BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Tera Environmental Resource Analyst Ltd. and Reid, Collins and Associates Ltd. - Hat Creek Project - Detailed Environmental Studies - <u>Forestry Report</u> - July 1978. Corrected to January 1979

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 17

TERA ENVIRONMENTAL RESOURCE ANALYST LIMITED

HAT CREEK PROJECT
DETAILED ENVIRONMENTAL STUDIES

APPENDIX A3 - FORESTRY

JULY 1978

Corrected to January 1979

PREPARED BY: [signature]
H. Bunce, Ph.D., R.P.F.

REID, COLLINS AND ASSOCIATES LIMITED

Reid Collins

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are Douglas-fir (73-82 percent), lodgepole pine (2-12 percent) and ponderosa pine (11-13 percent). The volume of wood contributory to the allowable annual cut ranges from 2 394 m^3 to 3 295 m^3 (845 to 1 163 cunits) according to the ash disposal option used, i.e. 1.6% to 2.3% of the allowable cut of the local study area.

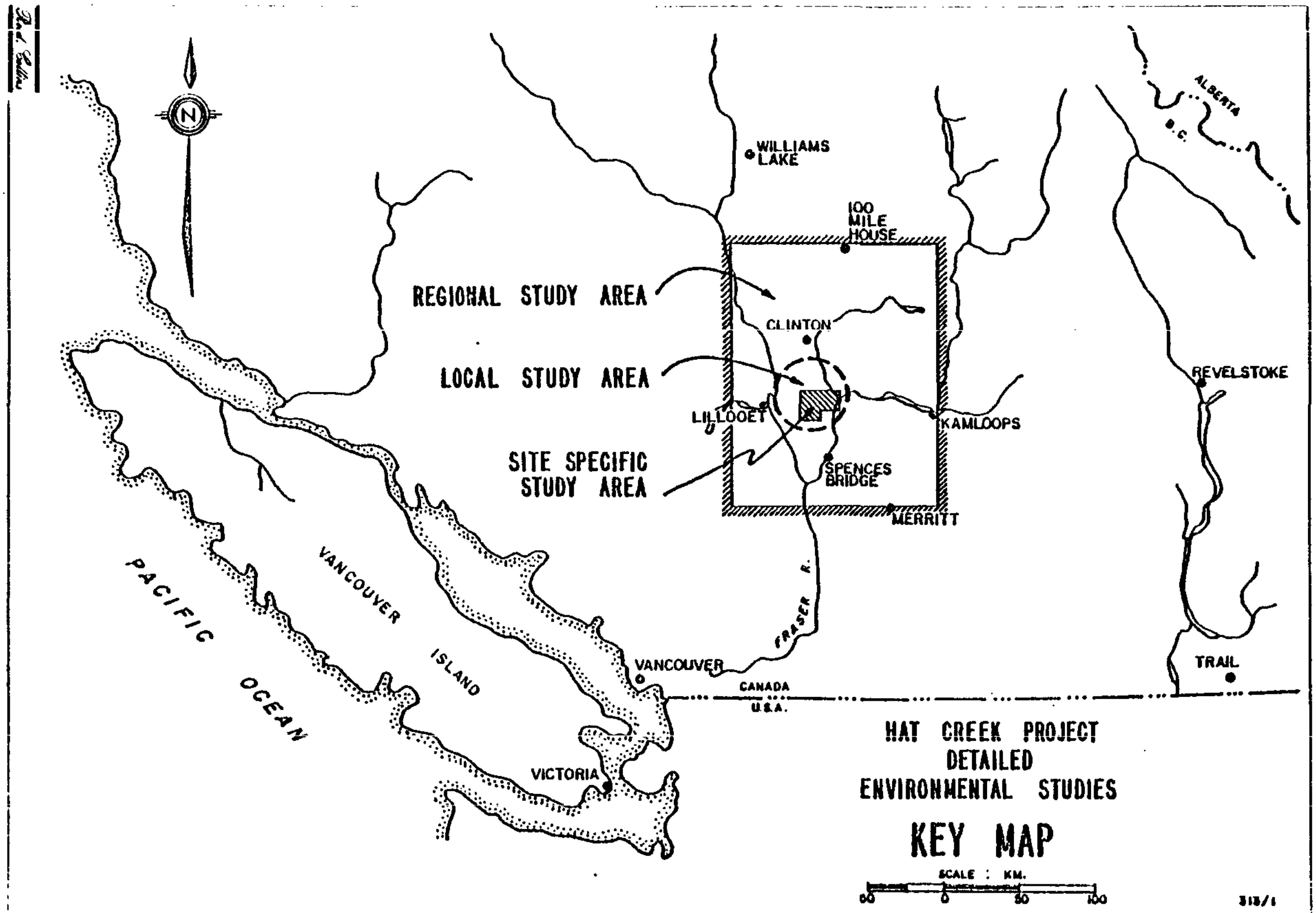
The estimated impacts on forestry caused by the proposed project are almost entirely related to forested areas affected by land clearing and to forest tree species affected by fume emissions. The effects of hydrogen fluoride (HF) and sulfur dioxide (SO_2) fume emissions are discussed in this report.

For sulfur dioxide there are three alternative control strategies: two meteorological control systems (MCS) based on two stack heights (244m and 366m) and flue gas desulfurization (FGD) with a 366m stack. The FGD system would cause the least effect on allowable annual cut (0 m^3) as compared to 132 m^3 and 77 m^3 respectively for the MCS 244 and MCS 366 systems, or 0%, 0.09% and 0.05% respectively of the allowable cut of the local study area.

While it is recognized that a controlled emission system is preferred by B. C. Hydro and Power Authority, differing opinions on the release rate of fluorine or hydrogen fluoride in the stack gases make necessary a probable and worst probable case analysis based on uncontrolled emissions. The estimate of additional effects on allowable annual cut is 0 m^3 and 22 852m^3 for the probable and worst probable cases respectively, or 0% and 15.6% of the allowable cut of the local study area. The estimated loss of allowable annual cut due to the fume emissions is between 0m^3 and 22 984m^3, 0% and 15.8% of the cut, and the loss due to land clearing is between 2 400m^3 and 3 300m^3 or 1.6% and 2.3% of the cut. The estimated total loss of allowable annual cut is likely to be between 2 400m^3 and 26 700m^3, or 1.6% and 18.3% of the allowable cut of the local study area.

The total annual value of this volume is between \$13 200 and \$143 800 for a total present worth of \$110 000 to \$3 319 000 depending on discount rate, ash disposal and fume emission control method selected. Without the project

ADDENDA



N
WILLIAMS LAKE
100 MILE HOUSE
ALBERTA
B.C.
REGIONAL STUDY AREA
CLINTON
LOCAL STUDY AREA
REVELSTOKE
LILLOOET
KAMLOOPS
SITE SPECIFIC STUDY AREA
SPENCES BRIDGE
MERRITT
PACIFIC OCEAN
VANCOUVER ISLAND
FRASER R.
VANCOUVER
CANADA
U.S.A.
TRAIL
VICTORIA
HAT CREEK PROJECT
DETAILED
ENVIRONMENTAL STUDIES
KEY MAP
SCALE : KM.
50 0 50 100

1.0 SUMMARY

This appendix of the Hat Creek Detailed Environmental Studies provides forest resource and forest insect and disease inventories of the regional, local and site specific study areas. Based on those inventories, estimates are made of the economic benefit potentially possible from the forestry sector without the project. Estimates are also made of loss of benefit that could come from the project in respect to the site specific features, such as the coal mine, ash dumps, plant site and power line and road right-of-ways, all located near Harry Lake, and from the air emissions of the plant during its operational life. Subtraction of these losses from the without the project benefits provides the level of economic benefit from the forestry sector to be expected with the project. Recommendations for mitigation of the impacts and for monitoring programs are also provided.

The regional study area covers 2 335 800 hectares (ha) (5 771 900 acres) of which 74 percent is forest land. The mature standing volume of timber is 135.6 million cubic metres (47.9 million cunits) at close utilization standards, * or 1.1 percent of the provincial inventory. The principal species are lodgepole pine (38 percent), Douglas-fir (36 percent), and spruce (15 percent). Within the regional study area the allowable annual cut for all Public Sustained Yield Units (PSYUs) totals 1 857 500 cubic metres (m^3) (656 000 cunits).

In 1976 the forest industries in the regional study area consisted of twelve sawmills, three plywood plants and one pulpmill. The 1976 regional production was: lumber, 1.3 million m^3 (0.6 billion board feet) or 5.3% of B. C. production; plywood and veneer, 0.2 million m^3 (0.2 billion square feet) or 8.8% of B. C. production; wood chips, 1.1 million m^3 (0.4 million bone dry units) or 4.1 % of B. C. production; and pulp, 0.3 million tonnes (0.4 million tons) or 6.3% of B. C. production.

*See Glossary in Section 8.0 for definitions of forestry terms.

The forest resource in the regional study area is a major employer and is significant to the economy of the region. The 1976 average employment in the plants described above was 2 415 persons, including office and supervisory staff. None of the forest products plants is located within the local study area.

In the past, insects have attacked the forest in the regional and local study areas; in particular sites the attacks were serious. Insect damage will continue to occur. In certain situations air pollutant emissions can cause damage to the forest which may resemble insect damage. Disease damage in the study areas has been normal for the area and has not significantly affected timber production.

The local study area covers 196 350 ha (485 190 acres), of which 75 percent is forest land. The mature standing timber volume in the local study area is 10 472 500 m^3 (3 698 400 cunits) at close utilization standards. The principal species are Douglas-fir (55 percent), lodgepole pine (25 percent), spruce (14 percent), and ponderosa pine (3 percent). The estimated allowable annual cut in the area is 146 189 m^3 (51 626 cunits). The local study area standing volume is 7.7 percent of the volume in the regional study area. The B. C. Forest Service have already anticipated the Hat Creek development in their allowable annual cut calculation. Therefore, if the Hat Creek mine is developed, there would be no administrative reduction in the allowable cut presently calculated.

The site specific study area contains proposed operating areas such as the mine, dumps, generation site and offsite facilities. Within the site specific area three options for ash disposal from the power plant are being considered. Between 3 900 ha and 4 320 ha (9 640 to 10 680 acres) of land would be affected, of which 58 percent is productive forest land. The mature standing volume in the site specific area ranges from 139 778 cubic metres (49 362 cunits) for the Dry Ash Scheme I to 156 998 cubic metres (55 443 cunits) for the Wet Ash disposal. The principal species are Douglas-fir (73-82 percent), lodgepole pine (2-12 percent) and ponderosa pine (11-13 percent). The volume of wood contributory to the allowable annual cut ranges from 2 394 m^3 to 3 295 m^3 (845 to 1 163 cunits) according to the ash disposal option used, i.e. 1.6% to 2.3% of the allowable cut of the local study area.

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The total annual value of this volume is between $13 200 and $143 800 for a total present worth of $110 000 to $3 319 000 depending on discount rate, ash disposal and fume emission control method selected. Without the project the economic benefit from forestry in the local study area is estimated to be \$804 000 per year which has a present worth of from \$26 800 000 at 3% discount rate to \$6 700 000 at 12% discount rate. With the project the local study area should provide an economic benefit from forestry which has a range of present worth of from \$26 400 000 to \$5 500 000 according to the discount rate, ash disposal scheme, and emission control combination and level chosen.

Prediction of fume impacts on vegetation is not an exact science. Because of the many unknown or poorly understood factors, intangibles, synergisms and the highly variable responses to documented treatments, the estimate of allowable annual cut lost and its annual value each year is at a confidence level of plus or minus one order of magnitude.

Based on these possible impacts and the forest resource only, it is recommended that dry ash disposal schemes I or II be used, flue gas desulfurization be used to reduce emissions, and an effective mass balance of fluorine emissions be developed. However the relatively small value of the predicted loss caused by SO_2 should also be considered critically in this respect. While the allowable annual cuts potentially lost do not affect current, administrative allowable cut calculations because the B. C. Forest Service has already made allowances for these deductions, the potential loss of cut would still be a direct real loss to forestry as it benefits the province.

The values provided in this report are based on published information, much of it from the B. C. Forest Service, and are of a general, regional nature rather than specific to individual timber stands. They are therefore not suitable for use in cases of compensation of private individuals.

Synergistic effects between fume components and insects are possible, especially in light of the droughty conditions in the regional area for the past six or seven years. For this reason, two large scale studies are recommended, an entomological study and an environmental monitoring study. Other recommendations relating to rehabilitation and an intensive forest management program are given.

SECTION 2.0 - INTRODUCTION

In June 1976 Reid, Collins and Associates Limited was retained to investigate the forestry aspects of the environmental studies concerning the proposed coal mine - thermal generating station in the Hat Creek Valley, near Cache Creek, British Columbia.

2.1 TERMS OF REFERENCE

The original terms of reference, dated June 1976, are presented in Addendum 7. These were revised and clarified in the proposal and in subsequent correspondence. The major changes were as follows:

- site index was changed to site quality
- watershed value was changed to mean local study area
- description of relationships (original point 4) was transferred to the biophysical assessment portion of The Land Resources Subgroup (Appendix A-1)
- permanent sample plot program to be instituted (original point 5) was revised to providing recommendations on a monitoring program.

Site quality was interpreted and inventoried rather than site index. Site quality is divided into four site classes: good, medium, poor and low. Each site class is a grouping of site indices for each of the species in British Columbia. Site classes can be directly related to productivity and valuation measure. Site index is the average dominant or co-dominant tree height, at a given age, usually 50 or 100 years in B.C.

The revised terms of reference for the forest inventory and effects of development (Appendix A-3) are cited below:

Forest Inventory

- Inventory and map forest tree species, logging, and log reserves.
- State present allowable annual cut (AAC) and commitments.
- Map existing forest road patterns and projected development.

Effects of Development

- Identify sensitivity of forest tree components to project construction activity. Impacts should be quantitative, where possible, and related to construction and operation periods.
- Assess project impacts on allowable annual cut and other forest values.
- Assess alternatives and recommend measures to avoid or minimize adverse impacts, enhance beneficial impacts and compensate for losses. Practical alternative proposals should include estimated costs.

In addition to the Appendix A-3 terms of reference, an entomological overview study was prepared and is provided in Section 4.1 (b).

The terms of reference for appraisal of forest losses, Appendix C-3, are listed below:

Forestry

- Evaluate forests at the potential value of the timber harvested at its optimal harvest age, net of harvesting costs.
- The terms "Optimal Harvesting Age" and "Costs" are defined by present forest management and harvesting techniques as practiced by the B.C. Forest Service.
- Net present value should be calculated by using discount rates of 4, 6, 8, 10 and 12 percent.

In addition to the terms of reference, discount rates of 3 and 5 percent were also used in the appraisal of forest values. Discount rates of 3, 4 and 5 percent are used, almost universally, for forest economic comparisons of alternatives.

2.2 PURPOSE AND SCOPE

The purpose of the forest studies was to identify the magnitude and economic value of the existing forest resources and the sizes of the established forest industries in such a way that these data may be used as baselines for identification and evaluation of any changes which might occur as a result of establishment of the Hat Creek operations. Data are presented on a comparative basis to identify the resources in a provincial perspective. The study considered three areas, all roughly centered on the proposed mine - power generation site.

- The regional study area is bounded by 100 Mile House to the north, Kamloops to the east, Lytton to the south and Seton Lake to the west. Data for this area are presented on a map at 1:250 000. The block is approximately 2 335 800 hectares (5 771 900 acres) in size.
- The local study area is 25 kilometres (km) in radius centered around Harry Lake. Data are presented on maps at a scale of 1:50 000. This area is 196 350 ha (485 190 acres) in size.
- The site specific study area contains operating areas such as the mine, dumps, generation site and offsite facilities. Information is presented on a map at a scale of 1:24 000 in Addendum 10.

Within the regional study area the following items were inventoried:

- The forest resources
- Forest land tenures
- Forest stands
- Access
- Disposition of forest resources
- Location and allocated cut requirements of forest industries (sawmills, plywood plants and pulpmill)
- Location of environmental protection forests, ecological reserves, British Columbia Forest Service (BCFS) research plots
- Forest insects and diseases

For the local study area the following items were inventoried:

- The forest resources
- Forest stands
- Access
- Disposition of forest resources
- Location and allocated cut requirements of forest industries (sawmills, plywood plants and pulpmill)
- Area summaries by site classes
- Area-volume summaries by tree species
- Estimates of mean annual increments for comparison with mean annual increments in the Botanie Public Sustained Yield Unit (PSYU)
- AAC commitments in the Botanie PSYU AAC
- Estimates of AACs with comparisons to the Botanie PSYU

For the site specific study area the following items were inventoried:

- The forest resources
- Area of forest and non-forest land
- Area summaries by site classes
- Volume summaries by tree species
- Estimates of mean annual increments and theoretical contributions to sustained yield

The impact of the Hat Creek operations on the forest resource is assessed. A valuation of merchantable timber and of forest productivity on the site specific area is made. An appraisal of forest losses anticipated as a result of emissions from the plant is also included. Valuation of losses is based on the contribution of affected areas to the AAC.

The susceptibilities of various tree species to stack emissions are rated from stack emission data provided by other consultants.

2.3 ACKNOWLEDGEMENTS

Reid, Collins and Associates Limited acted as sub-contractors to Tera Consultants Limited who in turn were co-ordinated by Ebasco Services of Canada Limited who were contracted by British Columbia Hydro and Power Authority to prepare the overall Detailed Environmental Studies of the Hat Creek Project. Acknowledgement must be made to the people in these three organizations for their assistance in the forest inventory component of this study.

Acknowledgement must also be made for the statistics and other information supplied by the regional and Victoria offices of the British Columbia Forest Service, the Canadian Forest Service, especially the Forest Insect and Disease Survey Officers, the Council of the Forest Industries of British Columbia and the various forest products mills in the study area. In addition, acknowledgement is made of a special personal communication by Dr. K. Graham, retired University of British Columbia professor, regarding insects.

SECTION 3.0 - METHODOLOGY

3.1 RESOURCE INVENTORY

(a) The Regional Study Area

(i) Forest Resource

The regional study area is shown on the 1:250 000 scale map (Addendum 1). Within the regional study area are portions of two forest districts, Kamloops and Cariboo, portions of seven Public Sustained Yield Units, (PSYUs) Big Bar, Kamloops, Yalakom, Botanie, Nicola, Lac la Hache and Nehalliston, and part of one Tree Farm License (TFL #35).

Area volume summaries of crown forest lands were calculated from the British Columbia Forest Service Unit Survey Reports[1] for the PSYUs affected. Area summaries of alienated forest lands such as Crown grants including those in TFL Schedule "A", federal parks and other federal lands, were calculated from these survey reports and the volumes derived from Crown forest land volume averages[1]. All volumes are based on close utilization standards (18 cm+ dbh = 7.1" + dbh, less decay).

Area-volume information for TFL #35 was obtained from Weyerhaeuser Canada Limited[19] and pro-rated for that portion within the regional study area. All allowable annual cut information for PSYUs was obtained from the British Columbia Forest Service's "Forest Inventory Statistics of British Columbia (1973)[2] and was confirmed by the Resource Planning Division of the B.C. Forest Service in Victoria[20].

The B.C. Forest Service district offices in Kamloops and Williams Lake supplied reference lists of current established licensees by each PSYU in both the Kamloops and Cariboo forest districts. These lists are included in Addendum 2.

(ii) Forest Industrial Plants

To obtain data on production and employment in the sawmills, plywood plants and the pulpmill in the regional study area, all plants were canvassed. The companies were extremely cooperative and in general could provide the information requested. Data were collected for 1975 and 1976 for the volumes of lumber, plywood, veneer and pulp produced, and average number of persons employed.

British Columbia production statistics of 1975 and 1976 for sawn lumber, plywood and pulp were obtained from the B.C. Department of Economic Development [4]. To establish a comparative base, the regional production data are compared to the provincial totals.

(iii) Insect and Disease Survey

The Canadian Forestry Service Insect and Disease Survey provided historical information on insect and disease activity in the regional and local study areas[8]. Two brief field reconnaissances by Reid, Collins' staff, one including aerial surveillance, were completed. Previous field experience and literature references were utilized to expand the basic understanding of the situation in this area. All these information sources were used to prepare the text of the forest insect and disease sub-section.

(b) The Local Study Area

All area-volume calculations are based on B.C. Forest Service data supplied by the Forest Inventory Division[1]. This information included:

- Unit Survey Reports of the Big Bar PSYU (1962)[1],
  Botanie PSYU (1970) and
  Yalakom PSYU (1965).

- Forest cover maps from Big Bar PSYU (1962)[1], Botanie PSYU (1970)[1] and Yalakom PSYU (1965)[1].
- Map area and map volume statements for each of the forest cover maps[1] involved in the local study area.

To compile area and volume data by mature, immature, residual, not satisfactorily restocked (NSR) and non-commercial cover (NCC) forest types, the boundary of the local study area was first plotted on BCFS forest cover maps at a scale of 1:31 680. Summaries were compiled from the area volume statements accompanying the maps. These statements present data by compartments (a subdivision of a PSYU usually based on height-of-land boundaries). Where the study boundary divided a compartment, map areas were measured by forest type within the study area and volumes were computed proportionally from the compartment area volume statements.

Total acreages by site classes were calculated. Mean annual increments by site classes were computed from the unit survey reports and applied to the acreages by site classes to obtain total mean annual increments.

Total mean annual increment* was converted to net effective mean annual increment to obtain an estimated allowable annual cut for the portions of each of the PSYUs included within the 25 kilometre radius.

All calculations were made initially in imperial units and subsequently converted to metric values.

*Total mean annual increment is a measure of the productive capacity of forest land. To express this in net effective terms it is necessary to deduct for losses caused by factors including breakage, waste and decay, storms, insect damage, deletions for other uses of land such as rights-of-way, or environmental protection forests. The difficulty in making precise estimates of so many variables makes it preferable to group all possible causes of deduction into a single reduction factor based on an average of previous experience. This method of estimating AAC is useful only for overview calculations on the current rotations.

A forest productivity map at 1:50 000 was prepared for the local study area based on the BCFS 1:31 680 forest cover maps[1]. This map shows the rated site quality of the land under existing conditions and is included in Addendum 5.

(c) The Site Specific Area

All area and volume calculations are based on B.C. Forest Service data supplied by the Forest Inventory Division[1]. The information used included:

- Forest cover maps from Botanie PSYU
- Area and volume statements for each of the forest cover maps involved in the site specific study area
- Volume over Age curves and average line volume tables

To compile area and volume data by mature, immature, residual, NSR and NCC forest types, the boundaries of the various facilities were plotted on BCFS 1:15 840 forest cover maps, reduced to a scale of 1:24 000. Between some of the facilities there are areas that are rendered unsuitable for productive forestry purposes because of necessary space and machinery limitations and therefore these areas are included in the summaries. Summaries were compiled from volume and area estimates based on the maps. Total acreages by site classes were also calculated.

Mean annual increments by site classes were computed from the volume over age curve indices and applied to the acreages by site classes to obtain total mean annual increments.

A forest cover map at 1:24 000 was prepared for the site specific area based on the BCFS 1:15 840 forest cover maps. The 1:24 000 forest cover map shows forest tree species, age class, height class, stocking class, and site class for each forest cover stratum. Current land uses, logging roads and non-forest land are also shown. This map is included in Addendum 10.

3.2 IMPACT ASSESSMENT

(a) Without the Project

The basic premise upon which the without project case is evaluated is that the whole productive forest land area would be managed on a sustained yield basis. Therefore, the mean annual increment of this area would be its potential contribution to the allowable annual cut of the Botanie PSYU.

Valuation of mean annual increment (MAI) is based on average market values of logs in the regional and local study areas. These values are substantiated by conversion return calculations for the three main species in the area for 1976 and 1977. Methods used to calculate conversion return are similar to the standard B.C. Forest Service procedure.

The value of the contribution to AAC is computed by the following formula:

$$\frac{\text{Total MAI x Value/Volumetric Unit}}{\text{Discount Rate}} = \text{Value of contribution to AAC in perpetuity.}$$

This is the benefit in value from the forest resource without the project.

The total MAI is determined by applying the weighted average MAI for the Botanie PSYU over the land areas considered.

(b) With the Project

The basic premise upon which the project case is evaluated is that the mean annual increment attributable to the site specific areas taken out of forest production is lost in perpetuity because of specific peculiarities of restoring these areas to forest. This mean annual increment is valued as in the preceding section (a) Without the Project. However no loss is attributed to the existing standing inventory because it will be logged and the value recovered under approximately normal circumstances.

Any effect of air emissions in reducing growth is also valued in a similar manner in terms of mean annual increment not grown over the 35 year life of the thermal plant. The area affected should return to normal productivity subsequently.

(c) Impact of the Project

The impact of the project is the economic benefit attributable to the local forest resource "with the project" i.e. the residual benefits, deducted from the economic benefit attributable to the local forest resource "without the project". This difference equals the loss of forest resource caused by the project.

The value of the difference of the benefit without the project and the residual benefit with the project is an annual value. The benefit from the site specific areas will most likely not be regained in commercial terms at the end of operations. The coal mine will be a large hole, perhaps filled with water, the plant site will still be occupied by buildings and equipment, and the offsite facilities, roads, power lines and airport will likely still be required for further use. Only the dumps have realistic expectation of restoration to forest. It is estimated that their level of productivity will likely be low. In total therefore, the site specific areas are not considered for calculation of subsequent benefit to the forest resource. The valuation will be based on an annual income lost in perpetuity. The effect caused by air emissions will cease at the end of 35 years at the end of operation of the plant. It is therefore discounted as an annual income lost for 35 years at various discount rates.

3.3 STUDY PERSONNEL

Personnel involved in the project and their specific responsibilities are listed below:

Regional, local and site specific area inventories	:	D. Norris, B.S.F., M.F.
Regional forest industry inventory	:	B. Ford, B.S.F., R.P.F. E.W. Hindley, B.S.F., R.P.F.
Insect and disease survey	:	H. Bunce, Ph.D., R.P.F.
Air emission - Tree susceptibilities	:	H. Bunce, Ph.D., R.P.F. J. Richards, B.Sc.
Appraisal of forest losses	:	R. Jones, B.S.F., R.P.F.

SECTION 4.0 - RESOURCE INVENTORY

4.1 REGIONAL STUDY AREA

(a) Forest Resources

The regional study area covers 2 335 800 ha (5 771 900 acres). Sixty-five percent of the area is in the Kamloops Forest District* and 35 percent is in the Cariboo Forest District. The following PSYUs* lie partially within the study area: Big Bar, Botanie, Kamloops, Lac la Hache, Nehalliston, Nicola and Yalakom. Tables 4-1 and 4-2 list the total land areas, volumes and AACs for the complete PSYUs and for those sections of the PSYUs situated within the regional study area. A portion of Tree Farm License (TFL) #35 also lies within the area and data on this TFL are included in the tables where applicable.

(i) Forest Stands

A total of 1 731 500 ha (4 278 700 acres) of the regional study area is classified as forest land. This is 74 percent of the study area.

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*The forest administration of British Columbia is the responsibility of the British Columbia Forest Service. The province is divided into six forest districts for administrative control. Within and occasionally straddling a district boundary are the smaller Public Sustained Yield Units in which the forest management is carried out by the Forest Service. Other areas called Tree Farm Licenses have been allocated to industry and are managed by industrial foresters under license. Forest Service foresters inspect these to confirm that the terms of the licenses are being fulfilled. Another sub-division commonly used by the British Columbia Forest Service is that between the "Coast" and the "Interior", defined as west and east of the Coast Range (also known as the Cascades Range) of mountains. There is a marked difference in forest cover types on either side of the mountains, largely caused by the rain shadow effect of the mountains.

Tables 4-3 and 4-4 summarize the forest type areas in the regional study area and compare them to forest type totals of British Columbia, B.C. Interior, and the local study area. The total forest area of the regional study is 3.3 percent of the total forest area of B.C. and 3.9 percent of the B.C. Interior total forest area.

Tables 4-5 and 4-6 show the forest area distribution by tenure and broad forest types for the regional study area.

TABLE 4-1

SUMMARY OF AREAS, VOLUMES, ALLOWABLE ANNUAL CUTS AND MEAN ANNUAL INCREMENTS[1,2]

CROWN LAND ONLY

(Imperial Units)

PSYU	TOTAL PSYU			PORTION OF PSYU WITHIN REGIONAL STUDY AREA						Weighted Avg.MAI c.f./ac
	Area of Forest Land 1 000 Acres (a)	Mature Volume 1 000 Cunits	AAC 1 000 Cunits	Forest Land		Mature Volume		Allowable Annual Cut		(b)
				1 000 Acres (a)	Percent of PSYU	1 000 cunits	Percent of PSYU	1 000 Cunits	Percent of PSYU	
BIG BAR	1 404.3	8 434	175	1 188.5	85	6 798	81	155	89	17
BOTANIE	861.7	13 024	144	822.8	95	12 286	94	122	85	19
KAMLOOPS	679.0	6 191	115	408.1	60	3 983	64	74	64	23
LAC LA HACHE	1 524.5	22 950	275	486.2	32	6 091	27	96	35	25
NEHALLISTON	347.8	5 968	117	265.7	76	5 237	88	74	63	35
NICOLA	815.5	10 282	133	299.1	37	3 796	37	41	31	17
TALAKOM	906.8	17 432	225	396.5	44	6 012	34	94	42	31
TOTAL	6 539.6	84 281	1 184	3 866.9	-	44 203	-	656	-	

(a) Forest Land : Mature and Immature stands, NSR, NCC, Residual Lands.
(b) Calculations indicate these values apply both to the total PSYU and the portion within the Regional Study Area.

TABLE 4-2

SUMMARY OF AREAS, VOLUMES, ALLOWABLE ANNUAL CUTS AND MEAN ANNUAL INCREMENTS[1,2]

CROWN LAND ONLY

(Metric Units)

PSYU	TOTAL PSYU			PORTION OF PSYU WITHIN REGIONAL STUDY AREA						Weighted Avg. MAI m^3/ha (b)
	Area of Forest Land 1 000 ha (a)	Mature Volume 1 000 m^3	AAC 1 000 m^3	Forest Land 1 000 ha. (a)	Forest Land Percent of PSYU	Mature Volume 1 000 m^3	Mature Volume Percent of PSYU	Allowable Annual Cut 1 000 m^3	Allowable Annual Cut Percent of PSYU	
BIG BAR	568.3	23 882.1	495.5	481.0	85	19 249.6	81	438.9	89	1.2
BOTANIE	348.7	36 879.4	407.8	333.0	95	34 789.7	94	345.5	85	1.3
KAMLOOPS	274.8	17 530.7	325.6	165.2	60	11 278.5	64	209.5	64	1.6
LAC LA HACHE	616.9	64 986.4	778.7	196.8	32	17 247.6	27	271.8	35	1.7
MEHALLISTON	140.7	16 899.3	331.3	107.5	76	14 829.4	88	209.5	63	2.4
NICOLA	330.0	29 115.0	376.6	121.0	37	10 748.9	37	116.1	31	1.2
YALAKOM	367.0	49 361.3	637.1	160.5	44	17 023.9	34	266.2	42	2.2
TOTAL	2 645.4	238 654.2	3 352.6	1 565.0	-	125 167.6	-	1 857.5	-	

Metric Conversion of Table 4-1

(a) Forest Land : Mature area, Immature area, NSR, NCC, Residual Land areas.
(b) Calculations indicate these values apply both to the total PSYU and the portion within the Regional Study Area.

TABLE 4-3

FOREST AREA COMPARISONS

ALL OF B.C., INTERIOR B.C. REGIONAL AND LOCAL STUDY AREAS[2]

(Imperial Units)

All Ownerships

FOREST TYPE	ALL OF BC		BC INTERIOR			REGIONAL STUDY AREA				LOCAL STUDY AREA				
	1 000 Acres	% of BC Total Forest Area	1 000 Acres	% of BC Interior Total Forest Area	As % of BC Total Forest Area	1 000 Acres	As % of Reg.Study Total Forest Area	As % of BC Total Forest Area	As % of BC Interior Total Forest Area	1 000 Acres	% of Local Study Total Forest Area	As % of BC Total Forest Area	As % of BC Interior Total Forest Area	As % of Regional Study Area Total
						(a)				(b)				
MATURE	63 385	49	49 859	46	39	2 076.3	48.5	1.6	1.9	181.5	50.0	0.1	0.2	4.2
IMMATURE	53 086	41	48 232	44	37	1 911.2	44.7	1.5	1.8	145.1	40.0	0.1	0.1	3.4
RESIDUAL	752	1	726	1	1	150.1	3.5	0.1	0.1	24.7	6.8	T	T	0.6
N.S.R.	6 641	5	5 792	.5	4	130.0	3.0	0.1	0.1	11.0	3.0	T	T	0.3
NON COMM.	4 884	4	4 599	4	4	11.1	0.3	T	T	0.6	0.2	T	T	T
TOTAL	128 748	100	109 208	100	85	4 278.7	100	3.3	3.9	362.9	100	0.28	0.33	8.5

T = Trace, less than 0.1%
Source: (a) From Table 4-6
(b) From Table 4-16

TABLE 4-4

FOREST AREA COMPARISONS

ALL OF B.C., INTERIOR B.C, REGIONAL AND LOCAL STUDY AREAS

(Metric Units)

All Ownerships

FOREST TYPE	ALL OF BC		B.C. INTERIOR			REGIONAL STUDY AREA				LOCAL STUDY AREA				
	1 000 ha	% of BC Total Forest Area	1 000 ha	% of BC Interior Total Forest Area	As % of BC Total Forest Area	1 000 ha	As % of Reg.Study Total Forest Area	As % of BC Total Forest Area	As % of BC Interior Total Forest Area	1 000 ha	% of Local Study Total Forest Area	As % of BC Total Forest Area	As % of BC Interior Total Forest Area	As % of Regional Study Area Total
MATURE	25 651	49	20 177	46	39	840.3	48.5	1.6	1.9	73.5	50.0	0.1	0.2	4.2
IMMATURE	21 483	41	19 519	44	37	773.5	44.7	1.5	1.8	58.7	40.0	0.1	0.1	3.4
RESIDUAL	304	1	294	1	1	60.8	3.5	0.1	0.1	10.0	6.8	T	T	0.6
N.S.R.	2 688	5	2 344	5	4	52.6	3.0	0.1	0.1	4.5	3.0	T	T	0.3
NON COMM.	1 976	4	1 861	4	4	4.5	0.3	T	T	0.2	0.2	T	T	T
TOTAL	52 102	100	44 195	100	85	1 731.7	100	3.3	3.9	146.9	100	0.28	0.33	8.5

T - Trace, less than 0.1%

Metric conversion of Table 4-3.

TABLE 4-5

REGIONAL STUDY AREA

AREA SUMMARY BY FOREST TYPES AND TENURES

(Imperial Units)

1 000 Acres

TENURE	MATURE	IMMATURE	RESIDUAL	NSR	NCC	TOTAL	%
CROWN	1 929.7	1 706.5	118.7	106.0	6.0	3 866.9	90.4
ALIENATED	113.9	171.6	31.4	20.2	1.6	338.7	7.9
TFL #35	32.7	33.1	-	3.8	3.5	73.1	1.7
TOTAL	2 076.3	1 911.2	150.1	130.0	11.1	4 278.7	100.0
% of TOTAL	48.5	44.7	3.5	3.0	0.3	100.0	

TABLE 4-6

REGIONAL STUDY AREA

AREA SUMMARY BY FOREST TYPES AND TENURES

(Metric Units)

1 000 Hectares

TENURE	MATURE	IMMATURE	RESIDUAL	NSR	NCC	TOTAL
CROWN	781.0	690.6	48.1	42.9	2.4	1 565.0
ALIENATED	46.1	69.5	12.7	8.2	0.6	137.1
TFL #35	13.2	13.4	-	1.5	1.5	29.6
TOTAL	840.3	773.5	60.8	52.6	4.5	1 731.7

Source : Addendum 3

A summary of forest land distribution by site classes in the regional study area is provided in Tables 4-7 and 4-8: good site is 8.5 percent, medium 35.1 percent, poor 54.5 percent and low 1.9 percent of the total forest land.

