BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Tera Environmental Resource Analyst Ltd and Canadian Bio-Resources Consultants Ltd. - Hat Creek Project - Detailed Environmental Studies - Physical Habitat and Range Vegetation Report - Volume II - Impact Assessment - January 1979.

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 16c

ERRATA

TABLE 5-21

PREDICTED ANNUAL AREA IMPACTED AND PERCENT INJURY
FOR THE 244 m/MCS AIR QUALITY MODEL FOR SO_2/NO_2 FOR
THE PLANT SPECIES WITH DAMAGE INFORMATION BY RECEPTOR SITE

PLANT SPECIES	ANNULAR SECTOR NUMBER (km^2/yr)	Total Area Affected % Injury Range
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Total Area Affected % Injury Range	[illegible]	[illegible]
Area Affected (km^2/yr) % Injury	[illegible]	[illegible]

3.0 / 1.9

1.0 / 6.4

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES
LAND RESOURCES SUBGROUP

PHYSICAL HABITAT AND RANGE VEGETATION REPORT

IMPACT ASSESSMENT

PREPARED BY
THE TERA ENVIRONMENTAL RESOURCE
ANALYST LIMITED

AND

CANADIAN BIO RESOURCES
CONSULTANTS LTD.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

5.0 RESOURCE IMPACT

5.1 PHYSICAL HABITAT AND RESOURCE PROJECTION WITHOUT THE PROJECT

(a) Summary of Anticipated Environmental Changes

The physical habitat refers to the climate, bedrock and surficial geology, and soils of the regional, local and site-specific study areas. These form the physical environment which supports the flora and fauna. Generally, the forces of climate (wind, water, ice and temperature) weather rocks to form unconsolidated surficial materials. Then, in combination with climate, the flora and fauna act to alter the surficial materials to form various soil types. This process of soil genesis is measured in "geologic time". Consequently, many decades are needed before noticeable changes are evident in the structure and chemical composition of the bedrock, surficial materials and soil. Overall climatic changes are long-term, with minor short-term climatic fluctuations having a relatively small influence on the overall weathering and soil genesis.

Probably of greater influence, at least in soil development, are land use practices such as agriculture, grazing, forestry and utility developments. These practices tend to alter the vegetation and drainage patterns as well as disturb the surface layers (agriculture). The addition of fertilizer would also alter the nutrient balance and affect the soil micro organisms in the soil. However, the effect of these land use practices is still mainly on the surface soils and relatively localized.

In summary, major changes in climate, bedrock and surficial geology, and soil are not expected over the life of the project. the soil may undergo minor, localized changes due to land use practices, but the extent, direction and speed of these changes are difficult to assess.

(i) Climate

No major climatic changes are anticipated. Minor climatic fluctuations in temperature and precipitation are common and will continue to be so.

(ii) Landforms

No alterations in landforms are expected because of the time scale necessary to complete such changes. Localized landslides and various land use practices may cause small scale changes on a site-specific basis.

(iii) Geology

No changes to geology are expected. Local mining for mineral resources may cause the only changes.

(iv) Soils

Little, if any alteration is anticipated in the soil resource for the case without the project. This conclusion is drawn from the fact that in general the soil resource is considered a reasonably stable parameter. Changes to the soil resource, apart from those attributed to physical disturbances or induced through severe alteration in the physical environment, are extremely slow and occur over "geologic" time periods. Physical disturbances anticipated in the case without the project are considered minor, attributable mainly to extended transportation corridors, cultivation of farm lands, and logging activities, all of which are of limited significance in terms of large scale alterations to the soil resource of the study area. Also, no major changes are anticipated in the physical environment of the region. Therefore, the net effect in terms of alterations to the soil resource for the case without the project is considered insignificant when viewed within the time frame for which this assessment has been evaluated.

5.2 PHYSICAL HABITAT AND RESOURCE PROJECTION WITH THE PROJECT

The most direct impact the proposed Hat Creek project would have on the physical habitat is the removal of habitat (direct loss). Except for climate which is a special case, landform, geology and soils would all be affected by direct removal. Climate, on the other hand, would not be altered by physical removal but may be affected by air emissions from the operation of the plant. No construction effects on climate are expected. Indirect sources of impact may be incurred from changes in the drainage conditions or the addition of toxic substances to the physical environment.

The project itself has been divided into four categories: preliminary site development, construction, operation and decommissioning, in order to assess the impact on the physical habitat.

Preliminary site development consists of those facilities and activities necessary to formulate definitive plans for development. Most of these activities have been completed.

Construction begins once the decision to proceed has been made. Construction primarily involves the installation of facilities necessary to begin electrical power generation. The mine must be excavated so that a reliable supply of coal can be obtained, ane the power plant and all ancillary offsite transport (of coal, waste, people, equipment, water and electrical energy) and storage facilities must be completed.

The mine begins with a small excavation and is gradually enlarged until the final pit specifications are met. In addition, large waste dumps are necessary to contain the waste rock and overburden generated during the excavation of the pit. Consequently, no clean division is present between construction and operation phases. Because of this, we have arbitrarily included 15 percent of the pit, the north valley waste dump, the coal blending area near the pit mouth, the temporary topsoil stockpile, and the shop and maintenance buildings in the list of facilities associated with the "construction" of the mine. The other mine facilities are arbitrarily considered to comprise the "operation" of the mine.

The operation phase constitutes the actual operation and maintenance of the previously installed facilities. This includes mine activities, plant operation and creation of an ash disposal dump.

Decommissioning is the process of phasing out coal production and electricity generation to other land uses. All reclamation and revegetation are included in this category.

In order to determine the impact of the above three categories, the facilities have been grouped into mine construction, plant construction and off-site facilities (associated only with the construction phase) and mine and plant operation associated facilities (Table 5-1). This method of analysis has not been used for the preliminary site development activities because of the lack of information or existence of previous reports.

Official project descriptions[19, 20, 21, 22] have been used to produce a list of project facilities (Table 5-1), and to produce a working map which shows the approximate size, location and configuration of each facility (Map 5-1). The alignment, precise location and configuration of all project facilities currently cannot be determined. However, in most instances, a diminutive change in location or alignment of a facility would have a negligible effect on the overall impact analysis.

(a) Preliminary Site Development

(i) Drilling Programme

The impact of the drilling programme is difficult to assess as very little information on the extent and location of these activities is available.

TABLE 5-1

LIST OF PROJECT FACILITIES

	Facility Code
a) Mine Construction Facilities	
Mine Construction Camp Housing and Parking	CM1
Mine Construction Camp Sanitary Effluent Treatment Plant	CM2
Mine Construction Camp Effluent Treatment Basin	CM3
Mine Construction Camp Substation	CM4
Mine Construction Camp Water Storage Reservoir	CM5
Mine Construction Camp Water Supply Pipeline	CM6
Open Pit #1, Initial Stages (assumed 15 percent)	M1
North Valley Waste Dump	M3
Coal Blending Area	M14
Temporary Topsoil Stockpile	M16
Conveyors	M17
Shop and Maintenance Buildings	M18
b) Plant Construction Facilities	
Power Plant Construction Camp Housing and Parking	CP1
Power Plant Construction Camp Sanitary Effluent Treatment Plant	CP2
Power Plant Construction Camp Effluent Treatment Plant	CP3
Power Plant Construction Substation	CP4
Power Plant Construction Camp Water Storage Reservoir	CP5
Power Plant Construction Camp Water Supply Pipeline	CP6
Power Plant Site, entire area within fence	P1
Craft Parking Lot	P2
Office Parking Lot	P3
Make-up Water Reservoir and Dams	P4
Water Pipeline between Reservoir and Power Plant	P5

c) Offsite Facilities (associated completely with the construction phase)	Facility Code
Headworks Reservoir and Dam	OD1
Hat Creek Diversion Canal	OD2
Hat Creek Diversion Canal Discharge Conduit	OD3
Pit Rim Reservoir and Dam	OD4
Pipeline, Pit Rim Reservoir to Diversion Canal	OD5
Site 2 Storage Reservoir and Dam	OD7
Possible Pipeline from Diversion Canal to Make-up Reservoir	OD8
Finney Creek Diversion Canal	OD9
Make-up Water Pipeline from Thompson River	OW1
Booster Pumping Station I	OW2
Booster Pumping Station II	OW3
Water Intake Station	OW4
Summit Surge Tank	OW6
One-way Surge Tank	OW7
Drainage Pipeline	OW8
69 kV Transmission Line to Construction Substation	OT1
Twin 69 kV Transmission Line between Construction Substations	OT2
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station II	OT3
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station I	OT4
69 kV Transmission Line Tie-in	OT5
Rattlesnake Substation	OT7
Airstrip, Site A	OA1
Airstrip, Site C	OA3
Airstrip Access Road, Site A	OA4
Airstrip Access Road, Site C	OA6
Offloading Area	OF1
Offloading Railroad Spur	OF2
Offloading Access Road	OF3
Main Access Road	OR1

	Facility Code
c) Offsite Facilities (Continued)	
Power Plant Site Access Road	OR2
Water Intake Station Access Road	OR3
Booster Pumping Station I Access Road	OR4
Booster Pumping Station II Access Road	OR5
Spoil Areas	OR6
Borrow Pits	OR7
d) Mine Operation Facilities	
Open Pit #1, to 600 ft. Excavation	M1
Medicine Creek Waste Dump	M2
Houth Meadow Waste Dump	M4
Lagoon 1	M5
Lagoon 2	M6
Lagoon 3	M7
Lagoon 4	M8
Lagoon 5	M9
Lagoon 6	M10
Topsoil Stockpile, Mine Entrance	M11
Topsoil Stockpile, Landing Strip	M12
Topsoil Stockpile, South Medicine Creek	M13
Low Grade Coal Stocking Area	M15
Drainage Ditches	M19
e) Plant Operation Facilities (Ash Disposal Options)	
Wet Ash Disposal Scheme Ash Pond and Dam	P6
Wet Ash Disposal Scheme Ash Conveyance System	P7
Wet Ash Disposal Scheme Alternative Bottom Ash Dump	P7.5
Dry Ash Disposal Scheme I, Ash Dumps	P8, P9
Dry Ash Disposal Scheme II, Ash Dumps	P10, P11, P12

Field observations have been the major source of information used for this assessment.

While the actual drilling sites were small (10 to 15 m or 33 to 50 ft.) in diameter the degree of disturbance associated with an individual site was found to be extremely variable. The major contribution to disturbance by this programme is associated with site access and the construction of water holding ponds required for the drilling programme. Where reclamation procedures appeared to have been implemented, reestablishment of the previous natural environment appeared satisfactory. In other areas, particularly in the lower grasslands where reclamation procedures appeared neglected, there was little evidence of the reestablishment of vegetation cover with the resulting hazard of soil loss due to wind erosion. The extent of the drilling programme, and the overall attention paid to reestablishment of vegetation cover of the disturbed areas would largely determine the impact of this activity on the soil resource and, thus, other resource uses based on the vegetative growth potential of the soil media associated with these areas. From the limited field information gathered, it would seem that apart from those areas in the direct vicinity of the proposed mining operation, where the drilling programme was probably most extensive, the impacts from this activity would be minor and generally temporary in nature.

Besides the minor impact on soils described above, no impact is expected on climate, bedrock and surficial geology.

(ii) Bulk Sampling Programme

The expected impact of the bulk sampling programme on the physical habitat was previously submitted (June 27, 1977)[23]. This analysis illustrated that the soils would receive the greatest impact, although relatively minor.

Soil conditions can vary from moderately uniform to highly heterogeneous within a given location. The topsoil, as characteristic of a majority of the soils, is mainly very shallow due in part to the often compact nature of the parent materials and also due to a very droughty climatic condition which restricts chemical weathering within these soil materials. In general, however, apart from areas directly alienated by the bulk sampling programme, minimal impacts were perceived on the soil resource and these would generally be of a temporary nature provided reclamation procedures were initiated.

Areas of direct alienation due to the bulk sampling programme include: two excavation trenches; associated waste piles and topsoil storage areas; coal waste areas; revegetation test plots and road access corridors. The land that had been projected[23] as being alienated as a result of the programme consisted of 38 ha (94 acres) lying within the Agricultural Land Reserve and used primarily for livestock grazing. Although all alienated land areas have been mapped and described by the Modified Soil Series mapping of the site-specific study area a precise inventory of the areal extent for the soil units affected by these activities was unavailable due to a lack of information outlining the exact positioning of these activities.

During the bulk sampling programme it was found that many of the soils disturbed by this programme were subject to severe dusting problems and required special preventative procedures to help minimize the undesirable effects created as a result of this problem. Most of the areas affected were found to have extremely shallow topsoils that would be considered impractical to strip and save for reclamation. Also many of the subsoil materials are strongly calcareous and exhibit layers of free carbonate and salt accumulations that, unless leached from the root zone, are very restricting to plant growth.

As the bulk sampling programme was located within those areas directly alienated by the mine construction or operation, their significance in terms of environmental impact need only be evaluated for the case in which the project would not proceed.

The actual impact of the programme has been reported in a preliminary report by B.C. Hydro and Power Authority[24]. This report indicates that the actual effects on the physical habitat appears to be confined to the trench areas and no changes in air (dusting) and water quality have been noted to date. However, problems such as erosion and problems in reestablishment of vegetation may still occur.

The B.C. Hydro and Power Authority report[24] summarizes the environmental impacts as follows:

> *"Environmentally, results to date have been consistent in confirming that environmental impacts have been restricted to the immediate areas of the trenches and related (waste and coal storage) areas. There have been no project-related alterations to air or water (Hat Creek) quality. Noise has in no way been a major issue with the local residents almost unaware of the mining activities. Dusting from the trench workings proved to be a local, operational problem. Initial results would indicate no increase in ambient suspended particulate which could be attributed to this program. The transportation phase proceeded almost unnoticed by local residents; truck covers were effective in eliminating dust problems."*

(b) Construction

(i) Environmental Changes

The assessment of the effects of construction on the physical habitat has been approached two-fold: qualitatively and quantitatively. Both approaches will be utilized for the site-specific study area. Climate has not been considered affected during the construction phase and, therefore, has not been evaluated. Landform and geology have not been directly evaluated since they are important components from which the soil is derived and used extensively to identify, describe and map the soil types. Therefore, the detailed soil impact assessment presented below will indirectly assess the impact on landform and geology. In addition, the Minerals and Petroleum Report[13] by Dr. P.T. McCullough of B.C. Hydro and Power Authority evaluated many of the geological aspects of the Hat Creek project.

A. Qualitative Assessment

This assessment includes an evaluation of certain soil-related parameters to gauge the significance of the effects of construction activities on the soil resource and, thus, provide an indication of the sensitivity of soils to disturbance. The soil parameters addressed in this evaluation include: susceptibility to erosion; susceptibility to dusting; suitability for topsoil reclamation; and susceptibility to alkalinity-salinity problems relating to reestablishment of vegetation. The base soils information used for this assessment is the soil survey work carried out and reported for the site-specific study area.

In assigning a qualitative sensitivity of the erosion susceptibility to a particular soil unit it is necessary to evaluate such soil characteristics as texture and consistency of the parent soil materials, depth and texture of the topsoil or zone of soil development, slopes, and the physiographic nature of the soil unit in general. Each of these characteristics have been weighted subjectively as to their influence on the characteristics to soil erosion and combined to establish an overall rating of the sensitivity to erosion for a given soil unit. Four sensitivity categories have been established: low, moderate, high and severe. For example, a silty lacustrine material on a greater than 15 percent slope would be classed as having a severe sensitivity to erosion, while a similarly textured till deposit on even a greater slope would be classed as having only a moderate sensitivity to erosion.

In assigning a qualitative sensitivity of the susceptibility to dusting of a particular soil unit, soil characteristics such as texture and depth of the topsoil materials, extent of free carbonate enrichment and salt accumulation within the profile, and texture and consistency of the parent materials, have been evaluated. Each of these characteristics have been weighted as to their influence on the susceptibility to soil dusting and combined to establish an overall sensitivity to dusting for a given soil unit. This sensitivity has also been evaluated in terms of four categories, these being low, moderate, high or severe. For example, a fine-textured soil material in a dry climatic environment has a high dusting sensitivity. This can be further accentuated by the presence of excessive amounts of free carbonate which often leave soil particles in a disturbed rather than aggregated state and thus more susceptible to dusting effects. Generally, the deeper less compacted materials such as lacustrine and alluvial colluvial deposits are most susceptible while till and well washed outwash materials have much lower susceptibility.

In assigning a qualitative sensitivity of soil susceptibility to alkalinity-salinity problems relating to the reestablishment of vegetation, the following soil characteristics have been considered: the depth at which free carbonates are evident in the soil profile; the presence of salts in the soil profile; the existence of poor drainage conditions; and the extent of the zone in which the salts or free carbonates exist. Soil material with excessive amounts of carbonates or salts serve as poor plant growth media because of their toxicity to plant species. Four sensitivity categories have been established to describe this soil characteristic: low (1), moderate (2), high (3) and severe (4).

The four types of sensitivity classifications have been combined to give sensitivity ratings for each soil type mapped for the site-specific study area.

In assigning a qualitative rating of the suitability of a soil unit for topsoil reclamation, the following soil criteria have been evaluated: depth of topsoil above the zone of salt and carbonate enrichment, extent of the zone of salt and carbonate enrichment in the soil profile, depth of water table, degree of stoniness, depth of soil above bedrock, and texture of topsoil materials. Soils have been classed into the following four suitability categories: good moderate, limited, and of no suitability for reclamation. Numerically, a four (4) rating has been applied to soils having good potential for reclamation (least sensitive to disturbance), while a one (1) rating has been applied to soils with no reclamation potential.

Table 5-2 presents the results of the qualitative soil assessment in terms of an overall sensitivity to potential project disturbance and individual sensitivities relating to the following soil-related parameters: susceptibility to erosion; susceptibility to dusting; suitability for topsoil reclamation; and susceptibility to alkalinity-salinity problems relating to reestablishment of vegetation. Sensitivities are reported for each of the 86 individual soil types mapped for the site-specific study area. Of these, 20 have been assessed to have a high (H) overall sensitivity to disturbance.

Soils that are highly susceptible to erosion have been identified in the upper Hat Creek lowlands and adjacent to the Thompson River in the vicinity of Ashcroft. These soils contain a high percentage of silts in the upper horizons and in some instances a loess capping is present.

Nearly all of the soils within the site-specific study area are moderately to highly susceptible to dusting. Soils with a low susceptibility to dusting are located in the north end of the upper Hat Creek Valley adjacent to Hat Creek and at the south end of the upper Hat Creek Valley near the confluence of Oregon Jack Creek and Hat Creek. Scattered pockets of soil with low susceptibility to dusting are also located in the Medicine Creek watershed, on the upper Cornwall Creek watershed and adjacent to the Thompson River in the vicinity of Ashcroft.

The soils, within the upper Hat Creek area, are generally all highly susceptible to alkalinity-salinity problems while the soils within the Medicine Creek and Cornwall Creek watershed generally have only low susceptibility to these problems.

TABLE 5-2

SOIL SENSITIVITY
SITE-SPECIFIC STUDY AREA

Soil Unit	Susceptibility to Erosion (1 - 4)	Susceptibility to Dusting (1 - 4)	Susceptibility to Alkalinity-Salinity Problems (1 - 4)	Total (3 - 12)	Overall Soil Sensitivity Rating	Suitability of Topsoil to Reclamation Procedures (1 - 4)
1	2	3	3	8	M	4
2	2	3	3	8	M	4
3	2	3	3	8	M	3
4	2	2	3	7	M	3
5	2	3	3	8	M	4
6A	2	3	3	8	M	4
6B	2.5	2.5	4	9	H	2
7	2	3	3	8	M	4
8	1.5	2	3	6.5	L	2
9	2	3	3	8	M	3
10	2	3	4	9	H	3
11	1.5	2	3	6.5	L	2
12	1	3	3	7	M	3
13	2	3	4	9	H	4
14	2	3	4	9	H	3
15	1.5	3	3	7.5	M	3
16	1.5	3	3	7.5	M	3
17	2	4	3	9	H	2
18	2	3	2	7	M	4
19	2.5	3.5	3	9	H	3
20A	3	4	4	11	H	1
20B	3	4	4	11	H	1
20C	3	4	4	11	H	3
20D	4	4	4	12	H	3
20E	3	4	4	11	H	3
21	2	4	3	9	H	3
22	2	4	3	9	H	3
23	2	3.5	3	8.5	M	4
24	1.5	3	3	7.5	M	2
25	2	3	4	9	H	2
26	2	3	3	8	M	2
27	2	3.5	3	8.5	M	4
28	2	3	3	8	M	2
29	1.5	3.5	4	9	H	2
30	2	4	4	10	H	4
31	1.5	3	4	8.5	M*	2
32	1	3.5	3	7.5	M	1
33	2.5	2.5	3	8	M	3
34	1	3	4	8	M*	1

TABLE 5-2 (Continued)

Soil Unit	Susceptibility to Erosion (1 - 4)	Susceptibility to Dusting (1 - 4)	Susceptibility to Alkalinity-Salinity Problems (1 - 4)	Total (3 - 12)	Overall Soil Sensitivity Rating	Suitability of Topsoil to Reclamation Procedures (1 - 4)
35	1.5	3	3	7.5	M	3
36	1.5	3	3	7.5	M	3
37	2	3	2	7	M	3
38	2	3	2	7	M	3
39	3	2.5	3	8.5	M	3
40	2	3	2	7	M	4
41	2	3	3	8	M	3
42	2.5	2.5	2	7	M	2
43	2	2.5	1	5.5	L	3
44	2	2.5	1	5.5	L	3
45	2	2.5	2	6.5	L	3
46	2	2.5	2	6.5	L	3
47	2.5	2	2	6.5	L	2
48	2.5	2	2	6.5	L	2
49	2	3	2	7	M	3
50	1	3	2	6	L	3
51	2	3	3	8	M	3
52	2	2.5	3	7.5	M	2
53	2	3.5	3	8.5	M	4
54	2	3	2	7	M	1
55	2	3.5	4	9.5	H	3
56	2	3	3	8	M	4
57	2	3.5	4	9.5	H	3
58	1	3.5	3	7.5	M	1
59	1	3	4	8	M*	3
60	2	2.5	3	7.5	M	3
61	2	3	3	8	M	3
62	2	2.5	3	7.5	M	3
63	2.5	3	4	9.5	H	3
64	2	3	4	9	H	3
AY	1	2	1	4	L	3
BS	1	1.5	4	6.5	L*	2
BE	2	3	3	8	M	4
BN	2	3.5	2	7.5	M	4
CC	1.5	3	4	8.5	M	3
CR	1	3	2	6	L	4
CT	3	2.5	4	9.5	H	3
JS	1.5	2.5	3	7	M	3
MA	2.5	4	2	8.5	M*	4+
NE	2.5	3	2	7.5	M	4
SV	2	1.5	2	5.5	L	3
SE	2	3	3	8	M	3
TL	3	2.5	3	8.5	M	3
TN	1	1	4	6	L*	2
WA	1.5	3	2	6.5	L	3
VS	1.5	3.5	3	8	M	4
RO	1	1	1	3	L	1

Overall Sensitivity Code: 3 - 6.5 Low Sensitivity; 7.0 - 8.5 Moderate Sensitivity; 9.0 - 12 High Sensitivity

Code for Suitability for Reclamation: 4 - High Suitability; 2.0 - 3.0 Moderate Sensitivity; 1.0 Low Sensitivity

* Refers to units that have moderate or low overall sensitivity rating but are highly sensitive to a specific soil parameter

Soils with high suitability for topsoil reclamation are located mainly in the upper Hat Creek lowlands with some areas also present in the lowlands of the Medicine Creek watershed and in the Trachyte Hills near Harry Lake. There are also areas adjacent to Highway 1 that are highly suitable for topsoil reclamation.

B. Direct Loss

The alienation (direct loss/disturbance) of soils by project construction activities has been determined by superimposing a plan of these activities (at an approximate scale of 1:24,000) over the soils map for the site-specific study area. The alienated areas have been measured and reported in terms of soil type and whether the activity was associated with the mine, plant or offsites. A further breakdown is supplied on the basis of the major facilities for each of these project activities. The activities considered in the construction phase are given in Table 5-3.

The direct alienation of soils by project construction (base scheme) are reported in Table 5-3 and by offsite facilities (alternate schemes) in Table 5-4. A total of 728 ha (1798 acres) of land would be alienated by the base scheme activities, 205 ha (506 acres) attributable to mine construction, 199 ha (492 acres) to plant construction, and 324 ha (800 acres) to offsite construction.

Mine

The areal extent of the soil units that would be alienated during the construction phase of mine development are shown in Table 5-3. This table includes the areal extent of the soils that would be alienated for the initial stages of open pit #1 (M1) and the north valley waste dump (M3). The total areal extent of soils alienated by these two facility activities are 115 and 30 ha (284 and 74 acres), respectively. The soil units highly affected by the open pit #1 (M1) facility would be numbers 17 (19.8 ha or 49 acres lost), 19 (15.1 ha or 37 acres lost), 200 (10.2 ha or 25 acres lost), and 62 (13.9 ha

TABLE 5-3

DIRECT ALIENATION FROM CONSTRUCTION - BASE SCHEME (AREAS IN HECTARES)

Soil Unit	Mine				Plant				Offsites					Total
	M1	M3	Other	Total	P1	P4	Other	Total	OR1	OA1	OA4	Other	Total	
3	-	-	-	-	-	-	-	-	-	-	-	6.9	6.9	6.9
4	5.9	15.4	5.6	26.9	-	-	-	-	-	-	-	11.5	11.5	38.4
6A	7.4	9.3	22.0	38.7	-	-	-	-	3.2	-	-	4.8	8.0	46.7
6B	6.1	-	-	6.1	-	-	-	-	-	-	-	-	-	6.1
7	-	4.9	1.6	6.5	-	-	-	-	-	-	-	0.4	0.4	6.9
14	-	-	-	-	-	-	-	-	-	-	-	8.5	8.5	8.5
15	1.3	-	-	1.3	-	-	-	-	-	4.8	0.8	0.1	5.7	7.0
17	19.8	-	-	19.8	-	-	-	-	-	-	-	6.5	6.5	26.3
18	8.9	0.1	16.4	25.4	-	-	0.8	0.8	-	-	-	9.5	9.5	35.7
19	15.1	-	25.8	40.9	-	-	-	-	2.4	-	-	12.5	14.9	55.8
20A	1.2	-	-	1.2	-	-	-	-	5.7	-	-	-	5.7	6.9
20B	1.2	-	-	1.2	-	-	-	-	-	-	-	-	-	1.2
20C	2.5	-	-	2.5	-	-	-	-	-	-	-	-	-	2.5
20D	10.2	-	-	10.2	-	-	-	-	-	-	-	-	-	10.2
20E	3.5	-	-	3.5	-	-	-	-	-	-	-	-	-	3.5
21	8.6	-	-	8.6	-	-	-	-	-	-	-	-	-	8.6
22	-	-	-	-	-	-	-	-	-	-	-	0.4	0.4	0.4
24	-	-	-	-	-	-	-	-	-	-	0.8	-	0.8	0.8
25	-	-	-	-	-	-	-	-	3.6	13.8	2.1	3.1	22.6	22.6
27	-	-	-	-	-	-	-	-	-	16.2	0.8	-	17.0	17.0
29	-	-	-	-	-	-	-	-	0.4	-	-	0.8	1.2	1.2
30	-	-	-	-	-	-	-	-	0.4	-	-	-	0.4	0.4
31	-	-	-	-	1.6	-	-	1.6	2.4	-	-	3.3	5.7	7.3
32	-	-	-	-	-	-	-	-	-	2.0	-	-	2.0	2.0
34	-	-	1.2	1.2	-	-	0.2	0.2	2.8	-	-	4.1	6.9	8.3
35	-	-	0.4	0.4	-	-	-	-	-	-	-	-	-	0.4
36	-	-	0.4	0.4	-	-	-	-	6.2	-	-	4.2	10.4	10.8
37	-	-	10.7	10.7	-	-	1.2	1.2	5.7	-	-	1.6	7.3	19.2
38	-	-	-	-	-	2.0	0.2	2.2	16.2	-	-	10.7	26.9	29.1
39	-	-	-	-	-	-	-	-	5.3	-	-	-	5.3	5.3
40	-	-	-	-	-	-	-	-	1.2	-	-	-	1.2	1.2
41	-	-	-	-	5.7	5.2	-	10.9	-	-	-	0.4	0.4	11.3
42	-	-	-	-	-	8.9	-	8.9	2.8	-	-	-	2.8	11.7
43	-	-	-	-	-	-	-	-	9.1	-	-	-	9.1	9.1
45	-	-	-	-	-	-	-	-	4.5	-	-	-	4.5	4.5
47	-	-	-	-	-	-	-	-	15.0	-	-	3.6	18.6	18.6
48	-	-	-	-	-	-	-	-	1.2	-	-	-	1.2	1.2
49	-	-	-	-	-	1.2	-	1.2	-	-	-	1.2	1.2	2.4
50	-	-	-	-	-	7.7	-	7.7	2.4	-	-	2.5	4.9	12.6
51	5.8	-	4.0	9.8	8.0	1.6	1.5	11.1	7.3	-	-	2.4	9.7	30.6
52	-	-	-	-	-	-	-	-	1.6	-	-	-	1.6	1.6
54	-	-	-	-	6.5	40.4	2.2	49.1	2.4	-	-	6.5	8.9	58.0
56	-	-	-	-	-	-	-	-	5.7	-	-	-	5.7	5.7
57	-	-	-	-	-	-	-	-	-	-	-	5.7	5.7	5.7
58	-	-	1.2	1.2	66.1	0.3	2.2	68.6	-	-	-	0.4	0.4	70.2
59	-	-	-	-	-	-	-	-	0.8	-	-	-	0.8	0.8
60	-	-	1.2	1.2	3.2	-	1.1	4.3	-	-	-	0.4	0.4	5.9
6	-	-	-	-	-	-	-	-	2.8	-	-	-	2.8	2.8
62	13.9	-	-	13.9	-	-	-	-	-	-	-	-	-	13.9
A'	-	-	-	-	-	-	-	-	-	-	-	4.5	4.5	4.5
BL	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8	0.8
BH	-	-	-	-	-	-	-	-	-	-	-	1.6	1.6	1.6
CH	-	-	-	-	-	-	-	-	-	-	-	0.4	0.4	0.4
C''	-	-	-	-	-	-	-	-	-	-	-	8.2	8.2	8.2
JS	-	-	-	-	-	-	-	-	-	-	-	5.2	5.2	5.2
TI	-	-	-	-	-	-	-	-	8.5	-	-	7.2	15.7	15.7
TH	-	-	-	-	-	-	-	-	0.4	-	-	0.8	1.2	1.2
RO	-	-	-	-	-	-	-	-	-	-	-	1.6	1.6	1.6
B	-	-	-	-	-	-	-	-	-	-	-	4.9	4.9	4.9
SV	-	-	-	-	-	-	-	-	-	-	-	0.4	0.4	0.4
L	-	-	-	-	0.9	-	-	0.9	-	-	-	-	-	0.9
Uncl.	3.6	-	-	3.6	-	-	-	-	-	8.5	-	6.5	15.0	18.6
Total	115.0	29.7	90.5	235.2	92.0	67.3	9.4	168.7	120.0	45.3	4.5	154.1	323.9	727.8

TABLE 5-4

DIRECT ALIENATION FROM CONSTRUCTION OF ALTERNATIVE OFFSITE FACILITIES

	(Hectares)			
Soil Unit	OD7	OD8	OA3	OA6
3	50.4	-	-	-
14	14.1	-	-	-
15	50.2	-	-	-
18	-	0.8	-	-
34	-	0.4	-	-
37	-	0.4	-	-
38	-	2.0	-	-
51	-	3.7	-	-
59	-	0.4	-	-
RO	-	-	-	-
CT	-	-	-	-
TW	-	-	-	-
TT	-	-	21.0	1.5
MT	-	-	13.4	-
Unclassified	5.3	-	-	-
Total	120.0	7.7	34.4	1.5

or 34 acres lost). The soil units highly affected by the north valley waste dump (M3) would be number 4 (15.4 ha or 38 acres) and 6A (9.3 ha or 23 acres). Other facilities connected with the mine development would highly affect soil units 6A (22.0 ha or 54 acres), 18 (16.4 ha or 41 acres), 19 (25.8 ha or 64 acres), and 37 (10.7 ha or 26 acres). An examination of the land areas alienated by the mine construction for all facilities shows that the soil units most affected would be numbers 4 (26.9 ha or 66 acres), 6A (38.7 ha or 96 acres), 17 (19.8 ha or 49 acres), 18 (25.4 ha or 63 acres), 19 (40.9 ha or 101 acres), 20D (10.2 ha or 25 acres), 37 (10.7 ha or 29 acres) and 62 (13.9 ha or 34 acres).

Plant

The areal extent of the soil units that would be alienated during the construction phase of the plant development are shown in Table 5-3. Included in this table are separate measurements for the power plant site (P1) and the make-up water reservoir and dams (P4) facilities. The soils most highly affected by these two facilities would be: for P1 soil unit 58 (66.1 ha or 163 acres) and for P4 soil unit number 54 (40.4 ha or 100 acres). The areal extent of soils alienated by the construction of the plant would be 199 ha (492 acres) of which 92 and 67 ha (227 and 165 acres) would be attributable to facilities P1 and P4, respectively. In addition to soil units number 54 and 58, the total plant construction would also highly affect soil units 41 (10.9 ha or 27 acres) and 51 (11.1 ha or 27 acres).

Offsite Facilities

The offsite facilities associated with the construction phase of development include a wide range of activities such as transmission lines, pipelines, roads and an airport. The areal extent of soils that would be alienated by these activities amount to 324 ha (800 acres) and the areas of each soil unit are shown in Table 5-3. In addition to the total area alienated, the individual soil unit area alienated by the following activities that are part of the offsite facilities, are also shown: main access road (OR1), airstrip Site A (OA1) and airstrip access road, Site A (OA4).

The soil units highly affected by the main access road (OR1) would be number 38 (16.2 ha or 40 acres) and number 47 (15.0 ha or 37 acres), and by the airstrip Site A are number 25 (13.8 ha or 34 acres) and number 27 (16.2 ha or 40 acres). The airstrip access road, Site A does not highly affect any individual soil unit.

During this study, a Site 2 storage reservoir and dam (OD4), an airstrip Site C (OA3), an access road to the Site A airstrip (OA4), and a Site C airstrip access road (OA6) have been identified as alternatives to the facilities previously discussed. The areal extent of soils affected by these facilities and a possible pipeline from diversion canal to make-up reservoir (OD8) are shown in Table 5-4. The Site 2 storage reservoir and dam (OD4) would affect entirely the following three soil units, 3 (50.4 ha or 124 acres), 14 (14.1 ha or 35 acres), and 15 (50.2 ha or 124 acres). The alternate airport facility (OA3) would highly affect soil units TT (21.0 ha or 52 acres) and MT (13.4 ha or 33 acres).

In addition to the areas shown in Tables 5-3 and 5-4, there are a number of project activities that were undefined in terms of size and location at the time of their analysis. These are:

OR5	Pump Station II Access Road (3.2 km x 30 m)
OR6	Spoil Area
OR7	Borrow Pits
OT3	69 kV Transmission Line from Rattlesnake A to Pump Station II (6.1 km x 20 m)
OD10	Medicine and Ambusten Creeks Canal Crossings
OF1	Off-loading Area
OF2	Railroad Spur
OF3	Access Road

In total these activities account for 24.8 ha (61 acres) of soils that would be affected by the project.

Summary

The construction of the mine, plant and offsite facilities would alienate or disturbs 880 ha (2174 acres) of soils. The proportional impact of this construction relative to the areal extent of the soils within the site-specific study area are shown in Table 5-5. This table shows that the areas that would be alienated by a high percentage are soil unit numbers 4, 6A, 16, 18, 20A, 20B, 20E, 21, 27, 39, 58, 61 and 62. Of these soil units, the first four (units 4, 6A, 16 and 18) are classified as agriculturally arable or partially arable, units 20A and 20B have no agricultural significance and the remaining units have agricultural grazing significance.

The soil units encompass approximately 663 ha (1638 acres) of the total area of the site-specific study area of 163 km^2 or 4 percent.

C. Dust

During the construction period, dusting would be a problem on nearly all of the soil units disturbed. Those areas that are disturbed, but not alienated, could be reduced in value if measures are not taken to ensure that dusting does not lead to loss of soil productivity through wind erosion. The use of proper dust suppression procedures would reduce the possibility of further soil losses during construction.

D. Waste Disposal

During the construction phase, waste disposal would be an insignificant impact on the soil. The land application of waste waters through spray irrigation programmes should take into consideration such factors as infiltration rates, soil moisture holding capacity, slope, etc. to ensure that problems such as soil erosion and slope sloughing do not occur.

TABLE 5-5

SOIL UNIT ALIENATION AND DISTURBANCE COMPARED TO SITE-SPECIFIC STUDY AREA CONSTRUCTION PHASE

Soil Units Site Specific Study Area				
Map Symbol	No. of Separate Areas	Total Area (km²)	Area Impacted (Hectares)	Percentage of Unit in S.S.S.A.
1	3	0.91	-	-
2	3	1.11	-	-
3	2	1.96	6.9	4
4	3	1.37	38.4	28
5	2	0.14	-	-
6A	12	2.69	46.7	17
6B	3	0.86	6.1	7
7	1	0.54	6.9	13
8	2	1.25	-	-
9	1	0.17	-	-
10	2	2.34	-	-
11	1	1.62	-	-
12	2	1.74	-	-
13	5	5.25	-	-
14	10	8.22	8.5	1
15	11	4.22	-	-
16	12	0.48	7.0	15
17	1	3.23	26.3	8
18	2	2.26	35.7	16
19	9	5.24	55.8	11
20A	1	0.18	6.9	38
20B	1	0.07	1.2	17
20C	1	0.18	2.5	14
20D	1	1.30	10.2	8
20E	1	0.21	3.5	17
21	1	0.58	8.6	15
22	1	0.95	0.4	0.4
23	1	0.19	-	-
24	10	1.52	0.8	0.5
25	8	7.10	22.6	3
26	3	1.22	-	-
27	3	1.15	17.0	15
28	9	0.91	-	-
29	5	3.04	1.2	0.4
30	2	0.22	0.4	2

TABLE 5-5 (Continued)

Soil Units Site Specific Study Area

Map Symbol	No. of Separate Areas	Total Area (km^2)	Area Impacted (Hectares)	Percentage of Unit in S.S.S.A.
31	8	1.68	7.3	4
32	10	1.11	2.0	2
33	1	0.61	-	-
34	15	7.15	8.3	1
35	4	2.85	0.4	0.1
36	9	4.97	10.8	2
37	6	15.90	19.2	1
38	18	19.05	29.1	2
39	1	0.27	5.3	20
40	[illegible]	0.33	1.2	4
41	3	3.30	11.3	3
42	6	1.82	11.7	6
43	2	1.04	-	-
44	2	0.65	-	-
45	3	0.73	9.1	13
46	1	0.70	4.5	6
47	6	3.33	18.6	6
48	1	0.43	1.2	3
49	3	0.91	2.4	3
50	8	6.87	12.6	2
51	19	4.67	30.6	7
52	3	4.46	1.6	0.4
53	12	0.70	-	-
54	5	7.09	58.0	8
55	9	0.59	-	-
56	4	0.95	5.7	6
57	6	5.44	5.7	1
58	3	2.46	70.2	29
59	3	0.51	0.8	2
60	5	0.65	5.9	9
61	1	0.05	2.8	56
62	1	0.96	13.9	15
63	1	0.93	-	-
64	2	1.10	-	-
Total		168.68	663.8	4

(ii) Resource Projection - Impact of the Project

A. Climate

The effects of the construction phase of the Hat Creek project on the climate of the regional, local and site-specific study areas has been done by Environmental Research and Technology, Inc.[25]. The possible effects on the climate discussed below are a summary of their findings.

Dust from the construction activities would be the only emission that may effect the climate, mainly causing a slight decrease in temperature. It would result from a reduction of solar radiation incident at the ground. However, the decrease in temperature would be slight and of consequence in the immediate vicinity of the construction activities. It would not approach the natural variability present in the annual average temperatures.

B. Landforms

Impacts to be discussed under Section D., "Soils", and Section 5.5, "Biophysical Impact Analysis".

C. Geology

The possible impacts were discussed in the Minerals and Petroleum Report by Dr. P.T. McCullough[13]. A summary appears below:

> *"The impact on geological resources relates to sterilization of the resources, so that they cannot be exploited. As a result the effects of the project occur primarily during the operating phase of the project. Effects during construction consist of utilization of local aggregate resources for construction purposes, but these effects are not regarded as significant because of the large aggregate resources that are believed to be available in the region and within the Upper Hat Creek Valley in particular."*

D. Soils

The impact on the soil resource by construction activities has been assessed by combining the sensitivity analysis of each soil type with the extent of each soil type alienated by the construction phase. This provided a means by which the impacts on soil could be identified in terms of the type of effects produced by disturbance and the relative extent of these effects.

Construction activities (base scheme) would alienate (each alienation being greater than 10 ha) four soil types which exhibit a high (H) sensitivity to disturbance. The soil unit, area affected, sensitivity parameter(s), and the major construction activity responsible are listed below:

Soil Unit 17	26.3 ha	high susceptibility to dusting	M1
Soil Unit 20D	10.2 ha	high susceptibility to alkalinity-salinity problems	M1
Soil Unit 25	22.7 ha	high susceptibility to alkalinity-salinity problems	OA1
Soil Unit 14	14.1 ha	high susceptibility to alkalinity-salinity problems	OD7

Construction activities associated with the base scheme that would alienate soil types with moderate sensitivity and where the alienation was greater than 20 hectares have been identified. The soil unit area affected, sensitivity parameter(s), and the major construction activity responsible for the impact are shown below:

Soil Unit 4	38.4 ha	susceptibility to alkalinity -salinity problems	M3
Soil Unit 6A	46.7 ha	susceptibility to dusting and alkalinity-salinity problems	Mining
Soil Unit 17	26.3 ha	susceptibility to alkalinity -salinity problems	M1
Soil Unit 18	35.7 ha	susceptibility to dusting	Mining, Offsite

Soil Unit 19	55.8 ha	susceptibility to dusting and alkalinity-salinity problems	Mining
Soil Unit 25	22.7 ha	susceptibility to dusting	OA1
Soil Unit 38	29.1 ha	susceptibility to dusting	OR1
Soil Unit 51	30.6 ha	susceptibility to dusting and alkalinity-salinity problems	Plant
Soil Unit 58	70.2 ha	susceptibility to dusting and alkalinity-salinity problems	P1

The consequences of soil sensitivity such as susceptibility to dusting and alkalinity-salinity problems are to a large extent dependent upon the type of construction activity. In the case of susceptibility to dusting, the use of soils with this sensitivity for reclamation, roadway, or in stockpiles could result in problems of excessive dust entering the environment and creating problems for surrounding vegetation, livestock or wildlife. Dust control measures such as watering, covering with less sensitive material or revegetating could mitigate this problem. Sensitivity to alkalinity-salinity problems could result in problems if these soil units are disturbed in such a manner that their less desirable constituents (e.g. high chlorides or alkalies) contaminate adjoining soil units being used for vegetative production or soil units to be used for revegetation.

Sensitivity to dusting would occur on nearly all the soil units identified in the site-specific study area with the exception of some of the units adjacent to the Hat Creek and its major tributaries. In general terms, the soil units in the upper elevations would have low susceptibility to alkalinity-salinity problems and the lowland soils would have moderate to low susceptibility to these problems.

In addition to the soil sensitivity impacts, the impact on lands suitable or not suitable for topsoil reclamation have also been identified. These soil units are shown below:

Soil units affected that have excellent suitability for topsoil reclamation and with affected areas greater than 10 hectares are:

Soil Unit 6A	46.7 ha	Mine
Soil Unit 18	35.7 ha	Mine
Soil Unit 27	17.0 ha	OA1

Soil units affected that have moderate suitability for topsoil reclamation and with affected areas greater than 20 hectares are:

Soil Unit 4	38.4 ha	Mine
Soil Unit 19	55.8 ha	Mine
Soil Unit 38	29.1 ha	Offsite
Soil Unit 51	30.6 ha	Plant

Soil units affected that have poor suitability for topsoil reclamation and with affected areas greater than 20 hectares are:

Soil Unit 54	58.0 ha	Plant
Soil Unit 58	70.2 ha	Plant
Soil Unit 27	16.2 ha	moderate to high sensitivity to dusting and alkalinity-salinity problems
Soil Unit 32	2.0 ha	moderate to high sensitivity to dusting and alkalinity-salinity problems

Soil units 6A and 18 are particularly important since they have excellent suitability for topsoil reclamation and are located near areas where reclamation would occur. Soil unit 27, although also high in suitability, is less important since it is located outside of the Hat Creek Valley and away from areas where extensive reclamation would occur.

