0.13 to 2.03 percent sulphur. If all this sulphur were to be converted to sulphuric acid it would be equivalent to 8 to 122 pounds per ton of coal. However, present indications (not yet confirmed by detailed analyses) are that most of the sulphur is organic in origin and thus not susceptible to oxidation by *Thiobacillus ferrooxidans*.

Little information is available concerning the sulphur content of the overburden and bedrock which would be excavated in the openpit. However, three samples of overburden and two of bedrock were tested to see how much acid they could consume compared to how much sulphur they contained. Sulphur analysis indicated that all samples contained less than 0.1 per cent sulphur and thus could not produce more acid than they could consume. Two of the three overburden samples and one of the two bedrock samples examined would consume more acid than could be produced by material containing up to 2.1 percent sulphur, the maximum level recorded in any of the coal samples. The remaining two samples were more readily acidified. As little as 0.4 percent sulphur could theoretically generate more sulphuric acid than the overburden sample could absorb, a level frequently exceeded by the coal in the No. 1 Deposit.

Based on the samples examined, and the indication that the sulphur in Hat Creek coal is organic in nature, the probability of acidic drainage water resulting during the exploitation of the Hat Creek deposit is remote. However, some samples have a low acid consuming ability and they should not be mixed with any sulphur-bearing waste. Further investigation to identify potential acid-producers in relation to disposal practice is recommended.

4. HYDROLOGY

(a) WATER REQUIREMENTS OF THE PROPOSED PROJECT

The water requirements of the proposed system would depend on the cooling-water system adapted. In Hat Creek Valley only a wet cooling tower system is considered feasible.

Table 5-5 sets out the water requirements of the proposed development using these towers. The maximum demand would be 25,000 Igpm or 66.7 cfs. B.C. Hydro would install pumping capacity of 40,000 Ipgm (107 cfs) so that it would not be necessary to pump water during the periods of peak power demand.

TABLE 5-5
ESTIMATED WATER REQUIREMENT (Igpm) FOR A 2000 Mw PLANT*

Evaporation and boiler blowdown	16,700
Steam generator blowdown	250
Potable water for domestic use	400
Coal preparation	4,600
Ash disposal	1,800
Contingency	1,250
Total	25,000

* Total estimated requirement for a 5000 Mw plant is 50,000 Igpm.

The requirements for an adequate supply of water for a once-through cooling system (Figure 5-3) render it impractical for use at Upper Hat Creek Valley sites for several reasons.

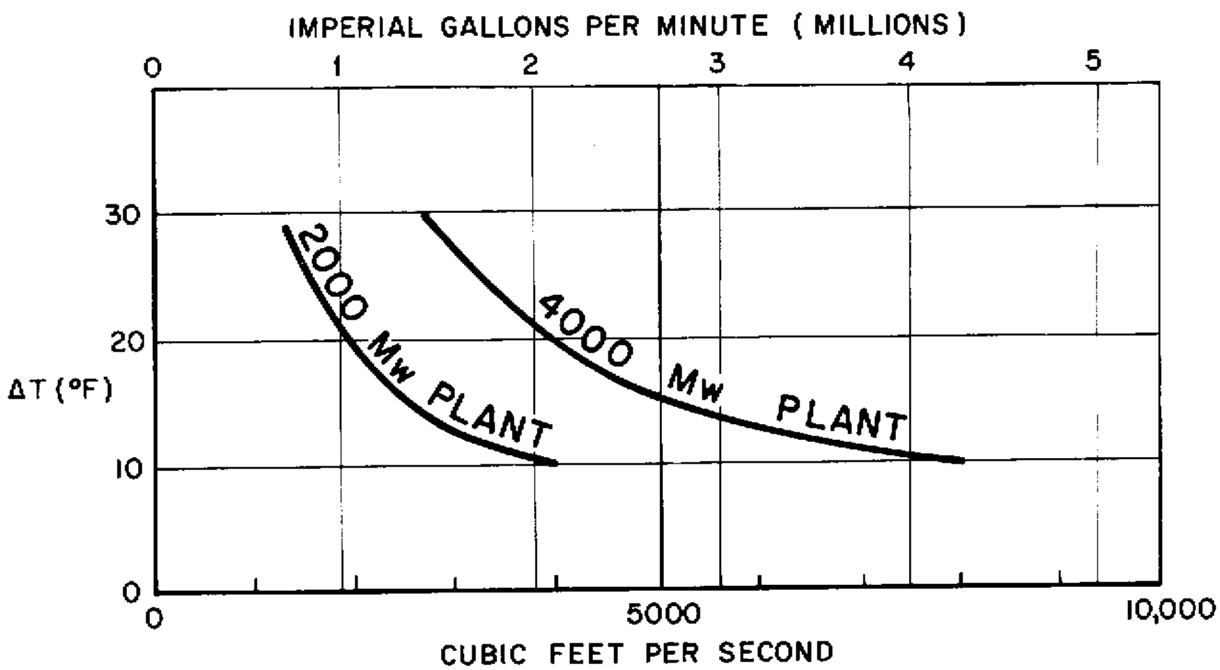


FIGURE 5-3

WATER DEMAND FOR ONCE-THROUGH COOLING SYSTEM

The power requirements for pumping would be a significant fraction (perhaps one quarter) of the output of the proposed generating station. The volumes of water to be circulated could not be discharged into Hat Creek without causing major downstream flooding. The temperature rises (possibly up to 30°F) would be unacceptable in the small stream. Other adverse effects on the fisheries such as disorientation and salmonid screening problems would further compound the problem. The possibility of returning once-through cooling water to the source via tunnel or pipeline has not been considered worth investigating at this stage.

(b) POTENTIAL SOURCES OF WATER

The flow rates for the Bonaparte, Fraser and Thompson rivers and for Hat Creek are shown in Tables 5A-3, 5A-4, 5A-5, and 5A-6 of Appendix V-3. Obviously only the Fraser and Thompson rivers are an adequate source of water for the proposed project. The quality of the water in the various potential sources is discussed in Section 5 below.

The installed pumping capacity would be 40,000 Ipgm (107 cfs) so that it would not be necessary to pump water during the period of peak power demand. At this rate the maximum withdrawal of Thompson River water would be 2.6 percent of the recorded 1:50 low flow and it would be less than 1 percent of the recorded 1:25 low flow from the Fraser.

A pumping requirement of 107 cfs is within the capability of current screening technology. No protection would be required for downstream flood plains or fishery with respect to rate of water discharge or to water temperature. The magnitude of the impact of any potential discharge of Fraser River water is reduced significantly.

5. WATER QUALITY

(a) PRESENT STATUS

Water samples have been collected and analyzed by Pollution Control Branch personnel periodically since November, 1971, from the sites shown in Figure 5-4. Sampling locations are defined in Table 5A-7, Appendix V-3. The frequency of sampling has been adequate to describe water quality at the various stations in Hat Creek, Bonaparte River, Fraser River and Thompson River through all seasons. However, the siting of sample stations does not permit detailed prediction or monitoring of the effects of the proposed mine and power station on water quality in the area. In this report, flow data have been used as a basis for discussion of the changes that may occur in the water quality of the various streams.

HAT CREEK (STATION 0600073)

Maxima and minima are shown in Table 5A-8, Appendix V-3 for Hat Creek water quality parameters measured since November, 1972. The water in Hat Creek may be classified as "very hard" at all times[1]. Dissolved solids, conductance and alkalinity values were high; sulfate ranged from 52 to 58 mg/l, but chloride, nutrient and heavy metal concentrations were low. In winter, dissolved oxygen was only 50 percent of the saturation level. Oxygen readings are not available for summer months. During spring run-off, suspended solids reached 68 mg/l.

Flows in Hat Creek, Figure 5-5 (data in Table 5A-3, Appendix V-3) ranged from a minimum monthly average of 4.4 cfs in August, 1973 to a maximum monthly average of 340 cfs in June, 1964. Annual mean flows were between 11 cfs and 54 cfs in the years 1963-1973.

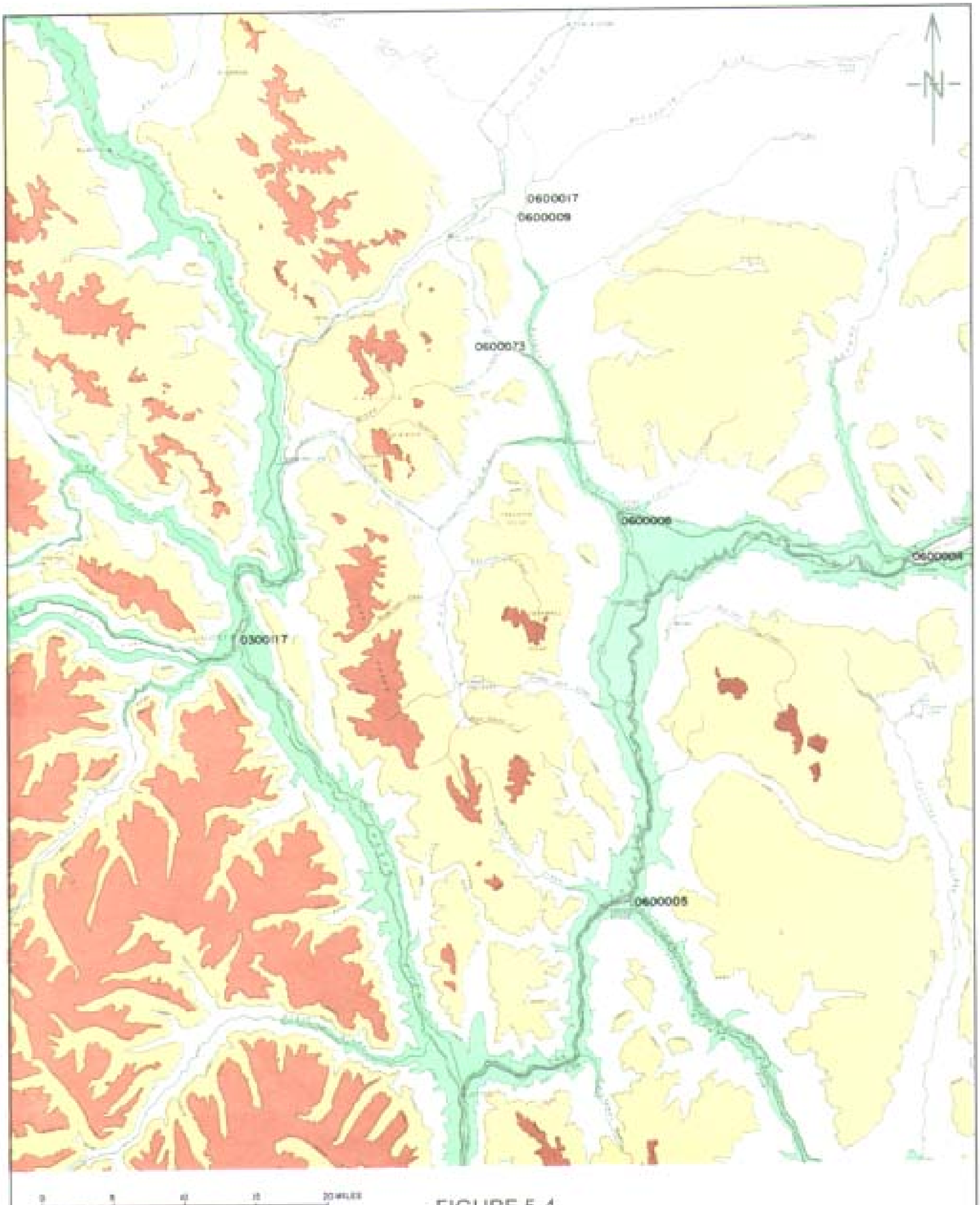


FIGURE 5-4

PCB SAMPLING STATION LOCATIONS

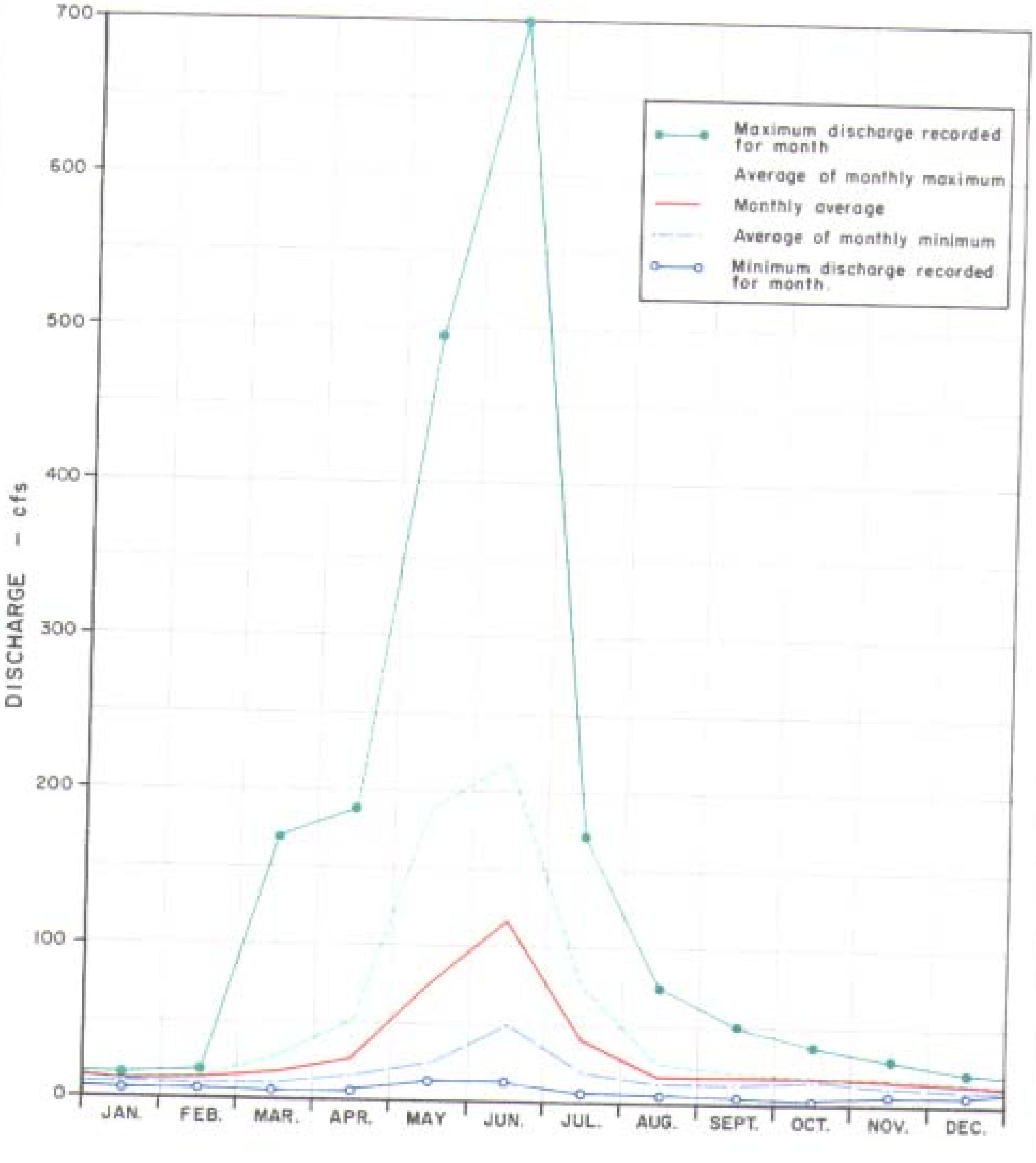


FIGURE 5-5

STREAM DISCHARGE, HAT CREEK, 1960-1973

(NEAR CACHE CREEK Ga 8L1015)

BONAPARTE RIVER (STATIONS 0600008, 0600017)

Since November, 1971, fifteen samples have been analyzed by the Pollution Control Branch from the Bonaparte River below the township of Cache Creek (Station 0600008) and thirteen samples from above Clinton Creek (Station 0600017). Bonaparte River water is "hard/very hard" (81-258 mg $CaCO_3$/l) according to the classification of Durfor and Becker[1]. Values for dissolved constituents were correspondingly high, though there were wide seasonal variations (see Table 5A-8, Appendix V-3). Nutrient concentrations below the Cache Creek sewage outfall were moderately high and dissolved oxygen at this station ranged from 43 percent of the saturation level in March, 1974 to 125 percent saturation in September, 1973. Concentrations of dissolved constituents in the Bonaparte River increased considerably between Station 0600017 and Station 0600008, as shown in Table 5-6. However, changes in water quality due to the influx of water from Clinton Creek, Hat Creek, Cache Creek sewage outfall and the discharges from other creeks cannot be assessed due to the absence of intermediate sampling stations. Table 5-7 contains flow ratios for the

TABLE 5-6
CHANGES IN BONAPARTE RIVER WATER QUALITY
FROM ABOVE CLINTON CREEK (SITE 0600017)
TO BELOW CACHE CREEK (SITE 0600008)

	11/9/73		9/1/74	
ANALYTICAL PARAMETER	SITE 0600017	SITE 0600008	SITE 0600017	SITE 0600008
Alkalinity (mg/1)	130.0	218.0	211.0	252.0
pH	8.5	8.8	8.0	8.7
Dissolved Solids (mg/1)	162.0	322.0	244.0	362.0
Suspended Solids (mg/1)	—	—	2.0	12.0
Specific Conductance (µmhos/cm)	220.0	510.0	400.0	580.0
Nitrate (mg N/1)	<0.02	0.028	<0.005	0.13
Sulphate (mg/1)	<5.0	54.6	—	—
Dissolved Oxygen (mg/l)	13.8	12.7	—	—
Temperature (°C)	23.0	15.0	0	0

TABLE 5-7
BONAPARTE RIVER/HAT CREEK FLOW RATIOS, 1963-73

YEAR	FLOW RATIO ON DAY OF: BONAPARTE RIVER MINIMUM	DATE	HAT CREEK MAXIMUM	DATE	RATIO OF ANNUAL MEANS
1963	—	—	1.7	May 23	5.2
1964	4.5	Jan 5	0.7	Jun 12	3.2
1965	—	—	—	—	—
1966	1.8	Dec 8	0.7	Mar 29	5.1
1967	0.9	Dec 18	1.2	Jun 5	4.2
1968	2.1	Jan 29	3.6	Jun 10	5.0
1969	10.0	Jan 1	3.6	May 25	9.2
1970	4.0	Dec 20	5.5	Jun 7	9.9
1971	—	—	—	—	—
1972	3.7	Dec 10	2.8	Jun 1	5.4
1973	2.7	Dec 31	2.3	May 20	7.2

Bonaparte River and Hat Creek on the day of minimum discharge from the Bonaparte River and on the day of maximum discharge from Hat Creek in each year from 1963 to 1973. The data indicate approximate annual minimum dilutions of Hat Creek water by the Bonaparte River. Daily ratios for this period can be obtained readily, since the flow data are available as a computer printout.

THOMPSON RIVER

Since 1971, 24 samples from the Thompson River near Savona (Station 0600004) and 26 samples from the Thompson at Spences Bridge (Station 0600005) have been analyzed in the laboratories of the Pollution Control Branch. In contrast to Hat Creek and the Bonaparte River, Thompson River water is moderately soft. At Savona, hardness values were 30-44 mg

TABLE 5-8
CHANGES IN THOMPSON RIVER WATER QUALITY BETWEEN SAVONA (SITE 0600004) AND SPENCES BRIDGE (SITE 0600005)

ANALYTICAL PARAMETER	13-14/3/74		8-9/5/74	
	SITE 0600004	SITE 0600005	SITE 0600004	SITE 0600005
Alkalinity (mg/l)	38.5	44.5	39.3	42.5
pH	7.6	7.7	7.6	7.8
Hardness (mg $CaCO_3$/l)	43.2	51.0	42.6	46.2
Dissolved Solids (mg/l)	70.0	78.0	64.0	70.0
Suspended Solids (mg/l)	2.0	4.0	8.0	22.0
Specific Conductance (μmhos/cm)	108.0	125.0	104.0	115.0
Nitrate (mg N/l)	0.12	0.10	—	—
Phosphate (mg P/l)	0.005	0.003	—	—
Sulphate (mg/l)	7.8	10.3	—	—
Turbidity (JTU)	0.9	3.4	3.2	8.0
Dissolved Oxygen (mg/l)	11.0	6.8	8.6	9.4
Temperature (°C)	5.0	4.0	11.2	11.0

TABLE 5-9
THOMPSON RIVER/BONAPARTE RIVER FLOW RATIOS, 1963-73

YEAR	FLOW RATIO ON DAY OF:				RATIO OF ANNUAL MEAN FLOWS
	MINIMUM THOMPSON RIVER FLOW	DATE	MAXIMUM FLOW	DATE	
1963	184	Jan 12	83	May 8	271
1964	91	Mar 4	105	May 27	159
1965	158	Jan 12	105	Jun 17	135
1966	198	Dec 24	96	May 13	199
1967	69	Mar 15	44	May 6	109
1968	221	Jan 12	104	Jun 2	226
1969	71	Mar 21	34	May 12	195
1970	68	Mar 25	108	Jul 29	148
1971	87	Dec 31	78	May 15	148
1972	78	Mar 28	161	Jun 20	183
1973	72	Feb 2	171	Jun 6	151

$CaCO_3$/l, pH was in the range 6.8-8.4 and the concentrations of chloride, sulphate, heavy metals and nutrients were low, as shown in Table 5A-8, Appendix V-3. Dissolved oxygen was 45-85 percent of saturation at Savona and 45-125 percent at Spences Bridge. The low oxygen levels reported for the Thompson at Spences Bridge are unusual in a turbulent river. High suspended solids may be expected during spring run-off, although the maximum value reported at Savona was 9 mg/l in June, 1972.

The Thompson River accumulates small amounts of dissolved solids between Savona and Spences Bridge as shown by the data in Table 5-8. The net effect of the Bonaparte River on water quality in the Thompson appears to be small. Flows at Spences Bridge for 1963-1973 are shown in Table 5A-5, Appendix V-3; Table 5-9 contains Thompson/Bonaparte river flow ratios. The minimum dilution of Bonaparte River water by the Thompson was 34-fold.

Overall quality of Thompson River water is adequate to permit its use without treatment as cooling water for the generating station. Reductions in suspended and dissolved solids, pH adjustment and de-oxygenation would be needed before use as boiler feed water[2].

FRASER RIVER

Process water for the proposed power station might alternatively be obtained from the Fraser River between Pavilion and Lillooet. Water quality in this area is described in results (Table 5A-8, Appendix V-3) obtained by the Pollution Control Branch from analysis of 14 water samples collected since November, 1972 from the Fraser River at Lillooet (Station 0300117). Dissolved solids levels are approximately twice the concentrations that occur in the Thompson River. Fraser River water at Lillooet is moderately hard (55-89 mg $CaCO_3$/l) and contains high levels (up to 478 mg/l) of suspended solids in months when flows are high. Chloride, sulphate, nutrient and heavy metal concentrations were low, though on one occasion (11/5/72), 0.52 mg/l dissolved iron was reported. Oxygen levels were sometimes depleted in winter, but normally concentrations were 90-100 percent of the saturation value.

Suspended solids removal would be required during high run-off conditions if Fraser River water were to be used for cooling purposes in the proposed generating station. Dissolved solids levels are acceptable without treatment for cooling water make-up[2]. Use of Fraser River water as boiler feed supply would necessitate more extensive purification than if Thompson River water were used.

(b) WATER LICENSES

The use of water for irrigation from both Hat Creek and the Bonaparte River is intensive with three of the tributaries being fully recorded, (Figure 5-6, and Table 5A-9, Appendix V-3). Licenced storage within the Hat Creek basin is approximately 60 cfs over a three month period. Minimum flows during 1960-67 were measured at the stream mouth to be as follows:

June	— 14.8 cfs
July	— 9.4 cfs
August	— 3.9 cfs

The Water Resources Service and the Department of Agriculture are planning a review of the existing irrigation facilities to determine the merits of replacing existing facilities with a modern storage and distribution system.

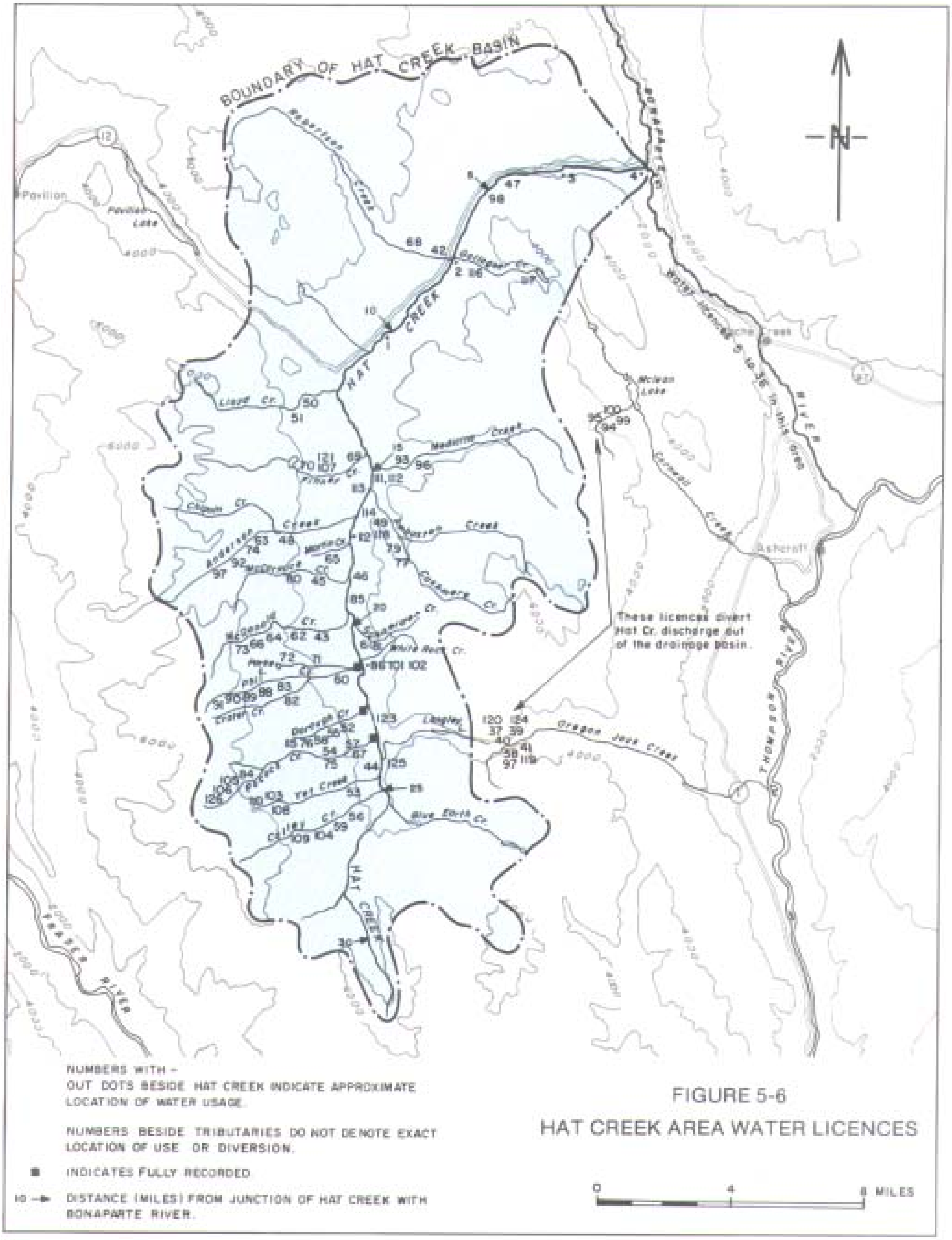


FIGURE 5-6
HAT CREEK AREA WATER LICENCES

(c) POTENTIAL IMPACTS OF THE PROPOSED PROJECT

Two alternative plans are under consideration for Hat Creek. In one plan, the Creek would be diverted around the proposed mine site without appreciable loss of flow. As a second alternative, Hat Creek would be dammed above the proposed area of operation and the water used for partial plant make-up requirements; water to downstream licensees would be made up from the Thompson River or the Fraser River. In either case, precautions should be taken during construction to minimize the risk of increased suspended solids in Hat Creek and to avoid spills of contaminants such as oils.

If Hat Creek were diverted around the mine site and power station, minimal changes would be expected in water quality except for suspended sediments which are expected to increase downstream for some period during early development. Proposed plans are that there would be no discharge of any kind from the power station and thus there should be no contamination of Hat Creek by corrosion inhibitors, descaling agents, antifouling agents, water purification wastes or boiler blowdown wastes. Hat Creek is unsuitable for disposal of such effluents because of their high toxicity potential to humans and animals.

If Hat Creek water is used in the proposed plant, substitution of soft Thompson River water for very hard Hat Creek water would decrease dissolved solids in lower Hat Creek and should improve its suitability for irrigation by the four licensees on the creek. The effect would be less pronounced if the Fraser River is the source of make-up water. Since Hat Creek water may constitute more than 50 percent of the Bonaparte River flow the presence of Thompson or Fraser river water would result in noticeable softening of the Bonaparte River supply on occasions. Although this could be interpreted as an improvement in the water quality of the Bonaparte River, subtle but practical difficulties may arise: e.g. in household detergent requirements (excess foaming); variations in drinking water taste in the township of Cache Creek, which is licensed to use 700,000 gpd from the river. The 18 licensees on the Bonaparte River downstream of Cache Creek would probably be less affected by a softening of Hat Creek water than by variations in the sewage discharged from the town.