Land areas broken down by tenure, forest types and site classes in acres and hectares may be found in Addendum 3.

The total volume of mature timber in the regional study area is 135.6 million cubic metres (m^3) or 47.9 million cunits with the three major species, lodgepole pine (38 percent), Douglas-fir (36 percent), and spruce (15 percent), accounting for 89 percent of the volume. These species produce wood of good quality suitable for lumber, plywood and pulp.

TABLE 4-7

REGIONAL STUDY AREA

AREA SUMMARY BY SITE CLASSES AND TENURE

ALL FOREST TYPES

(Imperial Units)

1 000 Acres

TENURE	SITE CLASSES				TOTAL
	GOOD	MEDIUM	POOR	LOW	
CROWN	308.1	1 346.6	2 135.6	76.6	3 866.9
ALIENATED	21.7	122.1	188.3	6.6	338.7
TFL #35	35.5	34.2	3.3	0.1	73.1
TOTAL	365.3	1 502.9	2 327.2	83.3	4 278.7

TABLE 4-8

REGIONAL STUDY AREA

AREA SUMMARY BY SITE CLASSES AND TENURE

ALL FOREST TYPES

(Metric Units)

1 000 Hectares

TENURE	SITE CLASSES				TOTAL
	GOOD	MEDIUM	POOR	LOW	
CROWN	124.7	545.0	864.2	31.1	1 565.0
ALIENATED	8.8	49.4	76.2	2.7	137.1
TFL #35	14.4	13.8	1.4	-	29.6
TOTAL	147.9	608.2	941.8	33.8	1 731.7

Source : Addendum 3

Tables 4-9 and 4-10 summarize and compare the mature volumes by species in the regional study area to the provincial and B.C. Interior totals. The total volume for all species in the regional study area constitutes 2.9 percent of the total B.C. Interior volume and 1.7 percent of the total volume for the entire province, which is locally important but of less significance to British Columbia as a whole.

Tables 4-11 and 4-12 list the wood volumes by forest tree species for the Crown Alienated and TFL areas. A further detailed listing for PSYUs, Alienated Lands and TFL #35 is included in Addendum 4. The major manager of the timber resource in this area is the B.C. Forest Service operating on behalf of the Crown. Private timber holdings are of negligible significance. The Crown has assigned some of the forest management of the timber inventory to private industry in the case of Tree Farm Licenses and, to a lesser extent, in Timber Sale Harvesting Licenses.

TABLE 4-9

STANDING MATURE VOLUME COMPARISONS BY SPECIES

ALL OF B.C., B.C. INTERIOR AND STUDY AREAS[2]

All Ownerships

7.1 inches + dbh - Imperial Units
Close utilization less decay only

SPECIES	ALL OF BC		B.C. INTERIOR			REGIONAL STUDY AREA				LOCAL STUDY AREA				
	1 000 Cunits	% of BC Total Volume	1 000 Cunits	% of BC Interior Total Volume	As % of BC Total Volume	1 000 Cunits	As % of Reg. Study Total Volume	As % of BC Total Volume	As % of BC Interior Total Volume	1 000 Cunits	% of Local Study Total Volume	As % of BC Total Volume	As % of BC Interior Total Volume	As % of Regional Study Area Volume
HEMLOCK	648 339	22.7	161 267	9.8	5.7	77.8	0.2	T	T	0	0	0	0	0
SPRUCE	618 315	21.7	556 042	33.3	19.5	7 349.6	15.6	0.3	0.4	511.3	13.8	T	T	1.1
BALSAM	526 234	18.4	326 500	19.5	11.4	2 529.5	5.3	0.1	0.2	84.0	2.2	T	T	0.2
LODGEPOLE PINE	395 914	13.9	389 371	23.3	13.6	18 433.0(a)	38.5	0.6	1.1	913.3	24.7	T	T	1.9
RED CEDAR	322 605	11.3	59 101	3.5	2.1	47.3	0.1	T	T	2.8	0.1	T	T	T
DOUGLAS-FIR	187 312	6.6	89 826	5.4	3.2	17 437.9	36.4	0.6	1.0	2 029.6	54.9	0.1	0.1	4.2
YELLOW CEDAR	60 632	2.1	55	T	T	0	0	0	0	0	0	0	0	0
WHITE PINE	10 560	0.4	8 084	0.5	0.3	307.1	0.6	T	T	37.2	1.0	T	T	T
LARCH	6 720	0.2	6 720	0.4	0.2	2.9	T	T	T	0	0	0	0	0
YELLOW PINE	2 647	0.1	2 041	0.2	0.1	1 159.8	2.4	T	0.1	116.3	3.1	T	T	0.2
TOTAL CONIFER	2 779 699	97.4	1 601 669	95.9	56.1	47 394.3	99.0	1.7	2.8	3 692.3	99.8	0.1	0.2	7.7
ASPEN	46 426	1.6	46 387	2.8	1.6	419.2	0.9	T	T	2.5	0.1	T	T	T
COTTONWOOD	16 227	0.6	14 252	0.8	0.5	24.4	T	T	T	1.0	T	T	T	T
BIRCH	7 964	0.3	7 822	0.5	0.3	53.8	0.1	T	T	2.6	0.1	T	T	T
ALDER	3 563	0.1	65	T	T	0	0	0	0	0	0	0	0	0
MAPLE	347	T	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL BROAD-LEAVED	76 531	2.6	68 526	4.1	2.4	497.4	1.0	T	T	6.1	0.2	T	T	T
TOTAL ALL SPECIES	2 856 230	100	1 670 195	100	58.5	47 891.7	100	1.7	2.9	3 698.4	100	0.1	0.2	7.7

T - Trace, less than 0.1%
(a) - Includes 184 300 cunits of whitebark pine

Reid, Collins

TABLE 4-10

STANDING MATURE VOLUME COMPARISONS BY SPECIES

ALL OF B.C., B.C. INTERIOR AND STUDY AREAS

All Ownerships
18 cm+ dbh - Metric Units

Close Utilization - less decay only

SPECIES	ALL OF BC: 1 000 m³	ALL OF BC: % of BC Total Volume	B.C. INTERIOR: 1 000 m³	B.C. INTERIOR: % of BC Interior Total Volume	B.C. INTERIOR: As % of BC Total Volume	REGIONAL STUDY AREA: 1 000 m³	REGIONAL STUDY AREA: As % of Reg. Study Total Volume	REGIONAL STUDY AREA: As % of BC Total Volume	REGIONAL STUDY AREA: As % of BC Interior Total Volume	LOCAL STUDY AREA: 1 000 m³	LOCAL STUDY AREA: % of Local Study Total Volume	LOCAL STUDY AREA: As % of BC Total Volume	LOCAL STUDY AREA: As % of BC Interior Total Volume	LOCAL STUDY AREA: As % of Regional Study Area Volume
HEMLOCK	1 833 926	22.7	461 371	9.8	5.7	218.6	0.2	T	T	0	0	0	0	0
SPRUCE	1 730 852	21.7	1 574 516	33.3	19.5	20 924.8	15.6	0.3	0.4	1 447.8	13.8	T	T	1.1
BALSAM	1 490 111	18.4	924 534	19.6	11.4	7 142.7	5.3	0.1	0.2	237.9	2.2	T	T	0.2
LODGEPOLE PINE	1 126 090	13.9	1 101 996	23.2	13.6	52 195.8(a)	38.3	0.6	1.1	2 586.1	24.7	T	T	1.9
RED CEDAR	913 504	11.3	167 353	3.5	2.1	190.6	0.1	T	T	7.0	0.1	T	T	T
DOUGLAS-FIR	530 402	6.6	254 361	5.4	3.2	49 349.7	36.4	0.6	1.0	3 746.5	34.9	0.1	0.1	4.3
YELLOW CEDAR	172 258	2.1	265	T	T	0	0	0	0	0	0	0	0	0
WHITE PINE	29 902	0.4	22 891	0.5	0.3	669.6	0.6	T	T	105.6	1.0	T	T	T
LARCH	10 029	0.1	19 029	0.4	0.2	8.2	T	T	T	0	0	0	0	0
YELLOW PINE	8 062	0.1	8 045	0.2	0.1	3 284.5	2.4	T	0.1	323.6	3.1	T	T	0.2
TOTAL CONIFER	7 871 136	97.4	4 533 366	95.9	56.1	134 204.1	99.0	1.7	2.8	10 435.2	99.8	0.1	0.2	7.7
ASPEN	131 468	1.6	131 352	2.8	1.6	1 167.0	0.9	T	T	7.1	0.1	T	T	T
COTTONWOOD	43 849	0.6	40 357	0.8	0.5	69.1	T	T	T	3.8	T	T	T	T
BIRCH	22 531	0.3	22 149	0.5	0.3	152.3	0.1	T	T	7.4	0.1	T	T	T
ALDER	10 095	0.1	184	T	T	0	0	0	0	0	0	0	0	0
MAPLE	963	T	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL BROAD-LEAVED	211 046	2.6	194 043	4.1	2.4	1 408.4	1.0	T	T	17.3	0.2	T	T	T
TOTAL ALL SPECIES	8 082 182	100	4 728 404	100	58.5	135 612.5	100	1.7	2.9	10 472.5	100	0.1	0.2	7.7

Notes to Table : T = trace, less than 0.1%
(a) = Includes 444 474 m³ of whitebark pine

TABLE 4-11

REGIONAL STUDY AREA

SUMMARY OF MATURE STANDING VOLUME BY SPECIES AND TENURES

(Imperial Units)

7.1"+ dbh - Close Utilization less decay

1 000 cunits

TENURE	CONIFER SPECIES											BROADLEAF SPECIES				All Species Total
	F *	C	H	B	S	Pa	Pw	Pl	Py	L	Sub-Total	Cot	Bi	A	Sub-Total	
CROWN	16 403.6	63.4	73.8	2 331.2	6 729.7	157.9	291.1	16 605.5	1 101.2	2.8	43 760.2	23.1	48.3	372.0	443.4	44 203.6
ALIENATED	954.6	2.7	3.4	101.2	307.6	6.2	16.0	962.4	58.6	0.1	2 412.8	1.3	3.0	26.0	30.3	2 443.1
TFL #35	69.7	1.2	0	97.1	352.3	0	0	701.0	0	0	1 221.3	0	2.5	21.2	23.7	1 245.0
TOTAL	17 427.9	67.3	77.2	2 529.5	7 389.6	164.1	307.1	18 268.9	1 159.8	2.9	47 394.3	24.4	53.8	419.2	497.4	47 891.7

TABLE 4-12

REGIONAL STUDY AREA

SUMMARY OF MATURE STANDING VOLUMES BY SPECIES AND TENURES

(Metric Units)

18 cm+ dbh - Close Utilization less decay

1 000 cubic metres

TENURE	CONIFER SPECIES											BROADLEAF SPECIES				All Species Total
	F *	C	H	B	S	Pa	Pw	Pl	Py	L	Sub-Total	Cot	Bi	A	Sub-Total	
CROWN	46 449.2	179.5	209.0	6 601.1	19 056.2	447.1	824.0	47 021.0	3 118.2	7.9	123 913.2	65.4	136.8	1 053.4	1 255.6	125 168.8
ALIENATED	2 703.1	7.6	9.6	286.6	871.0	17.6	45.3	2 725.2	165.9	0.3	6 832.2	3.7	8.5	73.6	85.8	6 918.0
TFL #35	197.4	3.4	0	275.0	997.6	0	0	1 985.0	0	0	3 458.4	0	7.1	60.0	67.1	3 525.5
TOTAL	49 349.7	190.5	218.6	7 162.7	20 924.8	464.7	869.3	51 731.2	3 284.1	8.2	134 203.8	69.1	152.4	1 187.0	1 408.5	135 612.3

* For standard B.C. Forest Service tree species symbols code see Section 8.1

(ii) Access

The area is well-served by rail and road. Three of the railways serving B.C. cross the area. The Canadian National Railway and the Canadian Pacific Railway supply transportation to Vancouver to the west and the rest of Canada to the east. The British Columbia Railway serves Vancouver to the west by a different route and Prince George and northern British Columbia, to the north. Kamloops is the major carloading centre for the forest industry. Major sawmills are located beside the various railway lines and each is serviced by a loading spur line.

Major roads parallel the railways fairly closely. The Trans-Canada Highway follows the CPR route while Highway 97 goes north to Prince George. Numerous provincial highways and secondary roads, B.C. Forest Service logging access and mining roads provide a good transportation network for the area. Major access routes are shown on the map in Addendum 1. Access in the western limits of the area is somewhat restricted by the high mountains of the Coast Range. Minor access roads including forest development roads, are mapped on 1:15 840 B.C. Forest Service forest cover maps and these maps are available from the District Offices of the B.C. Forest Service, Inventory Division of the B.C. Forest Service in Victoria, or the Consultant's office.

Logging operators in the area are not seriously constrained by the cost of obtaining or constructing access to timber, except west of the Fraser River. The transportation opportunity from operational areas to mill sites is good and most of the mill sites have ready access to the railways for long distance shipment of forest products.

The area's major airport at Kamloops is served by Pacific Western Airlines. There are also local airstrips served by charter airline companies.

(iii) Disposition of Forest Resources

Approximately 90 percent of the forest land and 92 percent of the mature timber volume in the regional study area is owned by the Crown. The B.C. Forest Service, acting as the Crown's agent, disposes of timber via Timber Sale Harvesting Licenses, Timber Sale Licenses, Tree Farm Licenses and other Special Use Permits. The Forest Service has calculated an AAC for each PSYU[2] (see Tables 4-1 and 4-2) and from time to time releases part of the AAC to established licensees or quota holders. A list of these licensees (logging operators with quotas) and their portions of AAC for total PSYUs are shown in Addendum 2. A special allowance in the AAC calculations has been made for 50 000 acres in the Botanie PSYU used for other purposes, such as parks and open pit mines. This acreage is equivalent to approximately 7 600 cunits of allowable annual cut based on the weighted average MAI for the Botanie PSYU[2]. It is accepted that this area of forest land is likely to be permanently lost from commercial production. Current recalculation of the allowable cut to incorporate environmental protection areas has specifically assigned 5 000 acres (2 080 hectares) of the previous special allowance of 50 000 acres in anticipation of alienation of productive forest land over one rotation because of the potential development of coal lands at Hat Creek. Therefore if the Hat Creek mine is developed there would be no further reduction in the allowable cut for the Botanie PSYU as presently calculated.

The existing harvesting areas occur throughout the PSYUs and are of varied sizes and distribution. Plotting at a map scale of 1:250 000 is not feasible. The location of future harvesting areas is controlled by the BCFS but takes into consideration requests made by quota holders. Information available is not sufficiently precise to make accurate projections of the locations of future harvesting areas. However the calculation of the allowable annual cut is not dependent on the location of these harvesting areas. Quota holders or independent loggers, when approaching the B.C. Forest Service for timber to cut, broadly outline their area of interest.

This area is referred to as a chart area. If the chart area is approved in principle by the B.C. Forest Service, a Timber Sale Harvesting License is issued to the logging concern, subject to fulfillment of planning requirements.

Timber Sale Harvesting Licenses (TSHLs) contain one or more units called cutting permits. Within cutting permits there are at least two kinds of areas; one is referred to as a leave block, and the other is called a cut block. Leave blocks may not be harvested until adjacent cut-over areas are regenerated to commercial forest tree species. This may take up to ten years or longer. Tenures such as TSHLs do not usually remain more than 5 to 10 years in the same location.

Tables 4-1 and 4-2 also show the volume of AAC for the total area of the PSYUs, in the portion of the PSYUs located within the regional study area, because the regional study area boundaries do not precisely match the PSYU boundaries. Ten percent of the forest land which supports eight percent of the mature timber volumes is classified as alienated land. With the exception of TFL Schedule "A" lands, timber disposal on these areas is controlled by the owners.

Ecological reserves are areas of land set aside by Orders-in-Council under the authority of the Ecological Reserves Act[12] for a variety of purposes. A detailed description of those purposes is included in Addendum 6. Logging is not permitted in the reserves. Within the regional study area, and in the general vicinity of Hat Creek, there are three ecological reserves.[12] One is south of Spences Bridge (Soap Lake Reserve, Order-in-Council Number 1565) and one north of Clinton (Chasm Reserve, Order-in-Council Number 2010). The third reserve (Tranquille Reserve, Order-in-Council Numbers 3684 + 3992) is located just north of Kamloops Lake. There is also a proposed ecological reserve approximately 18 miles south of Upper Hat Creek on Skwaha Mountain. Ecological reserves within the study area are shown on the regional study map in Addendum 1.

Environmental Protection Forests or Environment Protection Areas (EPFs or EPAs) are lands which are partly or completely protected from logging by B.C. Forest Service regulations because the land has unstable or steep slopes or is important for its wildlife, fish, recreation or aesthetic reasons. Within the general vicinity of Hat Creek several EPFs have been proposed for these reasons. These are in the Robertson Creek area, and around Pavilion Lake (see Addendum 1). Other areas, as yet unspecified, are in the process of being analyzed for inclusion into EPFs by B.C. Forest Service personnel.

Two B.C. Forest Service, Research Division research plots have been established in the area to conduct long term investigations of a variety of factors concerning forestry. They are near Lac le Jeune Provincial Park in the Kamloops PSYU (see Addendum 1).

(iv) Forest Industrial Plants

During 1975, eleven sawmills, three plywood plants and one pulpmill were in operation in the regional study area. In 1976 a new sawmill in Clinton started production. Table 4-13 (Imperial Units) and Table 4-14 (Metric Units) summarize production and employment by plant in the regional study area. In 1976 total regional plant production* was:

Lumber	- 1 330 100 m^3	(564 million board feet)
Plywood and Veneer	- 171 700 m^3	(194 million square feet)
Wood Chip Shipments	- 1 100 600 m^3	(388 700 Bone Dry Units)
Pulp	- 336 490 tonnes	(370 917 tons)

* Please refer to Conversion Factors for comments on the usage and applicability of conversion factors - Section 8.2.

TABLE 4-13

PRODUCTION AND EMPLOYMENT AT FOREST INDUSTRIAL PLANTS IN THE REGIONAL STUDY AREA

(Imperial Units)

MILL LOCATION AND COMPANY	LUMBER PRODUCTION (million bd. ft.)		PLYWOOD & VENEER (l) 3/8" Basis-Million ft^2		CHIP SHIPMENTS 1 000 BDU(l)		PULP PRODUCTION (Tons)		PLANT EMPLOYMENT	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
CLINTON										
Ainsworth Lumber Co.	0(a)	35	-	-	0 (a)	25.0	-	-	0(a)	150
KAMLOOPS										
Balco Industries (b)	35	63	-	-	30.9	56.3	-	-	165	215
Balco Industries	-	-	47 Ply	62 Ply	-	-	-	-	110	130
Kamloops Pulp (c)	-	-	-	-	-	-	297 869	370 917	263(k)	263(k)
Weyerhaeuser of Canada	59	79	-	-	33.3	47.5	-	-	166	166
LILLOOET										
Commercial Lbr. Co.(d)	28	49	-	-	5.3	12.8	-	-	96	163
LYTTON										
Spatsum Lbr. Co.	6	6	-	-	2.4	2.8	-	-	15	15
MERRITT										
Aspen Planers Ltd.	26	28	-	-	8.3	19.5	-	-	60	60
Nicola Valley (e)	13(f)	39(f)	-	-	14.4	30.5	-	-	99	169
Weyerhaeuser of Canada	56	77	-	-	31.5	36.7	-	-	168	168
100 MILE HOUSE										
Ainsworth Lbr. Co.	45	50	-	-	37.0	37.0	-	-	150	150
Canim Lake Sawmills (g)	52	64	-	-	75.0	88.0	-	-	148	148
Weldwood of Canada	-	-	(64 Ply	84 Ply	-	-	-	-	(205	245
			(0 Ven	23 Ven(h)	-	-	-	-	(	
									43(i)	43(i)
SAVONA										
Savona Timber (d)	36	52	-	-	18.0	23.0	-	-	180	180
Savona Timber	-	-	25 Ply	25 Ply	-	-	-	-	100	100
70 MILE HOUSE										
Kamori Lbr. Co. (j)	20	20	-	-	7.0	9.6	-	-	46	50
TOTAL	396	564	136	196	283.1	388.7	297 869	370 917	2 012	2 415

Notes to Table:

Source : Unless otherwise noted, data supplied by mills.

(a) Mill built in 1975 and started production in January 1976
(b) Part of Canadian Forest Products
(c) Part of Weyerhaeuser of Canada
(d) Part of Evans Products Co.
(e) Part of Canadian Forest Products through BALCO
(f) From Annual Lumber Review & Buyers Guide - Forest Industries
(g) Part of Weldwood of Canada
(h) Veneer, 140 million ft^2 1/16" basis
(i) Supervision and staff for both sawmill and plywood plant
(j) Sold to Lignum in 1977
(k) Includes 95 head office staff in Kamloops
(l) See Section 4.2 - Conversion Factors

TABLE 4-14

PRODUCTION AND EMPLOYMENT AT FOREST INDUSTRIAL PLANTS IN THE REGIONAL STUDY AREA

(Metric Units)

MILL LOCATION AND COMPANY	LUMBER PRODUCTION 1 000 m^3		PLYWOOD AND VENEER 9.5 mm Basis 1 000 m^3		CHIP SHIPMENTS 1 000 M^3 Solid Wood Equivalent		PULP PRODUCTION (Tonnes)		PLANT EMPLOYMENT	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
CLINTON										
Ainsworth Lbr. Co.	0 (a)	82.5	-	-	0 (a)	70.8	-	-	0(a)	150
KAMLOOPS										
Balco Industries (b)	129.7	153.3	-	-	144.1	159.4	-	-	165	215
Balco Industries	-	-	41.6 Ply	54.9 Ply	-	-	-	-	110	130
Kamloops Pulp (c)	-	-	-	-	-	-	270 222	336 490	263(k)	263(k)
Weyerhaeuser of Canada	139.1	186.3	-	-	94.3	134.5	-	-	166	166
LILLOOET										
Commercial Lbr. Co. (d)	66.0	115.6	-	-	15.0	36.2	-	-	96	163
LYTTON										
Spatsum Lbr. Co.	14.2	14.2	-	-	6.8	7.9	-	-	15	15
MERRITT										
Aspen Planers Ltd.	61.3	66.0	-	-	23.5	55.2	-	-	60	60
Nicola Valley (e)	30.7	92.0	-	-	40.8	86.4	-	-	59	169
Weyerhaeuser of Canada	132.1	181.6	-	-	89.2	103.9	-	-	168	168
100 MILE HOUSE										
Ainsworth Lbr. Co.	106.1	117.9	-	-	104.8	104.8	-	-	150	150
Canim Lake Sawmills (g)	122.6	150.9	-	-	212.4	249.2	-	-	148	148
Weldwood of Canada	-	-	(56.6 Ply (0 Ven	74.3 Ply 20.4 Ven(h)	- -	- -	- -	- -	(205 (43(i)	245 43(i)
SAVONA										
Savona Timber (d)	84.9	122.6	-	-	51.0	65.1	-	-	180	180
Savona Timber	-	-	22.1 Ply	22.1 Ply	-	-	-	-	100	100
70 MILE HOUSE										
Komori Lbr. Co. (j)	47.2	47.2	-	-	19.8	27.2	-	-	44	50
TOTAL	933.9	1 330.1	120.3	171.7	801.7	1 100.6	270 222	336 490	2 012	2 415

Notes to Table:

Source : Metric Conversion of Table 4-13

(a) Mill built in 1975 and started production in January 1976
(b) Part of Canadian Forest Products
(c) Part of Weyerhaeuser of Canada
(d) Part of Evans Products Co.
(e) Part of Canadian Forest Products through BALCO
(f) From Annual Lumber Review & Buyers Guide - Forest Industries
(g) Part of Weldwood of Canada
(h) Veneer, 140 million ft^2 1/16" basis
(i) Supervision and staff for both sawmill and plywood plant
(j) Sold to Lignum in 1977
(k) Includes 95 head office staff in Kamloops

The 1976 average employment in these plants was 2 415 persons, including office and supervisory staff.

Table 4-15 compares the regional study area production to British Columbia production in 1975 and 1976. In 1976, industries within the region produced 6.3 percent of the British Columbia pulp, 5.3 percent of the lumber and 8.8 percent of the plywood.

TABLE 4-15

COMPARISON OF FOREST PRODUCTS PRODUCTION
IN REGIONAL STUDY AREA TO TOTAL BC PRODUCTION
1975 AND 1976

Product	Total BC Production		Regional Study Area Production			
	1975	1976	1975 (c)	As % of BC	1976 (c)	As % of BC
Pulp (a)	4 350 (b)	5 894 (b)	297.9	6.8	370.9	6.3
Lumber (d)	7 469 (b)	10 637 (b)	396	5.3	564	5.3
Plywood (e)	1 778 (f)	2 191 (f)	136	7.6	194	8.8

(a) 1 000 tons

(b) From B.C. Department of Economic Development Monthly Bulletin of Business Activity, March 1977

(c) From Table 4-13

(d) Million board feet

(e) Million square feet 3/8" basis

(f) See reference 17.

(b) Forest Insects and Diseases

(i) Significance of Forest Insects and Diseases

Forest insects and diseases often have a negative effect on the general health and growth of a forest. Insects cause forest damage primarily by reducing growth and killing trees. Secondary damage may be caused by reducing lumber and log grades, and indirectly by increasing the incidence of decay and increasing the incidence and rate of spread of forest fires.

Industrial air emissions are capable of similar effects, with many of the same symptoms. Therefore, prior to development, it is important to identify potential or existing forest insect and disease problems so that they may be distinguished from those which may be caused by industrial air emissions.

(ii) Historical Records

The records of the Forest Insect and Disease Survey of the Canadian Forestry Service (CFS), Environment Canada, have been used as source material[8]. CFS rangers, headquartered at Kamloops, survey the area systematically and annually record the total activity of insects and diseases. In addition, they study specific locations, i.e., fixed area permanent sample plots. The oldest of their records dates back to 1912. Their objectives are to identify species which have caused damage in the past and which are presumably capable of causing damage in the future,to record the pattern of insect population fluctuations and to identify areas that appear to have chronic problems.

Bark beetles have been the most destructive insects causing forest damage by loss of growth and death of trees.

The following listings have been summarized from the Annual District Reports of the Forest Insect and Disease Surveys 1912-1976[8].

Figure 4-1 indicates the frequency of occurrence by location and year for the 1912-1976 period as reported by the Canadian Forestry Service. The severity or extent of individual outbreaks is not consistently recorded.

COLOUR KEY TO MAJOR FOREST INSECT PESTS (FIGURE 4-1)

◊ Mountain pine beetle, *Dendroctonus ponderosae*

◊ Douglas-fir beetle, *Dendroctonus pseudotsugae*

◊ Douglas-fir tussock moth, *Orgyia pseudotsugata*

◊ Western blackheaded budworm, *Acleris gloverana*

◊ Spruce budworm, *Choristoneura occidentalis*

◊ Satin moth, *Stilpnotia salicis*

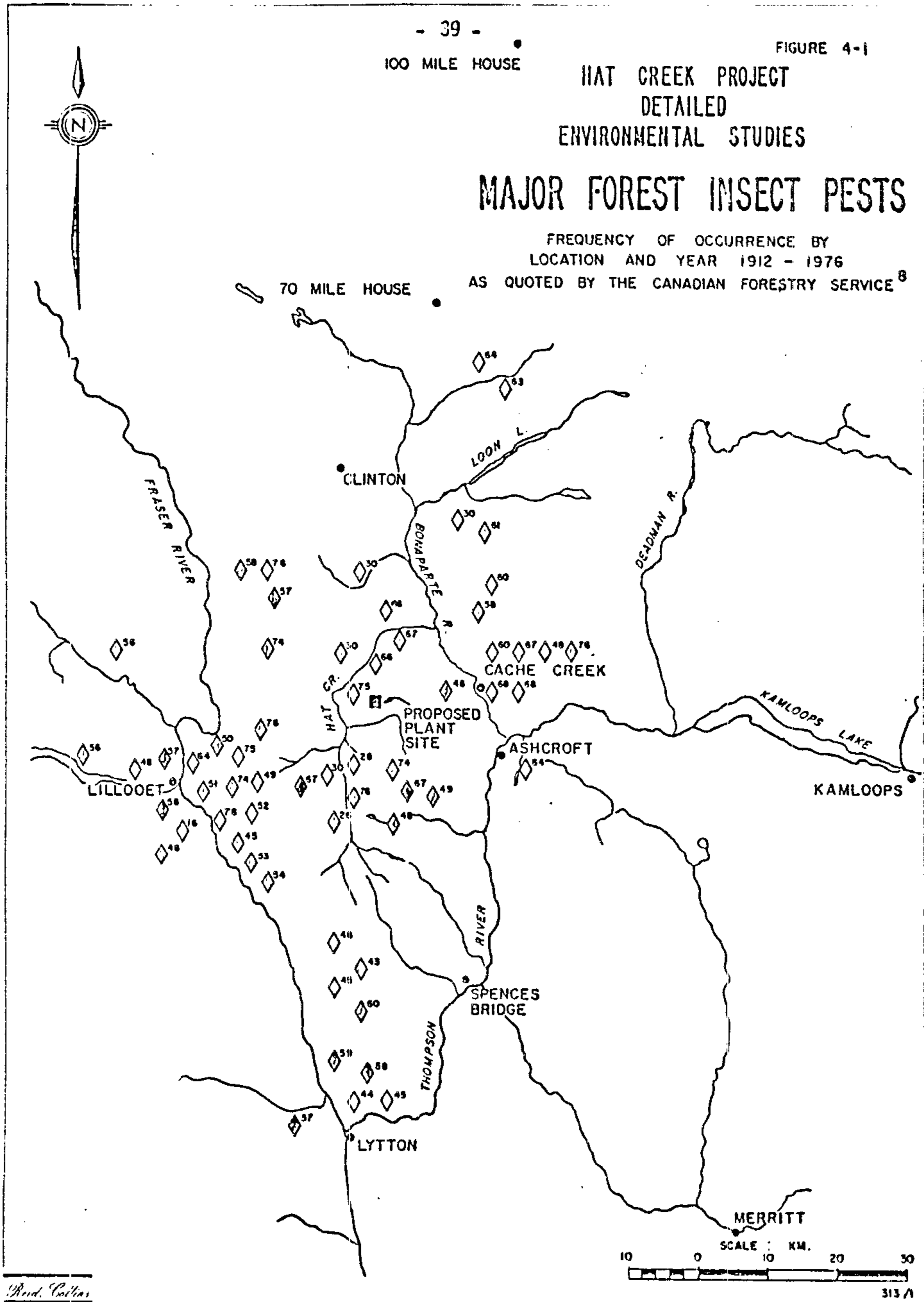
◊ Black pineleaf scale, *Nuculapsis californica*

FIGURE 4-1

HAT CREEK PROJECT
DETAILED
ENVIRONMENTAL STUDIES

MAJOR FOREST INSECT PESTS

FREQUENCY OF OCCURRENCE BY
LOCATION AND YEAR 1912 - 1976
AS QUOTED BY THE CANADIAN FORESTRY SERVICE [8]



A. Insects

Bark Beetle

Mountain Pine Beetle, Dendroctonus ponderosae, attacks all pine species and is often found in conjunction with the Western Pine Beetle, Dendroctonus brevicomis.

- 1930 - Small infestation north side of Hat Creek Valley.
- 1961 - Along Scottie Creek a few lodgepole pine "red-tops" (trees with mostly dead needles giving a red top appearance: such trees are unlikely to recover).
- 1964 - Small groups of red-top ponderosa pine - Lillooet and Ashcroft.
- 1966 - Lower Hat Creek, 3 000 ponderosa pine red-tops.
- 1967 - Lower Hat Creek, Gun Lake, 2 000 ponderosa pine red-tops.
- 1968 - Cache Creek, 250 - 500 red-tops.
- 1969 - Lower Hat Creek, infestation collapsed.
- 1975 - Small outbreak at Hat Creek on ponderosa pine.
- 1976 - Upper Hat Creek, 210 ha of ponderosa pine killed and 48 ha of lodgepole pine at Pavilion Mountain. Cinquefoil Creek, 65 ha of lodgepole pine killed.

Douglas-fir Beetle, Dendroctonus pseudotsugae. This beetle is a major pest of Douglas-fir.

- 1926 - Scattered infested trees in Upper Hat Creek.
- 1928 - Scattered infestations on Hat Creek Forest Reserve. Infestations at Scottie Creek and Deadman River cover 10 km^2.
- 1930 - Outbreaks along Upper Hat Creek and Scottie Creek (70% kill over 15 km^2). On Nicola Forest Reserve near Maiden Creek - 90% kill over 4 ha .
- 1958 - Groups of 70 to 600 red-tops in Arrowstone Hills.
- 1960 - Cache Creek, 300 red-tops. Arrowstone Hills, groups of over 100 red-tops.
- 1962 - Groups of up to 900 red-tops on Bonaparte plateau.
- 1963 - Bonaparte plateau, 2 100 red-tops.

1964 - Bonaparte River, 2 200 red-tops. Scottie Creek groups of 200 to 900 red-tops.

1965 - Bonaparte River, 1 900 red-tops.

1968 - Cache Creek, small groups up to 170 red-tops.

1974 - Fountain, Pavilion Lake, Cornwall, groups of 5 to 50 red-tops.

1975 - Fountain Valley, 300 red-tops.

Defoliators

Douglas-fir Tussock Moth, Orgyia pseudotsugata. The most important defoliator in the area, it attacks Douglas-fir and sometimes ponderosa pine. It is capable of sudden outbreaks which cause tree mortality.

1948 - Oregon Jack Creek, 1 600 ha serious defoliation, also at Cache Creek.

1949 - Oregon Jack Creek, light population.

1957 - Lillooet, up to 27 larvae per sample.

1958 - Lillooet, increase in population.

1959 - Lillooet, small infestation collapsed.

Western Blackheaded Budworm, Acleris gloverana. An important defoliator of western hemlock that also feeds on Douglas-fir.

1967 - Oregon Jack Creek, Upper Hat Creek, noticeable feeding damage along roads.

Spruce Budworm, Choristoneura occidentalis. An important defoliator of Douglas-fir. Severe outbreaks have occurred in the western part of the area.

1916 to 1976 Clear Range - western slopes. Active sporadically, particularly active in 1976.

Satin Moth, Stilpnotia salicis. Infests trembling aspen, black cottonwood and willow.

1944 & 1945 - Lytton, small infestation.

1946 - Botanie Valley, 80 ha infestation. Spences Bridge, occurrence.

1948 - Cache Creek, moth flight.

Scales

Black Pineleaf Scale, Nuculapsis californica. Attacks ponderosa pine occurring in the drier areas in the western parts of the area. Favoured in dusty locations[9].