The soil units affected by alternative construction facilities have been examined in regards to their sensitivity. The soil units, their area affected and their sensitivity for airport, Site A, are shown below:

Facility OA1:

Soil Unit 16	4.8 ha	moderate to high sensitivity to dusting and alkalinity-salinity problems
Soil Unit 25	13.8 ha	moderate sensitivity to dusting, high sensitivity to alkalinity-salinity problems

Facility OA4:

Soil Unit 16	0.8 ha	moderate sensitivity to dusting and alkalinity-salinity problems
Soil Unit 24	0.8 ha	moderate sensitivity to dusting and alkalinity-salinity problems
Soil Unit 25	2.1 ha	moderate to high sensitivity to dusting and alkalinity-salinity problems
Soil Unit 27	0.8 ha	moderate sensitivity to dusting and alkalinity problems

For the airport alternative (OA3), a detailed sensitivity has not been done on the soil units affected since they occur outside of the site-specific study area. However, an examination of the characteristics of these soil units, as described in the B.C. Department of Agriculture soil survey[16] indicates that the soils would have a moderate to high susceptibility to dusting and problems of alkalinity-salinity. The soil units affected would be:

Soil Unit TT	21.0 ha	OA3
Soil Unit MT	13.4 ha	OA6
no individual soil unit greater than 2 hectares		OA6

The first alternative airstrip, Site A, would alienate 45.3 ha (112 acres) of land area directly, plus 4.5 ha (11 acres) lost due to its access roads. The second alternative airstrip, Site C, would alienate 34.4 ha (85 acres), plus 1.5 ha (4 acres) for its access road.

The sensitivity of the soil units affected by the construction activities is shown in Table 5-6. The construction would only affect a relatively small area of soils with high sensitivity with the majority of the activity occurring on soil units with low sensitivity or on areas below the prescribed area size used in this analysis. In terms of overall impact, based on soil sensitivity to dusting, erosion and alkalinity-salinity problems, the plant, mine and offsite facilities can be ranked as follows during the construction phase in decreasing order of impact as: mine, offsite, plant.

(c) Operation

(i) Environmental Changes

This section deals with the impact on the soils and climate associated with the operation of the mine and power plant. As indicated earlier, the mine has been arbitrarily divided into construction and operation facilities. Fifteen percent has been allocated to construction and 85 percent allocated to the operation phase. During the operation phase, the northern Hat Creek Valley would entail a considerable amount of physical disturbance. The pit would continue to expand, producing large amounts of coal, overburden and waste rock. This material would be transported to the appropriate coal storage or waste dumps located in the northern portion of Hat Creek Valley. A series of catchment ditches would be required around the circumference of the mine and waste dumps to prevent surface and near-surface seepage water from flowing into the pit or runoff from the waste dumps from contaminating the groundwater supply. An estimated six lagoons would be necessary to collect this water.

TABLE 5-6

AREA WITHIN EACH OVERALL SOIL SENSITIVITY CLASS ALIENATED BY THE CONSTRUCTION OF PLANT, MINE AND OFFSITE FACILITIES (HECTARES)

Sensitivity	Plant	Mine	Offsite	Construction Total	Major Soil Units Affected
High	-	30.0	27.9	57.9	14, 17, 20D, 25
Medium	96.7	108.6	62.2	267.5	4, 6A, 17, 18, 19, 25, 38, 51, 58
Low or Non-Classified*	-	-	-	554.9	

• Non-classified refers to lands not included because alienation was below the prescribed area size (i.e., less than 10 hectares for high sensitivity, less than 20 hectares for moderate sensitivity).

The operation of the plant would alienate lands by the formation of ash disposal ponds. The large quantities of fly and bottom ash produced by the power plant would be disposed of in this manner. This represents the major impact in the operation of the power plant except for the possible wide-ranging effects of the air emissions produced and their effects on climate.

A. Qualitative Assessment

The qualitative assessment for the operation of the plant is the same as outlined for the construction phase, Section 5.4(b)(i)A.

B. Direct Loss

The alienation (direct loss/disturbance) of soils by project operation activities has been determined by superimposing a plan of these activities (at an approximate scale of 1:24,000) over the soils mapping for the site-specific study area. The alienated areas have been measured and reported in terms of soil type and whether the activity is associated with the mine, plant or offsites. The activities considered in the operation phase are given in Table 5-7.

Mine

The areal extent of the soil units that would be alienated as the result of mining activities during the operation phase of the project are shown in Table 5-7. The principal mining activities (i.e., open pit #1), Medicine Creek waste dump (M2), Houth Meadow waste dump (M4), topsoil stockpile from airstrip (M12), topsoil stockpile at south Medicine Creek (M13) and low grade coal stocking area (M15) and the soil units that they affect are also shown in this table.

The mine (M1) and the two waste dumps (M2 and M4) would affect the largest land areas and respectively alienate 31, 23 and 29 percent of 2100 ha (5187 acres)

TABLE 5-7

DIRECT ALIENATION FROM OPERATION - BASE SCHEME
(AREAS IN HECTARES)

Soil Unit	Mine								Plant			Total
	M1	M2	M4	M12	M13	M15	Other	Total	P6	P7	Total	
4	33.4	-	-	-	-	-	-	33.4	-	-	-	33.4
6A	41.6	-	64.7	-	-	-	1.7	108.0	-	-	-	108.0
6B	34.4	-	-	-	-	-	-	34.4	-	-	-	34.4
7	-	-	-	-	-	-	0.4	0.4	-	-	-	0.4
10	-	-	76.5	-	-	-	1.6	78.1	-	-	-	78.1
15	-	-	-	-	-	-	-	-	0.8	-	0.8	0.8
16	7.6	-	-	-	-	-	-	7.6	12.5	-	12.5	20.1
17	112.1	-	-	61.8	-	-	1.7	175.6	-	-	-	175.6
18	50.6	-	-	-	-	-	-	50.6	-	-	-	50.6
19	85.7	-	-	-	-	-	22.7	108.4	-	-	-	108.4
20A	6.9	-	-	-	-	-	-	6.9	-	-	-	6.9
20B	6.9	-	-	-	-	-	-	6.9	-	-	-	6.9
20C	14.1	-	-	-	-	-	-	14.1	-	-	-	14.1
20D	57.9	-	17.8	-	-	-	1.2	76.9	-	-	-	76.9
20E	19.6	-	-	-	-	-	-	19.6	-	-	-	19.6
21	48.8	-	-	-	-	-	-	48.8	-	-	-	48.8
28	-	-	-	-	-	-	-	-	11.3	-	11.3	11.3
31	-	-	32.0	-	-	-	-	32.0	-	-	-	32.0
34	-	60.7	25.0	-	19.0	-	3.4	108.1	-	-	-	108.1
35	-	59.1	-	-	-	71.3	2.9	133.3	8.1	0.8	8.9	142.2
36	-	23.5	-	-	-	-	-	23.5	-	-	-	23.5
37	-	4.0	-	-	-	-	0.4	4.4	-	-	-	4.4
38	-	2.0	-	-	-	-	0.4	2.4	146.7	1.6	148.3	150.7
42	-	43.7	-	-	-	-	0.8	44.5	4.9	-	4.9	49.4
45	-	-	-	-	-	-	-	-	11.8	-	11.8	11.8
47	-	1.6	-	-	-	-	0.4	2.0	20.2	-	20.2	22.2
50	-	58.7	-	-	-	-	1.6	60.3	2.4	-	2.4	62.7
51	33.0	38.8	2.0	-	73.1	50.6	5.7	203.2	89.0	7.7	96.7	299.9
52	-	-	-	-	-	-	0.8	0.8	120.2	-	120.2	121.0
53	-	28.3	-	-	-	-	-	28.3	34.0	-	34.0	62.3
54	-	-	-	-	-	-	0.8	0.8	9.3	2.4	11.7	12.5
55	-	5.7	-	-	-	-	-	5.7	35.2	-	35.2	40.9
56	-	-	-	-	-	-	0.8	0.8	85.0	-	85.0	85.8
57	-	137.2	129.9	-	-	-	1.6	268.7	8.6	-	8.6	277.3
59	-	23.9	-	-	-	-	-	23.9	-	-	-	23.9
60	-	-	-	-	7.3	1.6	-	8.9	-	0.4	0.4	9.3
62	78.8	-	-	-	-	-	-	78.8	-	-	-	78.8
63	-	-	83.0	-	-	-	0.4	83.4	-	-	-	83.4
64	-	-	51.0	-	-	-	2.4	53.4	-	-	-	53.4
RO	-	-	91.9	-	-	-	4.0	95.9	-	-	-	95.9
Uncl.	20.6	-	41.3	-	-	-	5.9	67.8	60.7	-	60.7	128.5
Total	652.0	487.2	615.1	61.8	99.4	123.5	61.6	2100.6	660.7	12.9	673.6	2774.2

of land alienation attributable to mining activities.

The soil units most affected by the mining activities would be: Unit 6A (108 ha or 266 acres), Unit 10 (78.1 ha or 193 acres), Unit 17 (175.6 ha or 434 acres), Unit 18 (50.6 ha or 125 acres), Unit 19 (108.4 ha or 268 acres), Unit 20D (76.9 ha or 190 acres), Unit 34 (108.1 ha or 267 acres), Unit 35 (133.3 ha or 329 acres), Unit 50 (60.3 ha or 149 acres), Unit 51 (203.2 ha or 502 acres), Unit 57 (268.7 ha or 664 acres), Unit 62 (78.8 ha of 195 acres), Unit 63 (83.4 ha or 206 acres) and Unit 64 (53.4 ha or 132 acres).

Plant

The areal extent of soil units that would be alienated due to plant activities during the operation phase of the project are also shown in Table 5-7. This alienation would be the result of two activities primarily; firstly, the wet ash disposal scheme pond and dam (P6) which accounts for 660.7 ha (1632 acres) or 98 percent of the total land alienated, and secondly, the wet ash disposal scheme ash conveyance system (P7) which accounts for 12.9 ha (32 acres) of the total.

The soil units most affected by the plant operation activities would be: Unit 38 (148.3 ha or 366 acres), Unit 5 (96.7 ha or 239 acres), Unit 52 (120.2 ha or 297 acres) and Unit 56 (85.0 ha or 210 acres).

The alternative schemes for ash disposal during the plant operation phase are shown in Table 5-8. The wet ash disposal scheme alternative bottom ash dump (P7.5) would alienate the same area as P6 plus the additional 180.6 ha (446 acres) shown in this table. The dry ash disposal scheme (P8 and P9) would alienate 303.6 ha (750 acres) with the soil units most highly impacted being Unit 37 (63.5 ha or 157 acres) and Unit 51 (174 ha or 430 acres). The dry ash disposal scheme II (P10 to P13) would alienate 260.5 ha (643 acres) and would impact most highly Soil Unit 51 (135.9 ha or 336 acres).

TABLE 5-8

DIRECT ALIENATION FROM PLANT OPERATION
PROPOSED ALTERNATIVES
(AREA IN HECTARES)

Soil Unit	P7.5	P8 & 9	P10-13
15	-	-	-
16	-	-	-
28	-	-	-
35	-	6.9	2.0
37	26.3	63.5	40.5
38	-	0.8	5.7
42	-	-	-
45	-	-	-
47	-	-	-
50	-	-	2.0
51	99.3	174.1	135.9
52	-	-	-
53	-	-	-
54	2.0	6.9	20.2
55	-	-	-
56	-	-	-
57	-	-	-
58	6.5	13.8	2.4
59	24.3	20.2	24.3
60	19.8	15.0	25.1
Unclassified	2.4	2.4	2.4
Total	180.6	303.6	260.5

Offsite Facilities

No direct loss of the soil units would be expected from the operation of the offsite facilities.

Summary

The operation of the mine and plant facilities alienates or disturbs 2774 ha (6852 acres) of soils. The proportional impact of this operation relative to the areal extent of the soils within the site-specific study area are shown in Table 5-9. This table shows that areas that would be alienated to the highest percentage are soil unit numbers 17, 20B, 20C, 20D, 20E, 21, 35, 51, 53, 55, 56, 57, 61 and 62. Of these, soil units 17 and 2 are classified as agriculturally arable or partially arable, Unit 20B has no agricultural significance and the remaining units have agricultural grazing significance.

The soil units affected would encompass about 2774.2 ha (6852 acres) of the total area of the site-specific study area of 168 km^2 or 16 percent.

C. Dust

The operation phase would have the same problems with dust as the construction phase when disturbing soil units with susceptibility to dusting.

D. Air Emission Effects on Climate

The effects of the operation of the Hat Creek project on the climate of the regional, local and site-specific study areas has been done by Environmental Research and Technology, Inc.[25]. The possible effects on the climate discussed below are a summary of their findings.

Mine

The mine operation would generate fugitive dust emissions from the movement

TABLE 5-9

SOIL UNIT ALIENATION AND DISTURBANCE COMPARED TO SITE-SPECIFIC STUDY AREA

Soil Units Site Specific Study Area				
Map Symbol	No. of Separate Areas	Total Area (km²)	Area Impacted (Hectares)	Percentage of Unit in S.S.S.A.
1	3	0.91	-	-
2	3	1.11	-	-
3	2	1.96	-	-
4	3	1.37	33.4	24
5	2	0.14	-	-
6A	12	2.69	108.0	40
6B	3	0.86	34.4	40
7	1	0.54	0.4	0.7
8	2	1.25	-	-
9	1	0.17	-	-
10	2	2.34	78.1	33
11	1	1.62	-	-
12	2	1.74	-	-
13	5	5.25	-	-
14	10	8.22	-	-
15	11	4.22	0.8	0.2
16	12	0.48	20.1	42
17	1	3.23	175.6	54
18	2	2.26	50.6	22
19	9	5.24	108.4	21
20A	1	0.18	6.9	38
20B	1	0.07	6.9	99
20C	1	0.18	14.1	78
20D	1	1.30	76.9	59
20E	1	0.21	19.6	93
21	1	0.58	48.8	84
22	1	0.95	-	-
23	1	0.19	-	-
24	10	1.52	-	-
25	8	7.10	-	-
26	3	1.22	-	-
27	3	1.15	-	-
28	9	0.91	11.3	12
29	5	3.04	-	-
30	2	0.22	-	-
31	8	1.68	32.0	19
32	10	1.11	-	-

TABLE 5-9 (Continued)

Soil Units Site Specific Study Area				
Map Symbol	No. of Separate Areas	Total Area (km²)	Area Impacted (Hectares)	Percentage of Unit in S.S.S.A.
33	1	0.61	-	-
34	15	7.15	108.1	15
35	4	2.85	142.2	50
36	9	4.97	23.5	5
37	6	15.90	4.4	0.2
38	18	19.05	150.7	8
39	1	0.27	-	-
40	1	0.33	-	-
41	3	3.30	-	-
42	6	1.82	49.4	27
43	2	1.04	-	-
44	2	0.65	-	-
45	3	0.73	11.8	16
46	1	0.70	-	-
47	6	3.33	22.2	7
48	1	0.43	-	-
49	3	0.91	-	-
50	8	6.87	62.7	9
51	19	4.67	299.9	64
52	3	4.46	121.0	27
53	12	0.70	62.3	89
54	5	7.09	12.5	2
55	9	0.59	40.9	69
56	4	0.95	85.8	90
57	6	5.44	277.3	51
58	3	2.46	-	-
59	3	0.51	23.9	47
60	5	0.65	9.3	14
61	1	0.05	-	-
62	1	0.96	78.8	82
63	1	0.93	83.4	90
64	2	1.10	53.4	49
RO	-	-	95.9	-
Unclassified	-	-	128.5	-
Total		168.68	2774.2	16

of heavy equipment within the pit and along the unpaved haul roads. Blasting in the pit would also generate dust. Once areas are cleared of vegetation, they are exposed to wind erosion, which ERT[25] has shown as the most significant generator of fugitive dust emissions. Wind erosion may produce 941,000 kg/yr (2,070,200 lbs/yr) of fugitive dust, while overburden haul roads may produce 381,000 kg/yr (8,383,000 lbs/yr) and overburden removal, 196,000 kg/yr (431,000 lbs/yr). It is expected that a total of 2,288,800 kg/yr (5,035,360 lbs/yr) would be generated by all activities. These values assume the following types of dust control techniques being employed:

(1) frequent watering of haul roads and exposed surfaces, resulting in a 50 percent control of dust;
(2) a speed limit of 25 km/hr (15 mph) would be used on all haul roads to yield a control efficiency of 80 percent;
(3) the land reclaimed from the waste dumps midway in the life of the mine (year 2005-2006) would be the only reclaimed area by the model year 2017-2018; and
(4) the conveyor system would be completely enclosed, resulting in 100 percent control.

However, many mining activities take place below ground level and the natural climatic variability may significantly reduce these estimated values.

Consequently, even with the use of dust suppression techniques, a substantial amount of dust would be generated by mining activities. However, the possible effect of this amount of dust on climate would be localized in the immediate vicinity of the mine and waste dump areas (site-specific study area). The possible climatic effect is a temperature decrease due to a reduction of solar radiation incident at the ground. However, the degree of cooling would be very small when compared to the natural variability of the annual average temperatures and is not expected to alter the growing season.

Plant

The operation of the plant would consist of the generation of electricity by four nominal 500 Mw units exhausted by a single 4-flue chimney of either 366 m (1200 ft.) or 244 m (800 ft.) stack. One of two types of emission control strategies may be used, either flue gas desulfurization or meteorological control systems.

The waste heat generated by the plant would be discharged by means of two evaporative natural draft cooling towers.

The possible effect on the climate of the local study area of the operation of the plant would be:

(1) precipitation enhancement,
(2) thermal alterations,
(3) snow cover persistence and depth,
(4) ground-level fogging and icing.

Regionally, no climatic alterations are expected. The enhancement of precipitation may result from the operation of the cooling towers. A total of 5×10^7 kg (58,000 tons) of evaporated water and about 7×10^{13} calories (25×10^{10} Btu) would be liberated to the atmosphere each day of operation[26]. This moisture and heat may cause a small increase in precipitation. Low cumulus clouds may form on days characterized by natural convection instability in the vicinity of the plant site.

The hot stack gases, cooling tower plumes and reduction of solar radiation incident at the ground by aerosols in the stack plume may cause temperature changes. The effect of the hot stack gases and cooling tower plumes is expected to be small. The hot stack gases would be released at a sufficient altitude to allow dispersion and a thermal equilibrium with the ambient air upon reaching surface level. The heat contained in the cooling tower plume has been shown by ERT's cooling tower plume simulation model to be dissipated within a downwind distance of 500 m. Stack plume aerosols are not expected to reduce the amount or intensity of solar radiation at the ground in any significant way. Consequently, no temperature damages are expected due to the plant operation.

A slight enhancement of a few centimetres of snow per year is expected within the immediate vicinity of the plant as a result of cooling tower drift. This phenomenon can occur when:

(1) the ambient air temperature is below -12°C;
(2) relatively stable atmospheric conditions are present at plume height; and/or
(3) there are large cooling tower vapour emissions.

These conditions occur relatively frequently in winter in the Hat Creek area.

The incidence of fogging and icing is not expected to increase as a result of cooling tower operation with the use of the natural draft design.

Offsite Facilities

No impact on climate from the operation of the offsite facilities is expected.

E. Air Emission Effects on Soils

The operation of the proposed Hat Creek power plant and associated cooling towers would release many gaseous and particulate constituents into the surrounding atmosphere. The major emission from the power plant would be sulfur dioxide after carbon dioxide and water vapour. Other emissions would include oxides of nitrogen, hydrocarbons, carbon monoxide, and a wide range of trace elements largely in the form of particulates[25]. In addition, the conversion of sulfur dioxide and nitrogen dioxide to sulfates and nitrates

($SO_3^=$ and NO_3^-) and creation of "acid rain" would be of consequence especially to soil aspects. The cooling towers generally
heat and water vapour.

Little or no information is available as to the impact of air emissions on the soil resource[27]. Most sources only deal with vegetation or wildlife. Except in the case of "acid rain", cooling tower emissions and particulates, most impacts would be as a result of absorption by the vegetation of gaseous emissions, then deposition into the surface soils by litterfall or throughfall precipitation. In the case of cooling tower emissions, particulates and "acid rain" direct deposition could take place.

Direct deposition would have the most impact on soils. Indirect deposition in the form of litterfall and throughfall probably would have less of an impact. This results from varying absorption rates between plant species, season and diurnal variations in absorption, and location of element storage (e.g., bark, leaves or stems). In any case, gaseous emissions of oxides of nitrogen, carbon monoxide and hydrocarbons are expected to have no impact on the soils. The soil uptake of sulfur from litterfall would have a minor impact, if any, on soils that are either sulfur-deficient or rich. The first case would be beneficial, as sulfur is an essential element and used extensively by sulfofying bacteria, and the latter would have no impact unless soil sulfur levels are extremely high or anaerobic conditions exist where sulfates are readily reduced to sulfides, including hydrogen sulfide, which is toxic.

The impact of "acid precipitation" could possibly reduce the soil pH due to sulfates and nitrates being scavenged from the atmosphere and deposited in the form of sulfuric and nitric acid on the surface soil[28]. This acidifying process could lead to a reduction in calcium and other bases and a reduced activity of soil micro organisms, particularly nitrifiers and nitrogen-fixers. However, it is expected that within the local study area, because of the high buffering capacity of the soils, there would be no impact. This is true even in the "worst case" with precipitation having a pH of 3.7 as presented in the Report of the Acid Rain Committee[28].

The regional study area has not been investigated in enough detail to make the same assumption. However, since many of the soils in this region are derived from limestone and basalt, both of which are high in alkalies, most soils could be expected to be unaffected. Only in areas derived from granitic deposits with podzolic soils could minor impacts be expected.

The cooling towers associated with the proposed Hat Creek power plant would utilize water from the Thompson River. The evaporative cooling in such towers would result in the entrainment of water droplets containing dissolved solids, particularly salts, in the stream of air and water vapour they emit. Condensation of this water could result in visible plumes whose chemical composition reflects that of the cooling water. In the case of Thompson River water, it would be recycled 14 times before release, consequently, a concentration of the dissolved solids would take place.

ERT has provided an assessment of the atmospheric effects and deposition isopleths for four alternative cooling tower designs[26]. Of these four designs, the two natural draft towers are the preferred option. The projected maximum deposition rates would be[26]:

Four round mechanical draft towers	51,400 $kg/km^2/year$
Four rectangular mechanical draft towers	24,150 $kg/km^2/year$
Two natural draft towers	4,717 $kg/km^2/year$
Four natural draft towers	8,760 $kg/km^2/year$

In all cases, the deposition rate would drop to 560 $kg/km^2/year$ within 3 km of the towers. Maximum deposition generally would occur within one kilometer of the cooling towers.

The consequences of these deposition rates and dissolved solids to the soil resources would be increased moisture regimes and salt contents of the soil. ERT[26] has predicted salt deposition rates due to cooling tower drift for the four cooling tower designs. The annual predicted salt deposition rates would be as follows:

Four round mechanical draft towers	242 kg/ha/yr (215 lb/acre/year)
Four rectangular mechanical draft towers	513 kg/ha/yr (458 lb/acre/year)
Two natural draft towers	47 kg/ha/yr (42 lb/acre/year)
Four natural draft towers	86 kg/ha/yr (78 lb/acre/year)

Reference to Table 5-2 and Map 4-4 shows that the majority of the soils within the site-specific study area have a high alkalinity and salinity. Therefore, addition of the salts Ca, Mg and Na could cause excessive salt levels in soil units with a high alkalinity-salinity. These high salt levels could lead to secondary impacts on vegetation, livestock and wildlife. Vegetation that is not tolerant to such high salt levels may be degraded, thus, affecting both wildlife and livestock. In addition, the high salt levels could change the nutrient availability within the surface soils.

As a potential benefit to the arid soils of the site-specific study area, the cooling tower plume could provide additional moisture. Moisture is undoubtedly the most important limiting factor to plant growth in the local study area. Therefore, the addition of water to the soils would benefit the vegetation as well as livestock and wildlife.

Particulates and in particular their associated trace element levels are of potential concern because of the possible secondary impacts to livestock and wildlife that have consumed vegetation growing in soils possessing high trace element concentrations. High natural soil levels in the top 5 cm (2 in.) of soil were reported by ERT[29] for arsenic, cadmium, chromium, fluorine and selenium. Further additions of these trace elements could result in high soil levels. Of these arsenic and selenium are of particular concern since ingestion of vegetation containing high levels of these elements could injure livestock and wildlife. However, since much of the availability of trace elements contained in the soil is a function of soil pH and nutrient and moisture status, very little can be said about what the secondary impacts might be. Fluorine presents a further problem because it is a cumulative element and high levels could buildup. However, the fact that fluorine is generally immobile in the soil negates much of the problem of plant uptake from the soil[30, 31, 32].

F. Waste Disposal

The ash disposal schemes for the plant would require drainage ditches around the ash pond perimeter to catch surface and near-surface waters from the adjacent highlands before they reach the ash ponds. The water in the wet ash disposal scheme would be disposed of by evaporation as well as recycled for the sluicing of ash.

The waste disposal for the mine would require large waste dump areas to accommodate the large quanitities of waste rock and overburden. These waste disposal piles would be drained in order to prevent contaminated surface runoff to flow onto the surrounding land. Consequently, a system of drainage ditches would be located around the perimeter of the waste dumps and mine. These would drain into lagoons which would serve as settling basins and retention dams. Some of this water would be used for industrial purposes while the remainder would be discharged into Hat Creek. Treatment may be necessary.

The plant would be operated in a "no liquid discharge" mode. Water make-up would essentially equal consumption. Since the plant is operated on a "no liquid discharge" mode, no effect is expected on the soil. The sewage disposal schemes for both the plant and mine may have a minor beneficial effect because of an increase in nutrient and moisture to the soil, but this effect would be extremely localized.

The use of drainage ditches around the ash and mine waste disposal areas is important because it protects adjacent soil units from water erosion from uncontrolled runoff. In addition, as will be discussed in Section 5.4(c)(i)E., numerous trace elements are present in the waste water from these areas. These could leach into the adjacent soil areas and would be available to plant uptake.

(ii) Resource Projection - Impact of the Project

A. Climate

Environmental Research and Technology, Inc.[25] has outlined the probable changes that may take place as a result of the operation of the mine and plant. This would take the form of air emissions from the power plant stack, cooling towers and operation of the mine. This information is summarized below.

Mine

No detailed information is available concerning the levels of hydrocarbons, sulfur, carbon monoxide or particulates (dust) that would occur during the operation of the mine. However, it is expected that high, localized particulate concentrations may occur for brief periods. These would be more important in the construction phase. This would have no effect on the overall climate of the local or site-specific study areas.

Plant

Provincially, no appreciable effect on the temperature structure of the atmosphere or its energy balance would be anticipated. In addition, emissions from the plant would not alter the chemical and radiative processes governing the composition of the stratosphere.

Within the local study area, but primarily in the site-specific study area, slight increases in total precipitation would be expected as a result of the operation of the cooling towers. Occasionally, snowfall may be increased due to cooling tower emissions. Local cumulus or low stratus cloud initiation may result during days characterized by natural convective instability. Within the vicinity of the plant site, no ground-level fogging or icing would be expected from the cooling tower emissions.

In summary, the operation of the plant and mine appear to have little influence on the climate of the regional, local or site-specific study areas. The areas in the immediate vicinity of the mine may encounter high particulate levels in the air, depending on dust suppression effectiveness. Minor enhancement of precipitation levels would undoubtedly have a beneficial effect, since moisture in the local study area is one of the major limiting factors to plant growth. The occasional minor increase in snowfall is believed to have no impact.

B. Landforms

Any impacts are discussed under Section D, "Soils"

C. Geology

Impacts are addressed in the "Minerals and Petroleum Report" by P.T. McCullough [13].

D. Soils

Impact on the soil resource by operation activities has been assessed by combining the sensitivity analysis of each soil type with the extent of each soil type alienated by the operation phase. This provides a means by which the impacts on soil can be identified in terms of the type of effects produced by disturbance and the relative extent of these effects.

Operation activities (base scheme) would alienate (each alienation being greater than 10 ha) 14 soil types which exhibit a high (H) sensitivity to disturbance. The soil unit, area affected and sensitivity parameter(s) are listed below:

Soil Unit	Area Affected (ha)	Sensitivity Parameter*
6B	34.4	2
10	78.1	2
17	175.6	1
20C	14.1	2
20D	76.9	1,2,3
20E	19.6	1,2
21	48.8	1
31	32.0	2
34	108.1	2
55	40.9	2
57	277.3	2
59	23.9	2
63	83.4	2
64	53.4	2

* Sensitivity Parameters:
  1 Susceptible to dusting
  2 Susceptible to alkalinity-salinity problems
  3 Susceptible to erosion

Operation activities associated with the base scheme that would alienate soil types with moderate sensitivity and where the alienation was greater than 20 ha (49 acres) were also identified. The soil unit area affected and the sensitivity parameter(s) are shown below:

Soil Unit	Area Affected (ha)	Sensitivity Parameter*
4	33.0	2
6A	108.0	1,2

Soil Unit	Area Affected (ha)	Sensitivity Parameter*
16	20.1	1,2
18	50.6	1,2
19	108.4	1,2
35	142.2	1,2
36	23.5	1,2
38	150.7	1
50	62.7	1
51	299.9	1,2
52	121.0	1,2
53	62.3	1,2
56	85.8	1,2
62	78.8	2

* Sensitivity Parameter:

1 Susceptible to dusting
2 Susceptible to alkalinity-salinity problems
3 Susceptible to erosion

In addition to the operation activities associated with the base scheme, the soil units alienated by the alternative operation facilities, the extent of the area affected, and the sensitivity parameter(s) associated with these alternatives have been identified and are shown below:

Activity: Wet Ash Disposal Scheme Alternative Bottom Ash Dump (P7.5)

Soil Unit	Area Affected (ha)	Sensitivity Parameter*
37	26.3	1
51	99.3	1,2
54	2.0	1
58	6.5	1,2

Soil Unit	Area Affected (ha)	Sensitivity Parameter*
59	24.3	1,2
60	19.8	2

Activity: Dry Ash Disposal Scheme I (P8 and P9)

35	6.9	1,2
37	63.5	1
38	0.8	1
51	174.1	1,2
54	6.9	1
58	13.8	1,2
59	24.3	1,2
60	15.0	1,2

Activity: Dry Ash Disposal Scheme II (P10, P11 and P12)

35	2.0	1,2
37	40.5	1
38	5.7	1
50	2.0	1
51	135.9	1,2
54	20.2	1
58	2.4	1,2
59	24.3	1,2
60	25.1	1,2

* Sensitivity Parameter:

1 Susceptible to dusting

2 Susceptible to alkalinity-salinity problems

The soil units that would be alienated during operation and their potential for topsoil reclamation are shown below:

Soil Unit	Area Affected (ha)	Operation Activity
Excellent Potential (greater than 10 ha):		
6A	108.0	Mine
53	62.3	Mine, Plant
56	85.8	Plant
Good Potential (greater than 20 ha):		
4	33.4	Mine
10	78.1	Mine
16	20.1	Plant
18	50.6	Mine
19	108.4	Mine
20D	76.9	Mine
20E	19.6	Mine
21	48.8	Mine
35	142.2	Mine
36	23.5	Mine
42	49.4	Mine
50	62.7	Mine
51	299.1	Mine, Plant
55	40.9	Plant
57	277.2	Mine
58	23.9	Mine
62	78.8	Mine
63	83.4	Mine
64	53.4	Mine
Poor Potential (greater than 10 ha):		
34		Mine
54		Plant
Rock Outcrop		Mine

TABLE 5-10

AREA WITHIN EACH SENSITIVITY ALIENATED
BY THE OPERATION OF PLANT AND MINE FACILITIES
(HECTARES)

Sensitivity	Operation Total	Major Soil Units Affected**
High	1066.4	10, 17, 20D, 34, 57, 63, 64
Medium	1347.4	6A, 18, 19, 35, 38, 50, 51, 5 53, 56, 62
Low or Non-Classified*	360.4	---

* Non-classified refers to lands not included because alienation was below the prescribed area size (i.e., less than 10 hectares for high sensitivity, less than 20 hectares for moderate sensitivity).

** Major soil unit refers to an area greater than 50 hectares.

mine and plant would cease operation unless designed to operate an alternate function such as the make-up water pipeline from the Thompson River remaining operational to provide irrigation water or supplement the flow of Hat Creek.

Although land reclamation (recontouring and revegetation) would be a continuing process throughout the life of the mine waste dumps, the fly ash and bottom ash disposal areas would be reclaimed during the decommissioning period.

The land reclamation plan proposed by Acres[33] would initiate the revegetation of the mine waste dumps as early as possible during the mine operation, provided the centreline method of embankment construction is used. In this way, the embankments could be revegetated during the early years of the mine operation. The waste dump surface then could be progressively revegetated during the later years of operation. Suitable topsoil materials would be identified in disturbed areas, such as pit and waste dump areas and would be stored for future application to the waste dump areas to aid in the vegetation process. The waste disposal and ash disposal areas would be progressively stripped of vegetation and suitable topsoil material in order to minimize erosion. All recontouring of the waste piles would be done to a 26^{o} final slope angle to enhance the reclamation work.

In general, the final topography of the waste dump and ash disposal areas would consist of relatively steep benches (overall slope 26^{o}) with large, flat upper levels. Very few micro topographical changes would occur. The underlying materials and topography would be constructed so as to promote good surface drainage. This general uniform topography would provide few wet micro habitats.

Impacts on the soil resource due to project decommissioning are perceived as being minimal. There would be the potential, however, for dusting, erosion, and alkalinity-salinity problems occurring during the dismantling and reclamation procedures for the various project facilities.

Soil units that have been identified as being susceptible to erosion should be kept under vegetative cover wherever possible and if exposed they should be revegetated as quickly as possible. Any recontouring of landforms should take into consideration the susceptibility of the soil unit for erosion. Slopes on these recontoured surfaces should be kept to a minimum to reduce the potential for erosion. Similarly, soils with high susceptibility to dusting should be handled in a manner to control dusting. Procedures such as water sprays and immediate revegetation of disturbed areas are important to prevent this problem.

Soil units that are susceptible to alkalinity-salinity problems should be handled in such a manner thay they do not "contaminate" the root zone of adjacent or revegetated soil areas.

Table 5-2 identifies the soil units most suitable for use as topsoil material and Map 4-4 shows their location. Wherever possible, the soil units possessing the highest rating should be utilized. Use of these units would avoid or lessen the above mentioned problems.

(ii) Resource Projection - Impact of the Project

A. Climate

The decommissioning phase is expected to have no impact on climate.

B. Landforms

Any impacts that may result, would be a function of the degree of recontouring of the land, thus, changing slopes and drainage patterns.

C. Geology

Impacts to the geology from the decommissioning phase are discussed in "Minerals and Petroleum Report" by Dr. P.T. McCullough[13]. Generally, no impacts are expected.

D. Soils

In general, the impact of decommissioning should have a positive effect on the soils. Through revegetation of waste dumps and facility sites, problems of erosion and dusting would be reduced and the recontouring of land could reduce erosion or alkalinity-salinity problems on adjacent lands.

5.3 VEGETATION RESOURCE PROJECTION WITHOUT THE PROJECT

(a) Summary of Anticipated Environmental Changes

Basically, the development of vegetation is a function of soil, parent material, fauna and climate. It can be assumed that the environmental change of soil, parent material and faunal aspects will remain relatively low. Although macroclimate will be unchanged, short-term climatic fluctuations can occur at irregular intervals. These variations will necessarily be reflected in changes in tree growth and speed of successional trends. In some years, the encroachment of the forest onto grassland areas will be promoted, while in others the reverse will occur. These changes, however, can be considered minuscule compared to the changes brought about by various land use practices such as forest harvesting, agriculture and grazing. All of these practices can alter the vegetation pattern and, therefore, affect the microclimate and soil fauna and flora to the extent that changes in the soil and vegetation types may take place. Forest harvesting has already had a profound effect on the vegetation in that much of the local study area has had an extensive logging history or has been subjected to major forest fires. However, present information from the Forestry Report[49] indicates that 75 percent of the Annual Allowable Cut within the regional study area has already been allocated and little potential exists for forest industry expansion. Major forest fires, on the other hand, will always be a factor in the interior forests, although modern control methods limit their number and size.

Grazing to date has been very heavy with many open range areas depleted in terms of forage value. However, forest ranges have suffered less overgrazing than open ranges. This overgrazing has caused an alteration in the species composition towards range species that can withstand grazing pressure, many of which are relatively unpalatable to livestock. Information from the Agriculture Report[50] indicates that future grazing could either remain static or begin to increase slightly as major reseeding programmes become established in the overgrazed open range lands and better management of the forest ranges occurs.

(b) Resource Projection

(i) Forest Vegetation

The forest vegetation throughout the regional study area and especially the local and site-specific study areas is largely in a successional state because of previous forest fires and logging activities. If the forests are allowed to continue without further disturbances, a "climax" state will eventually be reached. The vegetation pattern in the climax state will change considerably. The forest canopy will be dominated by climax species such as Engelmann spruce, Douglas-fir or western hemlock, depending in which biogeoclimatic zone the climax state is reached. The understory will undoubtedly lose the shade-intolerant pioneer species such as fireweed (*Epilobium angustifolium*), while the most noticeable change will be an increase in the shade-tolerant species. In other words, understory successional trends will experience a quantitative change in cover with little change in species composition between the successional stages and final climax.

However, because forest harvesting, natural fires and continued grazing pressure in the future are not likely to decrease in any appreciable degree, the successional trend toward climax is further delayed. In terms of forest harvesting and forest fires, the pattern generally will remain consistent with that of the past, and the vegetation pattern will, therefore, remain similar. Some forest stands will continue toward climax, while others will be set back by logging or fires. This is true for the regional, local, and site-specific study areas. Grazing, on the other hand, has a more variable effect because the study areas have been subjected to different intensities of grazing pressure. Within the local and site-specific study areas, grazing has been very intensive, while the regional study area has a relatively variable grazing history. In forest ranges suffering from severe overgrazing, the dominant alterations occur in the grass and shrub layers of the understory. Tree species are relatively unaffected, although some inhibiting of the tree regeneration by trampling may occur. These changes are in the form of a reduction in the overall grass coverage and an increase in weed and unpalatable plant species.

Probably future trends indicate that these forest range areas will remain consistent in species composition and cover with present values. With better management, such as reduced livestock numbers and a shorter grazing period, the severely overgrazed areas will respond by increasing the overall cover of the grass layer. "Decreaser" species will begin to increase if a seed source is still available, at the expense of the weed invaders. With improved herding practices, areas that at this time are lightly grazed should receive moderate grazing pressure, generally enhancing their productivity[51].

(ii) Range Vegetation

The native rangelands for most of the regional, local and site-specific study areas have been subjected to varying degrees of grazing pressure with the local and site-specific study areas receiving continued heavy grazing pressure. Many of the open ranges are now severely overgrazed. The grasslands that have had heavy grazing pressure have formed a zootic climax and studies show that 20 to 40 years may be necessary for the climatic climax community to establish an excellent range condition[21]. Consequently, even with reduced grazing pressure, these rangeland areas are going to remain in their present condition for many years. Improvement of pastures with irrigation and range reseeding programmes will act to change the vegetation pattern by addition of new species. However, these changes are likely to be of only local significance, depending on the size of the improvement project.

5.4 VEGETATION RESOURCE PROJECTION WITH THE PROJECT

The most direct impact the proposed Hat Creek project would have on vegetation would involve removal of vegetation (direct loss). The most probable indirect source in altering vegetation patterns could be changes in hydrologic conditions, especially drainage characteristics. The addition of toxic substances to the environment is another example of an indirect source that has an important bearing on the problem of vegetation management in the vicinity of the plant and mine operations. Probably the most wide-ranging effect could be that derived from the thermal plant air emissions emissions because of the potential area that could be affected.

The project itself has been divided into four categories: preliminary site development, construction, operation and decommissioning, in order to assess the impact on vegetation.

Preliminary site development consists of those facilities and activities necessary to formulate definitive plans for development. Most of these activities have already been completed.

Construction could begin once the decision to proceed has been made. Construction would involve the installation of facilities necessary to begin power generation. Mine excavation would begin so that a reliable supply of coal could be obtained, the power plant must be completed, and all ancillary offsite transport (of coal, waste, people, equipment, water and electrical energy) and storage facilities would be completed.

The mine would begin with a small excavation and would gradually be enlarged until the final pit dimensions are reached. Large waste dumps would be necessary to contain the waste rock and overburden generated during the excavation of the pit. Consequently, a clean division present between construction and operation phases would be difficult. Therefore, we have arbitrarily included 15 percent of the pit, the north valley waste dump, the coal blending area near the pit mouth, the temporary topsoil stockpile, and the shop and maintenance buildings in the list of facilities associated with the "construction" of the mine. The other mine facilities are arbitrarily considered to comprise the "operation" of the mine. The operation phase includes mining, plant operation and the dumping of wastes.

Decommissioning concerns the process of changing from coal mining and electricity generation to other land uses. All reclamation and revegetation are included in this category.

In order to determine the impact of the above three categories, the facilities have been grouped into mine, plant and offsite facilities of construction, as well as mine, plant, and associated facilities for operation (Table 5-1). This method of analysis has not been used for the preliminary site development activities because of their low number and intensity and the lack of information available.

Official project descriptions[52, 53, 54, 55] have been used to produce a list of project facilities (Table 5-1), and a layout map which shows the approximate size, location and configuration of each facility (Map 5-1). The alignment, precise location and configuration of all project facilities currently cannot be determined. However, in most instances, a diminutive change in location or alignment of a facility would have a negligible effect on the overall environmental impact and their analysis.

(a) Preliminary Site Development

(i) Drilling Programme

The drilling programme began before the vegetation sampling programme commenced. Moreover, very little information was disseminated in order to evaluate its impact on vegetation. However, from the drilling which was observed in the Hat Creek Valley during the field studies, minor effects could be expected. Each hole was generally surrounded by a 10 to 15 m (33 to 50 ft.) area of disturbed land devoid of vegetation. In addition, a 5 m (16 ft.) wide access road was necessary to get the drilling equipment to the site.

The effect of this development is mainly in the form of direct loss of the vegetation associations affected. It is not known whether any sensitive vegetation associations would be affected. Indirect changes due to interruption of seepage water are thought to be minimal because of the shallow nature of the access road. The most notable change may be the possible invasion of these disturbed sites by noxious weed vegetation unless they are immediately revegetated.

(ii) Bulk Sampling Programme

The expected impact of the bulk sampling programme on the vegetation component was previously submitted (June 27, 1977)[56]. This analysis showed that the vegetation may be affected by direct loss, possible reduction in the productivity due to the interception of lateral seepage water by drainage ditches or roads, flooding due to these same facilities, and toxic leachates from collecting ponds. From a vegetation standpoint, Trench A was thought to show more environmental damage because of its size and number of associated access roads. The area around Trench B was already disturbed and was smaller in extent.

The actual impact of the programme has been described in a preliminary report by B.C. Hydro and Power Authority[57]. From this information, the actual environmental impact on vegetation appears to be mainly in the form of direct loss. No evidence of toxic leachates from the collection areas has been found. With respect to losses in photosynthetic efficiency of productivity, very limited information is available because of the long-term nature of these changes and special studies necessary to assess these changes. Consequently, the impact is difficult to determine.

The B.C. Hydro and Power Authority report[57] summarizes the environmental impact as follows:

> *"Environmentally, results to date have been consistent in confirming that environmental impacts have been restricted to the immediate areas of the trenches and related (waste and coal storage) areas. There have been no project related alterations to air or water (Hat Creek) quality. Noise has in no way been a major issue with the local residents almost unaware of the mining activities. Dusting from the trench workings proved to a local, operational problem. Initial results would indicate no increase in ambient suspended particulate which could be attributed to this program. The transportation phase proceeded almost unnoticed by local residents; truck covers were effective in eliminating dust problems."*

(b) Construction

(i) Environmental Changes

The problem of the assessment of the effects of construction on the vegetation was handled in two manners, qualitatively and quantitatively.

In the qualitative sense, the vegetation was considered as an independent entity, and by rating the various vegetation associations according to their intrinsic properties or qualities.

In the quantitative sense, the exactual loss of the vegetation due to construction, operation and decommissioning was assessed by determining the number of hectares of each vegetation association lost by the various developmental facilities and activities. This method essentially assesses the direct impact of the thermal plant development (direct removal). The quantitative analysis combined with the qualitative assessment provides a means of assessing the importance of the vegetation associations that would be lost as well as the amount. This combined analysis will be discussed in the subsequent section, "Resource Projection".