Negligible changes may be expected in Thompson River water quality if Hat Creek flow is supplemented by Thompson or Fraser river water. However, it is environmentally unsound to mix water from separate river systems, as would occur if Fraser River water was used in Hat Creek, since this could cause disorientation of returning salmon stocks. If this course of action is contemplated, further study would be necessary in order to predict the consequences of such action.

Of the 25,000 Igpm required by the proposed plant, some 16,000 Igpm would require treatment to reduce suspended sediment levels. If water from the Fraser River was used, a new problem could be created in disposing of waste suspended sediments. During freshet, suspended solids have reached levels of 478 ppm. Assuming the removal of only 150 ppm suspended solids for two months annually, 2162 tons of waste would require disposal and additional stabilization to ensure that it did not re-enter water courses. This problem might be overcome by siting the water treatment plant at the Fraser River and reinjecting the solids into the river.

Regardless of the plan proposed for Hat Creek, water quality could only remain unimpaired if drainage from exposed aquifers, mine leachates, oil, sewage, water treatment (fly ash slurry system if used) and boiler blowdown wastes, etc. is prevented from entering Hat Creek. Provisions for collection, storage and eventual disposal of these wastes should be made and a monitoring program instituted to ensure maintenance of water quality standards. In addition to the stations sampled by the Pollution Control Branch, frequent baseline analytical data would be required for the following sites:

Hat Creek above and immediately below the mine complex.
Bonaparte River above and below the junction with Hat Creek.
Thompson River above and below its confluence with the Bonaparte River.
Thompson River at proposed intake point.
Fraser River at proposed intake point.

The sampling schedule should coincide with that used by the Pollution Control Branch. Analyses should include pH, temperature, dissolved oxygen, hardness, suspended and dissolved solids, specific conductance, turbidity, Kjeldahl nitrogen, phosphate, total organic carbon (TOC), chloride, sulfate, chromium, iron, zinc, copper and lead. Major constituents in proposed additives to be used in mining or power station operation should also be determined.

(d) REMEDIAL ACTION AND RECOMMENDATIONS FOR FURTHER STUDY

WATER SUPPLY FOR PLANT

Several conditions of pumping demand, fish hazard and river discharge should be considered and a preliminary water intake design advanced for consideration by the regulatory agencies, keeping in mind the recommendations outlined below.

PRESENT WATER USE IN THE VALLEY

It appears that the water demands of the proposed plant would not conflict with future irrigation needs, and it is possible that use of agricultural lands for industry would increase the water supply for the remaining users. There would probably be a conflict in physical layout between the industrial/agricultural supply systems, and the fisheries requirement. A proposal to satisfy all interests should therefore be discussed and developed at an early stage. This is particularly true considering the need for reservoirs upstream of the relocation to store water for use during periods of peak power demand and for debris removal. A large and safe storage system upstream would allow construction of the most economical diversion works, provide a source for irrigation, and would moderate flows for the benefit of downstream fishery.

HAT CREEK RELOCATION

In preliminary consideration, an alternative involving relocation via tunnel and compensation of productivity, aesthetics and fishery, appears to have the greatest appeal. Although compensation is suggested for a site immediately downstream of the plant, (as is reasonable considering that this location would balance opportunity removed at this point) much greater returns in the form of productivity and angling success might be obtained if compensation were made at a lake site which presently lacked a suitable water supply for spawning. Lakes in the Cariboo Region, although highly productive, suffer from lack of salmonid spawning water. It may not be the best logic to provide more in a drainage basin which already has a surplus, but has no lake rearing capability. A discussion of this with the fish regulatory/management agencies would be productive. For rough guidance it could be considered that stream bottom loss in the diversion would be approximately 300,000 square feet and that cost of replacement (without flow control and to natural stream bottom gravel conditions) might be $1 per square foot. If the Hat Creek project proceeds, early discussions with the fisheries agencies as to their views on compensation would be desirable.

RIVER INTAKE STUDY

Determine the preferred location and related costs from an engineering standpoint; also determine second and third choice alternatives.

Establish the downstream migration patterns of fry/juveniles in the area of the preferred and alternative locations, and how migrations vary diurnally, seasonally, and with changes in water extraction, discharge and turbidity in these areas.

Determine whether intake and water withdrawal would introduce a migration hazard (e.g. disorientation of individuals or a haven for predators), or whether the intake could be designed to act as a haven for fry/juveniles. (e.g. as with the pulp mill intake at Campbell River)

Establish the advantages and disadvantages of lagoon, bay, shore, or pier arrangement of intake with respect to fry/smolt/adult upstreaming and carcass hazards.

Determine whether a rapid increase in the rate of water extraction would require additional screening area, or a switch to travelling screens, and re-check the practicalities of the screening criteria advanced by fisheries agencies.

Determine the applicability of experience obtained at Lornex Mines' intake on the Thompson River.

STUDIES RELATED TO PRESENT CONSUMPTIVE USE IN HAT CREEK VALLEY AND EFFECT ON FISH/FISHERY

Determine the present minimum, average and maximum use of water in the valley for irrigation purposes, domestic purposes, and stockwatering purposes. What normal increase is forecast? Do these uses presently affect fish, habitat and fishery? Would increased usage affect them proportionately?

Establish the present plans for improving storage and distribution systems. Will these affect fish/habitat/fishery in average, low, or high years of precipitation?

Outline agricultural practices and water demand change with development (i.e. market gardens, hobby farms) and whether this would affect water use.

Relate the population increase forecast for development to domestic water supply withdrawals, in part from Hat Creek, and the effect on fish/fishery.

Determine whether there is risk of related industrial/domestic pollution negating efforts made to maintain minimum flows.

Establish whether a reservoir would be required for cooling water, whether it could be integrated with other impoundments required by industrial/domestic systems, and how much valley/stream area would be occupied. Also, establish whether the physical limnology of the proposed reservoir would support survival of rainbow trout or other species.

Examine whether future agricultural/domestic/recreational reservoir usages could co-exist.

Investigate opportunities that may exist for compensation of fish/fishery/waterfowl resources within proposed plans for irrigation development.

Establish a range of options for compensation lying outside Hat Creek Valley, their feasibilities, productivities (species numbers and in the creel) and costs.

STUDIES RELATED TO DEVELOPMENT OF UPPER HAT CREEK VALLEY AND EFFECTS ON FISH AND FISHERY

Determine the cost and feasibility of multiple relocation of Hat Creek. Could water quality be maintained? How long would it take a food web to establish in a new channel? How much gravel would be required and what would be an ideal configuration? Would a reservoir and intake be necessary with this scheme?

Examine possible use of the pit as a future lake after completion of the mining operation. Would it support a fishery?

Delineate the significant/critical/marginal spawning and rearing habitats and the costs of protecting them if flood plains were occupied by industrial/domestic development.

What critical fish habitat/fishery/waterfowl areas could be prejudiced by future road and rail routing? What extra costs would be involved in relocation for protection? Could more economical protection be provided, particularly if the aesthetics of the fishery were degraded?

ACID MINE DRAINAGE

Samples examined indicate a remote possibility that acid mine drainage would result during exploitation of the Hat Creek coal deposit. Material with a very low acid consuming ability should not be mixed with any sulphur-bearing waste. Further investigation to identify potential acid-producing materials in relation to disposal practice is recommended.

(e) REFERENCES

1. Durfor, C.N. and Becker, E., Public Water Supplies of the 100 Largest Cities in the United States, U.S. Geological Survey Water Supply Paper 1812. 364pp. 1962.
2. Water Quality Criteria, Environmental Protection Agency, Washington, D.C. EPA-R3-73-033. 594pp. 1973.

B. OTHER SITES

1. ATMOSPHERIC ENVIRONMENT

This study has considered eleven potential sites where a power plant might be located. These sites were described in Part III, Section B. This section amplifies the atmospheric environment considerations of the potential sites.

The preceding section of this Part (V, A.) discussed the problems of the atmospheric dispersion of pollutants when locating a power plant in Upper Hat Creek Valley. It was shown that three meteorological conditions could potentially result in a high ground level concentration of pollutants. These were:

(i) a deep ground based nocturnal inversion with subsequent morning circulation and fumigation such as occurred at Trail,

(ii) a stable layer aloft into which the plume penetrates and is trapped, with possible impingement against mountain flanks. (This impingement phenomenon could also possibly occur with condition (i)),

(iii) a persistent elevated inversion layer which forms a lid over a valley under which the pollutants are trapped and hence accumulate at a rate proportional to the volume of the valley. This mixing volume will be a function of the size of the valley and the height of the inversion lid.

TABLE 5-10
AIR POLLUTION POTENTIAL OF ALTERNATIVE SITES

SITE	IMPINGEMENT SEVERITY (0-10)	FUMIGATION SEVERITY (0-10)	LIMITED MIXING VOLUME (cu. ft.)	*5 HOUR SO_2 CONCENTRATION-(ppm)
1. Upper Hat Creek Valley — north end	5	1	2.1×10^{12}	0.5
2. Upper Hat Creek Valley — center	5	2	2.7×10^{12}	0.4
3. Upper Hat Creek Valley — south end	4	2	3.0×10^{12}	0.3
4. Harry Lake	2	0	open to north and east	—
5. Trachyte Hills	2	0	open to north and east	—
6. Fraser Canyon	10	10	9.0×10^{11}	1.0
7. Lytton	10	10	9.8×10^{11}	1.0
8. Big Bar	8	4	Open to Interior Plateau	—
9. South Ashcroft	9	8	2.1×10^{12}	0.5
10. Lillooet	10	10	4.8×10^{11}	2.0
11. Lower Mainland	0	1	open	(see text)

* Concentrations based on an SO_2 emission of 550 lb/min into the limited mixing volume shown above.

As discussed previously, reliable dispersion estimates cannot be made unless a large amount of reliable meterological information is available. Hence site comparisons can be done only on the basis of topographical considerations. Mixing volume is arbitrarily based upon an inversion lid located 2000 feet above the plant site in question. Potential impingement severity is ranked on a 0-10 scale depending upon the proximity of high mountains. Possible diurnal fumigation severity is similarly ranked on a 0-10 scale depending upon the depth and drainage potential of the valley and upon its orientation. These factors are tabulated in Table 5-10.

This table shows that the sites located in deep narrow valleys have a high potential for both plume impingement and diurnal fumigation. The limited mixing volumes and attendant SO_2 buildups are rather arbitrary and are shown for purposes of comparison only. It can be seen that the upper altitude sites are the most favourably located with respect to dispersion.

The Lower Mainland site shows a low pollution potential using the three meteorological conditions considered. However, the Lower Mainland situation is complicated by the fact that this area forms an airshed (due to diurnal land-seabreezes) into which large quantities of pollutants are already being discharged. Hence another large source for emissions would tend to aggravate the existing situation as can be realized by examining Table 5-11.

TABLE 5-11
EMISSIONS COMPARISON

POLLUTANT	FORECAST 1979 LOWER MAINLAND EMISSIONS (tons/year)*	POWER PLANT EMISSIONS (tons/year)
Sulphur dioxide	19,117	142,560
Nitrogen oxides	56,538	54,000
Particulates	57,924	20,220
Carbon Monoxide	481,543	—
Hydrocarbons	58,350	—
Miscellaneous	7,324	

* Lynch, A.J. *et al.*, "An Analysis of Air Pollution in the Lower Mainland — Present and Future", Chemistry Laboratory, Water Resources, Dept. of Lands, Forests, and Water Resources, 3650 Wesbrook Crescent, Vancouver, B.C., Canada, May 1974.

2. GROUNDWATER

The siting of the power plant would cause little disturbance to the groundwater of the area in which it is located. However, the existing groundwater regime would require baseline study to establish the background against which future situations could be compared.

3. HYDROLOGY

The water requirements of the proposed power plant are governed in part by the location selected since at certain locations a once-through cooling system may be feasible. Of the potential sites examined in this study only a Lower Mainland site (and probably only one located on tidewater) would be amenable to a once-through system. All the Interior sites would require either Thompson or Fraser river water and the screening requirement to keep salmon smolt and fry out of the large volumes required for once-through cooling is beyond current technology. The additional problem of excessive water temperature rise during periods of low river flow also makes once-through systems impractical on the Interior rivers.

The water requirement of the plant will not change significantly regardless of its location and, at all Interior sites being considered, only the Thompson and Fraser rivers can be considered as potential sources. Thus, the considerations discussed with regard to sites in Upper Hat Creek Valley apply with the provision that the water from one river system should not be introduced into that of another river system above their natural confluence.

If the Lower Mainland site is selected a wider variety of water sources becomes available to meet the water demands of the proposed plant and the effects of using these waters for cooling would have to be investigated in detail.

4. WATER QUALITY

The water quality data cited with regard to Upper Hat Creek Valley sites is applicable to all other Interior sites. If the power plant were to be located outside Upper Hat Creek Valley the projected improvement in the quality of Bonaparte River water would not occur. At the other Interior sites the excess water would be returned directly to the source river and, assuming it had not become polluted, would have little downstream effect.

The thermal pollution of water if a once-through cooling system were employed at a Lower Mainland site would have to be considered. Other wastewater would probably fall under the jurisdiction of the Greater Vancouver Sewerage and Drainage District and would have to meet their requirements for discharge.

PART VI

SPECIES AND ECOSYSTEMS

PART VI — SPECIES AND ECOSYSTEMS

A. UPPER HAT CREEK VALLEY SITES

1. VEGETATION

(a) VEGETATION OF UPPER HAT CREEK VALLEY

The vegetation of any area depends upon the interaction of climate, soil, topography and time. In this section an attempt is made to examine the vegetation types of Upper Hat Creek Valley in relation to these important factors.

Upper Hat Creek Valley contains two major vegetation types, a steppe zone lying below the forest and occupying the valley floor, and a dry forest which comprises the lower zones of the montane forest. Both of these major types are characteristically divided into a number of associations and sub-associations on the basis of the dominant plant species. Such associations reflect the climatic conditions of the area as modified by interactions with topography, soil, and development time.

The climate of this general region is cool and continental with an annual precipitation in the valley floors of from 7 to 16 inches. Temperature and precipitation gradients result in pronounced altitudinal zonation of the vegetation. According to Brayshaw [2] the climate is of the Humid Continental (Dfb, Dsa, and Dsb), and Mid-Latitude Steppe (Bsk) types of Koppen's classification.

The vegetation of this general region has been studied by Beil[1], Brayshaw[2], van Ryswyk *et al*[6], Krajina[3], Tisdale and McLean[5], and Tisdale[4], although none of the workers sampled in Upper Hat Creek Valley.

The vegetation types shown in Figure 6-1 and described in Appendix VI-1 are the result of a helicopter survey of Hat Creek Valley during the summer of 1974. The major vegetation types were delimited on aerial photographs and topographic maps, and later transferred for construction of Figure 6-1. Type designations follow the work of Krajina[3], Brayshaw[2] and Beil[1]. This study was not intended as a definitive examination of the vegetation types, but rather a preliminary survey of the area.

(b) VEGETATION ASSOCIATIONS

Upper Hat Creek Valley contains twelve *natural* plant associations because it occupies a transitional area in terms of climate, soil, and topography. None of the vegetation associations in the valley appear to be unique, but are typical for much of the lower Interior of British Columbia. Most of the associations have undergone disturbance in one form or the other, with grazing being the major disruptive factor. The inter-relationships of the various environmental factors and vegetation types are summarized in Figure 6-2 taken from Brayshaw[2].

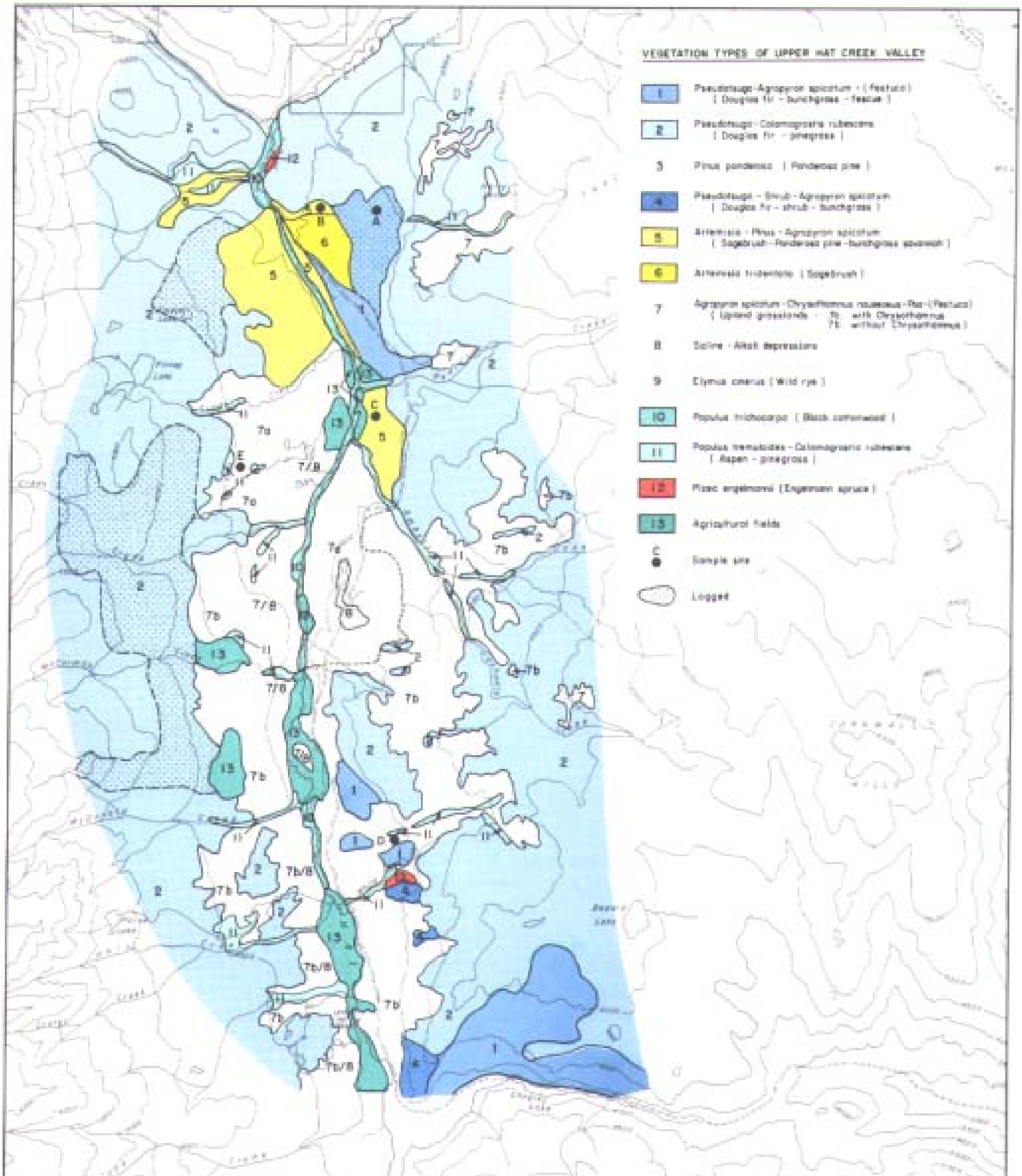
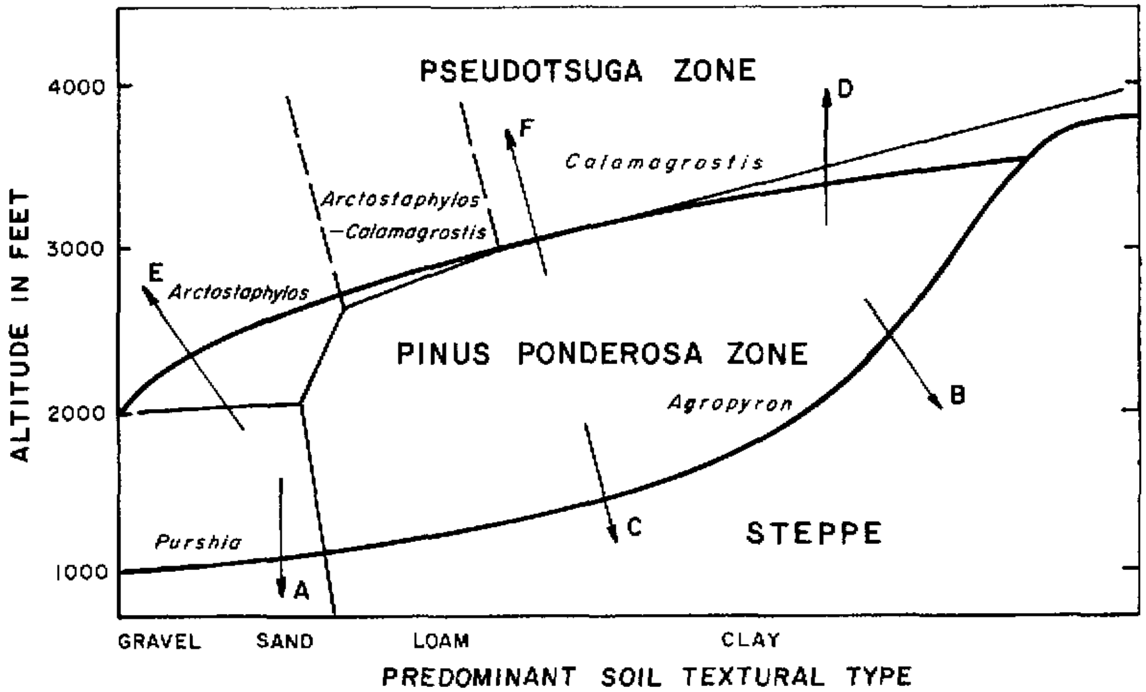


FIGURE 6-1

VEGETATION TYPES UPPER HAT CREEK VALLEY



RELATIONSHIP OF ZONES AND ZONAL ASSOCIATIONS TO ALTITUDE AND PREDOMINANT TEXTURAL CHARACTERISTICS OF THE SOIL; THE DIRECTIONS OF THE ECOLOGICAL IMPACT GRADIENTS AFFECTING GROWTH AND REPRODUCTION OF PONDEROSA PINE ARE SHOWN BY ARROWS, AND IDENTIFIED AS FOLLOWS:

A – INCREASING INCIDENCE OF SOIL SURFACE TEMPERATURES LETHAL TO PINE SEEDLINGS.

B – INCREASING DROUGHT.

C – INCREASING COMPETITION FROM STEPPE VEGETATION.

D – DECREASING HEAT-SUM IN GROWING SEASON.

E – INCREASING AVAILABILITY OF SOIL MOISTURE.

F – INCREASING COMPETITION FROM DOUGLAS FIR AND ITS ASSOCIATES

FROM BRAYSHAW (1970)

FIGURE 6-2

RELATIONSHIP OF VEGETATION TO ALTITUDE AND SOIL

(c) POTENTIAL IMPACTS OF THE PROPOSED PROJECT

The vegetation types affected by the proposed project are summarized in Table 6-1. The most valuable land in Upper Hat Creek Valley is the agricultural fields (type 13) of which 22 acres would be alienated by the proposed project (all by the reservoir). The largest total area of any vegetation type alienated would be 2255 acres of Douglas fir-pinegrass (type 2) of which 548 acres has already been logged. The next greatest loss would be 1165 acres of type 7a (upland grasses with Chrysothamnus) followed by 1070 acres of type 5 (sagebrush-ponderosa pine — bunchgrass savannah). The remaining acreage ranges from 337 acres of type 1 (165 acres of which have already been logged) down to 13 acres of type 12 (Englemann spruce).

Environmental impacts on non-alienated areas could be partially beneficial (favorable climatic alterations) as well as detrimental to the vegetation types and associations in these areas.

TABLE 6-1
VEGETATION TYPES AFFECTED BY PROPOSED HAT CREEK DEVELOPMENT

DEVELOPMENT	Approximate Acres of Vegetation Type No*												TOTAL ACRES
	1	1L**	2	2L**	3	5	6	7a	10	11	12	13	
Ash Disposal	—	—	658	51	—	109	—	—	—	102		—	920
Plant	—	115	381	—	—	58	64	—	19	—	13	—	650
Overburden	—	—	—	—	—	—	—	460	—	—	—	—	460
Waste	—	—	469	397	—	—	—	500	—	64	—	—	1430
Open Pit	102	—	109	—	—	724	70	45	70	—	—	—	1120
Buffer Zone	70	50	90	100	15	167	93	160	—	—	—	—	740
Reservoir	—	—	—	—	—	17	—	—	8	3	—	22	50
TOTAL FOR TYPE	172	165	1707	548	15	1070	1227	1165	97	169	13	22	5370

* See vegetation map Figure 6-1 and Appendix VI-1.
** L — logged.

(d) RECOMMENDATIONS FOR FURTHER STUDY

More data are required before a final assessment can be made of the environmental impact on vegetation in Upper Hat Creek Valley. A detailed vegetation survey should be conducted through a one year period to expand and confirm results of the preliminary study. Timber quantities and potential values should be determined and a vegetation productivity study conducted.

(e) REFERENCES

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2. FISHERIES

(a) PRESENT STATUS OF FISH HABITATS

Hat Creek varies in velocity, flow and bottom substrate along its length (Table 6-2 and Figure 6-3). The upper reaches of Hat Creek meander through farmland, old beaver dams, and willow groves at a much slower velocity than that of the lower creek. The creek varies in width from 5 to 30 feet with a mean width of 20 feet. Bottom substrate consists mainly of a mud-sand mixture with localized areas of coarse gravel and rock. Variations in flow pattern have produced many deep pools and slow moving flats making good fish habitat. Gravel sizes indicate good rainbow trout spawning potential in the upper creek, although these riffle areas are not as numerous as in the lower creek. Aquatic organisms used by fish as food are plentiful. Figure 6-3 illustrates the Hat Creek Profile upstream of the confluence with the Bonaparte River. This figure and the fish habitat descriptions were compiled during surveys of the valley by B.C. Research in the summer of 1974.

TABLE 6-2
DIVISION OF HAT CREEK INTO SIMILAR PHYSIOGRAPHIC UNITS

CREEK *SECTION*	MILES FROM BONAPARTE *RIVER*	LENGTH OF *SECTION*	VALLEY *GRADIENT*	STREAM *GRADIENT*	DRAINAGE AREA (sq. mi.) *SECTION*	*CUM.*	% OF BASIN *SECTION*	*CUM.*
Lower Hat Creek								
Confluence	0 -			½%	2	257	1	100%
Fan	0 - 0.5	0.5		½%	8	255	3	99%
Canyon	0 - 4.5	4.0	1¼%	1%	77	247	30	96%
Chute	3.8 - 4.5	0.7	10%					
Meander	4.5 - 12.0	7.5	1½%		43	170	17	66%
Upper Hat Creek								
Incised	12.0 - 17.3	5.3	2-5		67	127	26	49%
Meander	17.3 - 25.4	8.1	1¼%		50	60	19	23%
Headwater	25.4+		5%		10	10	4	4%

The Provincial Fish and Wildlife Branch, Kamloops, conducted limited fisheries evaluation in the immediate vicinity of the proposed mine site during a July, 1974, survey of the valley. A fish sample from Medicine Creek was obtained by shocking, and 54 trout were enumerated; a good spawning area was noted where the creek passes over the downstream limit of the known coal deposit.

Falls occur on the Bonaparte River approximately two miles above the junction with the Thompson River. Above these falls, to the confluence with Hat Creek, modest populations of rainbow trout up to 14 inches long exist but, because public access is limited by private property bordering the river, the fishery is not greatly exploited.