1957 - Lytton, 4 ha infested.

1958 & 1959 - Lytton, infestation expanded along Botanie Valley.

1960 - Botanie Valley, infestation declined.

B. Diseases

In the past and at present, fungal or other tree diseases are not indicated by the Canadian Forest Service[8] to be a critical factor to the health of trees in the area.

(iii) Reconnaissance

Two reconnaissances were made of the Hat Creek area. They were superficial and were intended to provide an impression of the forest in order to better understand the records of the insect and disease surveys. The first reconnaissance was made at the beginning of May 1976; the second,early in August 1976, included an extensive low-level flight over the whole area. Observation was concentrated on but not restricted to the local study area. The most significant observations were: (1) the high frequency of "red-tops" scattered throughout the regional area caused by bark beetle activity; (2) the large number of spruce budworm moths which were in flight around Cache Creek. The forest is presently under a relatively high level of attack by insect pests and the record indicates this to have been the pattern historically.

(iv) Types of Damage

Insects are one of many agents that damage trees. Ground examination and laboratory testing by trained professionals may be necessary to positively identify the causal agent of the damage.

Three classes of insects; bark beetles, defoliators and scales, have caused damage to the forests of the Hat Creek area in the past and are likely to do so again in the future. A brief description of the type of damage they cause follows. A useful dichotomous key for interpretation of forest damage as seen from the ground and on aerial photographs may be found in "A Guide to Air Photo Interpretation of Forest Damage in Canada" by P.A. Murtha[15]. This includes damage caused by storms, animals, fungi, fire and air pollution as well as by insects. For specific examples of air pollution damage,the atlas edited by Jacobsen and Hill[16] is useful.

A. Bark Beetles

Bark beetles such as the mountain pine and Douglas-fir bark beetles feed just beneath the bark of the trees attacked, often causing pitch to flow out of entry holes in addition to the boring dust from their tunnelling. Foliage discoloration begins with yellowing 3-4 weeks after attack or the following spring. In the next season the foliage turns reddish-brown and within a few years the tree may shed all its needles and die.

B. Defoliators

Insects such as the Douglas-fir tussock moth and the western blackheaded and spruce budworms damage trees in the insect's larval or caterpillar stage by devouring the foliage. Their feeding is seen as cropped needles, thin, yellow or brown foliage and bare twigs. Defoliations may lead to top-kill and mortality.

C. Scale Insects

The most obvious effect of pine scales is a thinning of the crowns of infected trees. A considerable yellowing discoloration and death of parts of the needles will occur especially in the middle third of their length. The needle length may be shortened in severely infested trees. Normally pines will hold their needles four or even five years but scale infestations reduce the number of years of needle retention and in extreme cases only the current year's growth may remain.

(v) Discussion

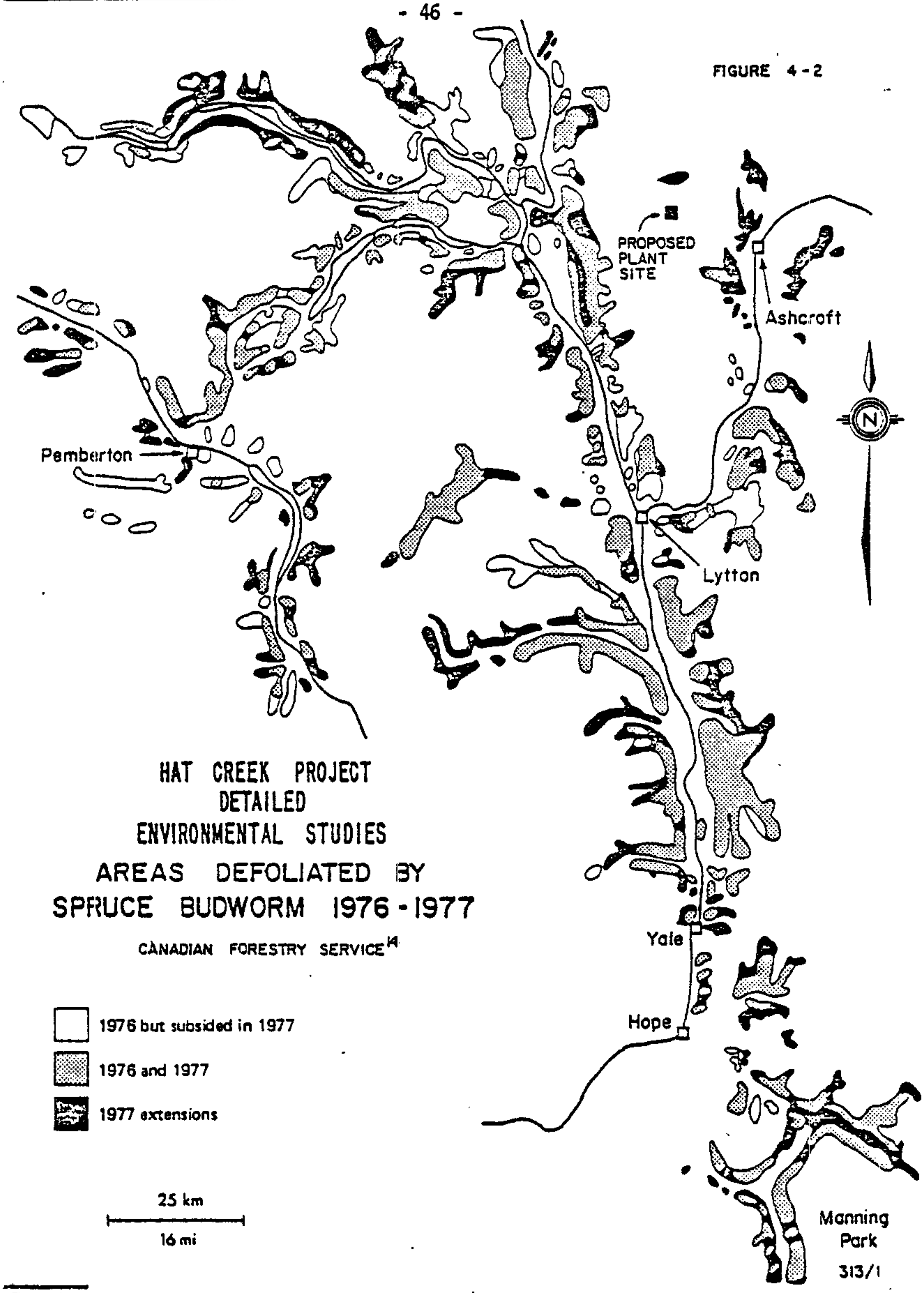
An awareness of the impact of insects on forest trees is useful because air pollutants can have an episodic damaging effect on forest growth similar in appearance to that caused by insects. It is therefore valuable to be aware of the insects, by type of feeding and damage, that are indigenous in the valley. The possibility also exists for the interaction of insect damage with air pollution damage and differentiation between the two types of damage is difficult. Technical definitions of specific interactions, both positive and negative, are infrequent in the literature. Other factors that weaken trees[11] have been shown to favour bark beetles. Dust has been shown to indirectly favour scale insects by reducing the population of predatory insects[9].

(vi) Summary of Insect Damage

Insects present and active in Hat Creek area have killed and will continue to kill individual and groups of ponderosa pine, Douglas-fir and lodgepole pine. The greatest hazards are the mountain pine and Douglas-fir bark beetles. The Douglas-fir tussock moth and the spruce budworm are less hazardous but significant as defoliators attacking Douglas-fir. The repetitious nature of attacks, as shown by the historical records, provides a strong basis for a confident prediction that significant mortality of Douglas-fir and ponderosa pine will occur from time to time in the regional and local study areas.

The most active insect in the area is the spruce budworm, a serious defoliator of conifers. Its present activity is shown in Figure 4-2 as recorded by the Canadian Forestry Service[14]. Studies of reduced tree diameter increment indicate the possibility of a cyclic recurrence of this insect with periods of infestation of about five years with ten year intervals between infestations[14]. On this record a five year period centered on 1990 might be important. The latest study results from BCFS (1977)[21] show that budworms are not now having a significant impact on the AAC in the affected area.

FIGURE 4-2


PROPOSED
PLANT
SITE
Ashcroft
Pemberton
Lytton
Yale
Hope
Manning
Park
313/1
HAT CREEK PROJECT
DETAILED
ENVIRONMENTAL STUDIES
AREAS DEFOLIATED BY
SPRUCE BUDWORM 1976-1977
CANADIAN FORESTRY SERVICE[14]
1976 but subsided in 1977
1976 and 1977
1977 extensions
25 km
16 mi

4.2 THE LOCAL STUDY AREA

(a) Forest Resources

The local study area is bounded by a circle, 25 km in radius, centered on the proposed Harry Lake thermal generation plant and covers 196 350 ha (485 190 ac). The area lies entirely within the Kamloops Forest District and contains portions of the Big Bar, Botanie and Yalakom PSYUs. Respectively 7.3, 23.4 and 12.7 percent of the total areas of these PSYUs fall in the local study area.

According to the BCFS forest cover maps, 146 893 ha (362 980 ac) or 75 percent of the area is classified as forest land. Ninety-four percent of the forest land is Crown land and the remaining 6 percent is alienated (see Tables 4-16 and 4-17). Most of the privately-held lands are in the valley bottoms.

(i) Forest Stands

Pure and mixed stands of Douglas-fir, lodgepole pine and spruce predominate in the local study area. Balsam, white pine and western red cedar are also present, but in smaller quantities. Some pure stands of yellow pine occur in the transition zone between open range land and higher more densely forested areas. Where there is sufficient moisture, aspen, birch and cottonwood are found in gullies.

The average diameters of mature Douglas-fir, lodgepole pine and spruce were estimated to be approximately 51 cm (20 in), 33 cm (13 in) and 30 cm (12 in) respectively. The average merchantable volumes per tree for the conifer species range from 0.5 to 1.7 m^3 (20 to 60 ft^3). Conifer log grades are estimated to be approximately 10 percent peeler, 75 percent sawlog and 15 percent pulp.

The size, density and quality of the timber in the area combine to provide a favourable opportunity for a profitable forest products industry to flourish.

(ii) Area-Volume Summaries

The broad forest type occurrence for all tenures in the local study area is presented below and compared to the regional study area[1, 2]:

	Local Study Area	Regional Study Area
Mature forest	50.0%	48.5%
Immature forest	40.0%	44.7%
Residual forest	6.8%	3.5%
Not Satisfactorily Restocked	3.0%	3.0%
Non-Commercial Cover	0.2%	0.3%

See Tables 4-16 and 4-17 for type distribution by tenure. A comparison of forest land by area of forest type of the regional British Columbia Interior, and total British Columbia is also to be found in Tables 4-3 and 4-4.

A comparison of the preceding type distributions in the local study area to those in the regional study area, the B.C. Interior and all of B.C. is presented in Tables 4-3 and 4-4. These tables show that the forest land total for the local study area is 8.5 percent of that in the regional study area, 0.33 percent of the B.C. Interior forest land area and 0.28 percent of the total British Columbia forest area.

TABLE 4-16

LOCAL STUDY AREA

AREA SUMMARY BY FOREST TYPES AND TENURES

(Imperial Units)

FOREST TYPE	CROWN		ALIENATED		TOTAL ACRES	%
	Acres	% of Forest Type in this Ownership	Acres	% of Forest Type in this Ownership		
MATURE	172 679	95.1	8 803	4.9	181 482	50.0
IMMATURE	134 441	92.6	10 696	7.4	145 137	40.0
RESIDUAL	23 044	93.2	1 694	6.8	24 738	6.8
NSR	10 245	93.2	746	6.8	10 991	3.0
NON-COMMERCIAL	320	50.4	315	49.6	635	0.2
TOTAL	340 729	94.0	22 254	6.0	362 983	100.0

TABLE 4-17

LOCAL STUDY AREA

AREA SUMMARY BY FOREST TYPES AND TENURES

(Metric Units)

FOREST TYPE	CROWN		ALIENATED		TOTAL ACRES
	Acres	% of Forest Type in this Ownership	Acres	% of Forest Type in this Ownership	
MATURE	69 881	95.1	3 563	4.9	73 444
IMMATURE	54 406	92.6	4 330	7.4	58 736
RESIDUAL	9 325	93.2	686	6.8	10 011
NSR	4 146	93.2	302	6.8	4 448
NON-COMMERCIAL	130	50.4	127	49.6	257
TOTAL	137 888	94.0	9 008	6.0	146 896

A listing of forest land distribution by growing sites on forest land in the local study area is presented in Tables 4-18 and 4-19 and is briefly summarized below compared to the regional study area. The local study area is less productive than the regional study area.

Site	Local Study Area	Regional Study Area
Good	1.6%	8.5%
Medium	25.1%	35.1%
Poor	71.4%	54.5%
Low	1.9%	1.9%

The map in Addendum 5 shows the location of the above-mentioned growing sites in the local study area.

Site class summaries for immature areas are included in Tables 4-20 and 4-21 and for mature forest areas in Tables 4-22 and 4-23.

At close utilization standards the total mature volume in the local study area is 10 472 500 m^3 (3 698 400 cunits). See Tables 4-22 to 25 for detailed listings of volumes by species. The total volumes for all species in the local study area are 7.7 percent of the volume in the regional study area, 0.2 percent of the volume of the B.C. Interior and 0.1 percent of the provincial total (see Tables 4-9 and 4-10).

To calculate the possible allowable annual cut for the local study area, compilations of the mean annual increment (MAI) were made by site class for those portions of the three PSYUs falling in the area. The results are tabulated in Tables 4-18 and 19. The total MAI values were then adjusted for volume losses which may occur because of insect and fire damage and area losses which may occur because of alienation or reallocation of lands to EPFs, stream bank protection areas or rights-of-way. A factor of 0.2 was used to reduce the total AAC to give net values. • The AAC for the local study area is computed to be 146 189 m^3 (51 626 cunits) per year or 8 percent of the AAC of the regional study area. See Table 4-1 for AAC values for the regional study area.

• See footnote on page 12.

Reid, Collins

TABLE 4-18

LOCAL STUDY AREA

Areas, MAI and Estimated AAC
by Site Classes in PSYUs
All Ownerships
(Imperial Units)

PSYU	Total Area in Acres - Mature & Immature					Total MAI in Cunits					AAC (cunits)
	Good	Medium	Poor	Low	Total	Good	Medium	Poor	Low	Total	
Big Bar	1 944	20 079	63 876	1 284	87 183	710	4 096	8 240	53	13 099	10 479
Botanie	1 539	41 736	142 350	3 507	189 132	754	12 356	21 210	175	35 495	28 396
Yalakom	1 701	20 219	26 975	1 409	50 304	1 123	7 825	6 906	85	15 939	12 751
TOTAL	5 184	82 034	233 201	6 200	326 619	2 587	25 277	36 356	313	64 533	51 626
% OF TOTAL	1.6	25.1	71.4	1.9	100%	4.0	39.2	56.3	0.5	100%	

TABLE 4-19

LOCAL STUDY AREA

Areas, MAI and Estimated AAC
by Site Classes in PSYUs
All Ownerships
(Metric Units)

PSYU	Total Area in Hectares - Mature & Immature					Total MAI in Cubic Metres					AAC (m3)
	Good	Medium	Poor	Low	Total	Good	Medium	Poor	Low	Total	
Big Bar	787	8 126	25 850	520	35 283	2 010	11 598	23 333	150	37 091	29 673
Botanie	623	16 890	57 607	1 419	76 539	2 135	37 820	60 059	496	100 510	80 408
Yalakom	688	8 183	10 917	570	20 358	3 180	22 158	19 556	241	45 135	36 108
TOTAL	2 098	33 199	94 374	2 509	132 180	7 325	71 576	102 948	887	182 736	146 189

TABLE 4-20
LOCAL STUDY AREA
IMMATURE AREAS BY SITE CLASSES IN PSYUs
All Ownerships
(Imperial Units)

PSYU	Immature Area in Acres				
	Good	Medium	Poor	Low	Total
Big Bar	1 944	14 305	19 146	1 284	36 679
Botanie	900	15 746	56 087	2 249	74 982
Yalakom	1 406	10 511	20 153	1 406	33 476
TOTAL	4 250	40 562	95 386	4 939	145 137

TABLE 4-21
LOCAL STUDY AREA
IMMATURE AREAS BY SITE CLASSES IN PSYUs
All Ownerships
(Metric Units)

PSYU	Immature Area in Hectares				
	Good	Medium	Poor	Low	Total
Big Bar	787	5 789	7 748	520	14 844
Botanie	364	6 372	22 698	910	30 344
Yalakom	569	4 254	8 156	569	13 548
TOTAL	1 720	16 415	38 602	1 999	58 736

TABLE 4-22

LOCAL STUDY AREA

MATURE FOREST AREAS AND VOLUMES BY SPECIES

7.1"+ dbh, Close Utilization less decay only
All Ownerships
(Imperial Units)

PSYU	Mature Area in Acres					Mature Volume (1 000 cunits)								
	Good	Medium	Poor	Low	Total	S	B	Pl	C	F	Pw	Py	Decid	Total
Big Bar	-	5 774	44 730	-	50 504	26.0	4.8	78.8	-	457.2	-	40.2	4.2	611.2
Botanie	639	25 990	86 263	1 258	114 150	397.7	58.8	743.5	2.8	1 328.9	34.6	39.0	1.9	2 607.2
Yalakom	295	9 708	6 822	3	16 828	87.6	20.4	91.0	-	243.3	2.6	35.1	-	480.0
TOTAL	934	41 472	137 815	1 261	181 482	511.3	84.0	913.3	2.8	2 029.4	37.2	114.3	6.1	3 698.4

TABLE 4-23

LOCAL STUDY AREA

MATURE FOREST AREAS AND VOLUMES BY SPECIES

18 cm+ dbh, Close Utilization less decay only
All Ownerships
(Metric Units)

PSYU	Mature Area in Hectares					Mature Volume (1 000 cubic metres)								
	Good	Medium	Poor	Low	Total	S	B	Pl	C	F	Pw	Py	Decid	Total
Big Bar	-	2 337	18 102	-	20 439	73.6	13.6	223.1	-	1 294.6	-	113.8	11.9	1 730.6
Botanie	259	10 518	34 909	509	46 195	1 126.1	166.5	2 105.3	7.9	3 763.0	98.0	110.4	5.4	7 382.6
Yalakom	119	3 929	2 761	1	6 810	248.1	57.8	257.7	-	688.9	7.4	99.4	-	1 359.3
TOTAL	378	16 784	55 773	510	73 444	1 447.8	237.9	2 586.1	7.9	5 746.5	105.4	323.6	17.3	10472.5

TABLE 4-24

LOCAL STUDY AREA

VOLUME SUMMARY BY TENURE AND SPECIES

7.1"+ dbh, Close Utilization less decay

(Imperial Units)

SPECIES	CROWN 1 000 Cunits	CROWN % in Crown	ALIENATED 1 000 Cunits	ALIENATED % in Alienated	Total 1 000 Cunits
HEMLOCK	0	0	0	0	0
SPRUCE	493.7	96.6	17.6	3.4	511.3
BALSAM	81.7	97.3	2.3	2.7	84.0
LODGEPOLE PINE	872.4	95.5	40.9	4.5	913.3
RED CEDAR	2.8	100.0	0	0	2.8
DOUGLAS-FIR	1 904.0	93.8	125.4	6.2	2 029.4
YELLOW CEDAR	0	0	0	0	0
WHITE PINE	36.8	98.9	0.4	1.1	37.2
LARCH	0	0	0	0	0
YELLOW PINE	105.7	92.6	8.6	7.4	114.3
CONIFER TOTAL	3 497.1	94.7	195.2	5.3	3 692.3
ASPEN	2.4	96.0	0.1	4.0	2.5
COTTONWOOD	0.9	90.0	0.1	10.0	1.0
BIRCH	2.6	100.0	0	0	2.6
ALDER	0	0	0	0	0
MAPLE	0	0	0	0	0
BROADLEAF TOTAL	5.9	96.7	0.2	3.3	6.1
GRAND TOTAL	3 503.0	94.7	195.4	5.3	3 698.4

TABLE 4-25

LOCAL STUDY AREA

VOLUME SUMMARY BY TENURE AND SPECIES

18 cm+ dbh, Close Utilization less decay

(Metric Units)

SPECIES	CROWN		ALIENATED		Total
	1 000 m^3	% in Crown	1 000 m^3	% in Alienated	1 000 m^3
HEMLOCK	0	0	0	0	0
SPRUCE	1 398.0	96.6	49.8	3.4	1 447.8
BALSAM	231.3	97.3	6.5	2.7	237.8
LODGEPOLE PINE	2 470.3	95.5	115.8	4.5	2 586.1
RED CEDAR	7.9	100.0	0	0	7.9
DOUGLAS-FIR	5 391.5	93.8	355.1	6.2	5 746.6
YELLOW CEDAR	0	0	0	0	0
WHITE PINE	104.2	98.9	1.1	1.1	105.3
LARCH	0	0	0	0	0
YELLOW PINE	299.3	92.6	24.4	7.4	323.7
CONIFER TOTAL	9 902.5	94.7	552.7	5.3	10 455.2
ASPEN	6.8	96.0	0.3	4.0	7.1
COTTONWOOD	2.5	90.0	0.3	10.0	2.8
BIRCH	7.4	100.0	0	0	7.4
ALDER	0	0	0	0	0
MAPLE	0	0	0	0	0
BROADLEAF TOTAL	16.7	96.7	0.6	3.3	17.3
GRAND TOTAL	9 919.2	94.7	553.3	5.3	10 472.5

In the Botanie PSYU the total AAC is computed to be 407 800 m^3 (144 000 cunits). The annual commitments to quota holders (see Addendum 2) are reported to be 323 921 m^3 (114 393 cunits). The AAC in the local study area is 45 percent of that in the total Botanie PSYU.

(iii) Access

Primary access to the local study area is provided by Highway 12 (paved) which starts 10 kilometres north of Cache Creek and runs west from Highway 97. The road connects to Pavilion Lake and Lillooet.

Secondary access is provided to the Hat Creek Valley by two roads, one a gravel-dirt road starting three kilometres north of Cache Creek, extending westward past McLaren Lake and through the Medicine Creek Valley, the other a gravel road through Oregon Jack Valley to Upper Hat Creek.

There are numerous logging and farm roads, some gravel, some dirt, in the area (see maps in Addendum 1 and Addendum 5). Construction of this type of road is relatively simple and inexpensive.

(iv) *Disposition of Forest Resources*

There are no existing or proposed ecological reserves within the local study area.

There is a proposed Environmental Protection Forest in the Robertson Creek area which has steep and unstable slopes. There is another proposed Environmental Protection Forest located around Pavilion Lake (between Marble Canyon Provincial Park and Indian Reserves 3 and 1A).

Current Timber Sale Harvesting Licenses (TSHL) and Timber Sale License (TSL) areas are shown on the map in Addendum 1.

The principal operator in the local study area is Evans Products Company Limited. Logs are trucked 56 kilometres to its sawmill and plywood plant at Savona. This company holds a TSHL in the Hat Creek Valley and plans to remain active in the valley until at least 1985.

Ainsworth Lumber Company Limited holds quota in the Big Bar PSYU and plans to log near the fringes of Hat Creek Valley. Proposed construction and mining operations will not conflict with their activities and hence with their sawmill production at Clinton. It is unlikely that their mill at 100 Mile House will use much timber from the Hat Creek area.

4.3 SITE SPECIFIC STUDY AREA

The site specific study area is composed of three main units: the plant and related facilities, the mine and related facilities, and the offsite facilities. These units and their component parts are shown on the 1:24 000 map of the site specific study area in Addendum 10. A list of the individual component parts, with their map codes, descriptions and land areas, dated December 7, 1977, supplied by Tera Consultants Limited and approved by EBASCO Services of Canada Limited, Environmental Consultants, is in Addendum 8.

The areas supplied excluded those areas lying between component parts of the various facilities which would be unavailable for forestry purposes. Trees adjacent to fences, buildings, transmission lines, stationary machinery or other structures are usually considered an unacceptable risk to the safety and security of the installations. In addition, some of the facilities themselves, particularly reservoirs and dry ash or overburden dumps, may be harmful to adjacent trees. Therefore a 20 metre buffer zone was added to most facilities in forested areas. Both the buffer zone areas and those areas between the component parts of the various facilities were put into a miscellaneous category. The areas of individual component parts for each of the three main units are presented in Addendum 9.

A supplementary list, dated January 26, 1978 contained areas for component parts that had no areas quoted in the previous listing. All of the new areas can be considered as being included within the miscellaneous category with the exception of the new ash dump.

The miscellaneous category did not introduce any undue bias into the inventory as these areas do not differ significantly either in quality, quantity per unit area or site productivity from the areas included within the specific components.

Access for logging is not limited within any of the site specific study areas.

(a) Plant and Related Facilities

As of January 1, 1978, there were three possible optional ash disposal systems being considered. While the plant generation site, plant reservoir and the connecting pipeline remain constant, the ash may be disposed of in three possible locations.

The three options are analyzed as separate entities for comparative purposes. All the alternatives are shown on the map in Addendum 10.

(i) Wet Ash Disposal: Option 1

In addition to the basic component facilities of the generating plant, this option contains a wet ash pond in Medicine Creek Valley. The pond requires a dam and four drainage canals to drain, stabilize and store the fly and bottom ash. The area between the drainage canals and the ash pond were included in the inventory.

The recent addition of another dry ash pond was not included in the inventory because of lack of information. It appears to add about 7 percent to the area, volume and productivity contained within Option 1.

The land area within Option 1 consists of:

- 615.7 ha (1 521.5 ac) of productive forest land.
- 7.9 ha (19.3 ac) of non-productive forest land.
- 285.1 ha (704.4 ac) of non-forest land, mainly open range.

The forest stands within Option 1 range from mature good site lodgepole pine to mature Douglas-fir (poor site) and aspen stands. Seventy-five percent of the forested land is classified as poor site immature Douglas-fir and lodgepole pine forest stands. All of the good site land is contained within the wet ash pond.

All merchantable forest stands are easily accessible from the Medicine Creek Valley road, and are within a 5 km radius of recently logged areas.

Table 4-26 summarizes the volume of merchantable timber that may be harvested within the boundaries of Option 1. The total merchantable volume is 26 701.6 m^3 of which lodgepole pine and Douglas-fir account for 94 percent (63 percent and 31 percent respectively).

TABLE 4-26

SITE SPECIFIC STUDY AREA: MERCHANTABLE VOLUME *
BY SPECIES: PLANT AND WET ASH DISPOSAL
OPTION 1

Species	Merchantable Volume Cubic Metres	Merchantable Volume Cunits
Douglas-fir	8 222.3	2 903.7
Red cedar	12.2	4.3
Hemlock	3.1	1.1
Balsam	130.0	45.9
Spruce	1 347.6	475.9
White pine	8.2	2.9
Lodgepole pine	16 902.6	5 969.1
Yellow pine	56.6	20.0
Deciduous (Aspen, Birch and Cottonwood)	19.0	6.7
TOTAL	26 701.6	9 429.6

* Close Utilization Standards

The productivity of forest land is dependent upon site quality: the capacity of land to produce timber. Site quality in turn varies for each tree species. For example, poor site for aspen could be medium site quality for Douglas-fir. The B.C. Forest Service has estimated productivity on the basis of site classes and groups of tree species. Such groups of tree species are referred to as forest growth types and these are used in the assessment of yield for AAC calculations.

Table 4-27 summarizes the productivity of the forested land within the boundaries of Option 1. The predominant forest growth type, lodgepole pine - conifer, is used as the basis for estimating forest productivity. The total annual increment in Table 4-27 is the amount of wood that the area could contribute to the allowable annual cut of the Botanie PSYU.

TABLE 4-27

SUMMARY OF PRODUCTIVITY: PLANT AND WET ASH DISPOSAL

OPTION 1

Site Class	Area		Mean Annual Increment		Total Annual Increment	
	Hectares	Acres	m^3/ha	Cunits/Ac	m^3	Cunits
Good	54.2	134.0	3.1	0.45	171	60
Medium	386.8	955.8	2.1	0.30	812	287
Poor	174.7	431.7	1.3	0.18	220	78
TOTAL	615.7	1 521.5			1 203	425

This plant and ash disposal option covers more surface area than either of the other two options and contains the greatest volume of merchantable timber. (See summary tables in Appendix 9)

(ii) Dry Ash Disposal Scheme I: Option 2

In addition to the basic component facilities of generating plant, reservoir and pipeline, Option 2 has two dry ash dumps south and southwest of and adjacent to the generating plant site. Option 2 is a compact design with low berms on the sides to confine the ash and divert the rain falling on the area to a central collecting point for subsequent disposal. The area between the dump site and the generating plant will be traversed by mechanisms designed to discharge the ash directly onto the dumps.

The forest stands within the confines of Option 2 are mainly poor site Douglas-fir and aspen stands. Approximately one-fifth of the area is covered in merchantable mature stands. The forest stands are generally contiguous to a central core of open range land centered near Harry Lake.

The land area within Option 2 consists of:

- 261.0 ha (644.8 ac) of productive forest land.
- 0.4 ha (0.9 ac) of non-productive forest land.
- 278.4 ha (687.8 ac) of non-forest land, mainly open range.

All of the merchantable stands are easily accessible from Hat Creek and Medicine Creek roads.

Within Option 2 there is a total of 9 482.2 cubic metres (3 348.6 cunits) of merchantable timber which can be harvested. Douglas-fir accounts for 88 percent of the total merchantable volume.

Table 4-28 below summarizes the volumes by species:

TABLE 4-28

SITE SPECIFIC STUDY AREA: MERCHANTABLE VOLUME*BY SPECIES: PLANT AND DRY ASH DISPOSAL SCHEME 1: OPTION 2

Species	Merchantable Volume m^3	Merchantable Volume Cunits
Douglas-fir	8 364.5	2 953.9
Red cedar	25.8	9.1
Hemlock	-	-
Balsam	42.2	14.9
Spruce	187.2	66.1
White pine	4.8	1.7
Lodgepole pine	180.4	63.7
Yellow pine	663.7	234.4
Deciduous (Birch, Aspen, and Cottonwood)	13.6	4.8
TOTAL	9 482.2	3 348.6

* Close Utilization Standards

Table 4-29 summarizes the productivity of the forested land within the boundaries of Option 2. The predominant forest growth type, pure Douglas-fir, is used as the basis for estimating forest productivity. The total annual increment in Table 4-29 is the amount of wood that the area could contribute to the allowable annual cut of the Botanie PSYU.

TABLE 4-29

SUMMARY OF PRODUCTIVITY: PLANT AND DRY ASH DISPOSAL

SCHEME I: OPTION 2

Site Class	Area		Mean Annual Increment		Total Annual Increment	
	Hectares	Acres	m^3/ha	Cunits/Ac	m^3	Cunits
Good	-	-	-	-	-	-
Medium	66.9	165.3	1.7	0.24	112	40
Poor	194.1	479.5	1.0	0.14	190	67
TOTAL	261.0	644.8			302	107

(iii) Dry Ash Disposal Scheme II: Option 3

In addition to the constant components of the plant sites, Option 3 has two dry ash dumps south to south-west of and adjacent to the plant site. The Option 3 ash dumps are slightly smaller and have a different configuration than the dumps in Option 2. The area between the dump sites and the generating station will be crossed by two or more mechanisms designed to discharge the bottom and fly ash directly onto the dump sites.

The forest stands within the borders of Option 3 are predominantly poor site Douglas-fir and aspen stands. Approximately one-fifth of the area is covered by merchantable mature stands of timber. The forest stands are generally located around a central core of open rangeland, centered around Harry Lake.

The land area within Option 3 consists of:

- 249.5 ha (616.3 acres) of productive forest land.
- 0.4 ha (0.9 acres) of non-productive forest land (swamp).
- 237.9 ha (587.7 acres) of non-forest land, mainly open range.

All of the merchantable stands are easily accessible from Medicine Creek Road.

Within Option 3, there is a total of 10 043.1 cubic metres of merchantable wood of which 92 percent is Douglas-fir. Table 4-30 below, summarizes the volume by species.

TABLE 4-30

SITE SPECIFIC STUDY AREA: MERCHANTABLE VOLUME *
BY SPECIES: PLANT AND DRY ASH DISPOSAL
SCHEME II: OPTION 3

Species	Merchantable Volume	
	Cubic Metres	Cunits
Douglas-fir	9 232.7	3 260.5
Red cedar	34.0	12.0
Hemlock	-	-
Balsam	55.2	19.5
Spruce	245.5	86.7
White pine	6.2	2.2
Lodgepole pine	236.2	83.4
Yellow pine	220.0	77.7
Deciduous (Aspen, Birch and Cottonwood)	13.3	4.7
TOTAL	10 043.1	3 546.7

* Close Utilization Standards

Table 4-31 summarizes the productivity of the forested land within the area of Option 3. The predominant pure Douglas-fir growth type is used as the basis for estimating forest productivity. The total annual increment in Table 4-31 is the amount of wood that the area could contribute to the allowable annual cut of the Botanie PSYU.

TABLE 4-31

SUMMARY OF PRODUCTIVITY: PLANT AND DRY ASH DISPOSAL

SCHEME II: OPTION 3

Site Class	Area		Mean Annual Increment		Total Annual Increment	
	Hectares	Acres	m^3/ha	Cunits/Ac	m^3	Cunits
Good	-	-	-	-	-	-
Medium	85.1	210.3	1.7	0.24	143	50
Poor	164.4	406.0	1.0	0.14	161	57
TOTAL	249.5	616.3			304	107

(iv) Comparative Summary of Ash Dump Options

Table 4-32 summarizes the effect that each of the options have on the forest value of the area.

There is a significant difference between Option 1 - the wet ash disposal system and the two dry ash schemes, even without including the new ash dump.

There is no significant difference in the areas, volumes or possible contribution to AAC between Options 2 or 3.

TABLE 4-32

AREA, VOLUME, INCREMENT SUMMARY FOR PLANT SITE OPTIONS

Option	Total Area		Productive Forest		Merchantable Volume**		Total Annual Increment	
	Hectares	Acres	Hectares	Acres	Cubic Metres	Cunits	Cubic Metres	Cunits
1 Wet Ash	908.7	2 245.2	615.7	1 521.5	26 701.6	9 429.6	1 203	425
2 Dry Ash I	539.8	1 333.5	261.0	644.8	9 482.2	3 348.6	302*	107
3 Dry Ash II	487.8	1 204.9	249.5	616.3	10.043.1	3 546.7	304*	107

*Slight differences due to rounding.
**Close Utilization Standards.

(b) Mine and Related Facilities

The major components of the mine include the main open pit, three main overburden dumps, coal blending or stockpiling areas and a system of draining or diverting water from the main pit.

Between the various components there are areas of land that will become unavailable for forestry purposes because of security, obstruction or aesthetics. Also some forest areas may be harmed by spillage and slumping around the edge of the overburden dumps. For example, trees adjacent to the edge of a dump could have earth piled a metre or so deep around their trunks. Such trees may die and thereby become a fire or insect hazard. For these reasons, a buffer zone of 20 metres was placed around many of the facilities. The buffer zone and isolated lands were placed in a miscellaneous category.

The mine and related facilities cover an area larger than either that covered by the thermal plant or the offsite facilities. They are bisected by a large area of open range land (35 percent of the total area) in the Hat Creek Valley bottom, with contiguous forest stands on either side. The forest stands are mainly mature merchantable Douglas-fir and yellow pine. Good site merchantable immature spruce (7.0 hectares) occurs in a small draw in the center of the south dump (designated M-4 on the map in Addendum 10).

