BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

GENERAL OUTLINE

PART FOUR

IMPACTS OF PROJECT DEVELOPMENT

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CHAPTER 1.0 - INTRODUCTION

Chapters 2.0, 3.0, 4.0 and 5.0 of this Part of the Environmental Impact Assessment Report (EIAR) evaluate the potential impacts of the Hat Creek Project (the powerplant, the mine and offsite facilities) during preconstruction, construction, operation and decommissioning activities. Analyses have been performed to estimate the impacts on:

1. Meteorology - Air Quality.

2. Water Resources.

3. Land Resources.

4. Socio-economics.

5. Noise.

Where the data was inadequate to quantify impacts, conservative assumptions were utilized to reasonably identify both the most likely and maximum possible adverse impacts. Environmental mitigation and compensation proposals to minimize potential adverse impacts from the Hat Creek Project (see Part Five) were identified for consideration by B.C. Hydro.

CHAPTER 2.0 - ENVIRONMENTAL IMPACTS OF PRELIMINARY PRECONSTRUCTION ACTIVITIES

Preliminary preconstruction activities are those that are necessary for testing coal characteristics, fixing locations of the project components, completing preliminary engineering tests on these locations and collecting environmental data. They provide essential information for determining project feasibility and developing the project descriptions that have been used in the environmental studies. Preconstruction activities include, but are not limited to:

1. Land surveying and acquisition.

2. Local access road construction.

3. Test drilling for coal, foundation and groundwater conditions.

4. Coal bulk sample programme.

5. Environmental studies.

Preliminary preconstruction impacts are described in this chapter by resource and impacts of all project components are included within each resource description. Most of the activities have already been completed. Most of the impacts are temporary and are extremely small from a regional resource perspective.

2.1 METEOROLOGY - AIR QUALITY

During the spring and summer of 1977, B.C. Hydro conducted a Bulk Sampling Programme to obtain coal samples from the proposed Hat Creek Mine for a series of comprehensive offsite combustion tests. Prior to commencing the programme, it was recognized that the sampling activities would have some temporary effect upon the air quality of the area. Therefore, mitigative techniques and practices were incorporated into the programme and carried out as the work proceeded.

The primary air quality effect of the Bulk Sampling Programme was an increase in suspended particulate concentrations caused by fugitive dust emissions during the excavating and handling of the coal samples. These fugitive dust emissions were controlled to a great extent through the use of a water spray truck.

During the programme, a network of high volume samplers was used to monitor the ambient suspended particulate concentrations in the upper and lower Hat Creek valleys. The locations of the six stations were depicted in Fig. 2.1-2, Part Three.

The high volume sampler network is part of the ongoing baseline monitoring programme, which was discussed in detail in Part Three of this report. The data collected at these network sites during the Bulk Sampling Programme were used as the basis for estimating the air quality and climatic effects of the programme. The sampling network also provided data on figitive dust from truck movements on nearby access roads. The material presented below is based in large part on a report on the programme prepared by Acres Consulting Services Limited.[1]

2.1 METEOROLOGY - AIR QUALITY - (Cont'd)

2.1.1 Air Quality

Localized increases in suspended particulate concentrations were recorded by the sampling network described above during the Bulk Sampling Programme which are attributed to the programme. The most significant changes in particulate concentrations occurred in the immediate vicinity of the excavation site during dry windy periods and were related to the blowing of topsoil and carbonaceous material from the overburden. Particulate loadings of the ambient air at locations removed from the excavation sites varied widely and are not readily correlated with excavation activities. In general, however, the mitigative measures employed kept fugitive dust emissions low except under very windy conditions within the immediate excavation area.

Fugitive dust emissions related to truck movement on access roads in the area were minimal compared to those in the actual excavation sites. A water spray truck was used continuously on the access roads and in the excavation area to suppress dust, but was apparently more effective on the roads.

The actual suspended particulate concentrations recorded during the Bulk Sampling Programme were low, with most of the 24-hour average readings, except those at Station 6 (Cache Creek),[2] below 60 $\mu g/m^3$. The geometric mean suspended particulate concentrations recorded during the programme ranged from 11 $\mu g/m^3$ at Station 1 (Highway 12) to 49 $\mu g/m^3$ at Station 6 (Cache Creek).[2] The high mean concentration at Station 6 is, however, not believed to be associated with fugitive dust sources related to the Bulk Sampling Programme, but probably resulted from the high volume of traffic through this location and the level of activity in the area. A summary of all of the suspended particulate data collected in the area which was initiated during the spring of 1977 was presented in Part Three of this report.

2.1.2 Meteorology

The fugitive dust emissions associated with the Bulk Sampling Programme activities resulted in localized reductions in visibility during extremely windy conditions. No visibility measurements are available, however, so the frequency, magnitude and areal extent of these reductions cannot be delineated. These intermittent visibility reductions have ceased with the conclusion of the Bulk Sampling Programme.

Localized suspended particulate increases also occurred along access roads to the powerplant site. Although these areas were not monitored, use of these roads was not intensive and particulate concentration increases should have been localized and temporary.

2.2 WATER RESOURCES

2.2.1 Powerplant

(a) Water Quality

Preliminary preconstruction activities have not caused long-term impacts on surface water and groundwater quality. Exploratory drilling undertaken to establish foundation conditions for powerplant facilities has caused only minor localized disturbances which have been and would continue to be reclaimed by revegetation should the project not proceed. Dusting from added traffic on Hat Creek Valley roads and upper trails has probably caused a certain amount of fine sediment to enter the creeks directly and through precipitation washout. Since the disturbed area in the vicinity of the powerplant is less than 1 percent of Medicine Creek's drainage area, the impact has been insignificant.

(b) Hydrology

The only notable activities relating to hydrology are exploratory drilling and minor access road construction. These are, however, too small to cause changes in the area's runoff regime and would not affect groundwater at all. Any activity would produce a certain amount of erosion generating sediment, but due to the minor nature of these activities, this has been insignificant.

(c) Water Use

This project phase has not affected groundwater or surface water usage.

(d) Aquatic Ecology

Impacts to the aquatic community are limited to those caused by the increased sediment loads described in (a) above. These impacts are considered insignificant due to the apparent lack of a trout population in Medicine Creek.

2.2.2 Mine

(a) Water Quality

The Bulk Sample Programme involved the excavation of coal from two trenches comprising an estimated area of 4 ha. A further 8 ha was utilized for overburden disposal, coal stockpiles and reclamation test plots. During this programme three groundwater stations and surface water stations were monitored. The data collected to date indicates no significant project related alterations in either groundwater or Hat Creek water quality.[1] Dusting was only a local operational problem and no leachates have been observed from the storage piles. Groundwater entering Trench B near Hat Creek was pumped to the Dry Lake area for evaporation without influencing the water quality of Hat Creek. The monitoring programme remains in progress.

Construction of access roads to the trench areas and exploratory drilling have caused some surface disturbance which can be subject to erosion by precipitation and runoff. Considering the small size of the disturbances, impacts have been minor and should the project not proceed, reclamation would be quite straight forward and no long-term impacts are visualized. The existing camp sanitary waste discharge of 8 m^3/d is too slight to have a noticeable effect on Hat Creek water quality.

2.2 WATER RESOURCES - (Cont'd)

(b) Hydrology

(i) Groundwater

The existing camp water supply utilizing an estimated 10 m^3/d and discharging an estimated 8 m^3/d induces an increased flow of infiltrated water from Hat Creek. After being used in the camp the water is returned to the alluvial aquifer with only a minor volumetric loss. This transfer has been observed to occur naturally at various reaches along the creek bed and hence the net impact is very minor.

The exploratory drilling programme includes several boreholes which were drilled and developed as water wells. These wells have been pump tested so that soil and rock hydraulic conductivities can be determined. In all cases, approximately 90 percent of this pumped groundwater would be returned to groundwater at a location greater than 200 m from each well. Water losses would result only from evapotranspiration on the land surface. The periods of pumping, or in some cases bailing, were less than 40 days. The impact, therefore, would be negligible in relation to the overall groundwater resource.

During the Bulk Sample Programme, Trench 8 was the only excavation to encounter the groundwater table. The estimated seepage pumped from this trench was 2000 m^3/d. This seepage had infiltrated from the surrounding alluvial aquifer, which in turn had exfiltrated from Hat Creek. Although dewatering Trench 8 represented a temporary major impact on the groundwater flow in the alluvial aquifer, the pumping activity was restricted to a period of only 2 months. Due to the short duration of this activity the overall impact on the groundwater resource and Hat Creek is considered minor. Should the project not proceed, the trenches would be reclaimed.

(ii) Surface Water

The only facility of concern was the Bulk Sample Programme overburden disposal area. The other activities, disturbing approximately 12 ha, have been too small to cause noticeable changes in the surface water hydrological patterns of the area. Because the disposal area was located in the Hat Creek floodplain it was exposed to potential erosion by floods. In order to mitigate this potential impact, the exposed toe of the disposal area was built out of coarse gravel which would sufficiently ameliorate any erosion problems.

(c) Water Use

The exploration camp well would be the only new water source. Minimal impact on groundwater use is expected because of the very small quantity of water withdrawn.

(d) Aquatic Ecology

Impacts to the existing aquatic community below the proposed mine site due to preconstruction activities have been minimal. These are limited to locally increased sediment loading in Hat

2.2 WATER RESOURCES - (Cont'd)

Creek and its subsequent effect on rainbow trout redds and food resources in the immediate vicinity. These events were transitory and extremely localized in nature.

2.2.3 Offsite Facilities

Preliminary preconstruction activities related to the intake structure include surveying, exploratory drillings, environmental sampling and other monitoring programmes. These activities can be scheduled to avoid critical river periods such as salmonid spawning or downstream fry migrations thus eliminating any potential impact to the resources of the Thompson River.

Impacts due to other offsite facility preconstruction activities have been limited to local increases in the sediment loading of various watersheds. Due to the slight intrusions of each facility in relation to its associated watershed and the temporary nature of these disturbances, impacts are considered insignificant.

2.3 LAND RESOURCES

2.3.1 Physical Environment

(a) Exploratory Drilling Programme

No adverse effects on climate, surficial deposits or bedrock formations are anticipated from the drilling programme, which was conducted as part of the preliminary preconstruction activities. However, there could be either direct or indirect effects on soils. Direct effects could result from physical disturbances and indirect effects from vegetation removal. Establishing access routes to the drill sites and the general activity associated with drilling are the principal factors contributing to physical disturbances and vegetation removal. These effects would be temporary in nature and would be restricted to small areas, no larger than the actual drilling sites. Thus, impacts to the physical resources within the Hat Creek Valley are considered to be negligible. In the event that the proposed project does not proceed, impacts to soils could be more substantial unless the affected areas are revegetated or restored to their natural state.

(b) Bulk Sampling Programme

Approximately 12 ha of land was disturbed as a result of the bulk sample programme. Facilities were located in close proximity to one another and in the general vicinity of the proposed mine site. As a result, the major effects were confined to the land areas in the immediate vicinity of the trench areas. Climate, physiography, surficial deposits and bedrock formations would be largely unaffected by the activities associated with this programme. Soils in the trench areas would receive the greatest effect, albeit insignificant in the event that the proposed mine is developed as planned.

In the event that the proposed development does not proceed, moderate impacts to the soil are anticipated. Much of the soil disturbed by the programme was found to be sensitive to erosion. Severe dusting problems were encountered and required special treatment. The soils affected, also have an extremely shallow topsoil horizon. Unless restoration programmes are initiated, much of the topsoil layer could be lost which would create problems in revegetating the areas.

2.3.2 Natural Vegetation

(a) Exploratory Drilling Programme

The primary effects of the drilling programme, including access roads, were direct losses of vegetation. Approximately 300 m^2 of vegetation was disturbed at each drill site. The majority of the drill holes were located within the boundaries of the proposed mine, where the existing vegetation was maintained in an unnatural state due to overgrazing by livestock. The areas disturbed by activities associated with drilling are, by comparison, minimal to the areal extent of natural vegetation disturbed by grazing.

In the event that the project is not developed as planned, some adverse impacts may result if the drill sites are not revegetated or restored immediately. Changes would occur in the vegetative composition, which could allow noxious weedy species to invade the disturbed areas. If the present grazing pressure persists, the probability that less palatable vegetation would become established is increased. As a result, the value of the range would be degraded.

(b) Bulk Sample Programme

The effects resulting from the bulk sample programme are, like the drilling programme, direct losses of vegetation. A greater loss of vegetation occurred from the development of Trench A than from Trench B. This was due to the larger size and greater number of access roads employed. The significance of the impact was greater at Trench A than B, since the vegetation in the area adjacent to Trench B had been previously disturbed. Other potential effects, which could have an adverse impact on remaining vegetation, include reduced productivity due to interception of lateral seepage water by drainage ditches or roads and possible flooding due to these same facilities. At present, impacts resulting from this programme appear to be minimal and are restricted to the immediate areas of the trenches and access roads.

2.3.3 Wildlife

The bulk sample and drilling programmes have had no significant impact on wildlife. No habitats critical to the continued existence of any species in the region were lost and the roads and trenches are unlikely to interfere with normal movements of wildlife within the area.

2.3.4 Forestry

(a) Exploratory Drilling Programme

A large number of the drill sites located in the Hat Creek Valley floor are in the area of proposed mine pit No. 1. This area is classified as open range with few trees of commercial value. The forest productivity of a large portion of the area is rated poor to low by the British Columbia Forest Service. In general, the area is considered to be of minimal value to the forestry resource within 25 km of the proposed powerplant site.

2.3 LAND RESOURCES - (Cont'd)

The effects of the drilling programme on the forest resource are the direct loss of forest species during the preparation of drill sites. Approximately 300 m^2 of land was disturbed at each drill site. However, no measurable impact to the forest resources is anticipated from the drilling programme due to the small area disturbed at each drill site and the present status of forest species. Some erosion of disturbed sites may occur if they are not restored or revegetated quickly.

(b) Bulk Sample Programme

Approximately 12 ha of land were disturbed by activities associated with the bulk sample programme. The areas disturbed are located along Hat Creek Valley bottom lands. Forest vegetation in this area is sparse and the land is classified as open range, which has been heavily overgrazed. Due to the open nature of the vegetation, few trees were removed during the programme and no measurable impacts were noted.

Some impacts to the forest species of the valley bottom could occur should the proposed development not proceed as planned and the areas disturbed by the bulk sample programme are not restored to their previous condition. These impacts, primarily in the form of erosion, would only affect the forest resources by degrading productivity of an area which is presently at a low level.

2.3.5 Agriculture

Preconstruction activities could reduce agricultural resources through land clearing required for exploratory drilling and the bulk sampling programme. The drilling programme, which has already been carried out, required small areas for water holding ponds and routes for moving heavy equipment. From initial observations of reclamation efforts, it is not considered likely that either of these temporary land requirements would result in any lasting reduction of grazing productivity, if further project activities were not affected.

The approximately 12 ha of grazing land required for the bulk sampling programme occur in an Agricultural Land Reserve. Reclamation of this area appears feasible, should the project not proceed.

2.3.6 Cultural Heritage Resources

The impact of the drilling and bulk sample programme on cultural heritage resources was minimal since field activities were monitored by archaeological consultants or the Provincial Archaeologist.

2.3.7 Geology

The impact of the drilling programme on the geological resources of the area was insignificant. The bulk sampling programme also had no significant impact on the availability of these resources.

2.4 SOCIO-ECONOMICS

2.4.1 Overall Considerations

(a) Introduction

The preconstruction phase began in 1974 when feasibility studies were first undertaken. Since then, specific studies have included exploratory drilling activities, the bulk sample programme, land acquisition, conceptual engineering design, community surveys, public information programmes, detailed environmental studies and the licensing application hearings should the project proceed to that stage. The overall impact of these efforts has been to provide information for decision makers within B.C. Hydro, various government agencies and ministries, government units and the public at large.

The impacts of preconstruction activities are discussed in the following sub-sections according to time periods.

(b) Preliminary Activities

Activities during this preliminary phase revolved around the nature of the coal deposit, development of the deposit and the use of the coal for thermal generation. The number of persons involved in the effort resulted in non-measurable economic gains and did not create servicing problems in the local communities. Land use impacts associated with exploratory drilling in the Hat Creek Valley were insignificant. However, these activities affected the attitudes of residents in the valley and the nearby communities.

Hat Creek Valley residents viewed the activities as a movement from coal potential to development which would affect them through land acquisition and through a change in the rural character and lifestyle of the existing valley. Community residents reflected a mixed reaction to these activities but sensed the potential significance of the project on the Hat Creek region.

(c) Evaluation and Preparation Activities

Beginning in late 1975 and continuing to the present time, B.C. Hydro has undertaken a number of activities to obtain technical, environmental and community related information for decision making purposes. The effect of these efforts has stimulated the development of community planning in Clinton, Ashcroft and Cache Creek and regional planning in the Thompson-Nicola Regional District.

The service enterprises have benefitted from expenditures that were made locally by B.C. Hydro personnel and consultants. Because the spending was done throughout the year and not just during the peak tourist months, seasonal fluctuations have been dampened. A few local residents have benefitted from direct and indirect employment, however, the effect on total local income was minimal. There was no need for increased investment in community infrastructure, housing stock, or community facilities as a result of evaluation or preparation activities.

Some land has been alienated from agriculture and other uses in the Hat Creek Valley as a result of the bulk sample programme, clearing and other activities. The increased level of activity

2.4 SOCIO-ECONOMICS - (Cont'd)

in Hat Creek Valley appears to have alienated land from outdoor recreation use by the area's residents. Property acquisition by B.C. Hydro has resulted in the movement of local residents. However, the majority of the land has been leased back for agricultural use. Within the communities, some local residents have purchased or consolidated land parcels for future developments.

Activities undertaken by the local communities (e.g. community plans) have resulted in administration costs and increased expectations. However the long-term benefits to the community are anticipated to cover the costs incurred.

The increased awareness of the project being proposed has changed the expectations of community residents with respect to the future of the community. While a number of study area residents view the project favourably, anticipating employment, income and lifestyle improvements, others see the proposed project as a disruptive factor, undermining what they would consider important elements of community life. With respect to the Hat Creek Valley residents, the increased B.C. Hydro activities have contributed to additional anxiety and insecurity.

(d) Assessment Activities

If the decision is made to apply for licensing of the project, the continued activities towards a final decision would intensify the disparate views among community residents. However, the majority of people are not expected to change their opinions as a result of the detailed studies. Also, the differences in opinion are not expected to cause an unresolvable or destructive polarization in the social fabric of the communities. The Hat Creek Valley residents would view the licensing and information efforts as a reaffirmation of their expectations that the project would proceed.

If the licensing effort is denied, those opposed to the project would be pleased but those who supported the project would feel a loss over what they perceived as opportunities foregone. Some residents might decide to leave the area for better employment opportunities in the future.

It appears that a majority of the local residents would favour the issuance of a development license. If the project were approved, the local communities might experience some speculative building, infrastructure investment and a rise in general business activity. These activities might result in short-term price increases in land due to speculation. Some residents particularly in the valley would move as a result of the project. Other residents might be resentful of B.C. Hydro and project supporters, while still others would adjust to what they might consider an unfortunate development.

2.4.2 Aesthetics

During the preconstruction phase, there have been necessary disruptions to the existing visual scene. The generation of noise and dust occurred due to the operation of heavy equipment and machinery on the site. Bulldozers were employed for clearing, grubbing and grading, as well as front end loaders, trucks and other pieces of heavy equipment. Chain saws were used for felling and sawing trees. The use of this equipment created noise, dust and debris in the area. Because, however, the nearest towns (Pavilion and Carquile) are both 18 km distant and appropriate dust suppression and noise abatement techniques were employed, these effects have been minimal.

2.4 SOCIO-ECONOMICS - (Cont'd)

2.4.3 Recreation

The Hat Creek Project can be expected to have two primary recreational effects:

1. A loss in recreational opportunities caused by changes in land use from existing agricultural-forestry use to electric power production and mining.

2. An induced recreational demand impact caused by increases in population directly related to site activities as well as by people attracted to the site to observe the operation.

Secondary recreational impacts could occur if natural resources beyond the immediate site are impacted by the project. Physical impacts associated with preconstruction activities would then have minimal effect on the recreational resources.

2.5 NOISE

Noise producing activities have been carried out in the Hat Creek Valley as a part of a programme to evaluate the coal deposits, which include the bulk sample and the exploratory drilling programmes.

2.5.1 Exploratory Drilling Programme

An intensive drilling programme to establish the extent and quality of the Hat Creek coal deposits was started by B.C. Hydro in 1974. This programme was at its peak from September 1977 to January 1978 when a total of nine drilling rigs were in use. The estimated noise levels of these rigs ranges from 80 to 100 dB(A) at a distance of 15 m.

Because the ambient noise levels in the Hat Creek Valley are typically less than 40 dB(A), drilling operations could be audible for a distance of 3.2 km under the worst conditions (no wind attenuation and no significant topographical shielding). Drilling near occupied property was avoided where possible. Any potential noise affects on the Hat Creek Valley ranches could have been attenuated by the high banks of the creek and the uneven valley terrain. Nevertheless, the noise levels increased over ambient conditions and several complaints were received from nearby ranchers.

2.5.2 Bulk Sample Programme

During the Bulk Sample Programme the major noise sources were caused by the excavation of Trench "A" and "B" (shown in Fig. 2.5-1) and transportation of the coal over Highways 12 and 97 to Ashcroft.

(a) Excavation Noise

A sound survey was conducted during the excavation of overburden from Trench "A" of the Hat Creek Bulk Sample Programme during 25 to 26 May 1977.[1] Baseline noise level measurements derived from the monitoring programme conducted in the valley were utilized for comparison purposes and are shown in Table 2.5-1.

2.5 NOISE - (Cont'd)

The estimated existing ambient sound level values at three selected monitoring points around Trench "A" (shown in Fig. 2.5-1), which were derived from the baseline noise monitoring study conducted previously in the valley, are shown in Table 2.5-1. Brief measurements were also made at the northern edge of the Lehman property, about 1220 m from Trench "A" and the background noise levels (generated by a light wind in the trees and from Hat Creek itself) were found to be 40 to 44 dB(A). The measured L_{eq} (1/2 hour equivalent energy level) values at the three monitoring sites during the excavation of Trench "A" are also shown in Table 2.5-1.

At Sites 1 and 2 the trench operation was completely shielded from view by the high points of the uneven terrain, whereas at Site 3 the trench operation was in full view and therefore did not benefit from "topographical shielding".

Brief measurements were made at two other locations in the valley to check the intrusiveness of the Trench "A" noise. At the northern edge of the Lehman property (the nearest significant noise receptor), the excavation noise could only be intermittently heard above the background noise. At the junction of Hat Creek Road and Highway 12, the operation was not audible above the background noise created by a light wind and running water.

The noise level generated by a blast in Trench "A" on 26 May was recorded at Site 3 (drill hole 76-168). The blast was used to break up a volcanic dome which was located roughly in the centre of the trench. The charge consisted of 477 kg of Iremite-H explosive and generated a noise level of 96 dB(A) at a distance of 945 m.

(b) Trucking Noise

Field data were not collected on the highway trucking noise generated during the Bulk Sample Programme. However the trucking of coal along Highway 12 was estimated to result in a 1 dB(A) increase in the Ld_n value (day night average level) on weekdays and only a slightly larger increase on weekends.[2] This estimate is based on the assumption that a maximum of 16 round trips of truck loads of coal occurred during the Bulk Sample Programme (32 truck events at each location). Highway 97 is presently a major trucking route and hence the additional 32 events per day are considered to have had a negligible effect on the L_{dn} value along this highway.[2]

CHAPTER 3.0 - ENVIRONMENTAL IMPACTS OF CONSTRUCTION ACTIVITIES

Construction activities are all of those activities necessary for constructing the powerplant, mine and offsite facilities, installing the equipment and preparing all systems for operation. The activities include, but are not limited to:

1. Providing construction-labour camps.

2. Providing power, water, sewage facilities, construction access roads and laydown areas.

3. Permanent road and railroad construction.

4. Purchase and erecting buildings and all other structures.

5. Constructing dams, dykes, drainage ditches and diversions.

6. Initial mine overburden stripping and coal stockpiling.

7. Purchase and installation of all machinery.

8. Final cleanup, grading and revegetating.

Because the powerplant would consist of four units, which would be constructed sequentially and are scheduled to start operation at 1 year intervals, the construction and operating phases would overlap. This affects all aspects of the project and requires detailed and complex scheduling. For the most part, facilities peripheral to the powerplant must be operational when the first unit starts up and subsequent to the first unit startup most construction activities would be concentrated at the plant.

3.1 AIR QUALITY AND METEOROLOGY

During construction of the plant, mine and offsite facilities the main air quality concerns would be activities that produce fugitive dust emissions. These activities include road construction, grading and excavation, erection of buildings and facilities, blasting, concrete batching and initial mining activities. Gaseous emissions from motorized construction equipment and construction workers' vehicles would cause localized but insignificant increases in onsite ambient concentrations of carbon monoxide, oxides of nitrogen and hydrocarbons.

3.1.1 Air Quality

Fugitive dust emissions from construction activities could cause elevated suspended particulate concentrations (e.g. 150 to 200 $\mu g/m^3$) within the plant site.[1] The size of the site and the relative lack of sensitive land uses near the site perimeters suggest that the air quality effects of powerplant construction activities would be minimal, if not negligible. If localized problems should arise, mitigative procedures, e.g. watering during windy periods, are available.

3.1 AIR QUALITY AND METEOROLOGY - (Cont'd)

Elevated suspended particulate concentrations would occur during the first few years of active mining, although they would be smaller than those expected during peak mining periods and mitigated to the maximum extent practical. Suspended particulates would, for the most part, be confined to the immediate vicinity of the mine itself. As is indicated in Chapter 4.0, annual average incremental suspended particulate concentrations during peak mining periods could reach approximately 260 $\mu g/m^3$ near the pit, but should be less than 100 $\mu g/m^3$ outside of the immediate vicinity of the mine.[1] Beyond 3 km from the mine the increase in annual suspended particulate levels during peak mining periods should be no more than 60 $\mu g/m^3$.[1] Maximum incremental 24-hour average suspended particulate concentrations in excess of 200 $\mu g/m^3$ are predicted for the southern sections of the Indian Reserve in the lower valley during peak mining activities, with incremental concentrations of 150 $\mu g/m^3$ extending to the northern boundary of the Reserve.[1] As is the case for annual averages, maximum short-term suspended particulate concentrations during mine "construction" activities are expected to be smaller than those during the peak mining period.

The principal air quality impact of constructing the intake structure, makeup water line, transmission lines, creek diversions, airport and equipment offloading facilities would be the fugitive dust emissions associated with both actual construction, including excavation, trenching, blasting, grading, etc., to the small areas immediately surrounding the construction activity and would be mitigated to the greatest extent practicable by dust abatement procedures (see Part Five).