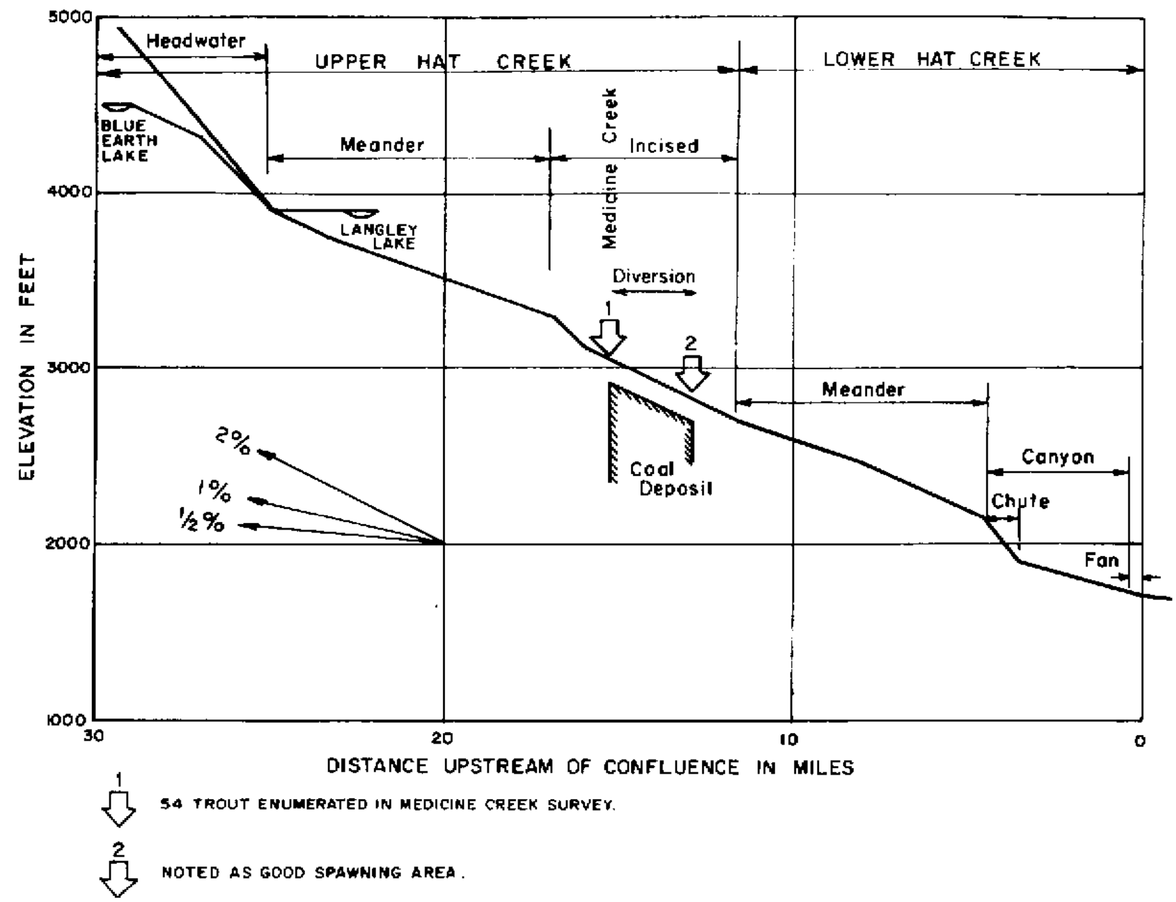

FIGURE 6-3

HAT CREEK PROFILE

Below the falls, to the Thompson River, the lower Bonapart River supports a small but significant salmon population according to the Fisheries Service, Environment Canada. For the years 1962-1971, the mean numbers of spring salmon, coho salmon, and pink salmon have been 31, 35, and 1510, respectively. Spawning occurs between August 20 and November 30. Rainbow trout and steelhead also occur in the lower river in unknown numbers. The Thompson River supports an extremely important pink salmon spawning population, averaging 250,000 fish for the last five odd-year cycles.* Below the Bonaparte River confluence (Mile 24) the distribution of this population is as follows:

Mile 0 to Mile 11	17,500 fish (7%)
Mile 11 to Mile 18	30,000 fish (12%)
Mile 18 to Mile 24	7,500 fish (3%)
Total	55,000 fish (22%)

(Mile 0 is confluence of Thompson and Fraser rivers)

Resident rainbow trout and migrant steelhead trout form the important part of the Thompson River sports fishery.

* Pink salmon have a larger spawning population in odd-numbered years and a smaller population in even-numbered years.

(b) POSSIBLE IMPACTS ON FISHERIES

The proposed development could affect the Hat Creek fishery in two primary ways: discharge of unfavourable substances; and creek modification. In the first case potentially deleterious substances would be introduced from dust, leachate and runoff from overburden, waste, and coal materials.

A fish bioassay was conducted using Hat Creek coal composite and bedrock composite from drill cores. The results, which are shown in Table 6-3, indicate that juvenile coho salmon can survive a "worst case" concentration of 10 percent (weight to volume) Hat Creek composite sample coal, but that bedrock in the same concentration is sufficiently alkaline (pH 9.1) to kill in less than 24 hours.

Proposed creek modifications include rerouting the stream around the pit site and construction of a dam above the pit. The impact of these activities would include sediment loading of the steam during construction, creation of barriers to migration, and possible heating of the reservoir.

Should the Thompson or Fraser rivers be used as a source of cooling water, the danger exists of entrainment of fish fry in an intake structure. The Federal Fisheries Service must *approve all intake and pumping structures before installation.*

TABLE 6-3
LIMIT BIOASSAY RESULTS OF HAT CREEK COAL AND BEDROCK

Tests started: October 20, 1974
Test fish: Juvenile coho salmon 10 fish/test solution
Mean fish weight: 0.6 g
Test volume: 6 liters
Test temperature: 11° ± 1°C
Dilution water: Vancouver City dechlorinated tap water
Dissolved oxygen content: > 9 mg/liter
96-hr static bioassay without exchange; pH not adjusted

SAMPLE	TEST CONCENTRATION (% wt/vol)*	pH AFTER STIRRING (mg/l)	TOTAL ORGANIC CARBON	SPECIFIC CONDUCTANCE (µmhos/cm)	% SURVIVAL		
					24 HRS.	48 HRS.	96 HRS.
Hat Creek coal composite from drill cores	10%	5.6	36	210	100	90	90
Hat Creek bedrock composite from drill cores	10%	9.1	—	155	0	0	0
Control		6.6	—	23	100	100	100

* Samples stirred for 5 min at < 10,000 rpm

(c) RECOMMENDED REMEDIAL ACTIONS AND FURTHER STUDY

Most of the impacts relating to fisheries can be circumvented by choice of alternatives. Apart from regulations of the Canada Fisheries Act which do not permit the discharge of any deleterious substance to waters inhabited by fish, it would be mandatory to ensure that Hat Creek bedrock be isolated to ensure that it never enters a watercourse. Should Hat Creek coal enter a watercourse through accident or mishap, the likelihood of toxicity to fish is remote.

A limited section of the stream would be removed from production by construction of the pit. In order to minimize the impact of the potential development on the fishery, the manner in which the stream would be relocated must be considered carefully, (in terms of timing and construction as related to discharge, and provision for maintaining minimum discharge levels of Hat Creek below the diversion).

Further studies, including test-work, surveys and inventories (data collection) are required and should include thorough investigations of existing water intake structures on the Thompson River in relation to fish migrations.

3. WILDLIFE

(a) WILDLIFE IN UPPER HAT CREEK VALLEY

In August, 1974, the Provincial Fish and Wildlife Branch, Kamloops, conducted a survey of wildlife in 12 sections of land held as coal licenses by B.C. Hydro in Upper Hat Creek Valley. They found the valley within the coal license area to be a Class 4 area, "moderate limitations to the production of ungulates" by Canada Land Inventory standards. Habitat limitations appear to be a result of deep snowpack, lack of cover, and overgrazing by domestic cattle. A small area of "important winter range" (Class 3W) exists on the western side of the valley. Although both deer and moose are present, neither species is abundant. Deer are more numerous on the western side of the valley (probably 20-30 animals), using this area primarily as wintering habitat. There are probably only 2-3 deer on the east side of the valley. Moose signs in the valley indicate only occasional use by probably less than 15 animals, with their primary habitat occurring near Finney Lake in the western half of the license area.

The potential site for the No. 1 open pit (1120 acres) would remove 780 acres (all acreages are approximate) of Class 4 (moderate) deer-moose habitat limited by snow depth and 340 acres of Class 3W (important winter range) moose-deer range limited by snow depth. The potential buffer zone would remove 500 acres of Class 4 and 240 acres of Class 3W habitat with the same capability and limitations as the pit area.

The waste dump site (1430 acres) would utilize 900 acres of Class 4 deer-moose habitat and 400 acres of Class 3W moose-deer habitat both limited by snow depth. About 590 acres of Class 4 habitat limited by exposure and moisture would be alienated by the waste dump (130 acres) and the overburden stockpile (460 acres).

The plant site would alienate 460 acres of Class 4 deer-moose habitat limited by snow depth, and 190 acres of Class 3W moose-deer habitat limited by snow depth, whereas the ash dump would utilize 650 and 270 acres of these two habitat types respectively. The potential reservoir would alienate 50 acres of Class 4 habitat limited by exposure and moisture.

Wetlands important to waterfowl production (Class 3, Canada Land Inventory) are located mainly in the southern region of the coal license area from the confluence of Finney Creek with Hat Creek south through a region of small lakes. Less important areas for waterfowl production (Class 4) are located near Finney and Aleece lakes. Primary limitations in the valley are reduced marsh edge, lack of adequate cover vegetation, and alkaline water. Ducks sighted were mallards, green winged teals, goldeneyes, buffleheads, and widgeons. Most of the broods observed were in areas with tall vegetative cover and were on wetlands of at least one acre in area. Approximately half of the 119 wetlands observed in the area are smaller than one acre.

The CLI *Waterfowl Capability* maps for Upper Hat Creek Valley indicate that the majority of the alienated land is Class 7 (almost no waterfowl production) limited by adverse topography. The remaining lands, about 1122 acres of the 5370 acres involved, are Class 3 (slight limitations to the production of waterfowl) limited by reduced marsh edge and adverse soil and water characteristics. This acreage is made up of 12 acres on the potential pit site, 100 acres in the buffer zone, 550 acres on the waste dump site and 460 acres (the entire area) of the overburden site.

Little information exists on the value of Upper Hat Creek Valley for maintaining populations of smaller mammals and birds. Further field studies are necessary to determine habitat values and species composition. Thus, the impact of habitat removal on upland game birds, raptors, song birds and small mammals is not known at this time, but should be studied.

(b) POTENTIAL IMPACTS OF THE PROPOSED PROJECT

Possible impacts of a mine-thermal plant operation on wildlife include topographic change (open pit, waste dumps, ancillary road and access construction) which might prevent animal movement, alter migration patterns, increase vulnerability to road traffic and isolate suitable habitat through use-avoidance. Since this type of impact would occur progressively throughout the life of the proposed project and detailed information on daily, seasonal and annual movement of animals is not currently available, further study is necessary.

The single most important impact of industrial development on animals is habitat removal, particularly that in short supply such as wetlands in a relatively dry area, and winter range upon which the survival of ungulate populations depends.

For waterfowl, the impact of the project would be minimal since about 4248 of the 5370 acres which might be used by development are unsuited for waterfowl habitat because of adverse topography. It is conceivable that a beneficial impact to waterfowl may derive from the 50 acre reservoir resulting from the damming of Hat Creek if stability of water level, proper edge vegetation and little disturbance can be ensured.

Physical pollutants are a factor having impact on wildlife. Dust can be created by industrial activity to be redistributed on vegetation used for forage, and particulates allowed to escape from a thermal plant might have a similar effect. Both of these factors are undesirable and rigid controls would be required.

There is some question as to whether industrial noise, as a physical pollutant, has a deleterious effect on ungulates. Experience with logging operations indicates that deer continue to occupy suitable habitat adjacent to noisy woods operations. Coal mining activity noise in the East Kootenay has not resulted in the large scale abandonment by elk of suitable habitat. On the contrary, in some areas the increase in elk browsing has become a serious problem in the establishment of reclamation plantings. The effect of noise on Hat Creek ungulates may require study should the project proceed.

The impact of chemical pollution can be combined with that of physical pollutants. Toxic elements associated with the mine-thermal plant operations are subject to pertinent legislation regarding discharge.

The influx of large numbers of personnel associated with the project would likely carry with it an increased population of hunters. This in turn could produce a heavier hunting pressure on local game populations. However, in terms of animal protection, the necessary restrictions on discharge of firearms around an industrial activity could conserve those populations using habitat within the "no-shooting" zone.

(c) RECOMMENDED REMEDIAL ACTIONS AND FURTHER STUDY

Should the project proceed, topographic changes related to mining, the thermal plant, their associated wastes and construction will be unavoidable. Detailed future studies are required to delineate wildlife populations and movements in order to avoid the impacts described in the preceding section. It should be stressed that impacts may not be serious or detectable during the early years since waste placement would occur progressively over the proposed 35 year life of the operation. Final configuration and reclamation of waste disposal areas should be planned to provide no barriers to wildlife. The possibility of establishing wetlands on waste areas should be investigated.

The final openpit would represent a major, permanent topographic change. Fencing might be necessary to avoid hazard to wildlife, domestic animals, and humans.

Habitat removal by the proposed operation would also be unavoidable. Detailed ecological surveys are required to provide a firm base for the degree of mitigation and the selection of the areas most suitable. Reclamation research for the specific area components is mandatory to guide final land use goals.

The Fish and Wildlife Branch, Kamloops, states with regard to waterfowl habitat protection:

> "If openpit mining adversely affects waterfowl wetlands and their water supplies, the best compensation is to sustain and improve other areas so as to retain an equivalent nesting population. The limitations of the present wetlands are: 1. lack of shoreline nesting cover; 2. lack of edge; 3. low water conditions; and 4. adverse water chemistry. To improve other sites, a program would have to consider: 1. eliminating domestic cattle grazing near the wetlands by fencing; 2. planting additional shoreline cover; 3. increasing edge either by creation of new wetlands, or edge-increasing earthwork such as island construction; and 4. maintaining and improving ditch systems to maintain water levels and to ameliorate adverse water chemistry."
>
> "Such a program could be implemented either on the coal license or by acquiring control of wetland areas further up Hat Creek. The amount of nesting habitat compensation needed can either be calculated from capabilities or from breeding pair counts."

A study of seasonal changes in wetlands areas and the extent of use is recommended.

Surveys of small mammals, raptors and songbirds should be undertaken to provide information on values of interest to non-consumptive users of wildlife. Small mammal population data would be required to determine what roles they might have in relation to success of revegetation and reclamation.

Discharge of physical and chemical pollutants such as dusts, particulates and stack gases should be rigidly controlled. Baseline data prior to the proposed development should be collected to provide a solid base for measuring the change and the need for special control.

Although hunting pressure would increase with increasing population associated with the project, some mitigation could be provided by the shelter offered to animals using the no-shooting habitat surrounding the project.

4. MAN

(a) ARCHAEOLOGICAL AND HISTORIC VALUES

The Provincial Archaeologist advises that although there are few known archaeological sites related to ancient Indian history in Upper Hat Creek Valley, the potential for numerous sites exists. Thus, virtually every activity associated with disturbance of surface materials has the potential for damage or destruction of unidentified archaeological values. Alternatively, with care, ancient history values may be revealed and recovered through construction activity.

B.C. Hydro should, through the Provincial Archaeologist, initiate studies to identify archaeological values in Upper Hat Creek Valley, particularly in those areas which would be disturbed by the proposed mine and plant operations.

(b) OUTDOOR RECREATION

The Canada Land Inventory rates most of the recreation potential of the proposed mine and plant area of Upper Hat Creek Valley as moderately low (Class 5) to moderate (Class 4) capability featuring uplands (modified by significant vegetation), topographic patterns, upland and wetland wildlife, significant small surface waters, rock forms, viewing, and cultural landscape.

Present recreational use of the environs of the proposed mine and Site 1 area include fishing and upland bird, waterfowl and ungulate hunting in season. Data on intensity of use are not currently available.

Because of the marked contrast in land use between the proposed industrial operation and the current relatively remote natural surroundings, the impact on recreation potential could be considerably greater than area-calculation from CLI mapping would suggest. In the areas which would be utilized by the proposed mine, plant, and associated activities the possibility exists that the area and quality of the recreation classification "cultural landscape" (or viewing mine-plant activities) could be improved. Considerable visitor interest appears to have been generated by new mining activities throughout the province in recent years. It seems likely that the proposed Hat Creek development would be no different.

The experience of mine operators in the Highland Valley shows increasing public interest in viewing mine-mill operations even though the journey from Highway 1 exceeds 25 miles. Since the same type of interest likely would be displayed toward the Hat Creek project, B.C. Hydro should initiate a co-ordinated study involving the establishment of view sites and mineplant tours for both the public and educational institutions. Involvement of specialists in the Provincial Parks Branch would provide good advice as would studies of similar operations at the Highland Valley mines and the experience B.C. Hydro gained with the Peace and Columbia River Projects.

Utilization of the fish and wildlife resources would be reduced not only through habitat removal but through reduced access and the likelihood that firearms discharge restrictions would be established as a personnel safety measure for distances up to three miles surrounding the mine and plant. Further studies based on future investigations on fish and wildlife utilization should provide guidance for mitigation for both consumptive and non-consumptive users of the Hat Creek area.

B. OTHER SITES

The vegetation of Sites 2-10 is similar to that described in detail for the No. 1 Openpit and Site 1 area, and thus the impacts will be similar. The vegetation in the Lower Mainland area is quite different and a detailed study would be required if a Lower Mainland site were selected.

The impact of the proposed power plant on fisheries is primarily through its effect on the source of the cooling and make-up water. Regardless of the site chosen in the Interior, the Thompson and Fraser rivers are the only potential sources of water and thus the data for Upper Hat Creek Valley sites would apply. The selection of a Lower Mainland site would require a detailed examination of the effects on the local fishery. On the Lower Mainland both the fresh and marine environments would be affected.

The effect on wildlife of siting the proposed power plant at Sites 6-11 has not been evaluated, but many of the factors listed in Part A would apply. A no-hunting reserve around the plant would provide a sanctuary for animals inhabiting the area. Specific siting of the plant should avoid alienating a major portion of the winter range in any particular area.

The existing industrial and population density of the Lower Mainland suggests that the influence of the proposed project on the wildlife of the area would be minimal.

The potential power plant would not have the "viewing potential" of the mining operation and thus it is less likely to become a tourist attraction regardless of where it is sited.

PART VII

SOCIAL AND ECONOMIC CONSIDERATIONS

PART VII — SOCIAL AND ECONOMIC CONSIDERATIONS

A. UPPER HAT CREEK VALLEY SITES

1. THE AREA AND ITS COMMUNITIES

The establishment of the proposed coal mine and thermal generating station at Upper Hat Creek (Sites 1-5), would principally affect the local area and its urban and rural populations. The people most involved would be those living in and about the towns of Cache Creek, Ashcroft, Clinton and Lillooet, and the residents of the Indian reserves, ranches and farms in Hat Creek Valley. Effects on people as far removed as Spences Bridge, Logan Lake, Kamloops and 100-Mile House would likely be minimal.

Road distances from Site 1 to the principal communities of interest and their populations are as follows:

	ROAD MILEAGE	APPROX. RECENT POPULATION
Cache Creek	19	1,200
Ashcroft	24	2,500
Clinton	30	800
Lillooet	38	1,500
Kamloops	68	55,000
Vancouver	235	1,135,000 (metro)

Not only are the towns in the area limited in number and small in size, but the rural and Indian reserve populations are also of low density. The total population of the 2500 square miles of Electoral Area 1, excluding the communities of Lytton, Ashcroft, and Cache Creek, was 1344 in 1971.

There are a number of Indian bands and reservations in the area (Fig. 7-1), as follows:

BAND	POPULATION AND WORK FORCE
Bonaparte	A 1973 survey showed 181 members (38 families) living on reserve lands, out of a Band membership of 343. Male employable members ages 17-65 on the reserves were 43. Six families lived on Upper Hat Creek I.R. #1, seven on Lower Hat Creek #2, and the rest lived on #3.
Oregon Jack Creek	Total band population was 16, of whom 11 lived on the reserve. Three were in the employable age group.

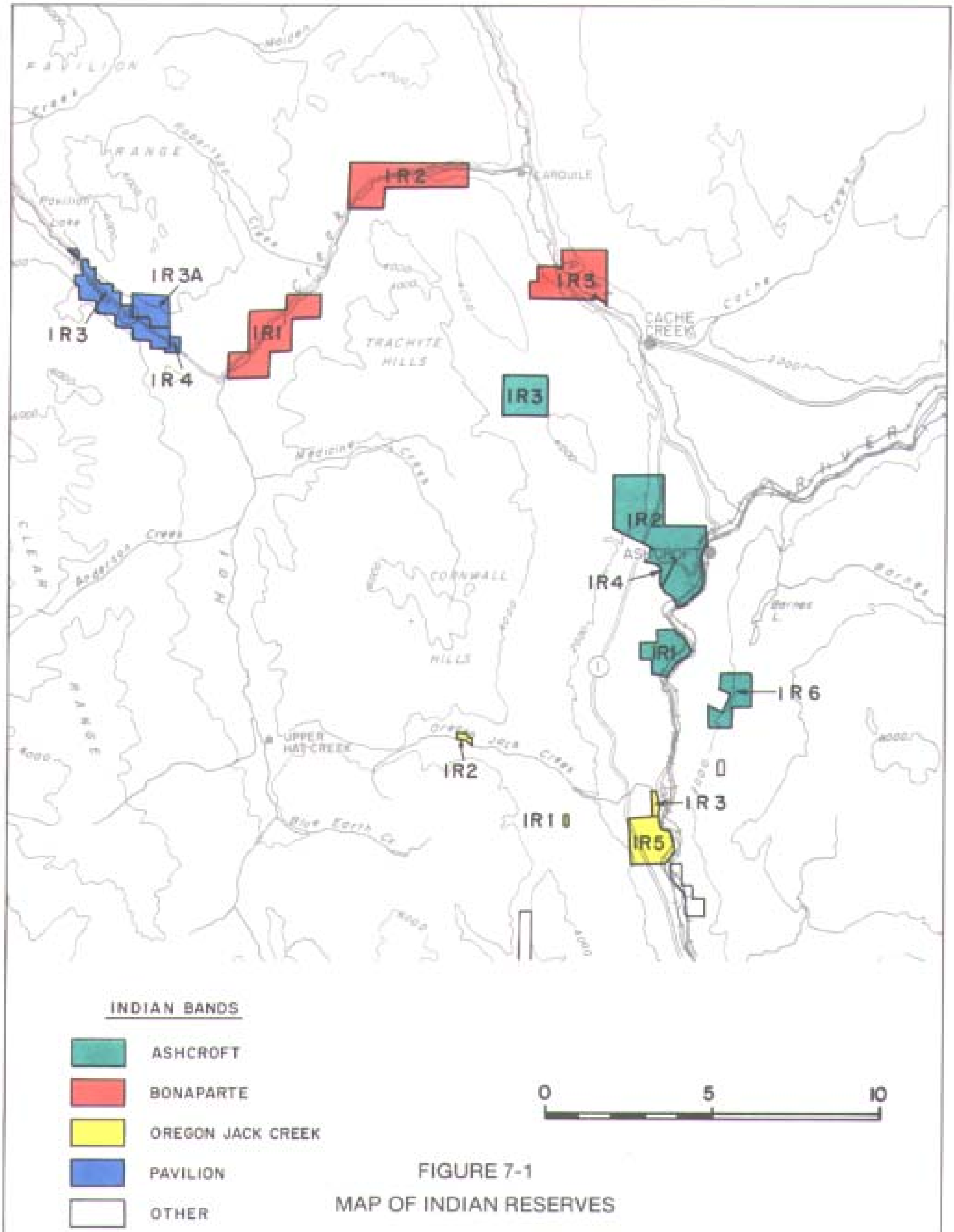

FIGURE 7-1
MAP OF INDIAN RESERVES

Ashcroft	About half of the 81 band members lived on Ashcroft I.R. #4, with 11 being in the male employable category. The McLean Lake Reserve #3 (500 acres) is used for cattle grazing; no band members live there.
Pavillion	Total band population was 184, including 32 employable males. There were 125 members living on the reserve.

If one assumes a commuting range of about 30 miles, some other bands might be the source of a few employees, and of course there is the possibility of members of other bands, or off-reserve members, being interested in moving to the area if opportunities became available.

The Ashcroft-Cache Creek area (excluding Lillooet) has a total labor force of about 2000 at the present time. Bethlehem Copper Corp. Ltd., and Lornex Mining Corp. Ltd. are the largest employers. Transportation and travel-related employment is important. Cache Creek depends primarily upon its position as a major highway intersection and consequently 75 percent of its commercial establishments are motels, restaurants, or service stations. Ranching, and government and other service industries largely complete the picture. It is an area of relatively low unemployment and seems unlikely to be able to supply a very significant percentage of the manpower requirements for the proposed Hat Creek project.

Annual volume of retail trade is reported by "Trade and Commerce" magazine to be of the order of $3 million in Ashcroft and considerably less in Cache Creek. Assessments are about $3 million in each village, and only another $7 million in the whole of Electoral Area 1. The magazine has also estimated the 1973 gross income of the population of Ashcroft to be $11.5 million, and $5.4 million for that of Cache Creek.

Lillooet has in recent years been heavily dependent on the forest industry and the British Columbia Railway for job support, and is currently at a low point in its up and down history. With mining in the area inactive and the forest products industry in recession, unemployment is higher than it has been for some time. It continues to serve as a distribution center for the surrounding ranching country.

Clinton has suffered a declining population over the last decade, but nearby mineral properties and increasing traffic on the Cariboo Highway offer some promise of future economic support.

2. THE WAY OF LIFE WITHOUT THE PROJECT

Ranching, mining, transportation and their related services constitute the principal sources of livelihood in the area. The towns are not large, the countryside (including a number of Indian reserves) is sparsely settled, and traffic is relatively light except for the main highway through Cache Creek. Many of the residents are attracted to the area because they like it the way it is, and the improvements they envision do not necessarily involve growth activities. Others perceive many economic and developmental advantages in greater growth. Occasional industrial developments, or promoted developments, have focussed attention on these points of view before, and no doubt the proposed Hat Creek project will do so again. The ranchers and Indian bands appear to have less reason to embrace the growth ethic than the urban dwellers. For more on their concerns, see discussion in 4 (a) and (b) following.

Without the project, the area would probably continue along the historical pattern. Mining would remain prominent, transportation-related activities would continue to grow

* "B.C. Population Projections 1974-1996", B.C. Research, November 1974.

and ranching would continue without much expansion. A "no-project" population forecast* for School District #30 anticipates a doubling by about the end of the century.

Neither transients nor elderly people are very numerous in the area because of the nature of the supporting economy. The residents, and especially the rural residents, have had minimal exposure to problems of noise, rapid growth or crowding, alteration of air quality, or exposure to numerous strangers. The Indian people are accustomed to hunting and fishing as their needs dictate. Kamloops has pre-empted the position of commercial, distribution, and manufacturing centre, hence the low growth pressure on these sectors in the study area.

Upper Hat Creek Valley might well continue its present ranching status indefinitely. However, the coal deposit has been identified for decades. Even without the proposed power project it could not be stated that development of some kind would not occur. Indeed even if this project were to proceed, additional developments could possibly be established by agencies or companies other than B.C. Hydro. It might be advisable to carry out studies of this potential and its implications, although not necessarily by B.C. Hydro nor as part of the impact assessment of this particular project.

3. POTENTIAL IMPACTS OF THE PROPOSED PROJECT

(a) EMPLOYMENT, INCOME AND POPULATION GROWTH

CONSTRUCTION PHASE

The approximate size of the power plant construction *work force,* and its application to the project over a time period of about 7 years, is given in Part III, B, 3 of this report. The requirement to fill over 900 jobs at mid-construction peak, many of them in quite specialized trades, is clearly beyond the capacity of the labour force of the local region. A recent Canada Manpower estimate places the existing force at about 2000 in the Cache Creek-Ashcroft-Logan Lake area. Most of these people hold jobs at copper mines, transportation companies, retail establishments, and tourism facilities. Unemployment is relatively low. Clearly, most of the required construction workers will have to come from outside the region, and in the case of some trades, partly from outside the province. The Vancouver area will be the source of most of the construction crews.

Although each power plant is an individual case and will differ in detail, such as in union jurisdictions, it is of interest to note the application of various trades to a recent project in the U.S.A.* It is appreciably smaller than the proposed Hat Creek plant; however the make-up of the labour force would be similar. Man-hours applied by trades were about nine million, distributed as follows:

Boilermakers	23%	Operators	7%	Sheet Metal	2%
Pipefitters	17%	Carpenters	5%	Bricklayers	1%
Electricians	13%	Insulators	4%	Teamsters	1%
Ironworkers	10%	Millwrights	3%	Cement masons	1%
Labourers	8%	Painters	3%	Others	2%

Non-manual and non-trade labour accounted for an additional 10-12 percent (about another million hours). The percentages shown are averages for the entire construction phase and as various trades come and go during the progress of the project, the composition and total size of the work force would change within fairly broad limits.

* Source: Portland Electric Co.

In addition to the power plant construction force, there would be what effectively amounted to a *construction phase work force for the mining operation.* In developing the mine, pre-production work involving machinery and building erection, road construction, overburden removal and stockpiling, and coal stockpiling would require a work force averaging about 150. These would be predominantly heavy equipment operators. For example the estimates for year 3 are:

Heavy equipment operators	104
Tradesmen	18
Labourers	8
Supervisory, engineering, clerical	20

While it might appear that anyone in the area wanting work would be able to obtain it, complicating factors would include exclusions deriving from union jurisdictions and hiring practices, re-training for those without required skills, competition by other employers and other projects, and the level of interest displayed by people not now in mining or power plant construction. In fact some required trades are presently in short supply throughout Western Canada and Western U.S.A. because of the pressure of other projects. Some of the workers would have to be attracted from considerable distances beyond British Columbia. This situation would change with time and circumstances and would be re-assessed in more specific detail if a project timetable is approved. The Department of Manpower and other interested federal and provincial agencies have been advised of the possibility of this project proceeding. Appropriate training programs could and should be established as soon as the need for them became more apparent. A labour supply and training requirements study should be conducted forthwith if the project is approved. Experience at other projects (e.g. Alberta Tar Sands) could provide relevant precedents.

A considerable *payroll* would be generated by construction employment. On the basis of an assumed $20,000 per year per man (including overheads) and the proposed timetable, the estimates for construction labour payroll is nearly $90 million, to be paid within British Columbia approximately as follows:

MINE AND POWER PLANT CONSTRUCTION PAYROLL*

YEAR	MINE	PLANT	TOTAL CONST. WORKERS	PAYROLL ($ million)	PAYROLL at +10%/yr ($ million)
1	50	100	150	3.00	3.00
2	190	250	440	8.80	9.68
3	150	475	625	12.50	15.13
4	150	800	950	19.00	25.29
5	150	730	880	17.60	25.76
6	150	650	800	16.00	25.77
7	150	300	450	9.00	15.94
8	150	—	150	3.00	5.85
				88.90	126.42

The final distribution of employment and payroll with time would depend on the ultimate project design and the start-up date, hence these projections must be considered as preliminary and indicative only.