The Medicine Creek overburden dump (designated M-2 on the map in Addendum 10) has low volume mature merchantable poor site Douglas-fir stands with some minor area of immature poor site Douglas-fir, aspen stands.

The land area within the mine site in both sections consists of:

- 1 847.9 ha (4 566.2 ac) of productive forest land.
- 43.5 ha (107.4 ac) of non-productive forest land.
- 1 077.0 ha (2 661.4 ac) of non-forest land, mainly open range.

All of the merchantable stands are accessible for logging from logging roads that lead to either the Hat Creek or Medicine Creek roads.

Within the mine site, there is a total of 120 148.0 cubic metres of merchantable wood which could be harvested. Eighty-one percent of the volume is Douglas-fir, while yellow pine and spruce comprise 14 percent and 3 percent respectively. Table 4-33, below summarizes the volume by species.

TABLE 4-33

SITE SPECIFIC STUDY AREA: MERCHANTABLE VOLUME* BY SPECIES FOR MINE AND RELATED FACILITIES

Species	Merchantable Volume	
	Cubic Metres	Cunits
Douglas-fir	97 898.5	34 572.6
Red cedar	133.4	47.1
Hemlock	7.1	2.5
Balsam	397.6	140.4
Spruce	3 077.5	1 086.8
White pine	145.0	51.2
Lodgepole pine	1 540.4	544.0
Yellow pine	16 861.0	5 954.4
Deciduous (Aspen, Birch and Cottonwood)	87.5	30.9
TOTAL	120 148.0	42 429.9

* Close Utilization Standards

Table 4-34 below, summarizes the productivity of the forested land within the areas of the mine site. The predominant growth type is pure Douglas-fir; this growth type is used as the basis for estimating forest productivity. The total annual increment in Table 4-34 is the amount of wood that the mine area could contribute to the AAC of the Botanie PSYU.

TABLE 4-34

SUMMARY OF PRODUCTIVITY: MINE AND RELATED FACILITIES

Site Class	Area		MAI Annual Increment		Total Annual Increment	
	Hectares	Acres	m^3/ha	Cunits/Ac	m^3	Cunits
Good	7.0	17.4	3.6	0.51	25	9
Medium	91.5	226.4	1.7	0.24	154	54
Poor	1 749.4	4 332.8	1.0	0.14	1 714	605
TOTAL	1 847.9	4 566.2			1 893	668

(c) Offsite Facilities

This category includes all facilities which do not directly relate to the mine or thermal electric generating plant: several of these are linear utility corridors. The precise locations of these corridors are not known; however those shown on the map in Addendum 10 may be considered as representative samples.

There are forty-six component parts included within the offsite category. Of these, twenty-four have calculated areas (as of January 1, 1978). It is within this group that almost all of the forest land occurs.

The remaining twenty-two component parts have no areas calculated because of engineering uncertainties or because they are included within another larger component.

An area summary by component parts is shown in Addendum 9.

Small buffer zones were added to the forested area adjacent to the reservoir. No buffer zones were added to utility corridors, such as roads or pipelines because of uncertainties in the precise location of cuts and fills.

The offsite facilities cover a total area of 446 hectares (1 102.2 acres) and are dispersed between Hat Creek Valley and Ashcroft, via Medicine Creek. Because of this dispersion, buffer zone uncertainties, and forthcoming additional area calculations, the total area is probably underestimated. The final area affected by the project will be known only after the engineering planning has been completed.

Most of the offsite facilities are at lower elevations in mainly open range areas. A high proportion (64 percent) of the offsite area is covered by non-forest land. The forests that are affected by the off-site facilities are covered by mainly poor site Douglas-fir stands, of which 40 percent is merchantable and mature. The land area within the offsite facilities consists of 160.7 ha (397.1 ac) of productive forest land and 285.3 ha (705.1 ac) of non-forest land, mainly open range. All of these merchantable stands are accessible from existing roads.

Within the offsite facilities there is a total of 10 148.5 cubic metres of merchantable wood that could be harvested. Eighty-five percent of the volume is Douglas-fir. The remainder is divided almost equally between spruce, lodgepole pine and yellow pine and the deciduous species. Table 4-35 below summarizes the volume by species.

TABLE 4-35

SITE SPECIFIC STUDY AREA: MERCHANTABLE VOLUME*BY SPECIES: OFFSITE AREAS

Species	Merchantable Volume	
	Cubic Metres	Cunits
Douglas-fir	8 668.3	3 061.2
Red cedar	25.2	8.9
Hemlock	-	-
Balsam	48.4	17.1
Spruce	291.7	103.0
White pine	9.1	3.2
Lodgepole pine	392.5	138.6
Yellow pine	366.7	129.5
Deciduous (Aspen, Birch and Cottonwood)	346.6	122.4
TOTAL	10 148.5	3 583.9

* Close Utilization Standards

Table 4-36 summarizes the productivity of the forested land within the offsite areas. Douglas-fir is the climax species; and the predominant Douglas-fir growth type is used as the basis for estimating forest productivity - MAI. The total annual increment of 199 cubic metres in Table 4-36 is the amount of wood that the offsite areas could contribute to the AAC of the Botanie PSYU.

TABLE 4-36

SUMMARY OF PRODUCTIVITY: OFFSITE FACILITIES

Site Class	Area		Mean Annual Increment		Total Annual Increment	
	Hectares	Acres	m^3/ha	Cunits/Ac	m^3	Cunits
Good	3.9	9.7	3.6	0.51	14	5
Medium	44.6	110.0	1.7	0.24	75	26
Poor	112.2	277.4	1.0	0.14	110	39
TOTAL	160.7	397.1			199	70

Not included in the above inventory is the proposed double 500 kV transmission line which may go from Nicola Substation to Kelly Lake Substation, past either the Ashcroft area or the Oregon Jack Creek area. The construction of this transmission line is independent of the Hat Creek Project. The Thompson River crossing is undecided and the location of the 500 kV transmission line connections or loop-in to the thermal generator at Harry Lake is uncertain. Therefore the area of the 500 kV loop-in cannot be included in the inventory.

(d) Summary of Site Specific Inventory

Section (a) (iv) above, summarizes the merchantable volumes and forest productivity of the three plant options. This section summarizes the merchantable volumes and forest productivity of the total project for each option of ash disposal alternative being considered. In this way the difference between options can be compared in the context of the whole project.

Table 4-37 summarizes the three options by total area, area of productive forest, merchantable volume and total annual increment. The inventory is based on a productivity classification of what is currently there - present land use conditions.

The total area, area of productive forest, merchantable volume and annual increment of Option 1 are significantly greater than either Option 2 or Option 3. The difference between Option 2 or 3 is insignificant.

Further, the weighted average mean annual increment of Option 1 is nearly equal to the average for the Botanie PSYU, whereas Options 2 and 3 are below average.

There would be a preference, from the forestry point of view, for either Scheme I, Option 2 or Scheme II, Option 3.

TABLE 4-37

SUMMARY OF SITE SPECIFIC INVENTORY

Facility Group	Total Area		Productive Forest Area		Merchantable Volume**		Total Annual Increment		Weighted Average MAI	
	Hectares	Acres	Hectares	Acres	Cubic Metres	Cunits	Cubic Metres	Cunits	m^3/ha	Cunits/Ac.
Mine,Offsite, Plant Option 1	4 323.1	10 682.4	2 624.3	6 484.8	156 998.1	55 443.4	3 295	1 163	1.3	0.18
Mine,Offsite, Plant Option 2	3 954.2	9 770.7	2 269.6	5 608.1	139 778.7	49 362.4	2 394*	845	1.1	0.15
Mine,Offsite, Plant Option 3	3 902.2	9 642.1	2 258.1	5 579.6	140 339.6	49 560.5	2 396*	845	1.1	0.15

* Slight differences due to rounding.
** Close Utilization Standards.

The weighted average MAI for the Botanie PSYU is 1.329 m^3/ha or 0.19 cunits per acre.

SECTION 5.0 - IMPACT OF THE PROJECT

The impact on site specific areas required by construction of the plant, mine and associated facilities and the potential operational impacts including stack emission effects are estimated.

The purpose of this evaluation is to estimate the potential impact of the project on currently productive forest land. Both Crown and private forest lands are assumed to be managed for sustained annual yields of timber.

The basic premise upon which the case "without the project" is considered is that the whole productive forest land area required or affected by the project is managed on a sustained yield basis. The annual increment of the area contributes to allowable annual cuts harvested on these and other managed lands in the region. Therefore, the value of the allowable annual cut contributed by these lands is the forestry value or benefit contributed to the region and province without the project.

The basic premise upon which the "with project" case is considered is that the removal of forest land from timber production by site specific areas required by the project would result in a reduction in the annual allowable cut. The mean annual increment contributed by these areas to the allowable cut would most likely be lost in perpetuity depending on the peculiarities of the reclaimability of the sites. The estimate of forest growth potentially reduced by fume emissions can be expressed in terms of mean annual volume increment lost only during the 35 year period of plant life.

Mature timber on areas required could be logged during normal harvesting procedures under local operators' annual cutting rights. This assumes reasonable planning and cooperation with the B. C. Forest Service. The project would require premature cutting of some older immature merchantable stands, however, accelerated cutting of mature stands would not be necessary. Therefore, harvesting mature timber would be attributable to current management practices and regional demand for logs rather than to the project. All merchantable timber on site specific areas required by the project would be harvested prior to construction.

The impact of the project on the forest resource can be measured by the reduction in the mean annual increment which would occur as a result of site requirements and fume emissions. This reduction is the potential difference in rate of timber production between the "without project" and "with project" cases. Therefore, the loss to the mean annual increment is the impact of the project on the forest resource. Loss of the mean annual increment is valued using market prices for stumpage in the local study area.

5.1 Forest Resource Projections Without the Project

(a) Anticipated Environmental Changes

Without the project, the utilization of forest resources will be carried out according to development and logging plans approved by the B. C. Forest Service in accordance with existing regulations and environmental guidelines.

(b) Forest Resource Projections

(i) Regional Study Area

The regional forest economy without the Hat Creek project would be affected by the following current situations and policies:

- success of regeneration on logged areas.
- budworm and beetle infestations (see Section 4.1 (b)).
- deletions of forest land due to other forms of land use such as transmission lines, pipelines and other non-commercial forestry uses.
- recommendations regarding Environmental Protection Forests and subsequent reductions in allowable cuts.
- recent legislation regarding tenure, second growth management, range land and watershed management; see the following proposed provincial acts dated May, 1978:
  - Bill 12 Ministry of Forests Act
  - Bill 13 Range Act
  - Bill 14 Forest Act

Regeneration can be a major problem in the dry belt areas because of droughty conditions. This is demonstrated by existing clear cut areas which have required 15-30 years to re-establish forest cover. Current measures to overcome regeneration problems use a combination of selective cutting and planting practices which tend to ensure adequate regeneration success.

Coal licences in the Hat Creek drainage and surrounding Crown Reserves include productive Crown forest lands which are managed for sustained yield forestry by the B. C. Forest Service. The calculated allowable annual cut of the Botanie PSYU already includes a reduction factor to allow for estimated alienations from the productive forest land base due to future single uses such as open pit mining operations, rights-of-way and parks. No increase in the AAC is probable in case of cancellation of the project because it is always possible that the coal potential will be developed in the future by another project. One operator holding quota in the Botanie PSYU is logging in the Hat Creek drainage.

The AAC of the Botanie PSYU is currently being re-calculated. It may be reduced further because of environmental protection forests and new estimates of non-recoverable forest land losses. EPF's will be highly variable between PSYUs so it is not possible to judge the effects that they will have on the AAC until they are established and approved. Similarly, it is not possible at this time to estimate the effect on the AAC that may result from currently proposed forest legislation.

Mills in the region generally utilize a little more than their B.C. Forest Service approved quotas. The extra is supplied from private sources and from District Forester sales. This situation is likely to continue for some time without the project.

More than 75 percent of the allowable annual cuts for all but one of the PSYUs in the regional area are committed (see Addendum 2).
This would tend to limit any major expansions, considering the probability of AAC reductions due to EPFs. The present levels of logging on Crown land do not represent an overcutting situation.

In summary, the forest economy of the region is expected to remain stabilized at its present level.

(ii) Local Study Area

The majority of forestry activity in the local study area is in Hat Creek valley. Evans Products Limited has TSHL A01979 and TSHL applications containing many cutting permits within and adjacent to the Hat Creek drainage. They currently remove 102 000 m^3 (36 000 cunits) of wood per year from the drainage, which is approximately 44 percent of their quota. Since they plan to remain active in the valley for at least another 5-6 years and in areas adjacent to the valley for a further 5-10 years, the Hat Creek area is a very important source of raw material. Once the selectively logged areas and small clear cuts are sufficiently restocked and the residual trees within the selectively logged areas reach commercial size (i.e.: 35.6 cm+ or 14 inches + dbh), logging activity may resume in these stands. In future, harvesting would be carried on with periodic cuts yielding lesser volumes per acre than present old growth stands.

Logging road access development is planned by Evans Products which may use both the highway and an upgraded Medicine Creek road.

Occasional small additional cutting permits could be allowed in the Hat Creek valley giving a chance for local logging contractors to harvest mature and/or insect-infested timber. The area would continue to supply local ranchers with fence rails, posts and building logs. If farm-woodlot forestry is encouraged,second growth management by local residents may be practiced on a very small scale. Lower elevation forests may retain their multiple uses for forestry, cattle and recreational purposes.

In the local study area, the forest economy and logging activity will likely remain stabilized at their present levels, unless future environmental protection forests result in a decrease in the allowable annual cut.

It is recognized that the presence of coal-bearing lands and attached licences and reserves have resulted in a reduced allowable annual cut calculation in the Botanie PSYU. This reduction has already eliminated the mean annual increment contributed by 5 000 acres to the calculated cut. If the project is delayed, the B. C. Forest Service will continue to manage these areas. Productive forests growing on coal lands are available and the volume may be harvested within Hat Creek and the Botanie PSYU at the discretion of the Forest Service.

In summary, long term forest commitments without the project will continue at a reduced level due to the presence of coal-bearing lands even though forest land on these areas would continue to be managed within the PSYU context. The benefit to forestry without the project can be estimated by allowable annual cut valuation.

Within a given forest management unit, such as a PSYU, the allowable annual cut is made up of two components - the net volume of mature or overmature timber and the annual increment of immature timber. In calculating the allowable annual cuts, the B. C. Forest Service adjusts either of the components for accessibility limits, merchantability size limits or species mixtures.

In B.C., rotation ages are currently set at a fixed level of 121 years for all coniferous species, except lodgepole pine and white bark pine at 81 years and all deciduous species at 41 years. These rotation ages do not necessarily relate to culmination age (the age when MAI reaches a maximum). However, once the first rotation is completed, and all the old growth timber removed, the second rotation length should be the weighted average culmination age for the management unit and the AAC will then reflect the MAI directly. Although the management units in the study area still contain old growth stands, the MAI applicable to all productive forest land is a valid and objective means of estimating the effect of land clearing on forest management units. The MAI component of the immature lands and the potential MAI of areas supporting merchantable stands are both used to value the benefits in each case.

The local and site specific study areas contain Dry Belt Douglas-fir. In the Hat Creek valley Douglas-fir log quality is estimated to be 15 percent peeler* and 85 percent sawlog. Spruce and lodgepole pine from this area are used mainly for lumber.

Average B. C. Forest Service stumpage rates** for Douglas-fir in the five year period 1972-76 were $12.55 (21) per cunit for the Lytton, Stein, Nicola, Ashcroft and Lillooet areas. However, valuation of mean annual increment is based on open market prices of private timber purchased in the regional area because these prices are the result of negotiation. Recent purchases of privately owned timber on a stumpage basis have ranged from about $10 per cunit to over $20 per cunit. Crown timber in the area has sold recently at competitive prices ranging from $11.50/cunit to over $18.00/cunit, which support those prices indicated by private transactions.

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* logs suitable for manufacture of rotary veneer for construction grades of plywood.

** B. C. Forest Service stumpage rates are recorded as calculated in imperial units.

In summary, negotiated prices for private timber sold on the stump in the area fall between \$10 and \$20 per cunit; therefore, stumpage for stands primarily composed of Douglas-fir in the area is estimated at \$15 per cunit, or \$5.30 per m^3, which is rounded to \$5.50/m^3.

This estimate of forestry values without the project is based on the following:

(i) Values are based on open market sales of private stumpage which is indicated to be \$15 per cunit, or \$5.50/m^3. This is the estimated replacement cost of timber in the area.

(ii) This estimate assumes that any increases in logging costs would be offset either by an increase in prices or by advantages due to technological change. Therefore, in terms of constant dollars, the effective value of \$15/cunit or \$5.50/m^3 is considered to remain steady.

(iii) There will be no effect of the project because of accelerated cutting. Most timber cut will be removed under normal logging development, and all timber would be removed by an established quota holder operating in the area either without or with the project.

The local study area has an estimated annual allowable cut of 146 189 m^3/yr (Table 4-19). The value of this at \$5.50 m^3 is \$804 000 which is a potential annual income to the provincial government, excepting collection costs.

(iii) <u>Site Specific Areas; Mine, Plant and Offsite Facilities</u>

Productive Crown forest lands within the areas required by site specific construction are located within the Botanie PSYU. The basic premise upon which the case without the project is considered is that sustained yield forest management would continue to be practiced in perpetuity on the productive forest area required by the specific facilities of the mine, plant and offsite structures of the Hat Creek project and so contribute to the allowable cut of the PSYU.

The value of the allowable annual cut is shown in Table 5-1. The value of each annual harvest is the total of each annual increment times the dollar value per unit of volume.

TABLE 5-1

VALUE OF THE MAI CONTRIBUTION TO ALLOWABLE CUT FROM THE SITE SPECIFIC AREA

Option	MAI (m^3)	Value per m^3	Total Annual Value (nearest $100)
1. Wet Ash Disposal	3 295	$5.50	$18 100
2. Dry Ash Disposal Scheme I	2 394	$5.50	$13 200
3. Dry Ash Disposal Scheme II	2 396	$5.50	$13 200

(iv) Summary of Forest Values - Without the Project

The forest resources in the local study area can generate an income for the provincial government estimated at $804 000 annually. The present worths of this sustained income at various discount rates are:

3%	$26 800 000
4%	20 100 000
5%	16 080 000
6%	13 400 000
8%	10 050 000
10%	8 040 000
12%	6 700 000

The discount rates of 3, 4 and 5 percent per annum are compatible with land investment returns in the forest industry in terms of constant dollars over the long run, and with the biological growth rates for the area. Discount rates of 6, 8, 10 and 12 percent are also included as specified in the B. C. provincial benefit - cost guidelines for estimating the opportunity cost of capital.

5.2 Forest Resource Projections and Impacts On Forest Values - With the Project

(a) Anticipated Environmental Changes

No unusual environmental changes are expected in the regional or local study areas as a result of site preparation and construction development. In the site specific areas, it is anticipated that work would be done in accordance with the existing regulations and environmental guidelines.

Environmental Research and Technology Inc., (ERT) projections (37) of ground level concentrations of sulfur dioxide (SO_2) and by association, hydrogen fluoride (HF), oxides of nitrogen and ozone, indicate that the low predicted levels outside the local study area are well below the level likely to induce injury according to available literature. For example, doses of 2.0 $\mu g/m^3$ * of SO_2 and 0.018 $\mu g/m^3$ of HF have not been recorded as having injured plants. Within the local study area, a circle of 25 km in radius from the Harry Lake stack, critical levels may be exceeded.

(i) Preliminary Site Development

In the site specific areas, the bulk coal sampling program carried out during preliminary site development will have an insignificant effect on forestry. Any minor effect it may have will be masked by the construction impact. However, should the project not proceed the area affected by the bulk sampling program will most likely be restored to its original condition.

* $\mu g/m^3$ is one microgram or one millionth of a gram per cubic metre.

(ii) Construction Impacts

It is anticipated that merchantable timber cut during clearing and/or construction will be salvaged for manufacturing. Only non-useable material will be burned. The disruption of soil and sub-surface material during construction will affect soil moisture regimes in areas of lateral seepage. Two such areas do occur but they will be covered by the Houth Meadow Dump (M4) and the Wet Ash Disposal Pond (P6) (shown on map - Addendum 10), therefore no additional forestry impact would occur. Areas adjacent to the site specific areas are unlikely to be affected by soil moisture changes but may be affected by dust during the construction period. Dust accumulation on needles may tend to cause needles to overheat during the day and thereby cause premature needle death. Dust also favours the black pineleaf scale, (9), which has attacked ponderosa pine in small areas around Lytton. (8).

(iii) Operational Impacts

A. Introduction

The fluorine compounds, especially hydrogen fluoride (HF), are considered for vegetation to be the most toxic of the atmospheric pollutants. The phytotoxicity of HF has been registered in ambient concentrations of parts per billion (ppb), three orders of magnitude more lethal than SO_2. The fluoride ion has no known function in plant growth (67). Its effect on a plant is dependent upon a number of parameters, the most critical of which are dosage, a function of pollutant concentration, and exposure, duration, plant species, and environmental conditions.

The responses of plants to fluorides may be traced in a sequence of biological organization from the cell through the tissue or organ level to the whole organism and beyond to the effect on the ecosystem. Disruption at the cellular level through interference with a metabolic pathway caused by a biochemical alteration of essential enzymes, or a major physiological function such as photosynthesis or respiration would be ultimately reflected at the next higher level of organization. The visible symptoms of fluoride injury at the organ level, foliar necroses, have been well documented (63).

When the normal functioning of the leaf has been adversely affected by pollutant stress and sufficient quantities of assimilates cannot be supplied to the dependent organs, the entire plant will be affected. Effects at the organism level can include altered growth, reduced reproduction, decreased fitness and resistance to other environmental stresses, or even death. If all plants of a particular species are so affected, the species significance in the plant community will be reduced with consequent effects on other biotic elements.

In the gaseous phase, HF penetrates the plant primarily through the open stomates of the leaf. It enters a water saturated atmosphere in the substomatal chamber and is then in direct contact with cell surfaces bathed in aqueous solution. The high solubility of this gas in water allows it to be readily dissolved and mobilized in a transpirational stream to the leaf tips(monocotyledons) or margins (dicotyledons). Accumulation in these peripheral regions causes the characteristic fluoride foliar injury called "tipburn". Garrec and Lhoste (39) found that the differential response of leaf cells is due to a greater accumulation of fluoride rather than a higher sensitivity of cells. Response thus depends on the distance of the cells from the point of entry of fluoride and paths of translocation within the leaf. The fluoride ion has been shown to collect in the leaf cell vacuole and cell wall as a calcium or aluminum salt (69). Localization of calcium and fluori e in fir needle tips suggests a direct relation between the possible precipitation of calcium fluoride and apical necrosis (38).

B. Metabolic Effects

The manner by which atmospheric fluorides affect the metabolism of the plant is not clearly understood. Experiments with isolated tissues (*in vitro*) have demonstrated that fluorides can inhibit enzyme activity by forming complexes that block the active site. Enzymes known to be sensitive to fluorides include phytase (34), acid phosphatase and

ATP-ase (68) and succinic dehydrogenase (59). Depression of enolase activity (a form of enzyme activity) is attributed to the formation of fluoromagnesium phosphate at the catalytic site (43). However, the data of these in vitro experiments cannot be directly extrapolated to the effects on these systems in vivo. The environment of a subcellular structure and/or system in vivo is quite different from that in an artificial in vitro medium. This environment may be crucial to the system's response to the gas. In addition, many biochemical in vitro studies have employed fluoride concentrations that may well exceed the concentration achieved in fumigation experiments.

Among the best documented effects on metabolic pathways of the plant are those found in carbohydrate metabolism. Exposure to fluoride appears to reduce the relative importance of the glycolytic pathway over the pentose phosphate pathway (56). Such a switch to alternate mechanisms may reduce the intermediates needed in biosynthesis and thereby restrict growth.

C. Physiological Effects

Increases in oxygen uptake have been demonstrated in intact plants in the presence or absence of foliar lesions. Applegate and Adams (27) in a controlled growth chamber study found that bush beans subjected to an average ambient HF concentration of 1.8 ppb for 20 days have increased respiration when compared with similar plants not subjected to the gas.

Carbon dioxide assimilation is decreased by acute HF fumigations in gladiolus, barley, alfalfa, and cotton if a threshold, peculiar to each plant, is exceeded (60). Surfside gladiolus was found to have a threshold of about 6 to 7 ppb in one set of experiments following exposure at the rate of 35 hours a week for several weeks (60). The reduction was found to be equivalent to the loss of leaf surface through necrosis. The rate of photosynthesis was reduced when oat, barley and alfalfa canopies were fumigated by two hour exposures to 10 ppm HF (29). These photosynthesis suppressed plants exhibited a short lag period after the exposure which was followed by a relatively slow recovery rate. The authors felt that this indicated fluoride accumulation in the leaf tissue with increasing length of exposure, followed by relatively slow removal or detoxification and repair after termination of treatment. No visible injury was recorded.

Studies of the effects of intermittent fumigations have revealed that post fumigation fluoride loss can occur from leaves (45,68). Elimination of fluoride absorbed by Norway spruce was reported by Knabe and Guenther (48). This apparent loss of fluoride led these researchers to propose that biosynthesis of toxic organic fluorides might occur.

D. Anatomical Effects

One effect of fluoride on the plant is a reduction in the chlorophyll content of foliage (54) accompanied by fluoride accumulation in chloroplasts (35). Bligny et al (30) found that fluoride delayed the formation of epicuticular waxes, caused a reduction in size of the chloroplasts, a swelling in the granal fretwork membranes, and a lack of close adherence of the granal compartments in silver fir needles. These findings suggest that fluoride probably affects the general metabolism of the cell, including the development and functioning of the chloroplast. The occurrence of the visible symptoms at the organ level, foliar chlorosis, is thus a manifestation of altered structure and function of chloroplasts once some threshold concentration of fluoride in the tissue has been exceeded.

Histologic changes occur in fluoride injured tissues. Solberg et al (57) reported the occurrence of a number of changes in the tissue immediately adjacent to the necrotic areas of ponderosa pine needles. These included hypertrophy of resin duct epithelial cells (often resulting in occlusion of the duct), hypertrophy of transfusion parenchyma and phloem and xylem parenchyma. This collapse of the phloem would seem to account for Halbwach's (42) observation that the necrosis of needle tips associated with smoke injuries has a particularly damaging effect on the water supply to the injured part of the crown. This water deficiency may lead to a die-back of the crown.

On most monocotyledonous plants, the initial symptom of fluoride injury is the development of chlorosis at the tips and margins of elongating leaves, usually followed by necrosis. Gymnosperms such as ponderosa pine first exhibit a lightening in color of the needles which turn light brown to reddish-brown at the tip progressing basipetally. The initial symptom of fluoride on leaves of dicotyledons is usually chlorosis of the leaf tip, which later extends downward along the margins and inward toward the midrib.

E. Effects on Plant Growth

When the role of the photosynthetic organ has been destroyed or disturbed through pollution stress, the concomittant effect on the whole organism will be one of altered growth pattern. Treshow et al (64) found that fluoride caused a net growth reduction of 26% in Douglas-fir without the development of visible needle necrosis. They suggested that 100 ppm F accumulation in the needles was the threshold for growth reduction in this species. Stimulation of needle elongation was the first response of Douglas-fir to elevated fluoride levels. The larger needles represented an abnormal phenomenon and obviously were of no benefit to the plant since the increasing size showed a negative correlation with radial growth.

The effect on annual ring formation has been studied by many researchers. Vins and Mrkva (65) found diameter increment reduction of 30-70% where no visible injury was apparent in pine stands injured by a fertilizer producing plant. Braun (32) found a positive correlation between increment depression and foliar fluoride damage in Norway spruce.

A reduction in the supply of translocated carbohydrates may lead to expansion of some plant organs at the expense of others. Wardlaw (66) has indicated that the growth of established shoots appears to have priority over the growth of buds and roots when the assimilate is deficient. Treshow et al (64) observed that shoot growth in Douglas-fir was stimulated by moderate concentrations of atmospheric fluorides. Brewer et al (33) found that yield from orange trees was reduced by 15 and 22% when 75 and 150 ppm F respectively had accumulated in the foliage. This reduction in growth and yield was accompanied by a proliferation of weaker offshoots at the expense of the main stem, thus producing dwarfed plants with decreased leaf area and leaf life, impaired ability to support the fruit load, and subsequent premature leaf and fruit drop. Thus premature scenescence as well as growth inhibition may occur as the result of pollution interference with leaf productivity.

Studies of relative growth rates of the whole plant under HF stress are lacking. However Taylor(59) demonstrated that pinto beans fumigated with ozone had reduced growth in both above and below ground biomass. Since roots supply anchorage, nutrients, water and hormones to the leaves a secondary pollution stress is created in the organism which further retards growth.

Another pathway of injury that could result from air pollution would be its effect on mycorrhiza. These fungus-root symbiotic associations are ubiquitous in many tree genera. Infection is induced by a high carbohydrate/amino acid ratio around root hairs, a condition that would not be met by a plant whose photosynthetic mechanisms were impeded by HF. Fungi are also suppliers of indol acetic acid (IAA), a growth hormone, to the plant (84). Thus a reduction in the quantity of assimilates translocated to the root system may have severe repercussions on total plant growth.

F. Effects on the Ecosystem

The possibility exists that air pollution predisposes vegetation to insect attack or microbial infection which may lead to local or regional outbreaks or disease epidemics. Many reports indicate that conifers weakened or injured by pollutants are more likely to incur attack from insects that prey and reproduce on weakened trees (41). Stark et al (58) found that trees exhibiting visual symptoms of oxidant injury were most frequently infested by bark beetles. Taylor (59) has shown that trees which do not show visual symptoms have reduced growth and water uptake which would lead to reduced phloem thickness and sapwood moisture content. Since the trees' resistance to bark beetle infestation is a function of these parameters, the probability of successful establishment of the insect is enhanced.

In addition to the possible harmful effects of fluoride on the vegetative component of the ecosystem which may potentially be diminished in diversity due to stress on susceptible species and a concomitant reduction in competitive ability, effects on the faunal population are also possible. In high dosages, fluoride is known to cause fluorosis in animals, a disease affecting the bones and teeth. Ingestion of fluoride contaminated plants is considered the most direct cause of fluorosis. Oelschlaeger(55) proposed that the F tolerance for cattle be set at 40 ppm in forage. Montana State Department of Health standards set the top allowable limit of fluoride accumulation in forage at 35 ppm. No such legislation exists in Canada. The values shown in Table 5-2 for grass indicate that further study may be required in this area.

As this discussion has illustrated, the introduction of fluorides into an ecosystem, even at low ambient levels, may be found to have subtle deteriorating effects on environmental quality. The precise quantification of these impacts in the Hat Creek area is difficult due to the paucity of experimental information on the effects of HF on the indigenous vegetation species. Edaphic and climatic factors are found to influence the susceptibility of plants to fluoride injury and thus complicate the evaluation of potential damage.

G. Bioaccumulation of Fluorides

Plants exhibit a broad range of tolerances to fluoride. The criteria used to establish differences in susceptibility between species have been traditionally based upon either the amount of injury produced by a given dose of fluoride, the dose required to reach the threshold for foliar injury, or the amount of fluoride present in injured leaves. Differences in tolerance have also been found to exist between different varieties of the same species. Certain conifers, such as the pines, which are made up of phenotypic varients among the natural population, each tree having a somewhat different genetic complement, have shown great differences in their response to air-borne fluoride. Listings of the relative susceptibilities of a number of plant species to atmospheric fluoride have been compiled (63). However Horntvedt and Robak (46) emphasized the difficulty in correlating the ranking of plants in the many available lists to the field situation because of the specific climatic, edaphic and topographic conditions in different geographic areas.

All plants contain characteristic amounts of fluorine. Soil is the principal source of the normal fluoride content of plants but most researchers attribute minor significance to soil F uptake causing injury. McCune (53) indicated that F originating in the soil tended to accumulate in roots. However some fluoride in the foliage has its origin in the soil. Root-acquired fluoride caused necrosis of internal leaf tissues, whereas leaf-acquired fluoride caused marginal and tip necrosis.

Fluoride induced injury is not related to the number of stomata, nor to leaf area, color or organic composition of the vegetation. The most susceptible plants accumulate much less fluoride than do the resistant types, probably because threshold of injury is reached and the decreased uptake for photosynthesis reduces the fluoride input to the leaf (74). For example, highly sensitive tulip and gladiolus varieties show injury with a fluoride accumulation of only 10-20 ppm in dry matter, whereas cabbage often remains uninjured with an accumulation of 2000 ppm and cotton shows no injury even at 4000 ppm in dry matter (81). It is possible that fluoride induced injury occurs when a plant possesses the ability to translocate fluoride quickly to localized sites where it accumulates faster than it can be excreted or faster than the plant can counter the interference with vital intracellular processes. Brandt and Heck (31) suggested that plants can be grouped into two classes: those that developed leaf symptoms when the fluoride content in the tissue is 50 - 200 ppm and plants that show no injury above 500 ppm. Hill (44) suggested a range of 20 - 200 ppm for probable injury to susceptible plants. Treshow and Pack

Rod. Collins

(63) reported that there is a highly susceptible group of plants that shows injury at a tissue concentration of less than 50 ppm. Ponderosa pine needles with 26.7 ppm accumulated F were found to exhibit 28% tip burn, a 30% reduction in needle retention and an overall necrosis of 11% (61).

Existing fluoride levels in the vegetation of the Hat Creek area indicate an affinity for fluoride that may be accelerated by atmospheric pollution. The levels reported in Air Quality and Climatic Effects of the Proposed Hat Creek Project Appendix F(ERT Document No. P-5074) show very high baseline concentrations especially in the Cornwall Mountain receptor site 4. (See table 5-2).

This is one of the areas that will experience high levels of ambient HF according to the PEAK projections (72) and could therefore be expected to accumulate critical quantities of fluoride.The forage in the area could exceed the safe level of fluoride concentration as previously discussed and should be monitored.

The fluoride accumulation of plants is influenced by a number of physical parameters such as temperature, moisture, relative humidity, age of tissue and time of day of the exposure.

MacLean and Schneider (52) studied the effect of temperature and the accumulation of fluorides by sunflower leaves. They found it to be significantly greater in plants maintained at 26° C than in plants maintained at 16° or 21°C. In gladioli necrosis was two times more severe on leaves of plants exposed to HF at 21° and 26°C than on plants maintained at 16°C.

TABLE 5-2

AVERAGE CONCENTRATION (ppm) OF FLUORIDE IN PLANT RECEPTOR MATERIAL, 1976 - 1977 (25)

PLANT	COLLECTION DATE *	SITE 1 PAVILION MTN.	SITE 2 LOWER HAT CREEK	SITE 3 ARROWSTONE CK.	SITE 4 ** CORNWALL MTN.	SITE 5 ASHCROFT	COMBINED
Elevation		2 089 m	750 m	1 500 m	2 036 m	1 250 m	
Shrub Willow (Salix Sp.)	Oct. 1976	263	111	78	< 707	115	255
	May 1977	9	26	19	558	169	156
Grass *** Bunchgrass (Agropyron Spicatum) or Sedge (Carex Sp.)	Oct. 1976	29	24	22	14	13	20
	May 1977	63	(1 360)	(1 600)	-	(2 770)	(1 448)
Lichen (Letharia vulpina)	Oct. 1976	16	157	49	47	52	64
	Jan. 1977	555	100	106	84	54	180
	May 1977	332	11	21	21	204	118

* Three samples were collected at each site on each date.