The construction of the access road would result in two primary effects upon local air quality. The first would be an increase in atmospheric particulate loadings due to the scraping and grading of the roadbed and the hauling of construction materials over unpaved roads. These particulate level increases would be confined to areas adjacent to active construction and would be minimized to the maximum extent possible using state-of-the-art dust abatement procedures. The second effect would be ambient level increases of other air contaminants resulting from the gaseous emissions of the temporary asphalt plants used during road paving.

Once the access road is completed it would serve as the major thoroughfare to and from the Hat Creek site for the duration of construction activities. The estimated peak traffic volume during construction is 500 to 700 vehicles per day at the beginning and end of the work week and 200 to 300 vehicles at shift changes during the remainder of the week. This traffic volume would not emit enough gaseous contaminants to significantly alter air quality.[1]

3.1.2 Meteorology

The particulate emissions from the initial mining activities would reduce slightly the amount of direct sunlight that reaches the ground in the immediate vicinity of the mine and might therefore produce a slight annual average decrease in temperature at locations in the immediate vicinity of the mine.[1] This temperature change would be less than the natural variation of annual average temperatures in the Hat Creek area.

The particulate emissions from mine construction during the initial phases would also have a somewhat adverse impact upon visibility in the adjacent surrounding area. According to ERTs analysis of visibility,[1,2] annual average visibility reductions could be on the order to 50 percent during the years

3.1 AIR QUALITY AND METEOROLOGY - (Cont'd)

of peak mining activity (see Chapter 4.0). Particulate concentrations during initial mining activities are expected to be smaller than during peak mining activities and visibility reductions are also expected to be significantly less.

Construction activities for all offsite facilities should produce only small amounts of fugitive dust which would have only localized effects on visibility and which should be insignificant. No other meteorological effects are expected.

3.2 WATER RESOURCES

3.2.1 Powerplant

(a) Water Quality

(i) Groundwater

The construction camp sewage disposal system and the concrete batch plant would have little effect on groundwater quality provided that the lagoon, impoundment and associated embankments are constructed of impermeable materials which are prevalent in this area. The present sewage disposal system design would also require the containment of natural surface runoff in the Harry Creek watershed above the impoundment. Consideration should be given to diverting surface runoff away from the lagoon. A sanitary waste disposal system would be provided to service the construction site facilities, and it is recommended that this facility be incorporated into the construction camp system. Due to the limited dilution and assimilative capacity of the creeks near the plant site, the discharge of treated sewage should be minimized.

Site selection for the disposal of refuse from the powerplant construction facilities, would ensure compliance with all criteria for a Level A landfill as discussed in the Pollution Control Objectives for Municipal type waste discharges in British Columbia.[1] This would negate any potential for groundwater pollution from this source. Other powerplant construction activities, including the reservoir and ash disposal facility construction, should not have any impact on the groundwater resources of the area.

(ii) Surface Water

Construction activities through disturbances of ground cover and dust generation have the potential to cause impact on the physical quality of Harry Creek and Medicine Creek surface water. The disturbed areas could encompass approximately 10 percent of Harry Creek's drainage area and up to 10 percent of Medicine Creek's drainage area if the ash pond and water reservoir are completely cleared. Sediment control facilities would be necessary to protect these tributaries of Hat Creek. Provided all construction area runoff would be treated via settling lagoons to prescribed or background levels,[2] the impact would be acceptable from a water quality viewpoint.

3.2 WATER RESOURCES - (Cont'd)

(b) Hydrology

(i) Groundwater

Activities including construction of ash and coal transport systems, drainage ditching, lagoons and most plant components would be performed above the water table and would not involve any major water transfer. Hence, there would be no impact on groundwater. All clearing and stripping activities would tend to cause increased runoff and decreased infiltration. This would cause a minor negative impact on the groundwater table, as it would be lowered slightly and on the groundwater flow regime. Increased infiltration (above natural levels) from the bottom of both the Harry Creek and Medicine Creek diversions would tend to raise the groundwater table. The seepage rates are likely to be low, 60 to 150 $m^3/d/km$ and would only apply during the few months of the year when there is water in the ditches.

(ii) Surface Water

Clearing and grading activities can have the following three principal effects:

1. Vegetation interception losses are almost eliminated, thereby making more precipitation available for storage in the snowpack, for infiltration and for runoff.

2. The depth of soil available for active water storage is reduced.

3. The lack of forest canopy tends to speed up snowmelt by several weeks, thereby reducing peak runoff rates during spring freshet.

Secondary effects due to clearing include decreased infiltration capacity, decreased surface storage and a hydraulically smoother surface. All these factors work in the same direction as the main effects, namely towards earlier and larger flows during spring freshet and during rain floods. Potential impacts from these larger flows could be reduced considerably if the makeup water reservoir and ash storage area, the two major land areas disturbed, are cleared only after the stream diversions, drainage ditches and sedimentation ponds have been installed. These latter facilities would tend to equalize flows, therefore minimizing peak flows to receiving waters.

Plant site storm runoff would probably be released to Harry Creek after passage through a sedimentation basin. The rate of release would depend on the detailed design of the facility and should be such that the total flow in Harry Creek does not exceed its natural capacity, which may be as low as 10 to 20 L/s, thereby avoiding extensive gullying and erosion, and the associated impacts.

3.2 WATER RESOURCES - (Cont'd)

(c) Water Use

(i) Groundwater

A maximum total requirement of 1324 m^3/d to supply the plant camp and other facilities would probably be obtained from a well or wells located in the buried bedrock valley aquifer. This usage represents approximately 26 percent of this aquifer's flow. The impact is, however, temporary and should not affect any existing wells in the valley.

(ii) Surface Water

Due to the diverse areal extent of water use impacts and their lack of facility dependence, all construction activity impacts are discussed in this section.

A. Irrigation

The quantities of irrigation water affected by the alienation of irrigable land are tabulated in Table 3.2-1. Activities of the base project scheme would alienate a total of 273 ha or 20 percent of lands projected as being irrigated in the future (probable use) without the project. The quantity or irrigated water associated with these lands is $156.5 \times 10^4 m^3$. These quantities may not represent a total loss as irrigation of other lands could be considered.

The draining of Finney Lake would result in the loss of irrigation storage and the construction of the Finney and Hat Creek diversions would restrict the use of present irrigation water conveyance systems (ditches) by blocking their present routes (see Table 3.2-1). Some of these affected uses could be effectively compensated by the provision of an alternate water conveyance route or alternate source of water.

B. Livestock Use

The impacts on livestock water use due to the construction of all project facilities are associated primarily with the alientation of rangeland. The Agriculture Report[4] states that about 3400 ha of rangeland would be alienated (lost to grazing use) by the project and thus eliminate, as well, the use of watering sites within the alienated areas.

C. Domestic, Municipal and Industrial

Combined population projections for the communities of Ashcroft and Cache Creek have been reported in the Socio-economic Report.[5] Total water usages have been calculated based on a per capita usage of 0.91 m^3/d. Due to the proximity and accessibility of Ashcroft to the project site it was assumed that two-thirds of the population increase would occur in Ashcroft and one-third in Cache Creek. This breakdown is within the assumed range of population distribution reflected in the Socio-economic Report.[5] Ashcroft obtains its water from the Thompson River and Cache Creek from the Bonaparte River. Based on this information population estimates and water usage projections are presented in Table 3.2-2. The impact of this increased usage on the two respective water bodies is deemed insignificant.

(d) Aquatic Ecology

The major impact to the aquatic community of Hat Creek from construction of the powerplant would be a potential increase in the levels of non-filterable residue and turbidity caused primarily by erosion from disturbed areas, from stream or intermittent-watercourse crossings and from fugitive dust. While most or all of this impact can be ameliorated by proper erosion control measures (runoff interception and treatment in settling basins), some increase in suspended solids concentrations in Hat Creek could be expected.

The continued existence of the rainbow trout population is intimately related to a combination of environmental factors including water depth, temperature, substrate composition and sediment load. Changes in these parameters could have an effect on the available trout habitat, available food resources (benthos) and reproductive potential (spawning habitat).

The deposition of silt, sand and small-grain gravel affects trout populations in several ways. It can act to decrease the quantity and quality of available food (macroinvertebrates) to both juvenile and adult trout because pebble and cobble substrates are more productive than sand/silt substrates. It also reduces the quantity and quality of available spawning habitat by reducing the interstitial flow. This would lower the flushing of the metabolic wastes and the amount of dissolved oxygen available to trout eggs and larvae in the redd. The effects of siltation and fine substrates on the emergence of several trout species has been demonstrated.[6,7] The relationships between diversity and production of benthic macroinvertebrates and substrate composition is also well established.[8,9]

The potential for impacts resulting from increased suspended solid loading and resultant siltation in Hat Creek, Bonaparte River and tributary streams is substantial. The benthic community of these streams is comprised primarily of insect larvae adapted to firm substrates with interstitial and/or epilithic niches (Part Three, Section 3.3.4(b)(ii)B). Trout, which subsist on these ogranisms, would also be affected directly by siltation of spawning area. These effects could be increased by possible flow reductions (described in the sections dealing with operation and decommissioning).

The inclusion of settling ponds to decrease suspended solids loadings to below 50 mg/L as specified[2] would protect the water body from habitat loss or modification (due to sedimentation) except in isolated spots such as stream crossings. With maintenance of the adequate instream flows recommended in Table 3.2-3, suspended solids which do enter the streams (i.e. up to 50 mg/L) should either settle out in pools and behind the existing dams, or be swept out of the system. There are no other projected adverse impacts to the aquatic community expected from construction of the plant.

3.2 WATER RESOURCES - (Cont'd)

3.2.2 Mine

(a) Water Quality

(i) Groundwater

The camp sanitary waste disposal system should not affect groundwater quality, providing dykes and the aerated lagoon are constructed of relatively impermeable materials to minimize seepage. Final disposal by deep well injection or irrigation should have little impact, provided there is sufficient subsurface travel or no direct surface runoff to Harry Creek consistent with regulatory guidelines.[1] Treated effluent from mine shops and warehouses would be used for dust control. This disposal system should not have any impact on groundwater quality.

Solid refuse disposal to a landfill site meeting all regulatory guidelines[1] would have minimal impact on groundwater quality. It would be advisable to select a suitable disposal site for all mine refuse rather than just a temporary site for construction refuse.

Coal and low-grade waste coal will begin to be stockpiled during this project phase. Since the quality of runoff and leachates from these areas would be poor (see subsequent Section (ii)), it is assumed that a relatively impermeable base would be used to minimize percolation of leachate thus minimizing any groundwater impacts. If implemented, leachates would appear in the surface drainage system.

Both pit dewatering and area dewatering would be required during the construction phase. Extraction of groundwater from the dewatering activities should not affect the quality of the remaining groundwater.

The estimated quantity and quality of seepage from each area and the subsequent groundwater quality impacts are discussed in Section 4.2.2. Other activities during the construction phase of the mine are not expected to affect groundwater quality.

(ii) Surface Water

Many operations would disturb the landscape by removing or destroying existing vegetation and thus expose areas to erosion. Since the areal disturbance in the valley during this phase is only a small fraction of that which will exist throughout the mine life, predictions on sediment yield are made in Section 4.2.2 based on the maximum areal disturbance subject to runoff erosion. Proper sedimentation and erosion control methods, however, should be implemented as soon as construction commences to minimize this impact and meet regulatory guidelines.[2]

Other pit area activities which can affect water quality include blasting and dewatering. Dewatering during construction is estimated at approximately 1000 m^3/d from the dewatering wells and the pit. An additional 780 m^3/d would occur during rainfall events from precipitation falling within the pit. An estimate of this water quality is presented in Table 3.2-4. This estimate is considered a worst case because the wastewater would be diluted whenever precipitation made up a significant portion of the total. This water, after passing through the proposed settling pond, should be of acceptable quality for discharge to Hat Creek. It would be saline, contain some colour and biodegradable materials and possible elevated levels of ammonia from blasting residuals. Hat Creek should, however, provide a satisfactory dilution (5-10:1) even at low flow. Comparison with Pollution Control Board objectives[2] indicates all parametres are within regulatory limits except sulphate (140 mg/L versus 50 mg/L for Level A) and zinc (1.0 mg/L versus 0.50 mg/L for Level A).

Estimates of the total leachate quality that can be expected from the coal pile are also shown in Table 3.2-4. This table indicates the probable worst wastewater quality from the coal pile during the "flush phenomena" effect of a prolonged rainstorm, assuming acid conditions do not develop. Under normal conditions it is likely that runoff and leachates would be non-existent as the average short duration rainfall would likely be totally infiltrated into the coal pile and would subsequently evaporate. A comparison of this table with Pollution Control Board objectives[2] indicates that chromium, copper, iron and mercury concentrations may be above the levels allowed for freshwater discharges. Coal pile drainage also contains biodegradeable organics as indicated by the leachate test data (see Table 3.4-3, Part Three). Assuming BOD_5 is extracted at the same rate as dissolved solids, the BOD_5 concentration of coal pile leachate could be as high as 1200 mg/L. This would cause a significant decrease in the dissolved oxygen levels of Hat Creek, if discharged. Based on this discussion, consideration should be given to further treatment of this discharge above simple sedimentation or a non-discharge form of operation.

The low-grade waste coal stockpile should exist in an unsaturated condition and be unlikely to produce any continuous seepage. The only leachates expected would be during spring snowmelt runoff and during rainstorms. Table 3.2-4 indicates the estimated leachate quality which is considered to represent a worst case, assuming acid drainage characteristics do not develop. Chemical parametres which could be above Level A effluent objectives[2] considering the physical (sedimentation) treatment proposed are: arsenic, chromium, copper, iron and mercury. The level of biodegradable organics in runoff could also be substantial. The flow from a once in 10-year, 24-hour storm, could add about 800 kg of BOD_5 to Hat Creek which would lower the dissolved oxygen levels. It would appear from the predictions that the proposed physical treatment would be inadequate and that either more extensive treatment or total containment with evaporation or reuse would be required.

Proposed lake dewatering activities include draining Finney and Aleece lakes. An impact from this activity could result from highly enriched water drained from the bottom of these lakes into Hat Creek. Timing of these dewaterings for a high flow period such as spring would allow considerable dilution potential in Hat Creek and minimize water quality impacts.

3.2 WATER RESOURCES - (Cont'd)

(b) Hydrology

(i) Groundwater

The dewatering of the coal pit to ensure slope stability would be achieved by means of vertical wells drilled in the pit and around the pit perimetre. Based on hydraulic conductivities, the radius of influence of the dewatered bedrock around the coal pit will be less tham 100 m beyond the pit face at any stage. As the final radius of the proposed coal pit is approximately 1.5 km, the maximum distance to the edge of the zone of groundwater influenced in bedrock would be about 1.6 km (see Fig. 3.2-1). Surficial sediments have higher hydraulic conductivities, the calculated maximum radius of influence could extend about 1 km beyond the pit perimeter (i.e. extending to a maximum radius of 2.5 km from the centre of the final pit) (see Fig. 3.2-1). The major impact from these dewatering activities would be that the shallow alluvial valley aquifer would be cut in two by the pit and blocked at the pit rim dam. The estimated length of this alluvial aquifer is 18 km and the length affected by the pit is 5 km. Thus, 28 percent of the alluvial aquifer would be affected and similarly 40 percent of the buried channel aquifer would be affected. The impacts, while significant in the vicinity of the pit, would be restricted to the area close to the pit and hence would not cause a major regional impact. Hat Creek flows downstream of the pit would be slightly reduced due to evaporation losses incurred as the groundwater is transported to the Hat Creek diversion canal.

Clearing and stripping operations in the pit area and in Houth Meadows would reduce groundwater recharge and increase surface water runoff. The result would be a minor lowering of the groundwater table through the decrease of recharge to the aquifers. No impacts would occur in the Medine Creek Valley where the water table is well below the valley floor.

A system of surface ditching to collect and convey runoff away from the pit area is proposed for the pit perimeter. These ditches may have to be lined in the general pit area, but in areas outside the dewatering cone of depression this would not be necessary. The net impact of the ditching system would be a reduction of groundwater recharge near the pit and some increased groundwater recharge in areas beyond the pit. These impacts are both relatively minor in terms of the groundwater resource.

The complete dewatering of both Aleece and Finney lakes would have little or no impact on the groundwater resources of the area. Only a small portion of the lake water is lost as seepage and most of this would be through the upper 1 m around the wetted perimeter of the lake.

The topsoil, coal and low-grade waste coal stockpiles are all located in areas where the surficial sediments are mostly glacial tills. The estimated seepage loss through the till would be between 1×10^{-5} and 5×10^{-4} $m^3/d/m^2$ of storage area. The total seepage from these three areas would be only slightly greater than the present rate of precipitation seeping to the groundwater table, resulting in a minor beneficial hydrological impact due to increased groundwater recharge.

It is presently proposed to drill two wells to supply both the mine and powerplant camps which, it is assumed, would also supply mine and powerplant construction facilities. If these wells were drilled and developed in the area close to Hat Creek, the groundwater extracted from these wells would come from an alluvial aquifer which is hydraulically connected to Hat Creek. As most of the water would come indirectly from Hat Creek there would be little or no impact on the groundwater resource. The small quantity of sewage effluent from the mine facilities would have an insignificant effect on the groundwater resources of the area.

Other activities such as the construction of creek diversions around waste disposal areas, embankment construction and spoil disposal would not impact on the groundwater resource because as previously mentioned, the water table is well below the ground surface in these areas.

(ii) Surface Water

Construction of the mine and associated facilities involves extensive clearing, grading and earth moving. Approximately 3400 ha of terrain would be disturbed during the course of mining. *In this area, however, surface runoff tends to be negligible.* *Erosion* and sedimentation facilities would be built prior to clearing and earthmoving, so that impacts would be relatively minor.

The source of both the mine and plant construction water supply would likely be from wells in one of the aquifers in Hat Creek Valley. A flow of approximately 0.18 m^3/s would be required. Any surface water source in the valley may be significantly affected by such a withdrawal, but the construction period of a few years is too short to cause significant alterations in channel morphology or other long-term surface water hydrology impacts.

(c) Water Use

All existing domestic wells and developed springs within the pit perimeter would be abandoned. *These would include DW-1, DW-2, DW-3, DW-4 and DW-14 (see Fig. 2.2-1, Part Three).* *The* estimated amount being pumped from these five groundwater sources is 16 m^3/d. The proposed water wells supplying the offices and warehouses, and the mine and plant construction camps would be the only new wells in the area. The estimated maximum water requirement for the mine camp is 100 m^3/d. This flow is small in comparison to aquifer flows and hence a minor impact would result. Surface water use impacts have been addressed in Section 3.2.1(c)(ii).

(d) Aquatic Ecology

The major impacts to the aquatic community of Hat Creek due to the construction of the mine are expected to be limited to those caused by increased loading of suspended solids from cleared areas and excavation and some increase in dissolved solids and nutrients from lake and pit dewatering activities. The potential effects of suspended solids and siltation on the aquatic resources have been discussed in Section 3.2.1(d). The increase in dissolved solids and nutrient levels of Hat

3.2 WATER RESOURCES - (Cont'd)

Creek during mine construction will be minimal and transitory in nature, and although the potential for increased growth of epilithic algae exists, this is not expected to be problematic.

3.2.3 Offsite Facilities

(a) Intake Structure

The intake structure would be constructed behind a cofferdam. Some temporary increases in suspended solids concentrations and turbidity levels could be expected. These should be of short duration incurring only minor water quality impacts. Excavated material would be disposed of in suitable landfill areas. Poor quality sediments are not expected to be encountered.

The timing of construction activities has been scheduled to avoid pink salmon spawning years. By exercising proper care and construction practices, it should be possible to limit impact due to intake construction to the loss of habitat associated with the placement of the intake pier in the river. This potential impact has been minimized by siting the intake in a reach of the Thompson River that contains little, if any, suitable salmon spawning habitat[11] and by the selection of a pier-type intake structure to be located in the river. This should avoid the potentially greater habitat disruption and fish disorientation that could occur from an installation on the riverbank. Access to the structure is provided by a small walkway which also carried the pipe to the pumping station onshore, again minimizing the structure's presence in the river. These design aspects are indicated in Figs. 3.2-2 and 3.2-3.

(b) Main Access Road

Construction of the main access road would entail such activities as clearing, stripping, excavation, fill, borrow areas, culvert installation and drainage ditching, disturbing a total of 100 to 200 ha between Ashcroft and the plant and mine site. The road crosses surface streams and creeks nine times. It would be necessary to control erosion related sediment loss and fugitive dust, particularly at the crossing of Cornwall Creek because of existing domestic water uses. Normal road construction sediment control measures would be necessary to protect surface water quality.

Impacts on aquatic ecology should be limited to flow disruption of watercourses at the nine necessary stream crossings, from erosion and sedimentation from these crossings and the clearing and excavations associated with roadbed and grade preparations. Replacement of the existing bridge crossing on the Bonaparte River with a more modern structure to provide adequate access to the intake site could be expected to improve presently existing flow patterns in the lower Bonaparte River. Impacts on aquatic biota due to siltation were discussed in more detail in that section dealing with the construction of the powerplant.

(c) Makeup Water Pipeline

Construction of 23 km pipeline, pump stations and access road would disturb about 38 ha of terrain. Activities such as clearing, stripping, trench excavation, blasting and spoil disposal have potential to cause erosion and fugitive dust related sediment loss to surface drainages. Extra precautions to avoid impact from sediment losses would be necessary at the Cornwall Creek and Bonaparte River crossings. Provided precautions are taken, impact on water quality should be minor and of short duration.

Impacts on aquatic ecology would be similar to those associated with the construction of the access road except for the additional habitat disruption caused by the buried pipeline crossing of the lower Bonaparte River. Because this area of the Bonaparte supports a small salmon run (see Section 3.3.4, Part Three) it would be necessary to properly time the activities in the streambed to avoid damage to the individuals of the population using this river as a spawning ground and nursery habitat. Habitat improvement of this area could occur if the proper pipeline burial techniques are employed. These aspects are discussed in more detail in the chapter dealing with mitigation of impacts.

(d) 69 kV Transmission Lines

The construction of these facilities would not impact on the water resources of the area.

(e) Creek Diversions

Construction of the Hat Creek diversion would entail clearing, stripping, excavation, fill, embankment and access road construction. The total disturbed area including reservoirs (base case) is about 46 ha assuming the reservoir bases are stripped of topsoil. Runoff from all construction areas must be controlled, collected and treated to appropriate levels to avoid serious impact on Hat Creek water quality. Construction of the reservoirs and the discharge conduit plunge pool would likely be done during the summer low flow period. During this time the creek is least able to cope with sediment and extremely good erosion control methods should be implemented to protect downstream creek values.

The construction of cutoff trenches and/or grouting of permeable sediments beneath the embankment structures for the Head Works and Pit Rim Dams would partially cut off the groundwater flow in the alluvial aquifer adjacent to Hat Creek. The estimated down valley flow in this aquifer is 2300 m^3/d. The reduced groundwater flow in this aquifer immediately downstream of the embankment would be in the order of 300 m^3/d. The result would be a major negative impact on the alluvial aquifer in the valley. Downstream impacts would, however, be negligible. The removal of vegetation and loose topsoil on upland areas would also cause a slight increase in runoff and a subsequent decrease in infiltration to the water table resulting in a minor lowering of water tables.

Impacts on aquatic ecology due to construction of the creek diversions are similar to those expected from construction of the access road. Care should be taken not to interrupt the natural watercourses until the diversion is actually scheduled for operation. The Hat Creek diversion would eliminate 9 km of existing habitat in the existing stream channel. This would be a significant impact as the diversion canal would not provide replacement habitat.

3.2 WATER RESOURCES - (Cont'd)

(f) Airstrip

The activities of clearing, stripping, base preparation and construction of drainage control structures would expose areas to possible erosion and a certain amount of fugitive dust. Impact on water quality due to sediment loss would likely be minor providing normal construction sediment loss procedures are utilized. The proposed sites for the airstrip (A and C) appear to be away from significant developed surface runoff systems, thus sediment loss should not be difficult to control.

(g) Equipment Offloading Facilities

The activities of clearing, stripping and facility construction would expose areas to possible erosion and some fugitive dust. Impact on water quality due to sediment loss would likely be minor providing normal construction sediment loss procedures are utilized.

3.3 LAND RESOURCES

3.3.1 Powerplant

The assessment of the effects on the land resources due to powerplant construction is based on the assumption that the total land area required for each facility component would be disturbed during the construction phase. Storage reservoirs and ash disposal areas are assumed to be completely cleared and ready for utilization. No sequential preparation of sites is assumed. Construction activities are considered to be restricted to the immediate vicinity of the facility and an appropriate buffer zone has been included in the estimate. Facility components discussed in this section include the plant island, makeup water reservoir, Medicine Creek ash disposal area, Harry Lake ash disposal area and other ancillary facilities.

(a) Physical Environment

Approximately 23 of the 86 soil units identified as occurring within the project locale would be disturbed during plant construction. These effects could result from either the permanent loss of soil, or the compaction of soils due to construction related activities. Each of these effects would be localized to the facility area.

The soil unit, area disturbed and sensitivity rating[1] for each of the plant facilities is presented in Table 3.3-1. The soil unit with the greatest area disturbed by the plant (unit 58) covers 66 ha. This unit has been given a moderate sensitivity rating, since it is moderately sensitive to dusting and alkalinity-salinity problems. The topsoil reclaimability is low and therefore the impact ot the soils within the project locale due to the loss of this unit is not considered significant. The soil unit with the largest area disturbed by the makeup water reservoir (unit 54) covers 40.4 ha. This unit is moderately sensitive to erosion, dusting and alkalinity-salinity problems. Its loss is considered to be insignificant. The Medicine Creek ash disposal area would disturb 147 ha of unit 38, 89 ha of unit 51, 120 ha of unit 52 and 85 ha of unit 56. Each of these units have been assigned a moderate sensitivity rating. Only two units disturbed by the ash disposal area have been rated as being of high sensitivity, namely units 55 (35.2 ha) and 57 (8.6 ha). The high rating is due to the high topsoil reclamation suitability. However, the small area affected suggests that the resulting impacts are minimal. The Harry Lake ash disposal area would use 99.3 ha of unit 51. This unit has a moderate overall sensitivity rating and moderate topsoil reclaimability. The impact of the loss of this unit is negligible in comparison to the total resources available.

The total soil area disturbed by plant construction is small in comparison to the soil resources in the project locale. Sensitivity ratings are generally moderate. Thus, any impact to the soils from plant construction is anticipated to be minimal.

(b) Natural Vegetation

(i) Direct Vegetation Losses

Construction of the powerplant and associated facilities would disturb portions of six vegetation associations found within 25 km of the project. The area disturbed and sensitivity ratings[1] for each vegetation association are summarized by facility components in Table 3.3-2.

The three associations with the largest total areas disturbed are the Engelmann - Spruce - Grouseberry - Pinegrass (95.4 ha), Douglas-fir - Pinegrass (438.5 ha) and Kentucky Bluegrass (471.3 ha). Construction of the makeup water reservoir would disturb the largest area of the Engelmann Spruce - Grouseberry - Pinegrass Association (57.9 ha) while the Medicine Creek ash disposal area would disturb the largest area of Douglas-fir - Pinegrass (328.0 ha) and Kentucky Bluegrass (306.7 ha) associations.