* The average figure of $20,000 per year per worker is used as an illustration, rather than as a forecast of probable rates. The effect of an annual 10 percent increase in wage rates is shown in the last column.

Other provinces and other countries would also benefit from the job and wage component of equipment purchased in those locations. However, except for the final transportation segment, these items would only appear as part of capital investment.

OPERATIONAL PHASE

Upon completion of some of the pre-production mine development during year four (the construction phase), the regular *mine* operating crew would develop over the next four years as follows:

CLASSIFICATION	5	6	7	8
Heavy equipment operators	60	84	129	180
Supervision, engineering, clerical	25	26	27	29
Tradesmen	21	34	45	57
Labourers	12	16	18	20
Total	118	160	219	286
Rounded	120	160	220	290

For the continued mining of approximately 12 million tons of coal annually to supply a 2000 Mw power plant, mine employment would stabilize at a level of nearly 300 men.

Operation of the completed *power plant* would require a staff of about 250 made up as follows:

CLASSIFICATION	% OF STAFF
Supervision	15%
Operation	25%
Maintenance	40%
Labour	7%
Clerical	5%
Coal and Ash Handling	8%
	100%

The finished project would permanently employ about 540 persons. These jobs would develop during years 5-8 approximately as follows:

	5	6	7	8
Coal mine	120	160	220	290
Power Plant	120	180	250	250
Project Total	240	340	470	540

Based on an average $20,000 per worker per year, the direct income generated by these jobs would build up as follows:

YEAR	NO. WORKERS	PAYROLL ($ millions)	PAYROLL at +10%/YR. FROM YEAR 1 ($ millions)
5	240	4.80	7.03
6	340	6.80	10.95
7	470	9.40	16.65
8	540	10.80	21.05
		31.80	55.68

The effect of 10 percent per year increase in pay scale over year 1 is shown in the last column.

A notable difference from the construction force is that permanent workers would be a more typical mixture of family sizes (households might average about 3½ persons) and, with a lower turnover rate, most would effectively integrate into their chosen community.

The effect on the population in the general area would be that while jobs would be much fewer than at the construction peak, there would be a greater percentage of families and a greater number of secondary jobs induced by the permanent primary jobs.

POPULATION

At this time it is anticipated that the population increase in the area, on a permanent basis, would be of the order of 2000 (see Figure 7-2). In effect this would be equivalent to adding a community larger than Cache Creek to the area.

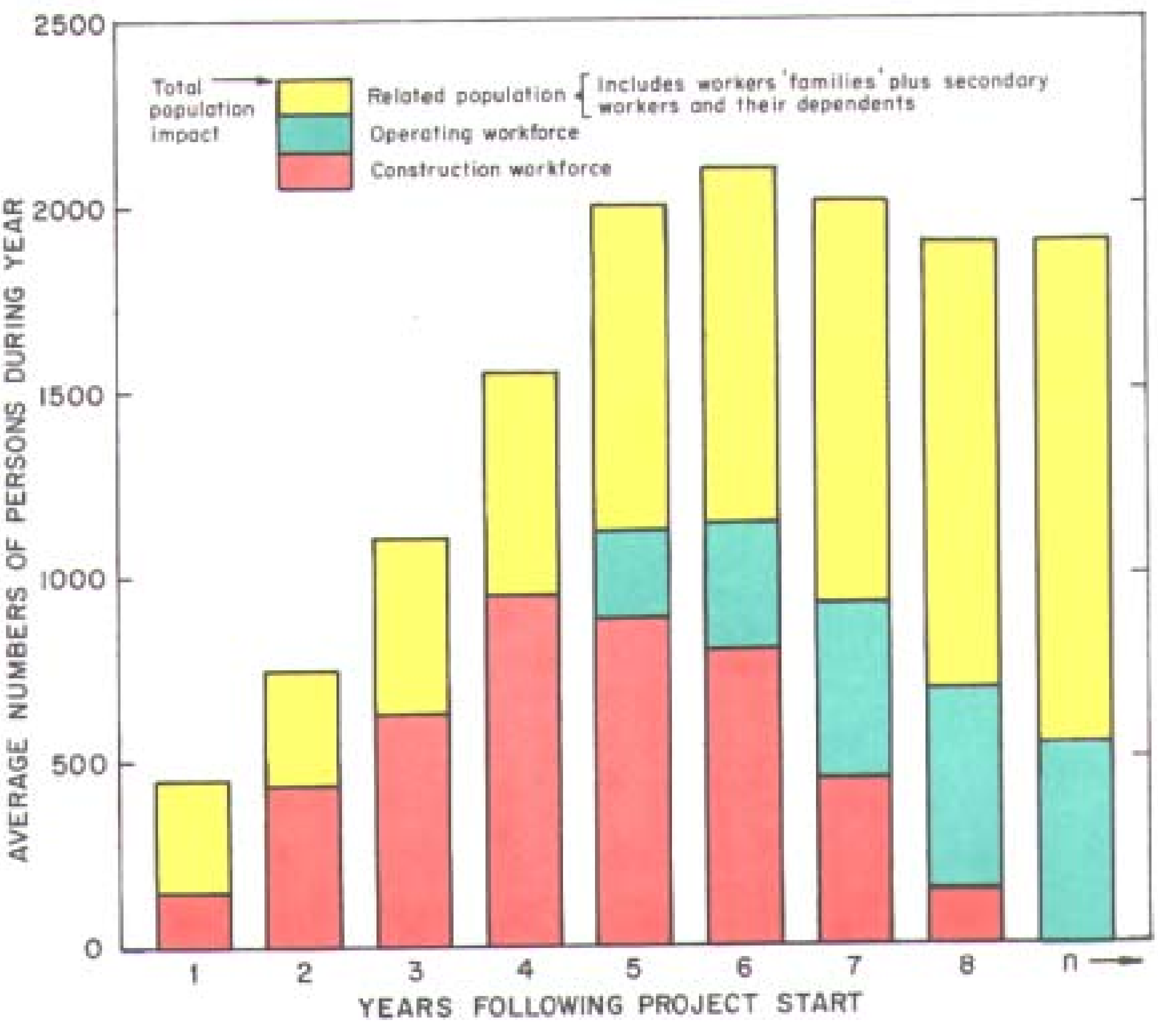

FIGURE 7-2

POTENTIAL POPULATION IMPACT OF PROPOSED HAT CREEK PROJECT ON THE ASHCROFT-LILLOOET-CLINTON AREA

The build-up of the construction work force and associated activities would result in a total population increase of perhaps 700 in addition to a similar number in the construction camp in peak years. Although some of these would come from the general area, most would be additional people. Their distribution would be influenced in part by what was done by various communities to assist or encourage them to take up residence, in part by what was done in project planning (power plant location), in part by what improvements were made to access roads, in part by the economic conditions prevailing at the time and the sources of the work force. Since the construction phase would merge gradually into the operating phase, and since some of the secondary effects would appear earlier in view of the continuing nature of the demand (i.e. a sizeable continuing work force in contrast to a hydro project) the separation of some of the potential impacts into 'construction-related' or 'operation-related' is somewhat uncertain. The preliminary estimate of potential for total population impact is illustrated in Figure 7-2.

(b) PROJECT PURCHASING

A preliminary estimate of powerplant investment is nearly $650 million, of which about half is direct cost of material and equipment. Of these material costs, nearly $42 million (about 13 percent) would probably be bought in British Columbia. Nearly $144 million (44 percent) would be expected to be bought in Canada outside of British Columbia, and a further $140 million could be spent either in Canada or in various other countries depending on availability, delivery, quality or price. Contract and engineering services for the powerplant would be expected to contribute nearly $37 million to the economy of British Columbia.

The mining construction phase, consisting of overburden removal and development of the pit, would continue directly into the operating phase with much the same sort of application of men and equipment. Investment would consist principally of the earth moving equipment previously described (See Part III, A, 2). Although it is not known at this time whether B.C. Hydro would operate the mine, or whether contractors and some equipment now in British Columbia would be employed, the primary equipment expenditure for mining has been estimated to total approximately $20 million.

Although most of these major purchases could not be made in British Columbia because of lack of local manufacturers, there would be a continuing sizeable market created for vehicle repairs, building materials, and miscellaneous merchandise and services which British Columbia businesses would be able to serve. A more detailed estimate of this could be provided as project planning progressed.

(c) TRADE, SERVICES AND SECONDARY EFFECTS

During the construction phase and because the Hat Creek region would not be able to supply a very large portion of the labour force, it is expected that a high proportion of workers would live in construction camps. This would materially affect spending patterns, which would be small relative to that of permanent residents. However, in view of the size of the proposed payroll, a spending level of even 5-10 percent of this payroll locally would inject up to a million dollars per year into a local economy which now only totals a few million dollars. It seems fairly certain that Kamloops, as the nearest city, would receive a greater share than its distance might otherwise indicate. There would probably be a high incidence of short-term travel to Kamloops and Vancouver, especially on weekends. Until plans for recreation, housing and travel service were more advanced it would be overly speculative to try to estimate the extent of this effect.

Residents of the camp (likely to be located in Upper Hat Creek Valley) would have relatively low requirements for food and shelter in the existing communities. However, the camp itself would create markets for bulk sales of fresh food, and create jobs in its kitchen and other operations.

Increased spending and population in the area would result in a considerable number of secondary employment opportunities in the nearby communities. New or expanded businesses and added staff at existing establishments would be required for hotels, restaurants, service stations, hospitals and for the selling of clothing, pharmaceuticals, sporting goods and other materials. Construction materials and supplies would be required. Although a large number of employees would reside in camp, there would still be an increase in school enrolment and an added demand for government, community and municipal services. A good program of mobile home park development and married quarters would give considerable impetus to this factor. In any event, during the construction phase, the employment multiplier would not likely be very large — perhaps one new job would be created for each three or four construction jobs. However, in view of the size of the current economy in the area, this would still be substantial.

If from the present work force of 2000 in the area, one subtracts the Bethlehem and Lornex mine employees and some other primary jobs, the service or secondary workforce is probably not more than 1000. An increase of as few as 250 in this sector would therefore be 25 percent and constitute an appreciable impact.

The effect on the overall economy of British Columbia would be appreciably greater as the secondary spending of workers and their families made its impact felt beyond the vicinity of the project. In total there would likely be a generation of additional jobs equal to that of total construction employment — e.g. about 900. The largest portion of these would be in the Vancouver area. A study currently underway by B.C. Hydro in cooperation with Statistics Canada will facilitate improved calculations of the impact of expenditures on provincial and national income.

As the construction work force was replaced by the operating work force the changes in population characteristics would be reflected in increased local spending and greater demand for the more usual spectrum of goods and services. There would then be many millions of dollars injected into the local economy each year. Opportunities would arise for the establishment of larger and more diverse retail stores and service establishments.

(d) TAX GENERATION

Governments at all three levels would receive revenues from various aspects of the *construction* operations.

Corporate income tax would be generated on the profits of Canadian contractors and equipment manufacturers. Assuming $250 million worth of such business, and 10 percent profit made on it, the Federal tax yield would probably exceed $10 million. Under the federal-provincial collection agreement British Columbia would receive about one quarter of such returns as accrue from participating British Columbia firms. Both figures would be further augmented by the "multiplier effect" (i.e. taxes on profits of other firms who do business with the "first-round" firms — suppliers of materials and services for example).

Personal income tax would be generated by both the direct and indirect employment, both in British Columbia and elsewhere. As a round-number example, if there were $250 million in wages generated in British Columbia in direct and secondary employment, the federal tax collection might be of the order of $50 million, of which British Columbia would receive about $12.5 million. Again this would be augmented federally in other provinces by taxes on the income from the labour component of purchases of goods or services outside British Columbia.

Import duties would derive from some items of foreign equipment, both for mining and for the power plant. There would also be a sizeable yield of both federal and provincial sales taxes. No calculations of them have been made at this stage, but they would likely total several million dollars.

Local taxes would be influenced more by the *permanent* operations, and there would also be a continuing flow of tax revenue to senior governments. There would be property taxes paid on new residences, on new or expanded business premises, and by B.C. Hydro itself either in normal taxes or grants in lieu of taxes. For private property this could amount to several hundred thousand dollars per year.

It is premature to estimate the amount of the B.C. Hydro contribution. Past policy has been that B.C. Hydro pays grants to municipalities and the Province with respect to unorganized areas based on land at normal tax rates, and on buildings and improvements at normal rates, or at 1 percent of gross revenue, depending on the nature of the facility. School taxes are paid at normal rates, but B.C. Hydro has been exempted from the Regional District and Regional Hospital levies.

As with the construction operations, there would be federal income tax generated by the project employees and by the induced businesses and their employees in direct relationship to payroll and business profits. For example, an annual payroll (direct or induced) of $10-20 million could generate income tax of $2-4 million per year, with $0.5-1 million rebated to British Columbia.

The mining of the coal would generate a direct royalty of $5.3 million per year to the British Columbia government, based on the current rate of 44.6 cents per short ton of coal. This would in effect only be a transfer payment to the government, derived through higher electricity rates paid by people and industry than if no royalty were levied. Hence, it is possible that at any future time government policy regarding royalties could change. For example, B.C. Hydro could conceivably be exempted from payment of royalties. On the other hand, the royalties may continue indefinitely and the rate may increase with time. In any event, the royalties paid would be of an illusory nature and would not represent a real net benefit to the people and industries of the province.

(e) HOUSING

Because of recent growth, neither Cache Creek nor Ashcroft have significant numbers of housing units for sale or rent. Several actual and prospective mining or industrial developments in the region in recent years have prompted both villages to have engineering studies made of their expansion potential[1 2 3 4].

Cache Creek has a good water supply system from the Bonaparte River and from wells. It and the secondary treatment sewage system are said to be capable of servicing double the present population without major expansion. A reservoir is planned. Potential subdivisions for several hundred additional homesites have been tentatively outlined as feasible.

Ashcroft has an ample water supply but will soon require a secondary sewage treatment plant. Its provision is currently under study. Some 300 Bethlehem Copper employees have been accommodated in Ashcroft in relatively new houses and apartments under a company-assisted plan. Several hundred acres have been tentatively examined as feasible housing sites for many thousands of potential new residents.

Clinton has a less satisfactory water supply situation, based on Clinton Creek. Nevertheless it has studied the feasibility of supplemental wells to augment the present system[5], has a sewage system and 93 serviced lots and would possibly welcome at least a portion of any additional population the proposed project might bring to the area.

Lillooet is a less likely prospect as a residential center, principally because of the inadequacies of the Lillooet-Pavilion portion of Highway 12. Water and sewer systems are capable of expansion and at least two additional sub-divisions have been considered, should need for them arise (space for 250-300 houses all told). If Site 10 should prove more satisfactory than is now foreseen for the generating station, then a detailed re-evaluation of this situation would be required.

Space for mobile homes is not in very good supply in any of the above communities but could be developed.

The Regional District of Thompson-Nicola has recently extended zoning control over the unorganized areas of the region, and supplies professional planning advice to the communities.

The prime requirement for housing *construction* workers would be a camp (or camps) in the general vicinity of the project to accommodate up to about 700 workers. The adequacy of this camp would be a matter of planning concern to the Regional District and the residents of the area, as well as to B.C. Hydro and its contractors, and various public agencies. Experience with other construction projects suggests that it would be quite impractical not to provide a camp. At least one physically suitable location has already been identified in the side valley to the west of Plant Site 1. It is a pleasant locale, close to but not adjacent to the work, and amenable to conversion to other uses later. Experience elsewhere suggests that it would be desirable to phase out the camp at the end of the construction period. There are always pressures to continue with camps into the operating phase, thus perpetuating the problems associated with temporary housing. The area seems to be adequate for transitional purposes between one use and another. The presence of a camp would substantially reduce commuter traffic from the communities to Upper Hat Creek Valley during the construction period when this problem would be most severe.

In addition to the camp, there would be a demand for a great many other housing units of all types; apartments, condominiums, houses and mobile homes, with the emphasis on rental space. A number of B.C. Hydro and contractor supervisory staff would be located in the area for lengthy periods and would probably want family accommodation. Similarly, many of the longer term project workers and those employed in the induced jobs in trade and service would be seeking family accommodation. Since no significant amount of rental or sale housing now exists in Ashcroft, Clinton, or Cache Creek, a sizeable subdivision (or subdivisions) and mobile home park expansions would be required. It is a matter of concern to all that these developments be integrated into the existing communities in orderly fashion. Fringe development is already occurring along the Cariboo Highway between Cache Creek and Clinton and this could receive unfortunate impetus unless controls are enforced. The Regional District of Thompson-Nicola is aware of the problem, as are the municipalities mentioned, and appropriate zoning precautions are being taken. Because of the extra distance over an inferior road, Lillooet would not be likely to share as much as the other communities in the provision of housing space. It may be, however, that pressures in the project area and the unemployment problem in Lillooet might combine to cause a significant number of workers to commute at least intermittently from there. Indeed, it is a concern of the Lillooet council that they could find their village called upon to provide residential services but not receive their share of tax revenue because of their location in the Regional District of Squamish-Lillooet, whereas the project might all be in Thompson-Nicola. If this were the case, the Provincial Government might have to consider appropriate transfer payments.

No unduly serious physical problems are anticipated in Ashcroft, Cache Creek, or Clinton in providing necessary space for housing units and additional shopping and other facilities. All have studied the possibilities for other reasons and have established the feasibility of sizeable expansion. Ashcroft needs a sewage treatment plant and Clinton appears to have some severe limitations to its water supply at present, though several wells have been drilled, capped, and approved by the Department of Health Services. Cache Creek has a sewer system adequate for four times its present population, and the present water system would serve up to 500 more people, with further expansion already planned. Clinton has sewer capacity for three or four times its present population, and has more than 100 lots ready to develop. Both Ashcroft and Cache Creek have at least a few hundred acres near or adjacent to present subdivisions that are suitable for housing development. Financing the needed expansions would likely be more of a challenge than provision of space for these relatively small communities.

A gauge of the impact of housing units on a village may be seen in Ashcroft. Bethlehem Copper has about 300 employees living in the community in a variety of housing units all of which were built for the purpose. These are for regular operating employees. Thus, provision of suitable permanent housing during the construction period would not be in danger of being wasted, since the units will be required thereafter for permanent operating personnel.

Requirements for housing development in communities near the project would be substantially greater for the *operating* phase than during construction. Both the permanent workers and the jobs induced by them would involve a normal complement of single persons, couples, and families with children. The construction camp would likely be phased out and a demand would arise for a mixture of rental and purchase accommodations of all types; bachelor apartments, larger suites, condominiums, single detached houses and mobile homes.

The experience of the copper mining companies operating in the Highland Valley is of interest in this regard. Bethlehem Copper Corp. first assisted senior staff (about nine) to build houses in Ashcroft, about 27 miles from the mine, with no-interest, rent-payback type financing. At the time of the 1966 mine expansion the company built 16 rental town houses for senior staff, then 40 single men's apartment units in the older part of town (mixed two-room, bachelor, etc.) and 44 apartment units near the town houses (12 bachelor, 4 two-bedroom, 28 two-room). In addition to the rental units there was a program of developing lots at cost with a number of subsidy or mortgage assistance provisions for workers wishing to build their own homes. The 1969-70 subdivision contained 34 lots, and a new 47-lot subdivision was opened in 1974. Of the work force of 375, about 300 are accommodated in Ashcroft, some in housing other than noted above. Other relevant factors included the 1960 closure of lumber operations which made some housing available in Ashcroft, a Company — Department of Highways cooperative program on improvements to the road to the mine, and gasoline purchase assistance to commuters.

Lornex took a different approach and developed the new town of Logan Lake, closer to the mine (about 11 miles distant) but more removed from the main road, rail and bus routes. The company has built 231 housing units for employees on an assisted financing basis, has developed 100 mobile home spaces, is building a new 60-unit apartment block, and still has 200 single men in the original camp adjacent to the mine. Total work force is about 700.

While the proposed Hat Creek development is not precisely comparable to either of these illustrations, the anticipated permanent work force would be greater than Bethlehem's and less than that of Lornex. The extent of the potential housing impact may be gauged, at least in order of magnitude, by these illustrations. Since there is no significant spare housing in these villages at present, nearly all of the additional requirements resulting from the Hat Creek project would have to be newly developed. It should be noted that these illustrations are, except for a few houses in Logan Lake, limited to company-assisted housing for project workers. Additional housing for the induced population would considerably increase the impact. Although it might be difficult to estimate the numbers and locations of needed units until project planning was more advanced, there would clearly be a need for several hundred new housing units within commuting distance of the mine and plant. Planning for necessary subdivisions, apartments, and mobile home parks should be carried out well in advance of the actual time of need.

Further development of existing communities appears preferable, from the community development point of view, over starting a new town. Commuting distances would be much less than for Bethlehem, and there would be many advantages to both the villages and the new residents. These include better development of services and shopping facilities, a more viable tax base to support desirable developments and avoiding the problems and feelings associated by many people with a "Company town".

The provisions of subdivisions, housing units, and mobile home parks could be achieved in an acceptable manner in accordance with good planning principles. The precedents established by mining companies in respect to advancing service costs and subsidizing or financing land and building costs point the way toward relieving small urban areas of some of their development problems. The co-operation of such agencies as Central Mortgage & Housing Corp., the B.C. Dept. of Housing, and the Regional District planning office should be enlisted.

(f) SCHOOLS

The area falls almost entirely (excepting Lillooet) within the boundaries of South Cariboo School District 30, headquartered in Ashcroft. It currently services 2300 students in the Lytton to Clinton area. One senior secondary school in Ashcroft serves the whole area including Hat Creek Valley, with the aid of 16 school buses. Cache Creek has an elementary school and Clinton has an elementary and a junior secondary which could be expanded to grade XII if required. In total there are ten schools in the District. Cariboo College offers a variety of Continuing Education courses, primarily in the evenings, in Clinton, Cache Creek, and Ashcroft.

With a construction-related population increase of 700 or more (plus up to another 700 at the construction camp) leading into an operations-related increase of the order of 2000 (including more than 500 continuing workers), there would be a very substantial increase in requirements for school services. The construction workers in camp would draw less on the services of the schools than families of permanent operating workers.

School age children tend to constitute about one quarter of the population, although this varies by locale, In 1971 School District 30 had a total population of 8130, and an enrolment total of 2374 (down to 2290 in 1974). Gradual declines in the enrolment ratio are anticipated over the province generally. Hence, instead of a levelling out of school enrolment, the area would, with the added effect of the project, experience expansion on a relatively gradual scale. Even after reaching its ultimate impact after eight or nine years the project would be unlikely to cause more than a 20 percent increase in school enrolment over that time, much less severe than the 47 percent enrolment increase that occurred in the five-year period from 1966-1971. Although the increase should be reasonably gradual, some preparation for occasional more sudden increases should be considered. Liaison with project and housing planning would be important.

(g) HOSPITALS AND MEDICAL SERVICES

Ashcroft has a modern (1972) 41-bed hospital, currently only used to about 50 percent capacity and capable of expansion on its present site. There are two physicians in Ashcroft and one in Clinton. Lillooet also has a recently extended and renovated hospital of 34 acute-care, and 3 extended-care beds. There are three resident physicians in the village.

Based on a rule-of-thumb of seven beds per 1000 population, these two hospitals are clearly capable of serving a much larger population should they be required to do so.

The hospital and medical care requirements for the construction force and related additional population might vary a little in the nature of specific services from those presently required; however the demand for services would increase basically in proportion to the increase in overall population in the district. The 75 beds currently available in the modern Ashcroft and Lillooet hospitals appear to be capable of looking after a considerable increase in demand without expanding physical plant. Services of course would have to increase. Since these institutions have fortunately been designed with future demand and expansion in mind, the boards and administrators are likely to find the increased demand related to the project not too difficult to cope with. Financing of increased budgets might require attention, especially in view of the historical exclusion of B.C. Hydro from participation in regional hospital district tax levies. This status regarding tax exemptions is a matter for separate consideration in the context of province-wide policy.

Major disasters or unusual procedures would require the use of hospitals in Kamloops or Vancouver.

(h) TRAFFIC AND TRANSPORTATION

Referring to Figure 2-1 it is evident that the proposed project would be quite centrally located in the Province with respect to road and rail networks. Outside the Lower Coast areas, Cache Creek has one of the highest highway traffic densities in the Province. Only two or three Okanagan points surpass its average summer traffic flow of 11-12,000 vehicles per day on Highway 1. Highway 12 is comparatively lightly travelled with 690 vehicles per day recorded in 1973 near the junction with Highway 97. Ashcroft has the commuting and other traffic to and from Highland Valley but is conveniently separated from the main flow on Highway 1 and Highway 97.

Railway lines in the area are the Canadian Pacific Rail and Canadian National Railways main lines which both pass through Ashcroft, and the British Columbia Railway line through Lillooet, Pavilion, and Clinton. A proposed intertie between these systems may be built via Cache Creek and Clinton, however it is now only at the preliminary feasibility study stage. Transport of coal might utilize such an intertie, but gradients would greatly favor southbound traffic.

There is frequent daily bus service via Highway 1 and Highway 97 to local, regional, and continental destinations.

The nearest scheduled air service is through Kamloops. There are four visual flight rules (VFR) air strips in the area, as follows:

LOCATIONS	LENGTH	ELEVATION	SURFACE
Ashcroft	2800	1100	Dirt
Bar Q Ranch	2780	1700	Dirt
Clinton	3082	3650	Dirt
Lillooet	2400	850	Grass

Source: Air Facilities Map, B.C. Aviation Council

The impacts of the proposed project on traffic in the area would require assessment after a generating plant site and its access routes were finally selected. Clearly there would be extensive commuting traffic and service traffic.

(i) LAW ENFORCEMENT

Policing in the area is carred out by the Royal Canadian Mounted Police, Kamloops Subdivision. Manpower in the Cache Creek-Ashcroft area is presently composed of six staff and two civilians. Over the entire Subdivision it is hoped to increase the present staff ratio of 1:1000 population to 1:750.

At present in the Ashcroft detachment area there are 60 Criminal Code cases per staff member per year, and the ratio of solved crimes to total crimes is 3:4.

Something like a proportionate increase in services would be required to take care of the demand imposed by a larger population.

(j) RECREATION

Although recreation and entertainment opportunities in the area may seem modest compared to those of the larger urban communities, there is already a considerable breadth of activity. For example, a single, randomly chosen ten-page issue of the weekly Ashcroft-Cache Creek Journal referred in news stories or announcements to the following:

South Cariboo Overture Concerts Association
Thompson-Cariboo Minor Hockey League
The Cub-Scout program
The Twin Village Recreation Office and its Director; fitness, creative exercise, group discussion, and art encounter sessions; games, meat cutting courses and pre-schooler program
The Cross Country Motorcycle Race
Order of Eastern Star
Local branches of the Thompson-Nicola Library System
The Community Resources Society
The Old Age Pensioners organization
Bookings in the Community Hall
The Ashcroft Art Club
Ashcroft and District Lions Club activities
Ashcroft Adult Badminton sessions
Elks Club activities
Cariboo College evening classes in Ashcroft, Cache Creek and Clinton in crocheting, sewing, yoga, ceramics, etching, batik, etc.

The B.C. Drama Association
Hunter's statistics from Cache Creek Checking Station
Television schedules for the week
Theatre and drive-in movie programs
Cabaret entertainment
Bingo at a hall in Ashcroft
A Church Bazaar
Gymnasium activities at two Community Halls
Pre-ski training courses

Undoubtedly the list could be lengthened but a detailed inventory has not been assembled.

A full-time Twin Village Recreation Co-ordinator has been appointed. Ashcroft has a four-sheet curling rink, a new artificial ice arena, an older outdoor swimming pool and tennis courts at the school. Cache Creek has a new swimming pool (and there are hopes to cover it for year-round use) and park plans call for a children's playground, lawnbowling green, shuffleboard, and like facilities. Bowling alleys are not available and baseball and other outdoor sports require improved facilities. Well-equipped ski hills are a short distance away in the Kamloops area.

In common with many interior communities in sparsely settled areas, opportunities for individual, un-organized outdoor activities are excellent. Snow-mobiling, fishing, hunting, hiking, boating, naturalist activities, photography, driving, scenic viewing, riding, and the like are readily accessible.

The whole matter of recreation is an important concern. Recreation facility development, if adequately assisted and planned in advance, can accomplish a great deal toward improving the working conditions for the labour force and reducing the undesirable overload on relatively small communities by sizeable numbers of off-duty workers with inadequate activities to occupy their time. Furthermore there is a good opportunity to plan facilities which complement those already existing and to integrate them with the ongoing recreational needs of the whole area. It is apparent that a strong recreation program would need to be developed for the construction camp. Villages the size of Ashcroft and Cache Creek could not be expected to cope unassisted with the leisure activity requirements of so large a work force. The adequacy of playing fields, swimming and gymnasium facilities, team sports organization, arts and crafts, etc. would have to be considered in detail as soon as firm decisions were made on campsite location, size, and time-table.