A. Qualitative Assessment

The qualitative assessment has been carried out for all vegetation associations delineated in the local study area, and is presented in Table 5-11. Each association has been scored for six qualities; the higher the number, the more valuable the vegetation type. Occurrence of the vegetation association within the local study area is easy to evaluate. For example, the Douglas-fir - Pinegrass and Engelmann Spruce - Grouseberry associations are common types and cover large areas, while the Mountain Avens - Sedge and Sagebrush - Bluebunch Wheatgrass associations are relatively uncommon and of small extent. Floristic diversity is an estimate of the richness of the flora and the equitability with which the individual plants in an association are distributed into different species derived from the field studies. The vegetation associations also differ in their structural complexity and diversity within themselves. The Grassland Associations have a simple pattern compared to the more complex Engelmann Spruce - Grouseberry - Red Heather Association. Productivity estimates are qualitative assessments of the biomass production of an association. For example, the productivity of the Willow - Sedge Bog Association is high; of Mountain Avens - Sedge Association, extremely low. The forest associations, though they may have a high biomass, generally have a low productivity. The occurrence of rare or uncommon plant species relies on the field studies, the investigator's knowledge of the flora or the study area, and discussions with people knowledgeable with the

TABLE 5-11

VEGETATION SENSITIVITY ANALYSIS
FOR THE VEGETATION ASSOCIATIONS FOUND IN THE LOCAL STUDY AREA

Vegetation	Occurrence within the Study Area 1 - 4	Floristic Diversity 1 - 4	Vegetational Diversity within the Map Unit 1 - 3	Productivity 1 - 4	Possible Occurrence of Rare or Uncommon Species 1 - 4	Tolerance to Development Caused by Disturbance 1 - 4	TOTAL 6 - 23
Alpine Tundra Zone							
Mountain Avens - Sedge Association	4	2	2	1	4	4	17
Engelmann Spruce - Subalpine Fir Zone							
Engelmann Spruce - Grouseberry Association	1	2	2	3	1	1	10
Engelmann Spruce - Grouseberry -Pinegrass Association	1	2	2	2	1	1	9
Engelmann Spruce - Grouseberry -White Rhododendron Association	3	2	2	2	3	2	14
Engelmann Spruce - Willow Red Heather Parkland Association	2	4	3	1	3	4	17
Englemann Spruce - Grouseberry -Lupines Association	2	3	2	1	2	3	13
Interior Douglas-fir Zone							
Douglas-fir - Pinegrass Association	1	1	2	2	1	1	8
Douglas-fir - Bunchgrass Association	3	1	2	1	2	4	13
Douglas-fir - Pinegrass - Bunchgrass Association	2	2	2	1	2	4	13
Douglas-fir - Spirea - Bearberry Association	4	2	2	1	3	4	16
Ponderosa Pine - Bunchgrass Zone							
Ponderosa Pine - Bunchgrass Association	3	1	2	1	2	3	12
Intrazonal							
Riparian Association	3	4	2	4	3	3	19
Engelmann Spruce - Horsetail Association	3	3	2	3	2	3	16
Willow - Sedge Bog Association	3	3	3	4	3	4	20
Grassland Association							
Highland Grassland Association	2	2	1	2	3	2	12
Kentucky Bluegrass Association	2	2	1	2	2	2	11
Bunchgrass - Kentucky Bluegrass Association	2	2	1	2	2	2	11
Sagebrush - Bluebunch Wheatgrass Association	4	1	1	1	2	4	13
Saline Depression Association	3	2	1	3	2	4	15
Big Sagebrush - Bunchgrass Association	2	1	1	1	2	2	9

vegetation of the area to estimate the vegetation association that is most likely to contain rare or uncommon species. The direct impact of development would be indiscriminate in the effect on the vegetation. Certain secondary disturbances, such as road building, coal dust, waste disposal and interception or impedance of drainage would affect some vegetation types more than others (i.e. tolerance to development caused by disturbance).

Sensitivity

The results of this analysis can be summarized in three sensitivity classes:

Class 1 - High Sensitivity
Mountain Avens - Sedge Association
Engelmann Spruce - Willow - Red Heather Parkland Association
Riparian Association
Willow - Sedge Bog Association
Sagebrush - Bluebunch Wheatgrass Association

Class 2 - Moderate Sensitivity
Engelmann Spruce - Grouseberry - White Rhododendron Association
Engelmann Spruce - Grouseberry - Lupines Association
Douglas-fir - Bunchgrass Association
Douglas-fir - Pinegrass - Bunchgrass Association
Douglas-fir - Spirea - Bearberry Association
Ponderosa Pine - Bunchgrass Association
Engelmann Spruce - Horsetail Association
Highland Grassland Association
Saline Depression Association

Class 3 - Low Sensitivity
Engelmann Spruce - Grouseberry Association
Engelmann Spruce - Grouseberry - Pinegrass Association
Douglas-fir - Pinegrass Association

Kentucky Bluegrass Association
Bunchgrass - Kentucky Bluegrass Association
Big Sagebrush - Bunchgrass Association

B. Direct Loss

This section identifies and quantifies impacts that result from the construction of the facilities for the proposed Hat Creek project (Table 5-1). The areas of each vegetation association affected by the individual facilities has been calculated using planimetry. For linear corridors such as roads, pipelines, transmission lines and conveyors, a linear measurement has been used. Table 5-12 gives the total number of hectares of each vegetation association potentially affected by construction and the proportion of the total amount found in the local study area. The percentage of logged area is also presented, since these areas tend to be less sensitive because of previous disturbances or alterations.

Mine

The vegetation that would be alienated during the construction phase of the mine development is classified by vegetation association against facility in Table 5-12. This table lists all facilities associated with the construction phase. Table 5-12 shows that the total area of land alienated would be 235.2 ha (581 acres) or 0.1 percent of the local study area. Most of the mine activity would be located in the valley bottom of the northern upper Hat Creek Valley.

The vegetation associations highly affected (direct loss) by the mine would be the Sagebrush - Bluebunch Wheatgrass Association with 61.03 ha (151 acres) lost, the Douglas-fir - Bunchgrass Association with 53.65 ha (133 acres) lost, the Douglas-fir - Bunchgrass - Pinegrass Association with 45.91 ha (113 acres) lost, and the Kentucky Bluegrass Association with 31.92 ha (70 acres) affected (Table 5-12). Of this land area, 9.7 percent has been logged.

TABLE 5-12

AREA EVALUATION OF THE VEGETATION ASSOCIATIONS AFFECTED BY THE CONSTRUCTION OF THE PLANT, MINE, AND OFFSITE FACILITIES

FACILITY	TOTAL FACILITY AREA (ha)	Mountain Avens - Sedge Assoc.	Engelmann Spruce - Grouseberry Assoc.	Engelmann Spruce - Grouseberry - Pinegrass Assoc.	Engelmann Spruce - Grouseberry - White Rhododendron Assoc.	Engelmann Spruce - Willow - Red Heather Parkland Assoc.	Engelmann Spruce - Grouseberry - Lupine Assoc.	Douglas-fir - Pinegrass Assoc.	Douglas-fir - Bunchgrass Assoc.	Douglas-fir - Spirea - Bearberry Assoc.	Douglas-fir - Bunchgrass - Pinegrass Assoc.	Ponderosa Pine - Bunchgrass Assoc.	Riparian Assoc.	Engelmann Spruce - Horsetail Assoc.	Willow - Sedge - Bog Assoc.	Highland Grassland Assoc.
Plant																
CP1	(13.2)							(13.2)								
CP2	(0.02)							(0.02)								
CP3	0.06															
CP4	(0.02)							(0.04)								
CP5	(0.06)							(0.06)								
CP6	3.1							1.1	1.26							
P1	92.0							71.03								
P2	1.1															
P3	0.3															
P4	67.3			57.4				3.20								
P5	4.8			0.40				3.37								
Mine																
CM1	5.1										5.1					
CM2	0.02										0.02					
CM3	0.07										0.07					
CM4	0.02										0.02					
CM5	0.06										0.06					
CM6	1.5										1.5					
M1	115.0							10.07	20.64		13.9		0.89		0.33	
M3	40.0							2.11	15.98				2.41			
M14	29.5								4.93		22.64		1.49			
M16	2.8										2.8					
M17	30.1							9.5	12.2							
M18	2.8															
Offsite																
OO1	7.3												1.8			
OO2	30.1								1.9		19.11		0.33			
OO3	6.3								0.46		4.72					
OO4	31.5												10.4			
OO5	0.8															
OO7	120.0												4.06			
OO8	7.7			0.26				1.25			3.97					
OO9	6.9															
OO10	[illegible]															
OW1	39.0			0.32				15.24				0.54				
OW2	2.8															
OW3	1.6							1.6								
OW4	-															
OW6	0.02							0.02								
OW7	0.02							0.02								
OW8	1.6															
OT1	2.4								0.23		1.27					
OT2	10.6							0.99			7.77					
OT3	17.2							1.25								
OT4	21.2															
OT5	2.7															
OT7	3.2															
OA1	45.3															
OA4	4.5															
OF1	3.0															
OF2	-															
OF3	-															
OR1	120.0			4.85				39.34	0.81		33.74					
OR2	4.5							3.6								
OR3	0.8															
OR4	1.6															
OR5	0.6							1.0								
OR6	-															
OR7	-															
Mine Construction Subtotal	235.2							20.66	53.65		45.91		4.79		0.33	
Plant Construction Subtotal	168.7			57.80				70.70	1.26							
Offsite Construction Subtotal	470.4			9.49				64.31	3.22		60.58	0.54	17.37			
Construction TOTAL	880.3			67.37				169.69	58.13		114.49	0.54	22.16		0.33	
Hat Creek Local Study Area	167,110.	-	19,790.	10,340.	5,750.	1,090.	3,000.	47,860.	3,340.	80.	14,300.	1,390.	1,019.	620.	450.	910.
% of Local Study Area Affected by Construction	0.55			0.41				0.46	1.75		0.86	0.045	2.21		0.05%	

FACILITY	Kentucky Bluegrass Assoc.	Bunchgrass - Kentucky Bluegrass Assoc.	Sagebrush - Bluebunch - Wheatgrass Assoc.	Saline Depression Assoc.	Big Sage - Bunchgrass Assoc.	Cultivated Fields	Bunchgrass - Kentucky Bluegrass/Saline Depression Complex	Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass - Pinegrass Complex	Kentucky Bluegrass/Riparian Complex	Rock/Douglas-fir - Spirea - Bearberry Complex	Douglas-fir - Pinegrass/Douglas-fir - Spirea - Bearberry Complex	Mountain Avens - Sedge/High Land Grassland Complex	Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Complex	Exposed Rock	% of Forested Associations Logged
Plant															
CP1															
CP2															
CP3	0.06														
CP4															
CP5															
CP6	0.74														
P1	20.97														7%
P2	1.1														100%
P3	0.3														100%
P4	6.70														5%
P5	0.95														82%
Mine															
CM1															
CM2															
CM3															
CM4															
CM5															
CM6															
M1	0.56	1.17	58.31				1.17								47%
M3	18.35		3.72						7.43						6%
M14		0.74													
M16															
M17	12.41	0.38													
M18	2.6														
Offsite															
OO1							9.5								
OO2		0.76													30%
OO3									1.19						
OO4		1.1													
OO5		0.6				0.2									
OO7						47.81	67.35								
OO8	4.22														70%
OO9							6.9								
OO10															
OW1					14.31	4.59									64%
OW2						2.0									
OW3															
OW4															
OW6															100%
OW7															100%
OW8					0.2	1.4									
OT1									0.90						
OT2	1.04														
OT3					10.0	0.95									
OT4					21.04	0.16									
OT5					1.0	4.9									
OT7					3.2										
OA1				3.23	42.07										
OA4					4.5										
OF1					3.0										
OF2															
OF3															
OR1	23.94				12.0	1.0			2.46						47%
OR2	0.90														53%
OR3					0.8										
OR4					1.6										
OR5					0.6										
OR6															
OR7															
Mine Construction Subtotal	31.92	2.3	61.03				1.17		7.43						9.7%
Plant Construction Subtotal	30.76														7.0%
Offsite Construction Subtotal	33.0	10.26		3.23	123.11	59.01	79.75		4.46						12.3%
Construction TOTAL	95.68	12.56	61.03	3.23	123.11	59.01	80.92		11.89						10.6%
Hat Creek Local Study Area	4,660.	2,560.	670.	30.	19,990.	3,030.	2,170.	1,420.	630.	50.	600.	2,330.	800.	1,010.	10.1%
% of Local Study Area Affected by Construction	2.15	0.55	9.15	10.83	0.65	1.95	3.75		1.45						

The land area (vegetation associations) that would be alienated by the mine facilities would be completely devoid of natural vegetation because of excavation of the pit, waste dumps, and associated ancillary facilities. Reclamation plans should be drafted to return the disturbed areas such as the waste dumps into a productive state. However, these reclamation plans would deal mainly with the use of grass or grass-legume mixtures rather than native species. The effect of this reclamation plan on the natural vegetation associations will be discussed in Section 5.4(d), "Decommissioning".

Plant

The plant facilities would be located in the Trachyte Hills in the vicinity of Harry Lake. The plant would consist of construction camps, a make-up water reservoir, a pipeline between the reservoir and power plant, and the power plant itself. Except for the reservoir and pipeline, all the remaining facilities would be located within the confines of a fenced site of 92 ha (227 acres). The area within the fenced power plant site was considered completely alienated although some areas of native grassland may still persist.

The greatest relative impact in terms of direct loss would be the removal of the Douglas-fir - Pinegrass Association of 78.8 ha (194 acres) as shown in Table 5-12. The Engelmann Spruce - Grouseberry - Pinegrass Association of which 57.88 ha (143 acres) would be lost, and the Kentucky Bluegrass Association with 30.76 ha (76 acres) affected would also be significantly alienated by the plant construction facilities. The total amount of land lost by the plant construction facilities would be 168.7 ha (417 acres) or 0.1 percent of the local study area.

The make-up reservoir would mainly affect the Engelmann Spruce - Grouseberry - Pinegrass Association, while the Douglas-fir - Pinegrass Association would mostly be lost to the fenced power plant site. It was found that 7.0 percent of the total land area alienated by the plant construction facilities (168.7

ha or 417 acres) had been logged in the past.

Offsite Facilities

The offsite facilities constitute all the ancillary facilities necessary for the operation of the mine and power plant, such as transmission lines, pipelines and roads. These facilities would be distributed over a wide area from Hat Creek Valley to the Thompson Valley, concentrating in the valley bottoms. Table 5-12 lists the vegetation associations lost by the construction of the offsite facilities.

Most of the offsite facilities would consist of broad corridors running between the Thompson Valley and the plant and mine. These would contain roads, pipelines and transmission lines of varying right-of-way widths. The storage of water and the Hat Creek diversion canal are also considered to be part of the offsite facilities.

A diversity of environmental changes could follow the construction of the linear offsite facilities because of the large number of vegetation associations that could be affected. Transmission lines (69 kV) which supply power to the mine and plant during construction and operation and to the make-up water pumping stations, would have a minor effect on the native vegetation. The rights-of-way would be cleared of all tall, woody vegetation. Much of the 69 kV transmission system would pass through open range in which trees are absent and shrubs are sufficiently low so that no clearing would be necessary. Except for the small amount of land lost when the power line poles are put in place and small access roads, very little vegetation would be disturbed. In forested areas, trees within the right-of-way would be cut down and removed. Because most of the forest land affected by the Hat Creek 69 kV lines is sparsely treed and contains a grass understory, the impact would be insignificant.

Other linear facilities would have more significant impact upon the flora.

Water pipelines would be buried below the frost line. The right-of-way would be excavated, the pipeline laid and covered, and then the right-of-way reseeded to grass or grass-legume mixtures. As a result, the right-of-way would be substantially altered from its original natural floristic condition. The introduced species may invade the surrounding natural communities, which may have a beneficial or negative effect on the native communities.

The paved portion of the airstrip and road would permanently be lost in terms of vegetation. Substations, pumping stations, surge tanks and the railway offloading area would also irreversibly remove land from biological productivity.

The graded portion of the roadway and airstrip would be disturbed and often would be further modified by cut-and-fill slope and reseeding programmes. Borrow pits and soil storage areas could also result in a permanent vegetation loss. The interception of near-surface seepage water by the road could lead to dehydration of the vegetation associations below the road.

At present, two locations are being considered for the airstrip. The preferred site (Site A) would be located just west of Highway 1 and just south of Cornwall Creek in the Big Sage - Bunchgrass Association. The alternative site (Site C) would be in a cultivated field in the Semlin Valley. The airstrip configurations would be similar in total areas alienated for the preferred site and the alternative site.

The presence of the mine pit in the valley floor would require diversion of Hat Creek around the mine. Two environmental modifications would result from the Hat Creek diversion. First, Hat Creek and Finney Creek would be channelized. The old creek bed below the point of diversion would dry up and much of the Riparian Association would be destroyed. The Hat Creek diversion canal would traverse the pit and then descend to the original creek bed enclosed in a culvert. Secondly, the diversion of Hat Creek would necessitate the construction of two or three water storage reservoirs upstream of the diversion in order to regulate the flow of water in the Hat Creek diversion canal. These storage reservoirs would fill with water in the spring and empty throughout summer, fall and winter. These storage reservoirs would alienate mainly the Riparian Association and Bunchgrass - Kentucky Bluegrass/Saline Depression Complex. In addition, leakage from these reservoirs or diversion canals could alter the hydrologic conditions significantly to change the vegetation pattern near these facilities.

The offsite facilities would affect 476.4 ha (1177 acres) or 0.3 percent of the local study area (Table 5-12). Logging has disturbed 12.3 percent of the total area affected by the offsite construction facilities. The largest amount of land lost would be in the Big Sage - Bunchgrass Association, of which 123.11 ha (304 acres) would be alienated. The Bunchgrass - Kentucky Bluegrass/Saline Depression Complex would suffer a loss of 79.75 ha (197 acres); the Douglas-fir - Bunchgrass - Pinegrass Association, a loss of 68.58 ha (169 acres); the Douglas-fir - Pinegrass Association, a loss of 64.31 ha (159 acres); and Cultivated Fields, a loss of 59.01 ha (146 acres). Although the Riparian Association would lose a relatively small amount (17.37 ha or 43 acres), this represents a significant amount of its total extent found in the local study area.

Summary

In total, the construction of the mine, plant and offsite facilities would permanently alienate or disturb approximately 880 ha (2174 acres) or 0.5 percent of the local study area (Table 5-12). The proportional impact, relative to the geographic extent found in the local study area is expressed as a percentage. These percentages of area lost express an absolute impact because they relate the amount of each vegetation association impacted to the relative importance (direct loss) of that vegetation association in the local study area.

Table 5-12 shows that the impacts are spread unevenly among the vegetation associations with only 15 out of 29 vegetation associations and complexes being affected. The most significant impact would occur on the Saline Depression Association (10.8 percent affected), and the Sagebrush - Bluebunch Wheatgrass Association, with 9.1 percent of the association affected. Of lesser significance would be the Bunchgrass - Kentucky Bluegrass/Saline Depression Complex (3.7 percent), Riparian Association (2.2 percent), Kentucky Bluegrass Association (2.1 percent), Cultivated Fields (1.9 percent), Douglas-fir - Bunchgrass Association (1.7 percent), and Kentucky Bluegrass/Riparian Complex (1.4 percent).

C. Dust

During the construction activities, dust emissions may be a problem in the dry summer months. Dust would be generated from a number of activities during the construction of the power plant, mine and offsite facilities. The use of water spray trucks and some oiling where streams would not be affected is planned to control the dust, but the effectiveness of these measures is not known.

Dust acts on the vegetation by coating the photosynthetic surfaces (leaves), reducing the amount of light available for photosynthesis[58, 59]. Darley[59] also noted a reduction in carbon dioxide exchange rates on dusted versus non-dusted leaves. He utilized levels of 3.8 g/m^3 for 8- to 10-hour periods for two to three days. This produced a 30 percent reduction in CO_2 exchange. He concluded that the toxicity of dust depends on its chemical composition, particle size and deposition rate. Plants with a pubescent surface are most likely to catch dust and could be expected to be the most sensitive. However, dust may also influence the effect of other air pollutants on vegetation. Vasiloff and Drummond[60] found that road dust partially protected buckwheat (*Fagopyron esculentum*) from sulfur dioxide injury.

Additionally, Edmunds[61] reported increased populations of black pineleaf scale (*Nuculaspis californica*) where dusting was present. A positive correlation between scale-insect density and dustfall was demonstrated. The increase in the scale-insect densities was related to the high mortality of *Prospaltella* parasitoids due to dustfall, not the death of the scale-insects themselves. Death of the *Prospaltella* parasitoids was due to dessication. Bartlett[62] also demonstrated that dusts were lethal to parasitic *Hymenoptera*, some mineral dusts of small size killing in times ranging from 0.6 to 1.7 hours, 50 percent of *Aphytus* and *Metaphycus* confined in cages having 200 $\mu g/cm^2$ of dust.

In the context of Hat Creek, no known infestation of the black pineleaf scale are present. However, Reid, Collins and Associates Ltd.[49] report known infestations around Lytton and in the Botanie Valley on ponderosa pine (*Pinus ponderosa*). The close proximity of these areas to Hat Creek could lead to outbreaks in the Hat Creek Valley.

The exact quantities of dust produced during the construction phase is not known, but it is expected that high, localized dust emission concentrations may occur along unpaved roads, scraping and stripping off vegetation on project areas such as the plant site, certain offsite facilities that require site clearing and mine site preparation.

It is difficult to assess the impact dusting may have on the vegetation, since the actual adequacy of the dust suppression techniques proposed is not known. However, the temporary, localized nature of many of the construction activities and use of water and oil on heavily travelled improved roads should preclude any significant impact on vegetation. The operation phase would undoubtedly have a greater impact which will be discussed in Section 5.2(c)(i)C.

Besides the restriction of the photosynthetic efficiency and CO_2 exchange, dust particles contain trace elements that may be absorbed by the plant through the stomata in a water soluble form. The surface soils generally contain a lower content of potentially mobile trace elements than the overburden and waste rock because of a longer weathering period. Once the overburden and waste rock are exposed by the mining operation and dusting occurs, mobile water soluble trace elements may be released and taken up by the plants in sufficient quantities to cause injury. However, the localized distribution of dust and the proper use of dust suppression techniques may preclude a significant impact on the vegetation by trace elements.

D. Waste Disposal

Waste disposal during the construction phase would be insignificant because only small volumes of the north valley waste dump and the sewage water from the construction camps of the mine and plant would be in operation at this stage. Wastes would become more significant when larger volumes would be created during the operation phase.

The sewage disposal for the plant and mine construction camps would be treated. At the plant site, the treated effluent would be pumped into a deep well impoundment basin near Harry Lake. With respect to the mine, deep well disposal together with spray irrigation would probably be chosen. A landfill in the vicinity of the mine would be used to dispose of solid wastes.

A description of the waste dump disposal methods and their possible impacts will be discussed under "Operation", Section (c).

The impact of the sewage disposal from the mine and plant is thought to be insignificant. In the dry belt, a beneficial effect could result because of an increase in water and nutrient status in the soils.

The landfill, on the other hand, could present problems from toxic leachates if not stored properly. These toxic leachates may destroy neighbouring vegetation. The location of the landfill should be situated such that the seepage and runoff water can be contained. Lining with impervious mine waste to prevent seepage water from entering the groundwater could be an alternative.

E. Indirect Changes

The major indirect change that may affect the vegetation pattern during the construction phase could be interception or interference with the near-surface seepage water. Many of the vegetation associations found in the local study area are dependent on this seepage water for their nutrient and water supply. Critically dependent are the Saline Depression and Willow - Sedge Bog associations. Other associations may not be as dependent on seepage water, but would show a decrease in productivity if disturbed.

The major activities that may interfere with the near-surface seepage water regime during the construction phase could be the main access road, Hat Creek diversion canal, Finney Creek diversion canal, power plant site access road and the conveyors. The extent these activities may affect the vegetation is difficult to assess until the exact nature and location of seepage areas are known. However, in the relatively dry climate of the Hat Creek area, the seepage areas are thought to be small and localized. In addition, the loss in productivity would be difficult to assess without long-term studies.

The above-mentioned facilities are all related to offsite developments. With respect to the mine and plant facilities, the interference with seepage water is expected to be minimal because of the location and size of these facilities. For example, the majority of the plant and mine facilities are large, site-specific features rather than linear and occur mainly in the valley bottoms or at the top of the ridges. Therefore, the chance of crossing potential seepage areas would be minimized.

(ii) Resource Projection - Impact of Project

The construction phase of the Hat Creek project would be expected to alienate 880.3 ha (2175 acres) or 0.5 percent of the various vegetation associations found in the local study area. This is approximately one-quarter of the area that would be alienated during the operation phase. The majority of the alienation during the construction phase would be a result of the development of the offsite facilities (476.4 ha or 1180 acres).

The greatest impact in the construction phase would be the result of the direct loss of important vegetation associations. Indirect changes in vegetation may be attributed to linear corridors such as roads, pipelines and drainage canals due to interception of seepage water. However, this impact is difficult to assess until it is known if and where seepage water is present.

Dusting from all construction activities would appear to have a minor effect on the vegetation associations if design criteria and control measures are effective. In any case, the effects of these would be very localized.

As discussed earlier, sewage disposal for the mine and plant would be done by deep well disposal and possibly a minor portion would be disposed of by spray irrigation. Sewage would be of minimal significance in determining the impact on vegetation. The spray irrigation method would probably be beneficial because of the addition of water and nutrients to the soil.

Assessment of the impact of the construction phase was done by comparing the amount lost (Table 5-12) and its location (Map 5-1) to the vegetation association's relative sensitivity (Table 5-11). This was completed separately for plant, mine and offsite related facilities.

A. Plant

The plant associated construction facilities that would have the most significant impact on the vegetation associations are the power plant site (P1) and the make-up water reservoir (P4). These two facilities would alienate portions of the Engelmann Spruce - Grouseberry - Pinegrass, Douglas-fir - Pinegrass, and Kentucky Bluegrass associations. All of these vegetation associations have been rated as having a low sensitivity to disturbance. Therefore, the impact on the vegetation resource would be minimal. Only the power plant construction camp water supply pipeline (CP6) would affect a small portion (1.26 ha or 3 acres) of the Douglas-fir - Bunchgrass Association that has been rated as moderately sensitive. It should be noted that a total of eight percent of the forested associations has been previously disturbed by logging.

B. Mine

The construction of the mine would affect a far greater number of vegetation associations than the plant, including several rated as highly sensitive. Significant impact would accrue to the Sagebrush - Bluebunch Wheatgrass Association, while the remaining highly sensitive associations would have only a small amount alienated. Open pit #1, north valley waste dump, coal blending areas, and the coal conveyors by their size and fact that they would affect a high proportion of both moderate and highly sensitive vegetation associations have the greatest impact. The following highly sensitive vegetation associations would be affected: Riparian, Willow - Sedge Bog, Sagebrush - Bluebunch Wheatgrass associations, and the Kentucky Bluegrass/Riparian Complex. In addition, the Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass associations, rated as moderately sensitive, would be affected.

The high sensitivity ratings assigned to the Riparian and Willow - Sedge Bog associations result from a high rating in all six categories assessed (Table 5-11), especially floristic diversity and productivity. The Sagebrush - Bluebunch Wheatgrass Association was given a high sensitivity rating mainly because of its relative scarcity in the local study area. The Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass associations carry moderate sensitivity ratings because of their poor reclaimability, especially where they occur on steep slopes.

The greatest impact during mine construction would be due to the excavation of open pit #1 in which 58.31 ha (144 acres) of the Sagebrush - Bluebunch Wheatgrass Association is lost, as well as 0.89 ha (2 acres) of the Riparian Association and 0.33 ha (.82 acres) of the Willow - Sedge Bog Association. This loss to the Sagebrush - Bluebunch Wheatgrass Association represents 8.7 percent of the total found in the local study area. The north valley dump would alienate a total of 48.0 ha (118 acres) of which 15.98 ha (38 acres) of the Douglas-fir - Bunchgrass, 2.41 ha (6 acres) of the Riparian, 3.72 ha (9.2 acres) of the Sagebrush - Bluebunch Wheatgrass associations are affected. The coal blending area would alienate 22.4 ha (55 acres) of the Douglas-fir - Bunchgrass - Pinegrass Association (moderate sensitivity) but only 1.49 ha (3.7 acres) of the highly sensitive Riparian Association would be affected.

Other mine associated facilities would affect low sensitivity vegetation associations or very small quantities of moderately sensitive areas.

C. Offsite Facilities

The offsite facilities comprise many types and sizes of facilities for both the construction and operation of the mine and plant. The total offsite facility area is 476.4 ha (1177 acres). The offsite facilities extend from the Thompson Valley to Hat Creek Valley and would affect a variety of different vegetation associations. Most offsite facilities are quite small and would alienate a small portion of each vegetation association. However, several linear facilities such as the main road (OR1), Hat Creek diversion canal (OD2), and make-up water pipeline from Thompson River (OW1), are present that would alienate both a substantial amount of the vegetation associations and a large number of them.

The majority of the impact from the offsite facilities would appear to be on the Douglas-fir - Pinegrass, Kentucky Bluegrass, and Big Sage - Bunchgrass associations, all rated as having a low sensitivity. In addition, major impacts could occur on the Douglas-fir - Bunchgrass - Pinegrass Association and Cultivated Fields, having a moderate and high sensitivity, respectively. The only other vegetation association possessing a high sensitivity that could be impacted by the offsite facilities is the Riparian Association.

The high sensitivity of the Cultivated Fields which is not rated on Table 5-11 is derived from its high productivity and importance to agriculture and livestock.

The Site 2 storage reservoir and dam (OD7) appears to have the greatest impact on high sensitivity vegetation associations, mainly the Cultivated Fields (47.81 ha or 119 acres) and Riparian Association (4.84 ha or 12 acres). The pit rim reservoir and dam (OD4) also affects 10.4 ha (26 acres) of the Riparian Association.

The remaining major impacts would be to the Douglas-fir - Bunchgrass - Pinegrass Association (moderate sensitivity) from the construction of the Hat Creek diversion canal (19.11 ha or 47 acres) and main access road (33.74 ha or 83 acres). However, with both of these facilities, a significant proportion has been previously disturbed by logging. Thirty-eight percent and 42 percent of the Hat Creek diversion canal and main access road respectively have been previously logged. This generally reduces the impact because the natural vegetation has already been altered, and many non-representative plant and soil disturbances are present. Much of the moderate sensitivity from this association would be a result of its difficult reclaimability once disturbed.

The remaining impacts from the other offsite facilities would be either on vegetation associations regarded as having a low sensitivity or very minor impacts in terms of area on moderate or high sensitivity vegetation associations.

In terms of direct loww, all the offsite facilities would remove portions of the natural vegetation associations, some facilities such as the 69 kV transmission lines (OT1 to OT5) and make-up water pipeline from Thompson River (OW1) could be revegetated with either natural plant species or commercial grass-legume mixtures. Consequently, some type of vegetation community is established that is available for natural plant invasion. In the case of the 69 kV transmission lines where they cross open range vegetation association, no clearing or disturbance to the natural vegetation should be necessary.

D. Airport Alternatives

Two alternative airport locations have been suggested and are under consideration: Site A, which is the preferred site would be located in the Thompson Valley near Cornwall Creek, or Site C, which would be located in the Semlin Valley. Site A would alienate 45.3 ha (111.9 acres), while the Site C airport would alienate 37.0 ha (90.0 acres). The access road for Site A would alienate 4.5 ha (11.1 acres). While no information is available on the access road into the Site C airport, its close proximity to Highway 97 indicates that it would be much shorter than the Site A access road.

Site A plus access road would affect 46.57 ha (115 acres) of the Big Sage - Bunchgrass Association (low sensitivity) and 3.23 ha (8 acres) of the Saline Depression Association which is rated as moderately sensitive (Tables 5-11 and 5-12). The Site C airport would affect 37.0 ha (90 acres) all within highly sensitive Cultivated Fields.

Although Site A would alienate a larger area, its overall sensitivity would be low. Site C would affect highly productive and sensitive Cultivated

Fields. Consequently, Site A is would be the preferred site from a vegetation standpoint.

E. Summary

Table 5-13 summarizes the impacts of the construction of the plant, mine and offsite facilities by sensitivity class. This table indicates major impacts on high and moderately sensitive vegetation associations from the development of the offsite and mine facilities. The construction of the plant appears to have very little effect on high or moderately sensitive vegetation associations. The plant, mine and offsite facilities can be ranked as follows in terms of overall impact during the construction phase in decreasing order of impact: offsite, mine and plant.

Overall, the greatest impact would result from open pit #1 (M1), north valley waste dump (M3), pit rim reservoir and dam (OD4), and Site 2 storage reservoir and dam (OD7). These facilities affect the Sagebrush - Bluebunch Wheatgrass Association and Cultivated Fields to the greatest extent. The Sagebrush - Bluebunch Wheatgrass Association is rated as having a high sensitivity mainly on the basis of its relative scarcity within the local study area. As far as the other scoring parameters are concerned, this association rates quite low. However, its sensitivity to development is rated high because the soils are erosion-prone and have poor reclaimability. The exact ecological status of this association in a regional context is difficult to assess since very few detailed ecological studies have been carried out. The only other study of this association is by McLean[O7] in the Similkameen Valley. Consequently, the exact direct loss of this association is difficult to evaluate without further studies into its importance and distribution in the Interior Douglas-fir Zone.

The Cultivated Fields represent a vegetation type that is highly productive and generally has been altered by the use of irrigation to increase the productivity. The vegetation can be crop species, such as timothy and alfalfa, or native range. However, because of limitations such as topography and

TABLE 5-13

AREA WITHIN EACH SENSITIVITY CLASS ALIENATED BY THE CONSTRUCTION OF THE PLANT, MINE, AND OFFSITE FACILITIES (HA)

Sensitivity	Plant	Mine	Offsite	Construction Total	Major Vegetation Associations Affected
High	-	73.58	80.84	154.42	Sagebrush - Bluebunch Wheatgrass Association Cultivated Fields Riparian Association
Moderate	1.26	98.39	154.78	254.43	Douglas-fir - Bunchgrass - Pinegrass Association Douglas-fir - Bunchgrass Association Bunchgrass - Kentucky Bluegrass/Saline Depression Complex
Low	167.34	60.90	240.71	468.95	Douglas-fir - Pinegrass Association Engelmann Spruce - Grouseberry - Pinegrass Association Kentucky Bluegrass Association Big Sage - Bunchgrass Association

soils, the irrigable acreages are relatively small and located in the bottom lands of the valleys. It was felt that, from a vegetation standpoint, these areas should be rated highly sensitive. A further analysis of cultivated lands can be found in the Agriculture Report[50].

The Riparian Association would also be significantly affected with 2.2 percent alienated during the construction phase (Table 5-12). This association is one of the most floristically diverse and has the highest productivity of any of the vegetation associations found in the local study area. It borders stream courses and is important in the prevention of streambank erosion and sedimentation.

Impacts of the above mentioned vegetation associations would be total (non-mitigable) since the reasons for the high sensitivities result from intrinsic vegetation properties. In terms of the Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass associations (moderate sensitivities), the sensitivity rating evolves from the erosion potential of their soils on steep slopes (> 30 percent) and poor reclaimability. Both these problems can be controlled with proper construction techniques and some relocation around the steeper slopes.

No rare or endangered plants have been encountered during the field surveys. Possible impact would be to showy spring flowers, such as shooting star (*Dodecathon pauciflorum*), spring beauty (*Claytonia lanceolata*) and yellow bells (*Fritillaria pudica*) that are common throughout the open range areas of Hat Creek Valley.

Further analysis of the vegetation will be done in the context of the biophysical impact analysis where the relationship of soils, vegetation and slope can be analyzed in homogeneous units.

(c) Operation

(i) Environmental Changes

This section deals with the direct loss of each vegetation association associated with the operation of the mine and power plant. As indicated earlier, the mine's extent is arbitrarily divided into construction and operation facilities. Fifteen percent has been allocated to construction and 85 percent allocated to the operation phase. During the operation phase, the northern Hat Creek Valley would experience a considerable amount of physical disturbance. The pit would continue to expand, producing large amounts of coal, overburden and waste rock. This material would be transported to the appropriate coal storage or waste dumps located in the northern portion of the Hat Creek Valley. A series of catchment ditches would be required around the circumference of the mine and waste dumps to prevent surface and near-surface seepage water from flowing into the pit or runoff from the waste dumps from contaminating the groundwater supply. An estimated six lagoons would be necessary to collect this water.

The operation of the plant would alienate lands by disposal of ash. The large quantities of fly and bottom ash produced by the power plant would be disposed of in ponds. This represents the major impact in the operation of the power plant except for the possible wide-ranging effects of the air emissions produced.

A. Qualitative Assessment

The qualitative assessment for the operation of the plant is the same as outlined for the construction phase, Section 5.4(b)(i)A.

B. Direct Loss

Mine

The impact of the mine facilities would be relatively severe because of the amount of the natural vegetation associations lost. Table 5-14 indicates

TABLE 5-14

AREA EVALUATION OF THE VEGETATION ASSOCIATIONS AFFECTED BY THE OPERATION OF THE MINE AND PLANT FACILITIES

Facility	Total Facility Area (ha)	Exposed Rock	Mountain Avens - Sedge Assoc.	Engelmann Spruce - Grouseberry Assoc.	Engelmann Spruce - Grouseberry - Pinegrass Assoc.	Engelmann Spruce - Grouseberry - White Rhododendron Assoc.	Engelmann Spruce - Willow - Red Heather Partland Assoc.	Engelmann Spruce - Grouseberry - Lupines Assoc.	Douglas-fir - Pinegrass Assoc.	Douglas-fir - Bunchgrass Assoc.	Douglas-fir - Spirea - Bearberry Assoc.	Douglas-fir - Bunchgrass - Pinegrass Assoc.	Ponderosa Pine - Bunchgrass Assoc.	Riparian Assoc.	Engelmann Spruce - Horsetail Assoc.	Willow - Sedge - Bog Assoc.	Highland Grassland Assoc.	Kentucky Bluegrass Assoc.	Bunchgrass - Kentucky Bluegrass Assoc.	Sagebrush - Bluebunch - Wheatgrass Assoc.	Saline Depression Assoc.	Big Sage - Bunchgrass Assoc.	Cultivated Fields	Bunchgrass - Kentucky Bluegrass/Saline Depression Complex	Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass - Pinegrass Complex	Kentucky Bluegrass/Riparian Complex	Rock/Douglas-fir - Spirea - Bearberry Complex	Douglas-fir - Pinegrass/Douglas-fir - Spirea - Bearberry Complex	Mountain Avens - Sedge/Highland Grassland Complex	Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Complex	% of Association Logged
Mine																															
M1	652.0								102.41	116.97		78.77		5.06		1.90		3.16	4.63	330.43				6.63							37.0%
M2	487.2								114.48			231.99						138.13	2.80												8.0%
M4	615.1	2.23							365.00	5.72		4.52						126.04							111.49						72.0%
M5	1.2																	1.2													
M6	0.4																								0.4						
M7	0.4								0.6																						
M8	0.8											0.8																			
M9	0.5											0.5																			
M10	0.5																													0.5	
M11	22.0											22.0																			
M12	61.8																			32.26				29.34							
M13	99.6								10.05			32.58						55.16	1.61												
M15	123.5								66.7			7.4						49.4													
M19	35.0				1.01				15.94	0.16		6.04						5.99	0.08	0.54				1.8	1.43						41.6%
Plant																															
P6	660.7				30.48				316.75							8.06		305.41													
P7	12.9				0.48				11.12									1.3													45.0%
Mine Operation	2,100.4	2.23			1.01				474.38	122.85		385.40		5.06		1.90		379.08	10.92	363.23				37.96	115.32					0.5	24.5%
Plant Operation	673.6				30.96				327.87							8.06		306.71													6.7%
Operation Total	2,774.2	2.23			31.97				1002.85	122.85		385.40		5.06		9.96		685.79	10.92	363.23				37.96	115.32					0.5	19.7%
Hat Creek Local Study Area	162,110.	700.	-	19,790.	18,340.	5,750.	1,090.	1,003.	47,850.	3,340.	80.	14,300.	1,190.	1,010.	620.	650.	910.	4,660.	2,560.	670.	30.	19,990.	3,030.	2,170.	1,420.	830.	50.	600.	2,330.	1,010.	10.1%
% of Local Study Area Affected by Operation	1.7%	0.3%			0.2%				2.0%	4.0%		2.7%		0.5%		1.5%		14.7%	0.4%	54.2%				1.7%	8.1%					0.05%	

that a total of 2100.6 ha (5188 acres) would be disturbed by the mining operation over its 35-year life. Most of this activity would result in a permanent loss of the natural vegetation. The reclamation plans would revegetate the waste dump areas, but this may significantly alter the present vegetation pattern.

The vegetation association with the greatest land area lost would be the Douglas-fir - Pinegrass Association with 674.98 ha (1667 acres). The Douglas-fir - Bunchgrass - Pinegrass Association would follow with 385.4 ha (952 acres), the Kentucky Bluegrass Association with 379.08 ha (936 acres), and the Sagebrush - Bluebunch Wheatgrass Association with 363.23 ha (897 acres) in area lost.

Plant

Four basic schemes have been advanced for disposing of ash[53]. The base scheme of one wet ash pond for both fly and bottom ash, an alternative using the same wet ash pond for fly ash and adding a bottom ash dump, and two configurations of separate dry fly and bottom ash dumps. The lands under eash proposed ash disposal site would be temporarily lost and, after reclamation, would be permanently altered.

Table 5-15 compares the vegetation associations that would be alienated by the four ash disposal schemes, including the provision for land alienated by the ash transportation system. In total, the base scheme would alienate 673.6 ha (1664 acres), mainly within the Douglas-fir - Pinegrass and Kentucky Bluegrass associations. The wet plus dry disposal alternative would alienate the same area plus an additional 180.6 ha (446 acres) in the grasslands (Kentucky Bluegrass Association) southwest of the power plant for a total of 854.2 ha (2111 acres). The dry ash schemes would alienate substantially less land than the two wet ash disposal schemes. The dry ash scheme #1 would alienate 303.6 ha (750 acres) in the Kentucky Bluegrass, Douglas-fir - Pinegrass, and Douglas-fir - Bunchgrass - Pinegrass associations.

TABLE 5-15

COMPARATIVE ANALYSIS OF THE BASE ASH DISPOSAL SCHEME*
WITH THE THREE ALTERNATIVE METHODS OF ASH DISPOSAL

Ash Disposal Schemes	Total Facilities Area (ha)	Engelmann Spruce - Grouseberry - Pinegrass Association	Douglas-fir - Pinegrass Association	Douglas-fir - Bunchgrass - Pinegrass Association	Willow - Sedge Bog Association	Kentucky Bluegrass Association
Base Scheme	673.6	30.96	327.87		8.06	306.71
Wet Alternative Ash Pond for Fly Ash; Dry Dump for Bottom Ash	854.2	37.48	359.71	8.48	8.06	440.47
Difference from Base Scheme	+180.6	+ 6.52	+ 31.84	+ 8.48	0	+133.76
Dry Ash Scheme #1	303.6		59.84	24.25		219.51
Difference from Base Scheme	-370.0	-30.96	-268.03	+24.25	-8.06	- 87.2
Dry Ash Scheme #2	260.5		45.79	22.13		192.58
Difference from Base Scheme	-413.1	-30.96	-282.88	+22.13	-8.06	-114.13

* wet ash disposal scheme

Dry ash scheme #2 would create a loss of 260.5 ha (643 acres) in the same area as dry ash scheme #1, and affect approximately the same proportion of the vegetation associations.

Offsite Facilities

No direct loss of the vegetation associations would be expected from the operation of the offsite facilities.

Summary

The total amount of the vegetation associations that would be affected by the operational aspects of the Hat Creek project is given in Table 5-14 for the base plan. The greatest proportional impacts compared to the local study area would be upon the Sagebrush - Bluebunch Wheatgrass Association (54.2 percent of the local study area), Kentucky Bluegrass Association (14.7 percent), Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass - Pinegrass Complex (8.1 percent), Douglas-fir - Bunchgrass Association (4.0 percent), and Douglas-fir - Bunchgrass - Pinegrass Association (2.7 percent). Of the operational total, 19.3 percent has been logged.

Table 5-16 summarizes the total impact of both construction and operation of the mine, plant and offsite facilities on the vegetation associations. This table clearly shows that the Sagebrush - Bluebunch Wheatgrass Association would suffer the greatest loss with 424.25 ha (1048 acres) or 63.3 percent of that found in the local study area affected. This would be a severe depletion of this vegetation association. The Kentucky Bluegrass Association would also suffer considerable depletion with 16.8 percent of that found in the local study area affected. In addition, the Saline Depression Association (10.8 percent), Douglas-fir - Spirea - Bearberry/Douglas-fir - Pinegrass - Bunchgrass Complex (8.1 percent) and Douglas-fir - Bunchgrass Association (5.4 percent) would substantially be impacted.

The total project impact would be 3654.5 ha (9027 acres), which represents

TABLE 5-16

SUMMARY OF THE CONSTRUCTION AND OPERATION FACILITIES ASSOCIATED WITH TOTAL HAT CREEK PROJECT

Vegetation Associations	Project Total (ha)	Hat Creek Local Study Area (ha)	% of Local Study Area Affected by Construction and Operation
Exposed Rock	2.23	700.0	0.3%
Engelmann Spruce - Grouseberry - Pinegrass Assoc.	99.34	18,340.0	0.5%
Douglas-fir - Pinegrass Assoc.	1,172.54	47,860.0	2.4%
Douglas-fir - Bunchgrass Assoc.	180.98	3,340.0	5.4%
Douglas-fir - Pinegrass - Bunchgrass Assoc.	499.89	14,300.0	3.5%
Ponderosa Pine - Bunchgrass Assoc.	0.54	1,390.0	0.03%
Riparian Assoc.	27.22	1,010.0	2.7%
Willow - Sedge Bog Assoc.	10.29	650.0	1.6%
Kentucky Bluegrass Assoc.	781.47	4,660.0	16.8%
Bunchgrass - Kentucky Bluegrass Assoc.	23.48	2,560.0	0.9%
Sagebrush - Bluebunch Wheatgrass Assoc.	424.26	670.0	63.3%
Saline Depression Assoc.	3.23	30.0	10.8%
Big Sagebrush - Bunchgrass Assoc.	123.11	19,990.0	0.6%
Cultivated Fields	59.01	3,030.0	1.9%
Bunchgrass - Kentucky Bluegrass/Saline Depression Complex	118.9	2,170.0	5.5%
Douglas-fir - Spirea - Bearberry/Douglas-fir - Pinegrass Bunchgrass Complex	115.32	1,420.0	8.1%
Kentucky Bluegrass/Riparian Complex	11.89	830.0	1.4%
Douglas-fir - Bunchgrass/Douglas-fir - Spirea - Bearberry Complex	0.5	1,010.0	0.04%
TOTAL	3,654.5	162,110.0	2.3%

0.5 percent of the local study area. Of this project total, 17.5 percent have already been disturbed by logging.