** The less than symbol (<) indicates that one or more of the replicate measurements were below the analytical detection limit. When such analytical data occurred, means were calculated by using the detection limit as the concentration and then reporting the mean with a < symbol.

*** No grass was available at Site 4 (Cornwall Mountain) during May 1977 due to cattle grazing.

( ) The four values for grass exceeding 1 000 ppm fluoride are about 100 times the normal range of values that might be expected. Whatever the explanation may be these data have been discounted for the purpose of this report. It is suggested that further samples be collected and analyzed to confirm or replace them.

From field observations, Treshow (62) maintains that should temperatures exceed 35 - 38^{o}C for more than a few hours, injury may result from fluoride concentrations generally regarded to be below injury threshold. Benedict et al (28) found that the concentration of fluoride in alfalfa and orchard grass increased as the temperature of the roots was increased.

The literature provides conflicting reports on the effect of moisture regime on fluoride uptake. Zimmerman and Hitchcock (70) found that plants with a water deficit were more resistant to fluoride than those receiving adequate water. Treshow (62) states that under arid conditions, high temperatures impose an added stress that may further reduce the threshold for injury. Bovey (74) found less fluoride in leaves in wet seasons than in dry seasons. Heavy rain may leach fluorides which have already entered the leaf tissue (47).

Daines et al (36) reported that plants absorbed more fluoride and were damaged more severely at high humidities than in drier air. MacLean et al (50) found that gladioli fumigated with HF were more severely injured at 85% relative humidity than at either 65 or 50% relative humidity even though fluoride accumulation did not follow this exact pattern. These results probably can be attributed to the fact that in humid conditions the stomata are open, favoring gas exchange and thereby expediting fluoride effects.

Other investigators have reported that fluoride accumulation in the tissues of plants was greater in light than in darkness (36) and concluded that uptake of fluorides in foliar tissue was lower in the dark because stomata were closed.

Time of year, because of its relationship with the plant's stage of development, is critical to the development of injury. Conifers are more sensitive during the period of needle emergence (63). The current year's needles of conifers, because of their greater metabolic rate, are more susceptible to fluoride inhibition of respiratory enzymes than are older needles which are becoming storage organs.

Leaf age and temperature interactions were reported by MacLean and Schneider (52) who found that the oldest leaves (sunflowers, gladioli sp.) were less susceptible to HF induced necrosis at temperatures of 16^{o}, 21^{o} and $26^{o}C$ than the younger leaves. The youngest leaves were most susceptible at 16^{o} and $21^{o}C$.

Susceptibility is also reported to be a function of height and age. Knabe and Guenther (48) exposed Norway spruce set up at different elevations above the ground to the emissions of an aluminum smelter. Tall old trees were injured while young ones growing next to them were seemingly healthy. This may be explained in terms of canopy contact with the polluted air stream. Mature dominant and codominant trees in the stand would be expected to experience the highest level of fumigation.

H. Discussion

The extrapolation of fumigation studies in controlled environments to the effects of ambient HF concentration is of limited utility. Constant concentrations over long durations are not encountered in the field and the effects of recurrent fumigations have not received much study. The sequence of exposures may outweigh, in importance, the actual level of fluoride used within a range of concentrations (26). MacLean et al (50) found that recurrence of exposure was as important as concentration and duration. Climatic, edaphic and topographic conditions are also known to modify plant response to HF.

The high levels of F found in the ERT baseline study (37) of trace elements in vegetation suggest that the ecosystems in the Hat Creek area may already be close to the limit at which damage may be expected. The ERT report did not provide information on the levels of fluoride in tree foliage. Such data might aid in the prediction of impact of the Hat Creek installation on the major tree species in the area. In a study of fluoride emissions from a coal-fired power plant, Tourangeau et al (61) found that a 10.5 ppm concentration in 8 month old needles of ponderosa pine corresponded to 0.9 percent tip burn, 8 percent basal necrosis and scale (caused by death of epidermal, hypodermal and mesophyll cells) and a 4 percent total necrosis. Twenty month old needles with a 21.5 ppm F concentration showed 7.2 percent tip burn, 18.3 percent basal necrosis and scale and 5 percent total necrosis. A USEPA field investigation (40) showed that continuous exposure to gaseous fluoride for 119 days during the growing season to ambient concentrations of 0.19 ppb maximum and 0.08 ppb average resulted in a dry weight fluoride accumulation of 10.5 ppm in 6 month old needles and 46.1 ppm in 18 month old needles of ponderosa pine. Correlating this information shows that at a concentration of 0.08 ppb average ambient HF level, significant injury to ponderosa pine will occur, in two year old needles total necrosis may be extensive. The normal expected fluoride content of whole conifer needles is less than 10 ppm based on data of the U. S. Forest Service and University of Montana (40). Without actual measurements of the fluoride content of ponderosa pine growing in the study area, this experience cannot be used.

Ecotype differences in ponderosa pine may result in variability in pollution susceptibility. Climatic stress such as high temperatures (absolute maximum temperatures in the Ponderosa Pine - Bunchgrass Biogeoclimatic Zone: 38°-44°C) may further affect plant response to HF. Ponderosa pine, lodgepole pine and Douglas-fir are cited as being highly susceptible to HF especially during the period of needle elongation (67).

The relationship between the concentration of gaseous hydrogen fluoride and the duration to which some coniferous tree species have been exposed as it relates to the effects on the plant is shown in Table 5-3. The tree species listed are all from the group considered to be most sensitive to hydrogen fluoride. Douglas-fir accounts for 55% of the total inventory volume of the local study area. Ponderosa pine, white pine and lodgepole pine, the last also classified as a sensitive species, account for a further 29% of the local study area or 84% in combination with the fir.

TABLE 5-3

SOME EFFECTS ON SOME SENSITIVE CONIFEROUS TREE SPECIES OF EXPOSURE TO GASEOUS HYDROGEN FLUORIDE BY CONCENTRATION AND DURATION (81)

Species	Ref. No.	Hydrogen Fluoride Concentration in Air ppb	μg/m³	Duration of Exposure Days	Effect on Plant
Ponderosa Pine	#1	0.49	0.37	14	Necrosis of needles.
Ponderosa Pine	#2	0.50	0.38	1.7	Internal microscopic damage.
Ponderosa Pine	#3	0.77	0.58	14	Necrosis of needles.
Norway Spruce	#4	1.30	0.98	Several	Extensive leaf injury.
White Pine	#5	1.30	0.98	Several	Extensive leaf injury.
Douglas-Fir	#6	1.50	1.12	2.7 to 4.6	Leaf injury
Ponderosa Pine	#7	1.99	1.5	15.3	First visible foliar injury.
Ponderosa Pine	#8	6.65	5.0	1.8	First visible foliar injury.
Ponderosa Pine	#9	13.3	10.0	0.8	First visible foliar injury.

Rod. Collins

McCune (82 as cited in 81 and 83) summarized available data to produce a graphical representation of the limit of injury to the most sensitive plants such as conifers by concentration of hydrogen fluoride in the air and the duration of exposure. Through the slow rise in the curve as compared to SO_2, the slight influence of concentration on degree of injury becomes evident. Through long-term exposure very low atmospheric fluoride concentrations can cause extensive injury. McCune's summary is shown in Figure 5-1. This provides a usable basis to assess which combinations of level and duration of fumigation of fluoride may be critical.

The concentrations of hydrogen fluoride in $\mu g/m^3$ as actually present in the air in the series of experiments summarized in Table 5-3 are shown plotted on McCune's graph in Figure 5-1, reference numbers 1-9. For comparison the values predicted as shown in Table 5-6 are also plotted on McCune's graph reference numbers 10-17. Consideration of the experimental values collected for sensitive conifers indicates that the boundary line values suggested by McCune are in general acceptable. Critical analysis might extend the right hand end of the line but adjust it downwards to accomodate reference #1. Consideration of reference #2 shows that it reflected internal microscopic damage which is unlikely to indicate a level at which real growth loss would occur. However this provides a basis upon which to estimate the likely effect of fluoride emissions from the operation of the thermal plant.

Discussion of the predicted values shown is given in association with Table 5-6 where they are reported.

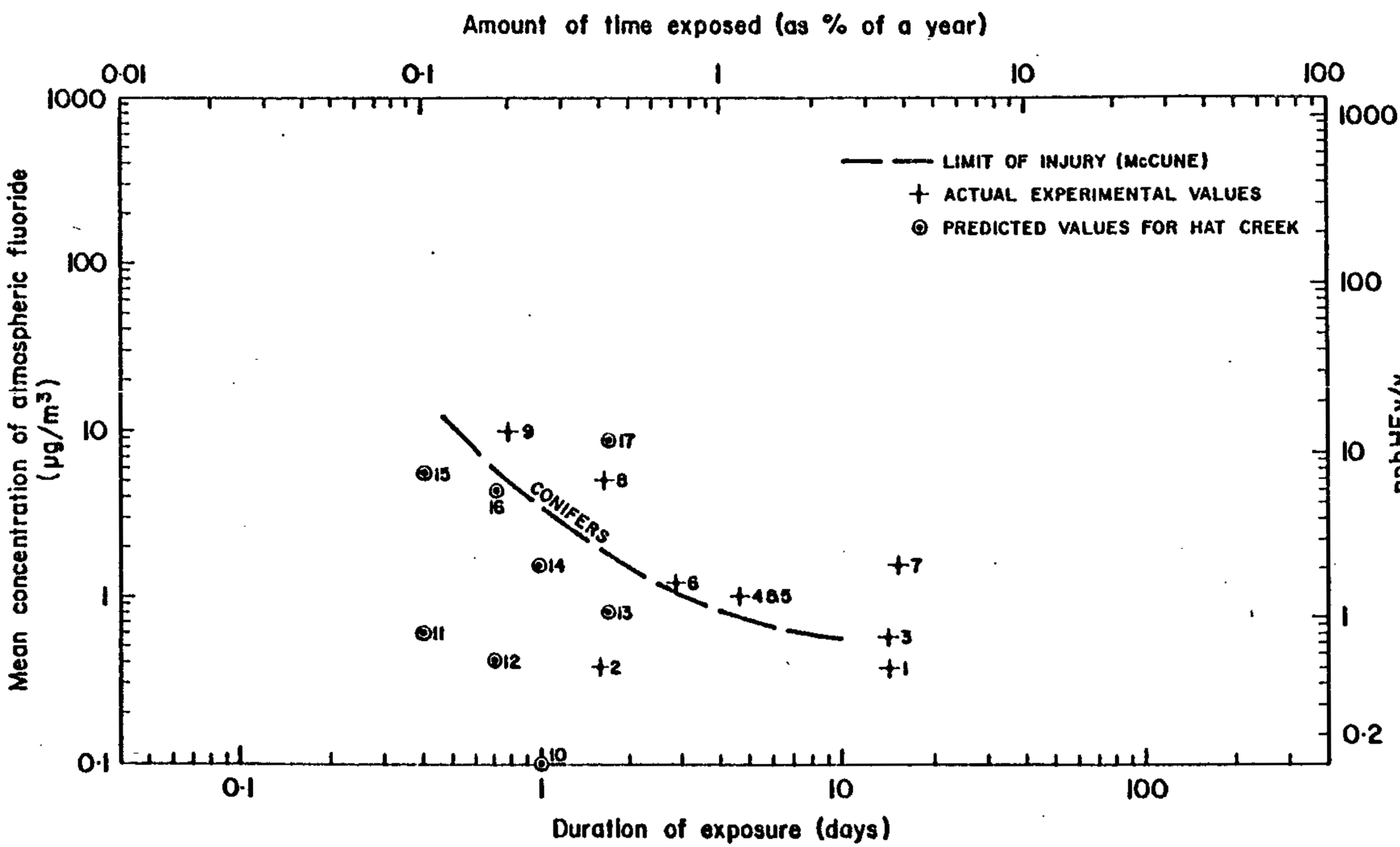

Fig. 5.1 Possible air-quality criteria for atmospheric fluoride, with reference to coniferous species. (After McCune, 1969 in ref. 81 and 83)

(iv) Decommissioning Impacts

It is assumed that soils on site specific areas would be restored and rehabilitated after project completion. The capacity of the restored sites to grow commercial trees for productive forestry purposes is unknown, but it can be assumed that some growth of tree species could be anticipated. This report assumes restored soils will grow trees at no more than one-half the rate of undisturbed soils presently growing trees, or no more than 0.665 m^3/ha per year. This productivity approximates low sites, which are currently excluded from calculations of the allowable annual cut. In summary, this evaluation assumes that restored soils will produce only nominal volumes which will not be included in future harvests.

(b) Appraisal of Impacts on Forestry

The purpose of estimating the impact on forestry is to indicate potential losses which could occur to the forest resource itself. In this case the losses would occur to the gross allowable annual cut because the area of forest land available for growing trees would be reduced for at least 35 years.

In order to avoid confusion when considering the impact on the allowable annual cut, a distinction should be made between the impact on the forest resource itself (gross AAC) and the impact on forest management practices (net AAC) and present operators.

The project would cause a physical loss of land available for growing trees; therefore, some potential annual growth would be lost, resulting in a reduced gross allowable annual cut. This would be a direct impact on the forest resource itself.

In respect to the mean annual increment associated with the allowance made in the cut calculation, distinction must be made between the real reduction in productivity of the forest resource as it may occur as the forest is removed and the theoretical reduction in allowable annual cut as calculated by the B. C. Forest Service for the Botanie PSYU. The second case reflects good forward planning by the B. C. Forest Service in anticipating the strip mining and thermal plant development. There will therefore now be no social impact because no reduction in allowable cut should be necessary. The subsequent hardship this might have for local logging and mill operators will not occur. The loss is real however and any past advantage should theoretically be chargeable to the coal deposit regardless of the use to which it was later put. In practice this theoretical charge is zero because for other reasons the allowable cut of the Botanie PSYU has not been fully allocated. This means that there has been insufficient demand to utilize even the reduced allowable cut. The province of B.C. has not yet lost revenue because of the mining allowance applied in the cut calculation. For assessment for future purposes, it is assumed that the demand will now be sufficient to utilize all available allowable cut.

Past and current forest management practices by the B. C. Forest Service have generally followed a policy of providing for a stable or growing forest industry, rather than a policy of maximizing annual cuts at present, with no regard for the future. In carrying out this policy, it has been necessary for the B. C. Forest Service to anticipate potential reductions to the productive forest land base, in order to make a realistic estimate of growing capacity over the long term or one rotation.

The calculated allowable annual cut for the Botanie PSYU, which is currently guiding forest management practices in respect to the gross AAC considers coal licences in the Hat Creek Drainage and surrounding Crown Reserves. These include some productive Crown forest lands that are managed for sustained yield forestry by the B. C. Forest Service. The timber and mean annual increment contributed by these lands has been included in calculation of the gross allowable annual cut of the Botanie PSYU. The current AAC of the Botanie PSYU is based on a 1970 calculation which indicated a gross figure of 194 840 cunits, before deductions for non-recoverable losses. These deductions for non-recoverable losses amount to 50 470 cunits or 25.9 percent of the gross. This deduction includes estimates of losses to forest cover due to fire, insects and disease. It also includes an estimate of reductions in the forest land base due to future single uses such as rights-of-way, parks, environmental protection forests and open pit mining. A deduction of the mean annual increment on 50 000 acres was made to the gross AAC to allow for open pit mines over one rotation. This includes potential mines in the Hat Creek drainage, Highland Valley and other locations. There was no specific deduction made for the proposed Hat Creek coal project. The net AAC currently used is 144 370 cunits.

Because the 1970 deduction for open pit mines still seems realistic, if Hat Creek coal was developed, no further reduction in the AAC for the Botanie PSYU is likely. Therefore, no impact on the net AAC is anticipated: local operators would face no cut reduction due to the Hat Creek Project, nor would current forest management practices be significantly altered.

In summary, the Hat Creek Project would not affect forest management as currently practiced, but it would affect the forest resource itself. It is the impact on the forest resource that is valued in this report.

(i) Regional and Local Study Areas

Construction will have a negligible impact on the forest industries in these areas because loss of the AAC represents a negligible portion of the regional allowable annual cut. All merchantable timber should be recovered during normal logging operations. This volume represents one third of one year's cut in the Botanie PSYU.

The B.C. Hydro road that may be built adjacent to Medicine Creek could be considered a benefit to logging access, if logging equipment is allowed to use it.

(ii) Construction Impacts on Site Specific Areas and Appraisal of Mine, Plant and Offsite Timber

The comparative impacts on forestry by ash disposal options, including mine and offsite facilities are shown in Table 4-37. This timber will be logged and removed as part of the regular forest management programme and quota allocation. It should neither increase nor decrease the local operators' long term wood supplies.

The value of the MAI contributing to the allowable annual cut from the site specific area subsequent to the mine and thermal plants operation is estimated to be $18,100 for Option 1, Wet Ash Disposal; $13,200 for Option 2, Dry Ash Disposal Scheme 1 and $13,200 for Option 3, Dry Ash Disposal Scheme 2. See Table 5-1.

It is assumed that restored sites will grow no more than one-half the productivity of present undisturbed soils, or no more than 0.665 m^3/ha. This is equivalent to a Low Site, which is not included in allowable annual cut calculations.

In Table 5-4 the present worths of all future annual incomes from AAC, in perpetuity, are shown.

TABLE 5-4

PRESENT WORTH OF ALLOWABLE ANNUAL CUT ON SITE SPECIFIC AREA THAT WOULD BE LOST WITH THE PROJECT

Option	Annual Value ÷	Discount Rate =	Present Worth of AAC in Perpetuity (in $000's)
1 Wet Ash Disposal	$18 100	0.03	$ 603
		0.04	453
		0.05	362
		0.06	302
		0.08	226
		0.10	181
		0.12	151
2 Dry Ash Disposal Scheme I	$13 200	0.03	440
		0.04	330
		0.05	264
		0.06	220
		0.08	165
		0.10	132
		0.12	110
3 Dry Ash Disposal Scheme II	$13 200	0.03	440
		0.04	330
		0.05	264
		0.06	220
		0.08	165
		0.10	132
		0.12	110

(iii) Operational Impacts

A. Stack Emissions

The impact of the stack emissions is most likely to be a low grade chronic injury causing a growth reduction over a considerable part of the local study area. Individual trees will respond to the irregular periodic short term fumigations in a variety of ways. Some individuals that are most sensitive may die outright while resistant ones show no visible symptoms of fumigation. The majority of individuals between the extremes will gradually show signs of degradation because of changes induced in physiology (e.g. rate of photosynthesis) and/or morphology (e.g. defoliation). Fumigation effects, especially those of short duration, are reversible to a point (81). However continued exposures will eventually have their effects. Trees that show no visible damage may still have a small growth reduction because of minor losses of photosynthetic production. Further fumigation will cause leaves or needles to change colour or have necrotic spots and/or tip dieback. At this point growth reductions are more marked as respiration as well as photosynthesis becomes impeded. If fumigation continues, crown thinning will occur involving some branch dieback as well as partial leaf fall. When a tree reaches this stage it is in a definite state of decline but it may yet recover by either adjusting to fume conditions or beginning new growth if fumigation stops. However, if fumigation continues, leaf fall may also continue and major branches die. If leaf kill continues for more than two growing seasons, the trees are quite likely to die. At any point during this sequence, insects, especially bark beetles, may attack the trees and the combined efforts of insects and fumes speed up the process of decline. Because of autecological and genetic factors, different trees will decline at different rates.

Consequently individual trees eventually affected by stack emissions will likely be scattered both in time and space. Salvaging these individual trees would be more expensive than normal clear cut logging but similar in cost to selective logging.

Benefits that would accrue to forestry because of building the project would be derived from harvesting trees that are either additional to the allowable annual cut or are made economically or environmentally accessible. Since none of these conditions are anticipated in this case no benefits to forestry are assumed to occur. The allowances made in the allowable annual cut calculation of the B. C. Forest Service consider the future loss of mean annual increment from land to be strip mined. They consider existing standing timber on these sites to be fully recoverable and therefore include it in the timber inventory and cut calculation.

I Controlled Stack Emissions - SO_2

The basic premise upon which the without project case is based also applies to those areas affected by fume emissions: the annual value to forestry is the value in dollars of the mean annual increment of the area concerned or the loss of this increment and value as appropriate. What is most likely to occur is that individual branches, branchlets or needles scattered throughout the crowns of trees will suffer partial or total necrosis, thereby reducing growth rates, and individual trees, scattered throughout Hat Creek valley, which are sensitive to the fume components may die sometime during the operational life of the plant.

Since affected individuals will likely be scattered throughout the forest, there will possibly be a low grade, chronic growth reduction, over a wide area. The appraisal of forest values lost is based on an equivalent loss of annual increment. Sporadic scattered losses of trees or chronic growth reductions are calculated as volume lost on an annual basis. From these values for the Meteorological Control System (MCS 244m and 366m stacks) and Flue Gas Desulfurization (FGD 366m stack) an estimate can be made of the total annual increment affected by the fume path, which represents the potential loss of allowable annual cut from the Botanie PSYU from stack emissions.

In addition to the loss of growth in the forest it is also possible that individual trees, especially overmature ones, may die outright. Premature mortality of individual trees as caused by fumigation, insects or other natural cause should be salvaged within the regular cutting cycle of the selective logging method applied in this forest. No additional allowance is made for this type of loss.

The values of these annual cuts that could be lost were derived by applying SO_2 effect levels (reference 73, tables 5-17 to 5-22 inclusive) to the weighted average mean annual increment, and the estimated stumpage rate of $5.50/$m^3$. These values are shown in Table 5-5 by SO_2 control systems.

In order to provide quantitative assessments of damage to vegetation, recourse must be made to the published or available data on the response of individual species to specific pollutants at dosages comparable to those predicted. The main problem is that the majority of such reports concern experimental data collected under "artificial" or "unnatural" conditions. Hence, extrapolation to field conditions is difficult. Nevertheless, for most species, they are the only data available and have had to be used in the present damage assessments. Also, almost without exception, the published data concern "acute" injury rather than "chronic" injury and hence suffer in their broad applicability to field situations. A multitude of environmental factors can influence the dose-response of any species of a given pollutant, further complicating any attempt to quantify specific data under varying conditions.

TABLE 5-5

ANNUAL VALUE OF MAI AFFECTED BY SO_2 FUMES

	Meteorological Control System			Flue Gas Desulfurization
	Stack Height			Stack Height
	244m	366m		366m
MAI (m^3)	131.7	77.1		0
Value ($/$m^3$)	$5.50	$5.50		$5.50
Annual Value Lost	723.25	424.05		0
Rounded	$700	$400		0

These values represent the potential production lost each year. The effects are not completely additive because some of the trees would recover from the previous growing season's fume effects. However, since the amount and duration of recovery can not be predicted on the basis of one year's model, no recovery is assumed.

It is emphasized that the assessments of impact on vegetation reported herein are based upon injury, whether expressed through visual symptoms or through modifications to plant growth. In addition, the data presented are assessments and not measurements, since few of the plant species indigenous to the Hat Creek region have been studied in the context of air pollution effects. Even where reports of effects on individual species occur in the literature, they seldom contain quantitative information about the severity or magnitude of impact. In the few cases where quantitative data exist, these in turn require cautious extrapolation to the conditions of Hat Creek.

2 Uncontrolled Stack Emissions - Fluorides

During the test burn of Hat Creek coal at Battle River Generating Station in Alberta, measurements of gaseous emissions of fluorine were made (22). Based on two measurements, an average of 0.279 kg/hr ±40% was determined. It appears that between 3.8 and 8.8 percent of the total input of fluorine in the coal was emitted as a gas. Fluorine gas emitted in the stack is most accurately determined by direct flue gas measurements.

All inputs and outputs in the test burn were reported in terms of kilograms (kg) per hour. Scaled up to 2000 megawatt generating capacity, the fluorine released to the atmosphere would be 290 kg/day. To obtain estimates of possible fluoride injury to the forest trees, the revised $F:SO_2$ ratio of $8.92 \times 10^{-4}:1$ provided by the ERT report (25) was applied to SO_2 isopleths for the uncontrolled emission case for the following minimum levels:

- $>$ 160 micrograms/m^3 for a maximum of twenty four hours
- $>$ 260 micrograms/m^3 for a maximum of twenty four hours
- $>$ 655 micrograms/m^3 for a maximum of three hours
- $>$ 1300 micrograms/m^3 for a maximum of three hours
- $>$ 450 micrograms/m^3 for a maximum of one hour
- $>$ 900 micrograms/m^3 for a maximum of one hour

Application of the $F:SO_2$ ratio converted SO_2 isopleths of ground concentrations, as provided by the analysis and maps in Dr. V. C. Runeckles' report (72), to isopleths of fluorine concentrations (Table 5-6) were made. The average frequency of occurrenceof these fumigations for the growing season April 1st to October 31st, was calculated from the reported number of occurrence for each receptor site as analyzed by Dr. V. C. Runeckles from the ERT data (72). These frequencies combined with the period of exposure gave a total period of exposure which was expressed in days and as a percentage of a year (Table 5-6). The area exposed to fumigation within each given isopleth was obtained by measurement from the maps in Dr. V. C. Runeckles' report (72). Where the period of exposure is the same but there are two levels of concentration of the fluoride ,the area affected by the higher concentration was deducted from the more extensive area affected by the lower concentration. In the cases where the period of fumigation is different,the effects were considered additive and no deduction of the affected area made.

A material mass balance was done by Western Research and Development (22). This accounted for 43 percent of the fluorine input; the remaining 57 percent of the fluorine remained undetected and unmeasured. While it is recognized that a material mass balance is only a rough check on the measurements made during the test burn, there is some possibility that the undetected fluorine did escape as a gas. The "missing" fluorine may have chemically combined with some other elements to form a stable compound and thereby remain undetected. However, there are other studies (23,24) which indicate that, if combustion temperatures are high enough, perhaps between 80 and 100 percent of the F could be emitted as HF vapour. On the other hand a study by the Radian Corporation (71) has indicated that approximately 8% of the fluoride input to a pulverized coal furnace was emitted as gas.

Because of the conflicts between measurements and different literature sources, it was decided that it would be prudent to have a supplementary worst probable case approach which assumes that all unaccounted for fluorine escaped detection in the test burn and was released to the atmosphere.

The impact could then be estimated as between two cases; a probable case and a worst probable case. The whole study is based on estimates having inherent weaknesses and because the ERT model, from which the isopleths were obtained, is based on only one year's weather records, it is quite likely that a much worse case is possible.

Using the fluorine emission rates reported by Western Research and Development in Table 3, page 8 of their report "Trace Element Material Balance for Hat Creek Coal Test Run" (22) indicates that while 4.43 kg/hr of fluorine were put into the system the total output recorded was only 1.91 kg/hr. Therefore 2.52 kg/hr were unaccounted for and may have escaped as an emission. In addition, 0.0207 kg/hr of fluorine was known to have been emitted with flyash and 0.279 kg/hr as gas. The maximum possible emission or worst possible case would therefore be 2.52 + 0.2997 = 2.82 kg/hr of fluoride.

Therefore, a possible 2.82 kg/hr of fluoride would be assumed to have escaped to the atmosphere. This value is 10.106 times as great as the average of the two measurements given at the beginning of this section (iv) 2. Therefore, the ratio of $F:SO_2$ for the worst probable case analysis is:

$$8.92 \times 10^{-4} \times 10.11 = 9.02 \times 10^{-3} \text{ (rounded)}$$

This ratio was then applied to the areas bounded by SO_2 isopleths of the uncontrolled emissions. These isopleths encompass the high mountain areas such as the Clear Range, Cornwall Mountain and Pavilion Mountain rather than the lowland areas around the plant site.

Table 5-6 below shows the area that may be affected by the fume emissions on the basis that the emission occurs during the growing season between April 1st and October 1st for the uncontrolled emissions for the probable and worst probable cases by frequency and intensity of fumigation by certain levels of emission. No fumigations were predicted for sulphur dioxide exceeding 260 kg/m^3 for a 24 hour period or 1300 kg/m^3 for a 3 hour period and hence none for hydrogen fluoride. The 900 $\mu g/m^3$ isopleth lies within the 450 $\mu g/m^3$ isopleth and therefore the area outlined by the higher isopleth is deducted from the total area outlined by the lower one in calculating the area of exposure. The three periods of exposure are considered to represent different types of fumigation effect and are considered additive.

TABLE 5-6

AREA OF EFFECT OF PREDICTED UNCONTROLLED FLUORIDE EMISSIONS * PROBABLE AND WORST PROBABLE CASES BY FREQUENCY AND INTENSITY OF FUMIGATION DURING SEVEN MONTH GROWING SEASON APRIL 1st-OCTOBER 31st

Equivalent Conc. of SO_2 µg/m^3	Period of Exposure Hours	Average Frequency of Occurrence	Total Growing Season Exposure		Probable Case			Worst Probable Case		
					Fluoride		Area** Exposed Hectares	Fluoride **		Area*** Exposed Hectares
			Days	%of Year	Ref. No.	µg/m^3		Ref. No.	µg/m^3	
160	24	1	1	0.27	10.	0.142	6 176	14.	1.44	6 176
260	24	0	0	0		0.232	0		2.35	0
655	3	3	0.4	0.10	11.	0.584	23 857	15.	5.91	23 857
1300	3	0	0	0		1.160	-		11.73	0
450	1	16	0.7	0.18	12.	0.401	132 272	16.	4.06	132 272
900	1	43	1.8	0.49	13.	0.803	34 390	17.	8.12	34 390

* From seasonal isopleths, April 1 - October 31st, see references 25 and 72.

** These reference numbers are shown as predicted points plotted by concentration and duration of exposure to hydrogen fluoride in Figure 5-1.

*** Area exposed to fumigation within each isopleth as shown in maps in Dr. V. C. Runeckles' report (72).

By reference to Figure 5-1 it will be seen that the critical value for effect on sensitive plants such as conifers is exceeded in the worst probable case with the fluoride concentration in the ambient air of 8.0 µg/m^3 (equivalent to a concentration of 900 µg/m^3 of SO_2) for an accumulated period of 1.8 days in the year. This isopleth encloses 34 390 hectares. The other remaining levels by concentration and length of exposure fall below the critical level. However it is well to note that the points shown by reference no.'s 14, 15 and 16 for the worst probable case all fall relatively close below the critical level and more significantly so does reference no. 13 from the probable case. Should the apparently high level of fluoride already present really be so then some of these reference no's may well be raised above the critical values. Certain definition of present fluoride levels in vegetation could be useful.

If this emission level is maintained for 35 years, the sensitive trees will be successively exposed and will accumulate fluoride for the time their needles are retained, normally from three to five years for these species. The effect will therefore be less significant at first and build in effect over the first few years. As it progresses, it will also weaken the trees and reduce their growth which will in turn reduce their resistance. The literature provides little specific guidance in estimating exact levels of the progressive decline that may be expected. It has therefore been necessary to arbitrarily estimate that the effect of fluoride at the level of 8.0 µg/m^3 fumigating the forest 43 times each year in the growing season for a maximum of one hour continued over 35 years will eventually reduce the forest growth to zero.

The weighted average mean annual increment of the *Botanie PSYU* is 1.329 m^3/ha. Over 35 years for 34 390 hectares this would amount to 1 599 650 m^3. If 50% of this is lost because of the gradual decline of the growth rate from the normal to zero over the period of the life of the thermal generating plant, then 799 825 m^3 of potential wood will not be grown. The value of this wood at $5.50 m^3 would be $4 400 000.

The total estimated loss caused by the fluoride in the uncontrolled stack emissions is in the worst probable case $125 686 on an average per year, however, it should be recalled that this worst probable case is based on the assumption that all the unaccounted for fluoride in the material balance developed by W. R. and D. (22) was assumed to escape from the stack as gaseous fluoride. While this is possible it is unlikely. It therefore indicates that a complete material balance for fluoride, if achieved would most likely reduce the estimated loss from this cause very considerably.

3. Summary of Operating Emission Effects

The summary of anticipated operating effects is shown in Table 5-7 below. The values in the table are estimates of the annual value of the potential growth reductions if the plant were built or losses because of the project. It should be noted that the sulphur dioxide is assessed on the basis of three alternative systems, while the fluoride is assessed on only one, which also differs from the SO_2 system. The effects caused by SO_2 and fluoride are considered for the purpose of this assessment to be additive. The literature indicates that the effects could be additive or synergistic, although a reduction of effect very seldom occurs (81).

TABLE 5-7

SUMMARY OF ANNUAL VALUES FOR OPERATING EMISSION EFFECTS

Control System	Probable Case	Worst Probable Case
Value of MAI affected by SO_2-MCS-244	$ 700	$ 700
Value of MAI affected by HF-Uncontrolled	-	125 686
Total 366	$ 700	$126 386
Value of MAI affected by SO_2-MCS-366	$ 400	$ 400
Value of MAI affected by HF-Uncontrolled	-	125 686
Total 366	$ 400	$126 086
Value of MAI affected by SO_2-FGD-366	$ 0	$ 0
Value of MAI affected by HF-Uncontrolled		
Total 366	0	125 686
	$ 0	$125 686

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From these tables, 5-8 and 5-9, it may be seen that excluding the worst probable case, the effect on allowable annual cut is mainly due to the clearing of land for the site specific areas and it is precisely that portion of the project's effect that has already been accounted for in the allowable annual cut of the Botanie PSYU and therefore will not reduce the current AAC.

TABLE 5-8

TOTAL ANNUAL VALUE OF MAI LOSS FOR WET ASH DISPOSAL

Option 1

Control Systems	Source of Loss	Probable Case	Worst Probable Case
		$	$
MCS-244	Site Specific Area	18 100	18 100
	HF Emission Effect	-	125 686
	SO_2 Emission Effect	700	700
	Total	18 800	144 486
MCS-366	Site Specific Area	18 100	18 100
	HF Emission Effect	-	125 686
	SO_2 Emission Effect	400	400
	Total	18,500	144 186
FGD-366	Site Specific Area	18 100	18 100
	HF Emission Effect	-	125 686
	SO_2 Emission Effect	-	-
	Total	18 100	143 786

TABLE 5-9

TOTAL ANNUAL VALUE OF MAI LOSS FOR DRY ASH DISPOSAL

Options 2 and 3 *

Control Systems	Source of Loss	Probable Case	Worst Probable Case
		$	$
MCS-244	Site Specific Area	13 200	13 200
	HF Emission Effect	-	125 686
	SO_2 Emission Effect	700	700
	Total	13 900	139 586
MCS-366	Site Specific Area	13 200	13 200
	HF Emission Effect	-	125 686
	SO_2 Emission Effect	400	400
	Total	13 600	139 286
FGD-366	Site Specific Area	13 200	13 200
	HF Emission Effects	-	125 686
	SO_2 Emission Effect	-	-
	Total	13 200	138 886

* Both options have identical site specific values, thus the same table is used for both options.

TABLE 5-10

PRESENT VALUE * OF MAI LOSSES
PREDICTED FOR FUME AFFECTED AREAS
VALUES IN $(000)'s

Discount Rate	Probable HF Emission			Worst Probable HF Emission		
	SO_2	Control	System	SO_2	Control	System
	MCS-244	MCS-366	FGD-366	MCS-244	MCS-366	FGD-366
0.03	15	9	0	2 716	2 710	2 701
0.04	13	7	0	2 358	2 353	2 345
0.05	11	7	0	2 069	2 064	2 057
0.06	10	6	0	1 833	1 828	1 822
0.08	8	5	0	1 472	1 469	1 464
0.10	7	4	0	1 218	1 215	1 212
0.12	6	3	0	1 034	1 031	1 028

* Value for 35 year period for emission affected areas.