(k) SOCIAL SERVICES

The Department of Human Resources has a resident area supervisor in Cache Creek assisted by two child welfare workers and one financial assistance worker. As of November 1974 there were 67 children in care in the Ashcroft-Cache Creek area. There were 41 single parents, 42 single-parent families, and 21 two-parent families receiving assistance. In the area from Spences Bridge to Cache Creek 13 juvenile problem cases were cited. Family counselling is available only on a part time basis from a worker in Kamloops. There are no mental health facilities. Alcoholism is said to be a major and increasing problem. AA and Alanon meetings are available. Several churches of varied denominations are active in the area.

In view of the sparse services available, expansion would be required to take care of increased case loads if the proposed project is initiated. This could be detailed at the same time as specific community studies for housing, recreation, municipal services, etc.

(l) REFERENCES

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2. Willis, Cunliffe, Tait and Company Ltd. (1969). Report on Ashcroft Community Development.
3. Willis and Cunliffe Engineering Ltd. (1966). Report on Mesa Vista Subdivision (for Ashcroft).
4. Strong, Lamb and Nelson (Kamloops) Ltd., (1971). A Storm Drainage and Street Improvement Study for Ashcroft.
5. Strong, Lamb and Nelson (Kamloops) Ltd., (1973). A Feasibility Study of Ground Water Sources to Supply the Village of Clinton.

4. SPECIAL SOCIAL AND LIFESTYLE CONSIDERATIONS

During the course of this preliminary study, meetings were held with the Indian bands, ranchers and municipal administrations to explain the potential scope of the project and to take note of people's concerns. Although the particular items may be discussed elsewhere in this report, they are summarized here because these particular groups are those who would be most affected by the proposed development.

(a) CONCERNS OF THE UPPER HAT CREEK VALLEY RANCHERS

The ranchers in the valley of Upper Hat Creek would be most directly affected by the proposed project.

They are concerned that the present quiet rural character of the area may be considerably altered by numerous strangers, new noises and traffic, dust and odors and alterations in the weather and scenery.

They are concerned about compensation.

They are doubtful whether it is worthwhile for them to invest in property improvement projects while this development is being studied.

They are concerned about added dangers to their families that would result from more heavily travelled roads, especially with respect to school buses and shopping trips.

They want to know what would happen to Hat Creek and to the groundwater in the valley.

They want to know exactly what portions of the valley area would be foreclosed from range land by the project.

They want to know what would be done about workmen's living quarters and access routes to the project.

They are concerned about maintaining their present lifestyle in the face of this sort of development.

They want to know if there will be continuing flows of information and dialogue as studies progress.

(b) CONCERNS OF THE INDIAN BANDS

A general concern of the Indian Bands is whether their specific interests will be noted, considered, and dealt with in a responsible manner. History has not encouraged them to be optimistic. One lady remarked: "My grandfather was a chief, my father was a chief, and my son is a chief. In our relations with the white man it has always been the same story. When they want to do something they send some nice men to explain how it won't bother us very much, how there will be some advantages in it for us, and how we will be fairly paid. Then when it comes time to do it we meet a new group of men who do not seem to know or care what the other men said, and who do what they want to get their job done. *Why will it be any different this time*?"

Another general concern of the Indian Bands is that it be understood how they view their land and their heritage. Land and their way of life are traditions which they do not easily equate with money, but see as an aboriginal right. The subject of compensation may be a difficult one for both parties to discuss in view of the lack of common definition of the subject matter. The current level of interest in achieving a general settlement of the land claims issue in B.C., although not apparently directly involving this particular project, is a further complicating factor which could be expected to influence the attitude of the bands in future discussions.

Among specific concerns, there is the obvious fact that some reserves are downstream from the proposed coal mine and possibly down wind from the power plant. They don't want to see damage to their water supply, the fish, or the air.

They are concerned with whether or not access routes for roads, water pipeline, transmission lines or railway tracks would cross reserve land.

There is concern about the added hunting load on area wildlife resources. They have a strong personal identification with this resource and a vital interest in its preservation.

There is concern regarding guarantees of job opportunities. They are not at all certain that they would be able to participate in either the jobs or any other opportunities that might develop. What about union and closed shop situations? Could they really take part in a new style economy or would it just leave them further than ever behind the rest? What avenues could be found to help them take part?

If compensation arrangements were required for use of Indian lands, they would not wish to consider one-time settlements. They would want a continuing formula of some kind. They would expect to be there after the construction had been completed and are concerned about arrangements for the future.

Numerous lesser questions were discussed at the meetings, including a request for affirmation that information about the proposed project will continue to come to them and that further opportunities to discuss it will be made available.

(c) MUNICIPAL AND OTHER CONCERNS

Municipal administrations tend to be favourably inclined toward additional diversity and strength in the economic sector, but naturally have some concerns about the cost of coping with expansion.

Municipal officials have voiced other concerns. Job training programs for local and potential new residents would be needed. Police and government administration offices would have increased duties to carry out. Increased traffic flows must be estimated. There would probably be a demand for better bus or other passenger service to Kamloops and

Vancouver. A case might be made for upgrading one of the airstrips to accept heavier traffic although this has not been given detailed study.

There is concern that uncontrolled developments not based on formal communities might cause unattractive or otherwise undersirable settlement patterns. The Regional District is aware of this and would presumably exert such control as lies within its power. Other levels or agencies of government would also have input here — for example Department of Highways, Department of Health,and Environment and Land Use Committee.

Interested tourists might wish opportunities to tour the operations. It would likely be desirable to encourage this within limitations of design, location, and access factors.

(d) POTENTIAL NOISE

Construction activities and on-going operations would inevitably produce some noise. For the most part these would principally affect the actual working forces producing the noise and little effect is anticipated on the neighboring population or passers-by.

Vehicular travel would increase dramatically from existing levels and road noise from highway vehicles, particularly trucks, might have irritating effects on the residents of the Indian reserves along Lower Hat Creek Valley due to the proximity of their homes to Highway 12. Such effects would be very much less felt by Upper Hat Creek Valley ranch families as traffic there would not be expected to reach high densities.

During both the construction and operation phases of the mine, noise would be generated by some of the mine excavating equipment and by trucks transporting overburden and pit waste to dumps. Such noise would normally be audible only in and near the pit and dumps and would not likely affect local residents to any troublesome degree. Use of exhaust mufflers and ear protectors, as is normal practice now, should protect the working force adequately. Blasting is not expected to be extensive in the pit. If it were found necessary then it might be required to confine blasts to normal daylight hours. The method of coal transport might be by trucks or conveyors. Trucks would require mufflers. Conveyors produce little noise.

The construction of the thermal plant (and coal cleaning plant, if required) would generate the normal tool and machinery noises of any large building project and no unusual problem should be expected. Operation of the thermal plant or coal cleaning plant would generate no noticeable external noise except for coal handling which would generate only innocuous noise levels. Internal plant noises would be dealt with in the normal way through employment of good design practice and use of ear protectors.

5. RECOMMENDATIONS FOR REMEDIAL ACTION AND FURTHER STUDY

(a) COMMUNICATIONS WITH LOCAL GROUPS

In view of the multiplicity of interests involved in this proposed project — some mutual, some overlapping, some conflicting, and some undefined — it is clear that a mechanism must be established for ensuring that adequate notice is taken of the people involved and that adequate channels of communication are established and continue to operate. There must be some identifiable and credible office or person to whom anyone can bring a problem related to the project. It may be a rancher concerned about fence damage, or an Indian band councillor concerned about trespass or compensation problems, or someone from a public agency. A high proportion of problems on projects arise as a result of misunderstanding, poor communication, lack of attention, action time delays, and the like.

Some mechanisms recommended for the Seven-Mile Hydro-Electric project near Trail, British Columbia, would be equally useful for the Hat Creek project. These were:

(i) the establishment of a permanent B.C. Hydro Liaison Team (probably only 1-3 people) to be stationed in the area, and
(ii) a Project Impact Committee.

This Committee should include representatives of various public agencies, B.C. Hydro and its contractors, and other interest groups who could meet regularly to keep the impacts of the project in proper focus, encourage development of suitable action plans, watch for potential problem areas, and act as a forum for expression of concerns. The efficacy of this approach can be observed as the Seven-Mile Project progresses, and suitable modifications could be made for the Hat Creek project if necessary. It might prove advisable for the Committee to have a permanent secretary or chairman or some other person who would always be available to accept enquiries and provide information. Various formats are possible, but the Regional District is one obvious agency under whose auspices such a Committee might operate.

(b) DEVELOPMENTS UNRELATED TO THE PROPOSED POWER PROJECT

In view of the potential of the Hat Creek coal deposit to support industrial activity or mining unrelated to the proposed power development, the nature of and prospects for such industry should be examined. Controls and various planning factors may require advance attention in the interests of both the region generally and the proposed project in particular.

(c) SITE-RELATED ITEMS

If the proposed project is approved in principle, and final selection of a generating station site is made, then a number of items dealt with in a very preliminary or generalized manner in this report would require more specific study and more rigorous analysis. These include:

i) Population growth studies in better detail for particular communities;

ii) Specific housing requirements as related to each affected community;

iii) Traffic and transportation volumes, routes, service, etc.;

iv) Regional urban and land development analysis, zoning changes;

v) Details of the construction camp;

vi) Recreation and social service requirements;

vii) Manpower study relating to sources of labour, trade requirements, training and re-training programs, the situation for local area residents including the Indian bands, availability of facilities and expertise;

viii) Further details of local trade and business requirements and opportunities. More detailed regional economic analysis will be required since study to date does not accurately define the relationship of project payroll, purchasing, etc. to the various sectors;

ix) More specific study of the implications of possible future expansion of the proposed generating station from 2000 Mw to 4000-5000 Mw.

B. OTHER SITES

Obviously the coal mine could only be located in the Upper Hat Creek Valley and any social or economic impacts relating to its development or operation would not have differing *alternative scenarios.*

Many of the factors discussed in A. above would relate in similar fashion to most of the proposed sites for the generating station. The number and nature of construction and operating jobs and the population and impact implications arising from these would be largely the same in principle for any of the ten Interior sites considered. The impact on particular communities would shift of course, and other residents or other agencies might have conerns to voice. The most notable difference would arise if the site were to be selected in the Lower Mainland area. There the impact, though equally real, would be much less noticeable because of its diminutive scale relative to the local population and economy. Supporting services, transportation routes, housing, recreation opportunities, and similar factors would require less attention because of the existing situation in the area.

PART VIII

CONCLUSIONS

PART VIII — CONCLUSIONS

The conclusions and recommendations which follow must be qualified by two major factors. First, this study is preliminary in nature, being based on presently available information and limited field surveys. Time has been the major constraint. Second, the proposed Hat Creek development is still in the early stages of engineering study, planning, scheduling, and economic evaluation and consequently background material necessary for thorough environmental evaluation has been to some degree approximate, preliminary or multiple choice (plant sites). It does not follow, however, that the conclusions and recommendations presented herein will be appreciably changed or altered after the completion of more thorough study based upon more definitive information. Obviously some changes will occur but the principal effects of further study may well be to confirm present conclusions and recommendations, to present additional conclusions and recommendations and to considerably reduce the number of recommendations for further study.

Only the major conclusions, recommendations for remedial action and recommendations for further study are presented in the following sections. Lesser potential impacts and remedial actions concerning specific areas of interest can be found in the appropriate sections of the report. These same sections contain details of the more generally expressed conclusions and recommendations which follow.

A. THERMAL PLANT SITE OPTIONS

The overall impact of many of the environmental as well as the social and economic considerations resulting from the thermal plant siting are similar regardless of the particular site chosen. Some impacts may be more severe at one site than they are at another but, conversely, others may be less severe (eg. social impacts resulting from a plant on the Lower Mainland). Consequently, with some exceptions, such impacts should have little influence on site selection although the effects of each require study and remedial action. The environmental impacts which would have the most obvious effect on site selection would be atmospheric emissions and land alienations.

With regard for these two major impacts, the preferred location of the generating station would be near the No. 1 Openpit coal deposit, (Sites 1-5 in Upper Hat Creek Valley). These sites are topographically situated such that their potential impact due to atmospheric emissions would be less than for Sites 6-11, with the possible exception of Site 8. Semi-permanent land alienations resulting from the transport of coal, water and electricity would also be less for Sites 1-5 than for Sites 6-11, with Site 1 requiring the least land alienation of all eleven potential sites.

B. ENVIRONMENTAL IMPACTS

1. LAND FEATURES AND USES

(a) TOPOGRAPHIC CHANGES

The openpit and its attendant waste disposal areas would be the major causes of topographic change in Upper Hat Creek Valley. The openpit would become a permanent excavation some 1400 feet in depth encompassing an area of 1120 acres which, with suitable reclamation of its upper slopes, might eventually become a scenic lake and useful reservoir. However, if other coal deposits were discovered elsewhere in the valley, the No. 1 Openpit could conceivably be used as a waste disposal area during the mining of these deposits. Also with suitable reclamation procedures, the waste and overburden dumps (total area of 1890 acres) could be returned to productivity (agriculture, animal habitat) similar to, and perhaps locally better than, that which these areas now provide. Progressive reclamation wherever possible during the life of the mining operation could limit and eventually eliminate the aesthetically unnatural appearance of these areas on the landscape.

(b) LAND ALIENATION

The landholders in Upper Hat Creek Valley would be affected by the proposed development. Some would lose sizeable portions of their present deeded and/or leased lands whereas others would lose little or none. However, all would be inconvenienced to some degree in terms of their present ranching operations by changes in access routes and by the effects of industrial activity, tourism and so forth on their operations. If the generating station were located at Site 1 a total of 5370 acres would be alienated of which over 95% is currently used as grazing land.

(c) TRACE ELEMENTS

The environmental effects of trace elements contained in the coal and waste rock are not clearly understood at present. Preliminary analytical data suggests that fluorine, lithium, arsenic and boron may be present in higher than normal concentrations and might cause some environmental problems. Insufficient data are available to assess any potential problems which might arise if beryllium, selenium and mercury are found to be present. However, the majority of the trace elements in the coal and waste rock are present in concentrations which would appear to pose no environmental hazard.

(d) IMPACT ON SOILS

The soils in Upper Hat Creek Valley are all fine textured and consequently their potential for dusting is high. Also because of their fine texture, they are not expected to be readily permeable to water; most moisture would be discharged via surface flow resulting in a high potential for erosion and the possibility of large quantities of silt reaching water courses, (eg. Hat Creek). Proper fertilization will permit reclamation of the overburden material but, from preliminary tests, will not improve the poor growing characteristics of the waste rock.

2. AIR AND WATER ENVIRONMENT

(a) ATMOSPHERIC ENVIRONMENT

The proposed 2000 Mw thermal generating station would result in the atmospheric discharge of approximately ten million lbs/hr of water vapour from the cooling towers and, from the boiler stack, about 400 tpd of SO_2, 150 tpd of nitrogen oxides and 56 tpd of fly-ash. It is expected that the impact of the water vapour discharge would be minimal if the cooling towers were large, natural-draft units incorporating highly efficient entrainment separators. If it were necessary, further reduction in plume impact might be achieved by using combination wet/dry cooling towers. It is assumed that the fly-ash collection system could be designed to remove 99.5 percent of the particulates from the flue gas which would achieve the relatively low 56 tpd of fly-ash emissions. Associated with the fly-ash emissions would be small amounts of various trace elements, some of which could be hazardous to the environment if present in sufficient quantity. A better understanding of the potential plant emissions could be obtained when a test burn of a large sample (50,000 tons) of Hat Creek coal is conducted at an operating thermal power plant.

The environmental impact of thermal plant emissions is dependent upon their ground-level concentrations; a potentially serious negative impact can result if these concentrations are too high. Prediction of concentrations requires an accurate knowledge of local meteorology which, unfortunately, is not yet available for the Hat Creek area. However, it is possible to delineate meteorological conditions which could result in adverse or unacceptable ground-level concentrations of plant emissions. These conditions are aggravated when a thermal generating plant is situated in a deep, narrow valley and minimized when it is located at a high open site.

(b) GROUNDWATER

The generating station, regardless of its location, would have a negligible effect on the local groundwater regime. On the other hand, the No. 1 Openpit would have two major impacts on the groundwater of Upper Hat Creek Valley. The most obvious and most serious impact would be the disruption of Hat Creek where it presently flows across the area of the proposed pit. The downstream flow should not be appreciably reduced because of irrigation requirements and fishery. The second impact would be a draw-down of subsurface water for some distance around the openpit (which would act as a sump into which the water would flow). Neither of these impacts could be avoided although their environmental consequences might be lessened by proper remedial actions.

(c) HYDROLOGY

A once-through cooling water system for the proposed power plant is impractical (except possibly for a plant located on the Lower Mainland). A wet cooling tower system plus other plant water uses would require a maximum of 25,000 Igpm of make-up water. Only the Thompson and Fraser rivers are an adequate source of water for the proposed development. The maximum withdrawal rate (40,000 Igpm to obviate pumping during daily periods of peak power demand) is within the limits of current fish screening technology and would be 2.6 percent, and less than 1 percent, of the recorded low flows of the Thompson and Fraser rivers respectively.

(d) WATER QUALITY

Hat Creek water is very hard; dissolved solids, conductance and alkalinity values are high whereas chloride, nutrient and heavy metal values are low. Bonaparte River water is hard to very hard and the concentration of associated dissolved constituents is high. The influence of Hat Creek on the Bonaparte River cannot be established from presently available water quality data. However, dilution of Hat Creek water by Bonaparte River water as low as 70% (0.7 times) has been recorded.

The water of the Thompson River is moderately soft and the concentration of dissolved constituents is low. However, due to its high volume the influence of the poor quality Bonaparte River water on the Thompson River is small. The minimum recorded dilution of Bonaparte River water by Thompson River water was 34 times.

The water of the Fraser River is moderately hard with dissolved solids levels being approximately twice those in Thompson River water. During freshets suspended solids levels are very high, the maximum being about 50 times that recorded in the Thompson. Considering that approximately 65 percent of the total plant water would require treatment to reduce the suspended solids content, the major disadvantage of Fraser River water in comparison to Thompson River water is obvious. The disposal of several thousand tons per year of very fine silty material would be the major environmental impact.

Hat Creek and Bonaparte River water are being used intensively for irrigation. The proposed project would not conflict with this use and the possibility exists that the project would increase the availability of water for irrigation by bringing additional water into the valley.

3. SPECIES AND ECOSYSTEMS

(a) VEGETATION

Upper Hat Creek Valley contains a number of vegetation associations because it occupies a transitional area in terms of climate (humid continental and mid-latitude steppe type), soil and topography. None of the vegetation associations in the valley appear to be unique but are typical for much of the lower Interior regions of British Columbia. The major disruptive forces in the area have been grazing and some logging.

The most valuable land which would be alienated by the proposed project would be the 22 acres of agricultural fields located on the proposed reservoir site. Other vegetation types alienated would be 2255 acres of Douglas fir-pine grass (of which 540 acres have already been logged), 1165 acres of upland grasses and 1070 acres of sage brush-ponderosa pine-bunch grass savannah.

The project could have a partly beneficial effect on vegetation on non-alienated land due to an increase in the availability of water in the valley.

(b) FISHERIES

Hat Creek varies in velocity, flow and bottom substrate along its length and these variations have produced many deep pools and slow moving flats which make good fish habitat. Aquatic organisms used by fish as food are plentiful. The Creek has good rainbow trout spawning potential.

The Bonaparte River above the falls supports a modest population of rainbow trout which is not greatly exploited due to limited access. Below the falls the river supports a small but significant salmon population (spring, coho, pink). Rainbow trout and steelhead also inhabit this portion of the river. Both the Thompson and Fraser rivers support extremely important salmon populations.

The proposed development could affect the Hat Creek fishery by the discharge of unfavourable substances such as dust, leachate and sediment loaded runoff, and by creek modification. Results of a fish bioassay using juvenile coho salmon indicate that ten percent by weight of coal is nontoxic but that a similar concentration of bedrock is sufficiently alkaline (pH 9.1) to kill in less than 24 hours. The proposed creek modifications (rerouting around the pit site and placing a dam above the pit) could result in sediment loading of the stream during construction and creation of barriers to migration.

The use of either the Thompson or Fraser rivers as a source of water for the proposed development presents the danger of entrainment of smolts or fry in the intake structure. However, this potential problem and most other impacts relating to fisheries could be circumvented, remedied or lessened by choice of design alternatives.

(c) WILDLIFE

Upper Hat Creek Valley is considered to have moderate limitations of habitat for the production of ungulates. These limitations appear to be the result of deep snow pack, lack of cover, and over-grazing by domestic cattle. There is a small area of important winter range on the western side of the valley. Both deer and moose are present but neither species is abundant.

Wetlands important to waterfowl production are located mainly in the southern portion of the valley from the confluence of Finney Lake with Hat Creek south through a region of small lakes. Less important areas are located near Finney and Aleece lakes. The primary limitations are reduced marsh edge, lack of adequate cover vegetation and alkaline water. The majority of the land which would be alienated by the proposed project is considered to have no waterfowl production potential.

Little information exists on the value of Upper Hat Creek Valley for maintaining populations of small mammals and birds.

The increase in population resulting from the project could produce a heavier hunting pressure on local game populations. However, this would be mitigated in part by the necessity of providing a no-shooting zone around the area of industrial activity.

Among the possible impacts of the proposed project on wildlife is topographic change which might prevent animal movement, alter migration patterns, increase vulnerability to road traffic and isolate suitable habitat through use avoidance. The most important impact would be habitat removal, particularly that in short supply such as wetlands in a relatively dry area and winter range upon which the survival of ungulate population depends. The impact on waterfowl would be minimal since the project primarily would utilize areas unsuited for waterfowl habitat. It is conceivable that a beneficial impact on waterfowl might derive from the proposed 50 acre reservoir particularly if water levels were stable, and proper edge vegetation was ensured.

(d) MAN

There are no known archaeological sites relating to ancient Indian history in Upper Hat Creek Valley but the potential for such sites exists. By utilizing care during construction, ancient historic values might be revealed and recovered.

C. SOCIAL AND ECONOMIC IMPACTS

1. EMPLOYMENT, INCOME AND POPULATION IMPACTS

(a) The proposed 2000 Mw project would require more than 1100 workers at mid-construction peak, and would, by the 8th year provide about 540 permanent jobs. Most employees would likely have to come from outside the region, many from outside the Province.

(b) A permanent population increase (in the area) approaching 2000 may result by the fifth year following commencement of construction. A "temporary" construction camp may have to accommodate up to 700 workers in peak years. If the generating station were located outside the region (eg. Lower Mainland) this population increase would be reduced to somewhat more than 1000, the construction force in the area being proportionately reduced.

(c) In terms of 1975 dollars, the construction payroll could amount to $25 million per year in peak years and the permanent payroll of the order of $10-20 million per year. Factors such as inflation, overtime, and engineering could substantially increase these figures.

(d) Expanding economic impacts based on mine and generating station investment and payrolls would generate secondary service jobs, increased trade, new business opportunities, and tax revenues.

(e) Present housing stock in the communities of the project area would be totally inadequate to serve the needs of the projected population increase, but adequate land and services potential exist for new subdivision development. Planning problems would require early attention.

(f) Currently declining school enrolments in most towns, and the availability of spare hospital capacity at Ashcroft and Lillooet, taken with the experience of previous mining-related expansions suggest that increased demands for these services could be met without major capital expenditures for new facilities.

(g) Other impacts that would be imposed by the project include increased traffic flows on area roads, increased law enforcement requirements, a need for enlarged and more diverse recreational facilities, and increased pressure on social services.

2. SPECIAL SOCIAL AND LIFESTYLE CONSIDERATIONS

(a) The Upper Hat Creek Valley ranchers would be most directly affected, and have a number of concerns regarding the alteration of the quiet rural character of their area, their future investment plans, water supplies in Hat Creek and in wells, land used or foreclosed to use by the project, and type and amount of compensation which would be provided.

(b) The Indian bands holding reserve land in the area would not likely experience significant pressure on use of land for project purposes. However they have a number of concerns, accentuated by their perception of historical injustices and the land claims issue. These include alteration of life style in the area, possible downstream water or air quality problems, access routes that might pass through reserve land, pressures on hunting by increased population, and lack of opportunity to participate in the economic benefits stemming from the proposed project.

(c) Additional concerns of a municipal or public nature involve issues such as job training programs, financing of increased demands for services of all kinds, planning control over potential undesirable settlement patterns, and possible problems of noise, traffic, law enforcement, and public welfare.

D. RECOMMENDED REMEDIAL ACTIONS

1. GENERAL RECOMMENDATIONS

(a) The areas of the mine and generating station should be landscaped and converted to the best possible aesthetic state within limits of continuing work (eg. mining).

(b) Wherever possible, the overburden, waste rock and ash disposal areas associated with the openpit mine and the thermal plant should be progressively reclaimed during the life of the operation in order to return the alienated land to productive use as soon as possible and to reduce the aesthetically unnatural appearance of these areas.

(c) The proposed coal sample for test burning at an operating thermal plant should be obtained at an early date so that sufficient time would be available to conduct environmentally related studies on the sample site and attendant disposal areas. More time would then be available to incorporate pertinent data from the test burn into other environmental studies (eg. nature and characteristics of the ash, flue gas composition).

2. THERMAL PLANT SITE OPTIONS

(a) To minimize alienation of Indian lands and productive bottom land resulting from the transport of coal the proposed generating station should be located near the No. 1 Openpit deposit. Any of Sites 1-5 in Upper Hat Creek Valley would be preferable to Sites 6-11 in this regard. Site 1 would be the optimum location with respect to such land alienation.

(b) If one of Sites 1, 2 or 3 in Upper Hat Creek Valley was chosen it would require adequate exploration to determine if it was situated over potentially mineable coal.

(c) For sites not adjacent to water supply, consideration should be given to transporting water via tunnel or buried pipeline-and-tunnel if it would obviate alienations of land of significant value.

3. LAND FEATURES AND USES

(a) For safety purposes the boundary of the openpit, including the active buffer zone, should be fenced.

(b) If conveyor belts were employed for the transport of coal they might require covering to prevent coal dusting and loss of product, and the land corridors they occupy would have to be fenced for safety reasons.

(c) Provision must be made for those ranchers whose properties would be isolated or physically reduced through development of the proposed project. It is understood that B.C. Hydro has already indicated a policy of purchasing, at current prices, any land in the Upper Hat Creek Valley offered for sale, whether directly affected or not. Lease-backs and relocations might be worth considering as added alternatives.

(d) Provision should be made for irrigation water to improve areas surrounding both the openpit operation and the thermal plant site.

(e) Topsoil should be progressively removed from the No. 1 Openpit and the overburden and waste rock disposal areas and preserved for future use in reclamation of the disposal dumps. This recommendation also applies to the ash disposal area, particularly if the proposed generating plant were to be located in Upper Hat Creek Valley.

4. AIR AND WATER ENVIRONMENT

(a) In order to minimize the environmental impact of atmospheric emissions from the thermal generating station, a preferred location would be in a relatively high, open area where adverse meteorological conditions occur infrequently. In this regard, Sites 1-5 in Upper Hat Creek Valley would have a distinct advantage over Sites 6-11, (with the possible exception of Site 8). The optimum sites with respect to atmospheric emissions would be 4 and 5 in the Trachyte Hills.

(b) Consideration should be given to the possibility of abating emissions during adverse meteorological conditions.

(c) For Sites 1-5, Thompson River water should be used as make-up water for the proposed operation thereby avoiding the discharge of one water system (the Fraser) into another (the Thompson via Hat Creek and the Bonaparte River).

(d) Provision should be made for the collection, storage and disposal of all effluents such as mine leachates, oil, sewage, water treatment waste, water from fly ash slurry systems, and boiler blowdown wastes.

5. SPECIES AND ECOSYSTEMS

(a) It would be mandatory that waste rock not be allowed to enter major water courses.

(b) Discharge of physical and chemical pollutants such as dust, particulate and stack gases would have to be rigidly controlled to prevent them from being distributed on vegetation used for forage by domestic stock or wildlife. Baseline data prior to proposed development should be collected to provide a comparative base for measuring changes and indicating the need for special controls.

(c) If the fishery in Hat Creek was disrupted by damming and/or diversion it would have to be replaced or compensated. This could be accomplished by either stocking the reservoir behind the dam or by creating spawning habitat downstream of the proposed development.

6. SOCIAL AND ECONOMIC CONSIDERATIONS

(a) A 'Project Impact Committee' should be established at an early date to provide a mechanism through which people can easily communicate their problems or concerns to B.C. Hydro, its contractors and appropriate agencies.

E. RECOMMENDATIONS FOR FURTHER STUDY

The following list comprises the major or more significant recommendations for further study which have become apparent during the course of this preliminary environmental evaluation of the proposed Hat Creek development. Details and reasons for them are contained in the appropriate sections of the report as are a number of less significant recommendations for further study. The purpose of these recommendations is dictated by two primary requirements: (1) the acquisition of more data, and (2) the need for more detailed evaluations. Before a final environmental study can be completed it will be necessary to establish the ultimate size of the proposed generating plant.

1) Studies of slope stability (pit excavation, overburden and waste rock dumps), groundwater intrusion, biological angle of repose, and revegetation and other reclamation procedures. These could be accomplished on a 'pilot' scale when the trenches and attendant disposal areas resulting from the mining of the burn sample are available for study and testwork.