C. Dust

Dust would be a major operational problem during the open pit mine operation. Very little dusting would occur from plant and offsite operation, except where unpaved access roads are present. Sources of dust emissions during the mine operation would include: overburden removal, coal removal, haul road vehicular movements and wind erosion. Scraping, blasting, loading, hauling and shovel operations are the activities most likely to create dust emissions. The conveyors carrying coal and mine wastes would be covered and, therefore, would show little dusting potential. Environmental Research and Technology, Inc.[63], with the use of computer modelling, estimate a total of 2,288,800 kg/yr (5,045,890 lbs/yr) of dust emissions based on the maximum level of activity for the year 2017-2018. The major source of dust emissions appears to be wind erosion from exposed soil surfaces (941,000 kg/yr or 2,074,529 lbs/yr). The overburden haul road follows with 381,000 kg/yr (838,200 lbs/yr) of dust generated. These values assume the following dust suppression techniques:

(1) frequent watering of haul roads and exposed surfaces would reduce dust emissions by 50 percent;
(2) a speed limit of 24 km/hr (15 mph) on all haul roads to give a control efficiency of 80 percent;
(3) land reclaimed from the waste dumps midway in the life of the mine (year 2005-2006) was assumed to be the only reclaimed area by the model year 2017-2018; and
(4) the conveyor system would be completely enclosed resulting in 100 percent control.

However, Environmental Research and Technology, Inc.[63] state that many mining activities occur below the ground level, which should exert a considerable influence on reducing the resulting amounts of suspended particulates.

The highest concentrations would be found closest to the mining areas. Annual average concentrations exceeding background levels by 30 μg/m³ or greater would extend approximately four km (2.5 mi.) from the mine. Annual average concentrations of 10 μg/m³ above background would occur up to 10 km (6 mi.) from the mine. The worst case 24-hour dust emission ranging from greater than 700 μg/m³, very close to the mine, to 300 μg/m³, beyond approximately 7 km (4 mi.) could occur with meteorological conditions of very low wind speeds and a stable atmosphere. The meteorological conditions assumed in the worst case 24-hour modelling rarely occur[63].

The model for predicting the above values assumes that all dust emitted remains suspended and the land contains no terrain features[63].

The fact that the mine occurs in Hat Creek Valley means that dust emitted at this source would probably impinge on the adjacent benchlands and sideslopes rather than move out of the valley, thus, localizing the dust emissions to some extent within Hat Creek Valley.

As outlined in Section 5.2(b)(i)C. on the effects of construction-oriented dust problems, vegetation has been shown to be affected by dust in a reduction of photosynthesis, reduction of CO_2 exchange, and an increase in insect-scale densities as a result of a reduction in parasitic insect populations. Little information exists on the exact levels causing damage. Darley[59] reports levels of 28,000 μg/m³ for 8- to 10-hour periods for two to three days reduce CO_2 exchange 30 percent while Bartlett[62] found 0.6 to 1.7 hour exposures of 200 μg/cm² of dust, killed 50 percent of *Aphytus* and *Metaphycus* insects. These levels are well above the worst case 24-hour level expected at Hat Creek. However, consistent exposure to low levels of dust without any precipitation, as might occur during the dry summer months, may cause a buildup of a dust layer on the leaf surfaces, thus, increasing the chances of vegetation damage from dusting.

D. Air Emissions

The following discussions are a synopsis of the possible impacts of sulfur dioxide, oxides of nitrogen, carbon monoxide, hydrocarbons, ozone, fluoride, acid precipitation and cooling tower emissions from the proposed Hat Creek power plant on the vegetation of the local and regional study areas. The data presented for sulfur dioxide and sulfur dioxide/nitrogen dioxide interaction was has been taken from Appendix F of this report, by Dr. V.C. Runeckles, Department of Plant Science, University of British Columbia. The impacts of fluorides have been compiled by Dr. H. Bunce of Reid, Collins and Associates Ltd.[49].

The Hat Creek coal deposit, which is to be mined to provide the fuel for the proposed 2000 Mw thermal generating station, contains an appreciable amount of sulfur. The sulfur dioxide formed during its combustion would represents the major emission into the atmosphere, after carbon dioxide and water vapour. Other emissions to the atmosphere would include oxides of nitrogen, carbon monoxide, hydrocarbons and fluorides, as well as a wide range of trace elements largely in the form of particulates[63]. Since SO_2 would be the major emission into the atmosphere in terms of possible vegetation injury at the predicted levels, major emphasis has been placed on this emission, especially its interaction with NO_x emissions. Consequently, a major portion of the subsequent assessment is based on the effects of SO_2/NO_2 emissions on vegetation.

For assessment purposes, the area surrounding the proposed Hat Creek operations is divided into a local zone of influence of 25 km radius centered on the proposed thermal generating station, and a regional zone of influence covered by a 100 km radius. Environmental and Research Technology, Inc. has developed models of projected levels of SO_2 throughout the year for both local and regional zones[63]. These projections have formed the basis for the present assessments of injury to vegetation caused by SO_2, oxides of nitrogen (particularly nitrogen dioxide, NO_2), carbon monoxide, hydrocarbons, and fluorides (as hydrogen fluoride, HF). Similar modelling by ERT[64] has permitted assessment of the effects of cooling tower emissions.

Alternative strategies exist for the operation of the thermal power generating station, and the design of the station and its components[65]. For the present report, assessments of the impacts of emissions from an uncontrolled 366 m (1200 ft.) stack under base load conditions (2000 Mw) have been developed first, and the assessment methodology has then been applied to three alternative systems:

366 m (1200 ft.) stack with partial flue gas desulfurization (FGD),
366 m (1200 ft.) stack with meteorological control (MCS),
244 m (800 ft.) stack with meteorological control (MCS).

The 366 m stack FGD systems proposed involve the diversion of part of the flue gas through wet scrubbers, leading to an approximate halving of the emissions of SO_2. However, while the system reduces soluble constituents of the flue gas, it inevitably results in the increased discharge of water vapour. The present assessment of impact on vegetation is based upon an FGD system in conjunction with a 366 m (1200 ft.) stack.

The remaining two strategies involve meteorological control systems (MCS). An MCS is a systematic sequence of defined procedures designed to result in a reduction in the rate of emission of airborne pollutants whenever meteorological forecasts indicate that high ground-level concentrations may occur. In the case of the Hat Creek project, evidence has been presented for two procedures by which MCS could operate: by load reduction, or by switching to a low-sulfur fuel. The two MCS strategies for which assessments are presented are for the two stack heights: 366 m (1200 ft.) and 244 m (800 ft.).

For each control strategy, a local zone of influence modelling within a 25 km radius of the stack has been conducted by ERT as described elsewhere[63, 66]. The ERT projections have been developed on a base of meteorological data from within the study area over a 12-month period, in conjunction with knowledge of the local topography. The Hat Creek model, a point-source Gaussian diffusion model, has been used to predict hourly ground-level concentrations of SO_2 throughout the year at each of 128 receptor sites arranged in rows of eight, radiating from the stack in each of the 16 points of the compass.

The hourly projections for the uncontrolled situation have been used as the basis for preparing compilations of 3-hour, 8-hour, 24-hour, seasonal (3-month) and annual average SO_2 concentrations. After selecting appropriate threshold concentrations for each averaging period, the number of SO_2 excursions above threshold have been computed for each site and plotted as frequency isopleths. Such procedures, accompanied by information as to the maximum concentrations reached at each receptor site during the year, provide an initial overview of the probable magnitudes of ground-level fumigations.

In order to obtain projections for the three control strategies, the base data for the uncontrolled situations have been modified as follows. For MCS, appropriate action (whether load reduction or fuel switching) was presumed to be effective in meeting specified criteria. The 3-hour and 24-hour concentration criteria used are:

Averaging Time	SO_2 Concentration ($\mu g/m^3$)	Basis
3-hour	655	Afton Smelter Permit
24-hour	260	B.C. PCB Level B

The same criteria have been used in the FGD case, but no intermittent action was invoked, the system simply being allowed to function with its scrubbers assumed to be continuously achieving 54 percent removal of SO_2 from the flue gas. The frequency isopleths (at a scale of 1:250,000) for the various averaging times for each strategy are reported elsewhere, together with the maximum predicted ground-level concentrations for each averaging time within the year[63].

While such a form of presentation of the data provides a general overview of the area within the local zone of influence which may receive concentrations of SO_2 above a given threshold, the assessment of vegetational injury requires a more detailed analysis of the projected concentrations, hour-by-hour, and receptor site-by-receptor site. Recourse has been made to PEAK programmes prepared by ERT[67], which provided a detailed print-out of 1-hour, 3-hour and 24-hour average concentrations for each of the three control strategy situations. For these PEAK programmes[67], the threshold selected for each averaging time has been at or below the most stringent B.C. Pollution Control Board standard. Thus, the threshold for 1-hour averages is 255 $\mu g/m^3$, for 3-hour averages is 300 $\mu g/m^3$, and for 24-hour averages is 160 $\mu g/m^3$. The selection of the ultra-low 1-hour threshold has been made in order to obtain information about the hour-by-hour concentration changes prior to and after the predicted occurrence of hourly peaks of significant magnitude, and in order to determine the temporal relationships of such peaks, both of which have an important bearing on injury to vegetation.

In order to provide quantitative assessments of injury 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. A particular problem is that the majority of such reports concern experimental data collected under "artificial" conditions. Hence, extrapolation to field conditions is fraught with difficulty. Nevertheless, for most species, such data are the only data which are available and, hence, have had to be used in the present injury assessments. Mention should also be made of the fact that, almost without exception, the published data concern "acute" injury rather than "chronic" injury and, hence, suffer further 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. Some of these environmental variables include season of year, time of day, genetic variability, edaphic factors and a mixed vegetation pattern (Appendix F of this report). Many of these are environmental factors which may or may not be controlled or even defined in many of the published reports.

It should be 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, in most cases these reports contain no quantitative information about severity or magnitude of impact. In the few cases where quantitative data exists, these in turn require cautious extrapolation to the conditions of Hat Creek.

Methodology for Determing the Effects of SO_2/NO_2 on Vegetation

The local and regional impacts of airborne emissions from the generating station have been assessed for the three strategies: 366 m stack with FGD, 366 m stack with MCS, and 244 m stack with MCS (Appendix F of this report). For each case, projected levels and frequencies of SO_2 concentrations, computed by ERT[63, 66] form the prime data base. The magnitudes of the impacts of these projected SO_2 concentrations have been derived in the light of the effects of the various factors, environmental and temporal, discussed in Appendix F, Section 4.0. Emphasis has been placed upon the impact of SO_2, the predominant gaseous emission, although assessments of fluorides, particulates, carbon monoxide, oxides of nitrogen, hydrocarbons, ozone and cooling tower emissions have been undertaken.

(1) Local Impact

The local impact of the generating station emissions covers the circular area of 25 km radius centered on the stack, close to Harry Lake. The ERT projections are presented as they relate to 128 receptor sites arranged radially in rows of eight along axes at 22.5^{0} intervals around the stack. The individual sites are located 4 km from the stack and subsequently at 3 km intervals out to 25 km. The sites are numbered outwards from the stack commencing with the axis facing south, and thence in sequence in a clockwise direction. The factors related to the locations of the individual receptor sites, to the extent and nature of the vegetational cover present around each site, and to the vegetational response itself are included in the assessment procedure. For purposes of assessing impact, each receptor site has been assumed to be located at the centre of an annular region extending 1.5 km along the radial axis in either direction, and occupying 22.5^{0} of arc. The areas of the annular sectors and the distances of their central receptor sites from the stack were computed.

Within each annual sector, the extent of individual vegetation associations has been estimated using the 1:50,000 vegetation cover maps of the local study area and Figure F2-1 of Appendix F of this report. From these data, the estimates of the vegetation associations present in the annular sectors, further estimates of the cover contributed by individual species have been made, using the plant species cover data, based upon vegetation plots in the area (see Appendix C, Environment and Vegetation Tables, of this report) cover for each species for which the mean cover per association exceeded one percent has been calculated for each association present within an annular sector, and summed to give the total cover provided by these species within the sector.

In addition to factors related to receptor sites and their associated vegetation, the numerous factors which influence plant response, described in Appendix F, Section 4.0, have been incorporated into the overall assessment of impact. The various weighting factors used in this incorporation are:

(1) where tree and shrub layers are dominant within an association, the impact on the lower vegetation is reduced because of the likelihood of their exposure to concentrations less than those predicted as a consequence of deposition in the upper stories[68, 69];

(2) enchanced impact has been attributed to exposures occuring during the early hours of daylight;

(3) enhanced impact on exposed species has been assumed relative to data generated in laboratory or chamber experiments in which low wind velocities are employed[70], except where the species are protected by upper stories of vegetation;

(4) in general, species have been assumed to be less sensitive when grown under natural conditions in the field than when grown in chambers and greenhouses[71];

(5) increased injury has been assessed where sequential exposures were predicted to occur, or where several peaks occur within a single daylight period, regardless of whether they are consecutive or intermittent; and

(6) impact of SO_2 has been considered enhanced 50 percent and thresholds have been considered reduced 25 percent by the simultaneous fumigation with NO_2 at SO_2/NO_2 ratios expected for the Hat Creek generating station emissions (see Appendix F, Section 4.5(f)).

(7) impact of SO_2 has been considered to be reduced by the concomitant presence of elevated levels of CO_2. Since there appears to be no information available as to the combined effects of SO_2 and CO_2 on tree and shrub species, and in the light of the relatively low levels of CO_2 enrichment likely to occur (Appendix F, Section F4.4), a 25% reduction of impact has been used for such species. On the other hand a 50% reduction has been applied to assessments of impact on graminaceous and herbaceous species.

(8) impact on tree and shrub species has been assumed to be increased 25% because of the likelihood of injury resulting from the deposition of SO_2 during the winter months (outside the growing season). In the table of impact assessment presented later in this report, the greatest emphasis has been placed on exposures April 1 - October 31

growing season (the period over which the mean monthly temperature in Hat Creek is above ^{o}C. However, the limited data available require that an adjustment be made for winter deposition.

One of these modifying factors (SO_2/NO_2 interaction) has been incorporated directly into the tables of sensitivities of individual species to airborne emissions presented in Appendix F, Section 5.3. Two others (CO_2 and winter deposition) have been incorporated directly into the cumulative dose-response curves used to estimate injury, presented in Appendix F, Section F5.4.

Sensitivity tables for SO_2/NO_2 have been constructed for all plant species encountered within the local study area (Appendix F, Section 5.3). These tables take into consideration the responses of the individual species to the different components of the emissions, in the light of the various factors which modify response and have been weighted accordingly. However, exhaustive literature searches failed to reveal dose-response data for the majority of the plant species present. Of special concern is the fact that a severe lack of information concerning important plant species to livestock and wildlife use such a bluebunch wheatgrass (*Agropyron spicatum*), pine-grass (*Calamagrostis rubescens*) and grouseberry (*Vaccinium scoparium*) exists. This greatly reduces the significance of the assessment where these species dominate.

Once all the base assessment data for the annual sectors vegetation associations within annual sectors has been calculated, the assessment of the individual air quality strategies can be completed.

Maps have been overlaid of the peak concentration and frequency isopleths for a given time of excursion (Appendix F, Section 6.0). This makes it possible to determine precisely those receptor sites which the ERT modelling predicts would be exposed to elevated concentrations and the number of such events likely to occur during the season of vegetational growth.

Tables were drawn up listing the 1-hour, 3-hour and 24-hour peaks projected to occur throughout the year for each receptor site around which it was considered likely that impact would be discernible. The assembled data were then subdivided into a) those pertaining to the April-October growing season, and b) those relating to daylight hours. For each site, the maximum predicted concentration occurring during the daylight hours of the growing season was noted (C_{max}) and the total number of peaks within the daylight hours of the growing season which were 80% or more of this maximum was calculated (n). The selection of 80% of the maximum peak concentration per site as the lower limit is admittedly arbitrary. In terms of the complete PEAK Programme data for each control strategy, however, the range 80-100% included approximately one half of the peaks above the threshold selected for the particular PEAK Programme output, in the case of the highest peak values (1500 - 1800 $\mu g/m^3$), and an increasing proportion as the value for the highest peak value decreased.

Where peaks occurred within 3 hours of daybreak, their impact was weighted by multiplying their number by 1.5, to account for their greater potential for injury. The products of C_{max} and the weighted number of peak occurrences just described (n_s for the growing season), i.e. $C_{max} \cdot n_s$ were used as an initial approximation of cumulative growing season dose for each site. These dose values were then interpretated as injury by reference to cumulative dose-response curves for the different species (Appendix F, Section 5.4).

The cumulative seasonal doses for the receptor sectors of interest were used to estimate cumulative injury or beneficial effect by reference to the dose-response curves. These preliminary estimates were then further refined in the light of the other site-specific modifying factors described above in Appendix F, Section F4.1, i.e. plant cover distribution, altitudinal range, mixing depth, etc.

Assessment of the Three Air Quality Control Strategies for SO_2/NO_2

In order to assess the impact of SO_2/NO_2 on the vegetation of the local study area, two approaches have been taken. Firstly, the potential injury of vegetation cover in km^2 and estimated percent injury in Tables F6-1 to F6- of Appendix F of this report have been compared for each receptor site. Secondly, a more detailed approach has been taken to obtain an estimate of the impact that each air quality control strategy might have on the individual vegetation associations. This approach evaluates the total amount of vegetation area that would be affected in each vegetation association within the receptor sites shown in Appendix F of this report. This has been done for each air quality control strategy.

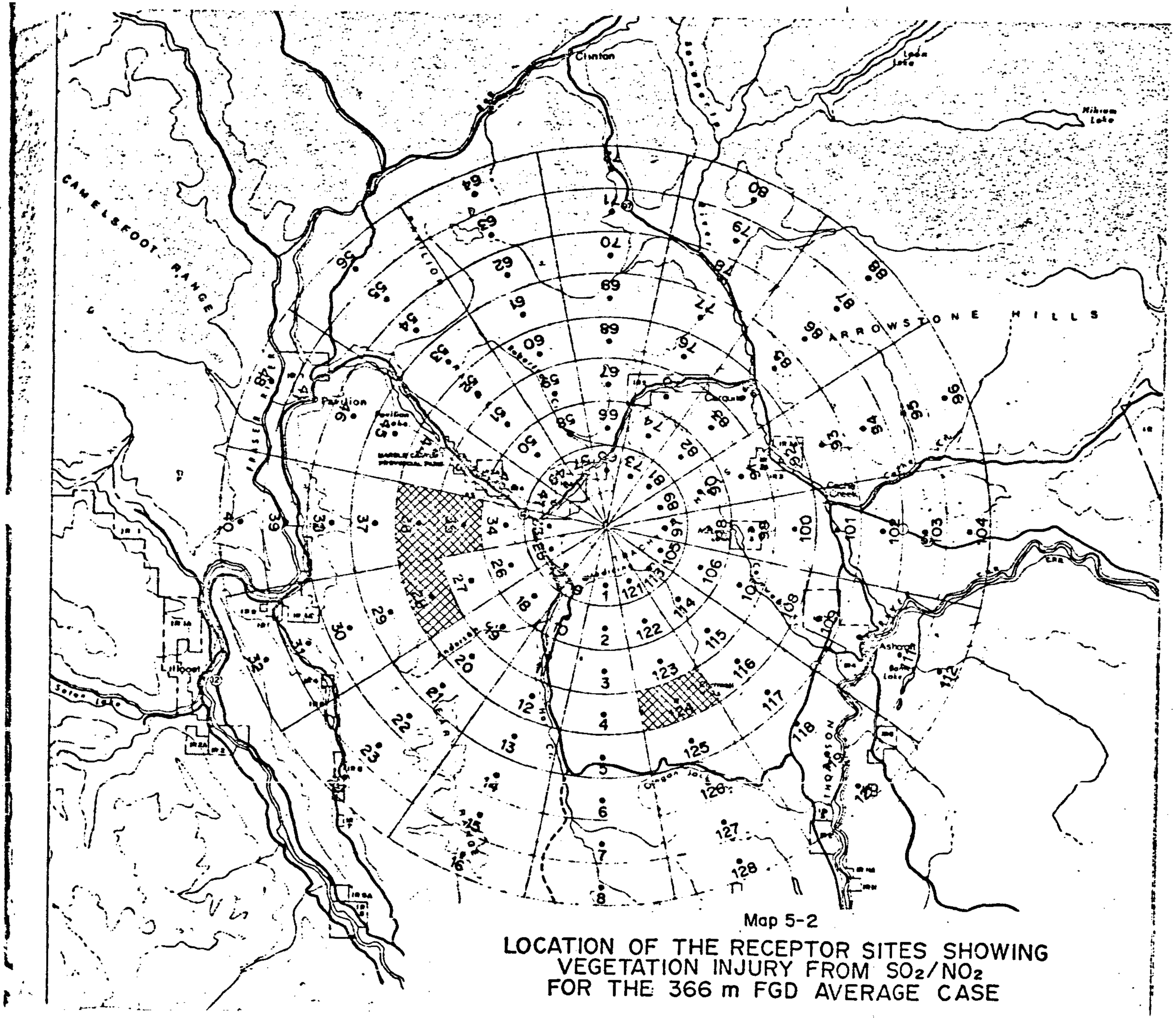
It should be pointed out that the information presented only pertains to plant species studied by other investigators that have shown injury to certain concentrations. Almost no data exists on important plant species and dominant plant species of the study area. For example, no information exists on bluebunch wheatgrass (*Agropyron spicatum*), pinegrass (*Calamagrostis rubescens*) or grouseberry (*Vaccinium scoparium*), probably the three most abundant understory species in the local study area. In addition, no information is available for any of the herbaceous species. Consequently, the data presented in this report on plant injury is soft. Possibly, more injury may occur than is recorded because of the lack of information on the dominant plant species or species important to wildlife and livestock grazing. Thus, no accurate determination of ecological changes is possible. The percent injury values given with the areas they impact are not localized to one spot within those areas, but generally occur throughout the whole area. In general, the larger the area affected the more diluted the injury value would be within that area. Most of these injury values represent chronic injury which would lack visual symptoms and is usually expressed as a loss in productivity.

(1) Local Impact of the 366 m Stack with Flue Gas Desulfurization

Appendix F of this report shows that receptor sites 28, 35, 36, and 124 may show possible vegetational injury due mainly to the occurrence of 1-hour peaks, Map 5-2 shows the distribution of these receptor sites. Table 5-17 illustrates the predicted annual area affected and percent injury for each receptor site by plant species. This information clearly shows that receptor site 36 would be affected the the greatest (5.5 km^2/yr), with receptor site 28 following with 3.0 km /yr of impacted area. On receptor site 124, the injury would be generally low (1 to 5 percent) except for willow (*Salix spp.*) and Kentucky bluegrass (*Poa pratensis*) which show injury values of 25 and 11 percent, respectively. The areas affected on receptor site 36 are derived from the 5.0 km^2/yr of *Pleurozium schreberi* impacted, although the percent injury would be only one percent. The remaining 0.5 km^2/yr is a result of a three percent injury to willow (*Salix spp.*). Receptor site 36 corresponds to the Mt. Martley area In terms of the plant species, *Pleurozium schreberi* and *Salix spp.* would be affected the most with area values of 9.4 and 1.0 km^2/yr, respectively. With respect to percent injury, willow (*Salix spp.*) would vary between 1 and 8 percent compared to Kentucky bluegrass (*Poa pratensis*) where a two percent injury could occur. The remaining receptor sites develop their total injury figures from only willow (*Salix spp.*) and *Pleurozium schreberi*. The total area that would be affected from this air quality strategy is estimated at 10.6 km^2/yr with between 1 and 8 percent injury possibly occurring.

Table 5-18 compares the number of km^2 affected per year for each vegetation association within the receptor sites predicted to have vegetation injury (Map 5-2). The Engelmann Spruce - Grouseberry and Engelmann Spruce - Grouseberry - Pinegrass associations appear to have the greatest area affected with values of 7.40 and 1.85 km^2/yr impacted, respectively.

In addition, the willow-Sedge Bog association is significantly affected due to the high cover of willow (*Salix spp.*). In the Engelmann Spruce - Grouseberry -



Map 5-2

LOCATION OF THE RECEPTOR SITES SHOWING VEGETATION INJURY FROM SO_2/NO_2 FOR THE 366 m FGD AVERAGE CASE

TABLE 5-17

PREDICTED ANNUAL AREA IMPACTED AND PERCENT INJURY FOR THE 366m/FGD AIR QUALITY MODEL FOR SO_2/NO_2 FOR THE PLANT SPECIES WITH DAMAGE INFORMATION BY RECEPTOR SITE (km^2/yr)

PLANT SPECIES	ANNUAL SECTOR NUMBER (km^2/yr)				Total Area Affected / % Injury Range
	28	35	36	124	
Salix spp.	0.3* / 1	0.1 / 1	0.5 / 3	0.1 / 8	1.0 / 1-8
Poa pratensis				0.2 / 2	0.2 / 2
Pleurozium schreberi	2.7 / 1	0.8 / 1	5.0 / 2	0.9 / 1	9.4 / 1-2
Total Area Impacted / % Injury Range	3.0 / 1	0.9 / 1	5.5 / 2-3	1.2 / 1-8	10.6 / 1-8

* Area Affected (km^2/yr) / % Injury

TABLE F5-18

MAXIMUM PREDICTED ANNUAL AREA AFFECTED
FOR THE RECEPTOR SITES SHOWING VEGETATION INJURY FOR THE
366 m/FGD AIR QUALITY MODEL BY VEGETATION ASSOCIATION

VEGETATION ASSOCIATION	PLANT SPECIES (km^2/yr) *Salix* spp.	*Poa pratensis*	*Pleuroxium schreberi*	Total Area Affected (km^2)
Injury Range	1-8	2	1-2	
Englemann Spruce - Grouseberry - Lupines Association	0.6			0.06
Engelmann Spruce - Grouseberry Association	0.20		7.20	7.40
Engelmann Spruce - Grouseberry - Pinegrass Association	0.13		1.72	1.85
Douglas-fir - Pinegrass Association	0.26			0.26
Douglas-fir - Pinegrass Bunchgrass Association		0.13		0.13
Douglas-fir - Pinegrass/ Douglas-fir - Pinegrass Bunchgrass Complex	0.04			0.04
Kentucky Bluegrass Association			0.28	0.28
Willow - Sedge Bog Association	0.95			0.95

Pinegrass Association, *Pleurozium schreberi* is the most important contributor to the overall areas affected, although the injury would be low (1 to 2 percent).

(2) Regional Impact of the 366 m Stack FGD Air Quality Strategy

The ERT regional projections for the uncontrolled emissions from a 366 m stack[63] are such that the predicted annual average concentrations of SO_2/NO_2 would be well below the thresholds of injury for vegetation. The ERT modelling, however, does not provide information as to the occurrence of individual peak concentrations beyond the 25 km local zone of impact. Nevertheless, in the 366 m stack FGD air quality model, the 1-hour peaks greater than 450 $\mu g/m^3$ SO_2 appear to be confined to the local zone of impact, although there is uncertainty as to whether such peaks would occur in the SSW direction, i.e. beyond receptor site 16 (Map 5-2). It appears, therefore, that no potentially injurious peak concentrations would likely occur outside the local zone of impact. As a consequence, the impact of the 366 m stack FGD system on the regional zone of impact would probably be minimal, and may largely be related to the marginal, if measurable, increases in growth.

(3) Local Impact of the 366 m Stack with Meteorological Control System

Appendix F of this report indicates that receptor sites 8, 13, 14, 15, 16, 20, 21, 22, 23, 27, 28, 29, 30, 35, 36, 37, 43, 44, 51, 52, 53, 54, 63, 123, 124 and 125 may show possible vegetation injury. Map 5-3 shows the distribution of these receptor sites.

Table 5-19 illustrates the predicted annual area impacted in km^2/yr for each receptor site by plant species. Receptor sites 13, 14, 15, 21, 19 and 124 appear to exhibit the greatest potential areas of impact. These receptor sites generally correspond to the higher peaks: Blustry and Cairn's peaks, Chipuin Mountain and Mt. Martley. Engelmann spruce (*Picea engelmanii*),

TABLE 5-19

PREDICTED ANNUAL AREA IMPACTED AND PERCENT INJURY FOR THE 366 M/MCS AIR QUALITY MODEL FOR SO_2/NO_2 FOR THE PLANT SPECIES WITH DAMAGE INFORMATION BY RECEPTOR SITE

PLANT SPECIES	ANNULAR SECTOR NUMBER (km²/yr)																											Total Area Affected / % Injury Range
	8	13	14	15	16	20	21	22	23	27	28	29	30	35	36	37	43	44	45	51	52	53	54	63	123	124	125	
Abies lasiocarpa		0.1*/1	0.4/4	0.5/3																						0.2/4		1.2/1 - 4
Picea engelmannii		1.9/1	5.6/2	6.0/2																						0.7/1		14.2/1 - 2
Pinus contorta		2.5/1	4.6/2	5.1/2																						1.6/1		13.8/1 - 2
Pinus ponderosa																										0.3/1		0.3/1
Pseudotsuga menziesii		2.0/1	1.8/2	1.1/2																						3.1/2		8.0/1 - 2
Populus tremuloides																		0.1/4										0.1/4
Amelanchier alnifolia		0.2/1	0.1/2								0.1/1															0.4/2		0.7/1 - 2
Salix cascadensis	0.8/3			0.7/24	0.8/10		1.9/5	1.2/4	1.1/2			3.5/5																10.0/2 - 24
Salix nivalis	0.9/3			0.8/24	0.9/10		2.0/5	1.4/4	1.2/2			3.8/5																11.0/2 - 24
Salix spp.		0.2/14	0.2/28			0.2/3		0.2/4	0.1/2	0.2/1	0.3/5	0.3/5	0.2/3	0.2/6	0.5/9	0.4/9	0.2/6	0.4/5	0.2/2	0.4/2	0.4/4	0.4/2	0.2/2	0.3/2		0.1/25	0.1/6	5.7/1 - 28
Poa pratensis		0.5/3	0.2/7																				0.2/1			0.3/9	0.5/1	1.7/1 - 7
Pleurozium schreberi		1.3/1	2.6/3	2.7/3	3.1/1		4.3/1				2.8/1	1.2/1		0.8/1	5.0/1			3.0/1			0.3/1	2.9/1	2.2/1		1.7/1	1.0/4		32.0/1 - 3
Alectoria jubata			2.7/1																									2.7/1
Total Area Affected / % Injury Range	1.7/3	8.7/1-14	18.2/1-28	16.9/2-24	4.8/1-10	0.2/3	8.2/1-5	2.8/4	2.4/2	0.2/1	3.1/1-5	8.8/1-5	0.2/3	1.0/1-6	5.5/1-9	0.4/9	0.2/6	3.5/1-5	0.2/2	0.4/2	0.7/1-4	3.3/1	2.6/1-2	0.3/2	1.7/1	7.7/1-25	0.6/1-6	101.4/1 - 28

* Area Affected (km²/yr) / % Injury

TABLE [illegible]-20

MAXIMUM PREDICTED ANNUAL AREA AFFECTED
FOR THE RECEPTOR SITES SHOWING VEGETATION INJURY FOR THE
366 M/MCS AIR QUALITY MODEL BY VEGETATION ASSOCIATION

VEGETATION ASSOCIATION	PLANT SPECIES (km^2/year)													
	Abies lasiocarpa	*Picea engelmannii*	*Pinus contorta*	*Pinus ponderosa*	*Pseudotsuga menziesii*	*Populus tremuloides*	*Amelanchier alnifolia*	*Salix cascadensis*	*Salix nivalis*	*Salix spp.*	*Poa pratensis*	*Pleurozium schreberi*	*Alectoria jubata*	TOTAL
% Injury Range	1-4	1-2	1-2	1	1-2	4	1-2	2-24	2-24	1-28	1-7	1-3	1	
Engelmann Spruce - Willow - Red Heather Parkland Association	0.05	1.0						9.81	10.74					21.60
Engelmann Spruce - Grouseberry - Lupines Association	0.45	6.26	2.24					0.27	0.92	0.49			0.72	11.35
Engelmann Spruce - Grouseberry Association	0.53	6.34	1.53							1.11		20.04	0.73	30.28
Engelmann Spruce - Grouseberry - Pinegrass Association		0.73	9.47		0.44		0.03			0.14		6.80	1.03	18.64
Engelmann Spruce - Horsetail Association										0.09		0.26		0.35
Douglas-fir - Pinegrass Association		.62	0.78	0.04	5.92		0.33			1.74	0.25		0.16	9.84
Douglas-fir - Bunchgrass - Pinegrass Association				0.34	1.70		0.35				0.40		0.01	2.80
Douglas-fir - Pinegrass/ Douglas-fir - Bunchgrass-Pinegrass Complex										0.10				0.10
Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Complex						0.23				0.13				0.36
Riparian Association										0.10				0.10
Mountain Avens - Sedge/ Highland Grassland Complex			0.03						0.91					0.94
Kentucky Bluegrass Association											0.76			0.76
Bunchgrass - Kentucky Bluegrass Association											0.93			0.93
Bunchgrass - Kentucky Bluegrass/ Saline Depression Complex											1.35			1.35
Highland Grassland Association			0.02											0.02
Sagebrush - Bluebunch Wheatgrass Association											0.01			0.01
Willow - Sedge Bog Association										4.34				4.34

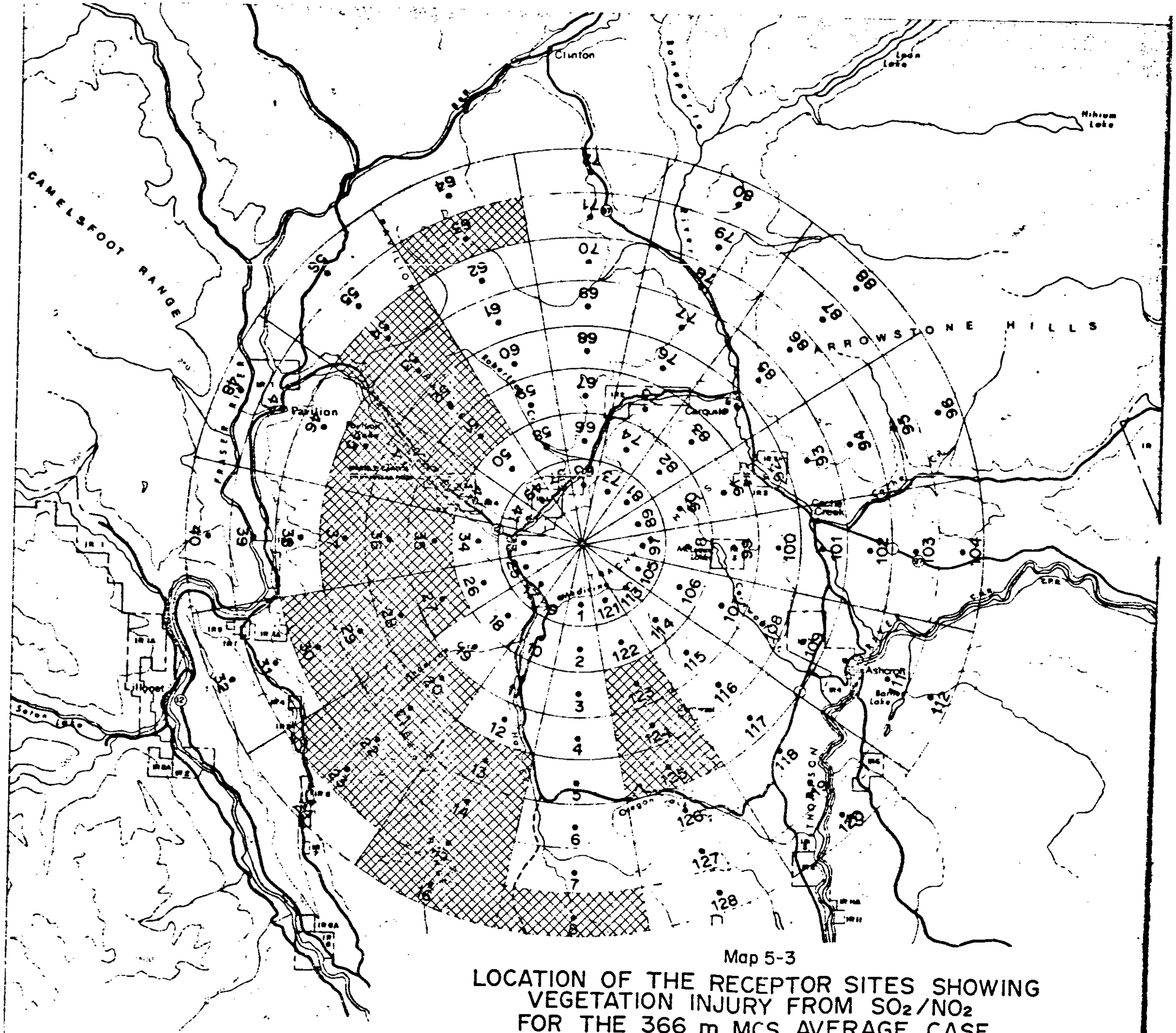
lodgepole pine (*Pinus contorta*) and *Pleurozium schreberi* would contribute the greatest areas but have low injury values of between 1 and 3 percent. On receptor sites 13, 14, 15, 21, and 24, between approximately 1 and 48 percent of the total area affected is made up of willow (*Salix spp.*) which would have a high injury of from 2 to 28 percent. Receptor site 29 would show the greatest impact on willow (*Salix spp*) with 2 to 24 percent injury. Willow (*Salix spp.*) comprises 83 percent of the total area affected on receptor site 29.

Receptor site 29 is expected to show the greatest vegetation injury because of the high willow (*Salix spp.*) component which shows a potential for high injury. Willow (*Salix spp.*) and Kentucky bluegrass (*Poa pratensis*) would show the greatest maximum injury values of 28 and 7 percent, respectively. The total area that would be affected for this air quality control strategy is 101.4 km^2/yr.

Within the local study area the receptor sites that may show vegetation injury in order of significance are, the Engelmann Spruce - Grouseberry, Engelmann Spruce -Willow - Red Heather Parkland associations and Engelmann Spruce - Grouseberry - Pinegrass, (Table 5-18). However, it is expected that the Engelmann Spruce - Willow - Red Heather Parkland Association would be heavily affected because of the high willow (*Salix spp.*) cover in this association. Willow (*Salix spp.*) could show an injury value of 24 percent for this association. The same is true in the Willow - Sedge Bog Association which would have a 4.34 km^2/yr area affected, with percent injuries ranging up to 28 percent. With respect to the other associations mentioned, Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*) and *Pleurozium schreberi* contribute substantially to the overall areas that could be affected. The injury figures for these species would be generally less than 3 percent.

(4) Regional Impact of the 366 m Stack MCS Air Quality Strategy

As in the case of the 366 m stack FGD strategy, the regional impact of the



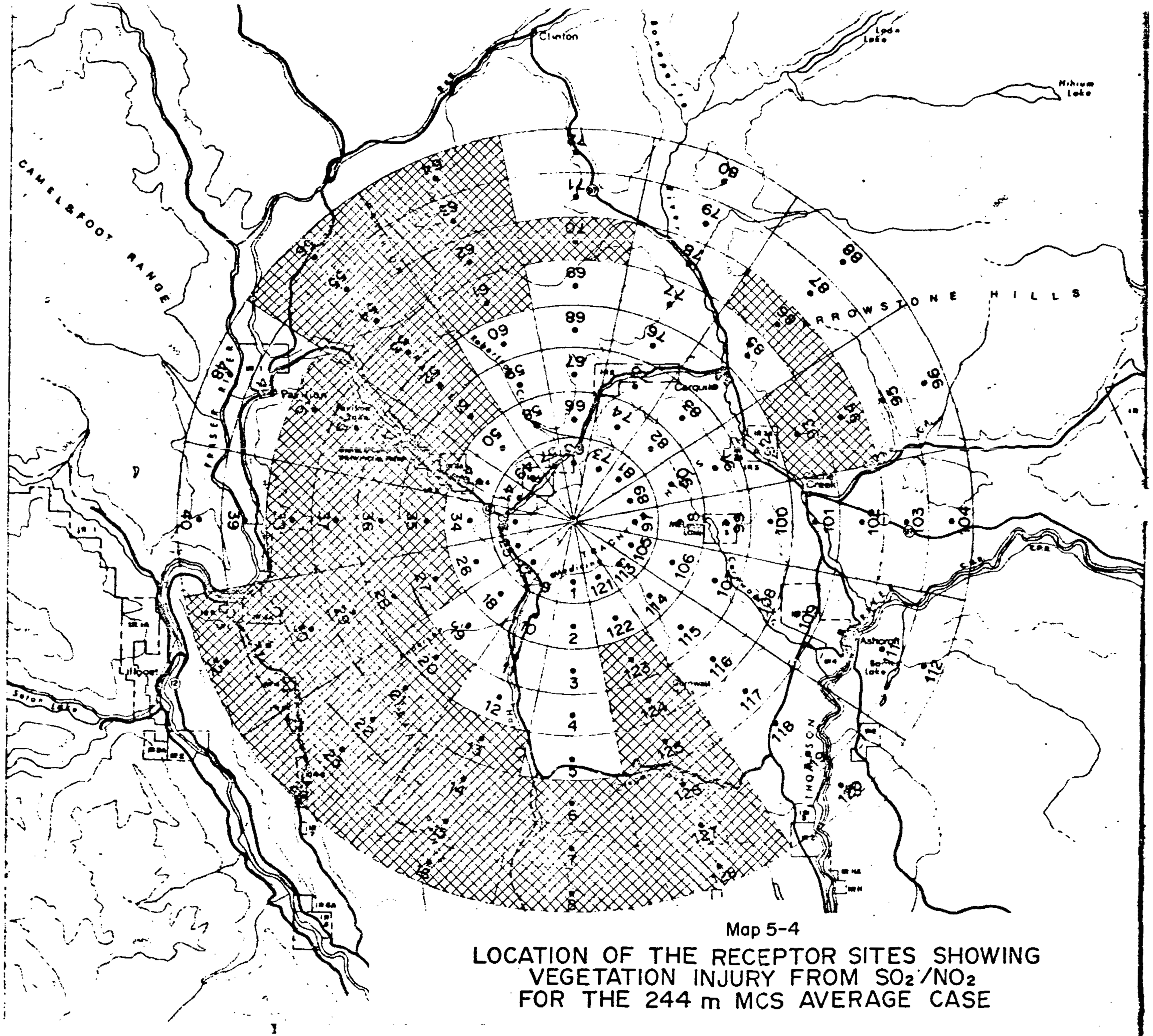
Map 5-3

LOCATION OF THE RECEPTOR SITES SHOWING VEGETATION INJURY FROM SO_2/NO_2 FOR THE 366 m MCS AVERAGE CASE predicted SO_2/NO_2 emissions from the 366 stack MCS system would be unlikely to involve measurable injury to vegetation. The only uncertainties concern the regions immediately surrounding the local zone of impact to the south, southwest and northwest. In particular, a pattern of increasing 1-hour peak concentrations and increasing numbers of excursions is seen in the southerly direction, through sites 6, 7 and 8 (Map 5-3). Similarly, high peak concentrations and frequencies appear possible in the SSW direction beyond site 16. Although peak concentrations are somewhat less to the northwest, there is uncertainty as to the ground-level concentrations beyond sites 56 and 64, although in these directions the number of 1-hour peaks appears to be diminishing (Appendix F, Section 6.0). Thus, on the basis of the uncontrolled 366 m stack emissions[63] and the detailed projections for the local zone of impact there again appears to be no reason to suspect adverse effects of the emissions under the 366 m stack MCS strategy within the extended regional zone. Such effects of SO_2 and NO_2 as occur would probably be marginally beneficial in nature. This may also be true of the impact, if any, immediately beyond receptor sites 8, 16, 56 and 64, as noted above.

(5) Local Impact of the 244 m Stack with Meteorological Control Strategy

Appendix F of this report indicates that receptor sites 6, 7, 8, 13, 14, 15, 16, 20, 21, 22, 23, 24, 27, 28, 29, 30, 35, 36, 37, 38, 43, 44, 45, 46, 51, 52, 53, 54, 55, 63, 64, 70, 86, 93, 94, 123, 124, 125, 126, 127 and 128 would show possible vegetation injury. Map 5-4 shows the distribution of these receptor sites.

Table 5-21 depicts the predicted annual area that could be affected in km^2/yr for each receptor site by plant species. This analysis indicates that receptor sites 13, 14, 15, 16, 21, 29, 94 and 124 would have the greatest area affected. These receptor sites correspond to the higher elevations of Blustry Mountain, Cairn's Peak, Chipuin Mountain, and the Arrowstone Hills. With the exception of receptor site 94, potentially impacted sites are identical to those that would be affected by the 366 m MCS air quality strategy. The



Map 5-4

LOCATION OF THE RECEPTOR SITES SHOWING VEGETATION INJURY FROM SO_2/NO_2 FOR THE 244 m MCS AVERAGE CASE

244 m MCS could affect the same receptor sites as the 366 m MCS as well as 14 others. Although the areas that would be affected by both the 366 m MCS and 244 m MCS strategies are the same, the percent injury values for the 244 m MCS would be greater. For example, receptor site 14 which would have the greatest area affected (18.2 km^2/yr) has a percent injury range of between 1 and 28 for the 366 m MCS and between 1.2 and 30.8 for the 244 m MCS case. *Pleurozium schreberi*, lodgepole pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*) and Engelmann spruce (*Picea engelmannii*) would have the largest areas affected with 38.4, 16.9, 16.7 and 15.6 km /yr, respectively. However, except for *Pleurozium schreberi* on receptor site 124 where an injury of 6.4 percent could be encountered, all injury values would be less than 3 percent. Of greater concern, are the areas dominated by willow (*Salix spp., Salix cascadensis, and Salix nivalis*) where the total area affected for these species could be 8.9, 13.1, and 12.4 km^2/yr, respectively, since a maximum percent injury of 40 may occur. The total area that could be affected for this strategy is 132.7 km^2/yr.