The Kentucky Bluegrass Association would be the most affected, since 10 percent of the total area covered by this association within the project locale would be disturbed during plant construction. In comparison, only 0.5 percent of the Engelmann Spruce - Grouseberry - Pinegrass and 0.9 percent of the Douglas-fir - Pinegrass associations would be disturbed. The impact to the vegetation associations resulting from the disturbances incurred during plant construction are considered to be minimal, since each of the associations with the largest area disturbed have been rated as low in overall sensitivity.

The other three associations which would have some portions disturbed during construction are the Douglas-fir - Bunchgrass (1.3 ha), Douglas-fir - Bunchgrass - Pinegrass (8.5 ha) and the Willow - Sedge Bog (8.1 ha). The Douglas-fir - Bunchgrass and the Douglas-fir - Bunchgrass - Pinegrass have been rated moderate in overall sensitivity. However, the impacts to these associations are considered to be minimal, since such small areas are affected and the loss of these areas would translate to less than a 0.1 percent reduction in the total area of these associations as found within 25 km of the project. The Willow - Sedge Bog Association was rated high in overall sensitivity due to its unique characteristics. The impact on this association from a local perspective is considered to be minimal, because the area disturbed is only 1.2 percent of the total area found within 25 km of the project.

(ii) Air Emissions

Dust emissions from construction activities may have an adverse effect on the vegetation. Dusting would only be a problem during the typically dry summer months and would be localized to the construction sites. The accumulation of dust on vegetation, particularly those with pubescent leaves, has been demonstrated to cause a reduction in photosynthetic activity. Impacts on vegetation due to dusting would be the result of reduced productivity. It is also possible that dust emissions may enhance the frequency of insect infestations and occurrence of diseases. The magnitude of these impacts can not be quantified since dust concentrations from plant construction have not been predicted. The means for translating dust accumulations to productivity reductions in quantative terms have not been reported in the literature. This data void also precludes the assessing of the magnitude of these impacts. However, it is anticipated that the impacts would be minimal because dust control measures are intended to be utilized and the extent of the dusting would be small, primarily affecting only the vegetation associations in the immediate vicinity of construction activities.

(iii) Indirect Factors

Vegetation could also be affected by changes in the near surface seepage water due to construction activities. The availability of this seepage water is important to the vegetation in the Hat Creek Valley since it provides both a source of water and nutrients necessary for growth. Two associations, Saline Depression and Willow - Sedge Bog, are critically dependent on seepage water. The other associations are not dependent on this water source, but could exhibit reduced productivity without it.

Impacts to the vegetation resulting from interference with seepage water during plant construction are considered to be minimal, because construction activities are not expected to occur in areas where seepage is prevalent. The Willow - Sedge Bog Association, which is the only association critically dependent on seepage water and affected by plant construction, occurs in the vicinity of the Medicine Creek ash disposal area. The minimal impact that construction would have on this association, due to the small area disturbed, would result primarily from direct disturbance. Impacts from reduced seepage water are not considered to be substantial. However, impacts resulting from seepage water interference on this association and others can not be assessed until seepage water patterns have been identified in detail.

(c) Wildlife

The Hat Creek Project and related activities will affect wildlife resources in three general ways.

1. Habitat loss.

2. Human disturbance.

3.3 LAND RESOURCES - (Cont'd)

3. Alteration of biological processes.

Habitat loss is used herein to denote alteration of an existing habitat so that indigenous species preferring that habitat can no longer use it for their life history requirements. Human disturbance involves the effect of man's activities (noise, machinery operation and hunting) on wildlife resources. Alteration of biological processes occurs when the resources upon which wildlife depend are impacted and these impacts are passed on to the wildlife population. For example contamination of food sources may result in accumulation of these contaminants in higher trophic levels (e.g. the larger carnivores) with subsequent lethal or sublethal (e.g. reduced reproductive success) effects.

The primary data source is the Appendix A-2, Wildlife Impact Assessment. Game, nongame and rare and endangered species have been considered. No measurable impact is expected to occur on rare and endangered species. Other species and their population status are summarized in the text.

(i) Habitat Loss

Plant construction would result in clearing and grubbing about 169 ha or 0.1 percent of the local study area (Table 3.3-3), exclusive of the ash disposal alternatives. Land area and habitat types needed for the ash disposal systems are presented in Table 3.3-4. The plant site would require removal of five habitat types. The largest habitat type loss (60 ha) will be aspen stands. This is 2.2 percent of the aspen habitat within the local study area. Engelmann spruce - lodgepole pine, midelevation grasslands are the two largest habitat types to be removed by the ash disposal systems. These habitat losses would most affect grouse populations; however only a small percentage of the local study area would be involved. Up to 5 percent of the riparian habitat within the local study area would be lost during construction of the Hat Creek Project. This habitat removal represents a loss of relatively valuable deer habitat and locally valuable waterfowl and furbearer habitat.

(ii) Human Disturbance

Noise and the presence of machinery and vehicles would be relatively constant during the construction period and would lessen in intensity as the site preparation process nears completion and internal plant construction increases. The potential impacts from these sources as well as those related to hunter pressures and demand largely parallel those summarized in the mine construction impact discussion except that their duration would be less. The additive impacts of mine and plant construction are not expected to be significant at the local study area level.

(iii) Alteration of Biological Processes

No major alteration of a species or population's biological processes is anticipated with construction since levels of air pollutants are expected to be low and no migration or dispersal pathways would be blocked.

3.3 LAND RESOURCES - (Cont'd)

(d) Forestry

(i) Direct Loss

Construction of the powerplant and associated facilities would disturb 623.6 ha of forest lands. This is 0.42 percent of the total forested land found within 25 km of the powerplant site. A large percentage (98.7 percent) of this land is considered to be productive forest land. Eight coniferous and three deciduous species were identified as occurring on the productive forest land disturbed by construction activities. The total merchantable volume affected by plant construction is approximately 26 702 m^3. Lodgepole pine accounts for 63 percent of this total, Douglas fir for 31 percent and spruce for 5 percent.

The site class breakdown, based on the predominant forest growth type, lodgepole pine - conifer, of the forest land disturbed by plant construction is 9 percent good, 63 percent medium and 28 percent poor. All of the good site land is found within the proposed Medicine Creek ash disposal area. The mean annual increment (MAI) for the good, medium and poor sites is 3.1, 2.1 and 1.3 m^3/ha respectively. This translates into a total annual increment of 168 812 and 227 m^3 for the good, medium and poor sites, respectively.

Construction of the powerplant and associated facilities would result in the physical loss of land available for the growth of forest species. As a result, it is anticipated that there would be an impact to the forest resources. This impact should be minimal, since the area lost for future growth is classified as predominantly medium or poor site class with a small percentage of good site class. The area of good, medium and poor site class as found within the project locale would only be reduced by 2.6, 1.2 and 0.2 percent, respectively, as a result of plant construction. In a similar manner, the total annual increment of good sites lost due to plant construction is only 2.3 percent of the total annual increment for good sites within the project locale. Sites rated as medium are only 1.1 percent of the project locale total, while poor sites are only 0.2 percent. Construction should have a negligible impact on the forest industries within the project locale since the loss of AAC represents, but a small percentage of the regional totals. It is also assumed that the timber on the land areas required for facility components would be logged and removed as part of the regular forest management programme and quota allocations.

(ii) Air Emissions

Dust emitted during construction activities may accumulate on the leaves of forest species occurring within the immediate vicinity of construction. These dust accumulations may cause the leaves to overheat during sunny periods and thereby cause premature needle death. Dust accumulations have also been found to enhance the susceptibility of trees to black pineleaf scale, which have attacked small areas of ponderosa pine in the vicinity of Lytton.

3.3 LAND RESOURCES - (Cont'd)

The magnitude of the impacts resulting from dust accumulations can not be assessed, since the levels have not been predicted for the construction phase of the project. However, it is anticipated that the impacts would be negligible, due to the utilization of dust suppression measures, the small areal extent affected and the tendency for localization within the area of the activity.

(e) Agriculture

(i) Land Disturbance

Sixty-two percent of the land disturbed by plant construction is leased and 38 percent permit-administrated. Sixteen ha are irrigated and the remainder utilized for cattle grazing. Forty-eight ha have been designated part of the Agricultural Land Reserves.

Approximately 830 ha of leased and permit land would be pre-empted from grazing use by construction the plant components. Two hundred fifty-five ha of Kentucky Bluegrass Association, 440 ha of Douglas-fir - Pinegrass Association and 130 ha of Engelmann Spruce - Grouseberry - Pinegrass Association would be thus affected. The Kentucky Bluegrass Association is grazed during the spring and has been ascribed a current carrying capacity of 2.0 ha per animal unit month (AUM); loss of 255 ha and approximately 130 AUM, would reduce present estimated spring grazing resources of the Hat Creek basin from 3920 AUM to 3790 AUM. With regard to agricultural resources projected for a without-project scenario, the Kentucky Bluegrass Association is expected to increase in productivity (due to reseeding) to a carrying capacity of 0.62 ha/AUM. When projected productivities are considered, the loss of 255 ha represents a loss of approximately 411 AUM per spring season (2 months).

The Douglas-fir - Pinegrass and Engelmann Spruce - Grouseberry - Pinegrass Association are utilized for summer grazing. Their estimated current carrying capacity of 6 ha/AUM is not expected to change markedly if the project is not executed. Construction of the plant components on 570 ha of these two associations would lessen summer season productivity by approximately 95 AUM or 30 animal units (AU). This can be compared to the current summer season productivity in the entire Hat Creek basin, 3000 AU.

The effect of plant land requirements on projected agricultural uses is presented, by Farm Unit, in Table 3.3-5. The impact of entire project land requirements on agricultural uses and tenure is summarized in Table 3.3-6.

(ii) Dust

The potential impact of dust from plant construction activities cannot be qualified. The site vicinity soils would promote dust formation. However, through employment of dust suppression measures the impact can be lessened.

3.3 LAND RESOURCES - (Cont'd)

(iii) Noise

General guidelines for predicting or avoiding sound effects on various land uses have been published for by the U.S. Department of Housing and Urban Development.[4] For livestock farming, 65 dB(A) and 75 dB(A) are considered compatable and marginally compatable, while for non-livestock agriculture the corresponding levels are 75 dB(A) and 85 dB(A).

Predicted construction noise levels within the Hat Creek Valley are generally within 30 to 35 dB(A). The highest levels occur at the north end of the valley. When construction activity is greatest, noise levels adjacent to the plant site are predicted to be 55 dB(A). Decibels (dB(A)). During no wind conditions, noise levels are expected to be 10 dB(A) higher.

The impact of noise from plant construction would be largely confined to the Hat Creek Valley and would not be of regional concern. Although a large portion of the Local Study Area will experience increased noise levels, in general these are sufficiently low to preclude affects on agriculture. The effect on livestock in the valley is expected to be minimal.

(f) Cultural Heritage Resources

Based on survey results, there would be no impact on the cultural heritage resources from the construction of the plant in the area corresponding to Stratum C of the Phase II survey. No resource sites were located during the intensive survey of that stratum. The possibility remains that buried or otherwise overlooked sites might be encountered during construction and need be dealt with.

(g) Geology

The impacts of plant construction on geology are considered to be minimal. Impacts are anticipated to result from the use of aggregate supplies in the valley. Depletion of these supplies is considered to be insignificant in comparison to supplies available in the regional area.

3.3.2 Mine

The assessment of effects on the land resources due to mine construction is based on the assumption that the total land required for each facility component would be disturbed during this phase. Waste dumps, topsoil storage and low grade coal storage areas are assumed to be completely cleared and ready to be utilized during the operation phase. No sequential preparation of facility sites has been assumed. Construction activity is considered to be restricted to the immediate vicinity of the facility and an appropriate buffer zone has been factored into the estimate of disturbed land. Facility components associated with mine construction include Mine Pit No. 1, Medicine Creek waste dump, North Valley waste dump, Houth Meadows waste dump, topsoil storage areas, low grade coal storage and other auxiliary facilities.

3.3 LAND RESOURCES - (Cont'd)

(a) Physical Environment

Construction of the mine and related facilities will begin a substantial modification of the local landsurface. Approximately 35 soil units were identified in the areas affected by the proposed mine and related activities. The effects resulting from mine construction would be derived from the removal and storage of both topsoil and overburden, and would be restricted to the mine pit and waste disposal areas.

The soil units, area disturbed, and sensitivity ratings for each of the mine facilities are presented in Table 3.3-7. Five soil units in the area of the proposed mine were identified as having a high overall sensitivity. The five units are 6B with 40.5 ha disturbed, 17 with 131.9 ha, 19 with 100.8 ha, 200 with 68.1 ha, and unit 21 with 57.4 ha. Soil unit 6B has a high susceptibility to alkalinity - salinity problems, but has a low soil reclaimability. Unit 17 has a high susceptibility to dusting and is also of little value for reclamation. Unit 19 is moderately susceptible to all factors and is moderately valuable for reclamation. Unit 200 is highly susceptible to all factors and has a moderate reclamation value. Soil Unit 21 has been rated as being highly susceptible to dusting, but is of little value for reclamation work. The remaining units are classified as either low or medium in overall sensitivity. Ultimately, the land area disturbed by the mine construction would be approximately 767 ha. Five soil units having high sensitivity ratings make up 50 percent of the mine area. However, from a regional perspective, the significance of soil disturbance should be minimal.

In the Medicine Creek waste dump area only one soil unit, No. 57, was assigned a high overall sensitivity. This unit occupies the largest area (137.2 ha) and is highly sensitive to both dusting and alkalinity - salinity problems, but is only moderately suitable for reclamation. It occurs on 28 percent of the area. The remaining soil units are rated as moderate in overall sensitivity. The impact of the Medicine Creek waste dump on soils, from a local perspective, would be minimal.

The North Valley waste dump is situated on soil units rated as moderate in overall sensitivity. Because of this rating and the small area required, the impact of this facility is considered to be minimal.

Five of the soil units identified in the area of the Houth Meadows waste dump are rated as being of high sensitivity. The areas of unit 10 (76.3 ha), unit 20 D (17.8 ha), unit 57 (129.9 ha), unit 63 (83 ha) and unit 64 (51.0 ha) comprise 57 percent of the total area. All of these units are highly sensitive to alkalinity - salinity problems and moderately to highly sensitive to dusting. The remaining units are rated as moderate in overall sensitivity, although two units, 31 and 34, are highly susceptible to alkalinity - salinity problems. On the basis of this evidence, the Houth Meadows waste dump is expected to have a moderate impact on the soils.

Topsoil storage area B, which is located south of the mine pit on the west side of Hat Creek, is composed of soil unit 17 (61.8 ha). This unit is rated as high in overall sensitivity due to its high susceptibility to dusting. The impact of this area on the soil is anticipated to be high from a local perspective and minimal from a regional perspective.

The soil units mapped in the topsoil storage area C, located south of the Medicine Creek dump, and the low grade coal storage area are all rated as being moderate in overall sensitivity. Thus, perceivable impacts would be anticipated.

The impacts on soils from the construction of ancillary mine facilities are also anticipated to be minimal. Only small areas of each soil unit are affected, and for the most part the units are rated moderate in overall sensitivity. However, soil unit 19, which would be covered by facilities totalling 48.5 ha in area, is rated as high sensitivity. Impacts to this soil unit would be high from a local perspective and negligible from a regional context.

(b) Natural Vegetation

(i) Direct Vegetation losses

Construction of the mine pit No. 1 and related facilities would disturb portions of thirteen vegetation associations found within 25 km of the project (project locale). The area disturbed and sensitivity rating for each vegetation association are summarized by facility component in Table 3.3-8.

The six associations with the largest total areas disturbed are Douglas-fir - Pinegrass (700.8 ha), Douglas-fir - Bunchgrass - Pinegrass (431.3 ha), Sagebrush - Bluebunch Wheatgrass (425.2 ha), Kentucky Bluegrass (411.0 ha), Douglas-fir - Spirea - Bearberry/ Douglas-fir - Bunchgrass - Pinegrass complex (115.3 ha). Three facilities, mine pit No. 1 (120.5 ha), Medicine Creek waste dump (114.5 ha) and the Houth Meadow waste dump (365.0 ha), make up a large percentage of the disturbed area in the Douglas-fir - Pinegrass Association. Mine pit No. 1 (137.6 ha) comprises a large percentage of the disturbed area in the Douglas-fir - Bunchgrass Association, while a large percentage of the area disturbed in the Douglas-fir - Pinegrass - Bunchgrass Association results from construction of the mine (92.7 ha) and Medicine Creek waste dump (232.0 ha). The Medicine Creek waste dump (138.1 ha) Houth Meadow waste dump (126.0 ha) and combined topsoil and coal storage areas (104.6 ha) disturb a greater percentage of land in the Kentucky Bluegrass Association than the other facility components evaluated. Development of mine pit No. 1 disturbs the largest percentage of land in the Sagebrush - Bluebunch Wheatgrass Association. Construction of the Houth Meadow waste dump (111.5 ha) makes up a large portion of the disturbed land in the Douglas-fir - Spirea - Bearberry/Douglas-fir Bunchgrass - Pinegrass complex.

In terms of total area disturbed, the Douglas-fir - Pinegrass Association would have the greatest impact, followed by the Douglas-fir - Bunchgrass - Pinegrass, Sagebrush - Bluebunch Wheatgrass, Kentucky Bluegrass, Douglas-fir - Spirea - Bearberry/Douglas-fir - Bunchgrass - Pinegrass complex in order of decreasing impact. The overall sensitivity of the Douglas-fir - Pinegrass and Kentucky Bluegrass Associations is low, moderate for Douglas-fir - Bunchgrass - Pinegrass and Dougles-fir - Bunchgrass Associations and high for Sagebrush - Bluebunch Wheatgrass Association. On the basis of the sensitivity ratings, the Sagebrush - Bluebunch Wheatgrass would incur a severe impact from mine construction. As further proof of the predicted severe impact, the disturbed area is 63 percent of the total area of this association within the project locale. This impact cannot be mitigated because a large percentage of the disturbed area occurs within the boundaries of the proposed mine.

The two other associations rated as moderate in overall sensitivity, Douglas-fir - Bunchgrass and Douglas-fir - Bunchgrass - Pinegrass, should not be as severely impacted as the Sagebrush - Bluebunch Wheatgrass Association, since the total areas of these two associations within the project locale would only be reduced by 5 and 3 percent, respectively.

The impact of the Kentucky Bluegrass Association should be minimal. Even though the mine construction would result in the disturbance of 411.0 ha of this association, the total area in the project locale would only be reduced by 8.8 percent. The overall sensitivity of this association has been rated low which is indicative of the relative unimportance of this association.

The two other associations which were rated high in overall sensitivity, Riparian and Willow - Sedge Bog Associations should experience a minimal impact. Minimal impacts are anticipated due to the small areas involved and the low percentage of these areas in relation to total areas within the project locale (0.9 and 0.3 percent, respectively).

(ii) Air Emissions

Dust emissions from mine construction may be a problem during the dry summer seasons. The accumulation of dust on vegetation, particularly those with pubescent leaves, has been demonstrated as the causal agent responsible for reductions in photosynthetic activity. Thus, impacts on vegetation due to dusting would result from reduced productivity levels. It is also possible that dusting may increase the frequency of insect infestations and the occurance of disease outbreaks. The significance of these impacts can not be quantified, since the dust emissions generated during mine construction have not been predicted. However, it is anticipated that impacts from dusting would be minimal and localized to the mine area. The use of dust control techniques would also reduce any potential impacts. Should there be an impact due to dusting, it would be small in comparison to the impacts resulting from direct vegetation loss.

(iii) Indirect Factors

There is a potential for an adverse impact on vegetation due to reductions in the supply of water or nutrients from near surface seepage water. The preparation of the mine area prior to mining operations may alter the movement of seepage water. Thus, vegetation, which relies on this seepage water for growth, may exhibit reductions in productivity. The extent or probability of this effect can not be assessed, since detailed information on the flow of seepage water has not been developed.

Two associations, which have been identified as critically dependent on this seepage water, are the Saline Depression and Willow - Sedge Bog. These two associations do not appear to occur to any great extent in the vicinity of the mine and any potential impacts due to loss of seepage water would, by comparison to direct disturbance, be substantially less.

(c) Wildlife

(i) Habitat Loss

Mine excavation would result in a habitat loss of about 2400 ha. Douglas-fir-Pinegrass (899 ha), Ponderosa Pine Douglas-fir-Bunchgrass (466 ha), Sagebrush (459 ha), and Mid-elevation Grassland (399 ha) habitats would be most affected. The Hat Creek Coal mine would involve 1.5 percent of the local study area. Mine development would remove less than 6 percent of any habitat type in the study area except for Sagebrush, where over 60 percent of this habitat will be lost to the study area (Table 3.3-9). Field studies indicated that the Sagebrush Habitat type is most intensively used by deer, and thus represents an important impact of the project on a local game population. Other habitat losses are of less importance.

The mine pit in the valley floor would require diversion of Hat Creek. Hat Creek and Finney Creek would be channelized. Riparian Habitat there would be disrupted or lost. Movements of animals such as mink, otter, and beaver would be partially or completely blocked. To regulate waterflows in the Hat Creek diversion canal, two or three storage reservoirs would be constructed. Upland wildlife habitats would be replaced with aquatic habitat types. Shoreline conditions should dictate what new wildlife potential would develop.

(ii) Human Disturbance

The noise and presence of operating machinery and vehicles should should be relatively constant during the life of the mine. Most animals would adapt to these impact sources in areas of "preferred" habitat near mine operations. Because noise levels should rarely exceed 55 dB(A) except in the vicinity of the mine, alteration of movement patterns rather than injury would be the primary impact.

The impact of noise and human activity on an individual or population depends on the current vigor and reproduction stage of animals subjected to these stresses. Consistent human activities and noise should result in nominal stresses. Sudden and unpredictable events, however, can disrupt nesting, breeding, territory establishment, care of young, etc. During periods of physiological stress such as low food availability when individual vigor is low, the sudden fright stimulus can result in population losses. Time and additional energy spent adjusting or fleeing new disturbances can under low vigor conditions induce animal mortality. Consequently, winter and breeding season non-routine human activities are most likely to impact wildlife populations.

Increases in hunting pressures on wildlife would be proportional to population increases associated with mine development. Fur trapping activities are not projected to increase as a result of this increase in personnel. Deer hunting pressure is expected to increase the most with lesser demands being made on moose, black bear, and big horn sheep within the local study area. A substantial increase in waterfowl hunting demand is expected which may be a significant impact at the local level when combined with construction and operation personnel. More modest increases are expected in numbers of upland game bird hunters. Increases in hunter demand or pressure indicate greater human related mortality levels and possibly lower standing stock of populations present, particularly those species with limited habitats and low population levels.

(iii) Alteration of Biological Processes

Impacts of the mine operation on biological processes include the introduction of potentially toxic or pathogenic agents into the food, water and air resources of wildlife populations. The most likely problem sources include:

1. Dust and particulates generation, and

2. Waste disposal.

Based on estimates of concentrations of particulate materials from mining activities, all dust generation should be sufficiently localized and short-lived so that significant impacts would be avoided. Dust control on roads will minimize problems from this source.

The primary source of waste related contaminants would be the waste dumps and mine construction camps. Sewage from the camps will be treated and disposed of by deep well injection and spray irrigation. Solid waste disposal would be at a land fill near the mine. No negative impacts are expected with liquid waste disposal because toxic materials should not become available to wildlife with this approach. If the landfill is within a waste dump, no additional impacts on wildlife are expected.

(d) Forestry

(i) Direct Loss

Construction of the mine and associated facilities would disturb 1891.4 ha of forest land. A large percentage of this land (97.7 percent) is considered to be productive forest land. Eight coniferous and three deciduous species were identified as occurring on the productive forest land disturbed by construction activities.[5] A total of 120 148 m^3 of merchantable volume would be lost from these species. Douglas-fir accounts for 81.5 percent of this total, ponderosa pine for 14 percent, spruce for 2.5 percent and lodgepole pine for 1.3 percent.

The site class breakdown, based on the predominant forest growth type, Douglas-fir, is 0.4 percent good, 5 percent medium, and 94.6 percent poor. The mean annual increment (MAI) for the good, medium and poor sites is 3.6, 1.7, and 1.0 m^3/ha, respectively. These translate into a total annual increment of 25, 154, and 1714 m^3 for the good, medium and poor sites, respectively.

3.3 LAND RESOURCES - (Cont'd)

Construction of the mine should have a negligible impact on the forest resources, since the area disturbed is predominantly poor site class. The areas of good, medium and poor site classes as found within the project locale would only be reduced by 0.3, 0.28 and 1.8 percent, respectively. In a similar manner, the total annual increment of good rated sites, which would be lost due to mine construction, is only 0.34 percent of the total annual increment rated as good for sites within the project locale. Sites rated as medium make up only 0.22 percent of the project locale total, while poor sites make up the highest percentage (1.7 percent).

The development of an open pit mine in the Hat Creek Valley has been factored into calculations of the allowable annual cut (AAC). This results in a reduced AAC for the Botanic Public Sustained Yield Unit (PSYU) in which the proposed development occurs. This reduction has effectively eliminated the mean annual increment contributed by the area disturbed during mine construction. However, a distinction should be made between the impact on the forest resource itself and the impact on forest management practices. The fact that the development of a major facility, such as an open pit mine, has been factored into the calculation of the AAC suggests that the impacts to forest management practices would be negligible. Development of the project would result in the physical loss of land available for tree growth which would result in an impact to the forest resource. This impact is considered to be minimal since the site class of the area, based on the predominant growth type, (Douglas-fir), is 94.6 percent poor. Construction would also have a negligible impact on the forest industries within the project locale because the loss of AAC represents but a small percentage of the regional totals.

(ii) Air Emissions

Dust emitted during construction activities may accumulate on leaves of forest species occurring within the immediate vicinity of the construction. These dust accumulations may cause the leaves to overheat during sunny periods and thereby cause premature needle death. Dust accumulations have also been found to enhance the susceptibility of conifers to black pine leaf scale, which have attacked small areas of ponderosa pine in the vicinity of Lytton.

The magnitude of the impacts resulting from dust accumulations cannot be assessed since the levels have not been predicted for the construction phase of the project. However, it is anticipated that the impacts would be negligible because dust suppression measures would be utilized and the areal extent of the affected areas would be small and tend to be localized in the vicinity of the disturbance.

(e) Agriculture

(i) Land Disturbance

The mine is expected to expand during the life of the facility to an eventual size of 2330 ha, 63 percent of the land requirements of the entire project. A large portion of the mine area, 1814 ha, would affect leaseland currently used predominantly for cattle grazing. Loss of leased land would affect five farm units with percent losses ranging from negligible to 33 percent (Farm Unit-7). Four hundred and ninety-seven ha of deeded land would be disturbed, affecting principally Farm Unit 6 which includes 11 ha of irrigated land. The mine would incorporate approximately 18 ha of permit land located in the McLean Lake A Unit.