2) More definitive study of trace elements (research, data acquisition, testwork) as they relate to water, soil and rock, plant and animal life, and possible economic recoveries.

3) Collection of meteorological and air quality data (on-going) for the establishment of background levels before operation, and use in site evaluation with respect to atmospheric emissions of the generating plant.

4) Further study of the potential use of fly ash for alumina production.

5) Studies associated with the diversion of Hat Creek around the openpit to determine the environmental effects of the various proposed methods of diversion and to select an optimum solution. Included in the study would be effects on, and required remedial actions for, fishery, water quality, irrigation, domestic use and so forth.

6) Determination of the groundwater regime in the pit area, the probable effect on it of the pit excavation, and suggestions for possibly required remedial action.

7) Effects of various water intake designs as they relate to fish hazard and fry migration.

8) Detailed vegetation survey through a minimum one-year period to determine productivity, seasonal use, potential values and timber quantities.

9) Detailed ecological studies of the effect of the proposed development on the wildlife of the area; acquisition of baseline data and application of other data (air and water quality, greater activity, etc.) with respect to its effect on fish, animals, birds and man.

10) Sources of project manpower; training programs.

11) More specific and detailed study of secondary project impacts on trade, income, employment.

12) Once the site or sites for final analysis are selected, then many factors can receive more specific local and regional analysis — housing and construction camp planning, traffic flow increases by route mode and facility, school requirements, municipal services, social services, recreational planning for the camp and principal towns.

13) The Indian bands' situation relative to the project — more specific analysis of job opportunities, commercial or development opportunities, means to preserve traditional values and reduce potential friction.

PART IX

APPENDICES

APPENDIX IV-1

LAND USE AND SOIL CHARACTERISTICS DATA

APPENDIX IV-1

LAND USE AND SOIL CHARACTERISTIC DATA

TABLE 4A-1
ACREAGE HELD BY LAND OWNERS AND LEASE HOLDERS
UPPER HAT CREEK VALLEY

HOLDER	DEEDED (acres)	AGRICULTURAL OR GRAZING LEASES (acres)	UNIDENTIFIED LAND HOLDINGS (acres)	TOTAL ACREAGE
A	480	0		480
B	720	9120		9840
C	40	0		40
D	60	0		60
E	160	1400		1560
F	1265	4500		5765
G	40	0		40
H	660	2040		2700
J	960	880		1840
K	600	640		1240
L	1390	8430		9820
M	150	0		150
N	560	960		1520
Totals	7085	27,880	110	35,055
Percentages	20%	79%	<1%	100%

TABLE 4A-2
GRAZING LEASE PERMITS UPPER HAT CREEK VALLEY

HOLDER	NUMBER OF CATTLE	PERIOD GRAZED	NUMBER OF MONTHS	ANIMAL UNIT MONTHS (AUM)
1	180	May 24 - October 16	4.8	864
2	200	June 20 - October 10	3.7	740
3	145	June 1 - September 15	2.5	362
4	165	May 15 - October 15	5.0	825
5	70	May 15 - September 30	4.5	315
6	60	July 1 - August 15	1.5	90
Totals	820		22.0	3196

TABLE 4A-3
SUMMARY OF CURRENT USE AND ACREAGE OF ALIENATED LAND

	ACRES OF LAND BY CURRENT USAGE								
	T_2K*	K	T_1K	W_1K	P.	M	X	U_2K	TOTAL ACREAGE
No. 1 Open Pit		480	530	88		12	10		1120
Buffer Zone	200	280	170	77		10	3		740
Waste Dump	696	672		45		13	4		1430
Overburden Stockpile		420					40		460
Plant Area		77	237	336					650
Ash Dump	600	179		141					920
Reservoir	5			13	32				50
Total	1501	2108	937	700	32	35	57		5370
% of Total	28	39	18	13	0.5	0.5	1		100

*See Table 4-1 for explanation of symbols.

TABLE 4A-4
SUMMARY OF CURRENT OWNERS AND LESSEES OF ACREAGE OF ALIENATED LAND

	ACREAGE OWNED BY						ACREAGE LEASED BY				
	A	D	F	G	H	UNIDENTIFIED	B	F	H	L	TOTAL ACREAGE
No. 1 open pit	420	15	15	40	30	0	0	270	330	0	1120
Buffer zone	60	40	60	0	35	0	130	130	285	0	740
Waste dump	0	0	0	0	0	0	0	205	690	535	1430
Overburden stockpile	0	0	0	0	0	0	0	0	85	375	460
Plant area	0	0	180	0	0	0	420	50	0	0	650
Ash dump	0	0	336	0	0	16	0	568	0	0	920
Reservoir	0	0	0	0	50	0	0	0	0	0	50
Total	480	55	591	40	115	16	550	1223	1390	910	5370
% of Total Acreage	8.9	1.0	11.0	0.8	2.1	0.3	10.2	22.8	25.9	17.0	100.0

Total deeded land	1281 acres — 23.9%
Total leased land	4073 acres — 75.8%
Total unidentified	16 acres — 0.3%
Total	5370 acres — 100.0%

TABLE 4A-5
SOILS DERIVED FROM GLACIAL TILL — UPPER HAT CREEK VALLEY

NAME	ASSOCIATION*		VEGETATION ZONE	BEDROCK DERIVATIVE	ELEVATION RANGE (ft)	REACTION	TEXTURE RANGE	LANDSCAPE POSITION
	MAJOR	MINOR						
Medicine (MC)	CaBLC	DEB (OGL) LBLC. RBLC-LC	Upper grassland	High base volcanic and limestone mixture	1500-3500	Moderately to strongly efferves-cent; moderately to strongly saline	Medium to fine dominant range silty loam to silty clay loam	Commonly found on bedrock controlled landforms, hummocky and drumlinized till, shallow till overlying bedrock.
Maiden (MD)	ELB	ERB	Ponderosa pine-bunch-grass and lower Douglas fir	High base volcanic and limestone mixture	1500-3500	Moderately to strongly efferves-cent; moderately to strongly saline	Medium to fine dominant range silty loam to silty clay loam	Commonly found on bedrock controlled landforms, hummocky and drumlinized till, shallow till overlying bedrock.
MacLaren (ML)	OGL	ELB	Upper interior Douglas fir mixture	High base metamorphic and limestone	3500-5500	Moderately effer-vescent nonsaline to weakly saline silty clay	Medium to fine dominant range silty loam to silty clay loam	Commonly found on bedrock controlled landforms, hummocky and drumlinized till, shallow till over-lying bedrock.
Minnie (MN)	OGL	ELB (ERB)	Interior Douglas fir	Granitic volcanic metamorphic	4000-5000	Weakly efferves-cent nonsaline	Medium silty loam	Commonly found on hummocky and drumlinized landforms, often in areas of strong bedrock control asso-ciated with shallow colluvium overlying bedrock.

*See Table 4A-9

TABLE 4A-6
SOILS DERIVED FROM COLLUVIUM — UPPER HAT CREEK VALLEY

NAME	ASSOCIATION*		VEGETATION ZONE	BEDROCK DERIVATIVE	ELEVATION RANGE (ft)	REACTION	TEXTURE RANGE	LANDSCAPE POSITION
	MAJOR	MINOR						
Community (CM)	ELB	ERB	Ponderosa pine-bunch-grass	Volcanic	800-3000+	Weakly to 1400. Effervescent weakly saline.	Medium silty loam to loam (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.
Cairn (CR)	DRB		Engelman spruce, sub-alpine fir	Volcanic	5500-6500	Weakly effervescent, nonsaline	Medium silty loam to loam (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.
Clemes (CE)	ELB	DRB, ERB	Interior Douglas fir	High base volcanic and metamorphic mixture	3000-3500	Moderately effervescent, weakly saline	Medium silty loam to loam (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock
Crown (CN)	CaRDGC		Ponderosa pine-bunch-grass and interior Douglas fir	Limestone	2500-4000	Strongly effervescent, weakly saline	Medium silty loam to loam (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.
Carson (CS)	ELB	CaDGC	Interior Douglas fir	Limestone	3500-5500	Strongly effervescent	Medium silty loam to loam (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.
Conant (CA)	ERB		Ponderosa pine-bunch-grass	Granitic	1000-3000	Noneffervescent nonsaline	Medium to coarse silty loam to loamy silt (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.
Clapperton (CP)	ELB	ERB	Interior Douglas fir	Granitic	3000-5000	Noneffervescent nonsaline	Medium to coarse silty loam to loamy silt (stony)	Commonly found on moderate and steep slopes. Often associated with shallow colluvium overlying bedrock.

*See Table 4A-9

TABLE 4A-7
SOILS DERIVED FROM ALLUVIAL DEPOSITS — UPPER HAT CREEK VALLEY

NAME	ASSOCIATION*		VEGETATION ZONE	BEDROCK DERIVATIVE	ELEVATION RANGE (ft)	REACTION	TEXTURE RANGE	LANDSCAPE POSITION
	MAJOR	MINOR						
Frances (FS)	MelR		Lower grassland (Hygrophytic)		1000-2500	Strongly effervescent, moderately saline	Medium to fine sandy loam to silty loam	Commonly found on flood plains

*See Table 4A-9

TABLE 4A-8
SOILS DERIVED FROM GLACIO-FLUVIAL DEPOSITS — UPPER HAT CREEK VALLEY

NAME	ASSOCIATION*		VEGETATION ZONE	BEDROCK DERIVATIVE	ELEVATION RANGE (ft)	REACTION	TEXTURE RANGE	LANDSCAPE POSITION
	MAJOR	MINOR						
Godey (GD)	OBC	ODBC	Lower grassland		600-2500	Moderately effervescent, weakly saline	Medium to fine sandy loam to silty loam	Commonly found in major valleys adjacent to present drainages
Glossey (GY)	ERB	ODBC (OBX)	Ponderosa pine-bunchgrass		600-1500	Moderately effervescent, weakly saline	Medium to fine sandy loam to silty loam	Commonly found in major valleys adjacent to present drainages
Gisborne (GN)	ELB		Interior Douglas fir		1500-5500	Weakly to moderately effervescent, weakly saline	Medium to fine sandy loam to silty loam (stony)	Commonly found in major valleys adjacent to present drainages and in upland valleys

*See Table 4A-9

TABLE 4A-9
SOIL DEVELOPMENT SYMBOLS USED IN TABLES 4A-5, 4A-6, 4A-7 and 4A-8

OBC	Orthic Brown Chernozem
ODBC	Orthic Dark Brown Chernozem
OBLC	Orthic Black Chernozem
ODGC	Orthic Dark Grey Chernozem
ERB	Eutric Regic Brunisol
ELB	Eutric Luvic Brunisol
DRB	Dystric Regic Brunisol
DPB	Dystric Podzic Brunisol
SRB	Sombric Regic Brunisol
ARB	Alpine Regic Brunisol
OHFP	Orthic Humo-Ferric Podzol
SHFP	Sombric Humo-Ferric Podzol
OGL	Orthic Grey Luvisol
BrGL	Brunisolic Grey Luvisol
BiGL	Bisequa Grey Luvisol
BiHFP	Bisequa Humo-Ferric Podzol
Sol.DBC	Solonetzic Dark Brown Chernozem

APPENDIX IV-2

PRELIMINARY GROWTH CHAMBER EXPERIMENT TO TEST HAT CREEK OVERBURDEN AND BEDROCK SAMPLES AS A MEDIUM FOR PLANT GROWTH

APPENDIX IV-2

PRELIMINARY GROWTH CHAMBER EXPERIMENT TO TEST HAT CREEK OVERBURDEN AND BEDROCK SAMPLES AS A MEDIUM FOR PLANT GROWTH

OBJECTIVES

1. To determine if overburden and waste which would be generated from the Hat Creek pit are capable of supporting plant growth given ideal conditions.
2. To determine some of the potential problems in revegetating this material.

MATERIALS AND METHODS

The methods were patterned after those outlined by Hodder *et al*[1].

DESCRIPTION OF WASTE SAMPLES (table 4A-10)

Overburden — samples 1 to 8
Bedrock — samples 9 to 11
Control — Vantro potting soil, sample 12

TREATMENT OF SAMPLE

Overburden size — 2.0 mm
Quantity — 300 gm/pot

Bedrock — crushed in a jaw crusher
150 g of 2.00 mm to 0.5 mm
150 g of $<$ 0.5 mm

Control — 300 gm/pot

Four pots of each sample (48 pots), two were unfertilized and two were fertilized with 50 ml solution containing 100 lb/A rate of N (Urea), P_2O_5 and K_2O.

Plant pots — round (O.S. plastic A/S Denmark 9B 3/8 F), set in plastic petri dishes.

Seed — Buckerfields Conquest Barley, 5 seeds per pot.

GROWTH CHAMBER

Lights — six fluorescent (total 240 watts) and six incandescent (total 150 watts).

Photoperiod — 16 hours light, 8 hours dark.
Temperature — 75° F
Humidity — 65%
Pot placement — completely randomized design.

TABLE 4A-10
HAT CREEK SAMPLES

SAMPLE NO.	ELEVATION	GRID REFERENCE	MATERIAL	DEPTH	LOCATION
1	3,270 ft	9000N 7400E	glacial till overburden	3" below surface	900' W of DH 74-23 Taken from bald side of hummock.
2	3.200 ft	9050N 8300E	glacial till overburden	3' below surface	at DH 74-23 On road cut.
3	3.080 ft	7000N 11000E	boulder till overburden		DH 74-24 From bulldozer scraped surface — few traces of fibrous roots.
4	2,930 ft	7300N 11950E	glacial fluvial overburden	3½'-6½' below surface	On road cut.
5	2,980 ft	11500N 10350E	glacial fluvial overburden	10' below surface	Near top of gravel pit excavation
6	2,920 ft	11500N 10300E	glacial fluvial overburden	70' below surface	Same pit as #5.
7	2.900 ft	11500N 10280E	glacial fluvial overburden	90' below surface	Same pit as #5 and 6.
8	2.980 ft	8200N 12300E	boulder till overburden	near surface	From "hoodoos" on east side of old Upper Hat Creek Road.
9	3,200 ft at surface	9050N 8300E	bedrock mixture	795-838'	DH-23 drill-core
10	3,200 ft at surface	9050N 8300E	bedrock mixture	856-920'	DH-23 drill-core
11	3,200 ft at surface	9050N 8300E	bedrock mixture	640-695'	DH-29 drill-core.

DURATION OF EXPERIMENT — 28 days

WATERING — Distilled water
— bottom watered
— top watered when required (all bedrock samples and overburden sample No. 1).

MEASURED PARAMETERS — Percent Germination
— After 28 days, plants clipped at soil level, dried and weighed
— pH of soil
— Leaf color
— Presence of cracked surface soil

ANALYSIS OF RESULTS

Data were analyzed using standard analysis of variance and Duncan's multiple range technique. Both seed germination and average dry weight data were used.

RESULTS

The results are tabulated in Tables 4A-11 and 4A-12.

SEED GERMINATION

ANALYSIS OF VARIANCE

SOURCE	DEGREE OF FREEDOM	F	PROBABILITY
Treatment	11	4.14	0.0018
Fertilizer	1	0.40	0.5357
Interaction	11	0.71	0.7192
Error	24		
Total	47		

1. There is a significant difference in the germination achieved with the twelve samples.
2. Fertilizer has no significant effect on germination.
3. There is no interaction between fertilizer and the twelve samples.

Duncan's multiple range test shows three homogeneous subsets (Figure 4A-1). In essence, samples 7 and 8 produced lower germination than all the others. Samples 7, 9, and 11 are similar as to percentage germination.

TABLE 4A-11
RESULTS WITH OVERBURDEN SAMPLES

SAMPLE NO.	POT NUMBER	FERTILIZER	SURFACE SOIL CONDITION	LEAF YELLOWING: LOWER LEAVES		LEAF YELLOWING: UPPER LEAVES		pH	NO. OF SEEDS GERMINATED	AVERAGE DRY WT. PER PLANT (gm)
				TIP ONLY	ALL	TIP ONLY	ALL			
1	1	-	cracked	+				8.2	4	0.03
	2	-	cracked	+				8.2	5	0.03
	3	+	cracked					8.1	4	0.12
	4	+	cracked					7.9	4	0.08
2	5	-			+	+		8.6	5	0.05
	6	-			+	+		8.5	5	0.04
	7	+		+				8.7	5	0.14
	8	+			+	+		8.7	5	0.11
3	9	-			+	+		9.1	4	0.04
	10	-			+	+		9.2	5	0.04
	11	+			+	+		8.9	5	0.17
	12	+			+	+		8.8	5	0.14
4	13	-			+			8.6	4	0.03
	14	-			+			8.4	5	0.05
	15	+		+				8.1	2	0.08
	16	+		+				8.4	5	0.08
5	17	-			+			8.8	5	0.03
	18	-			+			8.8	4	0.05
	19	+						8.4	5	0.14
	20	+						8.2	4	0.18
6	21	-			+			8.2	5	0.06
	22	-			+			8.1	5	0.08
	23	+		+				8.0	5	0.15
	24	+		+				8.0	5	0.14
7	25	-			+			8.6	2	0.06
	26	-			+			8.5	4	0.10
	27	+		+				8.6	2	0.20
	28	+						8.3	0	0.00
8	29	-			+			8.3	1	0.01
	30	-						8.2	0	0.00
	31	+		+				8.5	2	0.27
	32	+		+				8.5	2	0.24

Duncan's multiple range test shows four homogeneous subsets when the twelve soil types are compared. and five subsets when the treatments are partitioned into 24 units (12 soils and 2 fertilizer regions) (Figure 4A-2).

TABLE 4A-12
RESULTS WITH BEDROCK SAMPLES

SAMPLE NO.	POT NUMBER	FERTILIZER	SURFACE SOIL CONDITION	LEAF YELLOWING				pH	NO. OF SEEDS GERMINATED	AVERAGE DRY WT. PER PLANT (gm)
				LOWER LEAVES		UPPER LEAVES				
				TIP ONLY	ALL	TIP ONLY	ALL			
9	33	-	cracked		+			9.5	4	0.05
	34	-	cracked					9.3	3	0.05
	35	+	cracked	+				8.6	5	0.04
	36	+	cracked					8.8	2	0.01
10	37	-	cracked	+				9.7	2	0.04
	38	-	cracked		+			9.5	5	0.06
	39	+	cracked	+				9.0	4	0.05
	40	+	cracked	+				8.6	5	0.06
11	41	-	cracked	+				8.5	5	0.05
	42	-	cracked		+			8.8	3	0.09
	43	+	cracked					8.7	5	0.08
	44	+	cracked					8.5	1	0.13
12	45	-			+			4.7	5	0.08
	46	-			+			4.4	5	0.06
	47	+		+				4.6	4	0.18
	48	+		+				4.8	4	0.14

DRY WEIGHT

ANALYSIS OF VARIANCE

SOURCE	DEGREE OF FREEDOM	F	PROBABILITY
Treatment	11	2.53	0.0280
Fertilizer	1	54.20	0.0000
Interaction	11	4.24	0.0014
Error	24		
Total	47		

1. There is a significant difference in the average dry weight achieved with the twelve samples.
2. Fertilizer application makes a significant difference to the average dry weight.
3. The interaction term is significant and shows that fertilizer has more effect on some treatments than on others.

CONCLUSIONS

1. Fertilizer treatment improves the growth of barley on the overburden samples. The bedrock samples, even with the addition of fertilizer, show no marked improvement. It would appear that the physical structure of the bedrock materials is limiting growth no matter what the chemical characteristics.
2. Unfertilized overburden samples supported similar growth to that supported by the bedrock samples whether fertilized or unfertilized.

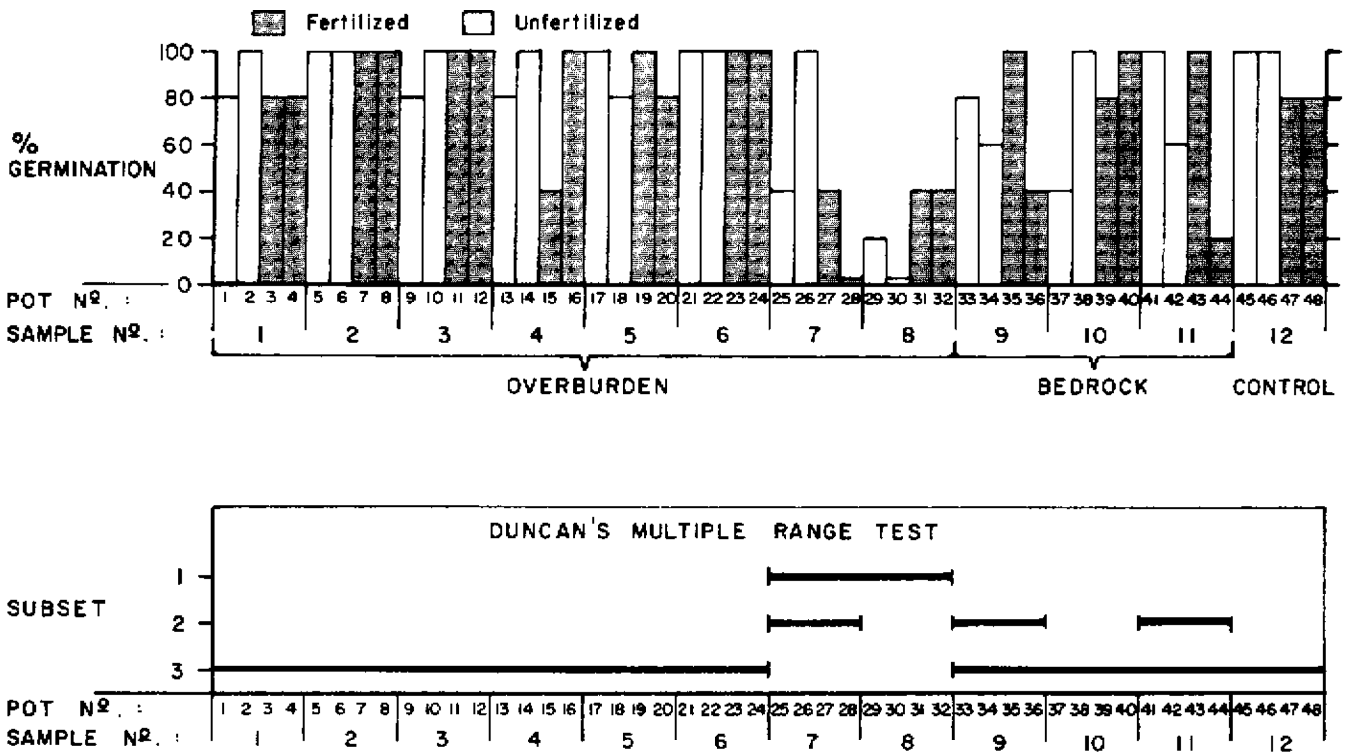
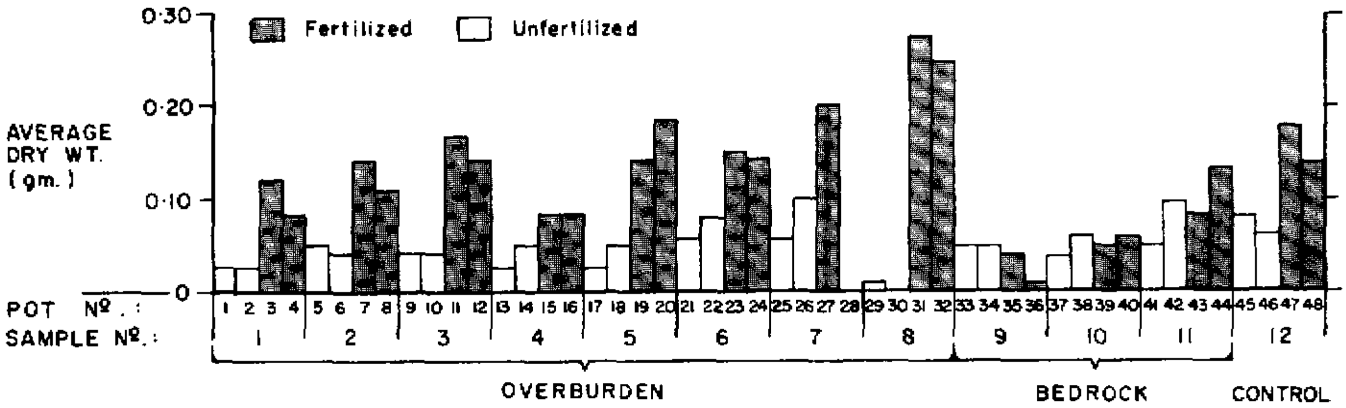


FIGURE 4A-1

GERMINATION OF BARLEY IN GROWTH CHAMBER, EXPERIMENT FOR HAT CREEK WASTE MATERIALS



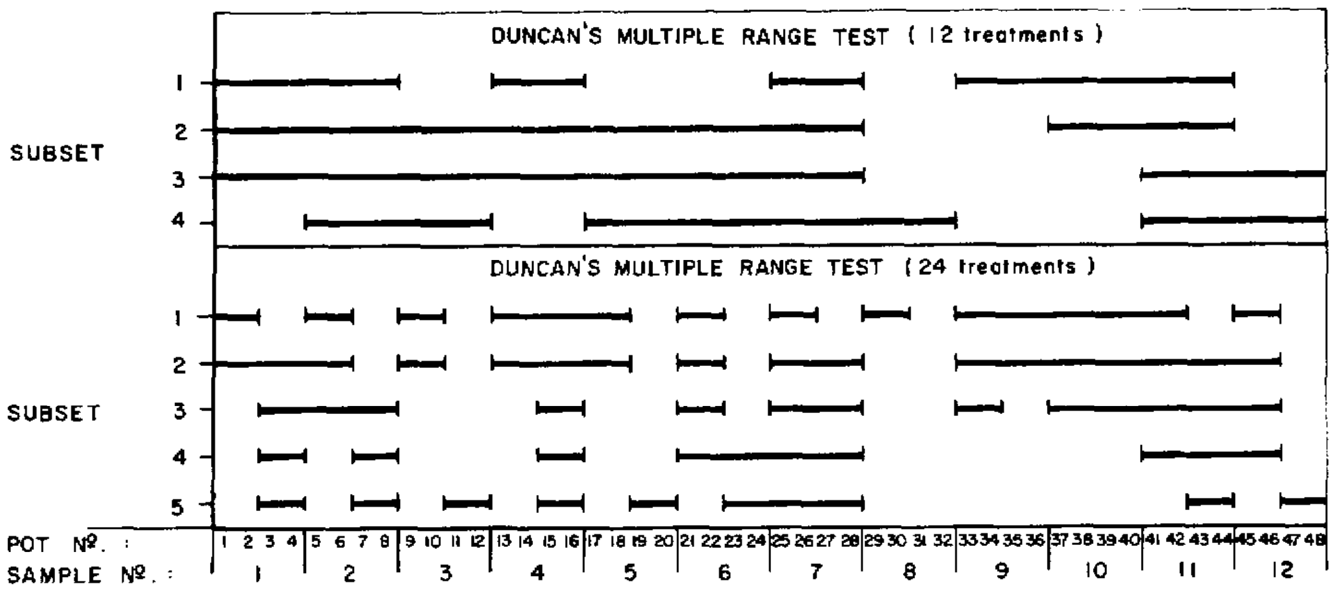


FIGURE 4A-2

AVERAGE DRY WEIGHT OF BARLEY IN GROWTH CHAMBER, EXPERIMENT FOR HAT CREEK WASTE MATERIALS

APPENDIX IV-3

POTENTIAL ASH UTILIZATION

APPENDIX IV-3

POTENTIAL ASH UTILIZATION

PRODUCTION AND UTILIZATION OF COAL ASH

Production of coal ash from generating stations in the United States in 1971, the latest year for which statistics are available, was 42 million tons. Of this total, 8.6 million tons or about 20 percent were used for various purposes. The 20 percent utilization in 1971 compares with 15 percent in 1969 and 5 percent in 1965. Table 4A-13 summarizes ash use for 1971.

TABLE 4A-13
ASH USE IN THE UNITED STATES (1971)

ASH USE	FLY ASH (TONS x 10^3)	BOTTOM ASH (TONS x 10^3)	BOILER SLAG* (TONS x 10^3)	TOTAL (TONS x 10^3)
Partial replacement of cement in:				
— structural concrete	185	—	—	185
— concrete products	177	50	77	304
— dams and other massive use	71	—	—	71
Fill Material	841	569	2858	4268
Manufacturing cement	69	—	—	69
Mixed to form cement clinker	104	—	92	196
Filler in asphalt mix	164	3	82	249
Anti-skid winter roads	83	178	166	427
Stabilizer for roads, etc.	42	8	50	100
Lightweight aggregate	179	14	—	193
Fertilizer filler	1	—	—	1
Mine fire control	129	39	—	168
Dust control	—	11	—	11
Miscellaneous	99	475	430	1004
Ash removed from sites for unknown purposes	1109	250	—	1359
Total ash use	3253	1597	3755	8605
Total ash produced	27,151	10,059	4971	42,181
Percent used	12.0	15.9	75.5	20.4

* If separated from bottom ash.

Miscellaneous ash uses for which no quantitative data are available are:

Water application — Sludge conditioning, filter aid, de-eutrophication, pesticide extenders.

Reclamation — Cover for sanitary landfills, soil conditioning.

Mining — Neutralization of mine waters, filling of underground cavities.

Forestry — Fighting forest fires.