Within all the receptor sites in the local study area that may show vegetation injury (Table 5-22), the Engelmann Spruce - Grouseberry, Engelmann Spruce - Grouseberry - Pinegrass, Engelmann Spruce - Willow - Red Heather Parkland, Douglas-fir - Pinegrass and Engelmann Spruce - Grouseberry - Lupines associations would be the most affected, with area values of 34.33 27.30, 24.15, 16.15, and 11.68 km^2/yr, respectively. However, it is expected that the Engelmann Spruce - Willow - Red Heather Parkland Association would be heavily affected because of the high density of willow (*Salix spp.*) in this association. Willow (*Salix spp.*) could show a possible injury value of 26.4 percent for this association. The same would be true in the willow - Sedge Bog Association which would only have a 4.69 km^2/yr area affected but a percent injury of up to 40.0 percent. Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta)* and *Pleurozium schreberi* would contribute substantially to the overall areas affected. The injury figures for these species are generally less than 5 percent. With the exception of the

TABLE 5-21

PREDICTED ANNUAL AREA IMPACTED AND PERCENT INJURY
FOR THE 244 m/MCS AIR QUALITY MODEL FOR SO_2/NO_2 FOR
THE PLANT SPECIES WITH DAMAGE INFORMATION BY RECEPTOR SITE

ANNULAR SECTOR NUMBER
(km²/yr)

PLANT SPECIES	6	7	8	13	14	15	16	20	21	22	23	24	27	28	29	30	35	36	37	38
Abies lasiocarpa				0.1*/1.1	0.4/4.4	0.5/3.3														
Picea engelmannii				1.9/1.1	5.6/2.2	6.0/2.2														
Pinus contorta				2.5/1.1	4.6/2.2	5.1/1.1														
Pinus ponderosa																				
Pseudotsuga menziesii	3.9/1			2.0/1.1	1.8/2.2	1.1/2.2														
Populus tremuloides	0.2/12																			0.2/2
Populus trichocarpa																				
Amelanchier alnifolia	0.3/1			0.2/1.1	0.1/2.2															
Salix cascadensis			0.8/6			0.7/26.4	0.8/14.0		1.9/6	1.2/4.8	1.1/2.2	1.2/2			3.5/4.5					
Salix nivalis			0.9/6			0.8/26.4	0.9/14.0		2.0/6	1.4/4.8	1.2/2.2	1.4/2			3.8/4.5					
Salix spp.	0.6/15	0.2/4		0.2/15.4	0.2/30.8			0.2/4.0		0.2/4.8	0.1/2.2	0.1/2	0.2/5	0.3/8	0.3/7.5	0.2/2.7	0.2/13.2	0.5/14.4	0.4/6	0.2/3
Poa pratensis	0.3/3			0.5/3.3	0.2/7.7							0.1/1								
Pleurozium schreberi	1.4/1			1.3/1.1	2.6/3.3	2.7/1.3	3.1/1.4		4.3/1.2					2.8/1.6	1.2/1.5		0.8/2.2	5.0/1.6		
Alectoria jubata					2.7/1.1															
Total Area Affected / % Injury Range	6.7/1-15	0.2/4	1.7/6	8.7/1.1-15.4	18.2/1.1-30.8	16.9/2.2-26.4	4.8/1.4-14.0	0.2/4	8.2/1.2-6.0	2.8/4.8	2.4/2.2	2.8/1-2	0.2/5	3.1/1.6-8.0	8.8/1.5-7.5	0.2/2.7	1.0/2.2-13.2	5.5/1.6-14.4	0.4/[illegible]	0.4/[illegible]3

PLANT SPECIES	43	44	45	46	51	52	53	54	55	63	70	86	93	94	123	124	125	126	127	128	Total Area Affected / % Injury Range
Abies lasiocarpa												0.4/1				0.2/6.4					1.6 / 1.1 - 6.4
Picea engelmannii														1.4/1		0.7/1.6					15.6 / 1 - 2.2
Pinus contorta														3.1/1		1.6/1.6					16.9 / 1 - 2.2
Pinus ponderosa													0.7/1	0.8/1		0.3/1.6					1.8 / 1 - 1.6
Pseudotsuga menziesii													2.8/2	2.0/1		3.1/3.2					16.7 / 1 - 3.2
Populus tremuloides		0.1/7.6																			0.5 / 2 - 12.0
Populus trichocarpa													0.1/2	0.1/1							0.2 / 1 - 2
Amelanchier alnifolia													0.4/2	0.3/1		0.4/3.2					1.7 / 1 - 3.2
Salix cascadensis																				1.9/1	13.1 / 1 - 26.4
Salix nivalis																					12.4 / 2 - 26.4
Salix spp.	0.2/7.2	0.4/9.5	0.2/4.0	0.3/5	0.4/3.8	0.4/5.2	0.4/2.6	0.2/2.4	0.2/1	0.3/1.8	0.4/1	0.2/12	0.2/25	0.3/24		0.1/40	0.1/9.6	0.1/8	0.2/1	0.2/1	8.9 / 1 - 40.0
Poa pratensis								0.2/1.2								0.3/14.4	0.5/1.6	0.1/1			2.2 / 1 - 14.4
Pleurozium schreberi		3.0/1.4				0.3/1.3		2.2/1.2				1.8/1		1.5/3	1.7/2.8	1.0/4		1.7/1			38.4 / 1 - 6.4
Alectoria jubata																					2.7/1.1
Total Area Affected / % Injury Range	0.2/7.2	3.5/1.9-9.5	0.2/4.0	0.3/5	0.4/3.8	0.7/1.3-5.2	0.4/2.6	2.6/1.2-2.4	0.2/1	0.3/1.8	0.4/1	2.4/1-12	4.2/1-25	9.5/1-24	1.7/2.8	7.7/1.6-40.0	0.6/1.6-9.6	1.9/1-8	0.2/1	2.1/1	132.7 / 1 - 40.0

Area Affected (km²/yr) / % Injury

3.0 / 1.9

1.0 / 6.4

TABLE 5-22

MAXIMUM PREDICTED ANNUAL AREA AFFECTED
FOR THE RECEPTOR SITES SHOWING VEGETATION FOR THE
244 M/MCS AIR QUALITY MODEL BY VEGETATION ASSOCIATION

PLANT SPECIES (km^2/yr)

VEGETATION ASSOCIATION	*Abies lasiocarpa*	*Picea engelmannii*	*Pinus contorta*	*Pinus ponderosa*	*Pseudotsuga menziesii*	*Populus tremuloides*	*Populus trichocarpa*	*Amelanchier alnifolia*	*Salix cascadensis*	*Salix nivalis*	*Salix spp.*	*Poa pratensis*	*Pleurozium schreberi*	*Alectoria jubata*	TOTA
% Injury Range	1.1-6.4	1-2.2	1-2.2	1-1.6	1-3.2	2-12.0	1-2	1-3.2	1-26.4	1-26.4	1-40.0	1-14.4	1-6.4	1.1	
Engelmann Spruce - Willow - Red Heather Parkland Association	0.05	1.0							11.01	12.09					24.1
Engelmann Spruce - Grouseberry - Lupines Association	0.45	6.26	2.24						0.33	0.98	0.70			0.72	11.6
Engelmann Spruce - Grouseberry Association	0.64	7.39	1.79								1.52		22.27	0.72	34.3
Engelmann Spruce - Grouseberry Pinegrass Association		0.95	12.35		0.82			0.08			1.04		11.02	1.04	27.3
Engelmann Spruce - Horsetail Association											0.09		0.26		0.35
Douglas-fir - Pinegrass Association		0.72	0.89	0.07	9.22			0.55			3.36	1.18		0.16	16.15
Douglas-fir - Bunchgrass Pinegrass Association				1.22	5.60			1.15				0.90			8.87
Douglas-fir - Bunchgrass Association				0.60	0.30			0.07							0.97
Douglas-fir - Pinegrass/Douglas-fir - Bunchgrass - Pinegrass Complex											0.02				0.02
Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Pinegrass Complex					1.12	0.34		0.17			0.11	0.13			1.87
Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Complex						0.23					0.13				0.36
Ponderosa Pine - Bunchgrass Association				0.11				0.01							0.12
Riparian Association							0.24	0.11			0.32				0.67
Mountain Avens - Sedge/Highland Grassland Complex			0.03							1.02					1.05
Kentucky Bluegrass Association												0.37			0.87
Bunchgrass - Kentucky Bluegrass Association												1.21			1.21
Bunchgrass - Kentucky Bluegrass/Saline Depression Complex												1.35			1.35
Highland Grassland Association			0.02			0.04									0.06
Big Sagebrush - Bunchgrass Association								0.10							0.10
Sagebrush - Bluebunch Wheatgrass Association													0.01		0.01
Willow - Sedge Bog Association											4.69				4.69

Douglas-fir - Pinegrass Association, these associations occur at elevations above 1525 m (5000 ft.).

(6) Regional Impact of the 244 m Stack MCS Air Quality Strategy

From the ERT projections[63] for regional air quality from the 244 m stack MCS system there is no reason to expect significant injury to vegetation within the outer parts of the regional zone of impact. However, as was noted in the case of the 366 m stack MCS situation, uncertainties exist around the local zone of impact. In the present case, there is still more reason for uncertainty because of the patterns of peak concentration predicted for the local zone as one progresses outwards along several axes. For example, inspection of Figure 17, Appendix F, clearly shows that peak 1-hour SO_2 concentrations greater than 600 $\mu g/m^3$ may occur SSE, S, SSW, NW and NNW of the stack (beyond receptor site 128, 8, 24, 56 and 64 respectively) while in the SSW direction, peaks up to 1200 g/m may occur beyond receptor 16. Because of the discontinuity between the local and regional modelling, it is impossible to make any definitive statements as to the magnitude of the impact of gaseous emissions immediately outside the local zone of impact in the directions noted. All that can be said is that for the more distant sites in the regional zone of impact, the effects, if any, of the generating station emsissions are likely to be marginally beneficial.

(7) Summary of the Local and Regional Impacts Caused by SO_2/NO_2

The effects of the proposed power plant emissions on the vegetation of the local study area have been evaluated for the three air quality models. It is clear from the previous discussions that the three air quality control options can be ranked in the following order:

366 m FGD < 366 m MCS < 244 m MCS

Table 5-23 summarizes some of the more important criteria for separating

TABLE 5-23

SUMMARY EVALUATION FOR THE THREE
AIR QUALITY STRATEGIES FOR SO_2/NO_2 EMISSIONS

Evaluation Parameter \ Air Quality Model	366m/FGD	366m/MCS	244m/MCS
Number of Receptor Sites Impacted	4	27	41
Number of Vegetation Associations Impacted	8	17	21
Total Area Impacted (km^2/yr)	10.6	101.4	132.7
Major Receptor Site Impacted	36	14	14
Major Vegetation Association Impacted	Engelmann Spruce - Grouseberry Association	Engelmann Spruce - Grouseberry Association	Engelmann Spruce - Grouseberry Association

the three options. In all categories, the 244 m MCS would have the highest adverse impact. The reason for this would be the lower stack height which could result in higher phytotoxic ground-level concentrations of SO_2/NO_2 over a wider area and at lower elevations. The areas that would show vegetation damage for all three options are the upper elevations of the Clear Range, Cornwall Peak and Pavillion Range. Some vegetation injury would be evident in the Arrowstone Hills for the 244m MCS option only. THe largest area affected could be associated with elevations above 1525 m (5000 ft.).

For all three air quality control options, the Engelmann Spruce - Grouseberry Association was found to be affected the most with area values of 7.4 km^2/yr for the 366 m FGD, 30.3 km^2/yr for the 366 m MCS and 34.3 km^2/yr for the 244 m MCS. Although receptor site 14 for the 366 m MCS and 244 m MCS strategies has the highest area affected (18.2 km^2/yr) it is expected that receptor site 29 may also be heavily affected because of its high content of willow. Receptor 29 is mainly composed of the Engelmann Spruce - Willow - Red Heather Parkland Association. This association is the most important because of its high vegetation diversity and possible occurrence of many showy alpine flowers. However, with respect to productivity, the Engelmann Spruce - Grouseberry Association is of more importance, especially in forest productivity.

The 366 m FGD would follow a slightly different pattern. It would affect a smaller area compared to the other two options (Table 5-23), with receptor site 36 the most affected with a value of 5.5 km^2/yr. This receptor site is in the vicinity of Cornwall Peak.

For all three air quality control strategies, the tree species are generally injured less than 5 percent. Willow (*Salix spp.*) and *Pleurozium schreberi* are the most consistently injured species by all three air quality control options. Willow (*Salix spp.*) is the most injured species with maximum injury values of 8, 28 and 40.0 percent from the 366 m FGD, 366 m MCS and 244 m MCS options, respectively, while *Pleurozium schreberi* has maximum injury values of 2, 3 and 6.4 percent, respectively. All maximum values are associated with receptor sites 14, 15 and 124, although the areas affected are low in comparison to the other receptor sites.

In general, the primary reason for the greater impact of the two options involving MCS would be a result of the large numbers of significantly injurious 1-hour concentrations of SO_2/NO_2 permitted by MCS based upon the 3-hour 655 $\mu g/m^3$ SO_2 standard. As well, in the case of the 244 m stack, the lower release height of emissions is important as stated above. The type of injury that could be expected is largely chronic in nature, resulting from repeated fumigations with SO_2 and NO_2 . The acute injury threshold for sensitive plant species would be exceeded more frequently under the MCS options, especially the 244 m stack option.

Particulates and Trace Elements

Particulates are predicted to be emitted from the stack at a rate of approximately 40,000 kg (88,000 lbs.) per day.

Based upon the ERT projections for annual average SO_2 concentrations the proposed 0.12 ratio of particulate/SO_2 emissions and a deposition velocity of 0.1/cm/sec, the greatest predicted annual deposition fluxes for particulates would be:

366 m stack FGD	17.0 $\mu g/m^2$/year
366 m stack MCS	26.5 $\mu g/m^2$/year
244 m stack MCS	35.2 $\mu g/m^2$/year

There is no evidence to suggest that vegetation would be affected by particulates deposited at such rates or by the specific trace elements present within them[72]. Of all the trace elements investigated vanadium shows the highest depositional flux of only 34.36 $\mu g/m^2$/year[72].

Oxides of Nitrogen

Nitrogen is emitted from the stack of coal-fired burners in the form of nitric oxide (NO). However, once exposed to the atmosphere, NO begins to oxidize to form appreciable quantities of nitrogen dioxide (NO_2). The speed of this reaction depends upon atmospheric conditions and the presence of other reactive airborne contaminants[73]. For the Hat Creek case, ERT[63] has assumed NO and NO_2 to occur in equal molar amounts in the local study area and to be 80 percent NO_2 and 20 percent NO in the regional study area.

In general, the concentrations of nitrogen oxides necessary to cause visible injury to vegetation are higher than those normally associated with coal-fired power plants. Concentrations of 3760 $\mu g/m^3$ to 18,000 $\mu g/m^3$ are necessary to produce acute injury in sensitive plants[74, 75].

Chronic injury may be caused by lower concentrations of nitrogen oxides. Concentrations as low as 1128 $\mu g/m^3$ of NO_x were found to inhibit CO_2 uptake in oats and alfalfa[76]. Depressed growth rates also have been observed in plants exposed to 940 $\mu g/m^3$ NO_x for extended periods . Thompson et al[77] noted that a continuous exposure of 282 to 489 $\mu g/m^3$ NO_x for 2 to 4 weeks caused chronic injury and growth reductions in sensitive plants. In addition, Tingey[78] found that NO_2 caused increased damage at lower concentrations in the dark than in the light.

No visible symptoms of leaf injury from nitric oxide (NO) have been reported[79]. However, growth reductions may take place at concentrations of 3800 to 7500 $\mu g/m^3$[73].

Table 5-24 shows the maximum ground-level concentrations predicted for NO_2 by ERT[63] for all three air quality strategies. Data from this table indicate that all concentration levels would be well below those shown to

TABLE 5-24

MAXIMAL GROUND-LEVEL CONCENTRATIONS PREDICTED FOR NO_2 WITHIN THE LOCAL STUDY AREA*

Averaging Time	Maximum Concentration ($\mu g/m^3$)		
	366 m FGD**	366 m MCS***	244 m MCS***
1-hour	284	641	675
3-hour	143	252	243
24-hour	81	101	101
Seasonal:			
winter	1.4	2.3	2.3
spring	2.7	5.1	6.7
summer	2.0	3.9	4.3
fall	2.8	2.9	3.6
Annual	1.8	2.7	3.6

* Data from ERT[63].

** Values probably too low because FGD would probably alter SO_2/NO_2 ratio in a manner which has not been adjusted for in ERT concentration estimates.

*** Values probably marginally low because use of coal-switching option would lower emissions of SO_2 but not of NO_x. These values are based on an assumed constant SO_2/NO_2 ratio.

cause acute or chronic injury. Consequently, no damage from NO_x should be expected.

The major effect of oxides of nitrogen, mainly NO_2 on vegetation would be their synergistic action with sulfur dioxide to produce vegetation injury at lower concentration levels than normally encountered. This factor has been taken into account in the assessment of impacts of sulfur dioxide.

Hydrocarbons

Hydrocarbons are known to cause injury and growth reduction to plant species, primarily due to the presence of ethylene[80]. Other saturated and unsaturated hydrocarbons generally have little effect on vegetation[81].

Ethylene can reduce apical growth, cause epinasty, chlorosis, leaf and bud abscission and necrosis in angiosperms, while in conifers effects are mainly premature needle and cone abscission, reatrded elongation of new needles, and poor cone development[74].

Ethylene concentrations as low as 55 $\mu g/m^3$ for 16 hours can cause epinasty in sensitive agricultural species (tomatoes, potatoes and buckwheat). In less sensitive plant species, ethylene exposure (55 $\mu g/m^3$) for a period of several weeks was necessary to cause growth reductions[74].

Based on the predicted 0.017 ratio of total hydrocarbons/SO_2 emissions the maximum predicted 1-hour ground-level hydrocarbon concentration for the 366 m stack MCS is 28 g/m^3, the 366 m stack FGD is 12 $\mu g/m^3$, and for the 244 m stack is 29 $\mu g/m^3$[63]. All other average time periods would be well below the 1-hour predicted values.

These values are low in comparison with those found to cause injury. In addition, the above predicted values include all forms of hydrocarbons, not only ethylene. Consequently, the proportion of ethylene to total predicted hydrocarbons is either equal to the total amount of hydrocarbons present or lower. The composition of the hydrocarbon stack emissions is not known. Therefore, no impact on vegetation from hydrocarbons would be expected.

Ozone

Ozone (O_3) is a highly reactive compound which is formed by photochemical reactions involving its components, moelcular and atomic oxygen (O_2 and O, respectively)[63]. Ozone formation is directly related to the NO /NO ratio and incoming solar radiation. ERT[63] predicts the NO_2/NO ratio to be low, as well as hydrocarbon emissions, which affect the reaction to some extent. Consequently, the ozone levels would not be expected to be above ambient levels and vegetation would not be impacted.

Carbon Monoxide

The 1-hour levels of carbon monoxide (CO) predicted for the 366 m stack FGD, 366 m MCS, and 244 m MCS air quality strategies would be 41 $\mu g/m^3$, 92 $\mu g/m^3$ and 96 $\mu g/m^3$, respectively. Very little information exists on the levels of CO that may cause vegetation injury. However, the low levels predicted above would not be expected to cause vegetation damage as they would be quickly diluted and/or converted to carbon dioxide (CO_2).

Acid Precipitation

The problem of acid precipitation as a result of the proposed Hat Creek power plant has been investigated in two reports[63, 82]

Acid precipitation results primarily from the oxidation of SO_2 to form SO_3

and eventually $SO_4^=$ (sulfate). Nitorgen oxides also may undergo a similar oxidation process with the resultant formation of NO_3^- (nitrate). In the presence of water, these undergo hydrolysis to form sulfuric acid (H_2SO_4) and nitric acid (H_2NO_3), respectively. The rate of the above chemical reaction depends on many factors. The presence of hydrocarbons and certain trace metals may act as catalysts. Other emissions such as fly ash will neutralize acid, to the degree it contains elements associated with carbonate including Ca, Al, Si and others[82].

Two types of deposition are possible: dry and wet. Dry deposition is a continual process and is dominated by the sulfur compound SO_2. Wet deposition results from precipitation scavenging the airborne sulfur in the form of sulfate ($SO_4^=$) which readily combines with water to form sulfuric acid, thereby creating "acid precipitation". Much the same process occurs with nitrates. Greeley et al[83] generalized that 20 percent of the sulfates are deposited by dry deposition, while 80 percent are removed by wet deposition.

Injury to vegetation is caused by wet deposition of sulfuric acid on the plant surfaces. Dry deposition if it remains in the dry state upon contact with the plant surfaces would have little effect[82]. However, if it encounters wet foliage conditions, effects similar to wet deposition would occur. Some of the more important effects of acid precipitation are cuticular erosion and decreasing populations of nitrogen-fixing lichens and micro flora and fauna[82].

In the Hat Creek context, little or no effect from acid precipitation would occur in the local study area or regional study area. Calculated rainfall acidities ranging from pH 3.7 to 5.5, depending upon the specific assumptions made with regard to b uffering capacity or neutralization by NH have been made[82]. A pH of 3.7 represents an extreme "worst case" situation where no interaction or buffering with other compounds exists and a high SO_2 concentration is present (30 $\mu g/m^3$). For the most part, ERT modelling produced values of 0.5 to 2.0 $\mu g/m^3$ of SO_2 from the uncontrolled 366 m stack[63]. Consequently, pH values of 3.7 would be extremely unlikely.

In any case, such values are at or above the threshold for direct injury to most vegetation, even the most susceptible pines[84], and are greater than those which significantly modify plant host-parasite relation[85]. Hence, it appears that no directly injurious effects on vegetation would occur.

Cooling Tower Emissions

The cooling towers associated with the generating station would utilize water from the Thompson River. Evaporative cooling in such towers inevitably results in the entrainment of droplets of cooling water containing dissolved solids, particularly salts, in the stream of air and water vapour which they emit. Condensation of this water results in visible plumes, containing saline aerosols whose chemical composition reflects that of the cooling water used and whose deposition occurs around the site of the cooling towers. ERT[64] has provided an assessment of the atmospheric effects and deposition isopleths for four alternative cooling tower designs[64]. The projected maximum deposition rates are[64]:

Four round mechanical draft towers	51,400 $kg/km^2/year$
Four rectangular mechanical draft towers	24,150 $kg/km^2/year$
Two natural draft towers	4,717 $kg/km^2/year$
Four natural draft towers	8,760 $kg/km^2/year$

In all cases the deposition rate drops to 560 $kg/km^2/year$ within 3 km of the towers. The preferred alternative is two natural draft towers.

McCune et al[86] have studied the effects of saline aerosols on a range of plant species. The aerosols which they used consisted 47.9 percent of chloride ion, in comparison with the 6 percent chloride content of the

Thompson River water. This wide discrepancy makes precise assessment impossible, since there is no information offered as to the particular sensitivities of the species tested to specific ions within the aerosol. However, the range of susceptibilities includes "sensitive" species such as hemlock (injured by 6-hour treatment with a deposition rate equivalent to 636 $kg/km^2/year$) and "resistant" species such as witchazel (injured by 6-hour treatment with a deposition rate equivalent to 46,500 $kg/km^2/year$). Runeckles, in Appendix F of this report, states:

> *"This range of response to such short term exposures makes it highly probable that some species of vegetation in Hat Creek even more distant than 3 km from the cooling towers will be adversely affected by aerosol deposition occurring throughout the year, regardless of the choice of cooling towers. Furthermore, within a distance of approximately 1 km from the towers, some injury to most species is likely to occur as a consequence of continued deposition. However, the quantitative assessment of such injury is not possible in the absence of specific information as to the effects of the particular mixture of salts typical of Thompson River water, applied to vegetation in aerosol form. Indeed, the presence of sulfate and calcium as two of the major ions may be of some nutritional benefit."*[87]

It should also be noted that, because of the water vapour content of the plumes from the cooling towers, impact on elevated terrain such as Cornwall Peak would result in conditions of local high humidity (approximately five times a year)[63]. If the impingement of the cooling tower plume coincides with that of the generating station stack, the locally high humidity would increase the probable impact of SO_2/NO_2 in the latter's emissions, through the effect of humidity on stomatal aperture[88].

In addition, the heat and moisture contained in the cooling tower plumes could create micro climate changes especially in the arid Hat Creek climate.

These changes may lead to alterations in the vegetation patterns within the circumference of the 3 km area affected by the cooling tower emissions. Possible successional changes toward more moisture-loving plant species may take place. However, the extent and time period necessary for these changes to occur are difficult to ascertain.

Trace elements are also contained in the cooling tower emissions. This may provide an extremely localized source of trace elements. However, ERT[63] projects that no measurable increase of trace elements would occur even if bioaccumulation occurs.

Fluoride

The fluorine compounds, especially hydrogen fluoride (HF) would be emitted from the stack, both in a gaseous and a particulate state. Studies indicate that approximately 10 percent would be emitted as particulate matter, while the remaining 90 percent would be in the gaseous state[72]. The gaseous state would by far be the most damaging to vegetation because of its absorption through the leaf stomata.

As with most air pollutants, the impact of fluorine on vegetation is dependent on a number of parameters, the most critical of which are pollutant concentration, exposure duration, genetic differences within plant species, and environmental conditions. However, unlike other air pollutants, fluorine is a cumulative toxicant. Fluorine has the ability to accumulate in the plant tissues (mainly leaf margins). Consequently, vegetation injury may occur after repeated low-level fumigations (below threshold). Some studies indicate that the effects of intermittent fumigations have revealed that post-fumigation fluoride loss can occur from leaves[99, 100]. Elimination of fluoride absorbed by spruce has been reported[101].

The fluoride accumulation in vegetation is influenced by a number of environmental factors such as temperature, moisture, and relative humidity. Tissue age and time of day of exposure are also important factors. In general, higher temperatures and relative humidities increase fluoride-induced injury in vegetation, while a water deficit decreases vegetation injury.

The accumulation of fluoride in leaf tissues can cause a variety of chronic effects. Generally, carbon dioxide assimulation is decreased, a reduction in the foliar chlorophyll content occurs and an alteration in carbohydrate metabolism and an increased oxygen uptake are found.

The impact of gaseous fluoride emissions on vegetation is based on a 8.92 x 10^{-4} ratio of gaseous fluoride to SO_2 emissions[72]. Table 5-25 indicates the maximal ground-level concentrations predicted for fluoride within the local study area for the three air quality strategies.

Exposures to levels of 0.4 and 1.5 $\mu g/m^3$ HF for over 65 days are necessary for injury to occur on ponderosa pine (*Pinus ponderosa*)[102] and Douglas-fir (*Pseudotsuga menziesii*)[103], respectively, while 16 days of exposure to 0.6 $\mu g/m^3$ HF were required to injure the sensitive tulip cultivar, Paris[104]. No short-term dosages of this magnitude are predicted for the annual or seasonal values (Table 5-25).

However, since fluoride is a cumulative toxicant, chronic fluoride injury may occur on sensitive vegetation at sites subjected to repeated fumigation. Ponderosa pine (*Pinus ponderosa*) has been reported by Gordon[105] to be injured by exposures to average concentrations as low as 0.06 $\mu g/m^3$ for 119 days with maxima ranging between 0.06 $\mu g/m^3$ and 0.25 $\mu g/m^3$. In addition, Weinstein[106] found that ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) are all highly sensitive to HF during the period of needle elongation. Consequently, chronic impact on these tree species may occur. Reid, Collins and Associates Ltd.[49], using the uncontrolled stack HF emissions, estimates that 459.8 m^3/year of the mean annual increment could be lost in the probable case. Information on the effect of fluoride emissions on understory shrubs, herbs and grasses is generally lacking for the vegetation species found in the Hat Creek local

TABLE 5-25

MAXIMAL GROUND-LEVEL CONCENTRATIONS
PREDICTED FOR F WITHIN THE LOCAL STUDY AREA *

AVERAGING TIME	366m/FGD $\mu g/m^3$	366m/MCS $\mu g/m^3$	244m/MCS $\mu g/m^3$
1-hour	0.65	1.46	1.54
3-hour	0.33	0.58	0.55
24-hour	0.19	0.23	0.23
Annual	0.004	0.006	0.008
Seasonal			
Winter	.003	.005	.005
Spring	.006	0.12	.015
Summer	.005	.009	.010
Fall	.006	.007	.008

* Data from ERT[63]

study area. Consequently, the effect of HF emissions on these species is difficult to assess, requiring further studies in order to evaluate any impacts. The present relatively high levels of fluorine in the shrub and grasses, reported by ERT[72], further stress the importance of monitoring fluoride emissions and their levels in various plant species.

E. Waste Disposal

The ash disposal schemes for the plant described in Section 5.4(b)(i) would require drainage ditches around the ash pond perimeter to catch surface and near-surface waters from the adjacent highlands before they reach the ash ponds. The water in the wet ash disposal scheme would be disposed of by evaporation as well as recycling for the sluicing of ash.

The waste disposal for the mine would require large waste dump areas to accommodate the large quantities of waste rock and overburden. These waste disposal piles would be drained in order to prevent contaminated surface runoff to flow onto the surrounding land. Consequently, a system of drainage ditches would be located around the perimeter of the waste dumps and mine. These would drain into lagoons which would serve as settling basins and retention dams. Some of this water would be used for industrial purposes while the remainder would be discharged into Hat Creek. Treatment may be necessary.

The waste disposal areas would undergo partial reclamation and revegetation mainly of the sloping portion during the operation phase[89]. The remainder would be reclaimed during the decommissioning period. The plant ash disposal areas would be reclaimed in the decommissioning period. All aspects of the reclamation and revegetation processes will be discussed under Section 5.4(d), "Decommissioning".

The plant would be operated in a "no liquid discharge" mode. Water make-up would essentially equal consumption. Cooling tower blowdown and water from soot-blowing activities may be the major functions that produce waste water.

Waste water transported to the ash disposal ponds would be disposed of by evaporation. If a dry ash disposal scheme is chosen, then this waste water would be treated to produce a water quality suitable for reuse in the primary water use systems of the plant.

The yard and plant floor drains would be kept separate to eliminate the potential for storm water contamination by plant process pollutants. The yard drainage would not be considered a waste and, therefore, would not be treated. All waste water from the plant drainage systems would be collected in a deep retention pond and evaporated.

If an emergency coal pile is necessary at the plant site, drainage from this would be treated and discharged to receiving waters or reused in the power plant.

Since the plant is operated on a "no liquid discharge mode", no effect is expected on the vegetation. The sewage disposal schemes for both the plant and mine may have a minor beneficial effect because of an increase in nutrient status, but this effect would be extremely localized.

The storage of overburden, waste rock, coal and ash in dumps and ponds may present problems concerning the buildup of trace element concentrations and their effects on vegetation. Trace elements naturally occurring in coal, overburden and waste rock would be liberated into the ecosystem during the mine and plant operations.

Utilizing the Environmental Research and Technology, Inc. (ERT) document on trace elements in the ecosystem[72], 21 trace elements investigated in detail were characterized as having a high, moderate or low potential toxicity to vegetation. This information is provided in Table 5-26. Arsenic, beryllium, cobalt and tin were rated as high, while lithium, boron, cadmium, chromium, lead, vanadium, zinc and antimony were classed as moderately toxic. It should be emphasized that this is only a relative toxicity rating since

TABLE 5-26

RELATIVE TOXICITY TO PLANTS OF THE TRACE ELEMENTS FOUND IN THE HAT CREEK ECOSYSTEM

Trace Elements	Relative Toxicity to Plants*	Levels* Injurious to Plants	Comments
Arsenic (As)	High	2 - 40 ppm	Plants generally accumulate As in the root tips; toxicity depends on solubility; greatest toxic effect at seedling stage.
Beryllium (Be)	High	3 - 5 ppm	
Cobalt (Co)	High	0.1 ppm	
Tin (Sn)	High	No information	Little information on toxicity levels.
Lithium (Li)	Moderate to High	>30 ppm	More toxic in acid soils and tends to accumulate in root tissue.
Boron (B)	Moderate	0.5 - 25 ppm	Toxicity depends on solubility; absorption by plants is highest in sandy loam and loamy soils and not in clay loam soils.
Cadmium (Cd)	Moderate	>3 ppm	Absorbed from soil and leaf surfaces through stomata; natural levels in the soil at Hat Creek are above literature-derived concentrations.
Chromium (Cr)	Moderate	8 - 16 ppm	Cr may interact synergistically with Ni, Co, and Mg in soil to produce toxic effects.
Lead (Pb)	Moderate	10 - 350 ppm	Plants tend to accumulate Pb in the root tips.
Vanadium (V)	Moderate	Variable	No toxicity reported to plants in field conditions.
Zinc (Zn)	Moderate	12.5% total Zn in soil	Accumulation greater in roots; that translated to leaves is in an insoluble form.
Antimony (Sb)	Moderate	No information	
Nickel (Ni)	Low	>50 ppm	Translocated from roots to leaves
Copper (Cu)	Low	>20 ppm	Governed by soil pH; the higher the pH, the more toxic.
Fluorine (F)	Low	No information	Gaseous and particulate form the most damaging to plant.
Gallium (Ga)	Low	No information	
Mercury (Hg)	Low	0.5 - 50 ppm	Hg is not concentrated to a great extent in plant tissues.
Selenium (Se)	Low	Variable	Many plants accumulate large quantities in the stems and leaves; plants show a great variability to Se toxicity.
Strontium (Sr)	Low	No information	
Thallium (Tl)	Low	No information	
Zirconium	Low	No information	

* Data from ERT[22]

many environmental factors affect a trace element's availability and mobility. Factors such as soil pH, synergistic reactions with other trace elements, water availability, trace element solubility, and cation exchange capacity (CEC) control whether or not a trace element would be available for plant uptake. Plants also vary with season and growth stage in their sensitivity to trace element toxicity. In addition, many plant species or trace elements have not been studied in enough detail to determine whether or not a particular trace element is toxic or a plant species would be injured. Most information is published on crop species rather than on native indigenous species.

Mine

Coal, topsoil, overburden, waste rock and possibly beneficiation plant tailings would be stockpiled as stated earlier. Much of this material would be exposed to the direct effects of weathering for the first time for varying periods of time, until they would be reclaimed. This weathering process could convert soluble trace elements into mobile forms at varying rates. Topsoil generally would have a much lower content of mobile trace elements, while the lower strata of overburden, waste rock and coal would have a high content because they have not been subjected to direct weathering.

These toxic trace elements could reach the plants in two ways: direct uptake and leaching. Because the more toxic trace elements in materials, such as fly ash, would be covered with approximately 2 m (6 ft.) of material that provides a superior growth medium, i.e. topsoil and glacial till, they would be less available. However, since evaporation and transpiration in the Hat Creek area exceeds the precipitation during the summer months, the potential exists for the water-soluble trace elements to be drawn to the soil surface and accumulated, thereby, being directly available to the plants. Secondly, downward leaching through the waste dumps may create highly toxic leachates. These leachates may contain appreciable quantities of trace elements, as well as sodium, calcium and magnesium. Both the mine and plant designs indicate that the runoff and leachates would be caught and contained in a series of ditches and lagoons. However, leakage from these sources could have a deleterious effect on the nearby vegetation. Beak[98] estimate that 400 m^3/d and 40 m^3/d of seepage water would reach the groundwater from the Houth Meadows and Medicine Creek waste dumps, respectively. The accumulation of trace elements at the surface due to evaporation is of more concern in the decommissioning phase.

To estimate the potential amounts of water soluble trace elements that might be leached from the waste dumps, coal storage areas and beneficiation plant tailing areas, leachate tests were preformed[89]. These leachates were then compared to the water ambient levels provided by Environmental Research and Tecnology, Inc.[72]. The results of this comparison are presented in Table 5-27. These results represent the concentration in ppm of solution and generally show the maximum leachate to be expected for each trace element of concern to vegetation. Concentrations of chromium and lead seem high in all waste, while boron would be high mainly in the waste rock. Arsenic could be high in all materials except coal and beneficiation plant tailings, while zinc could be high in the low-grade coal waste. It should be pointed out that beryllium, cobalt and tin, all rated as highly toxic to plants, lack leachate test information on the leachate levels to be expected from the various mined materials.

Of the above trace elements, arsenic and chromium would probably be the most mobile due to the high alkalinity characteristics of the Hat Creek waste materials. Beak[98], using rate of release tests, estimate that elevated levels of arsenic, chromium, copper and iron in the seepage water is expected to emanate from the Houth Meadows waste dump. Lead would be relatively immobile and would present less of a leachate problem. Although zinc is generally immobile in alkaline soils, the leachate tests indicate high mobility for zine.

Plant

The base ash disposal scheme would call for the sluicing of both fly ash and

TABLE 5-27

COMPARISON OF THE LEACHATE TEST RESULTS TO AMBIENT WATER CONCENTRATION FOR 11 RELATED TRACE ELEMENTS

Trace Elements of Concern to Plants	Relative Toxicity to Plants	Total Extractable Salts (Water Soluble): Over-burden** (ppm)	Waste Rock** (ppm)	Low Grade Coal Waste** (ppm)	Beneficiation Plant Tailings** (ppm)	Coal (ppm)	Fly Ash** (ppm)	Bottom Ash** (ppm)	Water Ambient Levels*: Oct. 1976 (ppm)	Jan. 1977 (ppm)	May 1977 (ppm)
Arsenic (As)	High	0.1 - 0.3	0.2	0.2	0.04	0.08 - .16	0.86	0.62	0.0023	-	0.05
Beryllium (Be)	High	-	-	-	-	-	-	-	0.0011	-	-
Cobalt (Co)	High	-	-	-	-	-	-	-	0.0012	-	-
Tin (Sn)	High	-	-	-	-	-	-	-	0.0011	-	-
Lithium (Li)	Moderate to High	0.06	0.06	0.12	0.03 - .3	.06 - 1.2	0.06	0.06	0.0016	-	-
Boron (B)	Moderate	0.2	0.4	0.2	0.2 - 0.24	0.2	1.3	0.14	0.0045	-	-
Cadmium (Cd)	Moderate	0.02	0.02	0.02	.004 - .006	.016	0.004	0.012	0.0013	-	0.005
Chromium (Cr)	Moderate	0.2 - 0.3	.2	.2	0.2 - 0.3	0.2	0.2	0.2	0.0133	-	0.002
Lead (Pb)	Moderate	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.05	-	0.05
Vanadium (V)	Moderate	0.04	0.04	0.06	.08 - .1	0.04	0.3	0.76	0.0018	-	0.007
Zinc (Zn)	Moderate	1.4 - 2.2	1.8	3.0	0.2 - 0.3	1.4 - 3.0	8.0	16.0	0.0223	-	0.05

* Data from ERT[72]

** Data from ACRES[73]

bottom ash into a major impoundment in the Medicine Creek Valley. Three other schemes locate the ash disposal areas near Harry Lake. All would be surrounded by drainage ditches that drain into a catchment basin. The estimated seepage into the groundwater system is 20 m^3/d for the base ash disposal scheme[98].

Table 5-27 illustrates the concentration of the water soluble portions of trace elements of concern to plants for fly ash and bottom ash. The table indicates that arsenic, zine, vanadium, chromium, lead and boron would be associated with the ash. Arsenic, vanadium and zinc appear to be the most important. Arsenic could be leached from both fly and bottom ash in relatively high concentrations, while vanadium and zinc would be highly leachable mainly from the bottom ash. No data exist for beryllium, cobalt or tin. As with arsenic and zinc, vanadium would be extremely mobile in an alkaline environment. Theis et al[107] in a study on a fly ash disposal site found that trace metals were released to the groundwater at generally low levels. Metals were found to accumulate in the soils beneath and around the pond.

Summary

Within the mine waste dumps, coal stockpile, and possibly the beneficiation plant tailings area, arsenic, zinc, chromium, lead and boron would be highly leachable. The fly ash and bottom ash from the plant would appear to concentrate large quantities of leachable trace elements. Arsenic, vanadium and zinc would be the most significant.

In both the mine and plant waste disposal systems, arsenic would be the most significant trace element because of its high toxicity to plants and relatively high concentrations that can be leached from the waste materials[72, 89, 98]. Consequently, mine waste dumps, coal stockpiles, beneficiation plant tailings and ash disposal areas should be properly designed and maintained to prevent possible toxic leachates from reaching the seepage or groundwater areas and becoming available to the vegetation.

Whether or not the actual runoff waters would attain similar or higher levels of dissolved trace elements is undertermined. However, ponds such as the ash pond and retention ponds in which evaporation is the sole or major means of water loss, could become extremely toxic. Similarly, the sediments in the bottom of the settling lagoons could have extremely high concentrations of heavy metals. All runoff water and groundwater should be monitored.

F. Indirect Changes

The major indirect change that may affect the vegetation pattern in the operation phase is interception or interference with the near-surface seepage water. Many of the vegetation associations found in the local study area would be dependent on this seepage water for their continued existence. These include the Saline Depression and Willow - Sedge Bog associations. Other associations may not exhibit external signs of the beneficial effects of seepage water, but would show an increase in the productivity of the site.

However, except for the depressional vegetation associations, the exact nature and location of seepage areas is not known. The relatively dry macro climate of Hat Creek greatly decreases the chances of seepage areas being very extensive and probably prevalent only during spring runoff. As a general rule, wherever pure trembling aspen (*Populus tremuloides*) stands occur in depressions, seepage water is present. However, these areas are generally small and occur sporadically throughout the local study area.

Most plant and mine operation facilities would be large site-specific facilities located in the valley bottoms (mine) or upland plateaus (plant) and, therefore, would not cross extensive sloping areas where seepage water may be flowing.

(ii) Resource Projection - Impact of the Project

The operation phase of the Hat Creek project is expected to alienate a total of 2774.2 ha (6852 acres) of land or 1.7 percent of the local study area. The development of open pit #1 and waste disposal dumps for the mine would account for 64 percent of this total alienation. This would represent a three-fold increase over the land alienated by the construction phase. Most of the land alienation would occur in the northern part of upper Hat Creek Valley, Medicine Creek, and the area surrounding Harry Lake. None would occur in the Thompson or Bonaparte valleys.

The impact of dust on vegetation is difficult to ascertain since actual quantitative levels causing vegetation damage are sparse and highly dependent on the type of dust, particle size, chemical composition and how effective the buildup of dust particles on the leaves would be during the dry summer months. A similar conclusion was arrived at in "Environmental Impacts of the Generation of Electricity in the Pacific Northwest, Volume II"[90] where they state the following: "Insufficient data on the effect on vegetation of the low-level to moderate concentrations of particulates are available to predict actual impact of TSP". In any case, it appears that the impact if any on vegetation would be confined mainly to the north end of Hat Creek Valley where the mining operation would create a significant portion of the dust emissions. In addition, the topography would confine the dust emissions even further within the Hat Creek Valley. Road dusting impacts should be insignificant and well controlled by the use of watering trucks.

Leachates from the mine waste and plant ash disposal areas may be of concern if seepage occurs from the drainage ditches or lagoons. A continuous monitoring programme should be developed to test leachate waters for unacceptable levels of trace elements. In case of seepage or runoff, toxic quantities of trace elements such as arsenic or chromium may buildup and cause damage to adjacent vegetation.

Section 5.4(c)(i)D. adequately assesses the individual impacts of the various air emission constituents that are of importance to vegetation. This analysis shows that SO_2 is probably the most important emission. Consequently, most attention has been paid to it. The only other constituent which may cause injury to vegetation is fluoride. However, the expected concentrations of gaseous and particulate fluorides are such that no acute injury is anticipated. On the other hand, since fluorides are cumulative toxicants, chronic injury may occur in some species, particularly perennials, over time. Other emissions, such as hydrocarbons, carbon monoxide and oxides of nitrogen are not expected to cause injury. The same is true for acid precipitation. In the case of cooling tower emissions, further study may be needed to assess the possible level of damage because of the lack of information concerning cooling tower emissions of similar salt contents. However, any vegetation injury can be expected to be very localized (within 3 km). The increased heat and moisture contained in the cooling tower plumes may also create micro climatic changes, thus possibly altering vegetation patterns over a long period of time.

The analysis of SO_2/NO_2 air emissions (Section 5.4(c)(i)D.) indicates that the 244 m MCS would have the most vegetation injury while the 366 m FGD would have the least. The total resultant area affected for the 366 m FGD, 366 m MCS and 244 m MCS could be 10.6, 101.4, and 132.7 km^2/yr, respectively. The Engelmann Spruce - Grouseberry, Engelman Spruce - Grouseberry - Pinegrass, Engelmann Spruce - Grouseberry - Lupines, Douglas-fir - Pinegrass and Engelmann Spruce - Willow - Red Heather Parkland associations would be affected the most for all three air quality options, except the 366 m FGD which has only a minor impact on any of the above associations. All except the Douglas-fir - Pinegrass association occur above 1525 m (5000 ft.) in elevation. The Engelmann Spruce - Willow - Red Heather Parkland Association is generally the msot affected associaton as compared to the others mentioned above. This is due to its high willow (*Salix spp.*) component, which appears from the air emissions analysis to be the vegetation species affected the most by SO_2/NO_2 emissions. In order to clearly evaluate these values, a number of assumptions and points must be emphasized that may otherwise lead to misinterpretation of the presented data. These assumptions appear below:

(1) the ERT modelling is based on 100 percent for 100 percent of the plant life and, therefore, this analysis is as well. This is an extremely unlikely situation, due to decreased load demand during certain months and necessary machinery repairs;

(2) benefits may accrue from low fumigations; and

(3) no "recovery rate" has been assumed. This is a very important point, since undoubtedly vegetation recovery from air emission injury would occur, both from acute and chronic injury types over the year. This is especially true of deciduous species which lose their leaves or die-back every year. Consequently, the predicted injury values may be high, especially if considered cumulative.