Land requirements of the entire project were presented in Table 3.3-6 as they related to individual Farm Units and agricultural land tenures. The contribution of mine development to the total land disturbance incurred from the complete project is substantial. With reference to both deeded and leased property, mine requirements represent 90 percent of the area alienated from Farm Unit 6. Mine land disturbance also accounts for 90 percent of the alienated leased area of Farm Unit 4, 69 percent of that of Farm Unit 5, and 93 percent of that of Farm Unit 7.

Mine land requirements include 1675 ha of Agricultural Land Reserve, representing 3 percent of that designated within the Local Study Area and 81 percent of that alienated by the entire project.

Effects of project land disturbance on projected agricultural uses were summarized in Table 3.3-5. The scenario of agricultural activities projected for the site area without project development, assumes an approximate doubline of the area placed under irrigation. The entire project would preempt 273 ha of land that would otherwise be irrigated if the project were not instigated. Fifty-one percent, 138 ha, of these would be attributable to land required for the mine. In terms of the effect of project land disturbance on probable use of agricultural resources the mine component represents the greatest source of impact.

In addition to irrigated land the proposed mine would also preempt 2186 ha of projected deeded and leased grazing land. Approximately 926 ha of this are grazed during the spring, while the remaining 1243 ha are considered summer range. The vegetation associations utilized during the spring currently exhibit carrying capacities of 2 to 2.4 ha/AUM. If re-seeding programmes are implemented and carrying capacities improve to 1.23 to 0.62 ha/AUM, as projected, then loss of 926 ha could represent a reduction in projected spring cattle numbers of 550 AU. Summer range productivities are not projected to improve. Removal of 1260 ha of summer range from grazing use lessens summer support by approximately 65 AU.

Total land requirements for the entire project are likely to reduce productivity of Farm Units 5, 6, 7 and 8, while not appreciably affecting Units 1, 2, 3, 4 or 11. The consequential reduction of beef production in the Hat Creek Valley over a 20 year period has been estimated at approximately 6 percent or 200 animal units. This assumes air quality effects as described in Section 3.1, and efficient use of project-related lands available for agricultural activities.

3.3 LAND RESOURCES - (Cont'd)

(ii) Dust

The potential impact of dust from mine activities cannot be quantified. The soils of the site vicinity promote dust formation. Through employment of dust suppression measures, however, this impact can be greatly reduced.

(f) Cultural Heritage Resources

The ground disturbing activities of the construction of the surface mine, hardly to be separated from the actual operation of the mine, would have the greatest impact of all project activities upon the cultural heritage resources contained within Stratum I as defined in the Phase II survey. Approximately 147 sites are projected to be contained within Stratum I. The mine is likely to obliterate the in-situ heritage resources and where significant finds have been identified appropriate mitigation would be implemented.

Where the surface within Stratum I is excavated to reach the underlying coal there will be a potential impact in the form of disruption of cultural context and loss of artifactual material unless complete survey and appropriate mitigation has occurred beforehand. Professional examination should also be arranged for unexpected sites discovered during construction.

(g) Geology

Impacts to the geological resources from mine construction would be derived from developing and mining the initial coal supply for the plant and from developing and utilizing aggregate supplied from the upper Hat Creek Quarry (Fig.3.4-2, Part Three). The development and exploitation of these resources would be beneficial to the Province. The amount of coal mined in this phase would be small in comparison to the operational phase. The amount of aggregate utilized would be small in relation to the regionally available supply.

3.3.3 Offsite Facilities

The assessment of the effects on the land resources from construction of the offsite facilities was based on the assumption that all offsite facilities are to be completely constructed in this phase and ready to be utilized during the operation phase. No sequential preparation of sites was assumed. Construction activity was considered to be restricted to the immediate vicinity of each facility and an appropriate buffer zone has been included in the estimates. Facility components associated with offsite construction include the main access road, airstrip, airstrip access road and a general grouping of the remaining facilities. The general group, selected by the detailed consultants,[1] consists of the makeup water pipeline, the 69 kV transmission lines, the intake structure and associated pump stations and other minor facility components.

(a) Physical Environment

Landforms would be largely unaffected by construction of offsite facilities. Some minor changes would occur during construction of the access road, however, the effects would be minimal. Construction of approach and departure zones for the proposed airstrip will involve grading the crown of one small hill to the north of the proposed runway (between Lone Star and Cornwall Creeks) and one to the south of the proposed runway. The portions to be removed are minimal, and the resultant impact on landforms would be insignificant.

A large number of the soil units identified as occurring within the project area are affected by the main access road and the other offsite facilities. Although construction of the proposed facilities would disturb a large number of units, only a few units are affected to any great areal extent.

The soil units, area disturbed, and sensitivity ratings for each of the soils affected by offsite facilities are presented in Table 3.3-10. The total area of soils disturbed during construction is approximately 324 ha. The soil units with the large areas disturbed by the main access road are units 38 and 47, and the areas occupied are 16.2 and 15.0 ha respectively. The overall sensitivity of unit 38 is moderate and of unit 47 is low. Thus, impacts to these two units would be considered minimal. Units 19, 20A and 25 have high overall sensitivity ratings due to high susceptibility to dusting and alkalinity-salinity problems. However, the land area affected by these units (2.4, 5.7 and 3.6 ha) is relatively small, and the disturbances should result in a minimal impact.

The soil units with the largest areas disturbed by airstrip construction are units 25 and 27, with areas of 13.8 and 16.2 ha respectively. Unit 25 is rated as high in overall sensitivity, while unit 27 is rated as medium. The high rating assigned to unit 25 is a result of high susceptibility to dusting and alkalinity-salinity problems. The impact from loss of this unit is considered to be minimal due to the small area disturbed, even in light of the high sensitivity rating. Impacts resulting from disturbance to other units are judged to be insignificant.

Soil units with large areas disturbed by the other offsite facilities (Table 3.3-10) are units 4, 19, 25, 27, 36, 38, 47, and TL with areas of 11.5, 14.9, 22.6, 17.0, 10.4, 26.9, 18.6, and 15.7 ha respectively. Only units 19 and 25 were assigned high overall sensitivity ratings. Disturbing these units would have a great impact. Impacts from disturbance to other units should be minimal.

In terms of the overall sensitivities and the land areas disturbed, construction of the offsite facilities would result in a greater impact to soils than construction of the plant but a lesser impact than construction of the mine and related facilities.

(b) Natural Vegetation

(1) Direct Vegetation Losses

Construction of the offsite facilities would disturb portions of 13 vegetation associations found within 25 km of the proposed development (project locale). The area disturbed and sensitivity rating for each vegetation association are summarized by facility component in Table 3.3-11.

The associations with large areas disturbed are Big Sage - Bunchgrass (120.1 ha), Douglas-fir - Bunchgrass - Pinegrass (66.5 ha), Douglas-fir - Pinegrass (63.0 ha), and Kentucky Bluegrass (28.7 ha). The proposed airstrip (46.6 ha), 69 kV lines (36.0 ha), and access roads (23.0 ha) combined make up a large percentage of the area disturbed in the Big Sage - Bunchgrass Association. A large area of the Douglas-fir - Bunchgrass - Pinegrass Association would be disturbed by the Hat Creek diversion canal (23.8 ha) and the main access road (33.7 ha). The main access road and makeup water pipeline would disturb 39.3 and 16.9 ha, respectively, of the Douglas-fir - Pinegrass Association. The main access road (25.0 ha) makes up a large percentage of the disturbed area in the Kentucky Bluegrass Association.

On the basis of the total area disturbed within each association, the Big Sage - Bunchgrass Association should have the greatest impact from construction, followed by the Douglas-fir - Bunchgrass - Pinegrass, Douglas-fir - Pinegrass, and Kentucky Bluegrass in order of decreasing impact. The Big Sage - Bunchgrass, Douglas-fir - Pinegrass, and Kentucky Bluegrass Associations have been rated as low in overall sensitivity. The Douglas-fir - Bunchgrass - Pinegrass has been rated as moderate. On the basis of the sensitivity ratings the Douglas-fir - Bunchgrass - Pinegrass Association should experience the greatest impact. The Riparian Association has a high sensitivity rating, but a relatively small area of disturbance (12.5 ha). A large percentage of the area disturbed in this association is due to construction of the pit rim reservoir.

The impact identified for the Big Sage - Bunchgrass Association is not significant, since the area disturbed during offsite construction is only 0.6 percent of the total area of this association as found within the project locale. In a similar manner, the impact on the Douglas-fir - Bunchgrass - Pinegrass Association is not considered to be significant, because the area disturbed would only reduce the area of this association within the project locale by 0.5 percent. This small percent reduction is a strong enough factor to negate the moderate sensitivity rating. Impacts to the Kentucky Bluegrass Association should also be negligible due to the low sensitivity rating and the small percentage (0.7) of land disturbed in relation to the total area found within the project locale.

The only association considered to have a significant impact is the Saline Depression. It has been rated as moderate in overall sensitivity with only a small area affected. However, the area constitutes 10 percent of the total area of this association found within the project locale and on this basis, the impact is judged to be significant. Other associations which could have a significant impact, but to a lesser degree than the Saline Depression, are the Riparian, Cultivated Fields, and Bunchgrass - Kentucky Bluegrass/Saline Depression complex. The areas within the project locale will be reduced by 1.7, 1.9 and 3.6 percent for the Riparian Association, Cultivated Fields, and Bunchgrass - Kentucky Bluegrass/Saline Depression complex, respectively. These percentages are typically 2-3 times greater than the largest reduction percentage for the other associations affected.

(ii) Air Emissions

Dust emissions from the construction of offsite facilities may be a potential problem, expecially during the typically dry summer months. The accumulation of dust on vegetation, particularly those with pubescent leaves, has been demonstrated to be the causal agent producing reduced photosynthetic activity. Impacts to the vegetation would result primarily from reductions in productivity. The significance of these impacts can not be assessed, since the dust emissions generated by offsite construction have not been predicted. However, should there be an impact due to dusting, it would be localized in the construction area and would be small in comparison to the impacts resulting from the direct disturbance of vegetation.

(iii) Indirect Factors

The major indirect factor, which could affect the vegetation during construction of the offsite facilities, is the interference with the movement of near surface seepage water. The Saline Depression and Willow - Sedge Bog are the only two associations found in the project locale, which are critically dependent on this seepage water as a nutrient and moisture supply. However, the Saline Depression is the only one, which could be affected by offsite construction. It is found in the vicinity of the proposed airstrip.

The facilities grouped under the other offsite facilities category, which could have an effect on the seepage water, include the main access road, Hat Creek diversion canal, Finney Creek diversion canal, power plant access road and the coal conveyors. The extent of the effects from construction of these facilities is difficult to assess until the nature and location of seepage areas have been identified.

The Saline Depression Association, as described previously, is critically dependent upon seepage water. The potential for an adverse impact on this association exists, since it occurs in the area where construction could potentially interfere with seepage water flow, and to complicate matters an impact is also anticipated from direct disturbance.

(c) Wildlife

Because a number of offsite facility locations are not known and relatively little wildlife data were collected from offsite facility locations, these structures are treated collectively and in general terms. The habitat occupied by each offsite facility, however, has been computed and provides the basis for impact assessment (Table 3.3-12).

(i) Habitat Loss

Offsite facilities would result in a loss of about 356.5 ha (Table 3.3-12). Big Sage, Low Elevation Grasslands, and Douglas-fir-Pinegrass habitats are the most important habitats affected. The Big Sage Habitat is important deer and ungulate habitat. The narrow configuration of most offsite facilities plus the fact that the construction effects

3.3 LAND RESOURCES - (Cont'd)

would be temporary lead to the conclusion that ungulates and upland big game would be little affected by offsite facility construction. Migratory waterfowl may use the reservoir for staging and resting. The long term effects on waterfowl breeding are uncertain.

Transmission line facilities construction would involve minimal impact except where woodlands occur in the right-of-way. Pipeline construction will require excavation of narrow strips of land. Habitats in early successional stages would be minimally affected. More mature habitats will be lost on a long term basis because maintenance requirements will dictate early successional stage habitat replacement. Access roads, the airstrip, pumping stations, railroad offloading areas, etc. would result in permanent habitat losses.

(ii) Human Disturbance

Relatively little additional human disturbances to wildlife is expected from the construction of offsite facilities.

(d) Forestry

(i) Direct Loss

Construction of the offsite facilities would disturb 160.7 ha of productive forest land. Seven coniferous and three deciduous species were identified as occurring on the forest land disturbed by construction activities. A total of 10 148 m^3 of merchantable volume from these species exists on the lands disturbed by construction. Eighty-five percent of the volume is Douglas-fir. The remaining 15 percent is distributed among lodgepole pine, ponderosa pine, deciduous trees and spruce (in descending order of total volume).

The site class breakdown, based on the predominant forest growth type, Douglas-fir, is 2.4 percent good, 27.8 percent medium, and 69.9 percent poor. The mean annual increment (MAI) for the good, medium and poor sites is 3.6, 1.7 and 1.0 m^3/ha, respectively. These translate into a total annual increment of 14, 75, and 110 m^3 for the good, medium and poor sites, respectively.

Construction of the offsite facilities would result in the physical loss of land available for the growth of forest species. As a result, it is anticipated that there would be an impact to the forest resources. This impact should be minimal, since the area disturbed is predominantly (69.8 percent) poor site class. The areas with good, medium and poor growing sites as found within the project locale would only be reduced by 0.2, 0.13 and 0.12 percent, respectively, as a result of offsite facilities construction. In a similar manner, the total annual increment of sites, rated good, which would be lost due to offsite facility construction, is only 0.2 percent of the total annual increment for the good rated sites within the project locale. Sites rated as medium and poor are only 0.1 percent of the project locale total. Construction should also have a negligible impact on the forest industries within the project locale, since the loss of AAC represents but a small percentage of the regional totals. It is also assumed that the timber on the land disturbed by construction of offsite facilities would be logged and removed as part of the regular forest management programme and quota allocation.

(ii) Air Emissions

Dust emitted during construction activities may accumulate on leaves of forest species occurring within the immediate vicinity of construction activities. These dust accumulations may cause the leaves to overheat during sunny periods and thereby cause premature needle death. Dust accumulations have also been found to enhance the susceptibility of conifers to black pineleaf scale, which have reportedly attached small stands of ponderosa pine in the vicinity of Lytton.

The magnitude of the impacts resulting from dust accumulations can not be assessed, since the dust emissions generated by construction have not been predicted. However, it is anticipated that the impacts would be negligible, because dust suppression measures would be utilized, the extent of the areas affected is small and the effects to be restricted to the immediate area of the disturbance.

(e) Agriculture

Offsite facilities require 324 ha of land. Twenty-four ha are deeded irrigated lands, 109 ha are deeded non-irrigated lands, 153 are leased and 38 are located on Crown permit units. Compared to other components, offsite system land requirements are relatively minor and are best evaluated as part of the entire projects' impact. A principal effect of offsite facilities is utilization of 103 ha of land projected to be irrigated (24 ha of which are presently irrigated) assuming no project development.

(f) Cultural Heritage Resources

Offsite construction and the ancillary service roads may have a severe impact on any cultural heritage resources that are present. Offsite areas should be examined professionally prior to construction. If construction has adverse impacts on these resources of a significant nature they should be mitigated accordingly.

The Hat Creek diversion area and the diversion reservoir have been subjected to preliminary examination. The diversion reservoir, corresponding to Stratum K of the Phase II survey, is estimated to contain 6 sites although others, buried or overlooked in survey, may, of course, be present.

Roads built for offsite facilities may provide access to previously undisturbed areas and there may be increased danger to vandalism to any cultural heritage resource adjacent to these roads. The magnitude of this indirect impact cannot be estimated.

3.3 LAND RESOURCES - (Cont'd)

(g) Geology

Operation of the water pipeline may restrict access to the aggregate deposits at Boston Flats. However, abundant aggregate is found throughout the project area so the impact is considered minor.

The construction of offsite facilities, expecially the access road, would require part of the aggregate found in the project area. Because aggregate deposits are common in the area and the aggregate could be stockpiled for later retrieval, this is considered to be a minor impact.

3.3.4 Biophysical Analysis

The biophysical analysis was used to assess the impacts from construction of the plant, mine and offsite facilities on the land resources of the project site. The impact assessments presented in Sections 1-3 (Part Four, Chapter 3.0) have addressed the land resources as separate entities, while the biophysical analysis incorporates possible interrelationships or interactions between each of the land resources and assesses impacts on the basis of an integrated approach. The assessments presented in this section are responsive to the direct loss of resources. Facilities are treated as complete entities and components are grouped under general headings of plant, mine and offsite facilities.

A total of 46 biophysical subunits, which had been assigned either a high physical and biological sensitivity or high integrated resource capability rating, were identified as being affected by construction of the plant, mine and offsite facilities. The biophysical subunits, areas affected by plant, mine and offsite facilities, occurrence in project area, primary and secondary land use practices and sensitivity ratings are presented in Table 3.3-13.

Impacts to two units, 2ABL1.17 and 2TG.7, with large areas disturbed by plant construction (Table 3.3-12) are considered to be negligible due to the moderate physical and biological feature sensitivity rating and the low integrated resource capability rating. Twelve subunits have large areas (greater than 50 ha) affected by construction of the mine and associated facility components. Three subunits, 1AE.19, 2TE1.19 and 3TE1.17 would exhibit a significant impact from construction of the mine due to the high physical and biological features sensitivity rating and high integrated resource capability rating (Table 3.3-13). Two of these three subunits (1AE.19 and 2TE1.19) are found in the north end of the Hat Creek Valley and the third (3TE1.17) within Houth Meadows. The other units, which could also have adverse impacts, although less severe than those previously discussed, are 1AE.10, 2TDB1.8, and 2TDB1.19. All three of these subunits are located in the north end of the upper Hat Creek Valley. Each of these subunits have been assigned one high and one moderate rating for either the physical and biological features or integrated resource capability. Other subunits with large areas affected but with a less significant impact than the other two groups of subunits discussed previously are 3CE1.10, 3CG1+2.24, 3TBL1.17, 3TDB.17 and 3TE1.10. The impacts to each of these units should be moderate, since they have been assigned one high and one low sensitivity rating (Table 3.3-13). Subunit 3CE1.10 is located on the steep slopes of lower Medicine Creek, 3CG1+2.24 on the steep slopes above Houth Meadows, 3TBL1.17 in the lower Medicine Creek Valley, 3TDB.17 in the lower reaches of Medicine Creek Valley and 3TE1.10 southeast of the confluence of Medicine and Hat Creeks.

Construction of the offsite facilities would only disturb a large area (>50 ha) of one subunit, 1BGS1+3.21 (Table 3.3-13). This subunit is found in the middle reaches of upper Hat Creek Valley. Subunit 1BGS1+3.21 has been assigned a moderate physical and biological features sensitivity rating and a high integrated resource capability rating. On the basis of these ratings, it is anticipated that the impact to this subunit would be minimal. Two other subunits, 2TB1.31 and 3TDB.23 have 32.19 and 32.22 ha disturbed, respectively. Subunit 2TB1.31 is found in the Thompson River Valley and subunit 3TDB.23 along upper Hat Creek between McDonald and Anderson Creeks.

Several trends are evident in the results of the biophysical analysis. Most of the high integrated resource capabilities are associated with biophysical subunits found on slopes of 0 to 9 percent. These high integrated resource capabilities are a result of the high agricultural capability and importance value ratings assigned 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 (Table 3.3-13). Physical and biological sensitivities for these subunits are moderate with a number of subunits possessing high alkalinity and salinity problems. Biophysical subunits 1BRL1+3.13 and 1BRL1+3.29 within the above group were the only two subunits rated as having a moderate level of resource integration because of their high wildlife capability.

Biophysical subunits 2AB1.31 through 2TGL.10 exhibit a more diverse trend in possible resource uses. In general, agriculture is the primary use, although forestry and grazing frequently replace agriculture as the primary use in about 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.

Biophysical subunits 3AE2.24 through 3THL.17 pose the greatest limitations to development (Table 3.3-13). Most of these biophysical subunits have high sensitivities while the others 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 resources uses on the above biophysical subunits. The Wetland - Bog biophysical subunit has a high physical and biological sensitivity, but a low integrated resource capability with wildlife as the primary use.

3.4 SOCIO-ECONOMICS

3.4.1 Labour Force, Population and Income

(a) Labour Force and Employment

(i) Direct Project Employment

Total direct employment requirements for the Hat Creek Project are listed in Table 3.4-1. The construction phase for the powerplant was proposed to begin in 1978 and continue through 1986 with peak labour requirements occurring during 1982 and 1983. The construction phase for the offsites as compared with the powerplant was expected to begin in 1978 and continue through 1986. The construction phase for the mine, as compared with the plant and offsites, involves construction-type activities past 2010. About 9400 man-years of labour are expected for plant construction, 9800 man-years for mine construction, and 1200 man-years for offsite construction. Construction activities are anticipated to involve one shift working a 7 1/2 hour day, 5 d/wk.

Labour requirements by trade skill classes for the plant and mine are included in Table 3.4-2. The early plant construction years would require inputs primarily from the general labourers, operating engineers, carpenters, and electrical workers while the peak and wind down periods would emphasize the inputs of plumbers, pipefitters, iron workers, electrical workers and boilermakers. The major trades in terms of numbers required for mine construction would be operating engineers, machinists/millwrights, and general labourers. Skills required for offsite construction include general earth moving and light construction skills with the exception of the water pipeline which would require more technical skills.

(ii) Regional Labour Force Participation in Direct Employment

The powerplant as well as the other project components would be constructed basically by a union labour force. Because it is likely that the British Columbia construction unions might experience relatively high levels of unemployment in the near future, job openings for local residents who are not union members are expected to be limited. The number of persons from the region in many trade categories of the unionized construction labour force is insufficient to meet the project's labour requirements. The effective regional supply of construction workers is tabulated in Table 3.4-3. Other projects are likely to compete with Hat Creek in terms of meeting their labour requirements from the regional labour pool. Construction supervisory and engineering personnel would most likely be obtained from outside the region. Given the above limitations and recognizing the opportunities for some of the currently unemployed and for new regional entrants to the labour force, Table 3.4-4 provides an estimate of direct local and regional participation for the total project.

Over the construction period, regional residents are likely to obtain about 11 200 man-years of employment directly on the project; local residents are expected to obtain about 2100 man-years of work.

3.4 SOCIO-ECONOMICS - (Cont'd)

(iii) Indirect and Induced Employment

Indirect employment arising from project expenditures on goods and services supplied within the Region would increase regional employment. These expenditures would probably include earth-moving equipment, trucks, small tools and consumables, including camp catering supplies. The local study area would not provide a significant amount of these requirements and Kamloops is the only community in the region capable of doing so. Limited regional purchases outside Kamloops might include lumber from Clinton or Savona and bulk fuels from Ashcroft. Incremental employment associated with these local area purchases would be minor.

The purchase of small tools and consumables from a distribution centre such as Kamloops would account for about 4 percent of the contract price for construction of the thermal plant.[2] If 50 percent of these items were purchased in Kamloops, an additional $20 million in sales would be generated during the plant construction period.

On the assumption that 40 percent of the equipment, materials and supplies came from Kamloops, the mining operation would spend about $5.5 million annually by 1985. This amount would increase to about $16.5 million, in 1976 dollar terms, by the year 2000.

The provision of catering supplies for the construction camps is an activity in which Kamloops could play an important role. Through discussions with industrial caterers, it has been estimated that about 25 percent of the pertinent supplies required for the camps could be supplied from Kamloops. Over the life of the construction camps their expenditures would contribute about $15 million to the Kamloops economy.

In total, then, it might be expected that the Hat Creek Project could increase industrial sales in the region, primarily in Kamloops, by about $435 million, in 1976 dollars, over the Project life. These increased sales would approximate an incremental 1200 man-years of indirect employment, averaging 35 persons per year, assuming wages constitute 4 percent of wholesale sales at an average salary of 15 000/yr.

Induced employment likely to occur in the Region as a result of the Hat Creek Project can be found in Table 3.4-5. Although most of this employment will be generated in the local study area, Kamloops would also share in the employment growth. The induced effects of direct construction workers are assumed to occur largely in Ashcroft and Cache Creek.

(iv) Regional Participation in Indirect and Induced Employment

Estimated local participation in indirect and induced employment is shown in Table 3.4-6. It was assumed that 30 percent of the employment positions created in the local study area will be obtained by local area residents. In Kamloops, it has been assumed that 60 percent of the service jobs would be obtained by Kamloop's area residents.

3.4 SOCIO-ECONOMICS - (Cont'd)

(v) Labour Supply for Other Regional Industries

The employment opportunities created by the Hat Creek Project would result in some persons job switching in spite of constraints to switching and incentives for staying in currently held positions in the region. The most likely regional sectors to experience personnel losses would be mining, transportation, forestry, local construction and pulp milling. Major problems would arise if extensive switching occurs in the heavy mechanical, electrical, machining and stationary engineering trades. Although the powerplant would result in heavy demands for steam engineers that cannot be provided by the existing B.C. Hydro unions, the mine would pose a potential threat to employers wanting to retain their mechanics, electricians, machinists and millwrights. In particular, higher turnover rates for Bethlehem Copper might occur because of uncertainties over the future of the Bethlehem property and the advantage of shorter travel distance on superior road conditions for Bethlehem Copper employees in Ashcroft and Cache Creek.

It is unlikely that many employees of machines, industrial repair and auto mechanic shops would be drawn to the Hat Creek mine.

(b) Population

(i) Population Growth

The increase in population associated with the project would be determined by the number of in-migrating employees, their marital status and dependents. The expected in-migrant population associated with direct, indirect and induced employment positions is shown by area of domicile in Table 3.4-7.

Most of the in-migrant direct employees, during the construction phase, would occupy single status construction camps proposed for the Hat Creek Valley. The remainder would reside in the nearby communities as well as in the rural areas. During the construction phase, the following considerations would affect the accommodation decisions of workers: 1. length of employment; 2. living-out allowance; 3. availability of housing; 4. project work schedule; 5. proximity of the jobsite to workers' current residences; 6. worker status and family influence. All workers interested in single status accommodation would be provided free room and board in a construction camp. Union members, currently residing outside the local area, but within the total region, would likely live in the camps or possibly commute to the jobsite; members residing outside the region, are expected to commute on a weekly or bi-weekly basis. It is expected that most of the supervisory and engineering staff would reside in the communities seeking family accomodation. In-migrants seeking community residence would probably be 95 percent married and this group would average 2.6 dependents.[1] Indirect and induced employees are expected to have similar marital and demographic characteristics to the direct operating employees.

Total local population changes with and without the project are shown in Table 3.4-8.

3.4 SOCIO-ECONOMICS - (Cont'd)

(ii) Settlement Patterns of Incremental Population in the Local Study Area

The alternative places of residence within the local study area include: 1. Ashcroft/Cache Creek; 2. Clinton; 3. Lillooet; and 4. Rural areas. The spatial distribution of residence would be influenced by: 1. commuting time and expense; 2. housing costs and availability by type; 3. property tax levels and utility rates; 4. natural features of a community; and 5. lifestyle preference. The Socio-economic Report[1] provides a comparative evaluation of the communities based on the above factors to which the reader is referred for details. For the purposes of projecting population the estimated percent of incremental population in Ashcroft/Cache Creek, Clinton, Lillooet, and rural areas are 80, 15, 0 and 5 respectively.