Cement-oriented uses — Mortar cement and grouting mixes, ferrocement (boats), pumpable concrete, brick, high strength masonry products, ceramic tiles.

Insulation — Admixture with paper, acoustical blocks, space shuttle insulation.

Refractory uses — Tape for fireproofing high voltage cables, monolithic refractory shapes.

Industrial uses — Addition to foundry sand, sandblasting compounds.

Filler — Soap, paper, rubber, plastics, light-reflecting paint.

These statistics and data show that a variety of uses for ash (both fly and bottom) have been developed and that the percent utilization is increasing at an encouraging rate. It appears that, at least with respect to major uses (such as structural applications), the difficulties of use are not technical; the major problem is user acceptance. The fact that American Society for Testing and Materials (ASTM) specifications for the use of fly ash in concrete have existed since 1953 indicates the technical level that ash use has attained. However, a comparison of the projected amount of fly ash from the proposed Hat Creek development (about three million tons per year) with the total amounts used in the United States (Table 4A-13) suggests that a gigantic marketing effort would be required to sell any significant portion of the projected production. A market study or an examination of sell-or-make alternatives for ash from the Hat Creek development should be undertaken.

ALUMINA FROM COAL ASH

In addition to the established ash uses outlined in the preceding section, the possibility of using fly ash for the manufacture of alumina was examined in a recent study for B.C. Research. The results of this study can be summarized as follows:

> A survey was made of seven of the major aluminum companies in British Columbia and the U.S. Pacific Northwest to establish their possible interest in manufacturing alumina from fly ash that might be obtained from a thermal power station fuelled by Hat Creek coal. Four of these, Aluminum Company of Canada Ltd. (Alcan), Aluminum Company of America (Alcoa), Kaiser Aluminum and Chemical Corp. and Reynolds Metals Co., all expressed interest in exploring the possibility further. Of the remaining three, Martin Marietta Aluminum Corp. is interested only if a block of power for aluminum manufacture were also available; Pechiney, Ugine, Kuhlmann Developments (Intalco smelter at Bellingham, Washington) have to obtain the opinion of their parent company in France; Anaconda Aluminum Company was not contacted.
>
> The size of the aluminum industry in the western part of Canada and the United States and its alumina consumption is presented in Table 4A-14. All of the alumina requirements are presently imported from the United States Gulf Coast, the Caribbean, Africa, South America or Australia. There is no local manufacture of alumina.

TABLE 4A-14
ALUMINUM CAPACITY AND ALUMINA CONSUMPTION OF THE BRITISH COLUMBIA AND UNITED STATES PACIFIC NORTHWEST ALUMINUM INDUSTRY (1972)

COMPANY	SMELTER LOCATION	ALUMINUM METAL PRODUCTION (tpy)	ALUMINA CONSUMPTION (typ)
British Columbia			
Alcan	Kitimat	300,000	600,000
Washington			
Intalco (Pechiney)	Bellingham	260,000	520,000
Kaiser	Tacoma	81,000	162,000
	Spokane	206,000	412,000
Alcoa	Wenatchee	175,000	350,000
	Vancouver	115,000	230,000
Reynolds	Longview	200,000	400,000
Oregon			
Martin Marietta	The Dalles	90,000	180,000
	Goldendale	110,000	220,000
Reynolds	Troutdale	130,000	260,000
Montana			
Anaconda	Great Falls	180,000	360,000
	TOTAL	1,847,000	3,694,000

With the exception of a small alumina plant in Norway, all of the non-communist alumina, and hence aluminum is manufactured from bauxite. Bauxite is a plentiful mineral but its occurrence is primarily limited to tropical and semi-tropical regions. Some bauxite is mined in Alabama but the aluminum industry is dependent primarily on developing nations for bauxite. The United States imports 90 percent and Canada 100 percent of their alumina requirements either as alumina or bauxite.

Initially, bauxite was mined and transported to alumina manufacturing plants in North America. To create jobs the bauxite nations pressured the aluminum companies to process bauxite into alumina in the bauxite-source countries. Lately, pressure has been applied to have aluminum metal made in these countries as well. The most recent action, and the one the industry finds most threatening, is the imposition by Jamaica of a stiff royalty on alumina exports. Other bauxite and alumina producing countries are expected to follow suit. Jamaica increased the royalty from $2 to $11 per ton of bauxite in 1974.

The aluminum industry is concerned about the actions taken by bauxite producing nations and is engaged in a program to evaluate non-bauxite sources of alumina. Should high royalties become general and hold at this level the North American aluminum industry will look at domestic non-bauxite sources of alumina.

The level of development being evaluated by B.C. Hydro for Hat Creek coal would produce fly ash of a quality and quantity that could be of interest for the manufacture of alumina. Hat Creek may be a good location for the manufacture of alumina; it is near the coast, close to major railways and is near one of the major alumina consuming areas in the world.

The technology to recover alumina from fly ash is still being developed. One method requires large quantities of limestone and produces a by-product material suitable for cement manufacture. Another method requires large quantities of sulfuric acid. Limestone is available near Hat Creek and at several locations on the coast. The cement industry in British Columbia is interested in exploring this possible new source of raw material. Large quantities of low cost sulfuric acid could be available if a copper smelter is built in British Columbia. (One possible copper smelter location is at Clinton near Hat Creek).

Those aluminum companies that expressed interest in the project wish to have further discussions to establish B.C. Hydro's plans and timetable, to collect more data for use in their evaluations and to make B.C. Hydro aware of their requirements. Further study may suggest that consideration of possible alumina recovery should be incorporated at an early stage into Hat Creek project planning. For example, fly ash from the proposed 50,000-ton coal burning test might well be stockpiled for alumina leaching test work.

Should an alumina plant be constructed based on Hat Creek fly ash it would probably be in the size range of 800,000 to 1,000,000 tpy. The capital cost would be in excess of 200 million dollars. The plant, which would create 500 to 1000 permanent jobs, would most likely be built by a consortium of aluminum companies. As a first step, a demonstration plant of 100,000 to 200,000 tpy aluminum oxide would probably be constructed. The water requirement for alumina extraction would (for a 200,000 tpy plant) probably be of the order of 9,000-17,000 Igpm depending on the type of process used.

All the aluminum companies contacted expressed interest in eventually obtaining a block of power for aluminum metal manufacture as an adjunct to alumina manufacture. Martin Marietta made the availability of 300 megawatts of power (100,000 tpy aluminum metal) a condition for interest in processing fly ash. This company would also give serious attention to an aluminum rolling mill employing 250 to 500 people as well. An aluminum smelter of 100,000 tpy capacity would employ 500 to 1000 people.

It must be emphasized that for any company to exploit Hat Creek fly ash, the ash must have essentially a zero cost to the alumina plant.

RECOMMENDATIONS

1. Discussions should be held with:
   Aluminum Company of Canada Ltd.
   Aluminum Company of America
   Kaiser Aluminum and Chemical Corp.
   Reynolds Metals Company

to outline the plans and timetable of the proposed Hat Creek Project and those of the aluminum companies and to exchange available data for respective feasibility studies.

2. As an aid to these discussions, preliminary laboratory work should be undertaken to establish the amenability of Hat Creek shale and fly ash to various acid leaching processes. The possibility of some iron and silica rejection from shale and fly ash by gravity or flotation techniques should also be established. The deportment of those impurities important to alumina manufacture (phosphorous, iron and potassium) should be determined.

3. B.C. Hydro should give consideration in its planning on the Hat Creek Project to the possibility of alumina manufacture. This may mean an earlier adoption of coal washing than could otherwise be justified; separate stockpiling of the fly ash from the proposed 50,000-ton coal burning test; adoption of a different mining plan to assure high alumina ash.

4. Consideration should be given to an integrated aluminum industry based on Hat Creek fly ash and Hat Creek power. If such a possibility exists then Martin Marietta should be included in the list of aluminum companies to be contacted for further discussion.

ALUMINA FROM CLAY AND SHALE

Although not directly related to ash produced by a coal-fired thermal generating plant, a new development in the aluminum field, the Pechiney "H + Process", could also have an effect on the waste disposal situation at Hat Creek. This process produces alumina from clays or shales. It is expected that all new refining capacity in France will be based on this process with the first large plant scheduled to go on-stream in 1979 or 1980. This process, like the fly ash processes, depends on high bauxite prices for its viability. The energy requirement for the H+ process is about 60 percent higher than for the conventional bauxite process.

Because of this new technology, it may be feasible to use the shale which would be mined at Hat Creek for the production of alumina. Accordingly consideration should be given to possible segregation of shale suitable for an aluminum plant.

SUMMARY

Needless to say all the ash uses listed in these notes are, at least to some extent, dependent on the nature of the particular ash which would be obtained from the Hat Creek coal. The most reliable data on the nature of the ash can best be obtained from the planned test burning at another utility. Consequently, it is suggested that the ash from the test burn be stockpiled separately for use in further test work. Furthermore, considering the numerous applications for the use of coal ash, it is recommended that on-going studies be conducted on the potential economic uses of Hat Creek coal ash.

APPENDIX V-1

ATMOSPHERIC DISPERSION OF GASEOUS EFFLUENTS IN COMPLEX TERRAIN

APPENDIX V-1

ATMOSPHERIC DISPERSION OF GASEOUS EFFLUENTS IN COMPLEX TERRAIN

The environmental impact of gaseous emissions is determined by their ambient concentration near ground level. For reasonably flat terrain, which is isolated from the influence of mountains or large bodies of water, theoretical methodology exists which allows fairly reliable estimates of ground level pollutant concentration to be made. There is presently no reliable method for predicting the dispersion of gaseous emissions in areas of complex topography. However, if some of the topographically induced phenomena are considered then it may be possible to identify some of the sites considered which could lead to high ambient pollutant levels. The following paragraphs contain a very simplified description of some of the more important phenomena.

Upper (geostrophic) winds are channeled by mountain valleys and passes. The preferred direction of channeling is in a counterclockwise orientation to the geostrophic wind. Generally, valley winds are lighter than those near mountain peaks, although when funneled through passes they can become relatively strong. Winds which pass over the flank of a mountain tend to downwash to the valley below. If the wind is sufficiently strong or if the terrain is very abrupt, a large circulating air pattern (eddy) will be established on the lee side of the mountain. Hence, gaseous effluents will become partially trapped and will thus accumulate if they are discharged into such a zone.

Another important factor is that temperature decreases with elevation and hence high altitude sites are colder than those at lower altitudes. The vertical temperature profile strongly influences the degree of turbulence and hence the dispersion capabilities of the atmosphere. Under certain conditions the temperature can actually increase with altitude; this is known as an inversion and results in a strong suppression of atmospheric turbulence and hence much reduced gaseous effluent dispersion. If this inversion is elevated it forms a lid under which pollutants can accumulate, as happens in the Los Angeles area and to a lesser extent, in the Burrard Inlet area of Vancouver. By the same token the gaseous effluents released above such a lid could be effectively prevented from returning to ground level unless, of course, they encounter a mountain peak. A large power plant plume emitted sufficiently close to the base of the inversion lid would frequently have sufficient thermal buoyancy to penetrate the inversion layer. If, however, the plume becomes embedded within a stable inversion layer, then dispersion is minimized and impingement against the side of a nearby mountain could lead to locally high pollutant concentrations. A plume convected by unstable air tends to rise over such topographical features and hence ambient concentrations are lower.

As previously stated, valley winds are generally lighter than geostrophic winds, due to a slowing down by surface friction. It is not uncommon to have calms prevail in a valley location while fairly brisk winds exist in an adjacent region. For example, when polar continental air funnels down into Georgia Strait it produces the "Squamish" with attendant strong easterly winds through the Fraser Valley. At the same time the concurrent winds in Burrard Inlet are often light and variable. Hence extreme caution must be exercised when applying surface wind data obtained from one area to a different but nearby area.

A further complication in topographically complex regions, when the geostrophic winds are light, is a diurnal effect caused by surface heating due to solar radiation during the day and by surface cooling due to long-wave radiation during the evening. As the ground cools by radiating heat off into space, it tends to cool the layer of air near the surface. On flat terrain this cooling results in a surface based inversion since air temperature will increase with height. These nocturnal inversions are frequently accompanied by the presence of fog if the daytime humidity was high. In mountainous terrain the relatively cold surface layer of air, being denser than the air above it, will sink and hence flow downhill and tend to fill a valley below. If the valley opens out to a lower plain then the resultant valley drainage wind can attain a speed in the order of 4 to 8 knots. If, on the other hand, the valley is bowl shaped, then this dense, stable layer will deepen until morning sunlight again heats the ground. Obviously gaseous effluents emitted into this stable layer could become trapped and hence accumulate at some distance above the point of discharge. Since our hypothetical valley is partially filled with dense, stable air, the upper winds will flow over it and anemometers near the ground will indicate little or no wind. This phenomenon helps to explain the high incidence of calms recorded in Interior valley locations. For instance, the town of Ashcroft, located in a deep, narrow valley carved by the Thompson River, experiences calms 40 percent of the time.

Morning sunlight, heating the ground below this mass of cold, stable air, warms the surface layer of air and results in strong vertical mixing. This unstable layer will continue to thicken and to erode the base of the stable layer as solar energy is convected aloft. If this unstable layer reaches a blanket of accumulated pollutants, then the strong vertical mixing will bring the pollutants down to the ground and result in a temporary fumigation condition with attendant high ground level concentrations.

Later on in the day, in the absence of an appreciable geostrophic wind, the inversion condition will, to a large extent, have been destroyed and a vertical circulation pattern will tend to form. Ideally, in an elongated valley, the heated air on the sides of the valley will rise up and be displaced by cooler air subsiding in the center of the valley. As this air sinks it compresses (becomes more dense) and hence heats, which leads to the possibility of a weak subsidence inversion elevated above the center of the valley. Hence the buoyant rise of a smoke plume emitted near the center of the valley will be suppressed and could possibly be carried down and against the sides of the valley. This phenomenon is probably more applicable to a relatively small and cool plume than to that from a large thermal power station.

From the above discussion it can be concluded that certain geographic locations would be less suitable for the discharge of gaseous effluents than others. Deep narrow valleys could lead to rapid pollutant accumulation during periods of light wind and temperature inversion. The same valley, if oriented perpendicular to strong prevailing winds, could experience pollutant trapping in a lee side eddy. Broad, shallow valleys, on the other hand, generally result in better dispersion for power plant emissions. This is partly because inversions tend to be shallower and hence there is a greater probability that the stack plume will penetrate the inversion. This is especially true if cold air can drain down out of the valley and hence not accumulate. Also there is less likelihood of the plume impinging against a nearby mountainside before it has had an opportunity to disperse to a low concentration.

It can be appreciated that it is extremely difficult to arrive at a reliable estimate of gaseous dispersion above complex terrain. Good historical data are required on the frequency of occurrence and on the important parameters of inversions, on the nature of wind trajectories within and above the valleys, on the effects of lapse rate and mechanically induced turbulence on dispersion parameters, and on the specific local diurnal phenomena. The collection of these data is both time-consuming and very expensive. In lieu of it only very approximate estimations can be carried out.

APPENDIX V-2

ENVIRONMENTAL EFFECTS OF ATMOSPHERIC CONTAMINANTS

APPENDIX V-2

ENVIRONMENTAL EFFECTS OF ATMOSPHERIC CONTAMINANTS

In the past man's knowledge of the effects of air pollution has been limited to what he could see or taste. Recently there has been a tremendous amount of research focused on this problem and many questions are being resolved. But the subject is complex and the environmental stress caused by individual pollutants, and the synergism occurring between pollutants and other stress factors, are not yet fully understood. The following sections will highlight some of these considerations.

1. OXIDES OF SULPHUR

Sulphur, a major element of seawater, is essential to the more advanced forms of life on this earth. Fossil fuels, naturally enough, contain this element in varying degrees of concentration and when combined with oxygen release oxides of sulphur. These sulphur oxides will mainly be in the form of sulphur dioxide (SO_2). In the atmosphere this gas is photochemically and catalytically converted to sulphuric acid and its salts. These reaction products are eventually removed from the atmosphere through the natural scrubbing action of precipitation, rain, snow and hail. Some authors[1,2] have argued that sulphur salts such as ammonium sulphate are plant nutrients and hence that the net effect of SO_2 emissions is beneficial to the ecology, but the bulk of the evidence[3,4] indicates that SO_2, at least at high concentrations, has in fact detrimental effects.

(a) EFFECT OF SULPHUR DIOXIDE ON VEGETATION

In general, plants are more susceptible to injury arising from high concentrations of this gas than are humans. Work done by Dreisinger and McGovern[5] in the Sudbury area points out that it is not the average levels of gas in the air that constitute a threat but the incidence of what are called potentially injurious fumigations. They assigned an intensity factor of 100 for each of various SO_2 dosages on the following basis:

0.95 ppm for 1 hour,
or 0.55 ppm for 2 hours,
or 0.35 ppm for 4 hours,
or 0.25 ppm for 8 hours.

The above dosages correspond to recorded plant exposures which, if equalled or exceeded, could result in damage. In a few instances during the months of June and July when hot, humid weather prevailed and hence produced conditions extremely favorable for a high photosynthetic rate, it was noted that some very sensitive species were injured with levels approximately 25 percent less than these.

TABLE 5A-1
MINIMAL AVERAGE SO_2 CONCENTRATIONS RECORDED AFTER WHICH INJURY TO VEGETATION WAS OBSERVED IN VARIOUS SPECIES AND MAXIMUM INTENSITIES TO WHICH THE SPECIES WERE EXPOSED AT OTHER TIMES WITH NO RESULTANT INJURY

SPECIES	MAXIMUM AVERAGE CONC. (ppm) FOR 1 hr	2 hr	4 hr	8 hr	LOWER INTENSITY TOLERANCE	MAXIMUM INTENSITY TO WHICH SPECIES EXPOSED WITH NO RESULTANT INJURY
		— Agricultural Species —				
Buckwheat	0.56	0.39	0.26	0.15	74	204
Barley	0.63	0.44	0.24	0.12	80	166
Red Clover	0.70	0.46	0.27	0.14	84	332
Radish	0.76	0.54	0.29	0.14	98	276
Oats	0.63	0.59	0.34	0.17	107	294
Peas	0.63	0.59	0.34	0.17	107	276
Rhubarb	0.63	0.59	0.34	0.17	107	276
Timothy	0.66	0.54	0.40	0.21	114	240
Swiss chard	0.88	0.64	0.42	0.27	120	268
Beans	0.46	0.45	0.43	0.21	123	272
Beets	1.31	0.77	0.45	0.23	140	272
Turnips	1.31	0.77	0.45	0.23	140	272
Carrots	1.08	0.79	0.50	0.25	144	276
Cucumbers	1.08	0.79	0.50	0.25	144	276
Lettuce	0.64	0.56	0.43	0.38	152	276
Tomatoes	0.64	0.56	0.43	0.38	152	272
Potatoes	0.64	0.56	0.43	0.38	152	332
Raspberry	0.74	0.63	0.53	0.39	156	332
Celery	0.87	0.74	0.55	0.29	157	240
Spinach	1.34	0.91	0.50	0.34	166	276
Cabbage	0.94	0.89	0.70	0.45	200	332
Corn		Never injured*			—	294
		— Forest Species —				
Trembling aspen	0.42	0.39	0.26	0.13	74	473
Jack pine	0.52	0.44	0.29	0.20	83	143
Bracken fern	0.45	0.34	0.25	0.21	84	209
White birch	0.46	0.38	0.28	0.21	84	473
White pine	0.45	0.35	0.25	0.21	84	224
Larch	0.41	0.38	0.34	0.26	104	160
Large-toothed aspen	0.66	0.43	0.37	0.20	106	473
Willow	0.41	0.38	0.33	0.30	120	332
Alder	0.46	0.43	0.43	0.21	123	332
Red pine	0.78	0.69	0.44	0.30	126	473
Balsam poplar	0.82	0.65	0.45	0.26	128	332
Australian pine	0.66	0.45	0.44	0.33	132	473
Witch hazel	1.14	0.75	0.45	0.23	136	192
Red oak	0.89	0.82	0.61	0.41	175	473
Sugar maple	0.82	0.65	0.62	0.46	184	473
White spruce	0.87	0.79	0.70	0.50	200	473
Cedar		Never injured*				

* Near recorder stations.

The findings of Dreisinger and McGovern[5] are summarized in Table 5A-1. Note that buckwheat and trembling aspen, the two most sensitive species, each have the low intensity factor tolerance of 74. If this value is used as the intensity factor which should not be exceeded in the proposed generating station area, the following maximum SO_2 dosage levels evolve:

0.70 ppm for 1 hour,
or 0.40 ppm for 2 hours,
or 0.26 ppm for 4 hours,
or 0.18 ppm for 8 hours.

The SO_2 sensitive plants found in the Hat Creek area are shown in Table 5A-2. The occurrence of trembling aspen justified the choice of 74 as the lower intensity factor tolerance for this project.

TABLE 5A-2
LIST OF SO_2-SENSITIVE PLANTS IN THE HAT CREEK AREA

POPULAR NAME	SCIENTIFIC NAME	LOWER INTENSITY TOLERANCE
Trembling aspen	*Populus tremuloides*	74
Yellow pine	*Pinus ponderosa*	*
Lodgepole pine	*Pinus contorta*	83
Birch	*Betula sp.*	84
White pine	*Pinus monticola*	84
Spruce	*Picea sp.*	200**
Willows	*Salix sp.*	120

* *Sensitivity noted during a sulphur dioxide railroad tank-car spill at Kamloops.*

** Sensitivity derived from White Spruce exposed in the Sudbury area.

While these results are applicable to the Sudbury area the question arises as to their validity in other areas where plant growth may not be as vigorous. Recent research by Hill et al[6] was aimed at determining air pollution injury potential to native vegetation as a result of constructing large coal-fired power plants in the southwestern desert areas of the U.S.A. Fumigation studies were conducted with portable chambers placed over native species in the field with SO_2, and SO_2 plus NO_2. Each fumigation was of two hours duration and the concentration ranged from 0.5 to 11 ppm SO_2 and from 0.1 to 5 ppm NO_2. They concluded that no synergism occurred between SO_2 and NO_2 at the ratio used (NO_2/SO_2 = 0.28) and that most of the plants studied required more than 2 ppm SO_2 for two hours to produce injury. This is equivalent to a dosage intensity factor of 360. It is interesting to note that *Populus tremuloides* (Trembling aspen) required a fumigation of 4 ppm SO_2 before significant injury occurred, whereas the Dreisinger study[5] showed that this species was very sensitive to this gas. This discrepancy may be due to the presence of acidic aerosol in the Sudbury study, where atmospheric photochemical and catalytic reactions would certainly occur. It is known[7] that there is a strong synergism between ozone and SO_2 in their ability to cause plant damage. A team of researchers from the University of Maryland recently used aircraft to follow the plume of a power generating plant for distances up to 90 miles[8]. Their tentative results indicate that power plants may be net producers of ozone at large distances from the stack. Initially, ambient ozone was depleted due to conversion of nitric oxide to nitrogen dioxide while at further distances ozone formation occurred due to the photochemically initiated free-radical interaction of nitrogen oxides and sulfur dioxide. These conclusions tend to substantiate Dreisinger's investigations where it was found that certain plant species are very sensitive to ambient SO_2 levels.

(b) EFFECT OF SULPHUR DIOXIDE ON MAN

The effects of sulphur dioxide on humans and animal life can be delineated into discomfort effects and damaging effects. In the former category the threshold for taste is commonly considered to be at 0.3 ppm, characteristically lower than the odor threshold, which is about 0.5 ppm. These thresholds are for the average human who had no prior exposure, and will increase with increased exposure time.

Whether or not these noticeable effects can be classified as discomforting depends upon the subjective sensitivity of individuals. It has been reported that a 10-minute exposure at 1 ppm increased respiratory and pulse rates in man, while a slightly higher concentration (1.6 ppm) for a few minutes was considered a threshold for inducing bronchoconstriction in unimpaired individuals. Hence it would appear that sulphur dioxide concentrations in excess of 1 ppm could be classified as discomforting.

Available data on the physiological effects of SO_2[3,4] indicate that this pollutant is relatively innocuous: one report states that no adverse effects on health could be found when industrial workers, who had been exposed to daily SO_2 concentrations of from 1 to 25 ppm for a period of from 1 to 19 years, were medically examined. Another source states that chronic effects of higher incidence of nasopharyngitis, cough, expectoration, shortness of breath and other signs of respiratory distress have been observed in industrial workers exposed for years to SO_2 concentrations up to 36 ppm. It is unlikely that SO_2 , by itself, can be considered hazardous when short term concentrations are in the order of 1 ppm.

There is however, a synergistic effect between SO_2 and aerosols (particulates) which greatly enhances the physiological impact of SO_2[4]. This could be due to SO_3 forming sulphuric acid after being absorbed by the particulate. (Catalysis can be effected by trace materials such as vanadium and the alkali metal salts.) Urban air pollution episodes may arise when SO_2 exceeds 0.2 ppm on a 24-hour average. These episodes resulted in an increase in the mortality rate accompanied by an increase in hospital admissions for acute illness. Those predominantly affected were individuals with chronic pulmonary disease or cardiac disorders, or very young or very old individuals.

(c) REGIONAL EFFECTS OF SULPHUR DIOXIDE

The above two sections examined some of the more immediate effects of sulphur oxide emissions upon the environment. As a pollutant this gas can be transported hundreds of miles before it is deposited in the form of an acidic rain or snow. Much of the increase in the acidity of Scandinavian lakes has been attributed to emissions from industrial Europe. A similar effect has been observed in the northeastern United States, and in lakes west of the Sudbury smelters. Serious fish mortality has been attributed directly to this increased acidity[9]. Hence caution must be used when resorting to tall stacks in order to reduce local pollutant levels. For very large SO_2 emissions in regions where the environment cannot assimilate the resultant sulphates, serious impacts could result. These effects are discussed in some detail in reference 9.

2. NITROGEN OXIDES

Nitrogen oxides are created during the combusion process; their formation is favoured by high temperatures and excess air. The major reason for the importance of nitrogen oxides as pollutants is their participation in photochemical reactions which produce ozone and the peroxyacyl nitrates (PANS), two highly phytotoxic oxidants.

It is generally accepted that nitrogen oxides act as smog precursors in heavily polluted atmospheres containing relatively high concentrations of hydrocarbons. Since a modern highly efficient power plant produces insignificant hydrocarbon it is felt that smog will not be a problem. Perhaps of more importance is the previously cited speculation[8] that power plants can produce ozone levels considerably higher than ambient values at large distances from the stack.

(a) EFFECT OF NITROGEN OXIDES ON VEGETATION

In addition to its role in producing ozone and PAN in the presence of light and hydrocarbons, nitrogen dioxide alone injures vegetation. The injury threshold for this gas is given[7] as 2.5 ppm for a 4 hour exposure. The same reference cites an ozone threshold of 0.03 ppm and a PAN threshold of 0.01 ppm.

(b) EFFECT OF NITROGEN OXIDES ON MAN

For pure NO_2 the range of odor threshold is reported to be 1 to 3 ppm. Workers exposed to mixed oxides of nitrogen and nitric acid fumes, and inured to vapors, voiced no complaints from exposures ranging from 5 to 30 ppm, and averaging 20 ppm for periods up to 18 months; and periodic medical examinations failed to reveal any evidence of characteristic adverse effects[3]. For industrial workers the threshold limit value for this gas, as adopted by the American Conference of Governmental Industrial Hygienists, is 5 ppm.

3. PARTICULATES

Particulates are the solid emissions from a stack. In the case of a coal fired power plant they consist of unburned carbon particles (soot) and the inorganic ash (fly ash) contained in the fuel. In the past the black plume emanating from a power plant was a highly obvious form of air pollution.

Modern engineering has largely eliminated this unsightly plume but complete control is technologically impossible. The obvious effect of these emissions is the impairment of visibility by fine particulate matter and the resultant reduction of solar radiation. Less obvious is the role in inadvertent weather modification due to the atmospheric nucleation phenomena[10], which can lead to a higher incidence of precipitation, fog, and ice fog.

The biological significance of particulate emissions from power plants arises mainly from two things: their role in catalytically oxidizing SO_2 to sulfates and to acid aerosol; and the toxicity of some of their associated trace elements. As previously discussed, there is a synergistic effect between SO_2 and certain particulates which greatly enhances the physiological impact of SO_2.

The biological effect of trace elements is mainly due to their accumulation in the body to levels where adverse physiological effects occur, as the human body contains all trace elements in varying amounts. Elements such as arsenic, beryllium, cadmium, lead, and mercury are known to be a hazard due to their buildup by modern technology. On the other hand, it is felt[11] that we generally have too little selenium, molybdenum, iodine, cobalt, vanadium, and chromium.