The data is difficient for the plant species that occur in the local study area concerning threshold response data to SO_2/NO_2 affects. The previous analysis only relates to those plant species where data exists.

As far as ecological changes from air emissions to plant communities is concerned, it is difficult to assess what may happen, but generally pollutants tend to simplify plant communities by causing the progressive loss of species. Species favoured tend to be those that are hardy, broadly adapted and have a high reproductive potential[91]. These species types may be sensitive to the particular pollutant, but their numbers, reproductive capacity, dissemination characteristics and adaptability to varied habitats compensate for this.

The assessment of the physical impact of the operation phase of the plant and mine was done by comparing the amount of each vegetation association lost (Table 5-14) and its location (Map 5-1) to the sensitivity rating established for each vegetation association (Table 5-11). In addition, the ash disposal alternatives were evaluated to indicate which caused the least impact.

A. Plant

The operation associated facilities for the plant would be limited to the base plan wet ash disposal pond and dam (P6) and its conveyance system (P7). All other facilities would be completed during the construction phase. The analysis of the alternative ash disposal schemes will also be discussed.

The base plan wet ash disposal pond and dam (P6) would impact 316.75 ha (782 acres) of Douglas-fir - Pinegrass Association and 305.41 ha (755 acres) of the Kentucky Bluegrass Association. Both were rated as having a low sensitivity. A minor portion of the Engelmann Spruce - Grouseberry - Pinegrass Association (30.48 ha or 75 acres) having a low sensitivity would be affected. In addition, 49 percent of the forested associations have already been disturbed by logging. The Willow - Sedge Bog Association would be the only highly sensitive association affected, but would be of minor extent (8.06 ha or 20 acres).

In comparison with the base ash disposal scheme, the combined wet fly ash/dry bottom ash alternative would alienate 180.6 ha (446 acres) more land, while the dry ash disposal schemes #1 and #2 affect 370 ha (914 acres) and 413.1 ha (1020 acres) less land, respectively than the base ash disposal scheme (Table 5-6). In general, the same vegetation associations would be affected, although the amount changes. The wet fly ash/dry bottom ash alternative would affect more of the Engelmann Spruce - Grouseberry - Pinegrass, Douglas-fir - Pinegrass, and Kentucky Bluegrass associations as well as an additional 8.48 ha (21 acres) of the Douglas-fir - Bunchgrass - Pinegrass Association. The dry ash schemes #1 and #2, on the other hand, would alienate less of the Douglas-fir - Pinegrass, Kentucky Bluegrass, and Willow - Sedge Bog associations, but would have an increased impact on the Douglas-fir - Bunchgrass - Pinegrass Association of 24.25 ha (60 acres) and 22.12 ha (55 acres), respectively, by each scheme.

From the above analysis, the two dry ash disposal schemes appear to have the least impact because they are the smallest and do not affect the highly sensitive Willow - Sedge Bog Association. However, they would alienate a minor portion of the moderately sensitive Douglas-fir - Bunchgrass - Pinegrass Association, but this is felt to be an insignificant impact compared to the overall reduction in land alienation of low sensitivity vegetation associations. The base ash disposal scheme would follow the wet fly ash - dry bottom ash disposal scheme as the highest in vegetation impact.

Toxic leachates have been discussed in Section 5.4(c)(i)E. It has been shown that the fly ash generally contained greater concentrations of trace elements than the mine wastes. Arsenic, vanadium and zine appear to be the most concentrated and possibly injurious to vegetation[72, 89]. At present, control measures are planned to collect all seepage and runoff waters from the ash disposal areas in lagoons. The water would be decanted from the lagoons if it meets acceptable guidelines. Consequently, there should not be any impact on vegetation if the leachates are successfully contained. Possible problems may arise where leakage would occur into the surrounding seepage and groundwater.

Absorption by the adjacent vegetation of trace elements as well as high concentrations of salts, such as sodium, calcium and magnesium, may lead to loss of vegetation. However, the resultant impact on vegetation due to possible leakage would be localized to the immediate area surrounding the ash disposal areas. The secondary impact to wildlife and livestock feeding off the contaminated vegetation may be potentially greater.

Indirect effects as a result of the operation of the plant (i.e., ash disposal areas) would be related to possible interception of lateral seepage waters. Because the base plan ash disposal scheme (P6) is located in the valley formed by Medicine Creek, very little impact on lateral seepage would be expected. However, if one of the other ash disposal schemes is chosen, their location on the sloping uplands near Harry Lake may intercept seepage water moving downslope, thus, possibly degrading the vegetation association below. The existence of lateral seepage in this area is not known and could not be determined without extensive field investigation but the types of vegetation associations below, dry macro climate and exposure, indicate that lateral seepage is probably absent except for a short period during spring runoff.

B. Mine

The operation of the mine associated facilities would alienate the greatest land area (2100.6 ha or 5190 acres). Alienation from the open pit #1 (M1), Medicine Creek waste dump (M2), Houth Meadows waste dump (M4), low grade coal stocking area (M15) and the topsoil stockpile, south Medicine Creek (M13) would have the greatest impact (Table 5-14). The majority of the impact would be on the Douglas-fir - Pinegrass, Douglas-fir - Bunchgrass - Pinegrass, Kentucky Bluegrass, and Sagebrush - Bluebunch Wheatgrass associations. Table 5-11 indicates that the Douglas-fir - Pinegrass and Kentucky Bluegrass associations have been rated as having a low sensitivity, the Douglas-fir - Bunchgrass - Pinegrass Association as moderately sensitive, and the Sagebrush - Bluebunch Wheatgrass Association as highly sensitive.

The Douglas-fir - Pinegrass Association would be affected the most by mine operation (674.98 ha or 1668 acres). However, its low sensitivity and the fact that only 0.1 percent of the association in the local study area would be affected, would result in a minor overall impact. The same would be true for the Kentucky Bluegrass Association, although the total amount affected would represent 7.0 percent of the association in the local study area. It is believed that while 7.0 percent of the local area would be affected within the regional study area, this would be of minor consequence since the Interior Douglas-fir Zone is common.

The Sagebrush - Bluebunch Wheatgrass Association would be affected by open pit #1 and a minor amount by the topsoil stockpile and landing strip (M12). These impacts would represent 54.2 percent of the total found in the local study area. The consequence of this loss was discussed under the impact of the operation of the plant.

Only minor impacts to the highly sensitive, Riparian and Willow - Sedge Bog associations by open pit #1 of 5.06 ha (12 acres) and 1.9 ha (4.7 acres), respectively, would occur.

The Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass associations would be affected mainly by the open pit #1 and Medicine Creek waste dump (M2). Major concern exists where these associations occur on steep slopes (30 percent) and where the erosion potential would be high. Where these associations occur on lesser slopes, the impact of their disturbance would be less.

The Houth Meadows waste dump (M4) would impact 111.5 ha (276 acres) of the Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass Complex. This complex has been rated as having a moderate sensitivity based mainly on its occurrence on steep slopes and its relative scarcity in the local study area. It also contains many uncommon plant species. The 111.5 ha (276 acres) represents 8.1 percent of that found in the local study area.

The possibility of toxic leachates affecting vegetation was discussed in Section 5.4(c)(i)E., and the impacts for the plant operation were outlined in the previous section. The operation of the mine would have the same basic problems since the design of the waste disposal areas are similar for both the mine and plant. Possibly the impacts of the mine operation are less because the concentrations of the trace elements would be generally lower for the mine waste disposal areas.

Indirect changes such as degradation of vegetation due to interception of lateral seepage should not be a problem during mine operation, since the mine operation facilities are mainly located in the north end of the Hat Creek Valley, in the valley bottom and on the lower slopes. Consequently, direct loss would be the most important impact.

C. Summary

Table 5-28 summarizes the impacts of the operation of the mine and plant by sensitivity class. The table indicates that the mine operation would have the greatest impact on vegetation. The plant operation would have a lesser impact both in total land area and high sensitivity vegetation associations affected. Except for 8.06 ha (20 acres), the remaining 665.54 ha (1644 acres) would affect the low sensitivity vegetation associations, Douglas-fir - Pinegrass and Kentucky Bluegrass associations.

The greatest impacts would result from open pit #1 (M1), topsoil stockpile, mine entrance (M12), Houth Meadows waste dump (M4), and Medicine Creek waste dump (M2) in that order, based on the amount of high and moderately sensitive vegetation associations affected.

The only vegetation association ranked as highly sensitive that would have a major impact is the Sagebrush - Bluebunch Wheatgrass Association. The Riparian and Willow - Sedge Bog associations would only have minor impacts. Comparison with the local study area shows that 54.2 percent of the Sagebrush - Bluebunch Wheatgrass Association would be affected during the mine operation. This would be a highly significant proportion. However, as was stated in the summary section of the construction phase (Section 5.4 (b)(ii), the exact consequence of this loss is difficult to evaluate based on the local study area field survey.

The vegetation association which would be affected the greatest in terms of area lost is the Douglas-fir - Pinegrass Association (1002.85 ha or 2478 acres).

TABLE 5-28

AREA WITHIN EACH SENSITIVITY CLASS ALIENATED BY THE OPERATION OF THE PLANT AND MINE FACILITIES

Sensitivity	Plant	Mine	Operation Total	Major Vegetation Associations Affected
High	8.06	370.19	378.25	Sagebrush - Bluebunch Wheatgrass Association Riparian Association Willow - Sedge Bog Association
Moderate	-	662.05	662.05	Douglas-fir - Bunchgrass Association Douglas-fir - Bunchgrass - Pinegrass Association Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass - Pinegrass Complex
Low	665.54	1067.24	1732.78	Douglas-fir - Pinegrass Association Kentucky Bluegrass Association

However, its low sensitivity combined with its known province-wide distribution in the Interior Douglas-fir Zone would lessen the impact. On the other hand, the low sensitivity Kentucky Bluegrass Association would lose 685.79 ha (1695 acres) or 14.7 percent of that found in the local study area with the operation of the mine and plant. Its probable wide distribution outside the local study area could negate the significance of its 14.7 percent loss.

Lessening of the impacts to the above mentioned vegetation associations would entail relocation of the facilities causing the impact, since the reasons for the high sensitivities result from intrinsic vegetation properties. In terms of the Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass associations (moderate sensitivities), the sensitivity rating evolves primarily from the erosion potential of their soils on steep slopes (> 30 percent) and poor reclaimability. Both these problems could be controlled with proper construction techniques and some relocation around the steeper slopes.

No rare or endangered plants have been found during the field surveys. The only possible impact would be to showy spring flowers, such as shooting star (*Dodocathon pauciflorum*), spring beauty (*Claytonia lanceolata*) and yellow bells (*Fritillaria pudica*) that are common throughout the open range areas of the Hat Creek Valley.

Further analysis of the vegetation will be done in the context of the biophysical impact analysis where the relationship of soils, vegetation and slope can be analyzed in homogeneous units.

(d) Decommissioning

Decommissioning would occur when the life expectancy of the mine and plant is completed. At this stage, the final revegetation of the fly ash ponds and mine waste dumps would take place. Mine buildings would be dismantled and concrete floors broken up and buried. All facilities of the mine and plant would cease operation unless designed to operate an alternate function such as the make-up water pipeline from the Thompson River remaining operational to provide irrigation water or supplement the flow of Hat Creek.

Although land reclamation (recontouring and revegetation) would be a continuing process throughout the life of the mine waste dumps, the fly ash and bottom ash disposal areas would be reclaimed during the decommissioning period.

The land reclamation plan proposed by Acres[89] would initiate the revegetation of the mine waste dumps as early as possible during the mine operation, provided the centreline method of embankment construction is used. In this way, the embankments could be revegetated during the early years of the mine operation. The waste dump surface then could be progressively revegetated during the later years of operation. Suitable topsoil materials would be identified in disturbed areas such as pit and waste dump areas and would be stored for future application to the waste dump areas to aid in their vegetation process.

Selective placement of mine spoils at the waste dump surfaces would be desirable since the mined waste materials possess varying growth mediums for plant growth; the topsoil and glacial till materials being superior to other materials listed. This selective surfacing should place approximately 2 m (6 ft.) of material over the waste dumps. An additional layer of 1.4 cm (0.6 in.) of topsoil should then be placed on top of this, to ensure adequate growth and germination. This is especially true of the fly ash disposal areas where the fly ash is nutrient-poor and may have very high levels of trace elements. These trace elements could restrict growth of the species used in the revegetation programme, as well as invading native species.

The exact species to be used in the revegetation programme have not been determined to date. The data from the field test plots are expected at the end of the 1978 growing season, at which time information on possible species to use and a preliminary revegetation plan would be developed. It should be emphasized that this would be an ongoing developmental programme. Early indications suggest that crested wheatgrass, Russian wild rye and legumes, such as drylander alfalfa and melrose sainfoin, may prove quite useful.

Hydroseeding, broadcast seeding and drill seeding would be employed for the distribution of seeds, fertilizer and mulch during the revegetation programmes. Irrigation of newly-seeded areas may be desirable to promote early seed germination and initial growth. It is suggested that possible development of a seed nursery to grow native species that fit the site-specific conditions may be advantageous for revegetation purposes.

High levels of trace elements in the waste dumps, fly ash, and bottom ash produced by Hat Creek coal are of potential concern to the future revegetation of these materials[89]. In addition, the overburden, waste rock, low grade coal waste and beneficiation plant tailings show high levels of trace elements. Some of these trace elements may be toxic to the plants used in the revegetation programme, as well as invading native species (Table 5-26).

Possible toxicity to plants could come from the accumulation of trace elements at the surface due to a precipitation-evaporation deficiency in the summer months. This may draw up trace elements from the lower strata of waste rock, low grade coal waste, and ash into the topsoil where they are available to plant uptake. In addition, sufficient quantities may be available in freshly exposed topsoil and overburden. The toxicity may occur as a reduced growth rate or direct killing of the plant.

The trace elements shown to be toxic to plants or to cause growth reduction are given in Table 5-26. To estimate the amount of these trace elements available to plants, Table 5-29 has been developed, comparing the total extractable portion of the trace elements of concern for each type of waste

TABLE 5-29

TOTAL EXTRACTABLE SALTS AND TOTAL SURFACE SOIL AMBIENT LEVELS FOR SIX TYPES OF WASTE MATERIAL

Trace Elements of Concern to Plants	Relative Toxicity to Plants*	Total Extractable Salts (Water Soluble)						Total Surface Soil Ambient Levels*		
		Overburden*	Waste Rock**	Low Grade Coal Waste**	Beneficiation Plant Tailings**	Fly Ash**	Bottom Ash**	October 1976	January 1977	May 1977
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Arsenic (As)	High	0.5 - 1.3	1.0	0.8	0.2	4.3	3.1	4.87	93.4	76.8
Beryllium (Be)	High	-	-	-	-	-	-	0.41	-	-
Cobalt (Co)	High	-	-	-	-	-	-	12.93	-	-
Tin (Sn)	High	-	-	-	-	-	-	>85.20	-	-
Lithium (Li)	Moderate to High	<0.3	<0.3	0.6	0.4 - 1.6	0.3	0.3	14.39	-	-
Boron (B)	Moderate	1.0	2.0	1.0	1.0 - 1.2	6.3	0.7	8.93	-	-
Cadmium (Cd)	Moderate	<0.03	<0.08	<0.08	0.02 - 0.03	0.02	0.06	< 0.58	10.30	<6.18
Chromium (Cr)	Moderate	1.0 - 1.5	<1.0	<1.0	<1.0 - 1.3	<1.0	<1.0	247.07	41.46	62.60
Lead (Pb)	Moderate	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	7.73	<2.0	<3.0
Vanadium (V)	Moderate	<0.2	0.2	0.3	0.4 - 0.6	1.4	3.8	297.60	32.61	59.20
Zinc (Zn)	Moderate	6.8 - 10.8	8.8	15.0	1.2 - 1.5	40.0	80.07	147.13	99.20	128.26
<u>Non-Toxic Salts</u>										
Sodium	-	178 - 225	542	1280	220 - 240	100	110	-	-	-
Calcium	-	290 - 400	480	600	340 - 580	3240	1320	-	-	-
Magnesium	-	358 - 380	440	540	52 - 54	190	190	-	-	-

* Data from ERT

** Data from ACRES[27]

material generated by the mine and plant to the total ambient soil levels. It is emphasized that the soil levels are total values, not the water extractable amounts. The latter values are not available.

(i) Environmental Change

A. Mine

The reclamation period for the waste dumps would be long. Therefore, the revegetation should begin as early as possible during the mine operation. The embankments would be revegetated first, while the waste dump surface would be progressively revegetated in the later years of the mining and decommissioning period. Topsoil followed by an approximately 2 m (6 ft.) layer of glacial till or overburden material would be placed over the waste rock and low grade coal waste. The placement of glacial till or overburden which generally consists of a mixture of glacial till, glacial-fluvial or alluvial deposits (unconsolidated material) over the waste rock would be preferable because it would provide a superior growth medium[89].

Table 5-29 indicates that arsenic, boron, chromium, lead and zinc could be leached from the overburden, waste rock and low grade coal waste in quantities greater than 1 mg/kg. Of these, arsenic, chromium and zine appear to be the potentially most toxic because of the already high levels present in the soils. Vanadium also appears to be highly concentrated in the soil. In addition to the toxic trace elements, the salts sodium, calcium and magnesium exist in the waste rock and low grade coal waste in relatively large quantities (Table 5-29). These could reach toxic levels for some plant species and cause the establishment of a different plant community such as that found in saline depressions.

B. Plant

The reclamation of the ash disposal areas would occur during the decommissioning period and should proceed similarly to the mine revegetation programme. The addition of topsoil and glacial till over the fly ash and bottom ash would develop the new growth medium.

The greatest amounts of trace elements would be contained in the fly ash and bottom ash (Table 5-29). Arsenic, boron, lead, vanadium and zinc are of most concern because of their high water soluble concentrations, high mobility and generally high ambient soil levels. Calcium also exhibits extremely high levels that may affect availability of other nutrients as well as trace elements. The effect of these high concentrations of trace elements in the fly ash and bottom ash would be one of increasing the already relatively high levels of arsenic, vanadium and zinc in the soil and overburden. This combined with soil enrichment due to evaporation and subsequent plant uptake may result in toxic levels.

C. Summary

Arsenic, vanadium and zinc have been identified to be of primary concern in the mine and plant disposal systems. Chromium and boron may be of secondary importance to plant establishment and growth. High salinity and alkalinity may restrict some plant species on the mine waste dumps and plant ash disposal areas. Salt-tolerant species and plant species able to withstand high alkalinity should be a natural choice for revegetation work. Invading native species would generally be of this character, if the soils are already quite alkaline and saline. Increase in these salts with time may eliminate the less tolerant species.

If the hypothesis that evaporation will bring increased levels of trace elements to the soil surface is correct, it is difficult to predict the ultimate vegetation damage or species composition alteration. As stated under waste disposal, Section 5.4(f), many factors affect a trace element's availability to plants, as well as a plant's sensitivity to certain trace element concentrations. It is not known in what time period toxic trace element levels will be reached.

However, if the hypothesis is true, it is expected that plant species planted during the reclamation would grow until their tolerance limits are exceeded and then would die. This also is true for invading species. The spaces that would be left by unsuccessful plants would be invaded by more tolerant types. Plant species that would be able to grow on these disposal areas generally are accumulators of trace elements. This factor would have an adverse effect on livestock and wildlife that utilize these plants for forage and some control measures may be necessary to prevent grazing in these areas.

In order to establish what the effect of these trace element concentrations would have on plants, a long-term study would be necessary. This study should be designed to monitor changes in both soil and vegetation trace element concentrations. Different plant species including invading native species should be monitored. In this way, resistant plant species could be chosen and the trace elements of concern could be identified.

If the problem with high trace element concentration or high levels of sodium, calcium or magnesium could be controlled, revegetation would establish a seeded plant cover of grasses and legumes to control erosion and runoff.

Because the recontouring of the topography of the waste dumps and ash disposal areas would consist of relatively steep benches (overall slope 26^{o}) with large, flat upper levels, very few micro topographical changes would result. The underlying materials and topography would be constructed so as to promote good surface drainage. This uniform topography would lack micro habitats for a diverse vegetational environment.

Once the area has been seeded, successional change would be slow. The successional trend would definitely follow that of a primary succession since the invading plant species would be invading an essentially unweathered parent material. However, the existence of a cover of seeded plant species may alter factors such as soil nitrogen, soil moisture, organic matter content of the soil, and soil biota. These factors could increase the speed of succession. The genesis of the plant communities formed in the process of primary succession basically consists of immigration, establishment, and multiplication. With each successive stage or sere, the habitat would be ameliorated and edaphic conditions improved and the dominance shifted from small plants low in the phytogenetic scale to large plants (shrubs and trees).

Competition plays a very important role in the succession process, exerting autogenic influences in the form of competition for light, moisture and the possibility of the production of toxins that inhibit the growth of other plants. This factor may play a very important role in the context of the revegetation programme because of the existence of a seeded plant cover that may restrict the influx of native plant species.

Generally, it is expected that the waste dumps and ash disposal areas would remain as seeded with a slow influx of native grass species. The greatest influx of native species would come from invading weed species, such as sweet-clover (*Melilotus spp.*), knapweed (*Centaurea diffusa*) and yarrow (*Achillea millefolium*). Range invaders such as compound fleabane (*Erigeron compositus*), prairie smoke avens (*Geum triflorum*), dandelion (*Taraxacum officinale*) and pussytoes (*Antennaria spp.*) may be pioneer invaders in the waste areas. Because of the well drained, exposed nature of the waste dumps and ash disposal areas, moisture would probably be the controlling factor in the types of species that would invade and establish themselves on the waste site. If these sites were irrigated, an influx of more moisture-loving species might be expected.

Further invasion of the waste dumps and ash disposal areas would probably be by nearby range grass species such as Kentucky bluegrass (*Poa pratensis*), junegrass (*Koeleria cristata*), western needlegrass (*Stipa occidentalis*) and needle-and-thread grass (*Hordeum jubatum*). The invasion of these sites by shrub species would be sporadic; little wild rose (*Rosa gymnocarpa*), junipers (*Juniperus spp.*) and probably sagebrush (*Artemisia spp.*) may invade the sites in very low numbers. Tree species, on the other hand, would be doubtful candidates for invasion until the very late stages of succession. Competition from herbaceous species, as well as the dense turf likely to form, may restrict seedling germination and establishment. Unfavourable moisture conditions would also be a contributing factor to the possible problems with tree encroachment on the waste dumps and ash disposal areas.

In summary, the expected result of the revegetation programme and subsequent successional trends would be toward a grass-herb dominated community with few shrubs or trees until the latter stages of succession (20 to 40 years).

(ii) Resource Projection - Impact of the Project

In general, the impact of the decommissioning phase would be a beneficial one, since both plant and mine waste disposal areas would be revegetated. This could provide stabilization to the exposed areas and create new habitats for the invasion of native plant species. In terms of negative impacts, the waste disposal areas may provide unwanted seed sources for noxious range and forest weeds, causing a further degradation of the ranges. The expected successional vegetational trends would lead towards a grass-herb dominated community with few shrubs or trees. Competition from planted grass and legume species may restrict invasion of native species.

Problems with high levels of trace elements and salts, such as sodium, magnesium and calcium, are difficult to assess since the exact quantities of trace elements, sensitive plant species, and role of evapotranspiration in concentrating the trace elements is not known. However, the possibility does exist for their increase in the surface soils because of high natural levels of arsenic, chromium, vanadium and zinc as well as the salts sodium, magnesium and calcium in the weathered soil. This combined with the addition of huge quantities of fly ash, unweathered overburden and waste rock, all high in trace elements and salts, may create toxic surface soil concentrations to plant species. However, secondary impacts to wildlife and livestock may be potentially greater when plants containing high levels of trace elements are grazed upon. This may require fencing of all waste disposal areas.

5.5 BIOPHYSICAL IMPACT ANALYSIS

Land, the complex of many interrelated and integrated parts, performs as a combined entity not separately as soil, topography, climate or vegetation. However, throughout the principles of biophysical classification, land variability can be expressed in terms of those combinations of features that are significant to meet the specific purpose of its use. The chosen physical and biological characteristics provide a basis for a systematic analysis of the land for agriculture, grazing, forestry and wildlife uses as was presented in Section 4.2(d). This has been presented in the form of land capabilities for each land use.

The previous Sections 5.2 and 5.4 have dealt with the impacts of the Hat Creek project on the individual resources, climate, landform, geology, soil and vegetation. These have been analyzed individually without assessing the possible interrelationship or interactions that occur between those resources or their ability to support various land uses. The biophysical impact analysis completes this function.

For the purposes of the biophysical impact analysis, environmental sensitivities were developed for each biophysical subunit affected by one of the project facilities. Environmental sensitivities have been developed for those biophysical subunits affected, not for the entire 254 subunits identified during the inventory phase. The biophysical subunit has been used for the impact analysis because it is the detailed mapping unit and possesses site-specific features important to the development of limitations and mitigation guidelines. This procedure is outlined in Section 3.2(e).

The biophysical impact has been analyzed using both a direct loss and qualitative sensitivity analysis. The direct loss analysis identifies the biophysical subunits affected by the various project facilities and quantifies the amount lost or disturbed. The qualitative sensitivity analysis ranks each biophysical subunit as having a high, moderate or low sensitivity to the development activities of the Hat Creek project based on its physical and biological characteristics and capability of supporting agriculture, grazing, forestry and/or wildlife. Both of these analysis techniques have been utilized to produce biophysical limitations to disturbance.

(a) Analysis of Direct Loss

This section quantifies the impacts resulting from the construction and operation of the facilities for the proposed Hat Creek project (Table 5-1). The areas of each biophysical subunit affected by mine, plant and offsite facilities have been grouped by construction and operation as shown on Table 5-30. The individual facility totals have not been calculated; only the totals for each major development have been calculated, i.e., mine, plant and offsite. Planimetry has been used to calculate site-specific facilities, while linear corridors such as pipelines, roads, transmission lines and conveyors have been measured in a linear fashion.

(i) Construction

A total of 64 biophysical subunits would be affected by the construction of the mine, plant and offsite facilities (Table 5-30). The offsite facilities would affect the greatest number (46), while the plant the least (7). The mine would fall in between with a total of 20 biophysical subunits affected. The total impact due to construction would be 880.3 ha (2174 acres).

TABLE 5-30

AREA EVALUATION OF THE CONSTRUCTION AND OPERATION IMPACTS OF THE HAT CREEK PROJECT ON THE BIOPHYSICAL SUBUNITS (Hectares)

Biophysical Subunit	Construction			Construction Total	Operation		Operation Total
	Mine	Plant	Offsite		Mine	Plant	
1AB.21			7.14	7.14			0
1ADB.27	2.97		0.90	3.87	0.50		0.50
1AE.8	15.86		1.87	17.73			0
1AE.10	13.72		1.94	15.66	50.69		50.69
1AE.19	15.85		0.42	16.27	86.01		86.01
1BGS1+3.21			59.09	59.09			0
1BGS1+3.28			6.95	6.95			0
1BRL1+3.10			1.47	1.47			0
1BRL1+3.13	22.96		3.79	26.75	2.29		2.29
1BRL1+3.21			8.23	8.23			0
1BRL1+3.29	6.99		-	6.99	39.63		39.63
1EB.21			11.13	11.13			0
1EB1.31			0.92	0.92			0
1TE1.17	14.62			14.62	15.66		15.66
2AB1.31			2.46	2.46			0
2ABL.17			4.99	4.99		1.53	1.53
2ABL1.17				0	2.57	210.29	212.86
2AE.7			9.33	9.33	39.65		39.65
2CB.31			18.60	18.60			0
2CB1.31			5.55	5.55			0
2CE.7			5.85	5.85			0
2CE1.7				0	266.0		266.0
2CE.21			1.47	1.47			0
2EB1.31			15.22	15.22			0

TABLE 5-30 (Continued)

Biophysical Subunit	Construction			Construction Total	Operation		Operation Total
	Mine	Plant	Offsite		Mine	Plant	
2TB.31			1.48	1.48			0
2TB1.31			32.19	32.19			0
2TBL1.7	3.64			3.64	21.09		21.09
2TBL.17			7.57	7.57			0
2TBL1.17	15.49	19.1	24.79	59.38	80.39		80.39
2TBL2.17		7.06		7.06		3.65	3.65
2TDB1.8	16.98		0.68	17.66	75.38		75.38
2TDB1.18			29.12	29.12			0
2TDB1.19	20.63		8.29	28.92	233.06		233.06
2TDB1.23			12.95	12.95	33.17		33.17
2TE.3				0	1.07	21.35	22.42
2TE.7	21.90		0.74	22.64	182.61		182.61
2TE1.7				0	13.06		13.06
2TE.10	21.64	0.74	22.32	44.7	41.21		41.21
2TE1.10	0.96		13.34	14.3	25.64		25.64
2TE.18	0.84			0.84	5.72		5.72
2TE1.19	16.91			16.91	95.82		95.82
2TG.7		56.87	1.45	58.32			0
2TG.17			5.86	5.86			0
2TGL.3		56.83	4.32	61.15	1.45	4.28	5.73
2TGL.7	3.48	9.87	38.94	52.29	63.30	387.94	451.24
2TGL.10			1.55	1.55			0
3AE2.24	5.26			5.26	12.93		12.93
3CB1.31			3.49	3.49			0
3CB2.31			6.13	6.13			0
3CE1.10				0	111.18		111.18
3CG1+2.24				0	71.52		71.52
3EB1.21			1.03	1.03			0

Table 5-30 (Continued)

Biophysical Subunit	Construction			Construction Total	Operation		Operation Total
	Mine	Plant	Offsite		Mine	Plant	
3EB1.31			10.34	10.34			0
3TB1.31			13.65	13.65			0
3TBL1.17				0	149.37		149.37
3TDB.17				0	75.32		75.32
3TDB.23			32.22	32.22			0
3TE.7				0	0.91		0.91
3TE1.7			3.97	3.97			0
3TE.10	13.77		13.84	27.61	17.74		17.74
3TE1.10			0		171.18		171.18
3TE1.17			0		103.57		103.57
3TGL.7		18.29	8.43	26.72	0.84	34.50	35.34
3TGL.17			3.55	3.55			0
W	0.73			0.73	4.11	9.06	13.17
R				0	5.96		5.96
Total	235.2	168.76	476.7	880.3	2100.6	673.6	2774.2

A. Mine

Four biophysical subunits would affected, losing more than 20 ha (49.4 acres). Subunit 1BRL1+3.13 would lose 22.96 ha (56.7 acres), Subunit 2TE.7, 21.90 ha (54.1 acres), Subunit 2TE.10, 21.64 ha (53.4 acres), and Subunit 2TDB1.19, 20.63 ha (53.4 acres). The majority of the remaining biophysical subunits would have impacts ranging from a low 0.84 ha (2.07 acres) to a high of 16.98 ha (41.9 acres).

B. Plant

Seven biophysical subunits would be affected by the plant. Subunits 2TG.7 and 2TGL.3 are the only ones which would be substantially affected with 56.87 ha (140.5 acres) and 56.83 ha (140.4 acres) affected, respectively. Of the remaining five subunits, Subunit 2TBL1.17 would be affected by 19.1 ha (47.2 acres) and Subunit 3TGL.7 would be affected by 18.29 ha (45.2 acres).

C. Offsite Facilities

The offsite facilities would disturb the greatest number of biophysical subunits (46) as well as the largest area in the construction phase (476.7 ha or 1177.3 acres).

Although a large number of biophysical subunits would be affected by the construction of the offsite facilities, the impact on any one biophysical subunit would be small. Subunit 1BGS1+3.21 would have the greatest impact (59.09 ha or 145.9 acres), while Subunit 2TGL.7 (38.94 ha or 96.2 acres), Subunit 2TBL.31 (32.19 ha or 79.5 acres), Subunit 3TDB.23 (32.22 ha or 79.6 acres), Subunit 2TDB1.18 (29.12 ha or 71.9 acres), and Subunit 2TE.10 (22.32 ha or 55.1 acres) follow. The remaining biophysical subunits would be affected to varying degrees, but all less than 20 ha (49.4 acres).

(ii) Operation

The operation of the plant and mine affects a total of 34 biophysical subunits

(Table 5-29). Many of the biophysical subunits would be significantly affected in contrast to those in the construction phase (> 100 ha). The operation of the mine affects 33 biophysical subunits, while the plant operation affects only seven. The total area impact of the operation phase would be 2774.2 ha (6851.7 acres).

A. Mine

Seven of the 33 biophysical subunits that may be affected by the mine operation would have area impacts exceeding 100 ha (247 acres). Subunits 2CE1.7 and 2TDB1.19 show the greatest impacts with 266.0 ha (657.0 acres) and 233.06 ha (575.6 acres) lost, respectively. The following biophysical subunits would be affected by more than 100 ha (247 acres) in order of significance, 2TE.7 (182.61 ha or 451.0 acres), 3TE1.17 (178.89 ha or 441.8 acres), 3TE1.10 (171.18 ha or 422.8 acres), 3TBL1.17 (149.37 ha or 368.9 acres) and 3CE1.10 (111.18 ha or 274.6 acres).

B. Plant

Within the plant operation, seven biophysical subunits would be affected. However, only two of these seven would be significantly alienated. Subunits 2TGL.7 and 2ABL1.17 would be affected 387.94 ha (958.1 acres) and 210.29 ha (519.4 acres), respectively.

(iii) *Summary of the Construction and Operation Quantitative* Impacts on the Biophysical Subunits

Sixty-four biophysical subunits would be disturbed by the construction and operation of the mine and plant. Subunit 2TGL.7 would be affected the greatest in comparison to other subunits by a two-fold margin (503.53 ha or 1243.6 acres). Subunits 2TE1.7 (266.0 ha or 657.0 acres) and 2TDB1.19 (261.98 ha or 647 acres) follow with the operation phase causing the greatest potential alienation. The following subunits would be all affected by greater than 100 ha (247 acres): 2ABL1.17 (212 ha or 525.7 acres), 2TE.7 (205.25 ha or 506.9 acres), 3TE1.17 (178.89 ha or 441.8 acres), 3TE1.10 (171.18 ha or 422.8 acres), 3TBL1.17 (149.37 ha or 368.9 acres), 2TBL1.17 (139.77 ha or 345.2 acres), 2TE1.19 (112.73 ha or 278.4 acres), 3CE1.10 (111.18 ha or 274.6 acres), and 1AE.19 (102.28 ha or 252.6 acres).

In addition to the 64 biophysical subunits, the Wetland Unit (W) and Rock Outcrop Unit would be affected to a minor extent, primarily during the operation phase. The Wetland Unit would be affected by 0.73 ha (1.8 acres) during the construction phase and 13.17 ha (32.5 acres) during the operation phase.

Although the construction phase may affect a greater number of subunits (54) mainly due to the construction of the offsite facilities, the relative affect on each biophysical subunit is less than the operation phase. The operation phase tends to affect several biophysical subunits highly, with moderate impacts on the remainder. The operation of the mine would have the greatest total impact in terms of area alienated. The operation phase would alienate more land area (2774.2 ha or 6851.7 acres) than the construction phase (880.3 ha or 2174.2 acres).

(b) Sensitivity Analysis for Biophysical Subunits

For each biophysical subunit in the site-specific study area that has been found to be affected by development in the direct loss analysis, a high, moderate or low sensitivity has been attached (Table 5-31). This has been done utilizing physical and biological data, and the resource capabilities developed during the inventory stage. A separate sensitivity rating has been derived for both the physical and biological data and the resource capabilities. The physical and biological sensitivity has been developed from the sensitivity ratings assigned for soils and vegetation (Tables 5-2 and 5-11, respectively). Slope has been assigned high, moderate or low sensitivity based on the following criteria: zero to nine percent (low); 10 to 29 percent (moderate); 30 percent plus (high).

TABLE 5-31

BIOPHYSICAL SENSITIVITY ANALYSIS FOR THE BIOPHYSICAL SUBUNITS BY THE CONSTRUCTION AND OPERATION OF THE MINE, PLANT AND OFFSITE FACILITIES

Resources / Biophysical Subunits	Physical & Biological Sensitivities			Resource Capabilities							Composite Sensitivity and Use Evaluation				
	Slope	Soil	Vegetation	Agriculture	Domestic Grazing	Forestry	Wildlife: Deer	Moose	Waterfowl	Other	Physical and Biological Sensitivity	Level of Resource Integration	Principal Utilization	Secondary Utilization	Integrated Resource Capability
Importance Value	1.0	1.0	1.0	10.0	3.0	7.0	1.1	0.2	0.1	0.6					
1AB.21	1	2*	3	10	0	0	6.0	1.0	0.1	3.0	6* M	I	Ag	-	108.61 H
1ADB.27	1	2	3	8	0	0	6.0	1.0	2.0	5.0	6 M	I	Ag	-	90.0 H
1AE.8	1	2	2	8	0	2.5	6.0	1.0	0	5.0	5 M	II	Ag	For	89.8** H
1AE.10	1	3	2	8	0	2.5	3.0	1.0	0	3.0	6* M	II	Ag	For	85.3** H
1AE.19	1	3	3	8	0	0.8	10.0	0	0	3.0	7 H	I	Ag	-	92.8 H
1BGS1+3.21	1	2	3	8	0	0	6.0	1.0	0.1	3.0	6 M	I	Ag	-	88.61 H
1BGS1+3.28	1	2	2	8	0	0	6.0	3.0	0.5	10.0	5 M	I	Ag	-	93.25 H
1BRL1+3.10	1	2	2	8	0	0	3.0	1.0	0	3.0	5 M	I	Ag	-	85.3 H
1BRL1+3.13	1	2	3	8	0	2.5	6.0	10.0	2.0	10.0	6 M	II	Ag	Wild	94.8** H
1BRL1+3.21	1	2	3	8	0	0	6.0	1.0	0.1	3.0	6 M	I	Ag	-	88.61 H
1BRL1+3.29	1	2	3	8	0	0	10.0	1.0	0.5	10.0	6 M	II	Ag	Wild	97.25 H
1EB.21	1	2	3	8	0	0	6.0	1.0	0.1	3.0	6* M	I	Ag	-	93.01 H
1EB1.31	1	3	1	10	0	0	6.0	0	0	3.0	5* M	I	Ag	-	108.4 H
1TE1.17	1	3	1	8	0	0	3.0	1.0	0	3.0	5* M	I	Ag	-	85.3 H
2AB1.31	2	2*	1	8	0	0	6.0	0	0	3.0	6* M	I	Ag	-	88.4 H
2ABL.17	2	2	1	0	8.6	0	3.0	0	0	2.0	5 M	I	Gr	-	30.3 L
2ABL1.17	2	2*	1	0	8.6	0	3.0	0	0	2.0	5* M	I	Gr	-	30.3 L
2AE.7	2	2	1	0	2.8	2.5	3.0	1.0	0	2.0	5 M	II	For	Gr	28.0 L
2CB.31	2	2	1	8	0	0	6.0	0	0	3.0	5 M	I	Ag	-	88.4 H
2CB1.31	2	3	1	8	0	0	6.0	0	0	3.0	6* M	I	Ag	-	88.4 H
2CE.7	2	2	1	0	8.6	2.5	3.0	1.0	0	2.0	5 M	II	For	Gr	48.0 M
2CE1.7	2	3	1	0	8.6	2.5	3.0	1.0	0	2.0	6* M	II	For	Gr	48.0 M
2CE.21	2	2	3	8	0	0	6.0	1.0	0.1	3.0	7 H	I	Ag	-	88.61 H
2EB.31	2	2	1	8	0	0	6.0	0	0	3.0	5 M	I	Ag	-	88.61 H
2EB1.31	2	3	1	8	0	0	6.0	0	0	3.0	6* M	I	Ag	-	88.4 H
2TB.31	2	2	1	8	0	0	6.0	0	0	3.0	5 M	I	Ag	-	88.4 H
2TB1.31	2	3	1	8	0	0	6.0	0	0	3.0	6* M	I	Ag	-	88.4 H
2TBL1.7	2	2	1	0	8.6	2.5	3.0	1.0	0	2.0	5 M	II	For	-	48.0 M
2TBL.17	2	2	1	0	8.6	0	3.0	1.0	0	2.0	5 M	I	Gr	-	30.5 L
2TBL1.17	2	2	1	0	8.6	0	3.0	1.0	0	2.0	5 M	I	Gr	-	30.5 L
2TBL2.17	2	2	1	0	10.0	0	3.0	1.0	0	2.0	5 M	I	Gr	-	34.7 L
2TDB1.8	2	3	2	6	0	2.5	3.0	1.0	0	2.0	7 H	II	Ag	For	64.7** M
2TDB1.18	2	3	1	6	0	0	6.0	1.0	0	2.0	6* M	II	Ag	Wild	68.8 M
2TDB1.19	2	3	3	6	0	0	10.0	0	0	2.0	8 H	II	Ag	Wild	72.2 M

TABLE 5-31 (Continued)

Biophysical Subunits \ Resources	Physical & Biological Sensitivities			Resource Capabilities							Composite Sensitivity and Use Evaluation				
							Wildlife								
	Slope	Soil	Vegetation	Agriculture	Domestic Grazing	Forestry	Deer	Moose	Waterfowl	Other	Physical and Biological Sensitivity	Level of Resource Integration	Principal Utilization	Secondary Utilization	Integrated Resource Capability
Importance Value	1.0	1.0	1.0	10.0	3.0	7.0	1.1	0.2	0.1	0.6					
2TDB1.23	2	3	2	8	0	0	6.0	1.0	10.0	3.0	7 H	II	Ag	Wild	89.6 H
2TE.3	2	2	1	0	1.4	4.2	3.0	3.0	0	2.0	5 M	II	For	Gr	38.7 L
2TE.7	2	1	1	0	8.6	2.5	3.0	1.0	0	2.0	4 L	II	For	Gr	48.0 M
2TE1.7	2	2*	1	0	8.6	2.5	3.0	1.0	0	2.0	5* M	II	For	Gr	48.0 M
2TE.10	2	2	2	8	0	2.5	6.0	1.0	0	2.0	6 M	II	Ag	For	33.9 L
2TE1.10	2	2*	2	0	8.6	2.5	6.0	1.0	0	2.0	6* M	II	Ag	For	51.3 M
2TE.18	2	3	1	6	0	0	6.0	1.0	0	2.0	6* M	I	Ag	-	68.0 M
2TE1.19	2	3	3	8	0	0	10.0	0	0	2.0	8 H	II	Ag	Wild	92.2 H
2TG.7	2	2*	1	0	8.6	2.5	3.0	1.0	0	2.0	5* M	II	For	Gr	48.0 L
2TG.17	2	2*	1	0	8.6	0	3.0	1.0	0	2.0	5* M	I	Gr	-	30.5 L
2TGL.3	2	2	1	0	8.6	4.2	3.0	3.0	0	2.0	5 M	II	For	Gr	60.3 M
2TGL.7	2	2	1	0	8.6	2.5	3.0	1.0	0	2.0	5 M	II	For	Gr	48.0 M
2TGL.10	2	2	2	0	8.6	2.5	6.0	1.0	0	2.0	6 M	III	Gr	For (Wild)	51.3 M
3AE2.24	3	2	2	0	2.8	2.5	3.0	1.0	0	2.0	7 H	II	For	Gr	30.6 L
3CB1.31	3	3	1	8	0	0	6.0	0	0	2.0	7 H	I	Ag	-	87.8 H
3CB2.31	3	3	1	0	2.8	0	6.0	0	0	2.0	7 H	II	Gr	Wild	16.2 L
3CE1.10	3	3	2	0	2.8	2.5	6.0	1.0	0	2.0	8 H	III	For	Gr (Wild)	33.9 L
3CG1+2.24	3	3	2	0	2.8	2.5	3.0	1.0	0	2.0	8 H	II	For	Gr	30.6 L
3EB1.21	3	2*	3	8	0	0	6.0	1.0	0	2.0	8 H	I	Ag	-	88.0 H
3EB1.31	3	3	1	10	0	0	6.0	0	0	2.0	7 H	I	Ag	-	107.8 H
3TB1.31	3	3	1	0	2.8	0	6.0	0	0	2.0	7 H	II	Gr	Wild	16.2 L
3TBL1.17	3	2*	1	0	8.6	0	3.0	1.0	0	2.0	6* H	I	Gr	-	30.5 L
3TDB.17	3	3	1	0	2.8	0	3.0	1.0	0	2.0	8 H	I	Gr	-	13.1 L
3TDB.23	3	2	2	8	0	0	6.0	1.0	10	5.0	7 H	II	Ag	Wild	90.8 H
3TE.7	3	2	1	0	2.8	2.5	3.0	1.0	0	2.0	6 M	II	For	Gr	30.6 L
3TE1.7	3	2*	1	0	1.4	2.5	3.0	1.0	0	2.0	6* M	II	For	Gr	26.4 L
3TE.10	3	3	2	6	0	0.8	6.0	1.0	0	2.0	8 H	III	Gr	-	73.6 M
3TE1.10	3	2*	2	0	8.6	0.8	6.0	1.0	0	2.0	7 H	III	Gr	-	39.4 L
3TE1.17	3	3	1	8	0	0	3.0	1.0	0	2.0	7 H	I	Ag	-	84.7 H
3TGL.7	3	2	1	0	8.6	2.5	3.0	1.0	0	2.0	6 M	II	For	Gr	48.0 M
3TGL.17	3	2	1	0	8.6	0	3.0	1.0	0	2.0	6 M	III	Gr	Wild	30.5 L
W	1	3	3	0	2.8	0	3.0	10.0	0.5	5.0	7 H	III	Wild	Gr	16.75 L

H = high; M = medium; L = low

* subunits possessing an overriding physical or biological characteristic

** subunits possessing an overriding resource capability

In order to establish a sensitivity rating for the resource capabilities, a two-step approach has been used. Utilizing the approach used by Jurdant[92] in the James Bay area, each resource, i.e., agriculture, grazing, forestry and wildlife has been assigned a numerical score based on the resource capabilities outlined in the inventory section. The resource capabilities produced during the inventory have been ranked on a scale of zero to ten in terms of the quantitative difference in resource capability in relation to the others. Table 5-32 illustrates the relationship of the within class rank scores to the capability classes for each discipline. A brief methodology for the derivation of the within class rank scores for each discipline follows and is basically a synopsis of that already presented in the inventory methodology (Section 3.2(e)).