The present value of MAI lost because of the fume emissions is calculated for a 35 year period since it is anticipated that fume effects will cease upon plant shut-down (Table 5-10). The present values of MAI losses for all ash disposal options, SO_2 control schemes and HF emission levels, are presented in Table 5-11 below. With the uncontrolled, probable HF emission level, the total value of the AAC ranges between $110 000 to $618 000 while with the worst HF emission levels anticipated the value of AAC in perpetuity could be as high as $3 319 000, depending on discount rate, ash disposal option and emission control method.

A comparison of the potential benefits to forestry without and with the Hat Creek project considering a series of discount rates, three ash disposal options, three sulphur dioxide control schemes and two levels of hydrogen fluoride emission is given in Table 5-12. The benefits range from a high of $26 800 000 at 3% discount rate without the project to a low of $5 500 000 at a 12% discount rate with project considering the least effective sulphur dioxide control system and the worst level of hydrogen fluoride emission.

Prediction of fume impacts on vegetation is not an exact science. Because of the many unknown or poorly understood factors, intangibles, synergisms and the highly variable responses to documented treatments, the estimate of allowable annual cut lost and its annual value each year is at a confidence level of plus or minus one order of magnitude.

TABLE 5- 11

PRESENT VALUE * OF MAI LOSSES THAT WOULD BE LOST FOR ALL OPTIONS AND CONTROL SYSTEMS

Values in $(000)'s

Discount Rate	Ash Disposal Option	Probable HF Emission SO_2 Control System MCS-244	MCS-366	FGD-366	Worst Probable HF Emission SO_2 Control System MCS-244	MCS-366	FGD-366
	Option						
0.03	1	618	612	603	3 319	3 313	3 304
0.04	Wet Ash	466	460	453	2 811	2 806	2 798
0.05		373	369	362	2 431	2 426	2 419
0.06	Disposal	312	308	302	2 135	2 130	2 124
0.08		234	231	226	1 698	1 695	1 690
0.10		188	185	181	1 399	1 396	1 393
0.12		157	154	151	1 185	1 182	1 179
	Option						
0.03	2	455	449	440	3 156	3 150	3 141
0.04	Dry Ash	343	337	330	2 688	2 683	2 675
0.05		275	271	264	2 333	2 328	2 321
0.06	Disposal	230	226	220	2 053	2 048	2 042
0.08		173	170	165	1 637	1 634	1 629
0.10	Scheme I	139	136	132	1 350	1 347	1 344
0.12		116	113	110	1 144	1 141	1 138
	Option						
0.03	3	455	449	440	3 156	3 150	3 141
0.04	Dry Ash	343	337	330	2 688	2 683	2 675
0.05		275	271	264	2 333	2 323	2 321
0.06	Disposal	230	226	220	2 053	2 048	2 042
0.08		173	170	165	1 637	1 634	1 629
0.10	Scheme II	139	136	132	1 350	1 347	1 344
0.12		116	113	110	1 144	1 141	1 138

* Value in perpetuity for site specific areas, value for 35 year period for emission affected areas.

TABLE 5-12

COMPARISON OF POTENTIAL BENEFITS TO FORESTRY IN THE HAT CREEK LOCAL STUDY AREA WITHOUT THE PROJECT AND WITH THE PROJECT CONSIDERING DISCOUNT RATE, ASH DISPOSAL OPTION, SO_2 CONTROL SYSTEM, AND HF EMISSION LEVEL

Values in $(000)'s

Discount Rate	WITHOUT THE PROJECT	WITH THE PROJECT						
	Total Potential Benefit	Ash Disposal Option	Probable HF Emission, SO_2 Control System			Worst Probable HF Emission, SO_2 Control System		
			MCS-244	MCS-366	FGD-366	MCS-244	MCS-366	FGD-366
0.03	26 800	Option 1 Wet Ash Disposal	26 182	26 188	26 197	23 481	23 487	23 496
0.04	20 100		19 634	19 640	19 647	17 289	17 294	17 302
0.05	16 080		15 707	15 711	15 718	13 649	13 654	13 661
0.06	13 040		12 728	12 732	12 738	10 905	10 910	10 916
0.08	10 050		9 816	9 819	9 824	8 352	8 355	8 360
0.10	8 040		7 852	7 855	7 859	6 641	6 644	6 647
0.12	6 700		6 543	6 546	6 549	5 515	5 518	5 521
0.03	26 800	Option 2 Dry Ash Disposal Scheme I	26 345	26 351	26 360	23 644	23 650	23 659
0.04	20 100		19 757	19 763	19 770	17 412	17 417	17 425
0.05	16 080		15 805	15 809	15 816	13 747	13 752	13 759
0.06	13 040		12 810	12 814	12 820	10 987	10 992	10 998
0.08	10 050		9 877	9 880	9 885	8 413	8 416	8 421
0.10	8 040		7 901	7 904	7 908	6 690	6 693	6 696
0.12	6 700		6 584	6 587	6 590	5 556	5 559	5 562
0.03	26 800	Option 3 Dry Ash Disposal Scheme II	25 345	26 351	26 360	23 644	23 650	23 659
0.04	20 100		19 757	19 763	19 770	17 412	17 417	17 425
0.05	16 080		15 805	15 809	15 816	13 747	13 752	13 759
0.06	13 040		12 810	12 814	12 820	10 987	10 992	10 998
0.08	10 050		9 877	9 880	9 885	8 413	8 416	8 421
0.10	8 040		7 901	7 904	7 908	6 690	6 693	6 696
0.12	6 700		6 584	6 587	6 590	5 556	5 559	5 562

B. Cooling Tower Emissions

No significant effects on forestry are anticipated because the potentially harmful emission and deposition paths are contained within the site specific areas.

C. Mine Air Emission

It is anticipated that the dust control will be sufficiently efficient to avoid any significant effect on forestry.

D. Mine Pit Dewatering

No significant impact on forestry is anticipated.

(iv) Decommissioning Impacts

There are no decommissioning impacts applicable to merchantable timber stands.

(v) Summary of Project Impacts

The impacts of the project considered by the various alternatives are summarized in Table 5-13 by cause, ash disposal option, air emission pollutant control strategy and level and by area, volume and value. In order to simplify the table only one discount rate 3% is used as an illustration. The full range of discount rate variation effect is shown in Tables 5-4, 5-10, 5-11 and 5-12.

The volume shown in the total column in Table 5-13 represents the estimated volume of the current merchantable growing stock potentially impacted by the proposed Hat Creek project. It is from this volume that premature mortality may occur from either plant construction or operation and this timber could be prelogged in the construction phase or salvaged in the operational phase. Merchantable timber not salvaged would count as a loss to forestry because of the project.

The MAI column predicts the loss of future tree growth that would result if the Hat Creek project were implemented.

TABLE 5-13

SUMMARY OF PROJECT IMPACTS
BY AREA, VOLUME AND VALUE

	AREA	VOLUME		VALUE	
	Hectares	M^3(000's) Total	MAI m^3/yr.	$ Annual	$ (000's) Present Worth at 3%
Site Specific					
Option 1	4 320	157	3 290	18 100	603
Option 2	3 950	140	2 390	13 200	440
Option 3	3 900	140	2 390	13 200	440
Emissions					
SO_2 - MCS-244	N/A	191	132	700	15
MCS-366	N/A	135	77	400	9
FGD-366	N/A	0	0	0	0
HF - Probable	0	0	0	0	0
Worst Probable	34 390	1 235	22 900	126 000	2 701

5.3 Comparison of the "Without the Project" and "With the Project" Cases

The potential benefit of the forest resource of the Hat Creek local study area without the project ranges from $26 800 000 (3%) to $6 700 000 (12%) according to the discount rate used.

The potential benefit of the forest resource of the same area with the project ranges from $26 400 000 for FGD-366 Dry Ash Disposal Options 2 or 3, probable hydrogen fluoride emission uncontrolled 366, at 3% discount rate to $5 500 000 for MCS-244 Wet Ash Disposal, Option 1, worst probable hydrogen fluoride emission uncontrolled 366 at 12% discount. The respective values lost are $400 000 and $1 200 000. Table 5-12 provides the complete series of values showing alternative discount rates, ash disposals, sulphur dioxide control systems and hydrogen fluoride emission probabilities.

6.0 MITIGATION RECOMMENDATIONS

This section provides recommendations for mitigating the negative impacts on forestry and estimates of the cost of implementing these recommendations where possible.

Recommendations are of a general nature in order to give B.C. Hydro and Power Authority planners and engineers enough flexibility to deal with individual problems.

6.1 Regional Study Area

(a) Monitoring Impacts on Tree Growth and Mortality

A long term plan to monitor the impacts on tree growth and tree mortality is recommended. This will determine if any adverse effects do exist and their dimensions so that rational actions may be taken only in response to significant effects caused by the project.

Such a plan would:

(1) Provide maps of the extent of confirmed acute and chronic fume damage,
(2) Record the quantitative impact of the project on the affected ecosystems,
(3) Provide a basis for adjudicating any possible future damage claims by any parties claiming to be affected adversely.

More detailed recommendations as to methodology are provided in Section 7.0, Monitoring Program Recommendations.

(b) Entomological Study

An entomological study should be instituted for the years prior to project development and continued throughout the life of the project. It would be desirable to begin work on the statistical design of the study as soon as possible in order to maximize the time available to gather baseline data before the generating plant begins operation.

(1) Record baseline level of activity for the major insect pests known to occur in the region during their active season within and adjacent to the area of influence of the project, as appropriate to the specific insects' life cycles,
(2) Develop standard criteria or methods of measuring insect activity so that relationships to damage (kind and duration) can be estimated,
(3) Identify population trends with the objective of providing some predictive capacities concerning future population trends and patterns of infestation, if possible,
(4) Provide a diagnostic description of insect damage to forest tree species which should allow distinctions to be made between insect and fume damage.

A major objective of the entomological study should be to demonstrate cause and effect linkages so that the effect of fumes on tree-insect interactions can be determined quantitatively, with a reasonable degree of accuracy.

Many aspects of such a study are considered in the present work of the Canadian Forestry Service's Forest Insect and Disease surveys and associated C.F.S. research. It is recommended that B.C. Hydro or their representatives enter into discussions with the C.F.S. officials with the objective of finding the best way to jointly resolve these questions. The B. C. Forest Service protection division foresters should also be involved.

6.2 Local Study Area

The following recommendations apply to areas within and adjacent to the local study area because fume emission effects may extend beyond the 25 km boundary of the local study area (72).

(a) Maintenance of a Green Forest by Intensive Forest Management

Monitoring of insect populations and permanent environmental sample plots will help in correctly assigning the cause of mortality of any dead trees that may occur near the thermal generating plant. However, regardless of cause, dead and dying trees in the vicinity of an industrial plant are usually considered by the general public to have been killed by the plant. It is therefore strongly recommended that intensive forest management be practiced in the area of influence in the vicinity of Hat Creek Valley.

The boundary of the local study area should be redefined to coincide with the probable boundary of the area of influence. Within this area intensive forest management should be practiced and any dead or dying trees salvaged immediately to minimize unfavourable aesthetic effect and public reaction. It is recommended that all Crown land within the area of influence be placed in a special management unit (SMU) wherein intensive local forest management be practiced rather than the extensive management as normally applied in B.C. The cutting rights held by operators now working within the designated area of the SMU held under PSYU administration would be transferred automatically to the SMU administration in order to avoid any hardship or inequity.

The forest management within the SMU should be carried out by professional foresters under the authority of B. C. Hydro and Power Authority in association with the B. C. Forest Service. At least one forester should be maintained on location so that any unfavourable conditions may be recognized immediately and appropriate action taken.

Since the major part of the SMU is within the Botanie PSYU, which already has a reduced AAC to account for possible open pit mines causing loss of timber lands, the establishment of the new unit would have little additional effect on AAC. Intensive forest management, if undertaken, could well justify an increase in the region's overall AAC.

The management plans for the SMU should consider the aesthetic interaction of the proposed industrial complex, the forest, open range land and salvage - logging operations, as well as other uses. A landscape architect should work closely with the foresters to design aesthetically acceptable logging patterns. It is very likely that the thermal generating plant will become a tourist attraction and therefore the plant - mine complex, the immediate surroundings and the setting should be kept as aesthetically pleasing as possible.

Upon complete decommissioning of the plant-mine facilities, the SMU could be returned to its original status.

The maintenance of a healthy green forest, a model forest, with no dead and dying trees or obviously contrasting logging scars, is the best possible mitigation against adverse public reaction.

(b) Mutual Use of Access Roads

New roads should be located to minimize conflict with long term logging operations and the high recreational traffic volume on Highway 12 during the summer months.

The principal operator in the development area, Evans Products Ltd., will require logging access through the Medicine Creek area. A special study is recommended to coordinate the location of the required roads, transmission lines, water pipes, canals and disposal areas so that no facility impedes the location and engineering requirements of the other facilities. Mutual use of an access road for construction and logging traffic can be accommodated, especially if only radio controlled traffic is allowed. Advantages of mutual use access roads include reduced overall road costs and reduced forest acreage taken out of production.

If mutual road use is not possible, at least one new logging road is likely to be required from Fish Hook Lake up to the 1 205m (3 950 foot) contour on the south side of Medicine Creek (see Addendum 1). If built to Class 5 standards with a normal logging road standard of vertical and horizontal alignment, such a road would require about 29 km (18 miles) of new road construction costing about $200,000.

(c) Tree Regeneration Trials

Regeneration of denuded or semi-denuded lands is very difficult in the area because of the hot dry summer climate and low annual precipitation as evidenced by high soil pH and high levels of soluble salts in most of the topsoils on elevations below 1 300m, including elevations below 1 200m on north facing slopes and up to 1 350m on southwest facing slopes. Planting trials should begin before or very soon after project start-up because of the difficulties anticipated in establishing vegetation and tree regeneration. Reclamation experiments should be aimed at determining which species or varieties will do the best in this area, the local time for sowing or planting trees and the silvicultural treatments required. Experimental work should also include soils and material from various levels of various overburden locations to determine suitability for use as topsoil in reclamation projects. The topsoil present in the area before construction may not be the best soil for reclamation purposes. Trees, shrubs and herbs native to British Columbia should be preferred in reclamation work as most likely to produce the best results in growth and be disease-free. Caution should be used in introducing exotic species that may be carriers of disease or insect pests not now present in the region.

(d) Reclamation Objectives

The disposal areas can be restored to forest but site productivity for wood production is likely to be low. The dry climate, fine textured soils and high summer temperatures will severely restrict tree regeneration on barren areas, especially at elevations of less than 1 250 metres. Given these constraints, reclamation for forestry purposes is difficult and can be expensive. Reclamation efforts should be oriented towards aesthetic, wildlife and agricultural goals, especially at the lower elevations.

6.3 Site Specific Study Area

(a) Coordination of Logging and Clearing Plans

Should the Hat Creek Project proceed, it is recommended that B.C. Hydro contact the B. C. Forest Service and Evans Products Limited to coordinate the 1978-80 logging plans with site specific clearing plans in order to expedite the harvesting of all merchantable timber.

For optimal clearing benefits and maximum wood utilization, logging method and specifications should be changed and cutting permit cut blocks relocated to match the various site specific locations of the project. Arrangements should also include the B. C. Forest Service, Kamloops District - Area forester so that certain regulatory limitations can be relaxed (eg: clear cutting replacing selective logging) where appropriate. Although slashburning or other hazard abatement procedures should be continued, planting requirements should be omitted on these areas.

(b) Buffer Zones

Both flooding and deposition of soil around the stems of trees will result in oxygen deprivation of the roots and cause mortality.

In those areas where flooding or deposition of overburden or soil material is to occur, a buffer zone adjacent to the affected site should be cleared of trees to prevent the possibility of an unsightly ring of dead trees around the facilities. Groups of dead trees, especially when adjacent to living forests, are an insect and fire hazard that should be avoided, especially in the Hat Creek area where the summer climate is very hot and dry.

Construction debris, particularly flammable debris such as paper, lumber, cardboard and wood shavings, should not be piled or deposited within 1 km (½ mile) of the edge of a continuous woodland (refer to Sections 100 to 124, Part XI of the Forest Act - Province of British Columbia).

(c) Use of Logs as Insect Traps

In those areas where logging can precede the clearing and construction phases by 6 to 12 months, trees should be felled, bucked, decked in the spring and left to attract an invasion by bark beetles. Once the invasion has occurred, usually by mid July, the logs can then be trucked to the mill where the beetles will be destroyed during the manufacturing process. This form of bark beetle control is currently used in the area and should be continued during the construction period.

Logging slash left after harvesting attracts and becomes the home for a variety of forest insect pests. These populations so formed often become a base from which attacks spread to adjacent forests. Occasionally these attacks are of epidemic proportions, and slash disposal, either by broadcast or pile and burn methods, could be timed so as to destroy as many insect pests as possible.

7.0 MONITORING PROGRAM RECOMMENDATIONS

In accordance with the terms of reference and proposal for the detailed environmental impact assessment for B. C. Hydro's proposed Hat Creek thermal generating project, an analysis of the requirements for a long term monitoring program of the impacts of air emissions on the forest vegetation has been prepared.

In this general analysis of the parameters necessary for a scientifically valid long term monitoring program, concentration has been placed on providing a framework into which site specific considerations can be most effectively fitted. The program should focus upon the following questions in relation to the effects of sulphur dioxide (SO_2) and hydrogen fluoride (HF) emissions:

1. What type of response can be expected from individual plants?
2. How will this response influence their competitive ability?
3. How will changes in competitive ability influence plant succession?
4. How long will it take for changes to be detectable in the field?
5. How can changes be documented?
6. What study methods would be most effective in obtaining the necessary documentation?
7. How can the monitoring program aid in mitigation and reclamation planning?

Plants can be expected to have an altered metabolism, with the most probable result being lowered photosynthesis and reduced growth. A considerable variation in the degree of response can be expected between species, and between individuals within a species.

The relative abilities of the plants in the community to obtain light, water, and nutrients will probably change because of individual and species differences. In the most probable situation all plants will suffer a reduced competitive ability, although it is possible that some plants may be stimulated. Plant succession can be expected to be modified in response to the new factors in the environment, resulting in a changed community structure. There is reason to expect that some air pollutant susceptible species may disappear over a period of time, resulting in plant communities which are simpler than those which would have occurred without the additional selective pressure.

Very little is known about the rates of successional change which can be expected with elevated levels of sulphur dioxide (SO_2). In situations following fire, logging, agricultural abandonment, and massive soil movement, the rate of change is initially quite rapid, but decreases gradually after invading species have become established. In the situation anticipated, this pattern will probably be rare because the successional change will start with established vegetation. It is most probable that changes will be gradual and quite subtle. The study design should allow for either condition, as well as for an accelerating rate of change should chronic effects approach possible critical threshold levels.

Documentation of changes will require establishment of permanent sample plots with repeated measurement of the same vegetation characteristics at these fixed plot locations over the operating life of the thermal generating plant and for some time after operations have stopped. This will demonstrate whether or not the plant communities are continuing to react to residual effects. Reliable documentation can be obtained only by comparing vegetation which is being subjected to the effluent to similar vegetation which is not. Standardized forest and vegetation inventory data should be based on a sound statistical design to take advantage of practical experience in interpretation of forest ecological data.

The most effective study methods to obtain the necessary documentation would depend upon the types of vegetation to be studied and the access. Standard field sampling techniques for overstory and understory vegetation are available using fixed area or prism point samples. The number of plots would be a function of the number of vegetation types which must be sampled, the extent by area of the expected influence zone, the complexity of the topography and soils, and the statistical variance between plots.

The use of low level infrared aerial photography as a tool in monitoring stress in vegetation caused by environmental or external factors should be considered (76). The technique is under development presently in B.C. and could prove a practical method of monitoring stress and any change in stress in the Hat Creek vegetation (77).

The monitoring program should include sampling of the fluoride content of the foliage of the Hat Creek vegetation. The results from such a sampling program can be quite misleading if not conducted, analysed and assessed by experienced personnel. The recording method and standardization of sample collection can be quite critical. Laboratory technique is now well developed for fluoride determination but cross-checking is still useful, especially when results do not fit the expected pattern. Quick recognition of this is important to resample the vegetation in as close as possible to the condition of the previous suspect sample in order that it may be proven or disproven. Field sampling design should also consider pollutant sensitive species such as Douglas-fir and ponderosa pine and also wildlife browse, grasses characteristic throughout the area of range, and lichens. Preliminary results of sampling for fluoride content indicate strange anomalies which may be characteristic of the area or of the sampling. This should be resolved, particularly for the grass with its importance to the range cattle.

The monitoring program can aid in mitigation and reclamation planning by incorporating a systematic search for native plants which are resistant to the effects of the effluents, and by developing a stock of these resistant plants for revegetation of denuded areas. These resistant individuals are usually too widely dispersed to interbreed and recolonize the area without assistance. Also, the monitoring program should be designed to identify areas where mitigation measures may be necessary as soon as such problem areas can be identified. For this it would be necessary to survey the airshed each year in addition to periodic remeasurement of permanent sample plots.

In general, the program which is recommended would incorporate the following:

1. Stratification of the influence area of the thermal generation plant into high, medium, low, and no probable increase in ambient SO_2 and related HF based upon the meteorological model of the airshed;

2. Stratification of the vegetation in the influence area into vegetation types based upon species, soils and landform in a site specific refinement of Krajina's biogeoclimatic classifications (78, 79, 80);

3. Location of permanent sample plots within each vegetation type to give a statistically valid sample with controls for the high, medium and low predicted impact zones (Note: because data are needed to calculate the necessary replication, a pilot study should be done to estimate variance). Tree ring analysis of growth rates before and after the thermal plant begins operation and within and without the actual fume path,once its location is determined from experience,will also help to give quantitative estimates of changes in growth rates.

4. An experimental design which will allow changes in the numbers of plots as experience with actual plume behavior is gained;

5. An annual survey of the airshed by qualified professionals to assess localized and general vegetation response, including phenological data such as time of growth initiation, flowering, fruiting, and dormancy;

6. A systematic search for individual plants resistant to the effects of SO_2,HF or other pollutants for use in reclamation plantings.

A detailed phase should be planned to incorporate the information from the detailed environmental impact assessment as it becomes available, and to concentrate on site specific considerations. Some of the detailed design, such as decisions on types of data to collect and analysis techniques, can be done independently of site specific considerations. It would therefore be more efficient to initiate the design phase early in order to maximize the time available to gather baseline data before the thermal generating plant begins operation. Detailed design is estimated to require about six months to allow for a pilot field program and the availability of meteorological, soils, and vegetation data.

Because of the complexity of the study design considerations, the need for the maximum amount of time to gather baseline data so that the control and study plots can be correlated, and the requirement that the monitoring program be sophisticated enough to remain valid for several decades, it is recommended that a detailed design be funded and initiated as soon as possible, to be followed by a pilot study and monitoring program. These should commence prior to operation of the thermal plant.

SECTION 8.0 - GLOSSARY

Alienated Land

- Crown grants for which title is held in fee simple, including Crown granted lands within tree farm licenses (Schedule "A").
- Federal lands including: National Parks, Indian Reserves and other lands controlled by agencies of the Federal Government[2].

Allowable Annual Cut (AAC)

This is the estimated average volume that may be harvested annually from a forest unit which will result in the eventual attainment and perpetuation of an approximately normal distribution of age classes, normal stocking, and a sustained-yield. The Allowable Annual Cut estimates[2] in this report are only possible if all logging operations are conducted at the Close Utilization level.

Board Foot

A board foot of lumber is the amount of timber equivalent to a piece 1 x 1 feet and 1 inch thick, equal to 1/12 cubic foot, being the unit in board-foot measure. The board-foot measure of surfaced timber is based on nominal size[10]. This should be distinguished from a board foot log scale which is defined by and varies according to the log scale used.

Close Utilization

The Forest Inventory Division of the B.C. Forest Service has established a standard utilization level to describe the useable portion of a tree stem as follows:

> All firm wood between a one-foot stump height and a four-inch top diameter inside bark. Included are stems 7.1 inches and over in diameter at breast height, except for lodgepole pine, which is 5.1 inches.

Conversion Return

The selling price of the appraised end product (e.g. logs or lumber) less the cost of producing the appraised product is the conversion return.

Crown Lands

As defined by the Forest Act means such ungranted Crown or public lands or Crown domain as are within and belong to Her Majesty in right of Province, and whether or not any waters flow over or cover the same, and lands forfeited to and vested in the Crown under the provisions of the Taxation Act, and lands given or devised to the Crown by any person, and lands purchased or acquired by the Crown.

Cunit

100 cubic feet of log or standing tree, solid measure, bark free wood[2].

DIB

Diameter of log measured inside the bark.

DBH

This is the abbreviation for diameter at breast height. In order to give a common, yet convenient datum level, the diameter of all trees outside bark is measured at 4.5 feet above the point of germination. For example, in this report, volumes at 7.1" + DBH (or dbh) include trees 7.1" and larger[2].

Discount Rate

An alternative rate of return (interest) for discounting future forest values, assuming constant dollars. (Expressed as a decimal equivalent to the appropriate percentage rate).

Immature Forest - see mature forest

Mature Forest

Mature and Immature Forest stands contain an acceptable number of trees per acre, the oldest stands being called mature and the youngest immature as follows[2].

Age Group	Year of Survey	Broad-leaved Stands (years)	Lodgepole and Whitebark Pine Stands (years)	All Other Coniferous Stands (years)
Immature	Pre-1963	1-40	1-80	1-120
	1963+	1-80	1-80	1-120
Mature	Pre-1963	41 and over	81 and over	121 and over
	1963+	81 and over	81 and over	121 and over

Mean Annual Increment

Mean Annual Increment[2] (MAI) is the annual growth in cubic foot volume per acre averaged for the total age throughout the life of a forest.

$MAI = \frac{\text{present volume}}{\text{present age}}$. In this report the culmination of MAI at rotation age is the value of MAI quoted.

Non-Commercial Cover (NCC)

Includes all non-commercial vegetation now occupying productive forest land[2].

Not-Satisfactorily Restocked (NSR)

Stands that have been disturbed over 75 percent by fire, logging, wind, insect, disease or other disturbances, and have not re-stocked with sufficient numbers of commercial species[2].

Public Sustained-Yield Unit (PSYU)

This is an area of Crown land, usually a natural topographic unit determined by drainage areas, managed for sustained-yield by the Crown through the British Columbia Forest Service. They include all Crown lands within the currently established boundaries of the unit, and exclude Federal lands, Provincial Parks, Experimental Forest Reserves, gazetted watersheds, and Tree Farm Licenses[2].

Residual Forest

Stands which have been disturbed 26 to 75 percent, usually by logging although other causes such as fires, insects or disease may be responsible for the disturbance. These all-age remnants of a stand usually result after diameter-limit cutting[2].

Rotation

Rotation is the planned number of years between the formation or regeneration of a crop or stand and its final cutting at a specified stage of maturity[10]. For the purpose of this report the rotation of maximum volume production is used which is that rotation which coincides with the age at which the mean annual increment culminates and hence yields the most wood per unit area per annum[10].

Tree Farm License (TFL)

A tree farm license is an agreement between the Crown and the owner of other tenures to combine such other tenures and Crown forest land for the purpose of management. This form of forest alienation permits the establishment of single, managed units which can be planned for on a sustained yield basis in areas which, due to various ownership patterns, could not otherwise be efficiently managed. The agreement reserves the area to the sole use of the licensee to harvest the growth in approximately equal annual or periodic cuts, adjusted to the sustained yield of the lands, to provide a source of raw materials for predetermined plants, owned or controlled by the licensee.[7]

8.1 Abbreviations

AAC	=	Allowable Annual Cut
ac	=	acres
asl	=	above sea level
BCFS	=	British Columbia Forest Service
BCR	=	British Columbia Railway
BDU	=	Bone Dry Unit (wood chips)
bd ft	=	board feet
bh	=	Breast height, 4.5 feet above mean ground line
CFS	=	Canadian Forestry Service
cm	=	centimetre
CNR	=	Canadian National Railway
CPR	=	Canadian Pacific Railway
C.U.	=	Close Utilization
cunits	=	100 cubic feet (log)
dbh	=	diameter at breast height
dib	=	diameter inside bark
EPA	=	Environmental Protection Area
EPF	=	Environmental Protection Forest
ft	=	feet
ft^3	=	cubic feet
ha	=	hectare
in	=	inch
km	=	kilometre
km^2	=	square kilometre
m	=	metre
m^2	=	square metre
m^3	=	cubic metre
MAI	=	mean annual increment
NCC	=	Non-commercial cover
NSR	=	Not sufficiently restocked
ply	=	plywood
PSYU	=	Public Sustained Yield Unit
R	=	Residual, timber remaining after selective logging
t	=	tonne = 1 000 kilograms
TFL	=	Tree Farm License
TSHL	=	Timber Sale Harvesting License
TSL	=	Timber Sale License
ven	=	Veneer

8.2 Conversion Factors

1	Bone Dry Unit (BDU)* of wood chips in B.C. Interior only.	= 2 400 pounds at 0% moisture content (bone dry)
		= 1 cunit solid wood (approximation)
		= 2.832 m^3 solid wood (approximation)
1	centimetre	= 0.393 7 inch
1	cunit	= 100 cubic feet roundwood
		= 2.831 65 m^3
1	hectare (ha)	= 2.471 05 acres
1	cubic metre (m^3) roundwood	= 35.315 cubic feet roundwood
1	cubic metre sawnwood	= 424 board feet sawn lumber**
1 000	square feet plywood 3/8" thickness basis	= 31.25 cubic feet plywood 0.885 m^3 plywood
1	metre	= 3.281 feet
1	tonne	= 1.102 31 tons
1	cm/ac.	= 6.997 m^3/ha
1	m^3/ha	= 0.1429 cm/ac.

* The bone dry unit is the commercial unit used for sale of wood chips in the British Columbia Interior and is defined as 2 400 pounds of chips, bone dry. As yet there is no official conversion factor of a BDU to metric units. The pulp industry has indicated a preference for use of solid wood equivalents rather than weight for future metric usage. Therefore, the metric unit will likely be a cubic metre (solid wood equivalent).

** See following page

On a solid wood basis a BDU is currently and unofficially considered to be equal to one cunit. This varies by species. Based on average B.C. Interior wood density values the solid contents of one BDU per species are:

Species	Cubic Feet	m^3
Spruce	107.1	3.03
Fir	85.5	2.42
Lodgepole pine	94.1	2.66
Balsam	113.1	3.20

** The Sawn Lumber Conversion Factor commonly in use in Canada is 1 cubic metre = 424 board feet. This factor is also used by many other countries. This factor is exact when wood is sawn in exact dimensions (eg. a 2" x 6" board has these exact dimensions). In practice, lumber dimensions are nominal values and a 2" x 6" board will be green rough sawn to 1 13/16" x 5 7/8" and when dried and planed will be 1 1/2" x 5 1/2". Thus, the green rough sawn board is 88.7 percent of nominal volume and the planed and dried board is 68.75 percent of nominal. The ratios between exact and nominal sizes vary for the dimensions produced.

8.3 Species by Name and Symbol

SPECIES	SPECIFIC NAME	SYMBOL
Alder	Alnus	
Red Alder	* A. rubra Bong.	D
Balsam	Abies	
Alpine Fir	A. lasiocarpa (Hook.) Nutt.	B
Amabilis Fir	* A. amabilis (Dougl.) Forb.	B
Balsam Fir	* A. balsamea (L.) Mill.	B
Grand Fir	A. grandis (Dougl.) Lindl	B
Birch	Betula	
White Birch	B. papyrifera Marsh.	Bi
Cedar	Thuja	
Western Red Cedar	T. plicata(Donn.)	C
Cypress	Chamaecyparis	
Yellow Cedar	* C. nootkatensis (D.Don) Spach	Cy
Douglas-fir	Pseudotsuga	
Douglas-fir	P. menziesii (Mirb.) Franco	F
Hemlock	Tsuga	
Mountain Hemlock	* T. mertensiana (Bong.) Carr	H
Western Hemlock	T. heterophylla (Raf.) Sarg.	H
Larch	Larix	
Alpine Larch	* L. lyallii Parl.	L
Tamarack	• L. laricina (DuRoi.) K. Koch	L
Western Larch	L. occidentalis Nutt.	L
Maple	Acer	
Broadleaved Maple	* A. macrophyllum Pursh.	Mb
Pine	Pinus	
Lodgepole Pine	P. contorta Dougl.	Pl
Western White Pine	P. monticola Dougl.	Pw
Whitebark Pine	P. albicaulis Engelm.	Pa
Ponderosa or Yellow Pine	P. ponderosa Laws.	Py
Poplar	Populus	
Aspen	P. tremuloides Michx.	A
Balsam Poplar	* P. balsamifera L.	Cot
Black Cottonwood	P. trichocarpa Torr. & Gray	Cot
Spruce	Picea	
Black Spruce	* P. mariana (Mill) B.S.P.	Sb
Engelmann Spruce	P. engelmanii (Pary)	S
Sitka Spruce	* P. sitchensis (Bong.) Carr.	S
White Spruce	P. glauca (Moench) Voss	S
Norway Spruce	* P. abies (Karst.)	

* Species not occurring naturally in Regional, Local or Site Specific Areas.

Rod. Collins

SECTION 9.0 - REFERENCES

1. Forest Inventory Division 1962-1974 — Forest Cover Maps, associated map area/volume statements, associated unit survey reports for the following PSYUs: Big Bar (1962), Botanie (1970), Kamloops (1968), Lac la Hache (1972), Nehalliston (1973), Nicola (1970), Yalakom (1965). British Columbia Forest Service; Forest Inventory Division, Victoria, B.C.

2. Forest Inventory Division 1973 — Forest Inventory Statistics of British Columbia. British Columbia Forest Service; Forest Inventory Division, Victoria, B.C.

3. Forest Inventory Division 1974 — Classification and Sampling Manual. British Columbia Forest Service; Forest Inventory Division, Victoria, B.C.

4. I.P.A. Staff 1976 — The Central Report '76, Interim Planning Agreement Staff, British Columbia Department of Economic Development, Victoria, B.C.

5. District Forester's Office 1976-1977 — Established Licencees by PSYU, British Columbia Forest Service, Kamloops District, District Forester's Office, Kamloops, B.C.

6. District Forester's Office 1976-1977 — Established Licencees by PSYU, British Columbia Forest Service, Cariboo District, District Forester's Office, Williams Lake, B.C.

7. Forest Club
1971
Forestry Handbook for British Columbia, 3rd ed. The Forest Club, University of British Columbia, Vancouver, B.C.

8. Forest Insect and Disease Survey
1912-1976
Annual Reports of Forest Insect and Disease Conditions, Kamloops Forest District, Canadian Forestry Service, Fisheries and Environment Canada, Victoria, B.C.

9. Edmunds, G.F., Jr.
1973.
Ecology of Black Pineleaf Scale, Homoptera: Diaspidadae. Environmental Entomology, 2:5:765-77.

10. Ford-Robertson, F.C. (Editor)
1971
Terminology of Forest Science, Technology, Practice and Products. The Multilingual Forestry Terminology, Series No. 1. Authorized by the Joint FAO/IUFRO Committee on Forest Bibliography and Terminology: Society of American Foresters, Washington, D.C.