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APPENDIX V-3

HYDROLOGY, WATER QUALITY AND WATER LICENSES

APPENDIX V-3

HYDROLOGY, WATER QUALITY AND WATER LICENSES

TABLE 5A-3
DISCHARGE FIGURES (cfs)* FOR HAT CREEK, BONAPARTE RIVER AND THOMPSON RIVER

Year	HAT CREEK 08LF015					BONAPARTE RIVER 08LF060					THOMPSON RIVER AT SPENCES BRIDGE 08LF022				
	Minimum Monthly Average	Daily Minimum	Maximum Monthly Average	Daily Maximum	Annual Mean	Minimum Monthly Average	Daily Minimum	Maximum Monthly Average	Daily Maximum	Annual Mean	Minimum Monthly Average	Daily Minimum	Maximum Monthly Average	Daily Maximum	Annual Mean
1963	10.0 (Sept)	7.7 (Nov 23)	93 (Jun)	213 (May 23)	32	62 (Nov)	52 (Jan 11)	345 (May)	388 (June 6)	163	9390 (Mar)	7580 (Feb 2)	68400 (Jun)	75000 (Jun 22)	24700
1964	10.0 (Feb)	9.0 (Feb 27)	340 (Jun)	700 (Jun 12)	54	55 (Jan)	54 (Jan 5)	492 (Jun)	761 (Jun 20)	172	5970 (Mar)	5670 (Mar 28)	103000 (Jun)	124000 (Jun 19)	31500
1965	12.0 (Dec)	9.4 (Dec 29)	93 (Jun)	154 (May 29)	32	—	—	—	567 (May 15)	—	8020 (Mar)	6800 (Dec 31)	80500 (Jun)	95500 (Jun 15)	25700
1966	7.5 (Feb)	7.1 (Feb 11)	81 (Jul)	169 (Mar 29)	36	70 (Jan)	32 (Dec 8)	351 (Jul)	495 (Jul 29)	183	6780 (Mar)	6560 (Mar 25)	77600 (Jun)	86900 (Jun 13)	27100
1967	5.3 (Sept)	2.9 (Oct 8)	181 (Jun)	508 (Jun 5)	35	21 (Sept)	14 (Dec 18)	563 (May)	800 (May 12)	149	7420 (Mar)	7280 (Mar 21)	106000 (Jun)	122000 (Jun 24)	29100
1968	11.0 (Feb)	9.5 (Feb 20)	117 (Jun)	179 (Jun 10)	28	38 (Jan)	24 (Jan 29)	557 (Jun)	778 (Jun 2)	142	9780 (Jan)	7740 (Jan 12)	92900 (Jun)	104000 (Jun 14)	32200
1969	9.5 (Jan)	7.2 (Mar 8)	108 (May)	236 (May 25)	29	81 (Jan)	72 (Jan 1)	812 (May)	991 (May 6)	269	7060 (Mar)	6760 (Mar 15)	83200 (Jun)	97100 (Jun 9)	29500
1970	5.1 (Oct)	5.0 (Nov 21)	25 (Jun)	39 (Jun 7)	11	33 (Dec)	28 (Dec 20)	219 (May)	254 (May 13)	100	6640 (Dec)	5940 (Dec 24)	71200 (Jun)	89600 (Jun 9)	19900
1971	—	—	118 (May)	201 (Jun 3)	—	36 (Dec)	22 (Jan 9)	828 (Jun)	970 (Jun 17)	222	6620 (Jan)	5460 (Jan 12)	101000 (Jun)	119000 (Jun 10)	30000
1972	9.0 (Dec)	7.4 (Dec 19)	191 (Jun)	308 (Jun 1)	38	40 (Dec)	36 (Dec 19)	221 (May)	905 (May 27)	86	7330 (Feb)	6670 (Mar 4)	124000 (Jun)	146000 (Jun 15)	32800
1973	4.4 (Aug)	3.7 (Aug 1)	37 (May)	92 (May 20)	12	36 (Dec)	21 (Dec 31)	738 (May)	245 (May 8)	206	7540 (Feb)	7360 (Jan 12)	67300 (Jun)	87500 (Jun 28)	23400

* From Water Survey of Canada Printouts

TABLE 5A-4
FRASER RIVER — FLOW RATES

Information from Water Survey of Canada

Station No. 08 MF 040

Location: Above Texas Creek — 14 miles west of Upper Hat Creek

Period of Record: Since 1951

Mean Annual Discharge
for Period 1951-1972 — 65,870 cfs = *24,620,000 Igpm*

EXTREMES IN PERIOD 1951-1972	TIME RECORDED	cfs	Igpm
Max Monthly Mean	June 1964	229,000	85,885,000
Min Monthly Mean	Jan. 1953	11,200	4,185,000
Max Daily Mean	20 June 1964	226,000	99,415,000
Min Daily Mean	16 Jan. 1953	11,100	4,150,000
Max Instantaneous	21 June 1964 at 0045 PST	269,000	100,535,000

TABLE 5A-5
THOMPSON RIVER NEAR SPENCES BRIDGE —
EXTREMES OF DISCHARGE IN PERIOD 1911-1972

EXTREME	TIME RECORDED	cfs	Igpm
Max Monthly Mean	June 1972	124,000	46,345,000
Min Monthly Mean	March 1917	4,410	1,650,000
Max Daily Mean	{ 3 June 1948 / 15 June 1972 }	146,000	54,565,000
Min Daily Mean	8 Jan 1973	4,100	1,530,000
Max Instantaneous	15 June 1972 at 0900 PST	146,000	54,565,000

TABLE 5A-6
THOMPSON RIVER — FLOW RATES

INFORMATION FROM WATER SURVEY OF CANADA

Period of Record	Station No.	Location
1911-1951	08 LF 022	at Spences Bridge
since 1951	08 LF 051	near Spences Bridge

MONTH	MEAN MONTHLY DISCHARGES FOR PERIOD 1911-1972	
	cfs	Igpm
January	7,490	3,000,000
February	7,593	2,840,000
March	7,753	2,900,000
April	12,150	4,540,000
May	55,150	20,610,000
June	97,250	36,345,000
July	66,900	25,005,000
August	35,525	13,275,000
September	21,933	8,195,000
October	16,025	5,990,000
November	12,575	4,700,000
December	9,330	3,485,000

Mean Annual Discharge for Period 1911-1972: 29,140 cfs = *10,890,000 Igpm*

TABLE 5A-7
DESCRIPTION OF SAMPLING LOCATIONS

0600004 — (08LF033)	Thompson River at Savona Lat. 50-45-45 Long. 120-52-00 at west bank, 50 yards N. of bridge
0600005 — (08LF022)	Thompson River at Spences Bridge Lat. 50-30-50 Long. 121-17-30 at mid-stream from highway bridge
0600008 — (08LF060)	Bonaparte River below Cache Creek Sewage Treatment Plant Lat 50-47-50 Long. 121-18-40 at midstream 200 yards below outfall
PE00264 —	Village of Cache Creek Sewage Treatment Plant average daily flow — 120,000 Igpd could be expected to double in summer
0600009 —	Clinton Creek at mouth Lat 51-06-45 Long. 121-29-00 downstream of bridge
0600017 —	Bonaparte River above Clinton Creek Lat. 51-06-55 Long. 121-28-30 midstream off bridge
0600073 — (08LF015)	Hat Creek at mouth Lat. 50-50-30 Long. 121-20-50 by highway at Carquile
0300117 —	Fraser River at Lillooet

TABLE 5A-8

SUMMARY OF WATER QUALITY DATA* FOR HAT CREEK, BONAPARTE RIVER, THOMPSON RIVER, FRASER RIVER

ANALYTICAL MEASUREMENTS	HAT CREEK AT MOUTH (0600073)		BONAPARTE RIVER BELOW CACHE CREEK SEWAGE TREATMENT PLANT (0600008)		THOMPSON RIVER NEAR SAVONA (0600004)		FRASER RIVER AT LILLOOET (0300117)	
	MINIMUM (date)	MAXIMUM (date)	MINIMUM (date)	MAXIMUM (date)	MINIMUM (date)	MAXIMUM (date)	MINIMUM (date)	MAXIMUM (date)
Alkalinity (mg/l)	193 (4/5/74)	275 (20/11/73)	111 (16/5/72)	288 (18/11/71)	28 (10/7/73)	45 (8/1/74)	38 (11/5/72)	85 (30/1/74)
pH	8.5	9.0	7.8	8.9	6.8	7.7	7.8	8.1
Hardness (mg $CaCO_3$/l)	196 (4/5/74)	288 (20/11/73)	258 (2/11/73)		30 (10/7/73)	44 (29/4/74)	55 (11/7/72)	89 (21/3/74)
Dissolved Solids (mg/l)	284 (4/5/74)	378 (22/11/72)	178 (3/5/72)	362 (1/1/74)	46 (15/8/73)	72 (7/12/72)	70 (28/8/72)	130 (30/1/74)
Suspended Solids (mg/l)	2 (12/2/73)	68 (4/5/74)	1 (18/11/71)	310 (16/5/72)	< 1 (18/11/71)	9 (19/6/72)	2 (30/1/74)	478 (11/5/72)
Specific Conductance (µmhos/cm)	440 (4/5/74)	590 (4/2/74)	220 (16/5/72)	580 (1/1/74)	71 (10/7/73)	225 (25/4/72)	110 (11/7/72)	204 (21/3/74)
Turbidity (Jackson Units)	1.5 (22/11/72) (19/2/73)	29 (4/5/74)	0.8 (2/11/73)	70 (16/5/72)	0.8 (4/4/73)	3.2 (8/5/74)	4.1 (18/1/73)	95 (11/5/72)
Dissolved Oxygen (% Saturation)	50		43 (12/3/74)	125 (12/9/73)	40 (18/10/73)	85 (14/3/74)	65 (4/12/72)	105 (11/7/72)
Temperature (°C)	1 (19/2/73)	15 (15/8/73)	0 (9/1/74)	15 (2/11/73)	0 (8/1/74)	18 (15/8/73)	0 (4/12/72)	18 (11/7/72)
Sulphate (mg/l)	52	58	15	58	< 5	10	< 5	14
Chloride (mg/l)	1.8	2.3	0.8	4.4	0.5	2.5	0.8	5.0
Nitrate (mg N/l)	< 0.02	0.07	< 0.02	0.5	0.05	0.22	0.02	0.18
Kjeldahl N (mg/l)	0.10	0.19	< 0.01	0.6	< 0.01	0.17	0.02	0.5
ortho-Phosphate (mg P/l)	0.012		0.01	0.08	< 0.003	0.009	< 0.003	0.018
Dissolved Heavy Metals (µg/l)	< 1	5	< 5	20	< 1	5	< 1	520 (Fe)

* Pollution Control Branch, B.C. Water Resources Service.

TABLE 5A-9
WATER LICENCES ON HAT CREEK AND BONAPARTE RIVER
(SEE FIGURE 5A-1 FOR LOCATIONS

LICENSEE NO.	LOCATION	WATER SOURCE	DATE	VOLUME	PURPOSE
1	I.R. #1	Hat Creek	Sept. 1888	1500 gpd	Irrigation
2	L.279	Hat Creek	Mar. 1894	500 gpd	Irrigation
3	I.R. #2	Hat Creek	Sept. 1888	1500 gpd	Irrigation
4	L.94	Hat Creek	Jan. 1871	1500 gpd	Irrigation
5	L.94	Bonaparte R.	May 1931	398.1 ac ft	Irrigation
6	L.91	Bonaparte R.	May 1892	168 ac ft	Irrigation
7	L.91, 92	Bonaparte R.	April 1933	75 ac ft	Irrigation
8	L.90, 91, 92	Bonaparte R.	April 1872	1000 gpd	Irrigation and domestic
9	I.R. #3	Bonaparte R.	Sept. 1888	135.9 ac ft	Irrigation
10	I.R. #3	Bonaparte R.	July 1963	2500 gpd	Domestic
11	L.1071	Bonaparte R.	Oct. 1920	73.5 ac ft	Irrigation
12	L.1071	Bonaparte R.	Feb. 1921	17 ac ft	Irrigation
13	L.1071	Bonaparte R.	Nov. 1966	30 ac ft	Irrigation
14	L.102	Bonaparte R.	Dec. 1871	500 gpd	Irrigation and domestic
15	L.102	Bonaparte R.	Mar. 1966	45 ac ft	Irrigation
16	Village of Cache Creek	Bonaparte R.	July 1968	700,000 gpd	Waterworks
17	L.103	Bonaparte R.	May 1940	30 ac ft	Irrigation
18	S.18,Tp.21,R.24	Bonaparte R.	Dec. 1908	500 gpd	Irrigation and domestic
19	S.18,Tp.21,R.24	Bonaparte R.	Nov. 1964	300 ac ft	Irrigation
20	L.5189	Bonaparte R.	Dec. 1950	1000 gpd	Domestic
21	L.377	Bonaparte R.	Apr. 1918	538 ac ft	Irrigation
22	L.377	Bonaparte R.	June 1962	500 gpd	Domestic
23	L.377	Bonaparte R.	Nov. 1964	750 ac ft	Irrigation
24	L.377	Bonaparte R.	Nov. 1964	2500 gpd	Domestic
25	S.8,Tp.21,R.24	Bonaparte R.	Jan. 1909	500 gpd	Irrigation and domestic
26	S.8,Tp.21,R.24	Bonaparte R.	June 1931	30 ac ft	Irrigation
27	S.5,Tp.21,R.24	Bonaparte R.	Nov. 1949	90 cfs	Power
28	S.4,Tp.21,R.24	Bonaparte R.	Nov. 1952	360 ac ft	Irrigation
29	L.406	Bonaparte R.	April 1940	180 ac ft	Irrigation
30	S.33,Tp.20,R.24	Bonaparte R.	July 1954	2000 gpd	Domestic
31	S.33,Tp.20,R.24	Bonaparte R.	July 1954	180 ac ft	Irrigation
32	S.33,Tp.20,R.24	Bonaparte R.	July 1954	414 ac ft	Irrigation
33	S.33,Tp.20,R.24	Bonaparte R.	Mar. 1955	7.5 ac ft	Irrigation
34	S.33,Tp.20,R.24	Bonaparte R.	May 1962	18 ac ft	Irrigation
35	L.378	Bonaparte R.	Aug. 1921	442.5 ac ft	Irrigation
36	L.378	Bonaparte R.	July 1954	15 ac ft	Irrigation
37	Via Oregon Jack Cr.	Hat Cr.	Apr. 18, 1871	41 ac ft	Irrigation
38	Via Oregon Jack Cr.	Hat Cr.	Apr. 18, 1871	388 ac ft	Irrigation
39	Via Oregon Jack Cr.	Medicine Cr.	Nov. 19, 1877	361 ac ft	Irrigation
40	Via Oregon Jack Cr.	Medicine Cr. & Cornwall	Nov. 19, 1877	300 ac ft	Storage
41	Via Oregon Jack Cr.	Hat Cr.	Jun. 1, 1883	703 ac ft	Irrigation
42	Hat Cr. Basin	Robertson Cr.	Nov. 4, 1883	46.5 ac ft	Irrigation
43	Hat Cr. Basin	McDonald Cr.	Oct. 19, 1885	82 ac ft	Irrigation
44	Hat Cr. Basin	Hat Cr.	Mar. 9, 1894	115 ac ft	Irrigation
45	Hat Cr. Basin	McCormick Cr.	Sep. 1, 1894	225 ac ft	Irrigation
46	Hat Cr. Basin	Hat Cr.	Oct. 9, 1894	128 ac ft	Irrigation
47	Hat Cr. Basin	Hat Cr.	Feb. 16, 1897	171 ac ft	Irrigation
48	Hat Cr. Basin	Anderson Cr.	Mar. 2, 1903	225 ac ft	Irrigation
49	Hat Cr. Basin	Ambusten Cr.	Apr. 10, 1905	96 ac ft	Irrigation
50	Hat Cr. Basin	Lloyd Cr.	May 4, 1911	86 ac ft	Irrigation
51	Hat Cr. Basin	Lloyd Cr.	May 4, 1911	16 ac ft	Irrigation
52	Hat Cr. Basin	Darough Cr.	May 15, 1911	82 ac ft	Irrigation

Table 5A-9 Continued

LICENSEE NO.	LOCATION	WATER SOURCE	DATE	VOLUME	PURPOSE
53	Hat Cr. Basin	Yet Cr.	Sep. 15, 1911	10 ac ft	Irrigation
54	Hat Cr. Basin	Pocock Cr.	Apr. 11, 1912	91 ac ft	Irrigation
55	Hat Cr. Basin	Darough Cr.	Apr. 18, 1912	20 ac ft	Irrigation
56	Hat Cr. Basin	Colley Cr.	Jun. 18, 1912	39 ac ft	Irrigation
57	Hat Cr. Basin	Pocock Cr.	Jun. 18, 1912	66½ ac ft	Irrigation
58	Hat Cr. Basin	Darough Cr.	Jul. 16, 1912	60 ac ft	Irrigation
59	Hat Cr. Basin	Colley Cr.	Jul. 18, 1912	28½ ac ft	Irrigation
60	Hat Cr. Basin	Phil Cr.	Jul. 18, 1912	192 ac ft	Irrigation
61	Hat Cr. Basin	Schneider Cr.	Jul. 18, 1912	60 ac ft	Irrigation
62	Hat Cr. Basin	McDonald Cr.	Oct. 11, 1912	11 ac ft	Irrigation
63	Hat Cr. Basin	Anderson Cr.	Dec. 16, 1912	110.8 ac ft	Irrigation
64	Hat Cr. Basin	McDonald Cr.	Mar. 3, 1913	80 ac ft	Irrigation
65	Hat Cr. Basin	Martin Cr.	Oct. 3, 1913	56 ac ft	Irrigation
66	Hat Cr. Basin	McDonald Cr.	Apr. 29, 1914	146 ac ft	Irrigation
67	Hat Cr. Basin	Pocock Cr.	May 17, 1915	31 ac ft	Irrigation
68	Hat Cr. Basin	Robertson Cr.	Jan. 9, 1917	50 ac ft	Irrigation
69	Hat Cr. Basin	Finney Cr.	Jan. 26, 1918	95 ac ft	Irrigation
70	Hat Cr. Basin	Finney Lake	Jan. 26, 1918	95 ac ft	Storage
71	Hat Cr. Basin	Parke Cr.	May 14, 1918	30 ac ft	Irrigation
72	Hat Cr. Basin	Parke Lake	May 14, 1918	20 ac ft	Irrigation
73	Hat Cr. Basin	McDonald Cr.	May 14, 1918	84 ac ft	Irrigation
74	Hat Cr. Basin	Anderson Cr.	May 15, 1919	95 ac ft	Irrigation
75	Hat Cr. Basin	Pocock Cr.	Sep. 29, 1919	44.8 ac ft	Irrigation
76	Hat Cr. Basin	Darough Cr.	Jun. 2, 1920		Irrigation
77	Hat Cr. Basin	Cashmere Cr.	Nov. 15, 1922	20 ac ft	Irrigation
78	Hat Cr. Basin	Hat Cr.	Nov. 29, 1922	23.6 ac ft	Irrigation
79	Hat Cr. Basin	Cashmere Cr.	Dec. 14, 1922	10 ac ft	Irrigation
80	Hat Cr. Basin	McCormick Cr.	Jan. 26, 1923	22 ac ft	Irrigation
81	Hat Cr. Basin	Schneider Cr.	Jun. 29, 1927	50 ac ft	Irrigation
82	Hat Cr. Basin	Crater Cr.	Aug. 2, 1927	24.5 ac ft	Irrigation
83	Hat Cr. Basin	Phil Cr.	Aug. 2, 1927	35 ac ft	Irrigation
84	Hat Cr. Basin	Pocock Cr.	Apr. 25, 1929	76.8 ac ft	Irrigation
85	Hat Cr. Basin	Hat Cr.	May 4, 1929	41 ac ft	Irrigation
86	Hat Cr. Basin	White Rock Cr.	May 4, 1929	14 ac ft	Irrigation
87	Via Langley L. Oregon Jack	Hat Cr.	Apr. 27, 1931	50 ac ft	Irrigation
88	Hat Cr. Basin	Phil Cr.	Jun. 25, 1931	50 ac ft	Irrigation
89	Hat Cr. Basin	Phil Cr.	Jun. 25, 1931	40 ac ft	Storage
90	Hat Cr. Basin	Phil Cr.	Jul. 7, 1931	60 ac ft	Irrigation
91	Hat Cr. Basin	Phil Cr.	Apr. 22, 1932		Irrigation
92	Hat Cr. Basin	Anderson Cr.	Jul. 8, 1932	35 ac ft	Irrigation
93	Hat Cr. Basin	Medicine Cr.	Jun. 18, 1938	50 ac ft	Irrigation
94	Cornwall Cr. Via McLean L.	Medicine Cr.	Dec. 21, 1944	700 ac ft	Irrigation
95	Cornwall Cr. Via McLean L.	Medicine Cr.	Dec. 21, 1944	700 ac ft	Irrigation
96		Medicine Cr.	May 10, 1945	50 ac ft	Irrigation
97		Anderson Cr.	Sep. 17, 1949	50 ac ft	Irrigation
98		Hat Cr.	Oct. 30, 1951	4 ac ft	Irrigation
99	Cornwall Cr. Via McLean L.	Medicine Cr.	Apr. 21, 1953	750 ac ft	Irrigation
100	Cornwall Cr. Via McLean L.	Medicine Cr.	Apr. 21, 1953	750 ac ft	Storage
101		White Rock Cr.	Aug. 17, 1953	30 ac ft	Irrigation
102	Hat Cr. Basin.	White Rock Cr.	Aug. 17, 1953	30 ac ft	Storage
103	Hat Cr. Basin	Yet Cr.	May 27, 1958	60 ac ft	Irrigation
104	Hat Cr. Basin	Colley Cr.	Oct. 30, 1958	130 ac ft	Irrigation
105	Hat Cr. Basin	Pocock Cr.	Jun. 5, 1958	16 ac ft	Irrigation

Table 5A-9 Continued

LICENSEE NO.	LOCATION	WATER SOURCE	DATE	VOLUME	PURPOSE
106	Hat Cr. Basin	Pocock Cr.	Oct. 30, 1958	120 ac ft	Irrigation
107	Hat Cr. Basin	Finney Cr.	Aug. 22, 1958	200 ac ft	Irrigation
108	Hat Cr. Basin	Yet Cr.	Aug. 22, 1958	30 ac ft	Irrigation
109	Hat Cr. Basin	Colley Cr.	Dec. 23, 1959	130 ac ft	Irrigation
110	Hat Cr. Basin	Yet Cr.	Aug. 19, 1959		Irrigation
111	Hat Cr. Basin	Hat Cr.	Aug. 1, 1961	86 ac ft	Irrigation
112	Hat Cr. Basin	Hat Cr.	Aug. 1, 1961	30 ac ft	Irrigation
113	Hat Cr. Basin	Hat Cr.	Aug. 1, 1961	50 ac ft	Irrigation
114	Hat Cr. Basin	Ambusten Cr.	Aug. 1, 1961	30 ac ft	Irrigation
115	Hat Cr. Basin	Darough Cr.	Nov. 1, 1961	Whole flow	Land Improv.
116	Hat Cr. Basin	Gallagher Cr.	Jan. 5, 1962	90 ac ft	Irrigation
117	Hat Cr. Basin	Gallagher Lake	Jan. 5, 1962	90 ac ft	Storage
118	Hat Cr. Basin	Ambusten Cr.	Nov. 1, 1962		
119	Via Langley L. Oregon Jack	Hat Cr.	Jul. 19, 1963	240 ac ft	Irrigation
120	Via Langley L. Oregon Jack	Hat Cr.	Jul. 19, 1963	240 ac ft	Storage
121	Hat Cr. Basin	Finney Cr.	Aug. 1, 1966	100 ac ft	Irrigation
122	Hat Cr. Basin		Nov. 6, 1968	100 ac ft	Dam
123	Hat Cr. Basin	Hat Cr.	Jun. 12, 1969	90 ac ft	Irrigation
124	Via Langley L. Oregon Jack	Hat Cr.	Nov. 7, 1973	300 ac ft	Storage
125	Hat Cr. Basin	Hat Cr.	Mar. 13, 1974	100 ac ft	Irrigation
126	Hat Cr. Basin	Pocock Cr.	Mar. 13, 1974	90 ac ft	Irrigation

APPENDIX VI-1

VEGETATION TYPES IN UPPER HAT CREEK VALLEY

APPENDIX VI-1

VEGETATION TYPES IN UPPER HAT CREEK VALLEY

The following vegetation types were observed during a helicopter survey of Upper Hat Creek Valley in the summer of 1974 (see Figure 6-1).

1. *PSEUDOTSUGA-AGROPYRON SPICATUM-(FESTUCA)* ASSOCIATION

This association has a limited distribution at the northern end of the valley where it occurs on minor topographic ridges. These ridges are drier than the adjacent depressions which are occupied by the *Pseudotsuga - Calamagrostis* association, thus forming an alternating pattern of the two associations. *Balsamorhiza sagittata* occurs extensively, replacing *Agropyron* and *Festuca* due to intensive grazing.

2. *PSEUDOTSUGA - CALAMAGROSTIS RUBESCENS* ASSOCIATION

This is a common association throughout much of the southern Interior occurring on fine-textured soils along the sides of valleys. It is an important association for forest utilization with the herbaceous ground cover providing good grazing range, and tree growth is generally good. Some logging of this association has occurred in the valley, probably for either disease control or increasing grazing range. Early stages of secondary succession within this association are dominated by ponderosa pine (type 3) following fires (type 2). South of Oregon Jack Creek this association occurs with Lodgepole pine, *Pinus contorta.*

3. *PINUS PONDEROSA* SUB-ASSOCIATION

As mentioned above, this sub-association in the Upper Hat Creek area is found only as a successional community within type 2. As the areal extent of this sub-association was limited to a few small stands north of Medicine Creek it was included within type 2 for areal determinations.

4. *PSEUDOTSUGA* - SHRUB - *AGROPYRON SPICATUM* ASSOCIATION

This association is restricted to unstable talus slopes oriented southwest along the east side of the valley. These sites are warm and have a well-drained soil, creating a dry habitat in which tree growth is poor. Xerophytic shrubs are conspicuous, particularly *Juniperus scopulorum* which, with its low spreading habit may help stabilize the surface. The herb layer is typically poorly developed.

5. *ARTEMISIA - PINUS - AGROPYRON SPICATUM* SUB-ASSOCIATION

Heavy over-grazing of the *Pinus - Agropyron spicatum* association typical of medium to fine-textured soils at lower elevations in the southern Interior results in the development of this sub-association. The change is induced by heavy grazing, particularly on clay soils, and results in the elimination of the grasses and increased dominance by sagebrush. The latter is less palatable to livestock and less flammable. The reduction in grass cover permits more rapid erosion to take place and gullying may occur. Usually this situation can be reversed by protection of the area from grazing pressures. In Upper Hat Creek Valley this sub-association intermingles with type 6 (which were areas of particularly heavy grazing in the past).

6. *ARTEMISIA TRIDENTATA*

This vegetation type is part of the type 5 sub-association and is differentiated on the vegetation map of the valley to denote areas without forest cover. As stated previously it arises from heavy overgrazing. Its distribution is limited to benches on both sides of the north end of the valley.

7. *AGROPYRON SPICATUM - CHRYSOTHAMNUS NAUSEOSUS - POA - (FESTUCA)*

The grasslands of this area of British Columbia have been included in the *Stipeto - Agropyron spicati* subzone of Krajina (1965), the composition of which varies greatly with altitude, soil characteristics and history. Tisdale (1947) describes three altitudinally determined zones and the effects of grazing on these communities.

Much of the grassland designated areas of the valley have been badly overgrazed as indicated, in the lower elevations, by the presence of *Chrysothamnus nauseosus* (type 7a). Environmental limitations probably restrict *Chrysothamnus* from the higher elevations (type 7b).

The grasslands of the valley also alternate in many areas with saline-alkali depressions (type 8), usually with abrupt transitions between the types. As the depressions are generally of small size they could not be resolved at the scale of the map and are included in the area calculations for type 7.

8. SALINE-ALKALI DEPRESSIONS

These depressions are the result of poor soil drainage and high soluble salt content in a dry climate with high evaporation stress. In the valley they are typically dominated by *Scirpus, Juncus, Distichlis, and Hordeum* species.

9. *ELYMUS CINERUS* SAVANNA ASSOCIATION

Along the banks of streams and on flood plains in the valley a complex assemblage of alluvial communities develop. On the valley floor, in areas of moisture gain by flooding or seepage, a surface accumulation of salts may occur due to high evaporation loss in the dry climate. In such areas a tall grass savanna develops. If salination proceeds further this will be replaced by communities of salt adapted plants similar to type 8 sites.

10. *POPULUS TRICHOCARPA* SUB-ASSOCIATION

Another alluvial association in the valley is represented by the cottonwood and is restricted to the margins of Hat Creek. As these areas tend to be repositories for plants carried downstream this sub-association is typically varied in composition. Understory shrubs *Rosa nutkana and Cornus stolonifera.*

11. *POPULUS TREMULOIDES - CALAMAGROSTIS RUBESCENS* SUB-ASSOCIATION

As mentioned earlier this sub-association is successional in the type 2 association, typically coming into the area following a fire. Aspen tends to become the local dominant because of its ability to regenerate abundantly from root suckers. In the valley this sub-association is generally found in moister habitats bordering secondary streams and seepage areas, at higher elevations than the type 10 sub-association. Shrub understory typically contains *Rosa acicularis* and *Symphoricarpus albus. Balsamorhiza saggittata* is found in many of the sites of this sub-association as a result of livestock grazing.

12. *PICEA ENGELMANNII*

Several small stands of *Picea* were noted in the lower end of the valley. The presence of this species denotes a cooler and moister local habitat, typically due to the catch-all nature of alluvial communities and packets of cold air drainage. At higher elevations at the south end of the valley *Picea* also occurs in scattered small stands interspersed with *Pseudotsuga* and *Pinus contorta.*