In order to assess the effects of population changes, two settlement scenarios have been constructed for Ashcroft and Cache Creek. Scenario 1 assumes that 70 percent of the designated Ashcroft/Cache Creek population would settle in Ashcroft and 30 percent in Cache Creek. Scenario 2 reverses this distribution. The population projections with and without the project are shown in Table 3.4-9.

(iii) Socio-cultural Characteristics of the Incremental Population

The characteristics of the incoming construction workforce encompass age, sex, marital status, family size and mobility. It is assumed that these characteristics would differ only slightly from those of workforces that have been employed on other B.C. Hydro projects; e.g. Mica Creek Dam and the Seven Mile Project.

The age distribution of these previous B.C. Hydro workforces indicates a larger proportion of older workers. Nearly one-third are aged 34 years or less, one-third age 35-44 years and one-third 45 years or more. Nearly 95 percent of the workers were employed on previous B.C. Hydro construction projects, one half of these on three or more projects. Although the current B.C. Hydro construction workers are very mobile as identified in the Labour Force Analysis of the Seven Mile Project, their families are not as mobile. It is estimated that approximately 15 percent of the workers would seek accommodation in the towns while the majority would live in the construction camps. Therefore, an older workforce is anticipated for Hat Creek with 9 percent of the workforce between 16 and 24 years of age; 54 percent between 25 and 44 years of age; and 37 percent from 45 years of age and older.

Three-quarters of the construction workers are anticipated to be married with an average family size of 3.4 and average of 1.4 children. Of the married workers who would bring their families to the study area, over one-third would have no children and slightly less than one-half would have one or two children.

Characteristics of the incoming population combined with the existing population in the study area communities "without the project" are discussed in the Socio-economic Report[1] to which the reader is referred for details.

3.4 SOCIO-ECONOMICS - (Cont'd)

(c) Income

(i) Direct Net Income

Direct income is defined as wages and salaries paid directly to the project workforce. Annual income estimates are derived from union wage rates selected from 1975 Columbia Hydro Constructors contracts, updated to 1976 and assuming a 37.5 hour work-week for 52 wk/yr.[3] As shown in Table 3.4-10, total direct net income gains are estimated at $239 million, in 1976 dollars, throughout the construction phase. About 55 percent of the total would accrue to regional residents. The gross income figures are adjusted for foregone opportunities from Unemployment Insurance Commission benefits as well as job switching. The direct income gains of regional in-migrants, also in Table 3.4-10, are expected to account for 40 percent of the direct regional income total. In-migrants residing in the construction camps are expected to spend about 10 percent of their earnings in the region. This amount, as indicated in Table 3.4-10, has been included in the direct income estimates.

Table 3.4-10 also itemizes the direct net income gain in the local area. The local study area would share a substantial portion of direct regional income gains, primarily in the form of in-migrant resident income and camp resident spending.

(ii) Indirect and Induced Income

Indirect and induced regional income[1] estimates for the construction phase are shown in Table 3.4-11. The total project expenditures expected to occur in the region are approximately $140 million. The regional value added associated with these sales is expected to be about $4.8 million.[1] Induced income is expected to total around $122 million in the Region, $46.9 million of which would benefit the local study area. Total regional income benefits are estimated at $366 million with the local study area obtaining about $236 million.

3.4.2 Land Use

(a) Introduction

This section is only concerned with land use impacts that are likely to occur in the municipalities of Ashcroft, Cache Creek, and Clinton. An evaluation of the availability of land to accommodate the projected space requirements for new development is undertaken in order to understand impacts associated with land use changes. Land use impacts in areas other than the municipalities are covered in various subsections of this report.

(b) Space Requirements and Land Availability

In the Village of Ashcroft, space requirements for residential development attributable to the project are estimated to vary between approximately 18 ha and 40 ha for population settlement, scenarios 2 and 1 respectively. Delays or time lags may be experienced however in Ashcroft and Cache Creek in the process of converting vacant land into serviced residential land. The central business district is expected to expand further as a result of the project and a shopping center might be built. If a shopping center is constructed, 2 to 3 ha would be required as opposed to 0.8 or 1.2 ha without it. Also, less than 12 ha would be required for expansion in the light industrial and service commercial sector with the project. Although additional acreage would be required to accommodate residential, commercial and industrial expansion, an adequate supply of land would be available when needed.

With respect to residential space requirements in Cache Creek attributable to the project, approximately 18 ha and 40 ha would be needed under population settlement scenario 1 and 2, respectively. Given the assumption that new commercial development would be evenly distributed between Cache Creek and Ashcroft, about 2 to 3 ha of land are expected "with" the project as opposed to 0.3 or 0.4 ha "without" the project. If serviced land is available, up to 40 ha of land may be required for new business established to provide services related to the project. Given the projected space requirement of a maximum of 51 ha in relation to approximately 109 ha suitable for residential development, an adequate supply of land is evident. Preliminary planning in the village has identified vacant sites for potential shopping centers and has provided for further general commercial development through redevelopment of older and presently mixed use areas. Cache Creek has submitted a boundary extension application to provide for light industrial or service commercial development.

Space requirements in Clinton for residential development attributable to the project are expected to be about 12 ha. If development occurred at densities consistent with existing patterns, total residential space requirements with the project would be about 30 ha, of which 18 ha would be accounted for by the project. Less than 2 ha would be required for general commercial development and less than 4 ha for light industrial and service commercial development in Clinton. The available land suitable for residential development as well as commercial development is adequate in Clinton. Several areas just outside Clinton's municipal boundaries can be made available for light industrial and service commercial development commensurate with demand.

3.4.3 Housing

(a) Introduction

A separate housing market analysis has been carried out for Ashcroft, Cache Creek and Clinton covering demand and supply factors with and without the project. Demand for new housing is examined in terms of the quantity (number) of dwelling units required and the associated housing type units needed. On the supply side, factors considered include: 1. availability of developable land; 2. output capabilities of the construction industry; and 3. municipal land development policies. For the purposes of this report, supply and demand considerations related to housing quantities and type by municipality will be discussed. The reader is referred to the Socio-economic Report for details and topics not discussed here.[1]

(b) Quantity of Housing Units

In Ashcroft and Cache Creek, two projections, one for each settlement scenario, have been undertaken to estimate housing demand. An average household size of 3.4 is used for transforming projected population increases into projected increases in the number of households for Ashcroft, Cache Creek and Clinton.

In Ashcroft, approximately 625 households of the estimated increase of 900 households under Scenario 1 are attributable to the project. Following 1990, increases attributable to the project are expected to be only about 15 housing units. Under Scenario 2, approximately 270 households are attributable to the project and, similar to Scenario 1, the housing formation is concentrated in the time period from 1978 to 1984. Table 3.4-12 provides data on projected increases in housing units associated with both scenarios for Ashcroft.

The estimates of housing units that would be required in Cache Creek under Scenario 1 and 2 are outlined in Table 3.4-13. Under Scenario 1, approximately 265 households out of the estimated increase of 415 households are attributable to the project. With respect to Scenario 2, approximately 625 out of 775 households are attributable to the project. Similar to Ashcroft, household formation is prominent from 1978 to 1984. Following 1990, increases accounted for by the project are expected to be few in number.

Table 3.4-13 also contains estimates of the housing units that would be required in Clinton. The project would account for about 170 out of the total estimated increase of 270 households to 1990. The probable demand both with and without the project is expected to be concentrated in the time period from 1980 to 1984; increases after 1984 are anticipated to be insignificant.

(c) Housing Types

The demand for housing types can be explained by such variables as ability to pay, demographic characteristics, and lifestyle preferences. An analysis of these considerations as well as empirical data from the 1971 Census[4] on the distribution of housing types for Sparwood, Grande Cache and Logan Lake provided the basis for projecting the mix of new housing stimulated by the Hat Creek Project. The housing types comprise: 1. single and two family; 2. townhouses, rowhouses; 3. apartments; and 4. mobile homes. The projected percentage distributions and number of units required for Ashcroft, Cache Creek and Clinton to 1990 are shown in Table 3.4-14.

(d) Housing Supply Concerns

In Ashcroft, it is likely that during the period of high housing demand immediately following project commencement, that there would be some time lags or delays in the supply process. Any delay in the process which could give rise to a temporary housing shortage would be much more pronounced under Scenario 1 than under Scenario 2. The general concerns stated above apply to Cache Creek as well. However, any delays in the housing supply process are likely, particularly under Scenario 2, during the first 4 years after project initiation. With respect to Clinton, it is likely that twice the number of housing units projected with the project could be supplied without any delays. During the first 4 years after project start-up, this would represent an increase from 125 to 250 additional housing units.

3.4.4 Services

(a) Introduction

The impacts of the project on public services are described by identifying the differences between the level of services "with" and "without" the Hat Creek Project. On the basis of current government standards for building and staff requirements and the 1976 data pertaining to each service system, service projections from 1977 to 1990 are made using population forecasts for the study area with the Hat Creek Project. These projections of service requirements consist of facility, staff and land requirements, operating and capital costs. The service projections assume that a service would be in place and ready for operation the year that the population reaches the size required to meet the government standards.

(b) Education

(i) Elementary Education

The forecasts of elementary school enrollments for the 1976-1990 with and without the project for Ashcroft, Cache Creek and Clinton are shown in Figures 3.4-1 and 3.4-2. In the three communities, there is expected to be a substantial increase in enrollment as a result of the proposed Project. With the project, enrollment is estimated at 1945 students in 1990, a 116 percent increase from the 1976-77 academic year enrollment and a 77 percent growth in enrollment in the study area by 1990 over that projected "without" the project.

The largest additions take place in Ashcroft's elementary schools in Scenario 1 where a 171 percent enrollment increase is expected from 1976 to 1990. Under Scenario 2, Ashcroft's elementary enrollment would increase by 105 percent from 1976 to 1990. The elementary schools in Ashcroft presently have space for 89 additional students. It is very likely that with Scenario 1, a new elementary school facility would be needed and ready for occupancy before the 1983-84 academic year. Because three additional classrooms would be required without the project, the student population increase in Ashcroft related to the Hat Creek Project would require an additional 17 classrooms with Scenario 1 and 7 classrooms with Scenario 2. The additional teaching complement for Ashcroft's elementary school attributed to the project population would be 20 teachers for Scenario 1 and 11 for Scenario 2.

Cache Creek's growth in elementary school enrollment for Scenario 1 represents a 51 percent greater increase than that expected without the project, while the Scenario 2 increase is 155 percent larger than that forecasted without the project. With the project, the student population in Cache Creek would require 3 more classrooms for Scenario 1 and 12 more classrooms for Scenario 2. Also, with the project, 8 additional teachers out of 15 required for Scenario 1 and 19 teachers out of 26 required for Scenario 2 are a result of the project population.

Clinton's elementary school would have the smallest increase in enrollment of the three communities. From 1976-1990, the increase in enrollment would be 51 percent greater than that projected for Clinton without the project. The projections without the project indicated a need for 3 classrooms from 1981 to 1990 thus 6 extra classrooms would be required for the incremental Hat Creek population. The elementary school in Clinton would need 8 additional teachers from 1978 to 1990 with the Hat Creek Project which represents an increase of 5 teachers from that expected to be needed to 1990 without the project.

The additional capital costs of elementary education in Ashcroft, Cache Creek and Clinton up to 1990 with the project under Scenario 1 would exceed 1976 levels by $1,876,368; $30,867; and $20,790 respectively. Analogously, the additional capital costs under Scenario 2 are estimated at $31,563; $1,860,174; and $20,790 for Ashcroft, Cache Creek and Clinton, respectively. With respect to operating costs associated with elementary education in Ashcroft, the average yearly impact on operating costs would equal $435,424 under Scenario 1 with the Hat Creek Project and would equal $209,039 under Scenario 2 with the project. The average yearly impact on operating costs in Cache Creek under Scenario 1 would be $179,397 and under Scenario 2 would be $398,159 more than the costs without the project. The annual operating costs for Clinton's elementary education would increase from $323,330 in 1976 to $607,830 in 1990, with average annual operating costs of $501,739 for both scenarios. The average yearly impact on operating costs would increase by $110,684 with the project.

(ii) Secondary Education

With the Hat Creek Project, the secondary education enrollment in the service study area is expected to increase at a rate similar to that of the elementary enrollment increases. The secondary school in Ashcroft would have a 108 percent increase in enrollment from 1976 to 1990. The projections for this school would be the same for both Scenario 1 and Scenario 2. The secondary enrollment in Ashcroft with the project is 71 percent greater than the enrollment increase projected without the Hat Creek Project. These enrollment forecasts are shown on the graph in Figure 3.4-3.

With the enrollments forecasted with the project, the school will have reached its full capacity by the 1979-80 academic year. From 1979 to 1990, an additional 24 classrooms would be required based on 25 children per classroom. It might be possible that a smaller secondary school would be required in Ashcroft or Cache Creek by the mid-1980s.

The population attributable to the Hat Creek Project, would require 16 more classrooms than what the population increases without the project would need.

This secondary school would require 35 additional teachers from 1977 to 1990 with the project based on the 1976-1977 pupil/teacher ratio (PTR) of 19.1. Twenty-four teachers out of the 35 required would be attributable to the Hat Creek Project.

Clinton's junior secondary school is expected to have a 112 percent increase in student population from 1976 to 1990 with the project, 76 percent greater than that projected for the same time period without the project. The school would not reach its full capacity before 1990 and, therefore, in either case, does not require any additional classrooms.

Nine additional teachers would be needed for Clinton's junior secondary school from 1979 to 1990, with the Hat Creek Project. This total represents an increase of 6 teachers from that required by the enrollment increases without the project based on 1976-1977 PTR of 13.

In Ashcroft, the capital costs for secondary education up to 1990 with the project would be $131,198 more than the 1976 capital costs for both scenarios and $89 303 over the capital costs without the project.

Ashcroft's secondary education would have an increase in operating costs up to $1,869,490 in 1990 with the project for both scenarios. When compared to the situation "without" the project, the average yearly impact on operating costs would be $410,355.

With respect to secondary education in Clinton, the capital costs would not increase over the 1976 capital costs in either scenario, and there would be no impact on capital costs as a result of the project. The operating costs with the project would increase to $327,800 in 1990 which would represent an average yearly impact on operating costs of $71,023 when compared to costs without the project.

(iii) *Post-Secondary and Continuing Education*

By 1982 or 1983, some administrative space might be required in the study area for the post-secondary and continuing education programmes.

Although enrollment in post-secondary and continuing education is expected to be noticeably greater with the project than without the project, the existing public school facilities should provide adequate space. However there might be a need, for some administrative space, administrators, additional teachers and materials.

(c) Health

(i) Hospital

The Ashcroft hospital is expected to be able to serve the increased population with the project to 1990. However during the peak years of population increase from 1982 to 1984, the hospital may be operating at close to its capacity.

Staff additions would be necessary up to 1990 to handle any increases in hospital admissions. If it is assumed that the present hospital occupancy rate and the existing ratio of staff to patients remains constant up to 1990, the following staff might be needed at the Ashcroft hospital:

1978	1 to 5 additional staff
1979	1 to 5 additional staff
1980	1 to 5 additional staff
1981	5 to 10 additional staff
1982	5 to 10 additional staff
1983	1 to 5 additional staff
Possible Total	14 to 40 staff above the 1976 total of 49 staff

Based on experiences with other similar projects in B.C., it is unlikely that the construction workforce associated with the Hat Creek Project would have a significant impact on the hospital occupancy rate up to 1990. Most injuries that would take place at the mine site or the plant would be treated by first aid or by the employee's own doctor.

With respect to impacts on hospital facilities, forecasts of requirements remain the same both without and with the Hat Creek Project. No additional hospital facilities would be needed in either case. Depending on the trends in hospital utilization, it is likely that more staff would be required at the hospital with the project than without it.

(ii) Medical

If a ratio of one general practitioner for 1320 population[1] is maintained, a total of 9 physicians would be needed in the service study area up to 1990 "with" the Hat Creek Project, four of the doctors would be needed as a result of the project related population increase.

With Scenario 1, two of the additional physicians would be needed in Ashcroft, two in Cache Creek and one in Clinton. With Scenario 2, one of these doctors would be needed in Ashcroft, three in Cache Creek and one in Clinton.

Without the Hat Creek Project, it was projected that only one additional physician would be required in the service study area up to 1990.

Capital costs for medical services in the study area up to 1990 with the project would be $108,620 more than the 1976 capital costs. The annual operating costs for medical services in the study area would increase to $720,000 in 1990, with an average annual operating cost of $581,333.

In terms of operating costs, the impact of the project would be $108,620 for capital costs and an average yearly impact on operating costs of $208,000.

(iii) Dental

Based on the standard of one dentist for 2500 population in rural areas in B.C.,[5] a total of 4 dentists would be required in the service study area up to 1990 with the Hat Creek Project. One of the dentists might locate in Clinton, and the remaining 3 in Ashcroft and Cache Creek, with two locating in Ashcroft in Scenario 1 and two in Cache Creek in Scenario 2.

Using an upper estimate, the capital costs for dental services in the study area with the project up to 1990 would be $180,000 for rental offices and $280,000 in facilities built by the College of Dental Surgeons of B.C. The operating costs with the project would increase from $160,000 in 1977 to $320,000 in 1990, with average annual operating costs of $256,000.

The effect of the project on the costs of dental services would be a difference in capital costs of $90,000 for rental offices or $140,000 for facilities built by the College of Dental Surgeons of B.C., and an average yearly impact on operating costs of $106,667.

(iv) Public Health

Based on the standard of one public health nurse for 4000 population[6] and the recommendations of the Public Health Branch of the Ministry of Health,[7] two additional public health nurses would be needed in the Ashcroft Public Health office up to 1990 with the Hat Creek Project. As well, one additional home care nurse would be needed to provide home care services in Clinton. Space provided by the Ashcroft Public Health Office in a new rental facility should be sufficient to accommodate the staff increases up to 1990. During the initial stages of construction associated with the Hat Creek Project, additional public health inspections would be required at the construction camp sites.

Without the Hat Creek Project, the Ministry of Health has recommended that one additional public health nurse and one home care nurse would be needed in the service study area up to 1990.[7] The Hat Creek Project would result in one extra public health nurse being needed in the area up to 1990.

Operating costs would increase from $120,663 in 1976 to $215,475 in 1990, with average yearly operating costs of $199,733. The effect of the project would be to increase the average yearly operating costs by $12,495.

(v) Mental Health

At least one additional mental health worker would be required by 1982 with the Hat Creek Project and should be sufficient to meet the needs of the population up to 1990. The Hat Creek Project can account for one additional mental health worker over the forecasted requirements without the project.

The capital costs to establish mental health services in a rental facility in the study area would be $3000. The operating costs would increase from $27,375 in 1976 to $54,365 in 1990 and give average annual operating costs of $41,744. With the project there would be no impact on capital costs but there would be an average yearly impact on operating costs of $16,302.

(vi) Ambulance

One additional full-time employee is needed presently to operate the second ambulance located in Ashcroft. With the Hat Creek Project, 2 additional full-time employees and 2 more ambulances might be required in Ashcroft and Cache Creek before 1990 depending on the demonstrated need. One full-time employee might be required in Clinton if the ambulance unit there receives more than 100 calls per year.

When compared with the projected service requirements without the Hat Creek Project, the Ashcroft ambulance unit might require 2 more employees and 2 more ambulances as a result of the Hat Creek Project.

The capital costs for the Ashcroft/Cache Creek ambulance unit up to 1990 with the project would be $30,000 plus the 1976 capital costs. The annual operating costs would increase from $37,500 in 1976 to $169,050 in 1990, with average yearly operating costs of $121,327.

The effect of the project on the costs of the Ashcroft/Cache Creek unit would be to increase the capital costs $30,000 up to 1990. The average yearly impact on operating costs for that unit would be $49,427.

The costs of the Clinton ambulance unit are expected to be $15,000 in capital costs up to 1990 and $5500 in average annual operating costs from 1976 to 1990 with the project. The capital and operating costs are expected to remain the same without and with the project.

(d) Recreation

In order to meet the needs of the population growth expected with the Hat Creek Project, improvements and additions to the recreation services system would be needed. Initially, the community halls in Ashcroft, Cache Creek, and Clinton would need upgrading and, possibly, enlarging. More open space would have to be developed in Ashcroft and Cache Creek in both scenarios.[8]

Additional recreation facilities such as a curling rink, bowling alley, indoor swimming pool, or multi-purpose facility might be required in Ashcroft, Cache Creek or Clinton both without and with the Hat Creek Project. However, the choice of recreation facilities and the timing of the additions should be determined by the residents of the communities and the needs of the construction workforce.

(e) Social

The existing ratio of population per Human Resources worker for B.C. regions, excluding the Lower Mainland, was applied in calculating requirements for the service study area.

Based on the population forecasts with the project, the Hat Creek Project would account for 2 additional social workers and 1 support staff being needed up to 1990. Additional day care services would also be needed as a result of the project. Initially, these services might be offered privately from family dwellings.

Capital costs with the project up to 1990 are not expected to increase over the 1976 capital costs. Operating costs would increase from $98,707 in 1976 to $147,457 in 1990, with average yearly operating costs of $129,957.

There would be no impact on capital costs of social services because of the project, but the average yearly impact on operating costs would be $31,250.

(f) Cultural

The B.C. Library Development Commission has developed standards for library services in B.C. Those standards indicate that some additional space would be needed for the Cache Creek library by 1982 with Scenario 2.[9] One extra staff would be needed in Ashcroft by 1982 with Scenario 1. The Cariboo Thompson Nicola Library System has suggested that a temporary library in portable facilities might be placed at the construction camp to provide library services for the work force living there.

Without the Hat Creek Project, it was projected that no additions to the existing library facilities and staff would be needed in the service study area up to 1990.

The operating costs are expected to increase from $52,800 in 1976 to $115,750 in 1990, with average annual operating costs of $96,623. The average yearly impact on operating costs as a result of the project would be $36,237.

Residents of the study area have expressed the desire for additional opportunities for cultural activities in their communities.

(g) Corrections

Without the Hat Creek Project, additional probation officers would not be needed in the service study area. However it is possible that one additional probation officer may be required by 1982 or 1983. Extra space would have to be provided for that person.

The capital costs for corrections services with the project would be the same as the 1976 capital costs. The average yearly operating costs would increase from $22,400 in 1976 to $32,775 in 1990 with the project, giving average yearly operating costs of $28,625. Capital costs would not increase for this service as a result of the project, but the average yearly impact on operating costs would be $6225.

3.4 SOCIO-ECONOMICS - (Cont'd)

(h) Courts

Additional staff or facilities for the Ashcroft Provincial Court are not expected to be needed as a result of population increases to 1990 with the Hat Creek Project. One sheriff is needed presently to provide sheriff services to the area as projected "without" the Hat Creek Project.

The capital costs up to 1990 with the project would be the same as the 1976 costs. The annual operating costs would increase from $89,100 in 1976 to $188,100 in 1990, giving average yearly operating costs of $158,180. There would be no impact on the capital costs of court services with the project, but the average yearly impact on operating costs would be $52,960.

(i) Legal

Based on information obtained from professionals in the study area, it is possible that the area could support at least one more lawyer up to 1990 with as well as without the Hat Creek Project.

(j) Police

Two extra officers are anticipated to be added to the Ashcroft police force over the next few years.[10] In addition to these 2 officers, 7 more RCMP would be needed to 1990 with the Hat Creek Project. Additional officers for highway patrol would also be needed but their numbers cannot be determined until projections of traffic volumes are available. Also, 1 or 2 more general duty officers may be needed by 1981 or 1982 to service the project construction camp. The new RCMP facility planned for 1979 should be adequate to 1990.

The total capital costs for the Ashcroft police services with the project would be $750,000 plus the 1976 capital costs. Operating costs would increase from $420,000 in 1976 to $735,000 in 1990. The project is not expected to generate any impact on capital costs, but the average yearly impact on operating costs would be $119,000.

The Clinton RCMP detachment would need 2 extra officers up to 1990 as a result of the Hat Creek Project. The existing facility space would be adequate over that time period.

The annual operating costs would increase from $140,000 in 1976 to $210,000 in 1977, with average yearly operating costs of $184,333. The average yearly impact on operating costs would be $44,333.

(k) Fire

The only change required to fire services in the area as a result of the Hat Creek Project would be the possible addition of a full-time fire chief in Ashcroft in Scenario 1 sometime between 1983 and 1987. The annual operating costs would increase from $24,768 in 1976 to $60,260 in 1990, giving average annual operating costs of $45,290. The impact on operating costs would result in an average yearly increase of $14,398.

3.4 SOCIO-ECONOMICS - (Cont'd)

(l) Communication

When the new federal building which will house the Ashcroft post office is completed, additional staff might be required. The operating costs for Scenario 1 would increase from $450,000 in 1976 to $1,131,750 in 1990, with average yearly operating costs of $834,900 in that Scenario. For Scenario 2, the operating costs would increase from $450,000 in 1976 to $1,083,500 in 1990, giving an average annual figure of $801,450. The effect of the project on operating costs would be to increase the average yearly costs by $476,917.

A radio transmitter and T.V. repeater might be required at the construction camp site. Otherwise, no additional transmitters or repeaters would be needed in the study area.

(m) Commercial Services

(i) Commercial Sector Development with the Project

Given the uncertain response of the private market to potential opportunities arising from a population increase and the lack of a well-defined relationship (in quantitative terms) between trade area population levels and commercial space provision on a square footage basis the type of commercial establishment which might be created in response to a population increase, as well as to the amount of the new commercial activity is estimated on an "order of magnitude" basis.

With the project, the combined population of Ashcroft and Cache Creek is projected to increase from 3200 to approximately 7700 by 1990. In response to an increase in the trading population of this magnitude, it is probable that existing businesses would expand and that new businesses providing services similar to existing facilities (e.g., small supermarkets, personal service establishments, variety stores with clothing and household appliances, etc.) would be established.

In addition it is probable that with an expanded trade area population a broader range of commercial services and products might become available including: 1. A small department store; 2. miscellaneous specialty retail stores; 3. finance, insurance and legal offices; 4. recreation commercial; and 5. larger consumer durables.

It is also anticipated that a trend toward increased involvement in the commercial sector by regional or national chains will arise, both by setting up new establishments and by purchasing existing establishments owned by independent proprietors. The small shopping centre which has been proposed for Cache Creek would likely be economically viable with, but questionable without, the project.

In terms of the amount of new commercial space which is likely to be created with the project, an "order of magnitude" estimate of gross floor area is approximately 5574 to 7432 m^2.

With the project, the population of Clinton is projected to increase from 800 to approximately 1750 by 1990. An increase of this magnitude would likely give impetus to the expansion of retail and service establishments providing goods and services required on a regular or convenience basis. Establishments marketing specialty goods and services or major consumer durable goods would not be likely to locate in Clinton in response to this population increase.