11. Personal Communication.
Letter dated September 23, 1977, from K. Graham, (retired), Faculty of Forestry. University of British Columbia, Vancouver, B.C.

12. Krajina, V.J., P.A. Larkin, J.B. Foster and D.F. Pearson
1974
Ecological Reserves in British Columbia. Canadian Committee for the International Biological Programme, Conservation of Terrestrial Communities Subcommittee (CCIBP-CT) Region 1: British Columbia, Vancouver, B.C.

13. Krajina, V.J. and R.C. Brooke 1969-1970 — Ecology of Western North America. Volume 2, Nos. 1 and 2. Department of Botany, University of British Columbia, Vancouver, B.C.

14. Shepherd, R., J. Harris, A. Van Sickle, L. Fiddick and L. McMullan 1977 — Status of Western Spruce Budworm on Douglas-fir in British Columbia, September 1977. Pacific Forest Research Centre, Victoria, B.C.

15. Murtha, P.A. 1972 — A Guide to Air Photo-Interpretation of Forest Damage in Canada, Publ. #1292, Canadian Forest Service, Ottawa.

16. Jacobsen, J.S. and A.C. Hill 1970 — Recognition of Air Pollution Injury to Vegetation, A Pictorial Atlas, Air Pollution Control Association, Pittsburgh, Pennsylvania.

17. Statistics Canada — Catalogue Number 35 001 1977, Statistics Canada, Ottawa, Ontario.

18. Goodman, H.J. and H.K. Williams, 1968. — Land Use and Land Alienation - Forestry vs Ranching in the Interior of British Columbia. Presented to the Public Hearing on Land Use held in Quesnel, B.C.

19. Personal Communication — Telex,dated 5th October, 1977, from S. Tolnai. Weyerhauser Canada Ltd., Kamloops.

20. Forest Resource Planning Division, 1976, 1977 — Approved Allowable Annual Cuts for Public Sustained Yield Units in B.C., February 1977. British Columbia Forest Service, Forest Resource Planning Division, Victoria, B.C.

21. Forest Protection Division , 1977 — Evaluation of the Western Spruce Budworm Problem in British Columbia, Ministry of Forests, Victoria, B. C.

22. Colley, D.G. (P. Eng.) and Smolarski, G.M. May - June 1978 — Trace Element Material Balance For Hat Creek Coal Test Burn, WR&D ref 3463-R1 Western Research and Development

23. Von Dässler, H.G., Börtitz, s.und Auermann, E. 1972 — Untersuchungen über Fluor-Immissionen aus Braunkohlen - Kraftwerken Aus der Sektion Forstwirtschaft der Technischen Universtät Dresden

24. Robinson, J.M., Gruber G.I., Lusk, W.D. and Santy M.J. January 1972 — Engineering and Cost Effectiveness Study of Fluoride Emissions Control - Volume 1 - Contract EHSD 71-14 - for Office of Air Programs Environmental Protection Agency

25. Environmental Research & Technology Inc. 1977 — Air Quality and Climatic Effects of the Proposed Hat Creek Project. ERT Document No. P-5074.

26. Adams, D.F. and Emerson, M.T. 1961 — Variations in Starch and Total Poly-sachoride Content of Pinus Ponderosa Needles with Fluoride Fumigation. Plant Physiol. 36 pp 261 - 265

27. Applegate, H.G. and Adams, D.F., 1960 — "Invisible Injury of Bush Beans by Atmospheric and Aqueous Fluorides" Int. J. Air Poll. 3(4) pp 231-248

28. Benedict, H.M., Ross, J.M. and Wade, R.H. 1965 — "Some Responses of Vegetation to Atmospheric Fluorides" Air Pollution Control Assoc. 15, pp 253-255

29. Bennett, J.H. and Hill, A.C. 1974 — Acute Inhibition of Apparent Photosynthesis by Phytotoxic Air Pollutants. In: M. Dugger, Ed., Air Pollution Effects Plant Growth ACS Symposium Series 3 150 pp.

30. Bligny, R., Bisch, A.M. Garrec, J.P. and Fourcy,A. 1973 — Observations morphologigues et structurales des effets de fluor sur les cires epicuricularies et sur les chloroplastes des aiguilles de sapin (Abies alba, M.), J. Microse (Paris) 17, pp 207-214.

31. Brandt, C.S. and Heck, W.W. 1968 — Effects of Air Pollutants on Vegetation, In: A.C. Stern, Ed., Air Pollution Vol. 1. (2nd ed.) New York, Academic Press, 1968.

32. Braun, G. 1974 — Increment Reactions and Fluorine Contents of Needles in Norway Spruce (Picea abies (L.) Karst) Demonstrated by an Example of Medium Sized Brickworks, Presented at Conference in Marianski Lazne, Czechoslovakia, Oct. 1974.

33. Brewer, R.F., Gorber, M.J. Guillemet, F.B. and Sutherland, F.H. — The Effects of Accumulated Fluoride on Yields and for Quality of Washington Navel Oranges, Proc. Amer. Soc. Hon. Sci. 91, pp 150-156, 1967.

34. Chang, C.W., 1967 — Study of Phytase and Fluoride Effects in Germinating Corn Seeds, Cereal Chem. 44, 129 - 142.

35. Chang, C.W. and Thompson, C.R. 1966 — Site of Fluoride Accumulation in Navel Orange Leaves, Plant Physiol 41 pp 211-213

36. Daines, R.H., Leone I. and Brennen, E. 1952 — The Effects of Fluoride on Plants as Determined by Soil Nutrition and Fumigation Studies, In: L. McCabe, ed., Air Pollution, New York, McGraw Hill.

37. Environmental Research & Technology Inc., 1977 — Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix F. The Influence of the Project on Trace Elements in the Ecosystem. ERT Document No. P-5074.

38. Garrec, J. P. , J. C. Oberlin, E. Ligeon, A.M. Bisch, and A. Fowley 1974 — Fluoride - Calcium Interaction in Polluted Fir Needles, Fluoride 7 (2) 1974 pp 78 - 83

39. Garrec, J.P. and Lhoste, A.M. 1976 — Electron Probe Microanalysis of Fluorine in Polluted Needle Sections of Abies Alba, Fluoride 9 (1) 1976 pp.63-70.

40. Gordon, C.C., 1974 — Environmental Effects of Fluoride: Glacier National Park and Vicinity USEPA 908/1 - 74 - 001.

41. Haegle, A.S., 1973 — Interactions Between Air Pollutants and Plant Parasites, Ann. Rev. Phytopathol 11, pp 365 - 388.

42. Halbwachs, G., 1967 — The Water Regime of Smoke-Damaged Woody Plants, Allg.Gorstztg 78 (9) pp196-197.

43. Hewitt, E.J. and Nichols, D.J.D., 1963 — Cations and Anions: Inhibitions and Interactions in Metabolism and in Enzyme Activity, In: P.M. Hochster and J.H. Zuostel, Eds., Metabolic Inhibitors, vol 2, pp 311-436.

44. Hill, A.C. 1969 — Air Quality Standards for Fluoride Vegetation Effects, J. Air Pollution Control Assoc. 19, pp 331 - 336.

45. Hitchcock, A.E., Zimmerman, P.W. and Cooe, R.R., 1962 — Results of Ten Years' Work (1951-1960) on the Effect of Fluorides on Gladiolus, Contrib. Boyce Thompson Inst. 21, pp 303-344.

46. Horntvedt, R. and Robak H., 1975 — Relative Susceptibility of Eleven Conifer Species to Fluoride Air Pollution, Rept. Norweg. Forest Res. Inst. 32 pp 185-206, 1975.

47. Knabe, W. 1970 — Natural Loss of Fluorine From Needles of Norway Spruce (Picea Obies, Karst.), Staub-Reinholt Luft 30 pp 29-32.

48. Knabe, W. and Guenther, K. H. 1971 — Contributions of Forestry to the Environmental Protection in North Rhine Westphalial, Allg. Forstz 26 (24), 503-506, 513-514.

49. Lovelace, J. and Miller, G.W., 1967 — In Vitro Effects of Fluoride on Tricarboxylic Acid Cycle Dehydrogenase and Oxidative Phosphorylation Part I, Histochem Cytochem 15, pp 195-201.

50. MacLean, D.C., Schneider R.E., and McCune, D.C. 1973 — Fluoride Toxicity as Affected by Relative Humidity, Proc. In Clean Air Congr. 3rd, 1973 pp A143-A145

51. MacLean, D.C. and Schneider, R.E., 1973 — Fluoride Accumulation by Forage: Continuous vs. Intermittent Exposures to Hydrogen Fluoride, J. Environ. Quality 2, pp. 501 - 503.

52. MacLean, D.C. and Schneider, R.E., 1970 — Fluoride Phytotoxicity: Its Alteration by Temperature, Second Intern. Clean Air Congress, Washington D.C. pp 292-295.

53. McCune, D.C., 1969 — A Symposium - The Technical Significance of Air Quality Standard, Environ. Sci. and Technology 3, pp 720 - 735.

54. McNulty, I.B. and Newman, D.W., 1961 — The Effect of Fluoride Fumigation on the Chlorophyll Content of Leaves, Plant Physiol 32 (Suppl): vii 1957 (Abst.)

55. Oelschlaeger, W., 1974 — Harmful Effects of Fluoride, Ziegelind (Wiesbaden), No. 4 pp. 169 - 174.

56. Ross, C.W., Wiebe, H.H. and Miller, G.W., 1962 — Effect of Fluoride on Glucose Catabolism in Plant Leaves, Plant Physiol.37: pp. 305 - 309.

57. Solberg, R.A., Adams, D.F. and Ferchau, H.A., 1955 — Some Effects of Hydrogen Fluoride on the Internal Structure of Pinus Ponderosa Needles, Proc. Natl. Air Pollution Symp., 3rd, Pasadena, Calif., pp. 164 - 176.

58. Stark, R.W., Miller, P.R., Cobb, E.W., Wood, D.L. and Parameter, J., 1968 — Phytochemical Oxident Injury and Bark Beetle (Colcoptera: Scolytidae) Infestation of Ponderosa pine, Hilgardia, 39, pp. 121 - 126.

59. Taylor, O.C., 1958 — Air Pollution With Relation to Agronomic Crops: IV. Plant Growth Suppressed by Exposure to Air-borne Oxidents (smog). Agron, J. 50, pp. 556 - 558.

60. Thomas, M.D., 1958 — Air Pollution with Relation to Agronomic Crops. I. General Status of Research on the Effects of Air Pollution on Plants, Agron. J. 50: 545-550.

61. Tourangeau, P.C., Gordon, C.C., and Carlson, C.E. 1977 — Fluoride Emissions of Coal-Fired Power Plants and Their Impact upon Plant and Animal Species, Fluoride 10 (2) pp 47-62.

62. Treshow, M., 1971 — Fluorides as Air Pollutants Affecting Plants, Ann. Rev. Phytopathol 9, pp. 21-44.

63. Treshow, M. and Pack, M.R., 1970 — Fluoride, pp D1 - D17 In: J.S. Jacobson and A. C. Hill, Eds., Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Information Report 1, TR-7 Agricultural Committee. Pittsburgh Air Pollution Control Association.

64. Treshow, M., Anderson, F.K., and Horner, F., 1967 — Responses of Douglas-fir to Elevated Atmospheric Fluorides, For. Sci. 13 pp 114 - 120.

65. Vins, B. and Mrkva, R., 1973 — The Diameter Increment Losses of Pine Stands as a Result of Injurious Emissions, Acta Universitatis Agriculturae (Brno) Series C (Facultas Silviculturae) 42, 1973 1: pp 25 - 46.

66. Wardlaw, I.E., 1968 — The Control and Pattern of Movement of Carbohydrates in Plants, Bot. Rev. 34:79-105.

67. Weinstein, L.H., 1977 — Fluoride and Plant Life, Journal of Occupational Medicine Vol 19, No. 1, pp 49 - 78.

68. Weinstein, L.H., 1961 — Effects of Atmospheric Fluoride on Metabolic Constituents of Tomato and Bean Leaves . Contrib. Boyce Thompson Inst. 21, pp. 215 - 231.

69. Ziegler, I., 1973 — The Effect of Air-Polluting Gases on Plant Metabolism, In: F. Coulstan and F. Karte, Eds., Environmental Quality and Safety, Global Aspects of Chemistry, Toxicology and Technology Applied to the Environment. Vol. II 333 p.

70. Zimmerman, P.W. and Hitchcock, A.E., 1956 — Susceptibility of Plants to Hydrofluoric Acid and Sulphur Dioxide Gases, Contrib. Boyce Thompson Inst. 18 pp. 263 - 279.

71. Magee, R.A., F.B. Meserole and R.G. Oldham 1975 — Coal Fired Power Plant Trace Element Study; Vol. III, Station II, Radian Corporation; Prepared for EPA Region VIII by Radian Corporation Austin, Texas.

72. Runeckles, V.C. 1978 — Assessment of Impacts of Airborne Emissions on Vegetation; Proposed Hat Creek Project, B.C. Hydro and Power Authority; TERA Environmental Resource Analyst Ltd. Unpublished.

73. TERA Environmental Resource Analyst Ltd. and Canadian Bio Resources Consultants Ltd. 1978 — Physical Habitat and Range Vegetation Report : Impact Assessment. Unpublished

74. Bovey, E. 1968 — Air Pollution Proceedings of the First European Congress on the Influence of Air Pollution on Plants and Animals, Wageningen, Holland.

75. Nash, T.H. 1973 — The Effect of Air Pollution on other Plants, Particularly Vascular Plants, in Air Pollution and Lichens, B. W. Ferry, M. S. Bradeley and D.L. Hawksworth, eds. Athlone Press, University of London, London, England. pp 192-223.

76. Murtha, P.A., 1972 — A Guide to Air Photo Interpretation of Forest Damage in Canada. Forest Management Institute, Canadian Forest Service, Ottawa.

77. Murtha, P.A. 1978 — Interpretation of the 1977, Large Scale, Colour-Infrared Aerial Photographs for Tree Damage, Kitimat Valley, B.C., Alcan, Kitimat (unpublished report).

78. Krajina, V.J. 1959 — Bioclimatic Zones in British Columbia, University of B. C., Botanical Series 1:1-47.

79. Krajina, V. J. 1965 — Biogeoclimatic Zones in British Columbia, Ecology of Western North America, University of B.C., 1(1): 1-17.

80. Krajina, V. J. 1973 — Biogeoclimatic Subzones of British Columbia, B.C. Ecological Reserve Committee, Dept. of Lands, Forest and Water Resources, Victoria, B.C. (map)

81. Guderian, R, 1977 — Air Pollution, Springer-Verlag, Berlin.

82. McCune, D.C., 1969. — On the establishment of air quality criteria with reference to the effects of atmospheric fluorine on vegetation. Air quality monograph 69-3, Am. Petrol. Inst. New York.

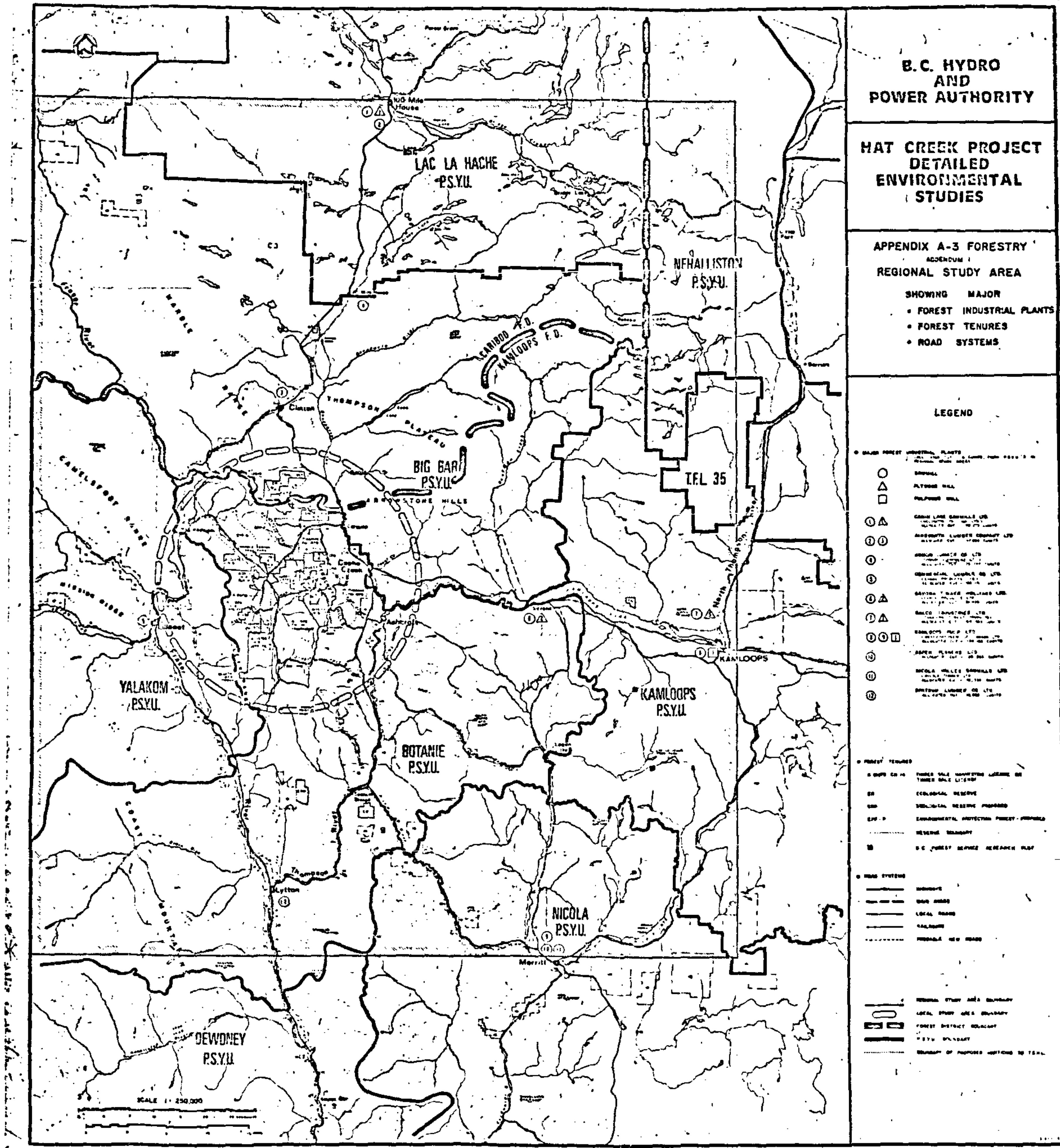
83. Vostal, J.J., ed., 1971 — Fluorides, Committee on Biological Effects of Atmospheric Pollutants, National Research Council, Washington, D.C.

84. Slankis, V. 1967 — Renewed Growth of Ecotropic Mycorrhizae as an indication of an unstable symbiotic relationship, XIV, proceedings of IUFRO Congress, Section 24, pp. 84-99.

ADDENDA

ADDENDUM 1

MAP OF THE REGIONAL STUDY AREA
1:250 000


B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT DETAILED ENVIRONMENTAL STUDIES
APPENDIX A-3 FORESTRY
REGIONAL STUDY AREA
SHOWING MAJOR
• FOREST INDUSTRIAL PLANTS
• FOREST TENURES
• ROAD SYSTEMS
LEGEND
LAC LA HACHE P.S.Y.U.
NEHALLISTON P.S.Y.U.
CARIBOO F.D.
KAMLOOPS F.D.
THOMPSON PLATEAU
BIG BAR P.S.Y.U.
T.F.L. 35
CAMELSFOOT RANGE
YALAKOM P.S.Y.U.
BOTANIE P.S.Y.U.
KAMLOOPS P.S.Y.U.
KAMLOOPS
NICOLA P.S.Y.U.
DEWDNEY P.S.Y.U.
100 Mile House
Clinton
Ashcroft
Lytton
Merritt
SCALE 1: 250,000

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Big Bar PSYU

Cariboo Forest District Portion

Timber Allocations as of January 15, 1977.

Licensee	Allocated Total Cut (Cunits)
Ainsworth Lumber Company Ltd. P.O. Box 67 100 Mile House, B.C.	50 000
Green Lake Forest Products Ltd. Pigeon Sawmill Ltd. 70 Mile House, B.C.	5 067
Komori Equipment Ltd. 765 West 39th Avenue Vancouver, B.C.	25 577
Pinette & Therrien Mills Ltd. R.R. #3, Glendale Drive Williams Lake, B.C.	17 827
Subtotal	98 471

Kamloops Forest District Portion

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Gateway Lumber Company Ltd. Box 127 Savona, B.C.	1 427
Savona Timber Holdings Ltd. Box 127 Savona, B.C.	41 013
Subtotal	42 440
TOTAL	140 911 or 399 011 m^3

Total AAC for Big Bar PSYU = 177 813 cunits:

Total Timber Allocations = 79% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Botanie PSYU

Kamloops Forest District

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Ainsworth Lumber Company Ltd. Box 67 100 Mile House, B.C.	9 000
Evans Products Ltd. Box 127 Savona, B.C.	18 793
B.C. Forest Products Ltd. 1050 West Pender Street Vancouver, B.C.	46 347
Komori Equipment Ltd. 765 West 39th Avenue Vancouver, B.C.	220
Pinette & Therrien Mills Ltd. R.R. #1 Glendale Drive Williams Lake, B.C.	587
Savona Timber Holdings Ltd. Box 127 Savona, B.C.	22 033
Weyerhaeuser Canada Ltd. Box 800 Kamloops, B.C.	17 413
TOTAL	114 393
or	323 921 m^3

Total AAC of Botanie PSYU = 144 370 cunits:

Total Timber Allocations = 79% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Kamloops PSYU

Kamloops Forest District

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Aspen Planers Ltd. Box 160 Merritt, B.C.	1 403
Balco Industries Ltd. R.R. #3 Kamloops, B.C.	60 583
Crown Zellerbach Canada Ltd. Box 220 Kelowna, B.C.	22 556
Weyerhaeuser Canada Ltd. Box 800 Kamloops, B.C.	27 170
TOTAL	111 712
or	316 329 m^3

Total AAC of Kamloops PSYU = 117 298 cunits:

Total Timber Allocations = 95% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Lac la Hache PSYU
Cariboo Forest District

Timber Allocations as of January 15, 1977.

Licensee	Allocated Total Cut (Cunits)
Ainsworth Lumber Company Ltd. (Clinton Complex) P.O. Box 67 100 Mile House, B.C.	21 000
Ainsworth Lumber Company Ltd. P.O. Box 67 100 Mile House, B.C.	67 893
Canim Lake Sawmills Ltd. P.O. Box 2179 Vancouver, B.C.	98 203
Cariboo Cedar Products Ltd. P.O. Box 39 100 Mile House, B.C.	1 000
Green Lake Forest Products Ltd. 70 Mile House, B.C.	3 973
TOTAL	192 069
	or 543 872 m^3

Total AAC of Lac la Hache PSYU = 337 036 cunits:

Total Timber Allocations = 57% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Nehalliston PSYU
Kamloops Forest District

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Fadear Creek Lumber Company Ltd. Box 520 Kamloops, B.C.	52 293
Gilbert Smith Forest Products Ltd. 585 Tunstall Crescent Kamloops, B.C.	1 447
McMillan Contractors Ltd. Box 40 Lone Butte, B.C.	9 460
Poucher Industrial Lumber Ltd. P.O. Box 86488 North Vancouver, B.C.	100
Rosen A.K. Box 12 Barriere, B.C.	10
Weyerhaeuser Canada Ltd. Box 800 Kamloops, B.C.	34 773
TOTAL	98 083
	or 277 737 m^3

Total AAC of Nehalliston PSYU = 120 341 cunits:

Total Timber Allocations = 81.5% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Nicola PSYU
Kamloops Forest District

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Aspen Planers Ltd. Box 160 Merritt, B.C.	24 860
Nicola Timber Ltd. & Nicola Valley Sawmills Box 39 Merritt, B.C.	46 334
Northwood Properties Ltd. 304 Martin Street Penticton, B.C.	1 600
Weyerhaeuser Canada Ltd. Box 800 Kamloops, B.C.	54 832
TOTAL	127 626
	or 361 392 m^3

Total AAC of Nicola PSYU = 137 359 cunits:

Total Timber Allocations = 93% of AAC.

ADDENDUM 2

LIST OF ESTABLISHED LICENSEES BY PSYU

Yalakom PSYU
Kamloops Forest District

Timber Allocations as of January 1, 1977.

Licensee	Allocated Total Cut (Cunits)
Commercial Lumber Company Ltd. Box 880 Lillooet, B.C.	165 771
Spatsum Lumber Company Ltd. Lytton, B.C.	10 000
N'Quatqua Logging Company Ltd. D'Arcy, B.C.	3 330
TOTAL	179 101
or	507 151 m^3

Total AAC of Yalakom PSYU = 231 751 cunits:

Total Timber Allocations = 77% of AAC.

ADDENDUM 3

AREA SUMMARIES BY SITE CLASSES AND FOREST TYPES FOR
PSYUs, TFL #35 AND ALIENATED LANDS WITHIN THE REGIONAL STUDY AREA

ADDENDUM 3

REGIONAL STUDY AREA

AREA SUMMARIES BY SITE CLASSES FOR PSYUs, TFL #35 AND ALIENATED LANDS WITHIN THE REGIONAL STUDY AREA

Tabular Values in 1 000 Acres

CROWN LANDS - PSYUs AND TFL #35

PSYU & TFL	SITE CLASSES				TOTAL 1 000 ac	TOTAL 1 000 ha
	GOOD	MEDIUM	POOR	LOW		
BIG BAR	35.9	422.0	702.2	28.4	1 188.5	481.0
BOTANIE	8.7	174.2	622.3	17.6	822.8	333.0
KAMLOOPS	30.6	174.5	197.6	5.4	408.1	165.2
LAC LA HACHE	53.0	270.0	158.0	5.2	486.2	196.8
NEHALLISTON	125.0	117.3	22.7	0.7	265.7	107.5
NICOLA	39.0	70.6	187.7	1.8	299.1	121.0
YALAKOM	15.9	118.0	244.9	17.7	396.5	160.5
SUBTOTAL PSYUs	308.1	1 346.6	2 135.6	76.6	3 866.9	1 565.0
TFL #35	35.5	34.2	3.3	0.1	73.1	29.6
TOTAL Ac	343.6	1 380.8	2 138.9	76.7	3 940.0	-
TOTAL ha	139.1	556.8	865.6	31.1	-	1 594.6

ALIENATED LANDS

PSYU & TFL	SITE CLASSES				TOTAL 1 000 ac	TOTAL 1 000 ha
	GOOD	MEDIUM	POOR	LOW		
BIG BAR	2.1	27.1	44.6	1.7	75.5	30.6
BOTANIE	0.4	10.2	39.0	1.1	50.7	20.5
KAMLOOPS	3.9	24.4	28.8	1.5	58.6	23.7
LAC LA HACHE	7.0	41.3	23.1	0.5	71.9	29.1
NEHALLISTON	0.7	0.7	0.1	-	1.5	0.6
NICOLA	6.0	6.7	28.7	0.1	41.5	16.8
YALAKOM	1.6	11.7	24.0	1.7	39.0	15.8
SUBTOTAL PSYUs	21.7	122.1	188.3	6.6	338.7	137.1
TFL #35	0	0	0	0	0	0
TOTAL Ac	21.7	122.1	188.3	6.6	338.7	-
TOTAL ha	8.8	49.4	76.2	2.7	-	137.1

TOTALS - CROWN AND ALIENATED

PSYU & TFL	SITE CLASSES				TOTAL 1 000 ac	TOTAL 1 000 ha
	GOOD	MEDIUM	POOR	LOW		
BIG BAR	38.0	449.1	746.8	30.1	1 264.0	511.6
BOTANIE	9.1	184.4	661.5	18.5	873.5	353.5
KAMLOOPS	34.5	198.9	226.4	6.9	466.7	188.9
LAC LA HACHE	60.0	311.3	181.1	5.7	558.1	225.9
NEHALLISTON	125.7	118.0	22.8	0.7	267.2	108.1
NICOLA	45.0	77.3	216.4	1.9	340.6	137.8
YALAKOM	17.5	129.7	268.9	19.4	435.5	176.3
SUBTOTAL PSYUs	329.8	1 668.7	2 323.9	83.2	4 205.6	1 702.1
TFL #35	35.5	34.2	3.3	0.1	73.1	29.6
TOTAL Ac	365.3	1 502.9	2 327.2	83.3	4 278.7	-
TOTAL ha	147.9	608.2	941.8	33.8	-	1 731.2

Rod. Collins

ADDENDUM 3

AREA SUMMARIES BY FOREST TYPES FOR PSYUs, TFL #35 AND ALIENATED LANDS WITHIN THE REGIONAL STUDY AREA

Tabular Values in 1 000 Acres

CROWN LANDS - PSYUs AND TFL #35

PSYU & TFL	FOREST TYPES					TOTAL 1 000 ac	TOTAL 1 000 ha
	MATURE	IMMATURE	RESIDUAL	NSR	NC		
BIG BAR	434.2	652.2	70.7	11.2	0.2	1 188.5	481.0
BOTANIE	507.4	257.6	25.4	31.8	0.6	822.8	333.0
KAMLOOPS	185.9	188.6	11.5	21.9	0.2	408.1	165.2
LAC LA HACHE	290.0	181.2	3.0	11.3	0.7	486.2	196.8
NEHALLISTON	152.8	109.2	0	0.1	3.6	265.7	107.5
NICOLA	147.3	128.2	7.8	15.4	0.4	299.1	121.0
TALAKON	192.1	189.5	0.3	14.3	0.3	396.5	160.5
SUBTOTAL PSYUs	1 929.7	1 706.5	118.7	106.0	6.0	3 866.9	1 565.0
TFL #35	32.7	33.1	-	3.8	3.5	73.1	29.6
TOTAL Ac	1 962.4	1 739.6	118.7	109.8	9.5	3 940.0	-
TOTAL ha	794.2	704.0	48.1	44.4	3.9	-	1 594.6

ALIENATED LANDS

PSYU & TFL	FOREST TYPES					TOTAL 1 000 ac	TOTAL 1 000 ha
	MATURE	IMMATURE	RESIDUAL	NSR	NC		
BIG BAR	29.9	37.7	7.2	0.7	0	75.5	30.6
BOTANIE	19.7	19.6	4.6	6.6	0.4	50.7	20.5
KAMLOOPS	15.7	29.2	11.4	2.3	0	58.6	23.7
LAC LA HACHE	28.7	39.9	1.8	1.2	0.3	71.9	29.1
NEHALLISTON	0.9	0.6	0	0	0	1.5	0.6
NICOLA	7.1	20.9	6.1	6.6	0.8	41.5	16.8
TALAKON	11.9	23.9	0.3	2.8	0.1	39.0	15.8
SUBTOTAL PSYUs	113.9	171.6	31.4	20.2	1.6	338.7	137.1
TFL #35	0	0	0	0	0	0	0
TOTAL Ac	113.9	171.6	31.4	20.2	1.6	338.7	-
TOTAL ha	46.1	69.5	12.7	8.2	0.6	-	137.1

TOTALS - CROWN AND ALIENATED

PSYU & TFL	FOREST TYPES					TOTAL 1 000 ac	TOTAL 1 000 ha
	MATURE	IMMATURE	RESIDUAL	NSR	NC		
BIG BAR	484.1	689.9	77.9	11.9	0.2	1 264.0	511.6
BOTANIE	527.1	277.0	30.0	38.4	1.0	873.5	353.5
KAMLOOPS	201.6	217.8	22.9	24.2	0.2	466.7	188.9
LAC LA HACHE	318.7	221.1	4.8	12.5	1.0	558.1	225.9
NEHALLISTON	153.7	109.8	0	0.1	3.6	267.2	108.1
NICOLA	154.4	149.1	13.9	22.0	1.2	340.6	137.8
TALAKON	204.0	213.4	0.6	17.1	0.4	435.5	176.3
SUBTOTAL PSYUs	2 043.6	1 878.1	150.1	126.2	7.6	4 205.6	1 702.1
TFL #35	32.7	33.1	0	3.8	3.5	73.1	29.6
TOTAL Ac	2 076.3	1 911.2	150.1	130.0	11.1	4 278.7	-
TOTAL ha	840.3	773.5	60.8	52.6	4.5	-	1 731.2

ADDENDUM 4

MATURE STANDING VOLUME BY SPECIES ON CROWN-OWNED PORTIONS OF PSYUs AND TFL #35 WITHIN THE REGIONAL STUDY AREA

ADDENDUM 4

REGIONAL STUDY AREA

MATURE STANDING VOLUME BY SPECIES ON CROWN-OWNED PORTIONS OF PSYUs AND TFL #35 WITHIN REGIONAL STUDY AREA

7.1"+ dbh (18 cm+) - Close Utilization less decay

Volume in 1 000 cunits with subtotals and totals converted to 1 000 cubic metres

PSYUs & TFL	CONIFER SPECIES												BROADLEAF SPECIES					ALL SPECIES	
	F	C	H	B	S	Pa	Pw	Pl	Py	L	Sub-Total 1 000 Cunits	Sub-Total 1 000 m^3	Cot	Bi	A	Sub-Total 1 000 Cunits	Sub-Total 1 000 m^3	Total 1 000 Cunits	Total 1 000 m^3
BIG BAR	4 249.9	0	0	35.9	234.1	0	3.5	2 046.0	196.8	0	6 766.2	19 159.5	4.0	7.0	20.5	31.5	89.2	6 797.7	19 248.7
BOTANIE	5 071.1	38.6	61.0	1 017.9	2 062.4	147.2	81.2	3 416.0	368.5	0	12 263.9	34 727.1	8.0	5.0	9.3	22.3	63.2	12 286.2	34 790.3
KAMLOOPS	1 356.3	0.1	0	126.0	657.2	0	0	1 490.4	84.7	0	3 944.7	11 170.0	0.7	2.4	35.4	38.5	109.0	3 983.2	11 279.0
LAC LA HACHE	1 162.7	8.2	6.7	76.6	387.2	0.9	0	4 226.9	0	0	5 869.2	16 619.5	3.5	16.8	201.8	222.1	628.9	6 091.3	17 248.4
NEHALLISTON	292.4	10.0	0	410.7	1 484.8	0	0	2 933.8	0	0	5 131.7	14 531.2	3.1	11.2	91.4	105.7	299.3	5 237.4	14 830.5
NICOLA	1 493.2	3.9	0.5	137.8	495.7	9.8	13.5	1 347.8	252.1	2.8	3 777.1	10 695.4	1.1	5.2	12.8	19.1	54.1	3 796.2	10 749.5
YALAKOM	2 540.0	2.6	5.6	506.3	1 408.3	0	192.9	1 144.6	199.1	0	6 007.4	17 010.9	2.7	0.7	0.8	4.2	11.9	6 011.6	17 022.8
TOTAL PSYUs Cunits	16 403.6	63.4	73.8	2 331.2	6 729.7	157.9	291.1	16 605.5	1 101.2	2.8	43 760.2	-	23.1	48.3	372.0	443.4	-	44 203.6	-
TOTAL PSYUs 1 000 m^3	46 449.3	179.5	209.0	6 601.1	19 056.2	447.1	824.3	47 021.0	3 118.2	7.9	-	123 913.6	65.4	136.8	1 053.4	-	1 255.6	-	125 169.2
TFL #35 1 000 Cunits	69.7	1.2	0	97.1	352.3	0	0	701.0	0	0	1 221.3	-	0	2.5	21.2	23.7	-	1 245.0	-
1 000 m^3	197.4	3.4	0	275.0	997.6	0	0	1 985.0	0	0	-	3 458.4	0	7.1	60.0	-	67.1	-	3 525.5

Source: BCFS data.