Forestry

The forestry within class ranking has been completed by Reid, Collins and Associates Ltd. using the relative productivity for the predominate forest growth type in the local study area. This has yielded the rankings shown in Table 5-32 for forestry.

Agriculture

The agriculture values have been based on the ratings applied to the various soil units by Canadian Bio Resources Consultants Ltd. which reflect their capability and productivity. Each of these ratings have been given a numerical score and a weight as expressed in Table 5-32. The weight illustrates the relationship of the applied agriculture ratings to each other, yielding the within class rank score.

Grazing

The grazing values have been based on the Canada Land Inventory classification

TABLE 5-32

RELATIONSHIP OF THE RESOURCE CAPABILITIES TO THE WITHIN CLASS RANK SCORES

Agriculture

Capability	Within Class Rank
Nil	0
Low	2
Medium	6
Medium-High	8
High	10

Grazing

Capability	Within Class Rank
Nil	0
Low	1.4
Medium	2.8
Medium-High	8.6
High	10.0

Forestry

Productivity	Within Class Rank
Nil	0
Low	0.8
Poor	2.5
Medium	4.2
Good	10.0

Deer & Moose

Capability	Within Class Rank
Nil	0
Low	1.0
Medium	3.0
Medium-High	6.0
High	10.0

Waterfowl

Capability	Within Class Rank
Nil	0
Low	0.1
Medium	0.5
Medium-High	2.0
High	10.0

Other

Capability	Within Class Rank
Nil	0
Low	2.0
Medium	3.0
Medium-High	5.0
High	10.0

ratings. Each Canada Land Inventory class has been given a within class rank as shown in Table 5-32.

Wildlife

Within each wildlife category (deer, moose, waterfowl and other) each biophysical unit has been ranked from zero to four based on its estimated capability for the resource: class four corresponds to the highest resource capability, one the lowest resource capability, and zero corresponds to biophysical units with no resource value.

The deer and moose rankings have been assessed in order to estimate relative ungulate densities derived from Canada Land Inventory (CLI) classifications. Resource capability Class 4 for deer and moose corresponds approximately to CLI Class 3 which can theoretically support an average of 50 white-tailed deer units per square mile (2.6 km^2)[93]. Resource capability Class 3 corresponds to CLI Class 4 which can support an average of 30 white-tailed deer units; resource capability Class 2 corresponds to CLI Class 5, or an average of 15 white-tailed deer units, and resource capability Class 1 corresponds to CLI Class 6, or an average supportive capability of 5 white-tailed deer units. Therefore, the values for the ranking should have the following interrelationships: 10:6:3:1:0 (Table 5-32).

Quantifiable resource capabilities are unavailable for waterfowl or other wildlife. Relative values have been assigned based on professional judgment tempered by field experience gained during the wildlife inventory. Waterfowl are much more restricted by habitat than are ungulates and tend to be more concentrated in the better areas than are ungulates, i.e., the difference in habitat capability between the ranks is greater. The values for the waterfowl rankings are estimated to relate to each other as follows: 10.0:2.0:0.5:0.1:0 (Table 5-32). Other wildlife habitat shows relatively less variation in resource capability, but the very best habitat does contain measurably greater numbers and diversity of animals than the average habitats.

The values for the "other" wildlife rankings are estimated to relate to each other as follows: 10.0:5.0:3.0:2.0:0 (Table 5-32). No biophysical units with zero value for "deer" or for "other wildlife" exist in the local study area.

Secondly, the resources are ranked between each other based on their importance within the local study area (importance value). This has been done in committee by all specialists involved with agriculture, grazing, forestry and wildlife within the Land Resources Subgroup. In this manner, some form of objectivity has been achieved, with what is necessarily a subjective approach. In order to attain an importance value for each resource, a common selection criteria is needed. The common selection criteria allows the committee to act on a common basis when establishing the importance value for each resource. The selection criteria used in this evaluation is the intensity of use and dollar value per unit area of land obtained within the local study area of each resource, i.e., agriculture, grazing, forestry and wildlife. The importance values have been graded on a one to 10 scale with 10 indicating the most intense type of use. Table 5-33 indicates the importance values assigned to each resource.

Wildlife has required an additional importance ranking since it is composed of four separate categories: deer, moose, waterfowl and other. These have different importance values concerning intensity of use within the local study area that must be evaluated.

All comparisons have been done on a relative basis. For wildlife, comparisons among moose, deer, waterfowl and other wildlife are based on the recorded or estimated number of user days plus an assessment of relative value per user day based on Pearse Bowden[94]. The value of moose hunting has been judged to be worth approximately one-fifth, the value of waterfowl hunting approximately one-tenth, and the value of other (including non-consumptive use, grouse hunting, trapping, bear and small game hunting) slightly more than one-half that of deer hunting. The sum of the four wildlife values is constrained to equal 2 (the value of "wildlife" compared to the other resources),

TABLE 5-33

RESOURCE IMPORTANCE VALUES

Resource	Importance Value
Agriculture	10.0
Grazing	3.0
Forestry	7.0
Wildlife	2.0

therefore, the following constants are designated: deer, 1.1; moose, 0.2; waterfowl, 0.1; and other wildlife, 0.6.

Once all the individual physical and biological sensitivities and ranked resource capabilities have been calculated, a composite can be derived for the physical and biological characteristics, and the resource capabilities (Table 5-30). The composite physical and biological sensitivity for each biophysical subunit is determined by rating all the biophysical subunits as high, moderate or low sensitivity based on the sum of their individual sensitivities. These have been given an equal value of 1.0. In some cases, it has been found that one physical or biological characteristic has an overriding effect on the final sensitivity, requiring a higher sensitivity than it would normally carry. These biophysical subunits are indicated by an asterisk on Table 5-31 and further assessed.

With respect to the resource capabilities, an integrated resource capability has been derived by multiplying the importance value of each resource by its within class rank for each biophysical subunit and summing their values, to obtain a final integrated resource capability for each biophysical subunit. In general, this value indicates the importance of each biophysical unit for a number of resource uses. Consequently, the higher the integrated resource sensitivity, the greater the number of resource uses possible and capability to support these uses. However, in some cases, one resource use has both a high importance value and capability, while other resource uses have nil or low rankings. This situation yields a low integrated resource capability, where it is felt that a higher rating should be applied. This occurrence is indicated by a two asterisk on Table 5-31 and a further analysis of that particular biophysical subunit conducted.

The physical and biological sensitivity and integrated resource capability are rated as high, medium and low on Table 5-31, based on the following criteria:

Physical and Biological Sensitivity		Integrated Resource Capability
High	7 - 9	> 77
Medium	5 - 6	46 - 77
Low	3 - 4	13.1 - 45

Each biophysical subunit rated high has been assessed again in committee in order to outline the environmental limitations. This information is presented in a tabular format along with a brief description.

In addition to the sensitivity and capability ratings, the level of resource integration is determined and the potential principal and secondary utilizations indicated. The level of resource integration implies what the potential best use or uses are of each particular biophysical subunit. The following levels of resource integration have been applied:

Class I: Low Level of Resource Integration. This class implies exclusive use or management for the potential principal utilization shown by the resource capabilities in Table 5-31.

Class II: Medium Level of Resource Integration. This class implies dominant use with possible secondary uses of slightly lower capability. Priority management should be for the potential principal utilization, although other factors may cause secondary utilizations to become more favourable.

Class III: High Level of Resource Integration. This class implies no one principal use, but all uses carrying equal weight. Management for any of the resources could yield similar results.

Maps have been prepared (Maps 5-5a and 5-5b) that depict biophysical subunit areas of high sensitivity or capability within the site-specific study area (1:24,000). These maps used in conjunction with the sensitivity tables, provide a site-specific evaluation of the problem areas and their limitations to development for the mine, plant and offsite developments.

(c) Summary

In total 46 biophysical subunits have been found to possess a high physical and biological sensitivity, integrated resource capability, or both (Table 5-31). Several trends are evident. Firstly, most high integrated resource capabilities are associated with biophysical subunits on slopes of 0 to 9 percent as a result of the high agricultural capability and importance value attached to these biophysical subunits. Wherever agriculture has been rated as having a high capability, it generally overrides the other possible resource uses, thus, yielding a low-level of resource integration. Biophysical subunits 1AB.21 through 1TE1.17 exhibit this trend. Physical and biological sensitivities for these subunits are medium with a number of subunits possessing problems in terms of high alkalinity and salinity. Biophysical subunits 1BRL1+3.13 and 1BRL1+3.29 within the above group were the only two subunits rated as having a medium level of resource integration because of their high wildlife capability.

Biophysical subunits 2AB1.31 through 2TGL.10 begin to show a more diverse trend in possible resource uses. Agriculture generally is the primary use, with forestry and grazing beginning to appear as primary uses in one-half of the above biophysical subunits. This results from many of these biophysical subunits having topographic limitations to agriculture. Where agriculture is absent, the integrated resource capability is generally low. In terms of physical and biological sensitivity, biophysical subunits 2CE.21, 2TDB1.8, 2TDB1.19, 2TDB1.23, 2TE1.10 and 2TE1.19 have been rated as highly sensitive.

Biophysical subunits 3AE2.24 through 3TGL.17 pose the greatest limitations to development. Of the above 17 biophysical subunits, 10 have high sensitivities while four more have at least one overriding physical or biological characteristic causing a higher rating to be assessed. However, in terms of the integrated resource capability, most were rated as low. In addition, the level of resource integration shows a medium or high level of integration indicating that these subunits are important to several uses. Forestry, grazing and in some instances wildlife form the dominant resource uses on the above biophysical subunits.

The Wetland biophysical subunit (W) has a high physical and biological sensitivity, but a low integrated resource capability with wildlife the probably principal use.

The following biophysical subunit tables act as a summary of all the physical and biological features studied in the local study area as well as their limitations to various developmental objectives. Only those biophysical subunits shown to have a high physical and biological sensitivity or high integrated resource capability on Table 5-31 were further analyzed. Two types of limitations are presented, those of a resource capability nature and those related to constraints of the physical (slope, landform and soil) and biological (vegetation) environment.

To a large extent the physical and biological limitations can be mitigated in some way depending on the limitations and their severity. It should be recognized that in many cases, the application of a physical and biological sensitivity, and associated limitations are not appropriate because of the type of project facility. For example, open pit #1 (M1) totally alienates a large portion of highly sensitive landscape, however, only the pit rim would be subject to limitations since the remaining portion is a large excavation. The same is true for the mine waste and ash disposal dump which covers a large surface area. On the other hand, offsite facilities such as pipelines and transmission lines only temporarily disturb surface soil conditions and may cause greater alkalinity and erosion problems. With respect to the resource capability limitations, no mitigation is possible. The only mitigation that may be applicable is a relocation of the project facility. However, the constraints imposed by the topography and coal deposit limit many relocation possibilities.

Conversely, many of the physical and biological limitations are mitigable and will be discussed under Section 6.3.

BIOPHYSICAL SUBUNIT 1AB.21

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
7.14	Construction - offsite

Limitations

High alkalinity and salinity of the soils present
High agricultural capability
High vegetation productivity

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs in the Thompson River Valley and is dominantly affected by the main access road (QR1). However, the impact is small (7.14 ha).
Vegetation Association Cultivated Fields	
Parent Material Glacio-fluvial	
Soil Brown Chernozems	
Landform Bottomland - flat 0 - 9%	
Texture Gravelly sandy loam	
Relative Depth of Solum 30 - 61 cm	

BIOPHYSICAL SUBUNIT 1ADB.27

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
4.37	Construction and operation

Limitations

Vegetation association with high productivity and ecological diversity present

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs at the north end of Hat Creek Valley along Highway 12. It is affected mainly by the north valley dump (M3). However, the impact is small (4.87 ha).
Vegetation Association Kentucky Bluegrass/Riparian Complex	
Parent Material Glacial outwash	
Soil Orthic Dark Brown Chernozems	
Landform Bottomland - flat 0 - 9%	
Texture Silty loam	
Relative Depth of Solum 76 cm	

BIOPHYSICAL SUBUNIT 1AE.8

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High**
Amount Affected (ha)	**Phase(s) Causing Alienation**
17.73	Construction - mine and offsite

Limitations

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs at the north end of Hat Creek Valley. It is affected mainly by the north valley dump (M3) and coal blending area (M14), although the impact is only 17.73 ha. In addition, it possesses no major limitations.
Vegetation Association Douglas-fir - Bunchgrass Association	
Parent Material Glacio-fluvial	
Soil Degraded Eutric Brunisol/Orthic Dark Brown Chernozem	
Landform Bottomland - flat 0 - 9%	
Texture Silty loam - silty clay	
Relative Depth of Solum 36 - 46 cm	

BIOPHYSICAL SUBUNIT 1AE.10

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High**
Amount Affected (ha)	**Phase(s) Causing Alienation**
66.35	Construction and operation

Limitations

High soil susceptibility to dusting
Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs at the north end of Hat Creek Valley. It is affected by both construction and operation by the topsoil stockpile, mine entrance (M11), open pit #1 (M1), and the main access road (OR1). The major limitation is the high dusting potential of the soils.
Vegetation Association Douglas-fir - Pinegrass - Bunchgrass Association	
Parent Material Glacio-fluvial	
Soil Degraded Eutric Brunisol/Orthic Dark Brown Chernozem	
Landform Bottomland - flat 0 - 9%	
Texture Silty loam - silty clay	
Relative Depth of Solum 36 - 46 cm	

BIOPHYSICAL SUBUNIT 1AE.19

Physical and Biological Sensitivity Medium*	Integrated Resource Capability High**
Amount Affected (ha) 102.28	Phase(s) Causing Alienation Construction and operation

Limitations

- High soil alkalinity and salinity
- High soil susceptibility to dusting
- High capability for wildlife (deer)
- Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs at the north end of Hat Creek Valley and is mainly affected by the open pit #1 (M1). A major portion of this highly sensitive subunit is impacted (102.28 ha). However, because much of the impact results from total alienation, the physical and biological impacts will only be important on exposed areas, devoid of vegetation. The loss of the vegetation association is also important to wildlife and is scarce within the local study area.
Vegetation Association Sagebrush - Bluebunch Wheatgrass Association	
Parent Material Glacio-fluvial	
Soil Degraded Eutric Brunisol/Orthic Dark Brown Chernozem	
Landform Bottomland - flat 0 - 9%	
Texture Silty loam - silty clay	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 1BGS1+3.21

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
59.09	Construction - offsite

Limitations

High vegetation productivity

Medium-high agricultural capability

Location along stream could be flooded

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along the middle reaches of upper Hat Creek Valley. The site 2 storage reservoir and dam (OD7) impacts 59.09 ha of this subunit. Its major limitation is its agricultural use.
Vegetation Association Cultivated Fields	
Parent Material Alluvium	
Soil Carbonated Gleysol	
Landform Bottomland - flat 0 - 5%	
Texture Loam	
Relative Depth of Solum 15 cm	

BIOPHYSICAL SUBUNIT 1BGS1+3.28

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
6.95	Construction - offsite

Limitations

High capability for wildlife (other)

Medium-high agricultural capability

Location along stream could be flooded

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along the middle reaches of upper Hat Creek and only has a minor impact of 6.95 ha. The major impact comes from the headworks reservoir and dam (OD1). Its high capability for wildlife is the major limitation.
Vegetation Association Bunchgrass - Kentucky Bluegrass/ Riparian Complex	
Parent Material Alluvium	
Soil Carbonated Gleysol	
Landform Bottomland - flat 0 - 5%	
Texture Loam	
Relative Depth of Solum 15 cm	

BIOPHYSICAL SUBUNIT 1BRL1+3.10

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
1.47	Construction - offsite

Limitations

Medium-high agricultural capability

Location along stream could be flooded

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along Ambusten Creek. The impact is only 1.47 ha and is caused by the upper Hat Creek diversion canal (OD2).
Vegetation Association Douglas-fir - Bunchgrass - Pinegrass Association	
Parent Material Alluvium	
Soil Orthic Regosol	
Landform Bottomland - flat 0 - 9%	
Texture Silty loam - gravelly sandy loam	
Relative Depth of Solum 15 - 25 cm	

BIOPHYSICAL SUBUNIT 1BRL1+3.13

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
29.04	Construction and operation

Limitations

High vegetation diversity and productivity
High wildlife capability
Medium-high agricultural capability
Location along stream could be flooded

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along Hat Creek in the north end of the valley. Construction and operation impact 29.04 ha of this subunit. The major project facility causing the impact is the north valley dump (M3). Because of the high species diversity and productivity of the vegetation, and high wildlife capability, this subunit should be preserved as much as possible.
Vegetation Association Riparian Association	
Parent Material Alluvium	
Soil Orthic Regosol	
Landform Bottomland - flat 0 - 9%	
Texture Loam - silty loam	
Relative Depth of Solum 15 - 76 cm	

BIOPHYSICAL SUBUNIT 1BRL1+3.21

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
8.23	Construction - offsite

Limitations

- High vegetation productivity
- Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs along the middle and lower reaches of upper Hat Creek. The impact is minor with 8.23 ha alienated by the pit rim reservoir (OD4) and pipelines (OD5). The major limitation is its agriculture use.
Vegetation Association Cultivated Fields	
Parent Material Alluvium	
Soil Orthic Regosol with some inclusions of Eutric Brunisols	
Landform Bottomland - flat 0 - 9%	
Texture Loam - silty loam	
Relative Depth of Solum 15 - 76 cm	

BIOPHYSICAL SUBUNIT 1BRL1+3.29

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
46.62	Construction and operation

Limitations

High vegetation productivity and diversity
High capability for wildlife (deer and other)
Medium-high agricultural capability
Location along stream could be flooded

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along the lower reaches of upper Hat Creek and is impacted by the open pit #1 (ML) with 46.62 ha affected. Its importance to wildlife and possible agricultural capability are the major limitations.
Vegetation Association Sagebrush - Bluebunch Wheatgrass/ Riparian Complex	
Parent Material Alluvium	
Soil Orthic Regosol	
Landform Bottomland - flat 0 - 9%	
Texture Loam - silty loam	
Relative Depth of Solum 15 - 76 cm	

BIOPHYSICAL SUBUNIT 1EB.21

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
11.13	Construction - offsite

Limitations

High vegetation productivity

High soil susceptibility for dusting

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs in the Thompson Valley and is impacted by the offsite facilities, make-up water pipeline (OW1), drainage pipeline (OW8), 69 kV transmission line to pump station II (OT3), pump station I access road (OR4) and booster station I (OW2). However, the impact is only 11.13 ha. The major limitations are the agricultural use and potential dust problem once the soils are disturbed.
Vegetation Association Cultivated Fields	
Parent Material Aeolian/Glacial outwash	
Soil Brown Chernozems	
Landform Bottomland - flat 0 - 9%	
Texture Fine sandy loam - gravelly sandy loam	
Relative Depth of Solum 46 - 91 cm	

BIOPHYSICAL SUBUNIT 1EB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
0.92	Construction - offsite

Limitations
- High agricultural capability
- High soil alkalinity and salinity

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson Valley and is only impacted by 0.92 ha by the construction of the make-up water pipeline (OW1).
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Aeolian/Glacial outwash	
Soil Brown Chernozems	
Landform Bottomland - flat 0 - 9%	
Texture Gravelly sandy loam	
Relative Depth of Solum 30 - 61 cm	

BIOPHYSICAL SUBUNIT 1TE1.17

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
30.28	Construction and operation

Limitations

High soil alkalinity and salinity

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the north end of upper Hat Creek Valley and is impacted by the north valley dump (M3) and Houth Meadows dump (M4). The total alienation is 30.28 ha. The major limitations are the high soil alkalinity and salinity, resulting in reclamation problems and the agricultural potential of this subunit.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacial till	
Soil Eutric Brunisol with minor inclusions of Dark Gray Chernozems	
Landform Bottomland - flat 0 - 9%	
Texture Loam - silty loam	
Relative Depth of Solum 46 cm	

BIOPHYSICAL SUBUNIT 2AB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
2.46	Construction - offsite

Limitations

High soil alkalinity and salinity

Medium-high agricultural capability

Medium-high soil susceptibility for dusting

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley and is affected by the main access road (OR1). However, only 2.46 ha is alienated. High soil alkalinity, salinity and dusting potential are the major limitations that may cause problems with restoration of the cutbanks and dust problems before paving.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Glacialfluvial	
Soil Brown Chernozems	
Landform Bottomland - dissected 10 - 29%	
Texture Fine sandy loam - silty loam	
Relative Depth of Solum 15 - 46 cm	

BIOPHYSICAL SUBUNIT 2ABL1.17

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Low
Amount Affected (ha) 212.86	**Phase(s) Causing Alienation** Operation - mine and plant

Limitations

High soil alkalinity and salinity

High soil susceptibility to dusting

Medium-high grazing capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the Medicine Creek Valley and is mainly impacted by the wet ash disposal pond (P6) with lesser impacts from the main access road (OR1), wet ash slurry pipelines (P7) and drainage ditches (M19). This subunit occurs has limitations because of high soil alkalinity and salinity, resulting in reclamation problems, and a high soil dusting potential, possibly causing operational problems.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacio-fluvial	
Soil Black Chernozems with inclusions of Dark Brown Chernozem and Grey Luvisol	
Landform Bottomland - rolling 10 - 29%	
Texture Loam - silty loam	
Relative Depth of Solum 25 - 35 cm	

BIOPHYSICAL SUBUNIT 2CB.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha) 18.6	**Phase(s) Causing Alienation** Construction - offsite
Limitations Medium-high agricultural capability	

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley. The airstrip, site A (OA1) and airstrip access road (OA4) impact 18.6 ha. The only limitation is the possible agricultural use of this subunit.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Colluvium	
Soil Orthic Brown Chernozems	
Landform Sloping Lands 10 - 29%	
Texture Fine sandy loam - silty loam	
Relative Depth of Solum 15 - 46 cm	

BIOPHYSICAL SUBUNIT 2CB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
5.55	Construction - offsite

Limitations

- High soil alkalinity and salinity
- Medium-high agricultural capability
- Medium-high soil erosion potential
- Localized soils having a high dusting potential

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley and is affected by the make-up water pipeline (OW1). A number of limitations exist causing possible problems with reclamation and operational problems with erosion and dusting.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Colluvium	
Soil Rego Brown Chernozems	
Landform Sloping Lands 10 - 29%	
Texture Gravelly silt loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 2CE1.7

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Medium
Amount Affected (ha)	**Phase(s) Causing Alienation**
266.0	Operation - mine

Limitations

- High soil alkalinity and salinity
- Medium-high susceptibility to dusting
- Medium-high grazing capability
- Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the north end of upper Hat Creek Valley and is impacted by the Houth Meadows waste dump (M4) with a lesser impact from the mine and waste drainage ditches (M19) for a total of 266.0 ha. Major limitations result from high soil alkalinity and salinity, dusting and poor soil suitability for reclamation purposes. These can lead to reclamation problems, operational problems and increased environmental hazards.
Vegetation Association Douglas-fir - Pinegrass Association	
Parent Material Colluvium	
Soil Degraded Eutric Brunisols with inclusions of Dark Brown Chernozems	
Landform Sloping Lands 10 - 29%	
Texture Silty loam - silty clay	
Relative Depth of Solum 15 - 45 cm	

BIOPHYSICAL SUBUNIT 2CE.21

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
1.47	Construction - offsite

Limitations

High vegetation productivity

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs at the confluence of Medicine and Hat creeks. The Hat Creek diversion canal (OD2) alienates 1.47 ha. The major limitation is the agricultural use.
Vegetation Association Cultivated Fields	
Parent Material Colluvium	
Soil Degraded Eutric Bunisol	
Landform Sloping Land - lower slope 10 - 29%	
Texture Loam - silty loam	
Relative Depth of Solum 61 - 91 cm	

BIOPHYSICAL SUBUNIT 2EB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
15.22	Construction - offsite

Limitations

High soil alkalinity and salinity

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley and is affected by the make-up water pipeline (OW1), 69 kV transmission line to pump station I (OT4) and the 69 kV transmission line to pump station II (OT3). The major limitation is the high soil alkalinity and salinity that may create reclamation problems.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Shallow Aeolian/Glacial till	
Soil Rego Brown Chernozems	
Landform Bottomland - *hummocky and ridged* 10 - 29%	
Texture Gravelly sandy loam - gravelly fine sandy loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 2TB.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium	High
Amount Affected (ha) 1.48	**Phase(s) Causing Alienation** Construction - offsite

Limitations

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley and only has a minor impact of 1.48 ha. The major limitation is its agricultural capability. The 69 kV transmission line to pump station II (OT3) is the only facility impacting this subunit.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Glacial till and Glacial outwash	
Soil Orthic and Rego Brown Chernozems	
Landform Bottomland - drumlinized 10 - 29%	
Texture Gravelly sandy loam - fine sandy loam	
Relative Depth of Solum 30 - 76 cm	

BIOPHYSICAL SUBUNIT 2TB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
32.19	Construction - offsite

Limitations

- High soil alkalinity and salinity
- Medium-high agricultural capability
- Localized soils having a high dusting potential

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley. A total of 32.19 ha is alienated by the airstrip, site A (OA1). The high soil alkalinity and salinity, and localized dust problems are the major limitations.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Glacial till	
Soil Orthic and Rego Brown Chernozems	
Landform Bottomland - drumlinized 10 - 29%	
Texture Silty loam - fine sandy loam	
Relative Depth of Solum 15 - 46 cm	

BIOPHYSICAL SUBUNIT 2TDB1.8

Physical and Biological Sensitivity	Integrated Resource Capability
High	Medium**
Amount Affected (ha)	**Phase(s) Causing Alienation**
93.04	Construction and operation

Limitations

High soil alkalinity and salinity

High soil susceptibility to dusting

Summary of Physical and Biological Characteristics

Characteristic	
Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the north end of upper Hat Creek. A total of 93.04 ha is alienated by open pit #1 (M1), diversion canal (OD2), north valley dump (M3) and mine and waste drainage ditches (M19). Environmental problems are associated with the high dusting and alkalinity properties of the soils.
Vegetation Association Douglas-fir - Bunchgrass Association	
Parent Material Glacial till	
Soil Eutric Brunisols with inclusions of Dark Brown Chernozems	
Landform Bottomland - hummocky 10 - 29%	
Texture Silty loam	
Relative Depth of Solum 20 - 46 cm	

BIOPHYSICAL SUBUNIT 2TDB1.19

Physical and Biological Sensitivity	Integrated Resource Capability
High	Medium
Amount Affected (ha)	**Phase(s) Causing Alienation**
261.98	Construction and operation

Limitations

High capability for wildlife (deer)

High soil alkalinity and salinity

High soil susceptibility to dusting

Medium-high erosion susceptibility

Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone
Interior Douglas-fir Zone

Vegetation Association
Sagebrush - Bluebunch Wheatgrass Association

Parent Material
Glacial till
(Glacial lacustrine)

Soil
Dark Brown Chernozems and Orthic Eutric Brunisols

Landform
Sloping Land - dissected and rolling 10 - 29%

Texture
Silty loam - silty clay

Relative Depth of Solum
10 - 46 cm

This subunit occurs in the north end of upper Hat Creek and possesses the most limitations of any of the biophysical subunits surveyed. A total of 261.98 ha are alienated by open pit #1 (M1), Houth Meadows waste dump (M4), pit rim reservoir and dam (OD4) and topsoil stockpile, landing strip (M12). Major limitations range from high soil alkalinity to high wildlife capability for deer.

BIOPHYSICAL SUBUNIT 2TDB1.23

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
46.12	Construction and operation

Limitations

- High capability for wildlife (waterfowl)
- High soil susceptibility to dusting
- High soil alkalinity and salinity
- Medium-high agricultural capability
- Unit contains a significant amount of highly productive and species diverse, saline depression vegetation association

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along Hat Creek just north of Anderson Creek. The topsoil stockpile, landing strip (M12), Finney Creek diversion canal (OD7), mine and waste drainage ditches (M19) alienate 46.12 ha of the subunit. Its high waterfowl capability and high dusting potential are the major limitations.
Vegetation Association Bunchgrass - Kentucky Bluegrass/ Saline Depressional Complex	
Parent Material Glacial till	
Soil Orthic Dark Brown Chernozems	
Landform Sloping Land - dissected and rolling 10 - 29%	
Texture Loam - silty loam - silty clay	
Relative Depth of Solum 0 - 46 cm	

BIOPHYSICAL SUBUNIT 2TE1.10

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Medium
Amount Affected (ha)	**Phase(s) Causing Alienation**
39.94	Construction and operation

Limitations

- High soil alkalinity and salinity
- Medium-high grazing capability
- Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along Medicine Creek within the Hat Creek Valley. The project facilities, Medicine Creek dump (M2), mine and waste pile drainage ditches (M19), lagoon 5 (M9), conveyors (M17) and power plant construction camp water supply line (CP6) alienate 39.94 ha of this subunit.
Vegetation Association Douglas-fir - Bunchgrass - Pinegrass Association	
Parent Material Glacial till mixed with Colluvial material	
Soil Lithic Eutric Brunisols	
Landform Sloping Land - hummocky and drumlinized 10 - 29%	
Texture Gravelly sandy loam - gravelly loam	
Relative Depth of Solum 10 - 15 cm	

BIOPHYSICAL SUBUNIT 2TE.18

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Medium
Amount Affected (ha) 6.56	**Phase(s) Causing Alienation** Construction and operation

Limitations

High soil susceptibility for dusting

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs to the southeast of Finney Lake. It is impacted mainly by open pit #1 (M1) although the amount alienated only represents 6.56 ha. High soil dusting potential is the major limitation.
Vegetation Association Bunchgrass - Kentucky Bluegrass Association	
Parent Material Glacial till	
Soil Degraded Eutric Brunisols/Orthic Dark Brown Chernozems	
Landform Sloping Land - hummocky and drumlinized 10 - 29%	
Texture Silty loam - silty clay	
Relative Depth of Solum 0 - 46 cm	

BIOPHYSICAL SUBUNIT 2TG.7

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Medium
Amount Affected (ha)	**Phase(s) Causing Alienation**
58.32	Construction - plant and offsite

Limitations

High soil susceptibility to dusting

Medium-high grazing capability

Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Characteristic	
Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the vicinity of Harry Lake. The plant site (P1) impacts the greatest portion of this subunit. Dusting and low soil suitability for reclamation purposes are the major limitations.
Vegetation Association Douglas-fir - Pinegrass Association	
Parent Material Glacial till	
Soil Lithic Dark Gray Chernozems	
Landform Sloping Lands - hummocky 10 - 29%	
Texture Silty loam - silty clay	
Relative Depth of Solum 3 - 5 cm	

BIOPHYSICAL SUBUNIT 2TE1.19

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
119.29	Construction and operation

Limitations

- High soil susceptibility to dusting
- High soil alkalinity and salinity
- Medium-high agricultural capability
- Medium-high erosion potential
- Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs on the steep bluffs along the lower reaches of upper Hat Creek. A total of 119.29 ha are alienated by open pit #1 (M1). This subunit possesses a large number limitations and is one of the most sensitive subunits investigated.
Vegetation Association Sagebrush - Bluebunch Wheatgrass Association	
Parent Material Glacial till with some inclusions of Glacial outwash	
Soil Degraded Eutric Brunisols	
Landform Sloping Land - hummocky and crumlinized 10 - 29%	
Texture Silty loam - silty clay	
Relative Depth of Solum 10 - 41 cm	

BIOPHYSICAL SUBUNIT 2TG.17

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Low
Amount Affected (ha) 5.86	**Phase(s) Causing Alienation** Construction - offsite

Limitations

Medium-high grazing capability

Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the vicinity of Harry Lake and is alienated by the twin 69 kV transmission line to mine from plant substation (OT2) and main access road (OR1). However, the amount of this subunit alienated is only 5.86 ha. The only limitation is its low soil suitability for reclamation purposes.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacial till	
Soil Rego Dark Gray Chernozems	
Landform Sloping Lands - *hummocky* 10 - 29%	
Texture Gravelly silty loam - silty loam	
Relative Depth of Solum 5 - 20 cm	

BIOPHYSICAL SUBUNIT 3AE2.24

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
18.19	Construction and operation

Limitations

Localized erosion potential on steep glacialfluvial bluffs

Summary of Physical and Biological Characteristics

Characteristic	
Biogeoclimatic Zone: Interior Douglas-fir Zone	This subunit occurs in the north end of upper Hat Creek Valley. The project facilities, Houth Meadows waste dump (M4) and north valley waste dump (M3) alienate 18.19 ha of this subunit. The only limitation is possible erosion on the steep glacio-fluvial bluffs.
Vegetation Association: Douglas-fir - Spirea - Bearberry/ Douglas-fir - Bunchgrass Complex	
Parent Material: Glacialfluvial	
Soil: Degraded Eutric Brunisols	
Landform: Steepland - terraced; many slopes < 5% 30%+	
Texture: Silty loam - silty clay	
Relative Depth of Solum: 35 - 46 cm	

BIOPHYSICAL SUBUNIT 3CB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
3.49	Construction - offsite

Limitations

High soil alkalinity and salinity

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley. The project facilities, 69 kV transmission line from Rattlesnake A to pump substation II (OT3), 69 kV transmission line from Rattlesnake A to pump substation I (OT4) and make-up water pipeline (OW1) alienate only 4.39 ha of this subunit. High soil alkalinity and salinity are the only major limitations.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Colluvium with eroding glacio-fluvial terraces present	
Soil Rego Brown Chernozems with many exposed bluffs	
Landform Steepland - fans 30%+	
Texture Gravelly sandy loam	
Relative Depth of Solum Variable - 0 - 76 cm	

BIOPHYSICAL SUBUNIT 3CB2.31

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
6.13	Construction - offsite

Limitations

High erosion potential

High soil alkalinity and salinity

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley and is impacted by the 69 kV transmission line from Rattlesnake A to pump sub-station (OT4) and water intake road (OR3). However, only 6.13 ha are alienated. This subunit has a high erosion and alkalinity potential.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Colluvium with eroding glacio-fluvial terraces present	
Soil Rego Brown Chernozems	
Landform Steepland - fans and bluff areas 30%+	
Texture Gravelly silty loam - gravelly fine sandy loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 3CG1+2.24

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
71.52	Operation - mine

Limitations

High erosion potential

High soil alkalinity and salinity

Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the north end of upper Hat Creek on the steeper slopes above Houth Meadows. The Houth Meadows waste dump (M4) alienates the major portion of this subunit. A high erosion potential, high soil alkalinity and salinity, and low soil suitability for reclamation purposes are the major limitations.
Vegetation Association Douglas-fir - Spirea - Bearberry/ Douglas-fir - Bunchgrass - Finegrass Complex	
Parent Material Colluvium/Rock	
Soil Dark Gray Chernozems	
Landform Steepland - simple 30%+	
Texture Sandy loam - laom	
Relative Depth of Solum Variable; < 1 metre	

BIOPHYSICAL SUBUNIT 3CE1.10

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha) 111.18	**Phase(s) Causing Alienation** Operation - mine

Limitations

High soil alkalinity and salinity

Medium-high soil susceptibility to dusting

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs along the steep slope of lower Medicine Creek Valley. The Medicine Creek waste dump (M2) and mine and waste drainage ditches (M19) alienates the major portion of this subunit, whose total alienation is 111.18 ha. High soil alkalinity and dusting potential may cause reclamation and operational problems.
Vegetation Association Douglas-fir - Bunchgrass - Pinegrass Association	
Parent Material Colluvium	
Soil Degraded Eutric Brunisols/Orthic Dark Brown Chernozems	
Landform Steepland - fan deposits 30%+	
Texture Silty loam - gravelly silty loam	
Relative Depth of Solum 15 - 20 cm	

BIOPHYSICAL SUBUNIT 3EB1.21

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
1.03	Construction - offsite

Limitations

High soil alkalinity and salinity

High vegetation productivity

Medium-high agricultural capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs in the Thompson River Valley near Cache Creek. The 69 kV transmission line loop-in (OT5) affects 1.03 ha of this subunit. It agriculture use and high soil alkalinity and salinity are the major limitations. However, the small amount affected lessens the major impacts.
Vegetation Association Cultivated Fields	
Parent Material Aeolian (overlying either glacial till or glacio-fluvial materials)	
Soil Rego Brown Chernozems	
Landform Bottomland - sloping and somewhat hummocky 30%+	
Texture Gravelly silty loam - gravelly fine sandy loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 3EB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
10.34	Construction - offsite

Limitations

High agricultural capability

High soil alkalinity and salinity

High erosion potential on steep slopes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit occurs in the Thompson River Valley. The 69 kV transmission line from Rattlesnake A to pump substation II (OT3), 69 kV transmission line from Rattlesnake A to pump substation I (OT4), and the 69 kV transmission line loop-in (LT5) all impact this subunit. However, the total alienation is only 10.34 ha.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Aeolian (overlying either glacial till or glacio-fluvial materials)	
Soil Rego Brown Chernozems	
Landform Bottomland with many steep bluffs 30%+	
Texture Fine sandy loam - gravelly loam	
Relative Depth of Solum 0 - 61 cm	

BIOPHYSICAL SUBUNIT 3TB1.31

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
13.65	Construction - offsite

Limitations

High soil alkalinity and salinity

High erosion potential on steeper slopes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Ponderosa Pine - Bunchgrass Zone	This subunit occurs in the Thompson River Valley. The 69 kV transmission line from Rattlesnake A to pump substation II (OT3) and make-up water pipeline (OW1) all impact this subunit. A total of 13.65 ha are impacted. High soil alkalinity and salinity, and localized erosion potential are the major limitations.
Vegetation Association Big Sagebrush - Bunchgrass Association	
Parent Material Glacial till	
Soil Rego Brown Chernozems	
Landform Steepland - dissected 30%+	
Texture Gravelly silty loam - gravelly fine sandy loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 3TBL1.17

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
149.37	Operation - mine

Limitations

High soil alkalinity and salinity
Medium-high grazing capability

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the lower Medicine Creek Valley is affected by the Medicine Creek waste dump (M2) and mine and waste drainage ditches (M19). A high soil alkalinity and salinity are the only major limitations.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacial till (minor inclusions of alluvial fans)	
Soil Calcareous Black Chernozems	
Landform Steepland - hummocky and channelled 30%+ complex slopes present	
Texture Loam - silty loam	
Relative Depth of Solum 5 - 15 cm (45 cm)	

BIOPHYSICAL SUBUNIT 3TDB.17

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
75.32	Operation - mine

Limitations

High soil alkalinity and salinity

Medium-high soil susceptibility to dusting

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the lower reaches of the Medicine Creek Valley. The Medicine Creek waste dump (M2) is the only project facility to impact this subunit. However, the 75.32 ha alienated represents all of this subunit found in the local study area.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacial till with colluvial material present	
Soil Dark Brown Chernozems/Degraded Eutric Brunisols	
Landform Bottomland - hummocky 30% with many slopes <10%	
Texture Silty loam - gravelly silty loam	
Relative Depth of Solum 15 - 20 cm	

BIOPHYSICAL SUBUNIT 3TDB.23

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
32.22	Construction - offsite

Limitations

High capability for wildlife (waterfowl)

Medium-high agricultural capability

Unit contains a significant amount of the highly productive and species diverse, Saline Depression Vegetation Association

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in upper Hat Creek between McDonald and Anderson creeks. The site 2 storage reservoir and dam (OD7) and headworks reservoir and dam (OD1) are the only project facility to impact this subunit. This subunit has a very high waterfowl capability which represents its major limitation.
Vegetation Association Bunchgrass - Kentucky Bluegrass/ Saline Depression Complex	
Parent Material Glacial till	
Soil Orthic Dark Brown Chernozems	
Landform Bottomland - hummocky 30%+ complex slopes present	
Texture Loam - silty loam	
Relative Depth of Solum 46 cm	

BIOPHYSICAL SUBUNIT 3TE1.7

Physical and Biological Sensitivity	Integrated Resource Capability
Medium*	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
3.97	Construction - offsite

Limitations

High alkalinity and salinity

Low soil suitability for reclamation purposes

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the extreme northeast end of upper Hat Creek Valley. The main access road (OR1) and twin 69 kV transmission line from mine to plant substation (OT2) alienate 3.97 ha of this subunit.
Vegetation Association Douglas-fir - Pinegrass Association	
Parent Material Glacial till - some colluvial material is usually present	
Soil Lithic Eutric Brunisols	
Landform Steepland - dissected and sometimes hummocky 30%_	
Texture Gravelly sandy loam - gravelly loam	
Relative Depth of Solum 10 - 15 cm	

BIOPHYSICAL SUBUNIT 3TE.10

Physical and Biological Sensitivity	Integrated Resource Capability
High	Medium
Amount Affected (ha)	**Phase(s) Causing Alienation**
45.35	Construction and operation

Limitations

High soil susceptibility to dusting

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the north end of Hat Creek Valley and is impacted by a large number of project facilities, although the impacted area is only 45.35 ha. The 69 kV transmission line to mine construction substation (OT1), the twin 69 kV transmission line from mine to plant substation (OT2), main access road (OR1), canal discharge conduit (OD3), open pit #1 (M1), north valley dump (M3), topsoil stockpile, mine entrance (M11), and conveyores (M17) all impact this unit.
Vegetation Association Douglas-fir - Bunchgrass - Pinegrass Association	
Parent Material Glacial till - with some areas of glacial outwash present	
Soil Degraded Eutric Brunisols/Orthic Dark Brown Chernozems	
Landform Steepland - dissected and sometimes hummocky 30%+	
Texture Silty loam	
Relative Depth of Solum 30 - 46 cm	

BIOPHYSICAL SUBUNIT 3TE1.10

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
171.18	Operation - mine

Limitations

- High soil alkalinity and salinity
- Medium-high grazing capability
- Medium high soil susceptibility to dusting

Summary of Physical and Biological Characteristics

Bicgeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs southeast of the confluence of Medicine and Hat creeks. It is mainly impacted by the Medicine Creek waste dump (M2), mine and waste piles drainage ditches (M19), lagoon 4 (M8) and topsoil stockpile, south Medicine Creek (M13). A total of 171.18 ha are impacted.
Vegetation Association Douglas-fir - Bunchgrass - Pinegrass Association	
Parent Material Glacial till - some colluvial material is usually present	
Soil Eutric Brunisols/Orthic Gray Luvisols	
Landform Steepland - dissected and sometimes hummocky 30%+	
Texture Gravelly sandy loam - fine sandy loam - silty loam	
Relative Depth of Solum 10 - 46 cm	

BIOPHYSICAL SUBUNIT 3TE1.17

Physical and Biological Sensitivity	Integrated Resource Capability
High	High
Amount Affected (ha)	**Phase(s) Causing Alienation**
103.57	Operation - mine

Limitations

High soil alkalinity and salinity
Medium-high agricultural capability

Summary of Physical and Biological Characteristics	
Biogeoclimatic Zone Interior Douglas-fir Zone	This subunit occurs in the Houth Meadows area and is impacted by the Houth Meadows waste dump (M4). A total alienation of 103.57 ha occurs, which represents all of this subunit found in the local study area. A high soil alkalinity and salinity and medium-high agricultural capability are the major limitations.
Vegetation Association Kentucky Bluegrass Association	
Parent Material Glacial till	
Soil Degraded Eutric Brunisols	
Landform Bottomlands - hummocky and dissected by streams 30%+ with many <5%	
Texture Loam - silty loam	
Relative Depth of Solum 46 cm	

BIOPHYSICAL SUBUNIT W

Physical and Biological Sensitivity	Integrated Resource Capability
High	Low
Amount Affected (ha)	**Phase(s) Causing Alienation**
13.9	Construction and operation

Limitations

High capability for wildlife (moose)

High water table

Poor foundation characteristics of the soil

Vegetation association dependent on the existence of the high water table

Summary of Physical and Biological Characteristics

Biogeoclimatic Zone Intrazonal	This subunit is found scattered throughout Medicine and Hat Creek valleys in poorly drained depressions. The wet ash disposal pond (P6) and open pit #1 (M1) impact this subunit. Most limitations are associated with the high water table and high capability for moose.
Vegetation Association Willow - Sedge Bog Association	
Parent Material Organic deposits	
Soil Organic to gleysolic	
Landform Bottomlands - flat 0 - 9%	
Texture -	
Relative Depth of Solum Variable - less than 1 metre to greater than 2 metres	

6.0 MITIGATION AND RECOMMENDATIONS

6.1 SOILS

The mitigation measures and recommendations presented below fall into two categories, mitigation measures to minimize adverse impacts and recommendation for further studies to be conducted in order to complete information gaps in the soils programme.

Because of the nature of the Hat Creek project many of the project facilities are non-mitigable. In other words, facilities such as open pit #1, mine waste dumps, and ash disposal areas are constrained to certain locations because of topography or in the case of open pit #1, the coal deposit itself.

(a) Specific Guidelines

The following specific guidelines were developed to handle the impacts on sensitive soils outlined in the previous sections.