(n) Industrial/Service Commercial Facilities

(i) Industrial/Service Commercial Sector Development with the Project

It is anticipated that the types of industrial and service commercial establishments likely to locate in the municipalities would be classified into two categories: 1. establishments providing services to the local trading area population; and 2. establishments providing services to the Hat Creek Project.

With the project and given the combined population of Ashcroft and Cache Creek, it is anticipated that there will be an expansion not only in the number of light industrial and service commercial establishments, but a broadening in the scope and range of services available as well. On an "order of magnitude" basis, it is estimated that in the two communities, approximately 10 to 20 ha of land would be required to adequately accommodate the demand. No constraints or restrictions on the supply of land are anticipated in either community.

With the project, there is also a possibility that establishments such as heavy duty equipment sales and service will find it economically feasible to locate in the Cache Creek/Ashcroft area. It is possible that if serviced land is available at reasonable prices, up to 40 ha may be required to accommodate the demand. It is anticipated that light industrial establishments of this nature will tend to concentrate in the proposed light industrial area south of Cache Creek, primarily because of proximity to the Trans-Canada Highway and the proposed access road to the project site.

In Ashcroft, during the proposed construction period, some light industrial activity associated with the trans-shipment of equipment and machinery from rail to trucks might take place if B.C. Hydro decides to develop offloading facilities off the CNR at Ashcroft. If the development would take place in Ashcroft, approximately 3 ha of land adjacent to the CNR in North Ashcroft would be utilized.

With the project, the magnitude of the increase of population in Clinton would likely provide an impetus for modest expansion of light industrial or service commercial establishments serving the local trading area population.

(o) Summary

In general, impacts to most service systems would occur in the area of additional staffing rather than extra facilities required as a result of the project. Differences in all service requirements, including capital and operating costs, without and with the project would be most substantial for education.

The largest impact to the education services in the study area, in terms of an increase in enrollment, would be found in the elementary school in Cache Creek. In that community, a new elementary school facility would be needed in Scenario 1. A new elementary school facility would be needed also in Ashcroft in Scenario 2. A new secondary school facility, or additions to the existing facility in Ashcroft, would be required in either scenario. Without the project, it is unlikely that these new facilities would be necessary.

As well as affecting school facilities, considerably more teachers would be needed in all schools in the service study area as a result of the project.

The hospital in Ashcroft may reach its full capacity at peak years of population, but additional facilities would not be needed as a result of the project. The construction workforce is not expected to have a significant impact on hospital services. The population increases as a result of the project would necessitate the addition of hospital staff.

Four more doctors, two additional dentists, and facilities for these professionals would be needed in the service study area in addition to those medical and dental services expected without the project.

More open space and additional recreation facilities would be needed in the three communities and in the Hat Creek Valley because of the added population with the project. Although the type of facility and the timing of its addition should be determined by the local residents these facilities would still be needed, especially between 1981 and 1983.

Local residents would want more cultural resources on account of the project, but, as with recreation services, the exact nature of these resources should be determined by the communities in the study area.

Because of the project, more library space would be required in Cache Creek in Scenario 1, and more library staff in Ashcroft in Scenario 2. Also, a portable library facility would be needed at the construction camp.

In Ashcroft and Cache Creek, five more police officers would be required because of the increased population with the project, and two extra officers would be needed in Clinton. In addition, one or two police officers would be needed to service the construction camp during the peak years.

3.4 SOCIO-ECONOMICS

3.4.5 Community and Regional Infrastructure

(a) Community Infrastructure

(i) Water System

With the project, additional improvements required in Ashcroft would include:

1. Supply mains and booster station upgrading to serve Mesa Vista bench.
2. Expansion of reservoir capacity to serve the Mesa Vista bench area.

In Cache Creek, improvements that would be required with the project include:

1. New water intake.
2. New water reservoir to serve the east sector of Cache Creek.
3. New supply main and reservoir to serve future light industrual-service commercial development areas immediately south of Cache Creek.

Trunk main extensions would be required in Clinton with the project, in addition to storage expansion at the source of supply, to serve the proposed new development areas in the westerly sector of the village.

(ii) Sanitary Sewerage System

With the project, it is anticipated that the population level in North Ashcroft would exceed the 1800 level and as a result, upgrading of the Tingley Street lift station and the forcemain across the Thompson River would be required. Also, a second outfall sewer main to connect to existing primary collectors on 6th Street in South Ashcroft would be required with further development in the Mesa Vista bench area.

A new trunk main to serve the future light industrial/service commercial development area south of Cache Creek would be the only improvement required with the project.

In Clinton, major improvements as a result of the project would include the extension of trunk mains to new development areas in the westerly sector of the village. Costs for extending trunk mains are expected to be relatively low. Also, upgraded disposal facilities are anticipated to be required with the project.

(iii) Solid Waste Disposal

The common landfill site utilized by the village of Ashcroft and Cache Creek has adequate capacity to accommodate the projected population increases both with and without the project. The existing landfill site has similarly adequate capacity for the village of Clinton and surrounding areas both with and without the project.

(iv) Roads

Development expansion in Ashcroft would tend to increase congestion at the Thompson River Bridge and the access road to Mesa Vista Bench. Therefore, upgrading of the above roadway components might be needed with the project, particularly under Scenario 1.

In Cache Creek, the project would require upgrading the following roads:

1. Upgrading main access route (Quartz Road/Stage Road) to east sector of the village; under Scenario 2, this access road would have to be extended eastward to reconnect to the Trans-Canada Highway.

2. Extension of new access road south to provide entrance to the proposed industrial/ service commercial area south of the village.

3. Extension of Old Stage Road north to connect into Cariboo Highway.

A new access road would be required with the project in Clinton to serve the proposed new development area west of the community.

(v) Storm Drainage

Although no major trunk storm sewer facilities would be required in Ashcroft, several outfalls from the natural drainage courses to the river would be needed. In Cache Creek and Clinton, no major trunk storm sewerage facilities would be required in light of the general accessibility of natural drainage features.

(vi) Timing Concerns

Ashcroft and Clinton might experience some short term delays or time lags in their infrastructure expansion programs; e.g. financing capital improvements, including the securing of commitments for infrastructure grants from senior governments.

(b) Regional Infrastructure

(i) Utilities

Each of the utility companies - B.C. Hydro, B.C. Telephone and Inland Natural Gas indicate that no problems are anticipated in providing additional services in Ashcroft, Cache Creek and Clinton. However, a significant amount of lead time would be needed to avoid delays in the delivery of new services during rapid development episodes.

(ii) Transportation

The Hat Creek Project would necessitate an increase in both vehicular and truck traffic through the local communities as well as the regional highway system. At present, Highway No. 12 provides the only access between the project, the main regional highways (No. 1 and No. 97) and the nearest communities. The proposed access road to the project, available in 1980, follows the Medicine and Cornwall Creeks and intersects Highway No. 1 near the south end of Ashcroft.

Table 3.4-15 provides estimates of probable passenger commuting patterns for those time periods when maximum traffic might be expected. The greatest volumes are likely to occur on Friday nights, during the peak construction years (1982 and 1983) as camp residents leave the area for the weekend. Although the volume and timing of evening trips for entertainment could not be estimated, they are likely to be substantial.

The major passenger vehicle impacts anticipated would occur at the junctions of the B.C. Hydro access road with Highway No. 1 and Highway No. 12 with Highway No. 97. The volumes of traffic arriving together at the junctions would produce congestion and pose safety hazards as they access and egress Highway No. 1 and No. 97. The safety hazard would be particularly severe during summer peak highway traffic times.

Truck movements, chiefly from the railyard and to the site, would approximate 50 vehicles per day. The major concern with respect to these vehicles occurs at their point of access to the major highways, where they present a potential safety hazard moving into through traffic.

3.4.6 Local and Regional Government

(a) Local Government Structure - Management and Provision of Services

The rapid growth rates projected for the communities, in particular Cache Creek and Ashcroft, would necessitate a greater level of planning and administrative activity on the part of government. Time lags in the delivery of services and processing of development applications would probably result in initial years of community growth. It is estimated that a lead time of about 1 to 1.5 years would be required to enable the municipalities to start and complete the changes and modifications required in the local government structure, even with a community plan and implementation bylaws in force.

(b) Municipal Finance and Budgeting

A comparative evaluation of projected expenditures, revenues, assessments and tax rates for each municipality indicates that over the long term, each of the municipalities would be financially capable of carying out its responsibilities without imposing undue tax burdens on taxpayers, both with and without the project. Temporary fiscal difficulties in Ashcroft and Cache Creek might result in excessive increases in taxation levels during the first few years after project commencement.

Projections of government expenditures covered the following categories:

1. General government.

2. Protective services.

3. Transportation.

4. Recreation and cultural.

5. Public health and welfare.

6. Environmental development.

7. Fiscal management services.

8. Other services.

9. Environmental health.

10. Water.

Contributions to other agencies for which the municipality collects taxes are not included in the projections. The projections of expenditures have been adjusted to reflect the "net costs" to the municipality thus taking into consideration available senior government grants as well as contributions from developers realized by implementation of a Development Cost Charge Bylaw. Projected revenues consider property tax sources as well as non-property tax sources such as:

1. Grants in lieu of taxes.

2. Revenue sharing programmes.

3. Infrastructure grants.

4. Municipal incentives grants.

5. Sales of services.

6. Development cost charges.

7. Revenues from own sources.

In projecting property assessment levels, the base year is 1976 and projections are made for residential and non-residential assessments. Residential assessments are expected to increase in direct proportion to the rate of population increase. The present ratio of non-residential to total assessments would remain stable at about 37 percent in Ashcroft and decrease slightly from the presently high level of 62 percent in Cache Creek. In Clinton, the non-residential component of the assessment base is expected to change in direct proportion with population changes.

With the project, it is projected that user rates and charges for water and sewer services would not increase to levels which by Provincial standards would be considered excessive that is, charges in excess of $150 each.

The projected data required for the calculation of property tax rates are summarized in Table 3.4-16 for Ashcroft, Table 3.4-17 for Cache Creek, and Table 3.4-18 for Clinton. The following subsections provide a comparative evaluation of projected tax rates for each of the above communities.

(i) Ashcroft

Tax rates are projected to rise rapidly in the initial period after project commencement. Tax rates are then expected to gradually decline, reaching a comparable level with rates projected without the project in 1986. In 1990, the tax rate under Scenario 1 reflects the increase in population to the 5000 level, at which time the municipality is required to finance police protection.

(ii) Cache Creek

With the project, it is projected that tax rates will jump sharply in the first year following project commencement, reflecting the rapid expansion of the local government structure required to adequately handle the increased level of development activities in the community. Under Scenario 1, it is projected that within three to four years following project commencement, tax rates with the project will be roughly equivalent to tax rates without the project. In 1990, the sharp jump in taxes under Scenario 1 is attributable to the increased expenditures on the welfare function required when the population reaches the 2500 level.

Under Scenario 2, it is projected that tax rates will exceed tax rates without the project by an average of approximately 30 percent. This can be attributed, among other things, to the following factors:

1. With the project under Scenario 2, the population is projected to exceed 2500, hence the municipality is required to make contributions toward the welfare function.

2. With significant population increases under Scenario 2, the per capita taxable assessment level is expected to decrease.

3. The smaller the size of the municipality, the more significant is the effect of the basic $30,000 grant given to all municipalities as part of the Revenue Sharing Programme.

3.4 SOCIO-ECONOMICS - (Cont'd)

(iii) Clinton

Without the project, the tax rates are projected to increase by about 6 mills when the population increases from 810 to 1155. Tax rates are projected to be only slightly higher (less than 1 mill) with the project than without it.

(c) Regional District

The role of the Regional District would be planning for new development in the unorganized rural areas of the study area. The Thompson Nicola Regional District has recently embarked on a planning program which should culminate in the adoption of an Official Regional Plan by the latter part of 1978. The Regional Plan will establish policies and guidelines for coordinating new development in these unorganized areas. The Regional District might participate with the member municipalities in the study area in joint financing programmes for certain services, and in particular, recreation and cultural services.

3.4.7 Social Environment

(a) Introduction

The Hat Creek Project would affect the social environment through changes in the natural environment; changes in economic structure and opportunity; population changes and community expansion; and adjustment problems associated with rapid change and development. Social impact is viewed therefore in terms of quality of life alterations. Quality of life changes would primarily occur in the local study area, particularly Ashcroft, Cache Creek and the Hat Creek Valley. Minimal effects would occur among the broader population of the region. Table 3.4-19 summarizes social impacts over the life of the Project.

(b) Impacts Resulting from Changes in the Natural Environment

In this section, spillovers associated with the project that result in a loss of amenities available from a natural environment are of prime concern. Social impact assessment should weigh the types of amenities provided by the natural resources without the project, the reduction of such amenities as a result of the project, the population(s) whose quality of life would be affected, and the permanence of these losses, as well as other criteria of significance.

The major changes in the natural environment arising from project elements in the Hat Creek Valley include: reduction in the quantity and quality of agricultural, recreational and forest land, reduction in the quantity and quality of wildlife habitat, reduction in the flow characteristics and quality of surface and groundwater supplies, reduction in Hat Creek fish population, increase in noise levels and alterations in noise characteristics and reduction in the quality of the ambient air.

The individuals affected include valley residents (30-40 people) and other users of the valley. It appears that a few valley residents might have to relocate as a direct result of land alienation but most residents would not have to relocate. With respect to the changes identified in the natural environment, the evaluation of amenity resources lost and consequent reduction in the quality of life would be a subjective decision on the part of the individual(s) involved. Hat Creek Valley residents would tend to value the amenity losses higher than non-residents who use the valley only for recreation or other purposes.

The proposed access road, pipeline and transmission line corridor would alienate small amounts of agriculture, forest and recreational lands, as well as some stream and fishery disruptions. However, the economic and social consequences are considered insignificant. The proposed airport is unlikely to generate significant negative social impacts in the short run. The residents of all study area communities generally favoured the proposed airport, the benefits of which would accrue to non-commercial users of the airport facilities.

On the assumption that the offloading facilities would be located at the CNR station in Ashcroft, increased trucking during the construction period on the likely route would affect residents and others in the vicinity. These individuals would have to adjust to minor disruptions and additional noise, albeit minimal, associated with additional traffic and offloading activity in the area. It is to be expected that residents would have some concern about the potential for road hazards and risk of injury with the presence of additional traffic in the local area. However, there is no reason for this potential to be realized given existing traffic regulations.

If the No. 1 booster pumping station for the water intake operates without acoustical mitigation, the incremental noise levels would probably affect 15 to 20 residents in the immediate area. Some of these residents might find the constant incremental background noise incompatible with residential satisfaction. However, the proposed mitigation at the pumping station would offset the significance of this annoyance.

(c) *Impacts Resulting from Changes in Economic Structure and Opportunity*

The Hat Creek Project would create a large number of short and long term employment opportunities, lower unemployment rates in the short run, create employment opportunities for individuals wanting to enter the local labour force and generate opportunities for individuals to improve their employment positions in the region.

The project would also raise the income and employment expectations of many residents in the study area. It is understandable that some local residents would be disappointed if their expectations were not realized. However, the hiring practices of B.C. Hydro as dictated in the labour management contracts and laws related to discrimination in hiring would inhibit maximizing local employment.

(d) Impacts Resulting from Population Changes and Community Expansion

The project would result in a large and rapid population increase in the local study area, producing a number of personal adjustments on the part of existing residents and inducing expansions in community social services, commercial goods and services, housing and community infrastructure.

Ephemeral reductions in the quality of life might result in the local area through the process of providing services and integrating the population.

Over the longer run, personal adjustments would normalize and new social patterns emerge. Expanded services would provide benefits to the local people through greater choice of more convenient and probably more efficient services than that likely to occur without the project. For most residents of the study area, changes in the physical character of the settlement communities would enhance the quality of life. The benefits of additional income and employment would continue over the life of the project.

(e) Social and Community Adjustment Problems

Adjustment problems might occur as a result of changes in social behaviour and health; changes in community stability; changes in community social stratification and structure. The adjustment problems identified below must be viewed as potential and the significance of them is unknown in the specific case of the Hat Creek Project. The reason for these caveats is that inferences were primarily made about adjustment problems based on those experienced on comarable projects.

Some communities affected by large-scale industrial developments and rapid population growth have experienced considerable increases in petty crimes. The proximity of the construction camp labour force and any increased flow of unemployed job seekers would tend to increase transiency levels in the study area communities. Because alcohol consumption would tend to increase, the potential exists for alcohol-related problems. Other areas subject to rapid growth have experienced an increase in juvenile delinquency and venereal disease.

New residents might question the values and assumptions of the established residents, possibly creating concerns in the community through the adjustment period. On the other hand, the Project would likely reduce out-migration from the study area, increase employment opportunities as well as provide an incentive for former residents to return to re-establish residency. In particular more local young people would remain in the local communities with the project than without it thus contributing to family stability.

Social stratification would occur through segregation of individuals in housing developments built for Hat Creek Project employees. The major effect of this stratification would retard integration between newcomers and existing residents. Over time, the process of integration would require understanding and adjustment on the inter-personal as well as community level. Changes in local politics in terms of key individuals and the relative strengths of vested interest groups would likely occur. New organizations would be formed that would meet the needs of community residents as well as new events and activities increasing the quality of life in the communities and assisting the integration of different resident groups.

3.4 SOCIO-ECONOMICS - (Cont'd)

3.4.8 Native Indian Studies

(a) Employment

The Hat Creek Project would provide a large number of employment opportunities. In addition to adding to the total number of employment opportunities available in the area, the Hat Creek project would offer the local Indian people a marginal benefit in that it is located near the Reserve, thus easing the communication and transportation barriers. In light of currently higher Indian than non-Indian unemployment and the forecasted level of local area participation, the number of jobs likely to be taken by Indians would not be extensive. It would appear that unless special steps, such as the development of an affirmative action program are taken to resolve specific employment problems of Indians, the likelihood of significant employment benefits accruing to the local Indian people, certainly in the short term, would be low.

The proposed project would create some wage employment and business opportunities in the local economy, which might offer further potential for Indian employment benefits. Although there might be some loss of employment in the agriculture sector as a result of the project, the lack of reliable data precludes an accurate prediction of employment changes. No significant impacts are anticipated with respect to Indian non-wage employment.

(b) Income

The Hat Creek Project is expected to provide an overall positive force in raising the level of Indian incomes. The basic rationale for this conclusion is that the project would generate income through direct, indirect and induced employment opportunities far in excess of employment opportunities that might be displaced, if any. Also, the project would not have an appreciable effect on non-wage income or income-in-kind. The Hat Creek Project would provide a large number of employment positions in skilled trades having higher wage levels than any that exist in the area at the present time. Therefore, the greater the employment of Indians directly on the project as well as other employment opportunities generated by the project, the greater one would expect the income benefits to be.

Local cost of living increases that might result from the project would reduce the real income of Indians and non-Indians on fixed incomes or incomes that do not keep pace with the general trend of prices. Lease revenues received by local bands might also be reduced if the demand for grazing land declines and the existing Ashcroft airport is taken out of service.

(c) Social

(i) Community/Construction Force Interactions

Although the anticipated construction work force would likely be very stable from a social point of view, interactions between the predominantly male work force and the female Band members may lead to social impacts.

The large numbers of males unattached on either a temporary or a permanent basis, the length of the construction phase of the project and the fact that the workers would be living either in the local communities or in camps nearby the communities, would probably result in the development of interracial personal relationships.

If these relationships are detrimental, family or marital disharmony among Reserve residents may occur as well as the incidence of additional stress and other problems related to mental health, alcohol abuse and acts of violence. However, the level and significance of such potential impact cannot be reliably predicted. Also, the possible occurrence of discrimination and prejudice subsequent to an increase in the non-Indian population defies prediction.

(ii) Population Impacts

The project would tend to increase the Reserve populations by lessening the motivation of Band members to leave the Reserve for economic reasons and by providing an incentive for some Band members to return to the area to participate in an expanded economy. However, Indians who perceive or realize lifestyle changes as a result of the project might leave the area. Therefore, two-opposing forces are anticipated to affect Indian populations in the study area, the net effect of which is uncertain.

(iii) Health Impacts

Based on Air Quality and Climatic Assessment Report[11] and the Epidemiology Report,[12] no significant impacts are anticipated to be experienced by the Indian as a result of the project. Negative effects identified in the report include a reduction in visibility from fugitive dust in the Hat Creek Valley and an increase in relative humidity within 5 km of the source which would produce additional local fogging. Fugitive dust can have potential adverse health consequences. The reader is referred to sections 3.1 and 4.1.1 for additional discussion on air quality considerations.

The residents of Bonaparte Reserves No. 1 and 2 might experience adverse health impacts if they obtain their domestic water supply from Hat Creek. The significance of this impact, if any, depends on the potential negative water quality effects identified[13] and the manner in which water is collected and distributed.

(iv) Noise

The Noise Report[14] of the Detailed Environmental Studies did not identify any significant impacts for any of the Reserves in the study area.

(v) Community Services

Because of uncertain future demand conditions and supply adjustments related to community services potential impacts on Indians are difficult to assess. Nevertheless, no significant adverse impacts are likely to be experienced by Indians as a result of increased demand for social services.

3.4 *SOCIO-ECONOMICS* - (Cont'd)

(d) Resource-Use Impacts

(i) Fisheries

The Fisheries Report[15] and the Water Intake Report[16] concluded that there were no significant impacts anticipated for salmon, trout and other fish species as a result of the project. However, the diversion of Hat Creek would significantly affect fish resources in certain stretches of Hat Creek. Also potential adverse impact on the salmon population might result from the Bonaparte River crossings by the water intake pipeline and the proposed new project access road. Given the total fish resources of the local area and region these resource losses would not affect the Indians in a significant manner. Also, increased fishing pressure might adversely impact Indian recreational and subsistence fishing.

(ii) Wildlife

Because the game harvesting activity and trapping on the part of local Indian people is minimal, the impact of some possible wildlife losses are expected to be minor in terms of consumptive use and income equivalency.

(iii) Agricultural and Natural Vegetation

The lack of basic information on the importance and use of natural vegetation; the extent of agricultural development on and off-Reserve; the potential reduction of productivity of grazing land through air quality changes; and present and future land use on the part of Indian people precludes accurate prediction of impacts, if any, and consequently the significance of potential impacts. For example, the project would divert some irrigation water use from lands that could be irrigated in the future but the impact cannot be directly ascertained without the land use plans developed by the Indian people.

(e) Cultural Impacts

The influx of a large number of non-Indian people into the area would intensify the ethnic minority status of the local Indian people. Individuals that attach significant preservation values on the traditional Indian lifestyle would probably be impacted by the incidence of inter-racial marriage and relationships, the potential reduction of land based activities and any erosion of cultural identity. Although the increased pressure of a non-Indian culture and lifestyle would suggest a negative impact on Indian people, the significance of impact cannot be determined.

(f) Settlement Impacts

It is not anticipated that the project would result in significant changes in the settlement patterns of the large majority of Reserve residents in the study area.

3.4.9 Recreation

Construction impacts of concern to recreation are those which create physical disturbance of the land surface. For the most part these impacts are caused by land clearance for construction of facilities. Dust, noise and other impacts are less significant being temporary in character.

Construction impacts occur predominantly in three analysis areas; Area A, B-3 and C-3 (refer to Fig. 2.5-1, Part Three). The mine, plant and some offsite facilities are located in Area A and B and the balance of the offsite facilities are found predominantly in Area C-3.

The second major recreational impact of concern is the induced recreation demand created by the construction labour force. It is anticipated that workers will take advantage of the recreation resources and facilities within the Valley and nearby areas creating much greater recreation pressure than exists at present.

(a) Physical Disturbance

From the recreational perspective, construction and operation impacts will overlap during the period between 1978 and 1987 at the end of which it is assumed all four powerplant units will be built and functioning. From the standpoint of land disturbance it can be assumed that areas covered by the ash dumps and the full open pit coal mine will grow to reach their ultimate size over many years, but at the time operation begins excavation and filling will have affected relatively small areas. Top soil and cover vegetation will have been removed to facilitate operations. At the end of the construction stage the area occupied by all project components will amount to about 790 ha.

There are no recreational facilities that will be affected by project construction. Activities which presently occur in disturbed site areas can move to other locations. These activities consist of hunting, fishing, backroad travel and sightseeing. In addition, gem hunting along Medicine Creek (which is included in the backroad travel category) will be substantially reduced or eliminated.

The amount and type of game animals affected by the disturbed area is unknown. It is assumed that a net loss in game population will occur owing to habitat loss, even though existing game may disperse to other areas as a result of project activities. Impacts on hunting are expected to extend well beyond the immediate construction areas as it is anticipated that many game animals will not venture near the actual site of operations.

The fish resource in Hat Creek will be disturbed over the 700 m section which is to be relocated. Relocation probably would result in the entire loss of fish in this section and there may be downstream consequences.[15] From the recreational perspective, angling that takes place in this section will be eliminated during construction. It is possible, however, that once project operations commence, angling could be restored depending on project characteristics and operational practices.

Backroad travel probably occurs in the area to be disturbed by the project, particularly in the Trachyte hills which are somewhat more open than other nearby terrain. Sightseeing of the

3.4 SOCIO-ECONOMICS - (Cont'd)

natural environment in the project area will also be affected. The project will be most visible in the Medicine Creek Valley and upper Hat Creek Valley, with some project elements visible from Marble Canyon, Cattle Valley and Highway 12. Sightseeing is not expected to be adversely affected by the project. During the project construction phase it can be reasonably expected that both local residents and tourists will make special trips to view the activities taking place. For travelers on Highway 12 it will be virtually impossible to avoid seeing the project during construction and thus substantial increases in sightseeing can be expected. Visitor numbers, however, have not been estimated. The estimated number of recreational activity days displaced by the project is contained in Table 3.4-20.

The impacts indicated in Table 3.4-20 are not correlated by project component. Because the activities affected are dispersed in location, there is no means for directly allocating impacts significantly to one particular aspect of the project. The only exception is angling, where the direct agent is the open pit mine which necessitates the diversion of Hat Creek.

3.4.10 Aesthetics

Visual impact issues are focused upon the operational (post-construction) phase of the development, since during the pre-construction and construction stages, visual impact would be too dynamic to propose meaningful mitigation or enhancement procedures. Therefore, the topic of visual impact is chiefly concerned with the quality of the built environment and not with the process by which it is created.[18]

It is acknowledged, however, that there will be infringements upon the existing aesthetic qualities of the site and its environs during the construction of the plant and its ancillary facilities.

During the construction period of a major installation there will be necessary interruptions to the existing visual scene and, therefore, to its aesthetic impact. Heavy equipment - such as cranes and loaders - will be employed to stockpile and transport building materials about the site. Bulldozers and trenching equipment will be used for underground excavation purposes. There will be approximately 1000 workers on the site.

All of these activities will create noise, dust and debris in the area. Fortunately, the aesthetic impact of these operations on residences will be minimal, since the nearest towns (Pavilion and Carquile) are both about 18 km distant.