Anal. Tables

ADDENDUM 4

REGIONAL STUDY AREA

MATURE STANDING VOLUME BY SPECIES ON ALIENATED PORTIONS OF PSYUs WITHIN REGIONAL STUDY AREA

7.1"+ dbh (18 cm+) - Close Utilization less decay

Volume in 1 000 cunits with subtotals and totals converted to 1 000 cubic metres

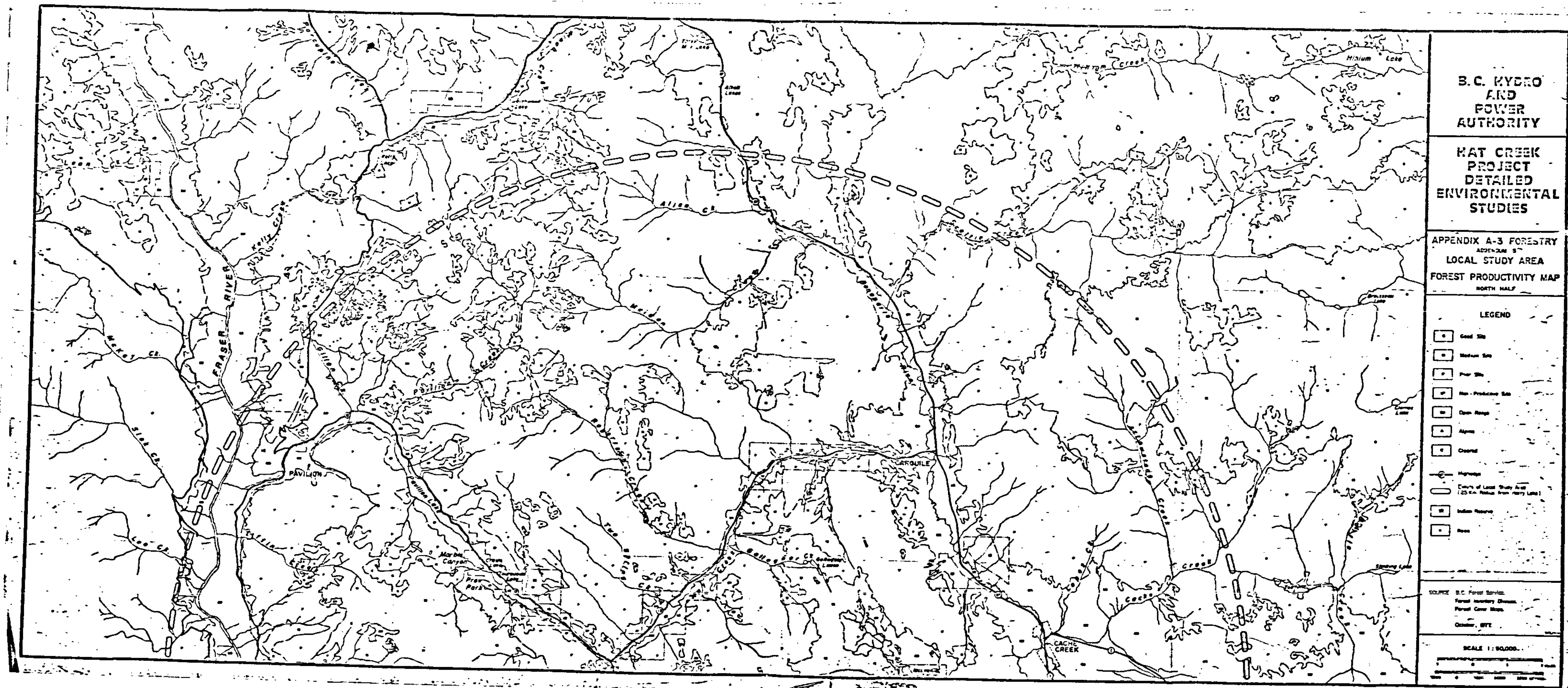
PSYU	CONIFER SPECIES												BROADLEAF SPECIES					ALL SPECIES	
	F	C	H	B	S	Pa	Pw	Pl	Py	L	Sub-Total 1 000 Cunits	Sub-Total 1 000 m³	Cot	Bt	A	Sub-Total 1 000 Cunits	Sub-Total 1 000 m³	Total 1 000 Cunits	Total 1 000 m³
BIG BAR	280.7	0	0	2.4	15.5	0	0.2	135.1	13.0	0	446.9	1 265.3	0.3	0.5	1.4	2.2	6.2	449.1	1 271.7
BOTANIE	196.8	1.5	2.4	39.5	80.0	5.7	3.2	132.5	14.3	0	475.9	1 347.6	0.3	0.2	0.4	0.9	2.5	476.8	1 350.1
KAMLOOPS	111.3	0	0	10.6	54.4	0	0	123.4	6.9	0	326.6	924.8	0	0.3	3.0	3.3	9.3	329.9	934.1
LAC LA HACHE	115.2	0.8	0.7	7.6	38.4	0	0	418.6	0	0	581.3	1 646.0	0.4	1.7	20.0	22.1	62.6	603.4	1 708.6
NEHALLISTON	1.7	0	0	2.4	8.8	0	0	17.3	0	0	30.2	85.5	0	0	0.6	0.6	1.7	30.8	87.2
NICOLA	72.3	0.2	0	7.6	24.0	0.5	0.7	65.3	12.2	0.3	182.8	517.6	0.1	0.3	0.6	1.0	2.8	183.8	520.4
YALAKOM	156.6	0.2	0.3	31.1	86.5	0	11.9	70.3	12.2	0	369.1	1 045.2	0.2	0	0	0.2	0.6	369.3	1 045.8
TOTAL 1 000 Cunits	934.6	2.7	3.4	101.2	307.6	6.2	16.0	962.4	58.6	0.1	2 412.8	-	1.3	3.0	26.0	30.3	-	2 443.1	-
TOTALS 1 000 m³	2 703.1	7.6	9.6	286.6	871.8	17.6	45.3	2 725.2	165.9	0.3	-	6 832.2	3.7	8.5	73.6	-	85.7	-	6 917.9

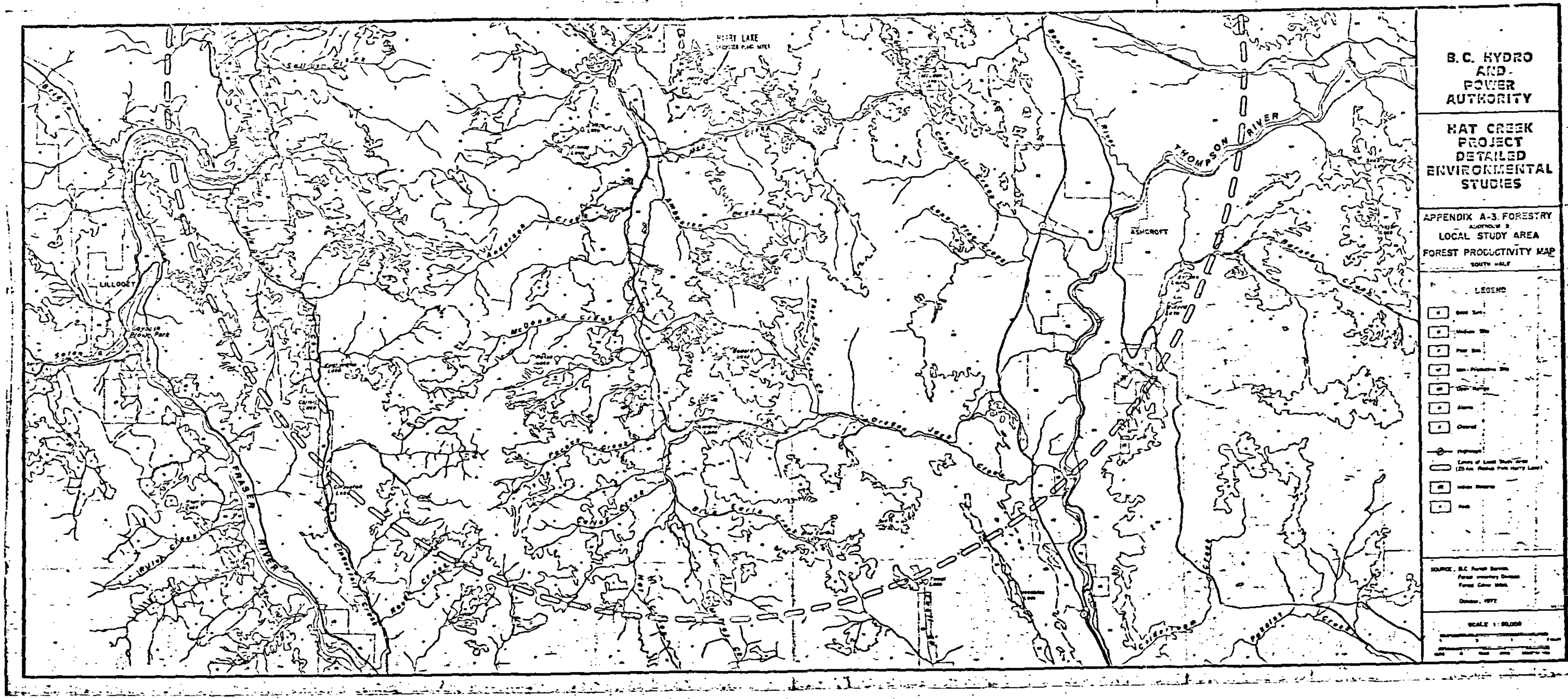
NOTE: No Alienated Volumes in portion of TFL #35 within Regional Study Area.

Source: BCFS data.

ADDENDUM 5

MAP OF THE LOCAL STUDY AREA
1:50 000


B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT DETAILED ENVIRONMENTAL STUDIES
APPENDIX A-3 FORESTRY
LOCAL STUDY AREA
FOREST PRODUCTIVITY MAP
NORTH HALF
LEGEND
Good Site
Medium Site
Poor Site
Non-Productive Site
Open Range
Alpine
Cleared
Highways
Indian Reserve
Hudson Creek
Kelly Creek
FRASER RIVER
PAVILION
Marble Canyon
CACHE CREEK
Hihium Lake
Cache Creek


B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT DETAILED ENVIRONMENTAL STUDIES
APPENDIX A-3. FORESTRY
LOCAL STUDY AREA
FOREST PRODUCTIVITY MAP
SOUTH HALF
LEGEND
HARRY LAKE
LILLOOET
ASHCROFT
THOMPSON RIVER
FRASER RIVER

ADDENDUM 6

PURPOSES OF ECOLOGICAL RESERVES

ADDENDUM 6

PURPOSES OF ECOLOGICAL RESERVES

Quoted from Ecological Reserves in British Columbia, 1976

" Basically the purpose of the Act is to reserve Crown Land for ecological purposes, including:

(a) areas suitable for scientific research and educational purposes associated with studies in productivity and other aspects of the natural environment.

(b) areas which are representative of natural ecosystems.

(c) areas that serve as examples of ecosystems that have been modified by man and that offer an opportunity to study the recovery of the natural ecosystem from such modification.

(d) areas in which rare or endangered native plants or animals may be preserved in their natural habitat.

(e) areas that contain unique and rare examples of botanical, zoological or geological phenomena.

Areas having potential for one or more of these purposes are proposed by members of the Ecological Reserves Committee, Naturalist Clubs and the concerned public. The proposals are screened through the Committee and relevant Government Departments to resolve any resource conflicts. Areas proposed for their scenic or recreational values are transferred to the Parks Branch.

Areas agreed upon by the Lieutenant-Governor in Council are subsequently published in the British Columbia Gazette. Protection from any activity which would disturb the natural balance is provided for under the Ecological Reserves Act.

While the Act stipulates that only Crown land may be made into an ecological reserve, funds are available for the Crown to purchase private property thereby allowing private lands to become a reserve.

Purposes of Ecological Reserves

1. *Permanent outdoor research laboratories, available to scientists once a permit is granted. Ecological reserves must be permanent to allow the continuity of research over decades or even centuries which is needed to unravel some of the basic ecological processes. Intensive short termed research is no alternative. We cannot predict the sort of questions that will be asked of our ecological reserves in 10 or 100 years.*

2. *Genetic banks - a nature museum function. As man continues to modify the surface of the earth species of plants and animals may become extinct before they are even known to science (mites and soil nematodes for example). Distinctive gene pools are an irreplaceable resource. Samples of both rare species and locally adapted common forms must be preserved.*

3. *Benchmark areas, against which man's modification of most of the province can be measured. Without such natural "control" areas it would be much more difficult to determine man's impact on the environment and how to lessen it.*

4. *Outdoor classroom of groups of students under permit to learn natural processes."*

ADDENDUM 7

ORIGINAL TERMS OF REFERENCE (A-3 and C-3)
JUNE 1976

ADDENDUM 7

ORIGINAL TERMS OF REFERENCE

APPENDIX A3
FORESTS

INVENTORY

1. Inventory and map species, site-index, watershed value, logging, and log reserves.

2. Give present Allowable Annual Cut and commitments.

3. Map existing forest road patterns and projected developments.

4. Describe relationships with soils, landforms, agriculture land reserves, wildlife, fisheries and grazing.

5. In conjunction with the Forest Research Division, establish and document permanent vegetation plots suitable for monitoring expected long term impacts upon tree species identified in Appendix A1.

6. Provide input to Appendix C3 Section 1.

EFFECT OF DEVELOPMENT

1. Identify sensitivity of forest tree components to project construction activity. Impacts should be quantitative, where possible, and related to construction and operation periods.

2. Assess impact of project on Allowable Annual Cut, grazing and other forest values.

3. Assess alternatives and recommend measures to avoid or minimize adverse impacts, enhance beneficial impacts and compensate for losses. Practical alternative proposals should include estimated costs.

APPENDIX C3
RESOURCE EVALUATION FOR PROVINCIAL, ENVIRONMENTAL AND REGIONAL ACCOUNTS

Power developments create positive and negative impacts on environmental systems. Some of these will be readily measured in monetary terms, for example, loss of agricultural production, and can be incorporated directly into the efficiency account. Others will not be amenable to monetary evaluation due to data or mensuration problems and will have to be evaluated in bio-physical terms. However, in all three accounts, resource impacts should be systematically identified.

The socio-economic consultant is required to evaluate all resources examined in the study. The methods for this evaluation are outlined below. For each resource, evaluation should be made for the case "with" and "without" the proposed development. Direction on the development of a methodology for this study will be given by the coordinating consultant. Input will be provided from study Appendices A2, A3, A4, A5, B1, B2 and E2.

1. FORESTRY

(a) Forests should be evaluated at the potential value of the timber harvested at its optimal harvest age, net of harvesting costs.

(b) The terms "Optimal Harvesting Age" and "Costs" are defined by present forest management and harvesting techniques as practiced by the B.C. Forest Service.

(c) Net present value should be calculated by using discount rates of 4, 6, 8, 10 and 12 percent.

ADDENDUM 8

FACILITY DESCRIPTIONS AND AREAS - DECEMBER 7, 1977
(Unchanged as of January 1, 1978)

December 7, 1977

Map Code	Facility	Affected Areas ha	Affected Areas Acres	Notes
P1	Fenced Power Plant Site	92.0	(227.3)	1
P2	Craft Parking Lot	1.1	(2.7)	
P3	Office Parking Lot	0.3	(0.7)	
P4	Make-up Water Reservoir & Dams	67.3	(166.3)	
P5	Make-up Water Pipeline & Pump Station			2*
P6	Wet Ash Disposal Ash Pond & Dam			
	4170' pond (mapped)	339.2	(838.2)	
	4200' pond (option)	489.6	(1209.8)	
	Area with drainage canals	660.7	(1632.6)	3
P7	Wet Ash Plan Slurry Lines and Pump Stations			2*
P8	Dry Ash Scheme I Fly Ash Dump	199.5	(493.0)	
P9	Dry Ash Scheme I Bottom Ash Dump	96.0	(237.2)	
P10	Dry Ash Scheme II Fly Ash Dump	113.0	(279.2)	
P11	Dry Ash Scheme II Bottom Ash Dump #1	16.4	(40.5)	
P12	Dry Ash Scheme II Bottom Ash Dump #2	101.1	(249.8)	
P13	Dry Ash Scheme II Ash Conveyance System			2*
OR1	Main Access Road (31 km by 30-100 m)	120.0	(296.5)	4
OR2	Power Plant Site Access Road (1.5 km by 30 m)	4.5	(11.1)	
OR3	Water Intake Station Access Road (0.25 km by m)			*
OR4	Pump Station I Access Road (0.53 km by m)			*
OR5	Pump Station II Access Road			2
OR6	Spoil Areas			2
OR7	Borrow Pits			2
OW1	Make-up Water Pipeline to Thompson R. (23 km by 17 m)	39.0	(96.4)	
OW2	Booster Pumping Station I (incl. 69 kV substation)	2.0	(5.0)	
OW3	Booster Pumping Station II	1.6	(4.0)	5
OW4	Water Intake Station			•
OW5	Substation II	0.03	(0.07)	5
OW6	Summit Surge Tank	0.02	(0.05)	
OW7	One-Way Surge Tank	0.02	(0.05)	
OW8	Drainage Pipeline (1.6 km)			*
OT1	69 kV trans. line to mine constr. substn. (1.2 km by 20 m)	2.4	(5.9)	
OT2	Twin 69 kV trans. line from mine to plant substn. (3.6 km by 30.5 m)	10.8	(26.7)	
OT3	69 kV trans. line from Rattlesnake A to pump substn. II (9.5 km by 20 m)	19.0	(47.0)	
OT4	69 kV trans. line from Rattlesnake A to pump substn. I (10.6 km by 20 m)	21.2	(52.4)	
OT5	69 kV trans. line loop-in (1.4 km by 20 m)	2.7	(6.7)	
OT6	500 kV trans. line			6
OT7	Rattlesnake substn.	3.2	(8.0)	

Map Code	Facility	Affected Areas ha.	Affected Areas Acres	Notes
M1	Open Pit #1, 600 ft. excavation	767.0	(1895.3)	
M2	Medicine Creek Dump	487.2	(1204.0)	
M3	North Valley Dump	48.0	(118.6)	
M4	Houth Meadow Dump	615.1	(152.0)	
M5	Lagoon 1	1.2	(3.0)	
M6	Lagoon 2	0.4	(1.0)	
M7	Lagoon 3	0.4	(1.0)	
M8	Lagoon 4	0.8	(2.0)	
M9	Lagoon 5			•
M10	Lagoon 6			•
M11	Topsoil Stockpile, Mine Entrance	22.8	(56.3)	
M12	Topsoil Stockpile, Landing Strip	61.8	(152.7)	
M13	Topsoil Stockpile, S. Medicine Creek	99.4	(245.6)	
M14	Coal Blending Area	29.5	(72.9)	
M15	Low Grade Coal Stocking Area	123.5	(305.2)	
M16	Temporary Topsoil Stockpile	59.1	(146.0)	
	(area outside of pit rim)	2.8	(6.9)	
M17	Conveyors			2
M18	Maintenance Buildings			12
M19	Mine and Waste Pile Drainage Ditches			2

Notes:

A Smaller facilities are not necessarily drawn to scale; area estimates are to be assumed as being accurate.

B Area estimates are derived from official engineering documents wherever possible.

C Areas of larger facilities were estimated or verified using planimetry.

D Documentation can be determined by prefix to map code. "P" or power plant facilities are described in a document entitled "B.C. Hydro and Power Authority, Hat Creek Project, Power Plant Description, Revision E" authored by INTEG-EBASCO and dated 1977-03-11.

"O" or offsite facilities are described in a document entitled "B.C. Hydro and Power Authority, Hat Creek Project, Project Description, Section 5, Offsite Facilities" authored by The Thermal Engineering Department of The Thermal Division of B.C. Hydro and Power Authority and dated 1977-09.

"C" or construction facilities are described in a document entitled "British Columbia Hydro, Hat Creek Project, Report on Single Status Construction Camps", authored by H.A. Simons (International) Ltd. and dated 1977-09.

"M" or mine facilities are described in a document entitled "Hat Creek Mining Project, Engineering Description for Environmental Report" by the Mining Department of The Thermal Division of B.C. Hydro and Power Authority, dated 1977-08.

Map Code	Facility	Affected Areas ha.	Affected Areas Acres	Notes
OD1	Headworks Reservoir and Dam	7.3	(18.0)	
OD2	Diversion Canal (including access roads) (7.0 km by 43 m)	30.1	(74.4)	7
OD3	Canal Discharge Conduit (2.1 km)			*
OD4	Pit Rim Reservoir and Dam	11.5	(28.4)	
OD5	Pipeline, Pit Rim Res. to Canal (0.6 km)			
OD6	Pump Stn. for OD5			
OD7	Site 2 Storage Reservoir & Dam	120.0	(296.5)	
OD8	Possible Pipeline from Canal to Make-up Res. (4.5 km)			
OD9	Finney Creek Diversion Canal			*
OD10	Medicine and Ambusten Cks. Canal Crossings			2
OA1	Airstrip, Site A (preferred)	25.4	(62.8)	
OA2	Airstrip, Site B (option, mapped)	22.1	(54.6)	
OA3	Airstrip, Site C (option, not mapped)	25.4	(62.8)	8
OA4	Airstrip Access Road, Site A (mapped)			
OA5	Airstrip Access Road, Site B (not mapped)			
OA6	Airstrip Access Road, Site C (not mapped)			8
OF1	Offloading Area (not mapped)	3.0	(7.5)	9
OF2	Railroad Spur (not mapped)			9
OF3	Access Road (not mapped)			9
CP1	Power Plant Construction Camp (P.P.C.C.) Housing & Parking (within P1)	13.2	(32.7)	10
CP2	Power Plant Construction Camp Sanitary Effl. Treatment Plant (within P1)	0.02	(0.05)	10
CP3	Power Plant Construction Camp Effluent Treatment Basin	0.06	(0.2)	13
CP4	Power Plant Construction Substation (within P1)	0.02	(0.05)	10
CP5	Power Plant Construction Camp Water Storage Res. (within P1)	0.06	(0.2)	10
CP6	Power Plant Construction Camp Water Supply Pipeline			
CM1	Mine Construction Camp Housing & Parking	5.1	(12.7)	
CM2	Mine Construction Camp Sanitary Effluent Treatment Plant	0.02	(0.06)	
CM3	Mine Construction Camp Sanitary Effluent Treatment Basin	0.07	(0.16)	
CM4	Mine Construction Substation	0.02	(0.06)	
CM5	Mine Construction Camp Water Storage Reservoir & Pumphouse	0.06	(0.15)	
CM6	Mine Construction Camp Water Supply & Pipeline (1.5 km)			11

Specific

1. Area within fence: includes switchyard, boilerhouse, precipitators, provision for scrubbers, short-term coal storage, construction camp and cooling towers. Configuration of mapped area may not be correct, but areal estimate is the latest figure available.

2. Engineering information currently insufficient to allow precise location of facilities or accurate estimation of affected area.

3. For worst case analysis, use this figure for area of ash pond.

4. Main access road is depicted differently in different documents. Some doubt exists regarding routing in the vicinity of the mine mouth. Right-of-way varies in width between 30 m and 100 m depending on side slope and the amount of cut-and-fill that will be necessary. Area estimate given by B.C. Hydro and Power Authority.

5. Pumping Station II is depicted at two different locations in the pipeline section and the 69 kV transmission line section of the Offsite Facilities report.

6. 500 kV line not depicted until clarification is received from B.C. Hydro and Power Authority regarding its location and how we are to deal with its impact.

7. Canal plus access road rights-of-way included in area estimate.

8. Site C is in the Semlin Valley.

9. Offloading facilities are still in the preliminary planning stages but could be located near Ashcroft, Kelly Lake, or Spences Bridge depending on the railroad involved.

10. Facility will eventually be within fenced power plant site.

11. An additional 1.8 km of pipeline exists within the boundaries of the full sized (600 ft. excavation) pit.

12. Maintenance buildings will probably be on or near the North Valley dump in the vicinity of the mine entrance.

13. Area given is for a man made basin. Map depicts Harry Lake which may be adversely affected by the discharge.

ADDENDUM 9

AREA SUMMARY OF PLANT, MINE AND OFFSITE FACILITIES BY COMPONENTS

AREA SUMMARY BY FACILITY COMPONENTS OF PLANT
AND WET ASH DISPOSAL: OPTION 1
(Metric and Imperial Units)

Facility		Area	
Map Code	Description	Hectares	Acres
P1	Fenced Power Plant Site	92.0	227.3
P2	Craft Parking Lot	1.1	2.7
P3	Office Parking Lot	0.3	0.7
P4	Make-up Water Reservoir	67.3	166.3
P5	Make-up Water Pipeline and Pump Station	Not Available	
P6	Wet Ash Disposal Basin and Canals	660.7	1 632.6
Sub-Total		821.4	2 029.6
Miscellaneous		87.3	215.6
TOTAL		908.7	2 245.2

AREA SUMMARY BY FACILITY COMPONENTS OF PLANT AND DRY ASH - SCHEME I: OPTION 2

(Metric and Imperial Units)

Facility		Area	
Map Code	Description	Hectares	Acres
P1	Fenced Power Plant Site	92.0	227.3
P2	Craft Parking Lot	1.1	2.7
P3	Office Parking Lot	0.3	0.7
P4	Make-up Water Reservoir	67.3	166.3
P5	Make-up Water Pipeline and Pump Station	Not Available	
P8	Fly Ash Dump	199.5	493.0
P9	Bottom Ash Dump	96.0	237.2
Sub-Total		456.2	1 127.2
Miscellaneous		83.5	206.3
TOTAL		539.7	1 333.5

AREA SUMMARY BY FACILITY COMPONENTS: PLANT AND DRY ASH DISPOSAL - SCHEME II: OPTION 3

(Metric and Imperial Units)

Facility		Area	
Map Code	Description	Hectares	Acres
P1	Fenced Power Plant Site	92.0	227.3
P2	Craft Parking Lot	1.1	2.7
P3	Office Parking Lot	0.3	0.7
P4	Make-up Water Reservoir	67.3	166.3
P5	Make-up Water Pipeline and Pump Station	Not Available	
P10	Fly Ash Dump	113.0	279.2
P11	Bottom Ash Dump #1	16.4	40.5
P12	Bottom Ash Dump #2	101.1	249.8
P13	Ash Conveyance Scheme	Not Available	
Sub Total		391.2	966.5
Miscellaneous		96.5	238.4
TOTAL		487.7	1 204.9

AREA SUMMARY OF MINE AND RELATED FACILITIES - BY COMPONENT PARTS

(Metric and Imperial Units)

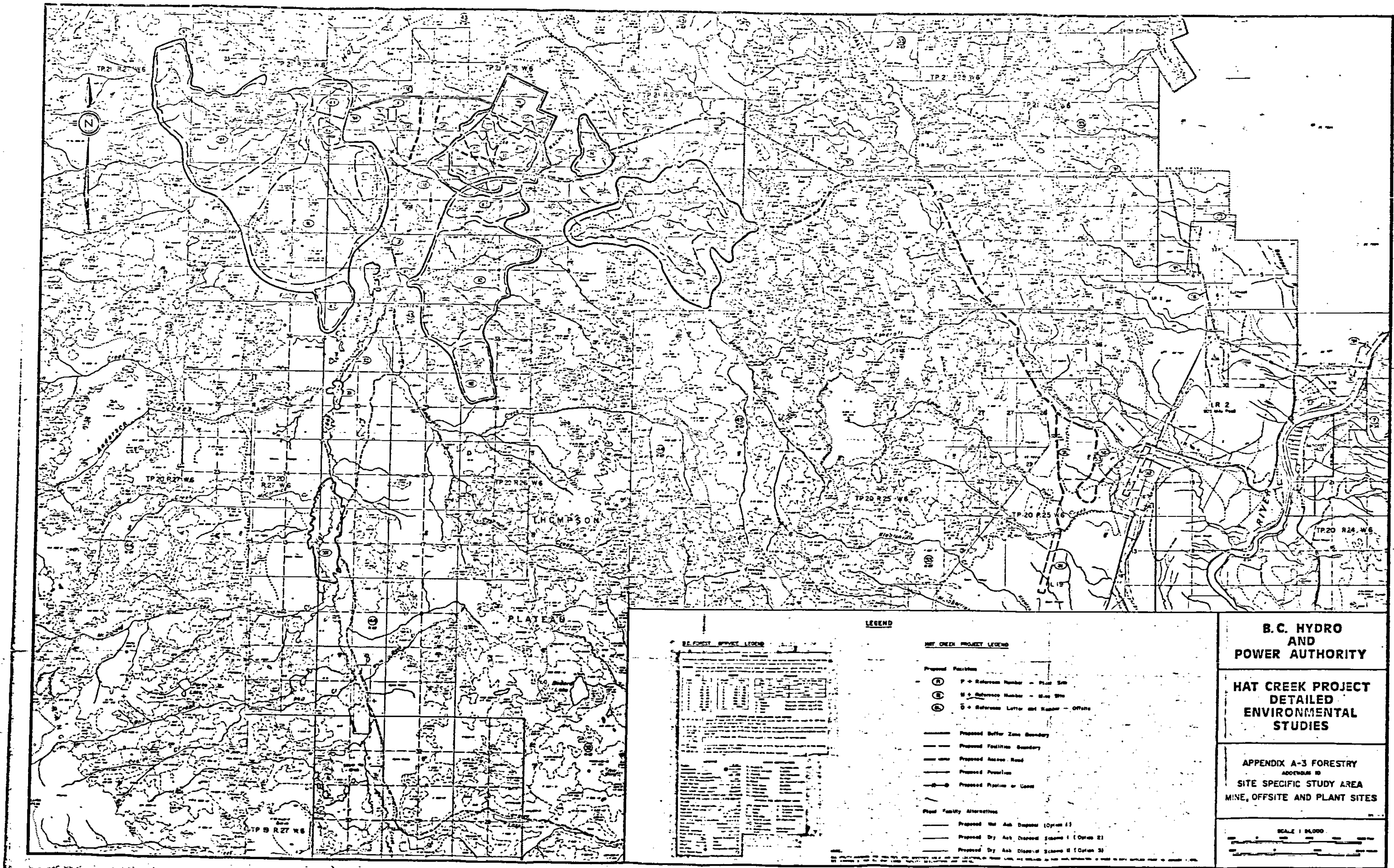
Facility		Area	
Map Code	Description	Hectares	Acres
M1	Open Pit #1; 600 ft. Excavation	767.0	1 895.3
M2	Medicine Creek Dump	487.2	1 204.0
M3	North Valley Dump	48.0	118.6
M4	South Meadow Dump	615.1	1 520.0
M5	Lagoon 1	1.2	3.0
M6	Lagoon 2	0.4	1.0
M7	Lagoon 3	0.4	1.0
M8	Lagoon 4	0.8	2.0
M9&M10	Lagoon 5 and 6 - Not available	Not	Available
M11	Top Soil Stockpile; Mine Entrance	22.8	56.3
M12	Top Soil Stockpile; Landing Strip	61.8	152.7
M13	Top soil Stockpile; South Medicine Creek	99.4	245.6
M14	Coal Blending Area	29.5	72.9
M15	Low Grade Coas Stocking Area	123.5	305.2
M16	Temporary Top soil Stockpile (area outside of Pit Rim Only)	2.8	6.9
M17,M18	Conveyors and Maintenance Buildings	Not	Available
M19	Mine and Waste Pile Drainage Ditches	Not	Available
Sub-Total		2 259.9	5 584.5
Miscellaneous		708.3	1 750.5
TOTAL		2 968.2	7 335.0

AREA SUMMARY OF OFFSITE
FACILITIES: BY COMPONENTS

Map Code	Facility Description	Area Hectare	Area Acres	Forestry Impact
OR1	Main Access Road (31 km x 30-100m)	120.0	296.5	Yes
OR2	Power Plant Access Road (1.5 km x 30m)	4.5	11.1	Yes
OR3-7		NOT AVAILABLE		?-No
OW1	Make-up Water Pipeline from Thompson R. (23 km x 17m)	39.0	96.4	Yes
OW2	Booster Pumping Station I	2.0	5.0	No
OW3	Booster Pumping Station II	1.6	4.0	Yes
OW5	Substation II	0.03	0.07	No
OW6	Summit Surge Tank	0.02	0.05	Yes
OW7	One-Way surge Tank	0.02	0.05	Yes
OW4&OW8		NOT AVAILABLE		No
OT1	69 KV T/L to Mine Constr. Substation (1.2 km x 20m)	2.4	5.9	Yes
OT2	2x69 KV T/L - Mine to Plant (3.6 km x 30.5m)	10.8	26.7	Yes
OT3	69 KV T/L from Rattlesnake A to Pump Station II (9.5 km x 20m)	19.0	47.0	No
OT4	As above but to Pump Station I (10.6 km x 20m)	21.2	52.4	No
OT5	69 KV T/L loop in (1.4 km x 20m)	2.7	6.7	No
OT6	500 KV T/L - Location Not Available	NOT AVAILABLE		Yes
OT7	Rattlesnake Substation	3.2	8.0	No
OD1	Headworks Reservoir and Dam	7.3	18.0	Yes
OD2	Diversion Canal (including access roads 70 km x 43m)	30.1	74.4	Yes
OD4	Pit Rim Reservoir and Dam	11.5	28.4	Yes
OD7	Site 2 Storage Reservoir and Dam	120.0	296.5	No
OD3; OD5; OD6; OD8; OD9; OD10;		NOT AVAILABLE		OD3 Yes OD6, & OD8-10 No
OA1	Airstrip, Site A	45.3	111.9	No
OA2	Airstrip, Site B			No
OA3-OA6		NOT AVAILABLE		OA4-Yes OA3,5&6?
OF1;OF2;OF3		NOT AVAILABLE		?
CP1;CP2;CP4;CP5 - Already included in P1(Plant Site)		NOT REQUIRED		No
CP3	Included in Schemes I and 2	NOT REQUIRED		No
CP6	Construction Camp Water Supply	NOT AVAILABLE		?
CM1	Mine Construction Camp Housing and Parking	5.1	12.7	Yes
CM2	Effluent Treatment Plant	0.02	0.06	Yes
CM3	Effluent Treatment Basin	0.07	0.16	Yes
CM4	Mine Construction Substation	0.02	0.06	Yes
CM5	Mine Construction Water Storage Reservoir and Pump House	0.06	0.15	Yes
CM6		NOT AVAILABLE		?
TOTAL		445.94	1 102.2	

ADDENDUM 10

MAP OF SITE SPECIFIC STUDY AREAS SHOWING
MINE, OFFSITE AND PLANT SITES
1:24 000


B.C. HYDRO
AND
POWER AUTHORITY
HAT CREEK PROJECT
DETAILED
ENVIRONMENTAL
STUDIES
APPENDIX A-3 FORESTRY
SITE SPECIFIC STUDY AREA
MINE, OFFSITE AND PLANT SITES
LEGEND
THOMPSON
PLATEAU
RIVER
TP 20 R 27 W6
TP 20 R 26 W6
TP 20 R 25 W6
TP 20 R 24 W6
TP 19 R 27 W6