(i) Erosion Hazards

Soils susceptible to erosion should, where possible, be avoided. The affected Soil Units 20D, CT and TL possess erosion hazards. Soil Units CT and TL would be affected by offsite facilities, while Soil Unit 20D would be affected by open pit #1. If these units cannot be avoided, the following mitigation measures should apply:

(1) slope stabilization techniques, including contouring and re-establishment of vegetation, should be employed as soon after disturbance as possible;

(2) drainage design should be given careful consideration which, in areas of high erosion susceptibility, may include ditch linings;

(3) the construction of the project facilities should disturb as little soil as possible. Unnecessary disturbances could lead to further erosion; and
(4) all road traffic should be kept to a predetermined road alignment to prevent disturbance of sod-forming vegetation.

(ii) Dusting Hazards

soils of the site-specific study area could possess some dusting problems because of their fine texture. However, certain soils are of more concern than others. Those soils having a high dusting potential which would be impacted are 20A, 20B, 20C, 20D, 20E, 17, 19, 53, 55, 57, 58 and BN. The following measures should be applied in these areas:

(1) preserve as much of the existing vegetative cover as possible;
(2) do as little disturbance as necessary to complete the project facilities;
(3) the use of water and/or chemical spraying should be undertaken; and
(4) immediate revegetation of disturbed areas.

(iii) Alkalinity-Salinity Hazards

A large number of soil units within the site-specific study area possess high alkalinity and/or salinity levels. Those soil units having the highest levels are 20A, 20B, 20C, 20D, 20E, 6B, 10, 14, 21, 25, 31, 34, 35, 57, 59, 63, 64, CT and TN. Where these soil units would be impacted, the following mitigation measures should apply:

(1) avoid where possible;
(2) areas impacted should be reclaimed using topsoil that is not contaminated with alkalinity-salinity components;
(3) soils with alkalinity-salinity problems if piled should be placed at the bottom of fills and measures taken to ensure that

excessive leaching does not occur;

(4) in some instances, it may be possible to leach out undesirable components in disturbed soils before reseeding; and

(5) where disturbance occurs, reseeding with salt-tolerant vegetation may be necessary.

(b) Recommended Further Studies

(1) There is limited information available on the trace element levels and availability that are contained in the various soil units identified within the local study area. These data are necessary to fully assess the effect that trace elements from air emissions would have on the soil units, as well as the secondary impacts to vegetation, livestock and wildlife. This study would involve the determination of trace element levels for the various soil units before and during plant operation.

(2) The cooling tower emissions would undoubtedly have some impact on the soils. However, the exact nature of this impact is uncertain. Consequently, a soil monitoring and lysimeter study should be instigated to study soil-water relations, high nutrient availability and changes in salt levels within the area affected by the cooling tower plume.

6.2 VEGETATION

Mitigation measures, strictly interpreted implies an effort to minimize or render less harsh the adverse effects of the project on vegetation. Mitigation of direct impacts may be achieved through relocation and avoidance of specific areas. Mitigation measures pertaining to indirect effects are more difficult to define.

The mitigation measures and recommendations presented below fall into two categories: mitigation measures to minimize adverse impacts and recommendation for further studies to be conducted in order to evaluate information gaps in the vegetation programme.

Because of the nature of the Hat Creek project, many of the project facilities are non-mitigable. In other words, facilities such as open pit #1, mine waste dumps and ash disposal areas are constrained to certain locations because of topography, or in the case of open pit #1, the coal deposit itself. In addition, the vegetation associations as defined include no rare or endangered plant species and are common throughout interior British Columbia, thus, lessening the necessity for major facility relocations.

The following general measures would mitigate any of the adverse impacts in the vegetation associations impacted by the project facilities:

(1) construction of the project facilities should disturb as little vegetation as possible. Unnecessary disturbances outside construction sites should be avoided;
(2) road traffic should be kept to predetermined road alignments and not allowed to drive over undisturbed open range vegetation;
(3) all rights-of-way widths and project facilities should be kept to the minimum size necessary to reduce the loss of native vegetation;
(4) revegetation of disturbed areas should take place immediately, otherwise rapid invasion of the disturbed areas would take place by noxious weed species. This is especially true in the Bonaparte-Thompson river valleys where knapweed (*Centaurea diffusa*) and stickseed (*Lappula echinata*) are serious invaders of disturbed areas and control measures are difficult. Consequently, the development of an early revegetation programme is mandatory to control noxious weed growth and prevent degradation of the adjacent native vegetation associations due to the development of a weed seed source.

(a) Specific Guidelines

(i) Riparian Association

The Riparian Association should be avoided if possible. This association is one of the most productive and ecologically diverse within the local study area. While reference to Table 5-16 indicates that only 2.7 percent of the Riparian Association would be affected by construction and operation, this is important in the context of the Riparian Association's high ecological diversity. Steps should be taken to prevent any unnecessary disturbance to areas adjacent to proposed project facilities. If disturbance is necessary to the streambank vegetation, restoration and replanting should be implemented in order to minimize siltation and reduce erosion.

(ii) Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass Associations

These associations generally occur on steep (30 percent +), south-facing slopes or on well drained glaciofluvial deposits. Where they are found on steep slopes, the vegetation tends to act as a soil stabilizer and control erosion. Consequently, disturbance of these associations may lead to erosion problems and an increased disturbance to the native vegetation. Revegetation should occur immediately once all construction activities are completed.

(b) Recommended Further Studies

(1) The present vegetation surveys were conducted in the early spring and late fall, thus, missing many plant species that could exist in the local study area, including possible rare or endangered plants. Consequently, it is recommended that further botanical surveys be carried out within the local study area, with special emphasis on the site-specific study area, alpine areas and areas predicted to be impacted by air emissions.

Timing is critical in such a programme, with a 4-season botanical survey being the most precise means of sampling all plant species because of phenology and elevational differences in flowering periods. Such a programme could consist of the following sampling periods:

(a) early spring (May 15 - May 31)
(b) *early season flowering (June 15 - June 30)*
(c) late season flowering (July 15 - July 31)
(d) summer growth and maturity (August - September)

This type of programme could form baseline data for later monitoring programmes.

(2) The construction and operation of the mine would effectively remove 63.3 percent of the Sagebrush - Bluebunch Wheatgrass Association found in the local study area. Within the local study area this is a significant ecological loss. However, the significance of this loss in a regional or provincial context is not known and should be established so that the exact consequences of the loss to the local study area can be assessed.

Such a study would entail discussions with local experts, reconnaissance field studies, and photo interpretation of small-scale aerial photographs.

(3) Monitoring should be conducted with groundwater and vegetation samples taken around the ash disposal pond and mine waste disposal areas once operation begins to establish whether toxic leachates are entering the groundwater system where they may be available *for plant uptake*.

(4) The high susceptibility of the soils in the site-specific study area to dusting and nature of the project indicates that dust may cause localized vegetation damage. However, because of the limited available information on the levels causing injury to

vegetation, a monitoring programme should be instituted to monitor large-scale changes in productivity and species composition, as well as leaf morphology changes.

(5) Because of the possible large-scale impacts of air emissions and cooling tower emissions on the vegetation of the local study area, a monitoring programme should be undertaken to establish baseline vegetation data before operation begins and should continue throughout the life of the plant (see Section 7.0).

(6) The present vegetation mapping should be expanded into those areas indicated in the air emission analysis (Appendix F) as possible zones of vegetation injury outside the present vegetation mapping area. These areas include receptor sites 8, 16, 24 and 128. Receptor sites 56 and 64 are of secondary importance because they show less of an increase in air emission levels.

6.3 BIOPHYSICAL MITIGATION GUIDELINES

The biophysical mitigation guidelines have been developed as a result of the information derived in the soils and vegetation inventory and assessment. Many of the mitigation guidelines suggested for soils and vegetation apply to the biophysical subunits. However, because a set of environmental limitations have been derived for each biophysical subunit based on soil, slope, vegetation and resource capability information, the proposed mitigation guidelines result in a site-specific, integrated summary of all mitigation guidelines.

The following mitigation guidelines apply only to reversible environmental impacts. These adverse impacts do not usually mean total alienation, but rather a temporary disturbance of the landscape. Project facilities, such as transmission lines, pipelines, roads and conveyors frequently offer the opportunity to mitigate reversible impacts. Irreversible impacts result from land areas that are totally displaced by project facilities and only relocation of a facility would avoid this type of impact. Open pit #1, mine waste dumps and the plant site are examples of project facilities causing irreversible impacts.

This section describes the types of alienation, describes their environmental limitations, and finally recommends mitigation guidelines. It should be emphasized that mitigation guidelines have been developed for only those biophysical subunits which are affected and show a high physical and biological sensitivity and/or resource capability. For brevity, these biophysical subunits have been grouped by the type of environmental limitations they impose, and therefore, mitigation guidelines have been developed for these groups. These are presented below:

Biophysical Subunits 3AE2.24 and 3CG1+2.24

Type of alienation	Irreversible
Facilities causing alienation	M3, M4
Limitations	High erosion potential
	High soil alkalinity and salinity (3CG1+2.24 only)
	Low soil suitability for reclamation purposes (3CG1+2.24 only)
Recommended mitigation guidelines	The high erosion potential and alkalinity-salinity of the soils, especially on steep slopes, normally require special precautionary measures. However, the direct alienation of this subunit negates many of the adverse impacts.

Biophysical Subunits 1TE1.17, 2TE1.10, 2TE1.17, 3TE1.7 and 3TBL1.17

Type of alienation	Reversible and irreversible
Facilities causing alienation	CP6, M2, M3, M4, M9, M17, M19, OR1 and OT2 (CP6, M17, M19, OR1 and OT2 are mitigable)
Limitations	High soil alkalinity and salinity
	Medium-high grazing capability (2TE1.10 and 3TBL1.17 only)

	Low soil suitability for reclamation purposes (2TE1.10 and 3TE1.7 only)
	Medium-high agricultural capability (1TE1.17 and 2TE1.17 only)
Recommended mitigation guidelines	All reversible impacts would be associated with conveyors (M17), drainage ditches (M19), camp water supply line (CP6), main access road (OR1) and transmission line (OT2), which cross over soils having a high alkalinity and salinity, sometimes possessing poor characteristics for reclamation.
	1 Where possible all existing vegetation should be retained.
	2 Where reclamation is necessary (banks of drainage ditches, water supply line, cutbank of road and transmission tower sites) revegetation should be prompt. The use of uncontaminated topsoil or salt-tolerant plant species may be necessary.
	3 Do not allow vehicles to use open range areas. One preferred access point should be established.

Biophysical Subunit 2TB1.31

Type of alienation	Reversible
Facilities causing alienation	OA1, OR1 and OW1
Limitations	High soil alkalinity and salinity
	Medium-high agricultural capability
	Some localized areas of high dusting potential
Recommended mitigation guidelines	1 The construction of the airstrip (OA1) should be the minimum size necessary as should the main access road (OR1) and make-up water pipeline (OW1). Where perpherial areas are disturbed, they should be reclaimed as soon as possible after construction. Revegetation with salt-tolerant vegetation or the use of uncontaminated topsoil material may be necessary.

2 Dusting is a localized problem and watering of the main access road may be necessary

Biophysical Subunits 3CB2.31, 3EB1.31 and 3TB1.31

Type of alienation	Reversible
Facilities causing alienation	OT3, OT4, OT5, OR3 and OW1
Limitations	High soil alkalinity and salinity
	High erosion potential on steeper slopes
	High agricultural capability (3EB1.31 only)
Recommended mitigation guidelines	1 Where erosion potential is high (3CB2.31), areas should be avoided where possible. Transmission tower footings should not be located on erosion-prone slopes. Where they must be crossed, slope stabilization including contouring and re-establishment of vegetation should be employed as soon after disturbance as possible. The design of drainage must be given careful consideration which, in areas of high erosion susceptibility, may include ditch linings.
	2 Road traffic should be kept to one alignment and not allowed to wander over open range areas.
	3 Revegetation should take place immediately around transmission tower footings and along pipeline rights-of-way. Revegetation with salt-tolerant vegetation or use of uncontaminated topsoil may be necessary.
	4 Road access (OR3) width should be kept to the minimum necessary, and cutbanks revegetated immediately after construction.

Biophysical Subunit 1EB.21

Type of alienation	Reversible

Facilities causing alienation	OW1, OW2, OW8, OT3 and OT4
Limitations	High vegetation productivity High soil susceptibility to dusting Medium-high agricultural capability
Recommended mitigation guidelines	The high dusting potential is the major mitigable limitation 1 When constructing the pipelines and transmission lines disturb as little of the existing vegetation as possible. 2 Revegetate the pipeline and around tower footings immediately after construction to prevent the spread of noxious weeds and dusting. 3 All access roads should be kept watered and cutbanks revegetated as soon as possible after construction.

Biophysical Subunit 2TDB1.23

Type of alienation	Irreversible and reversible
Facilities causing alienation	M12, M19 and OD7
Limitations	High capability for wildlife (waterfowl) High soil susceptibility to dusting High soil alkalinity and salinity Medium-high agricultural capability Unit contains a significant amount of the highly productive diverse species of the Saline Depression Vegetation Association
Recommended mitigation guidelines	1 Both the high soil susceptibility to dusting, and alkalinity and salinity problems require that as little of the existing vegetation be disturbed as possible, especially outside the project facility areas. Revegetation should take place immediately wherever disturbances take place. 2 Areas to be reclaimed should use topsoil that is not contaminated with alkalinity-salinity components.

3 Watering may be necessary to control dusting in disturbed areas, especially along access points.

4 The high capability of this subunit for waterfowl is of importance and steps should be taken to ensure that as few as possible of the water-filled depressional areas be disturbed. The edge vegetation also is ecologically diverse and should be retained where possible.

Biophysical Subunit 3TDB.23

Type of alienation	Irreversible
Facilities causing alienation	OD1 and OD7
Limitations	High capability for wildlife (waterfowl)
	Medium-high agricultural capability
	Unit contains a significant amount of the highly productive and species diverse, Saline Depression Vegetation Association
Recommended mitigation guidelines	Both OD1 and OD7 cause direct alienation and loss of habitat. Steps should be taken to ensure that as little as possible of the depressional areas containing water be disturbed because of their high capability for supporting waterfowl and ecological diversity of the edge vegetation.

Biophysical Subunits 1AE.19, 2TDB1.19 and 2TE1.19

Type of alienation	Irreversible
Facilities causing alienation	M1, M4, M12 and OD4
Limitations	High capability for wildlife (deer)
	High soil alkalinity and salinity
	High soil susceptibility to dusting
	Medium-high erosion susceptibility (2TDB1.19 and 2TE1.19 only)
	Low soil suitability for reclamation purposes (2TDB1.19 and 2TE1.19 only)

Recommended mitigation guidelines	All facilities cause direct alienation and are non-mitigable. However, steps should be taken to make sure only the minimum amount of disturbance necessary to construct the project facilities is done, considering the high capabilities and sensitivities associated with this subunit.

Biophysical Subunits 1AE.10, 2TE.18 and 3TE.10

Type of alienation	Reversible and irreversible
Facilities causing alienation	M1, M3, M11, M17, OD3, OR1, OT1 and OT2 (M17, OD3, OR1, OT1 and OT2 are mitigable)
Limitations	High soil susceptibility to dusting
	Medium-high agricultural capability (1AE .10 only)
Recommended mitigation guidelines 1	Preserve as much of the existing vegetation cover as possible.
2	Revegetation should follow promptly the completion of the facility.
3	Use water spraying to suppress dust.

Biophysical Subunit 2TG.7 and 2TG.16

Type of alienation	Reversible and irreversible
Facilities causing alienation	OR1, OT2 and P1
Limitations	High soil susceptibility to dusting (2TG.7 only)
	Medium-high grazing capability
	Low soil suitability for reclamation purposes
Recommended mitigation guidelines 1	Subunit 2TG.7 would be affected by the plant site (P1). Because of the high dusting potential of this subunit, special care should be exercised not to unnecessarily disturb areas outside those designated for the project facilities. Water should be used to control any dust problems within P1.

2 Both subunits have very shallow soils (less than 20 cm), which negate their use for reclamation and cause revegetation problems if the soil is removed and bedrock is exposed.

Biophysical Subunits 1AE.8, 2CB.31, 2CE.21 and 2TB.31

Type of alienation	Reversible and irreversible
Facilities causing alienation	M3, M14, OA1, OA4, OD2 and OT3 (OA1, OA4, OD2 and OT3 are mitigable)
Limitations	Medium-high agricultural capability
Recommended mitigation guidelines	The areas of medium-high agricultural capability would be directly destroyed and would require a facility relocation in order to mitigate any adverse impacts.

Biophysical Subunits 1BGS1+3.28, 1BRL1+3.13 and 1BRL1+3.29

Type of alienation	Irreversible
Facilities causing alienation	M1, M3 and OD1
Limitations	High vegetation productivity and diversity High capability for wildlife (deer and other) Medium-high agricultural capability Flooding potential along streams
Recommended mitigation guidelines	Although the above facilities represent irreversible alienation, the importance of this subunit cannot be overemphasized. This subunit should be avoided if possible because it is one of the most productive and ecologically diverse within the local study area. Steps should be taken to prevent any unnecessary disturbance to areas adjacent to proposed project facilities. If disturbance is necessary to the streambank vegetation, immediate restoration and/or revegetation should be implemented in order to minimize siltation and reduce erosion.

Biophysical Subunits 1BGS1+3.21, 1BRL1+3.10 and 1BRL1+3.21

Type of alienation	Reversible and irreversible
Facilities causing alienation	OD2, OD4, OD5 and OD7 (OD2 and OD5 are mitigable)
Limitations	High vegetation productivity
	Medium-high agricultural capability
Recommended mitigation guidelines	Both types of limitations are due to higher capabilities and are irreversibly affected, and only mitigable if relocation of facilities is feasible.

Biophysical Subunit 1ADB.27

Type of alienation	Irreversible
Facilities causing alienation	M3
Limitations	Vegetation association with high productivity and ecological diversity present
	Medium-high agricultural capability
Recommended mitigation guidelines	Complete alienation of subunit precludes any mitigation opportunities.

Biophysical Subunits 2ABL1.17, 2CE1.7, 2TDB1.8, 3CE1.10, 3TDB.17 and 3TE1.10

Type of alienation	Reversible and irreversible
Facilities causing alienation	M1, M2, M3, M4, M8, M13, M19, OD2, OR1, P6 and P7 (M19, OD2, OR1 and P7 are mitigable)
Limitations	High soil alkalinity and salinity
	High to medium-high soil susceptibility to dusting
	Medium-high grazing capability (2ABL1.17, 2CE1.7 and 3TE1.10 only)
	Low soil suitability for reclamation purposes (2CE1.7 only)
Recommended mitigation guidelines 1	When constructing the facilities, adjacent vegetation should be disturbed as little as possible because of the high dusting and alkalinity soil constraints.

2 Water should be used on disturbed soils to prevent dusting.

3 The use of topsoil containing little alkaline-saline components may be advantageous.

4 Revegetation of disturbed areas should take place immediately.

Biophysical Subunits 1AB.21, 1EB1.31, 2EB1.21, 2EB1.31 and 3CB1.31

Type of alienation	Reversible
Facilities causing alienation	OT3, OT4, OT5 and OW1
Limitations	High soil alkalinity and salinity
	High to medium-high agricultural capability
Recommended mitigation guidelines	1 Revegetation of disturbed areas should take place immediately, otherwise rapid invasion of the disturbed areas by noxious weed species may occur.
	2 In some depressional locations the use of salt-tolerant plant species may be necessary.
	3 When constructing the transmission lines and pipeline, the native vegetation should be disturbed as little as possible.

Biophysical Subunit W

Type of alienation	Irreversible
Facilities causing alienation	M1 and P6
Limitations	High capability for wildlife (moose)
	High water table
	Poor foundation characteristics of the soil
	Vegetation association dependent on the existence of the high water table
Recommended mitigation guidelines	Complete alienation by the above facilities precludes any mitigation opportunities.

7.0 MONITORING PROGRAMME

The following recommendations for a Hat Creek monitoring programme are largely those prepared by Dr. V.C. Runeckles, Department of Plant Science, University of British Columbia for The TERA Environmental Resource Analyst Limited. Some additional recommendations were completed by The TERA Environmental Resource Analyst Limited concerning soil monitoring and ecological approaches.

The basis of the monitoring proposals presented herein is the ERT modelling predictions with regard to air emission concentrations at ground level and the assessment of the vegetation impacts contained in Appendix F. The proposals are in no way absolute, but should be considered as recommendations towards the types of data necessary to evaluate the possible complex air emission impacts.

7.1 BASIS FOR MONITORING

The determination of the actual impact of the emissions of gases and particulates from sources such as the proposed Hat Creek power generating station and its associated cooling towers requires that observations be made over both short and long term periods. The frequency of such observations, their types and the sites at which they are made constitute a monitoring programme. Such monitoring serves several purposes. For example, it provides "ground truth" to substantiate or refute predictive modelling of the dispersion of emissions and the assessment of probable impact obtained by extrapolation from other data sources, and it provides direct information on the magnitude of both injury and economic damage which may occur as a result of air emissions, both of which are important for the resolution of problems which may involve litigation.

It has been pointed out elsewhere (Appendix F) that the prior assessment of the vegetational impact of the air emissions from the proposed Hat Creek project is fraught with difficulty. There is a serious lack of information, both as to the sensitivities of most of the dominant or important plant species present, and as to the roles of the specific environmental conditions which occur in the Hat Creek region in influencing the sensitivities of those species, for which data exists in the literature, to the different air emissions, e.g., sulfur dioxide, nitrogen dioxide, hydrogen fluoride, etc. In addition, no data exists concerning soils and the types of impacts to be expected.

Because of the major causes of uncertainty in predicting impact, it is appropriate to think in terms of a programme of investigations which would encompass observations both before and after the start of operations of the generating station, i.e., a continuum of studies, initially involving the establishment of "base line" conditions, and including simulated fumigations, and leading into ongoing field observations of the changes which may occur in field plots located at strategically important or highly vulnerable sites. Because of this interrelationship, the following proposals are addressed to both pre and post startup studies, including monitoring per se. In each case, a general rationale is presented first, followed by specific proposals.

7.2 PRE-STARTUP MONITORING AND RELATED STUDIES

The lack of an adequate data base upon which to predict impact of the Hat Creek air emissions on vegetation has been stressed repeatedly in the impact assessment report (Appendix F), together with the reasons for uncertainty in extrapolating from those data which exist in the literature. Furthermore, in Appendix F it was pointed out that such dose-response modelling as has been undertaken is largely suspect, and has almost exclusively been related to thresholds of acute injury; rarely has the magnitude of such injury been incorporated into the mathematical models as a variable.

If the anticipated air emissions from the Hat Creek project were such that no ground-level fumigations with concentrations of the major pollutants, SO_2 and NO_2, in excess of the minimum threshold were likely to occur, a monitoring programme could be modest in scale and complexity, and would serve mainly as an assurance that no significant adverse effects were occurring, and to provide evidence for any beneficial effects which might occur.

However, the impacts of the three control strategies (366 m stack with flue gas desulfurization (FGD) or meteorological control (MCS), or 244 m stack with MCS) reported elsewhere, all anticipate plant injury to varying extents, although it is conceded that these impacts are based on judgment rather than data, and largely involve chronic rather than acute injury. Indeed, the dearth of information specific to the Hat Creek region and its vegetation requires that serious consideration be given to undertaking the studies necessary to determine the likely effect of emissions such as SO_2 and NO_2 on the species of particular importance to the region. Furthermore, such studies must be undertaken under environmental conditions which approximate as closely as possible those experienced within the region.

While some useful studies of these types could be undertaken under controlled environmental conditions in the laboratory, the best approach to obtaining data of direct relevance to Hat Creek is field experimentation involving the application of simulated fumigations. The system of choice for such studies is the Zonal Air Pollution System (ZAPS)[95] or an adaptation thereof for example to fumigate forest trees[96], in which pollutants are released over an area of terrain from a manifold of perforated tubing. The conditions of concentration of pollutant and duration of exposures would be varied to simulate anticipated fumigation patterns such as those predicted by ERT modelling[63].

Such experimentation necessitates the selection of control areas of similar topography, soil type, aspect, slope, vegetation, etc. Many of these areas would then serve a double purpose, as a bridge between pre and post startup investigations, but providing base line information as well as serving as fumigation controls.

Thus, the objectives of pre-startup are numerous, and include:

(1) acquisition of relevant data on the effects over time of known fumigation regimes on natural vegetation in situ;
(2) determination of the sensitivities of natural vegetation to individual pollutants and mixtures of interest;
(3) identification of tolerant individuals and selection of tolerant strains which may be multiplied for use in revegetation;
(4) measurement of dose-response functions, both in terms of injury and economic damage or loss of important species of higher plants;
(5) determination of impact on important species of lichens and mosses;
(6) determination of the natural vegetation, and its natural successional changes prior to the advent of air emission fumigations;
(7) determination of the effects of SO_2/NO_2 combinations on present or potential crops of agricultural importance;
(8) determination of the existence and magnitude of any positive effects of SO_2/NO_2 fumigations with low concentrations.

Two types of pre-startup studies are proposed:

(1) dose-response studies on selected species, and
(2) field fumigation studies in the Hat Creek area.

(a) Dose-Response Studies on Selected Species

The detailed vegetation analysis presented in Appendix C shows that in addition to the tree species, there are several major shrub, herb and grass species which provide extensive cover in the Hat Creek local study area. Furthermore, Appendix F indicates that for the majority no (or limited) information is available as to their sensitivities to SO_2/NO_2 combinations.

The dose-response monitoring studies should be based on these species. As well, many of these species are important to livestock and wildlife. Where feasible, plants for these studies should be collected from a range of representative locations in the Hat Creek region, preferably from sites at which SO_2/NO_2 fumigations of significance are expected to occur. In the case of tree and shrub species, the collections would have to be confined to seedlings. In all cases, the plants should be collected with intact root masses, and be accompanied by additional soil samples to permit establishment of the transplants. For each species, a minimum of 20 specimens would be required, and these would be maintained under greenhouse conditions with a watering regime approximately that of the natural habitat as far as possible.

In terms of priority, 38 plant species have been identified as being important cover components of the vegetation associations likely to be impacted, or important to livestock and wildlife. These 38 plant species can be ranked as follows, in terms of sampling priority:

- Group 1: *Salix cascadensis, Salix nivalis, Shepherdia canadensis, Vaccinium scoparium, Agropyron spicatum* and *Calamagrostis rubescens*;
- Group 2: *Amelanchier alnifolia, Cornus canadensis, Dryas octopetala, Fragaria glauca, Linnaea borealis* and *Lupinus lepidus*;
- Group 3: *Arctostaphylos uva-ursi, Juniperus communis, Juniperus scopulorum, Rosa gymnocarpa, Pedicularis bracteosa* and *Phyllodoce empetriformis*;
- Group 4: *Carex albo-nigrum, Poa grayana, Achillea millefolium; Balsamorhiza sagittata, Pyrola secunda* and *Thalictrum occidentalis;*
- Group 5: *Abies lasiocarpa, Picea engelmannii, Pinus contorta, Pinus ponderosa* and *Pseudotsuga menziesii* (as seedlings and young trees);
- Group 6: *Alectoria fremontii, Alectoria jubata, Alectoria sarmentosa,*

Letharia vulpina, Peltigera aphthosa, Drepanocladus uncinatus and *Pleurozium schreberi.* (These species could probably be included with earlier groups in terms of acute fumigations, but would have to be dealt with separately, as a group, for chronic injury assessment.)

The type of experimentation proposed for the above species follows the general form of that used by Larsen and Heck[87], in which a dose-response function for acute injury for each species is derived from observations of such injury induced in individual specimens by a range of dosages. This particular methodology has the advantage of providing a model for each species from which injury levels for other dosages may be predicted with some measure of precision, taking into account the non-linearity of typical dose-response curves. In its present form, however, it is limited to acute injury, although there appears to be no a priori reason as to why it could not also be applied to chronic injury, although this, by definition, would require longer experimentation. Since this latter extension is currently untried, chronic injury evaluations would probably be best undertaken via field fumigations.

Similar experimentation should also be conducted on agriculturally important species. This should specifically involve those cultivars of alfalfa, alsike and white clovers, bromegrass, crested wheatgrass, orchardgrass, perennial ryegrass, reed canarygrass, timothy, oats, rye, faba bean, potato and tomato listed (from Canadian Bio Resources Consultants Ltd. information) in Appendix F. Since these are all grown (or could be grown) at elevations below those with the greatest likelihood of impact, they could be relegated to a Group 7 in terms of overall priority.

(b) Field Fumigation Studies in the Hat Creek Region

The type of field fumigation suggested is that based on the ZAPS approach[95]. The relative inaccessibility of field plots representative of the vegetation most vulnerable to air emissions makes such experimentation extremely difficult and costly. However, three such plots could be established within the Hat Creek region, together with adjacent control plots. The three locations should be:

(1) in the Clear Range, to the SSW of the stack, in the vicinity of ERT receptor sites 14 and 15; the site selected should be at a transition of the Alpine Sedge/ Grassland associations and be Engelmann - Grouseberry Association if possible;
(2) in the Arrowstone Hills, to the ENE of the stack, in the vicinity of ERT receptor sites 93 and 94; the site selected should be at a transition of the Douglas-fir - Bunchgrass - Pinegrass and Big Sage - Bunchgrass associations, if possible; and
(3) in the Cornwall Hills, to the SSE of the stack, in the vicinity of ERT receptor sites 123 and 124; the site selected should be at a transition of the Engelmann Spruce - Grouseberry - Pinegrass and Engelmann Spruce - Willow - Red Heather associations, if possible.

These three locations are proposed since they would provide information about the impact of SO_2 on the major vegetation associations at sites which are likely to show adverse effects of air emissions from one or more of the generating station/control strategy options.

Establishment of ZAPS plots at these locations would provide direct information on the magnitude of the response to be expected from vegetation in situ, by programming the releases of SO_2 according to the patterns of concentrations predicted by ERT modelling. The size of the plots could be reduced appreciably from the 0.6 ha size of those plots currently in use by the U.S. Environmental Protection Agency at Colstrip, Montana[95]. A single plot per site, 20 x 20 m, would suffice. Unlike the Colstrip programme and design, with ports at 3 m intervals, which lead to considerable local differences in concentration, ports at 1 m intervals should be used to provide a more uniform fumigation. Furthermore, and again unlike the Colstrip plots which seek to provide a continuous, predetermined, average SO_2 level over each plot throughout the growing season, the pattern of fumigations used in the three Hat Creek plots should be based on selected modelling, which more truly relate to the types of fumigations to be expected from a distant point source.

While it would be desirable to carry out such fumigations over several growing seasons, extremely valuable information could be obtained from fumigations carried out over periods as short as one month, preferably in early summer.

The sites selected for ZAPS plots provide for the establishment of control plots with essentially the same vegetation and soil characteristics. These should be located about 50 m distant in the direction of the prevailing wind, to minimize the risk of drift causing unwanted fumigations. While for control purposes such plots should ideally be subjected to exposure to compressed air through comparable manifolds, it appears to be unnecessary to impose such a "treatment". Such control plots would then serve the dual purpose of acting as controls for the ZAPS plots, and as baseline plots for future monitoring.

The observations to be made on the vegetation within the ZAPS and control plots should focus initially on non-destructive observations on the ground layer vegetation, over a period of a month's fumigations. A single harvest of aerial biomass from selected m^2 quadrats at the start and end of the fumigation period would indicate the effects of treatment on the growth of individual species. Detailed information on the distribution and cover of each species present should be collected, since it may be appropriate to select quadrats deliberately rather than randomly in order to reduce variability and thereby reduce the amount of replication needed. In selecting suitable quadrat locations, emphasis should be placed on the inclusion of as many of the important species listed in the previous section as possible.

(c) Baseline Studies

Other than the three control plots associated with the ZAPS plots already described, other baseline plots are desirable in order to provide reference data for the monitoring programme, and to reveal the succession changes which occur independently of air emission stress. However, these are best described in conjunction with the post-startup proposals, which are presented in Section 7.3.

7.3 POST-STARTUP MONITORING

Following the start of operations of the generating station, there will be an ongoing need for observations on both natural and agricultural vegetation, since regardless of the stack height and control strategy selected, there is expected to be measurable injury to vegetation in certain vulnerable locations. Equally certain is the likelihood that in some locations nutritional advantages to vegetation may accrue from fumigations with SO_2 or NO_2 or both at low concentrations. The impacts of the three strategies are, in order of increasing estimated severity (Appendix F):

366 m stack FGD
366 m stack MCS
244 m stack MCS

The estimated magnitudes of the impacts of the three strategies are, however, significantly different, so as to make no single proposal for vegetation monitoring meaningful in terms of sampling intensity. While there are a few particularly vulnerable locations which are likely to be adversely affected by all strategies, the number of affected locations increases dramatically as one progresses from the 366 m FGD to the 244 m MCS options.

The objectives of post-startup monitoring are clearly:

(1) to determine the occurrence and the magnitude of any short-term

effects of air emissions on the local vegetation;

(2) to determine the range of response among individuals within each species of importance, in order to identify potential sources of germplasm which may possess tolerance to the air emissions, and which hence may be of great value in terms of revegetation, where needed; and

(3) to measure the longer term effects, particularly ecological effects, either harmful or beneficial, of air emissions on plant growth, species composition and certain soil parameters.

In each case, the objectives include the desirability of acquiring data from which realistic estimates of economic loss or benefit may be prepared. Furthermore, it should be stressed that, in establishing the sites of monitoring plots, attention must also be paid not only to those locations at which adverse (or beneficial) effects are almost certain to occur, in spite of the satisfactory performance of a particular control strategy, but also to locations in which adverse effects may occur as a result of unexpected and unforeseen circumstance, e.g., unusually meteorological conditions, malfunction or breakdown of equipment in the generating station, human error, etc. These latter locations need not be numerous, but are likely to be those which generate data of particular importance in the event of litigation. While the ERT modelling of the ground-level concentrations of SO_2 from the uncontrolled 366 m stack, operating under base load, is of use in assisting the selection of such sites, no comparable data are available to the writer for the uncontrolled 244 m stack. In any event, even modelling is of limited value in such site selection since the sites are essentially anticipatory and have largely to be selected by intuition.

(a) Vegetation Monitoring

(i) Stack Emissions

Given that the prime objective of biological monitoring is to determine changes which are unequivocably attributable to the operation of the Hat Creek project, any monitoring proposal must seek the ideal compromise between providing too little information and too much. Essentially, this means avoiding both the waste of time and money involved in acquiring inadequate data and the wastage of time and money through "overkill".

ERT modelling has provided useful data sets for each operating/control option, which indicate those locations which are most likely to receive impact. Furthermore, although there are 20 vegetation associations in the Hat Creek region, there are many species common to several associations. In addition, those associations which occur at the higher elevations, at which the greatest impact is likely, number approximately 10. On the other hand, it would be unwise to confine monitoring sites to only those locations suggested directly by ERT modelling, as pointed out above, particularly because of uncertainties inherent in the modelling itself, because it is based on a single year's meteorological data.

The matter is further complicated by the different scale of monitoring required for each generating station/control strategy option. In order to be comprehensive, the following tabulations of suggested monitoring sites is arranged so that those sites appropriate to the 366 m stack FGD option are presented first, followed in turn by those additional sites recommended for the MCS strategy with a 366 m stack and a 244 m stack respectively. For ease of identification, the proposed locations are identified in relation to numbered ERT receptor sites or sectors.

366 m Stack FGD Strategy

Receptor Sector	Plots to be Located *Within Association*
Sites associated with elevated SO_2/NO_2 levels:	
14	C,D,G,H,S,X
20	C,D
35	D,H

Receptor Sector	Plots to be Located Within Association
36	W
51	E,H
52	E,K,W
116	M,V
123	D,F,G
124	B,U

Sites selected in order to provide information on other associations in locations in which exceptional fumigations are likely to occur:

Receptor Sector	Plots to be Located Within Association
12	S,X
22	A,B,C,F
34	J,U,Y
50	J,Q
93	M,N,P,V

In the above listing, the intent is that monitoring sites be established within vegetation representative of the associations indicated, be representative of a range of fumigation levels, and that the sites be as close as possible to the ERT receptor site listed, at least within the relevant receptor sector. It may be that some of the existing vegetation plots will meet these guidelines and contain important baseline data. These should be intensively investigated. A total of 38 plots are suggested.

366 m Stack MCS Strategy

Receptor Sector	Plots to be Located Within Association
13	H,H
15	A,B,C,G
21	C,D
29	A,B,F,W
44	K,J

Receptor Sector	Plots to be Located Within Association
63	E,W
125	M,U,V

Again, the intent is that these additional 19 plots be located within representative examples of the associations listed. In this case, all the additional sites relate to anticipated impact. No additional sites to provide information in the event of unexpected fumigations appear to be necessary. A total of 57 plots are suggested for this option.

244 m Stack MCS Strategy

The following sites are proposed in addition to those for the 366 m stack options:

Receptor Sector	Plots to be Located Within Association
Sites associated with elevated SO_2/NO_2 levels:	
6	W
8	A,B,C,F,G
16	A,B,C,F,G
61	E
70	H,M,Q
94	D,J,N,P,V
107	H
122	D
Sites selected in order to provide information on the effects of exceptional fumigations:	
2	H,U
11	X
19	S,X,Y
42	J,K
90	H,W

The additional 32 plots suggested above brings the total number of sites for this strategy to 89. However, this strategy also requires that several additional plots be established beyond the 25 km limit of the local zone of impact, to the S, SSW and NNW, i.e. beyond ERT receptor sites 8, 16 and 64. This is because the ERT modelling indicates that the trends in expected peak SO_2 concentrations are either still rising as one moves outward from the stack and reaches the outermost site, or have merely levelled off. Hence, impact may well be anticipated beyond these sites, and it is suggested that at least one site be established approximately 3 km beyond the outermost receptor site on each axis. The precise number of such sites cannot be suggested at this time, since the locations in question are beyond the limits of the detailed vegetational mapping.

In addition to the above recommended plots, a representative control site should be established outside the local zone of impact for each vegetation association shown to be impacted by air emissions. These control sites should be close as possible, representative of the climate, vegetation, elevation, soil and stand characteristics of those found in the Hat Creek area. The selection of these control sites is undoubtedly the most difficult task.

Since the value of a monitoring programme hinges on its ability to demonstrate change, not all sites need to be the focus of detailed study. Initially, it is suggested that a detailed floristic analysis be made of each site, including a photographic record when startup occurs. Semi-annual or annual plot inspections would be adequate thereafter. In these inspections, emphasis would be placed on observing symptoms which may occur and be attributable to air emissions. The use of low-level aerial colour infrared photography would be invaluable in detecting early changes in vegetation, such as stress and tissue damage. This type of imagery could be utilized either as a photographic record for each plot or pre-determined transects could be flown at set intervals. Annual flights during the growing season would probably be adequate in order to record natural vegetation change as well as that caused by air pollutants.

While the majority of the plots would be utilized as visual inspection plots for symptoms attributable to air emissions, some plots should be designed to collect very detailed vegetation and soils information. These detailed monitoring plots should be located in particularly vulnerable locations, where adverse effects to all levels of vegetation are likely to occur. In addition, one or two plots should be located in areas predicted to receive low-levels of air pollutants. Information to be collected on these plots would be detailed and time-consuming. Detailed biomass, mechanical vegetation cover estimates, insect and disease populations, and growth and productivity measurements should be undertaken at each plot on a regular basis before startup and after, to try to establish the natural variability as well as impact caused by air pollutants.

No attempt has been made to determine the ecological methods or plot types to be used in the monitoring programme. Before this can be attempted, the exact objectives, monies available, and intensity of the study must be determined. Many methods are available and vary in accuracy and time factors. These should be chosen to suit the study objectives. The use of already established vegetation plots could reduce costs, but it should be emphasized that the ecological methods necessary to properly analyze changes due to air pollutants must be more detailed. However, the present vegetation data does provide baseline data, in order to help select future monitoring plots and provides that many could be used for the less extensive monitoring plots or the detailed plots if more information is collected.

Furthermore, very little has been said on what emissions to monitor. Naturally, the best situation would be to monitor all types of emissions emanating from the stack. However, as the previous air emission impact analysis indicates, many of the emissions would probably have no impact (ozone, carbon monoxide, hydrocarbons and oxides of nitrogen), while other emissions may have a minor impact (particulates, trace elements and fluorides).

Undoubtedly, the greatest impact would be a result of combined SO_2/NO_x fumigations. Consequently, the order of priority should be: SO_2/NO_x, fluorides, particulates and trace elements, and other emissions (ozone, carbon monoxide and hydrocarbons).

(ii) Cooling Tower Emissions

In addition to the monitoring sites listed above, several plot sites should be located to observe the effects of the cooling tower emissions. A lack of information is present because of the type of cooling water used (non-brine). A similar programme could be developed as was suggested for stack emissions (Section 7.3(a)), although much less intensive because of the size of the area affected by cooling tower emissions. Both visual and detailed plots could be established along the various deposition zones indicated by ERT[63] and in the different vegetation associations. Because the major two emissions that may affect vegetation are moisture and the salt content of this moisture, these monitoring plots should coincide with those suggested for the soils. Any change in the soil moisture regime or increase in the salinity-alkalinity of the surface soils could alter the species composition and growth patterns of the vegetation.

(iii) Ash and Mine Waste Disposal Monitoring

The waste dumps and especially the ash disposal area have been shown to contain relatively high amounts of toxic trace elements. Most studies indicate that no leaching from these areas would occur[89, 98]. However, because the potential does exist for these toxic trace elements to get into the ecosystem, monitoring should take place. Both vegetation and soils monitoring (which will be discussed in Section 7.3(b) should be conducted).

The vegetation monitoring programme would include tissue sampling of the vegetation. All vegetation parts i.e., leaves, stems, roots, should be sampled, as well as trees, shrubs, grasses and herb species in order to establish if any changes are occurring in trace element concentrations above the baseline levels established before the operation of these waste disposal areas begin.

(iv) Dust Monitoring

Dust has been indicated in Section 5.4(c)(i)C. to be a potential problem during the operation phase, depending on the reliability of the dust suppression techniques proposed. Dust could reduce the productivity and cause mortality in sufficient quantities and chemical compositions. However, little information exists on what levels are necessary to cause injury.

In order to determine if dust is going to cause significant injury, vegetation plots should be established to monitor any changes in leaf condition, insect and disease occurrences, or changes in tree growth. High volume samplers should be associated with each plot. Analyses should be conducted on the dust particles collected for particle size distribution, trace element content, and chemical composition of the dust. The leaf condition of trees (conifers and deciduous), broad-leaved herbs, and grasses should be visually inspected, increases in the occurrence of insects and disease should be noted, and growth measurements should be taken on selected coniferous and deciduous trees. Climatic data should be kept, especially the occurrence, intensity, and length of the wetting periods of rainfall events. The number of these plots need not exceed six, but should be located at different distances from the mine and occupy various topographic locations, so terrain influences are accounted for.

(b) Soil Monitoring

(i) Stack Emissions

Stack emissions are thought to have relatively little impact on the soil resource. Acid precipitation may be important in areas in the regional study area having a granitic parent material. However, ERT[63] predictions indicate only small changes in percipitation pH may occur, negating any major impact. Probably of greatest importance in a soil monitoring scheme is trace elements. Early baseline inventories by ERT[64] indicate that several trace elements, i.e. arsenic, selenium, cadmium, chromium and fluorine, were present at levels higher than would be expected. The monitoring of these elements is important because of the impact they may have on livestock and wildlife if they are accumulated in the vegetation which the animals eat.

This type of soil monitoring programme should coincide with that of the vegetation monitoring programme. Fewer soil plots are necessary, since it is only necessary to sample in areas predicted to receive relatively high levels of air pollutants. If significant accumulation is occurring on these sites, further expansion of the programme may be necessary. Control sites should be located outside the zone of influence. Both soil samples and vegetation samples should be taken to establish whether certain trace elements are accumulating in the soil as well as if they are mobile and being absorbed by the vegetation.

Six-month sampling periods are probably sufficient to detect significant changes in trace element levels. These should begin before operational startup and continue throughout the operation period or until it is established whether or not accumulation is occurring.

(ii) Cooling Tower Emissions

As indicated earlier (Section 5.2(c)(i)E.), the addition of moisture and salts from the operation of the cooling towers may lead to increased soil moisture and salt levels in the soil, thus, having a potentially beneficial or negative impact on the vegetation. Monitoring of the soil moisture, soil pH, electrical conductivity, and availability of the macro-nutrients would be the minimal programme necessary to document soil changes. Baseline inventories should be done beginning at least two years before operation with sampling to occur at monthly intervals after operation begins. Observations of any vegetation changes such as leaf condition, changes or mortality should be documented. Soil plots designed to note changes due to cooling tower operation should be located at radial intervals from the cooling towers, in the various zones of deposition predicted by ERT[64], to establish where changes in the soil characteristics begin to exhibit differences from the baseline data.

The soil plots should consist of soil horizon identification with sampling of soil moisture, soil pH, electrical conductivity, and analysis for macronutrients done on a horizon basis. Undoubtedly, the upper horizons would exhibit the earliest and most definitive changes.

(iii) Ash and Mine Waste Monitoring

It was established in Section 5.2(c)(i)F. that providing the technical information was accurate, no impact from trace elements escaping from the mine and plant waste dump would occur. However, the high levels of mobile and toxic trace elements present in the waste disposal areas especially the ash disposal area, necessitate a closer investigation of these areas. Although any impact would be localized, the secondary impact on livestock and wildlife consuming contaminated vegetation could be much greater.

Such a programme to monitor the possible seepage of trace elements from the waste areas could include the use of lysimeters to collect the seepage through the soil and determination of the constituents removed. As well, actual soil samples should be taken throughout the soil profile and vegetation samples taken to establish whether the soil or vegetation is absorbing trace elements. The location of the sample plots would be governed by those areas where seepage may occur and travel a distance from the waste disposal area, and areas that slope away from the waste disposal areas.