3.5 NOISE

Noise levels anticipated from construction of the Hat Creek project were calculated in terms of yearly day-night average sound levels (YDNL). The YDNLs are derived from the sound pressure level of each major noise source normalized to a distance of 15 m and adjusted by a usage factor. In this study the usage factor for a piece of equipment is expressed relative to a time base of 1 year. For example, a compressor which operates 8 hr/d, 7 d/wk for 3 months would have a yearly usage factor of 8/24 x 7/7 x 3/12 = 1/12 ~~or~~ 0.0833. This factor would be applied to reduce the operating noise level of the compressor by 10 log (0.0833) or 10.8 dB(A) to obtain the YDNL.

3.5 NOISE - (Cont'd)

A sound propagation model was used to calculate the transmission of sound from project sources to various receptors. The model uses the following attenuating factors:

1. Geometric spreading.

2. Atmospheric absorption.

3. Topographical shielding.

Other factors, such as wind and temperature gradients and ground effects, have been neglected in the noise prediction procedure, thus making the model somewhat conservative.

Noise levels generated by construction activities vary continuously as a function of time and the first year of the project produces the highest noise (see Fig. 3.5-1). To maintain a conservative approach, the noise analysis presented in this report pertains to this first year of construction. The total noise levels produced during construction will comprise contributions from different project activities. During the first year of the project these activities are indicated to be:

1. Plant construction (excavations and foundations).

2. Mine preparation (filling of the North Valley Dump).

3. Access road construction.

4. Mine camp construction.

5. Project related traffic on Highway 12.

Construction work except the initial North Valley Dump filling operation, has been considered to be on a 5-day week basis with a simple 8-hour shift starting at 8 a.m. The initial North Valley Dump filling operation was based on a 13.5 hr/d schedule (7 a.m. to 10 p.m.), 7 d/wk during a period of 6 months.

3.5.1 Criteria

The noise impact criteria proposed for construction and operation of the Hat Creek project are based on noise limitations which will assure that the large majority of people are protected from hearing loss and other negative lealth and welfare effects with an adequate margin of safety.[2] The USEPA also provides guidelines for the assessment of community response to various degrees of intruding noise levels that takes into account factors such as previous exposure to noise and community attitudes.

The health and welfare effects are described in terms of Equivalent A - weighted sound level over 24 hours Leq(24) and yearly day-night sound level (YDNL). A maximum Leq(24) of 70 dB(A) is intended to protect the public against hearing loss and various stress-related diseases, whereas a maximum YDNL of 55 dB(A) is related to interference with activities such as speech communication and sleep.

3.5 NOISE - (Cont'd)

Community reaction to an intruding noise is estimated by correcting YDNL, using Table 3.5-1. The corrected level is the normalized YDNL. The estimated community response is determined from Fig. 3.5-2.

Because infrequent, intermittent noise events may be disturbing (although they may make a small contribution to the total YDNL), the following criteria have been established for intermittent noise sources:[3]

1. Where the YDNL is 55 dB(A) or less, no evening or nighttime (7:00 p.m. - 7:00 a.m.) intermittent noise level should exceed the YDNL by more than 20 dB(A).

2. Where the YDNL is greater than 55 dB(A), no evening or nighttime intermittent noise level should exceed 75 dB(A).

To assure that the noise levels created by individual impulsive noise events such as blasting do not create a hearing hazard, a 140 db peak sound level limitation is proposed as a maximum at the project property boundary. This level is based on B.C. Workmans' Compensation Board regulations of January 1, 1978.[5]

Maximum noise levels for various categories of land uses shown in Table 3.5-2 are based on noise impact criteria for major airports. The criterion proposed for farm lands is an Leq(24) of 70 dB(A) which would adequately protect farm workers against hearing loss in a normal lifetime.

The criterion proposed for cattle grazing is a YDNL of 65 dB(A). Noise produces the same general types of effects on animals as it does on humans, including hearing loss, effects on communications and behavioural and non-auditory physiological effects. At present, the experimental evidence on which to base noise level criteria for animal exposure to noise is incomplete. The current approach is to assume that animals will be at least partially protected by application of noise limitations developed for human exposures.

The various noise level criteria used in this report are summarized in Table 3.5-3.

3.5.2 Mine and Plant

The total noise levels produced during construction would be comprised of contributions from different project activities. During the first year of the project these activities would be:

1. Plant construction (excavations and foundations).

2. Mine preparation (filling of North Valley Dump).

3. Access road construction.

4. Mine camp construction.

5. Project-related traffic on Highway 12.

3.5 NOISE - (Cont'd)

Noise effects produced by the above activities in four important receptor areas are discussed below.

(a) Bonaparte Indian Reserve I

The noise from construction activities would vary from a YDNL of about 62 dB(A) at the south-west corner of the reserve to a YDNL of 35 dB(A) at the north-east corner, as shown in Fig. 3.5-3. By adding the background YDNL contour values of Fig. 3.5-4 to those of Fig. 3.5-3, the combined YDNLs at receptor points that would be expected during the first year of the project were obtained. These are shown on Fig. 3.5-5.

The areas of the Reserve in which the estimated YDNL would exceed 55 dB(A) and therefore are considered incompatible with residential land use, are also shown in Fig. 3.5-5. There is presently one occupied house within that area.

Cattle and horses are grazed over much of the Reserve and since the YDNL on the reserve will not exceed 65 dB(A), project effects should be compatible with grazing.

The normalized YDNLs that have been estimated to determine probable community reaction were obtained by using the correction factors of Table 3.5-4 and applying these to the YDNL contours of Fig. 3.5-3 within the Bonaparte Indian Reserve boundaries. The resulting normalized YDNL values range from 45 to 72 dB(A). Based on Fig. 3.5-2, it can be seen that the expected community reaction will vary from "no reaction" to "threats of legal action".

(b) Bonaparte Indian Reserve 2

The predominant noise that would affect the Bonaparte Indian Reserve 2 will be from traffic along Highway 12. Based on traffic predictions for the first year of the project, it is expected that an increase of 1.5 dB(A) would occur along the highway, thus producing a YDNL of 55 dB(A) at a distance of 27 m from the highway. Based on the available information, there are no dwellings within this distance.

The maximum normalized YDNL on the Reserve would be less than 55 dB(A) and according to Fig. 3.5-2, no community reaction is anticipated.

(c) Hat Creek Valley Ranches

The five ranches in the Hat Creek Valley that would be affected by noise from the various construction activities are shown in Fig. 3.5-6 and the expected project noise levels together with the normalized YDNLs are listed in Table 3.5-6. This table indicates that the normalized project YDNL varies between 45 and 61 dB(A) and that the estimated reaction of the community to the Hat Creek construction would be from "no reaction" to "widespread complaints".

Since none of the combined YDNLs at the receptor points exceeds the 55 dB(A) criterion (Table 4.5-5), the Hat Creek Valley ranches will be compatible with residential land use throughout the construction period.

The cattle grazing noise criterion of YDNL will be exceeded within about 150 m and 75 m of the North Valley Dump and the access road, respectively. It should be noted that fencing would probably be installed within 50 - 100 m of the pit and dump operations, thus preventing cattle grazing too close.

(d) Trachyte Hills

Plant construction noise levels would exceed the grazing land criterion of YDNL 65 up to about 210 m beyond the fence line, shown on Fig. 3.5-7. At the plant site elevation of 1400 m, however, the grazing capability of the land is about 10 percent high quality and 90 percent low quality.

3.5.3 Offsite Facilities

(a) Intake Structure

The construction of the makeup cooling water supply system would include the following activities:

1. River bottom preparation - November 1978 to April 1979.

2. Water intake construction - August 1980 to May 1981.

3. Pumping station construction - April 1981 to April 1982.

4. Pipeline construction - April 1981 to November 1981.

Only during the month of April 1981 would the various construction activities near the Bonaparte-Thompson confluence overlap in time and hence the impact of each activity has been evaluated independently from the others. Also, because the aforementioned construction activities have been considered as temporary sources of noise, a community sensitivity correction of -5 dB(A) has been applied in each case.

Fig. 3.5-8 shows the location of the nearby residential area, which presently contains six occupied dwellings (16-18 residents), relative to the various components of the water supply system near the confluence of the Thompson and Bonaparte Rivers.

(i) River Bottom Preparation

The noise levels produced by the river bottom preparation activities are expected to vary from YDNL 56 at the eastern edge of the residential area to YDNL 46 at the western edge.

Based on the existing noise level of YDNL 56 measured at monitoring site 5 and train traffic predictions, it is estimated that the existing levels in the residential area range from YDNL of 55 to about 62, as shown in Fig. 3.5-8. Hence, the existing ambient levels over most of the residential area are incompatible with residential land use. By adding the existing extreme ambient levels to the predicted river bottom preparation activities it is seen that the combined noise levels would range from about YDNL of 55 to 63 dB(A) and the compatability of the area for residential land use would not be degraded significantly. The normalized project YDNL is expected to range from 46 to 56 dB(A) and based on Fig. 3.5-2, the probable reaction of the community would be "no reaction" to "sporadic complaints".

(ii) Water Intake Construction

The construction of the cooling water intake is expected to last 10 months and would produce noise levels varying from YDNL 54 to 65 in the residential area bordering the confluence of the Thompson and Bonaparte.

The combined noise levels from the existing train traffic and intake construction would vary from about YDNL 58 to 67 as shown in Fig. 3.5-9. Therefore, the area would be made more incompatible with residential land use by 3 to 5 dB(A).

As can be seen from Table 3.5-4, a total sensitivity correction of +5 dB(A) has been applied to the intake construction noise levels, thus resulting in normalized intruding values of YDNL 59 to 70 dB(A).

Fig. 3.5-2 then predicts a community reaction resulting from "sporadic complaints" to "threats of legal action".

(iii) Pumping Station Construction

The Booster Pumping Station No. 1 is located about 90 m to 270 m from the residential area as shown in Fig. 3.5-10. Construction is to last one year and is expected to produce noise levels in this residential area ranging from YDNL 57 to 69. The combined pumping station construction and train noise YDNL would range from 60 to 70 dB(A), as shown in Fig. 3.5-10. Thus, during the construction of Booster Pumping Station No. 1, the residential area would be made more incompatible with residential land use by 5 to 8 dB(A).

The normalized project YDNL would vary from 57 to 69 dB(A), thus the predicted community response would be "sporadic complaints" to "threats of legal action".

The criterion for noise level compatibility with cattle grazing is YDNL of 65 or less. It is expected that at Booster Pumping Station No. 2 a YDNL of 65 dB(A) would be exceeded for roughly 150 m around the active construction zone, thus alienating from grazing a total area of about 0.3 km^2 for a period of one year.

(b) Main Access Road

The access road would be constructed in two phases, excavation and base course (October 1978 to December 1979) and paving (April to November 1980). The main impact would be generated

3.5 NOISE - (Cont'd)

during the excavation and base course phase, for the approximately 50 workdays adjacent to the McLean Lake Reserve. During this time, the daily average noise levels at the southern edge of the reserve would vary from and Ldn of 47 to 65 dB(A), which reflects a significant increase relative to an existing ambient levels of about 35 dB(A). Hence, annoyance could result especially if the excavation and base course phase activities near the McLean Lake reserve would be in the summer when recreational use of the area is likely.

The access road would run adjacent to the McLean Lake Reserve for about 1200 m, with its closest approach distance being about 360 m as shown in Fig. 3.5-11. The access road construction would then have an impact on grazing land for about 30 m along the southern boundary of the reserve (exceeding L_{dn} 65).

Highway trucking of gravel and asphalt would take place continuously during the paving operation. Assuming a mean value of 45 trucks/hr it is expected that the grazing land use criterion of Ldn 65 would be achieved within 30 m of the roadside. Also the noise impact of trucking on McLean Lake Reserve would be an Ldn of 42 dB(A) which is not considered significant.

(c) Makeup Water Line

The construction of the makeup pipeline would impact four receptor areas: the residential area at the Thompson-Bonaparte confluence, the North Ashcroft subdivision, the Cornwall hills grazing lands and the McLean Lake Indian Reserve. The residential area of the Thompson-Bonaparte confluence would be impacted by an Ldn of 68 to 75 dB(A) during the few days when the pipeline construction zone would be directly adjacent to it. These levels would be about 12 to 13 dB(A) above the daily ambient noises levels established by train traffic and therefore could result in some short term community complaints.

The pipeline construction noise in the North Ashcroft Subdivision is expected to generate a YDNL of 41 to 54 dB(A), thus increasing the range of noise levels in the area from about YDNL 50 to 56 to 50 to 58. The land use incompatibility would then be increased by a maximum of 2 dB(A). Reference to Table 3.5-4 reveals that a community sensivity correction of +5 should be applied, resulting in a normalized YDNL ranging from 46 to 59 dB(A). Based on Fig. 3.5-2, it is seen that the community reaction is expected to be between "no reaction" and "sporadic complaints".

In the Cornwall Hills grazing area an Ldn of 65 dB(A) would be exceeded for approximately 450 m on each side of the pipeline route. At any point along the route, a strip of land 900 m wide would become incompatible with grazing for a period of about a week; assuming a laying rate of 610 m/d.

The pipeline is to be located parallel to and about 210 m from the southern boundary of the McLean Lake Indian Reserve. Based on the grazing compatability criterion of Ldn 65 for the days when the operation is adjacent to the reserve, it appears that a 250 m strip along the south edge of the reserve would become incompatible with grazing for a period of less than a week.

3.5 NOISE - (Cont'd)

(d) Transmission Lines

The construction of the 69 kV transmission lines is not expected to make a significant contribution to the total project impact because of other predominant noise sources in the area such as pumping station construction and coal preparation facility construction.

(e) Creek Diversions

Creek diversion facilities construction would not be a significant source of noise impact because of its concurrence with other construction activities such as the excavation of the pit incline and the filling of the North Valley Dump, which would dominate the environmental noise impact.

(f) Airstrip

Two airstrip sites are being considered for this project; Site "A", 14 km south of Cache Creek near Highway 1 and Site C, 4 km east of Cache Creek near Highway 1. Site "A" is located on grazing land with no residences in the vicinity, while Site "C" is on agricultural land with the nearest ranch buildings about 300 m from the western end of the runway.

Airstrip construction is scheduled from April 1979 to April 1980 and at Site "A", with no residences in the vicinity, only grazing land area of about 0.6 km^2 would be made incompatible with grazing. At Site "C", the combined noise levels of traffic and construction would range from YDNL of 55 to 61 dB(A) from the nearest of the farthest building locations from Highway 1. Therefore, there is a possibility that airstrip construction would render a previously compatible residential location incompatible (YDNL greater than 55 dB(A)) depending upon existing occupancy. The area of residential land use incompatability during the existing construction is shown in Fig. 3.5-12. The ranch at Site "C" would be exposed to a normalized airstrip construction would level of YDNL 54 and Fig. 3.5-2 reveals that "no adverse reaction" is expected from the residents.

At Site "C" the agricultural land use noise criterion of Leq(24) of 70 dB(A) would be exceeded within about 53 m of the edges of the active construction zone, which will be 100 m, as shown in figure 3.5-12. Since it is possible that farming activity might take place within this incompatible zone, there is a potential for noise impact.

(g) Equipment Offloading Facilities

Because the precise locations of the site alternatives at Ashcroft, Kelly Lake and Spences Bridge are unknown, the existing noise levels at these three alternatives are also unknown. Therefore, only a qualitative assessment based on the present activities in the community can be made at this time. Thus, Spences Bridge (which has two railways and Highway 1) would be the first choice, while Ashcroft (which has two railways and a very light industrial area) and Kelly Lake (which has one railway and a highway which has some trucking) would be less compatible sites. Because of the potential impact on the greatest number of residents, Ashcroft is considered the least desirable site.

CHAPTER 4.0 - ENVIRONMENTAL EFFECTS OF THE OPERATION

4.1 POWERPLANT

4.1.1 Air Quality Control System

(a) Introduction

(i) Approach

A comprehensive approach to the determination of air quality effects was taken in the Detailed Environmental Studies. This approach, as outlined in the Terms of Reference, was designed to:

1. Identify allowable air contaminant threshold levels in terms of human health effects (literature surveys).

2. Postulate "guideline" concentrations well below those associated with adverse health effects for various averaging times.

3. Evaluate and make full use of existing data on ambient meteorological and air quality conditions.

4. Conduct brief field measurement programmes as necessary to augment these information sources.

5. Perform mathematical modelling and other studies to predict both the air quality and climatic effects of the various project components (plant, cooling towers, mine, offsite facilities), including the alternatives.

6. Design and install an extensive monitoring network for the collection of meteorological and air quality data during both the pre-operational and operational phases of the project.

(ii) Selection of Ambient Guidelines

Specific ambient air quality guidelines for coal-fired powerplants have not been established in British Columbia. The air quality effects of the project are therefore compared to the "guideline" concentrations developed as a result of the epidemiological review conducted as part of the Detailed Environmental Studies.[1] For review purposes these air quality effects have also been compared to existing guidelines for "Food Processing, Agriculturally Oriented and Other Miscellaneous Industries of British Columbia"[2] and the existing guidelines for "Mining, Mine-Milling and Smelting Industries of British Columbia".[3] The health effects of various contaminant levels and the proposed "guideline" values have been discussed by B.C. Hydro in a submission to the Pollution Control Branch Public Enquiry to Review Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries of British Columbia, January 1978.[4] The "guideline" values developed for this project are presented in Table 4.1-1, along with the existing guidelines for comparison purposes; their epidemiological basis is described in detail in Appendix G to the *Air Quality and Climatic Effects Report*.[1]

(iii) Selection of Air Quality Control Systems

Selection of the Air Quality Control Systems (AQCS) described in Part Two, Section 2.4, involved several considerations. These included the emission objectives contained in "Pollution Control Objectives for Food-Processing, Agriculturally Oriented and Other Miscellaneous Industries of British Columbia",[2] the emission objectives contained in "Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries of British Columbia",[3] the ambient guidelines referred to in the previous section, stack height optimization studies conducted by Environmental Research and Technology, Inc. (ERT); and information on the feasibility of various alternatives and standard powerplant practice provided by INTEG/EBASCO and B.C. Hydro. These considerations formed the basis for the criteria used in the selection of the control systems for particulates, oxides of nitrogen (NO_x) and sulfur dioxide (SO_2).

The design criteria and type of electrostatic precipitators (particulates control) have not yet been selected. However, cold-side electrostatic precipitators located after the air preheaters are proposed at this time. It is estimated that a collection efficiency of 99.52 percent is necessary to meet the emission objectives contained in "Pollution Control Objectives for Food-Processing, Agriculturally Oriented and Other Miscellaneous Industries of British Columbia"[2] for particulates (229 mg/m^3) using the worst acceptable coal and assuming that 80 percent of the ash is fly ash. Estimated incremental particulate concentrations in this report are based on this worst-case emission rate.

The Hat Creek boilers will be designed to meet the provincial objectives contained in "Pollution Control Objectives for Food-Processing, Agriculturally Oriented and Other Miscellaneous Industries of British Columbia"[2] for NO_x emissions (1146 mg/m^3). Although the boiler design has not yet been selected, it is anticipated that the design would provide for low excess air and a low flame temperature, thus reducing NO_x formation to a minimum. Emissions for actual operating conditions with 30 percent excess air should be well below the emission objective. However, estimated incremental NO and NO_2 concentrations in this report are again based on the worst-case emission rate.

Although the specific designs for the particulates and NO_x emission control systems are not yet finalized, the general criteria for system selection have been determined. In the case of SO_2, however, several alternatives are under consideration. Studies conducted by ERT early in the Detailed Environmental Studies indicated the need for a stack height in the range of 244 to 366 m, depending on the extent of additional control measures, to meet various assumed ambient guideline levels. The additional control measures under consideration included a meteorological control system (MCS) and flue gas desulphurization (FGD). Once identification was made on the SO_2 guidelines which the plant design should consider (see previous section), it became clear that there were still several control system/stack height combinations which could be employed. Because of the need to limit the number of alternate systems studied in order to complete the analysis of the environmental effects of these alternatives in time for inclusion in this report, three of the most likely alternatives were selected for detailed study: 1. FGD with a 366 m stack, 2. MCS with a 366 m stack, and, 3. MCS with a 244 m stack. The results of the detailed study of these alternatives are provided in the Air Quality and Climatic Effects Report and its Appendix C - Alternate Methods of Ambient Sulfur Dioxide Control.[5]

The decision process concerning these three SO_2 control alternatives would be complex. The environmental costs and benefits must be weighed against engineering and economic considerations, and a system chosen which is acceptable to all parties involved. This decision process is not yet complete. Hence, it is not the intent of this report to recommend a stack height/control system combination for SO_2. This report does provide an analysis of the environmental effects of three alternatives (all of which meet the selected ambient guidelines). The results of this analysis can then provide input to the decision process.

(b) Projected Air Quality

(i) Predicted Local Air Quality

A. Modelling Methodology

A program of diffusion modelling was designed to estimate the effects of the Hat Creek Project on local air quality (within 25 km of the site). Regional air quality effects (25 to 100 km from the site) are discussed in a separate section. A point source Gaussian diffusion model was employed by ERT to predict ground-level concentrations of contaminants emitted by the proposed powerplant. The model simulates the rise, transport and dispersion of buoyant stack gases. The Briggs formulation is employed for estimating the plume rise. The transport is calculated using steady-state meteorological conditions. The effects of terrain on plume transport are simulated by a method based on potential flow theory which allows the plume to be lifted somewhat (depending on atmospheric stability) when travelling over elevated terrain features. The dispersion in the cross-wind and vertical directions is assumed to be well represented by Gaussian (bell-shaped) curves. Removal processes (chemical transformations and deposition) are assumed to have little effect on the local scale.

Inputs to the model include a sequential record of local meteorological data (one year of onsite data from the mechanical weather station nearest the plant site (WS 7), supplemented by data from other stations), terrain elevations within a radial distance of 25 km and emission characteristics corresponding to operation with each of three potential air quality control configurations. Base-load emission parameters are presented in Table 4.1-2. The stack base was considered at elevation of 1418 m MSL; consisting of four flues (inside diameter 7 m) in one chimney which will be either 244 or 366 m high. The flue gas temperature would be 149°C and the volumetric flow rate would be 248 816 m^3/min for the base-load, uncontrolled case (differences between these emission parameter values and those expected for each of the three air quality control configurations are discussed in the sections concerning the effects of the individual system on ambient concentrations). Parameterization of diffusion rates in the Hat Creek facility was accomplished by analysis of onsite trace plume simulations. The basic model was thus tailored to reflect site-specific terrain and weather features. It is referred to as the Hat Creek Model (HCM) in this report and is described in detail in Appendix B to the Air Quality and Climatic Effects Report.[8]

Ground-level, incremental, centerline (plume moving directly toward the receptor) concentrations for sulphur dioxide were computed for each hour for a one-year period. The sequence of hourly centerline values was used together with a "sector-averaging" technique (which distributes a portion of the plume over a 22 1/2 degree wind direction sector) to develop several longer time averages, including 3-hour, 8-hour, 24-hour and annual periods. The results were analyzed to determine maximum values and to develop frequency distributions for each averaging time. Ambient incremental concentrations for the other contaminants considered (oxides of nitrogen, particulates, hydrocarbons, carbon monoxide and trace elements) were computed from the results for sulphur dioxide based on the ratio of the emission rate of the particular contaminant to that of sulphur dioxide. Summaries of the results for each of the three alternate air quality control configurations (FGD with a 366 m stack, MCS with a 366 m stack and MCS with a 244 m stack) are provided in the sections that follow. Detailed results can be found in the Air Quality and Climatic Effects Report[7] and its Appendix C.[5]

Because the proposed site is located in a relatively remote area with no major source of air contaminants, zero background levels were assumed in the modelling analyses for all contaminants except particulates. Non-zero background levels for particulates were indicated by monitoring in the Hat Creek Valley (see Appendix A to the Air Quality and Climatic Effects Report).[9] Conservative average values of 40 $\mu g/m^3$ in Upper Hat Creek Valley and 20 $\mu g/m^3$ in the Lower Hat Creek Valley were assumed by ERT in the modelling analyses. The available monitoring data now indicate that annual background levels are in the range of 10-20 $\mu g/m^3$. The monitoring programme described in Part Three, Section 2.1-3 of this report would produce data on background contaminant levels which can be used to confirm or alter these assumptions.

B. Ground-Level Concentrations - Partial FGD With 366 m Stack

The local air quality effects of the powerplant with a 366 m stack and the partial FGD system described in Part Two, Section 2.5.5(b) of this report were evaluated using the Hat Creek Model. The major difference between the emission parameters for the partial FGD case and those previously indicated for base load with no controls (Table 4.1-2) is that the SO_2 emission rate is 46 percent of the uncontrolled rate. In addition, the flue gas temperature is decreased as by 67°C to 82°C and the volumetric flow rate is increased by 13 373 m^3/min. All other emission parameters were assumed to remain the same. This is believed to be a conservative assumption since the FGD system would undoubtedly reduce the emissions of some of the other contaminants. However, the extent of any such emission reduction is not quantifiable at this point.

The results of the modelling analysis are presented in Table 4.1-3 for the contaminants and averaging times for which ambient guidelines have been assumed, based on the epidemiological studies (see Section 4.1.1(a)(i). It should be noted that values presented in this table are maximum predicted values. The annual values, therefore, represent the highest predicted average for any point within a 25 km radius from the proposed plant. The short-term values represent the absolute highest predicted value for that particular averaging time for any point within the 25 km radius area. Detailed information on the expected frequency of various contaminant levels is contained in Appendix C to the Air Quality and Climatic Effects Report.[5]

Sulphur Dioxide

Maximum predicted SO_2 concentrations for plant operation with partial flue gas desulphurization (FGD) are listed for various averaging times in Table 4.1-3. As indicated in the table, this control system, with full availability, would be expected to maintain ambient levels well below the ambient guidelines assumed in this report (Table 4.1-1). Results of the modelling analysis suggest, in fact, that compliance could be achieved with recommended Pollution Control Branch (PCB) ambient guidelines by the partial FGD system with a shorter stack or smaller portion of scrubbing, i.e., less than 56 percent.

Figure 4.1-1 depicts the distribution of predicted incremental annual average SO_2 concentrations within 25 km from the proposed generating station. Maximum concentrations are expected to occur at locations with the highest elevations, specifically in the Cornwall Hills, Arrowstone Hills and Clear Range. Terrain effects and the annual distribution of wind direction are the most important factors producing the pattern seen in Figure 4.1-1.

Oxides of Nitrogen

For purposes of computing the local-scale contribution of the powerplant to ambient levels of nitrogen oxide (NO) and nitrogen dioxide (NO_2), it was assumed (based on previous studies) that a total NO_x emission rate of 600 ppm is equally divided between NO and NO_2. Due to the difference in the molecular weights of the two compounds, the mass emission rate of NO_2 is, therefore, about 51 percent greater than that for NO. In this way, the complex series of reactions that attend the conversion of NO are accounted for in a manner consistent with results of powerplant plume measurements. For the local air quality analysis, plume travel times are considered insufficient to produce appreciable quantities of organic and inorganic nitrates.[7]

Figures 4.1-2 and 4.1-3 indicate the distribution of computed annual average NO and NO_2, respectively. Maximum values of 2.5 μg/m^3 and 3.7 μg/m^3 are predicted for these species. No guidelines for ambient NO or NO_2 are currently in effect in British Columbia, nor have any been assumed in this report (see Section 4.1.1(a)(ii)). The quantitative effect of the FGD on emissions of NO_x is not established. Thus, the *most conservative estimate of emissions (corresponding to uncontrolled operation)* have been used in the calculations for these compounds.

Particulates

Isopleths of predicted local annual arithmetic mean concentrations of total suspended particulates (TSP) are presented in Figure 4.1-4. Annual guidelines for TSP assumed in this report are expressed in terms of the geometric mean. The model, however, produces results in terms of the arithmetic mean. The arithmetic mean is always greater than or equal to the geometric mean. Thus, the presentation of *arithmetic mean concentrations in discussions of TSP effects in this report is* inherently conservative in terms of compliance with the annual guidelines.

A maximum annual particulate concentration of 1.2 μg/m^3 is predicted in the Cornwall Hills, 13 km south-southeast from the generating station. This value is small in comparison with the annual guideline even when added to the existing background concentrations. Table 4.1-3 lists the maximum predicted TSP concentration for the other averaging time of interest (24-hours).

Total Hydrocarbons and Carbon Monoxide

Emissions of total hydrocarbons (HC) and carbon monoxide (CO) are assumed to be about 3.6 percent and 12.1 percent of FGD-controlled SO_2 emissions, respectively. Estimated annual concentrations for these contaminants may be obtained from Figure 4.1-1 by multiplying calculated SO_2 concentrations by these emission ratios. No applicable guidelines pertaining to ambient levels of hydrocarbons are currently in effect in British Columbia, nor have any been assumed in this report (see Section 4.1.1(a)(ii)). Maximum 1-hour and 8-hour CO concentration guidelines of 14 300 μg/m^3 and 5500 μg/m^3, respectively, are assumed in this study. Table 4.1-3 provides the predicted maximum 1-hour and 8-hour CO concentrations. Clearly, the predicted values are negligible in terms of these guidelines.

Trace Elements

Table 4.1-3 also indicates predicted maximum 24-hour and annual mean concentrations for selected trace elements that will be emitted from the proposed powerplant. The tabulated values correspond to those substances for which ambient *guidelines have been assumed in this report, as provided in Section 4.1.1(a)(ii).* As indicated in the table, no values approaching the assumed short-term or long-term guidelines are expected. Concentrations for other trace elements listed in Table 4.1-3 may be estimated by scaling predicted SO_2 concentrations by the appropriate emission ratios.

Commitment of the Air Resources

Maximum predicted 3-hour and 24-hour SO_2 concentrations with FGD are 366 and 208 $\mu g/m^3$, respectively. These values represent 56 percent and 80 percent of the assumed guideline levels. Care must be exercised in interpreting these percentages, because the maxima represent the highest single concentrations predicted at any point. It should be recognized that on a long-term basis, the average of 3 or 24-hour values at a particular location would, in fact, be the annual average. Flue gas desulphurization was predicted to result in a maximum annual average SO_2 concentration of 4.5 $\mu g/m^3$; this is 18 percent of the assumed guideline, which probably represents the best overall estimate of the air quality resource commitment associated with this SO_2 control strategy. The corresponding incremental commitment for particulates is about 2 percent. Results of other contaminants, including carbon monoxide and trace elements, indicate a neglibible degradation in terms of the applicable guidelines.

C. Ground-Level Concentrations - MCS with a 366 m Stack

This section presents the local air quality modelling results that would correspond to powerplant operation with a 366 m stack height and a meteorological control system (MCS) for sulphur dioxide control (described in Part Two, Section 2.5.5(a) of this report). The assumed mode of MCS operation is as follows:

1. During periods of adequate dispersion, the plant fuel would be 0.45 percent sulphur coal with a mean heating value of 14 644 kJ/kg.

2. When the predicted maximum 3-hour ambient SO_2 concentrations would exceed 655 $\mu g/m^3$, or when the 24-hour maximum would exceed 260 $\mu g/m^3$, emission reductions would be made by one of two methods: during the months of November through February, the fuel would be switched to 0.21 percent sulphur coal with a heating value of 17 587 kJ/kg; or during the remaining months, the generating capacity of the four 500 Mw (net) units would be uniformly reduced as required to bring ambient concentrations below the 3-hour and 24-hour criteria.

3. To minimize the number of physical fuel-switch operations, it is assumed that the minimum period of low-sulphur coal use would be 3-hours and that the minimum interval of high sulphur coal use between switch periods would be 9-hours.

Plant emissions would, of course, remain the same as for the base-load, uncontrolled case presented in Table 4.1-2 except when MCS control action (fuel switching or load reduction) would be required. For fuel switching, it has been assumed that all emission parameters would remain the same as for the base-load, uncontrolled case except that SO_2 emissions would decrease to 39 percent of the uncontrolled rate and the volumetric flow rate would decrease by 10 432 m^3/min to 238 384 m^3/min. In the case of load reduction, emission parameters would be reduced nearly in proportion to the reduction in load (see Table 4.1-4). As indicated in the table, emission rates for the various contaminants under various load conditions can be obtained by using the "adjustment factors" in Table 4.1-4 together with the base-load, uncontrolled emission rates in Table 4.1-2. As an extra measure of conservatism *for trace elements, no emission reduction with either load reduction or fuel switching* has been assumed for these parameters in the analysis.

A modelling study based on 1-year of input data was conducted to evaluate the feasibility of the MCS. The results, provided in detail in Appendix C to the Air Quality and Climatic Effects Report,[5] indicate that:

1. MCS control actions would be limited to a few fuel switching periods during the winter. Use of 0.21 percent sulphur fuel on those occasions would be adequate to prevent ambient violations, even with control criteria set at 80 percent of the assumed guideline values.

2. Load reduction requirements during the remaining months would come infrequently, if necessary at all and the annual generating capacity loss due to any such curtailments would be negligible.

3. The model analyses show that the installation of a 366 m stack would ensure that the powerplant could be operated virtually as a base-load facility with uncontrolled emissions of sulphur dioxide.

Table 4.1-5 presents the predicted maximum concentrations for the contaminants and averaging times for which ambient guidelines have been assumed (see Section 4.1.1(a)(ii)). Detailed information on the expected frequency of various contaminant levels for MCS operation with a 366 m stack is contained in Appendix C to the Air Quality and Climatic Effects Report.[5]

Sulphur Dioxide

Maximum computed SO_2 concentrations from powerplant emissions with an MCS and a 366 m stack are presented for various averaging times in Table 4.1-5. A comparison of these values with those in Table 4.1-3 points out the differences between the effects of constant emission reduction technologies (such as FGD) and intermittent controls (such as MCS) designed to eliminate only peak concentrations above the assumed guidelines. Maximum concentrations for all averaging times with the MCS are higher than those calculated with FGD. Predicted maximums with MCS are close to the assumed guildelines for the 3-hour and 24-hour averaging times.

Figure 4.1-5 indicates the geographical distribution of annual average SO_2 concentrations within 25 km from the proposed generating station. Maximum values are higher than those predicted for FGD controls, but are still nearly an order of magnitude below the assumed guideline (25 $\mu g/m^3$). The highest concentrations are expected to occur in remote, elevated locations.

Oxides of Nitrogen

Maximum local concentrations of NO and NO_2 may be estimated from the SO_2 modelling results in Table 4.1-5 by scaling predicted SO_2 values by the factors 0.25 and 0.38 respectively. Maximum annual averages computed in this way are 1.8 $\mu g/m^3$ for NO and 2.7 $\mu g/m^3$ for NO_2. Distributions of annual average concentrations of these species may be similarly obtained from the SO_2 values in Figure 4.1-5. No ambient guidelines for NO_x have been assumed for this report.

Particulates

Maximum computed total suspended particulate (TSP) concentrations within 25 km of the powerplant with MCS are displayed in Table 4.1-5. Predicted concentrations are well below the assumed guidelines. The distribution of predicted annual average TSP concentrations may be inferred from the pattern displayed in Figure 4.1-5, by scaling the plotted values for SO_2 by the factor 0.12.

Total Hydrocarbons and Carbon Monoxide

Emission ratios of total hydrocarbons and carbon monoxide to uncontrolled sulphur dioxide emissions are approximately 0.017 and 0.055, respectively. Conservative estimates of annual concentrations of these contaminants may be obtained by scaling predicted SO_2 levels given in Figure 4.1-5 by the appropriate ratios. Table 4.1-5 lists predicted CO levels for the 1-hour and 8-hour averaging times. Calculated concentrations are well below assumed guidelines.

Trace Elements

Maximum 24-hour and annual (arithmetic) mean predicted concentrations of selected trace elements within 25 km of the powerplant are indicated in Table 4.1-5. Annual average concentration patterns for these trace elements, as well as the others for which emission rates are given in Table 4.1-2 may be estimated from Figure 4.1-5 by scaling the SO_2 concentrations in the figure by the ratio of the appropriate emission rate to that of SO_2. As was predicted for FGD, ambient levels of trace elements are expected to be well below the assumed guideline values.

Commitment of the Air Resources

Using the same assumptions discussed in Section 4.1.1(b)(i), the degradation of the air quality resource associated with powerplant operation with MCS and a 366 m stack was examined for the major contaminant emissions. Peak predicted 3-hour, 24-hour and annual average SO_2 concentrations are 99 percent, 100 percent and 28 percent of the applicable guidelines. Short-term concentrations at or near guideline levels would be expected with this form of emission control, because MCS is designed to eliminate only those values above the guideline thresholds. Use of this control strategy, therefore, represents commitment of a larger fraction of the air resource than that associated with FGD. Model-predicted maximum incremental concentrations for other contaminants correspond to air quality degradation of 2 percent or less.

D. Ground-Level Concentrations - MCS with a 244 m stack

This section provides results of a modelling analysis to predict local ambient concentrations resulting from operation of the proposed powerplant with an MCS and a 244 m stack height. The assumed operating rules and emission parameters for the MCS are identical to those presented for the 366 m stack/MCS configuration (see Section 4.1.1(b)(i)).

A complete study of the feasibility of this control strategy and all of the modelling results (including the expected frequency of various contaminant levels) are included in Appendix C to the Air Quality and Climatic Effects Report.[5] In that study, it was indicated that the MCS would be capable of maintaining 3-hour and 24-hour SO_2 concentrations below the assumed guideline levels by: 1. switching to lower-sulphur fuel for about 195 hours during the months from November through February; and 2. reducing plant generating capacity to 80 percent load for about 80 hours and to 60 percent load for about 5 hours during the remaining 8 months. Table 4.1-6 presents the maximum concentrations predicted by the model for the contaminant and averaging times for which ambient guidelines have been assumed (see Section 4.1.1(a)(ii)).

Sulphur Dioxide

Maximum predicted SO_2 concentrations within 25 km of the plant for the 244 m stack/MCS emission scenario are presented in Table 4.1-6. As expected, the ambient levels would be highest for this control strategy, but 3-hour, 24-hour and annual maxima would be at or below the assumed guidelines. Isopleths of annual average SO_2 concentrations with the 244 m stack height and MCS are shown in Figure 4.1-6.

Oxides of Nitrogen

Maximum local concentrations of NO and NO_2 may be estimated from the SO_2 modelling results in Table 4.1-6 by scaling predicted SO_2 values by the factors 0.25 and 0.38 respectively. Maximum annual averages computed in this way are 2.3 $\mu g/m^3$ for NO and 3.5 $\mu g/m^3$ for NO_2. Distributions of annual average concentrations of these species may be similarly obtained from Figure 4.1-6. No ambient guidelines for NO_x have been assumed for this study.

Particulates

Table 4.1-6 lists local maximum computed TSP concentrations for various averaging times. The distribution of annual average values for the 244 m stack/MCS configuration may be obtained from Figure 4.1-6 if the plotted SO_2 values are scaled by the emission ratio factor of 12. No concentrations approaching the assumed 24-hour and annual guideline values are indicated.

Total Hydrocarbons and Carbon Monoxide

Annual average concentration patterns for HC and CO may be estimated from Figure 4.1-6 by means of the scaling factors 0.017 and 0.055, respectively. Peak calculated 1-hour and 8-hour CO concentrations are listed in Table 4.1-6. Predicted concentration levels are insignificant by comparison with the assumed guideline values.

Trace Elements

Table 4.1-6 lists annual and 24-hour maximum computed concentrations for selected trace elements emitted by the powerplant with the MCS and a 244 m stack. Peak values would be well below assumed guideline levels. Geographical distributions of annual average concentrations may be estimated from the computed SO_2 concentrations in Figure 4.1-6 if the plotted values are scaled by the appropriate emission ratio factors.

Commitment of the Air Resource

In terms of the relationships between predicted peak concentrations and assumed ambient guidelines, SO_2 is the only significant contaminant from the standpoint of air resource commitment for powerplant operation with a 244 m stack and meteorological controls. Maximum calculated values for 3-hour, 24-hour and annual averages represent 95, 100 and 37 percent of the corresponding guidelines, respectively. Of the three technologies considered in this analysis, this control strategy would result in degradation of the largest fraction of the air quality resource. Fractional commitments in terms of contaminants other than SO_2, however, are expected to be negligible.

(ii) Predicted Regional Air Quality

A. Modelling Methodology

The air quality effects of the powerplant emissions of a regional scale (between 25 and 100 km from the proposed plant) were estimated by ERT using an adaptation of the same model that was used to evaluate the local air quality concentrations, the "Hat Creek Model".[8] The regional modelling is therefore based on the same theoretical assumptions as the local modelling. That is, the Briggs formulation is used for plume rise, transport is calculated using steady-state meteorological conditions, the effects of terrain are simulated by a method based on potential flow theory and dispersion is assumed to be well represented by Gaussian (bell-shaped) curves calibrated using the onsite tracer plume simulations. The primary difference between the local and regional models is in the area of removal processes. On a regional scale, it is not appropriate to assume, as is done for the local scale, that contaminant removal mechanisms (chemical transformation and dry deposition) are not important. Therefore, the regional model incorporates algorithms to simulate these processes.

While the Gaussian plume formation is generally not intended for regional scale applications, the low density of meteorological monitoring stations in the area favors the use of this relatively simple approach over more sophisticated numerical models which require more input information. To compensate for the uncertainty associated with the application of a Gaussian model for regional scale calculations, model input parameters were selected to ensure that conservative air quality predictions would result.

The meteorological input to the model consists of an annual wind rose developed from 700 millibars (mb) (about 30 000 m MSL) and winds measured twice daily at Vernon, B.C. The terrain elevations of receptors out to 100 km (modified to ensure that concentration predictions for valley locations are conservative) are also input to the model as well as plant emission characteristics. All regional modelling was performed using the base-load uncontrolled emission parameters presented in Table 4.1-2 (Section 4.1.1(b)(i)) and a stack height of 366 m. Since the calculated concentrations and deposition rates beyond 25 km presented in the following section are extremely small, the modelling was not repeated for all three sulphur dioxide control strategies. It is expected that concentrations and deposition rates for the 244 m stack would be about 50 percent higher than those predicted for the 366 m stack. However, in view of the small concentrations predicted for the 366 m stack, this increase would not be significant.[7]

B. Ground-Level Concentrations

Only long-term (seasonal and annual) concentrations and deposition rates were computed on the regional scale. The following sections present a summary of the ambient concentration results for SO_2, $SO_4^=$ (Sulphate), NO, NO_2, particulates and trace elements. Deposition rates were determined to be less important and therefore complete results are not included in this report. A brief discussion on photochemical oxidants is also presented. A complete set of regional modelling results (both concentrations and deposition) is presented in Appendix C to the Air Quality and Climatic Effects Report.[5]

Sulphur Dixoide and Sulphates

Figures 4.1-7 and 4.1-8 illustrate predicted annual average concentrations of SO_2 and $SO_4^=$. Beyond 25 km, the maximum concentrations for these species are 1.7 and 0.1 $\mu g/m^3$, respectively. Peak annual deposition rates of less than 0.1 $\mu g/m^2/sec$ are predicted for both SO_2 and $SO_4^=$. The locations of the regional scale maxima reflect the highest terrain features and the prevailing upper-level winds over southern British Columbia.

Annual average sulphate concentrations increase with downwind distance to a maximum at approximately 70 to 80 km from the proposed plant because of the slow chemical transformation of SO_2 and $SO_4^{=}$. Beyond 70 to 80 km, the ambient $SO_4^{=}$ concentrations begin to decrease as plume mass concentrations are depleted by diffusion, deposition and chemical reaction process.

Oxides of Nitrogen

The Hat Creek Regional Model was used to calculate regional NO and NO_2 concentrations that would occur because of NO_x emissions from the thermal plant (see Appendix B to the Air Quality and Climatic Effects Report).[8] The model does not simulate the complicated atmospheric reactions that convert NO to NO_2. Therefore, the published results of field studies were used to adjust the emission rates in the model simulations. Because maximum NO_2 to NO ratios of about 4 are observed in powerplant plumes at long downwind distances, it was assumed that 80 percent of the NO_x emissions were in the form of NO_2. These emissions result in peak predicted annual average NO_2 and NO concentrations (beyond 25 km) of 1.0 $\mu g/m^3$ and 0.1 $\mu g/m^3$, respectively. Organic and inorganic nitrate compounds would not be produced in any significant amount by the Hat Creek plume. Annual distributions of NO and NO_2 concentrations on a regional scale are presented in Figure 4.1-9 and 4.1-10 respectively.

Particulates and Trace Elements

The regional effects on air quality due to the emissions of particulate fly ash and trace elements were calculated by ERT from the emission rates presented in Table 4.1-2 (Section 4.1.1(b)(i)). Regional annual average particulate concentrations above background levels are presented in Figure 4.1-11. The maximum concentration beyond 25 km was calculated to be approximately 0.2 $\mu g/m^3$. Concentrations of trace elements can be calculated from the particulate isopleths by scaling predicted particulate values by the ratio of the emission rate of the trace element to the particulate emission rate. Trace element concentrations are scaled to the particulate values in the regional modelling rather than the SO_2 values (as was the case in the local modelling) because chemical transformations are incorporated in the SO_2 modelling which are not appropriate for the trace elements.

Photochemical Oxidants

Powerplant plumes have been observed to produce a net increase in photochemical oxidant concentrations only in highly polluted urban areas with significant ambient concentrations of reactive hydrocarbons. These compounds are necessary precursors to the formation of photochemical oxidants (see Appendix B to the Air Quality and Climatic Effects Report).[8] Because background reactive hydrocarbon levels are expected to be very low in the Hat Creek Region, the thermal plant would not produce oxidants. In fact, any oxidants in the atmosphere would be depleted by the Hat Creek plume for several tens of kilometres downwind because the excess NO in the plume at these close-in distances would react with the O_3 to produce NO_2 and O_2.[7]

C. Cumulative Effects of the Project and Other Sources

The Hat Creek Project would be located in an area which would be isolated from major industrial sources of sulphur oxides, nitrogen oxides and particulate matter. However, since there are industrial sources located within 100 km of the project, the potential interaction of the emissions that would be produced by the Hat Creek plant and other industrial emissions was considered by ERT.[7] Assuming base-load, uncontrolled emissions, Hat Creek would produce approximately 324 768 kg/d of SO_2, 207 248 kg/d of NO_x and 40 000 kg/d of particulates (Table 4.1-2), which would be added to the emissions from the existing sources and other planned sources discussed in Part Three, Section 3.2.2(a). However, the results of the regional modelling analysis discussed in previous subsections demonstrated that Hat Creek stack emissions would produce extremely low ambient concentrations at large downwind distances. The meteorological conditions conducive to the long-range transport of the Hat Creek plume are such that the plume would have to be transported in elevated stable layers in the atmosphere. Under these conditions, any impact would therefore be confined to elevated terrain locations. Because other existing and proposed industrial sources[10] are located in river valleys, or at least at elevations well below the Hat Creek powerplant site, it would be expected that the incremental effect of the Hat Creek plume would not produce any significant cumulative concentrations of air contaminants within the impact ranges of these sources. Local industrial sources would be the dominant contributors to ambient levels in their own environs.

(c) Effects on Climate

(i) Evaluation Methodology

Potential effects of the powerplant air contaminant emissions on climate including acid rain, visibility degradation and a number of other mesoscale (local and regional) and global scale effects have been investigated. Using various methodologies based upon state-of-the-art data and techniques, ERT developed estimates of the climatic effects of the Hat Creek Project.[11]

Acid rain is a complex phenomenon which has only recently begun to receive much public attention. Most experimental evidence of acid rain has been developed in Scandinavian and eastern North American areas which are frequently downwind of very large industrial regions. Published reports on this topic consist primarily of reports of measurements. No discussions or modelling techniques to estimate pH change due to a point source such as the proposed Hat Creek powerplant were found by ERT in the literature. Hence, the evaluation of the potential for acid precipitation as a result of this project was conducted primarily using qualitiative estimates based on material contained in the literature. ERT did estimate local and regional precipitation pH changes through a modelling technique (see Appendix B to the Air Quality and Climatic Effects Report)[8] which utilized the results of chemical analyses of snow samples and predicted ambient sulphur dioxide and sulphate concentrations. However, because of the uncertainties involved, the results should be used to provide qualitative rather than quantitative indications of potential precipitation pH changes.

The visibility degradation analysis conducted by ERT is based on the application of the linear theory of visual acuity to visibility reduction by particulates in the air. This approach (discussed in detail in Appendix B to the Air Quality and Climatic Effects Report)[8] is based on the following assumptions: the eye-brain system is nearly linear in its response to light stimulus; all objects can be defined in terms of sinusoidal light patterns given in cycles per angular degree of arc; and the light scattering coefficient is proportional to the mass concentration of particulates in the air. Local visibility degradation was assessed by this technique. Regional visibility effects and plume opacity were estimated by less sophisticated techniques, based on a literature survey.

Other climatic parameters which would conceivably be modified by the operation of the proposed facility are divided into two groups depending on the scale of the potential alteration. On a global scale, the atmospheric temperature structure and energy balance, as well as the chemical composition of the stratosphere, were examined. The mesoscale factors examined include precipitation amount, temperature, relative humidity, snow-cover persistence and depth, growing season and wind flow patterns. The evaluation of effects of the proposed project on these parameters was conducted through an extensive literature survey and through the use of analytical techniques where appropriate. Appendix E to the Air Quality and Climatic Effects Report[11] contains the results of these analyses.

The most significant findings for those meteorological parameters that would be primarily affected by emissions from the plant are discussed in later paragraphs of this section. Effects due to the cooling towers and mining activities are discussed separately is Section 4.1.2(a) and 4.1.1(c), respectively.

(ii) Acid Rain

Current interest in the topic of acid precipitation stems primarily from numerous published reports of steadily increasing acidity in rain and snow samples collected in Scandinavia and eastern North America. Widespread precipitation pH reductions are associated primarily with long-range transport of contaminants (SO_x and NO_x) to these areas from large, highly industralized regions. Obviously, the effects of a single stack source would produce considerably smaller effects. Only the precipitation actually passing through the Hat Creek powerplant plume or precipitation formed in clouds affected by the plume would experience any change in acidity. The area affected by the modified precipitation in any one precipitation event would be small in comparison with the overall area subjected to rainfall or snowfall, although over the course of a full year, the total area upon which some modified precipitation falls could be significant. Snow is apparently only about one-fourth as effective as rain in scavenging air contaminents from a stack plume.[8] Since almost half of the precipitation falling in the Hat Creek Valley is snow, one would expect that precipitation acidification due to the Hat Creek powerplant plume would occur primarily in the summer.

Appendix B to the Air Quality and Climatic Effects Report[8] includes a discussion of published accounts on acid precipitation and the chemical and physical processes responsible for the phenomenon. On the basis of experience near other coal-fired powerplants, it was concluded by ERT[7] that short-term decreases in precipitation pH values would occur beneath the plume within about 20 km of the plant site during typical summer showers. Calculations were based on: 1. conservative assumptions, i.e., complete absorption of sulphur oxides and complete dissociation of sulphuric acid within the precipitation; 2. model-predicted increases in the ambient levels of SO_2 and sulphates; and 3. results of chemical analyses of snow samples taken in eastern British Columbia which indicated that precipitation pH reductions could also occur in limited areas beneath the plume during short-term episodes out to 100 km from the plant. According to the analysis, precipitation pH reductions should be more significant close to the plant than at large distances because SO_2 scavenging would be relatively more important than sulphate scavenging. As indicated in Section 4.1.1(b), SO_2 concentrations would be highest close to the stack, whereas sulphate concentrations would be expected to reach a maximum at approximately 70 to 80 km from the plant. However, the extent and magnitude of these effects are extremely difficult to predict. A monitoring programme is recommended to ensure that potential problems due to acid rain are identified at an early stage.

(iii) Visibility

Modern electrostatic precipitators would curtail particulate emissions to a maximum value of 0.23 gram per standard cubic meter of stack gas. This concentration corresponds to a plume that would be slightly visible, but the relatively narrow width of the plume and natural wind variability would preclude any appreciable decreases of visibility within about 25 km of the stack. However, sulphate aerosols, slowly generated by SO_x in the plume and the small fraction of other particulates that remain suspended for extended travel distances would cause some reduction in visibility on a regional scale. It has been estimated that these aerosols would reduce visibility by about 6 percent on an annual basis.[7]

(iv) Other Climatic Effects

A. Global Scale Effects

Based on the literature review described in the methodology section above, ERT concluded that the project would have no appreciable effect on the atmospheric temperature structure or energy balance. This conclusion was based on the fact that the project's discharge of heat, moisture, particulates and gaseous contaminants is very small compared to world-wide natural and anthropogenic emissions. Likewise, it was concluded that the chemical and radiative processes governing the composition of the stratosphere would not be appreciably altered as a result of the project.[11]

B. Mesoscale (Local and Regional) Effects

The possibility of precipitation enhancement as a result of the particulate emissions from the plant was investigated through a literature survey. The particulate matter could act as condensation nuclei and affect cloud and precipitation formation. However, studies of the effects of this particulate matter on precipitation augmentation have concluded that precipitation amounts resulting from such emissions are very small compared to natural amounts (less than one percent on an annual basis). The stack plume could, however, help initiate the formation of small clouds on occasion.

Thermal alterations would be expected more as a result of cooling tower effluents than as a result of the stack plume. Potential temperature changes as a result of plant operation as well as potential changes in local relative humidity conditions are summarized in Section 4.1.2(a)(vi), concerning the climatic effects of the cooling tower system.

The plant is also expected to have little or no effect on the growing season, snow-cover persistence and depth and wind flow patterns (except in the immediate vicinity of the plant structure). These topics are discussed in detail in Appendix E to the Air Quality and Climatic Effects Report.[11]

(d) Effects on Human Health

(i) Recommendations for Primary Air Contaminant Ambient Air Quality Achievement Guidelines

Table 4.1-7 summarizes recommendations for ambient air quality achievement guidelines for the five commonly occurring atmospheric contaminants. Comprehensive review of the toxicological and epidemiological data base for these five common atmospheric contaminants leads to the conclusion that the recommended achievement guidelines are completely protective of human health. In some cases, no recommendation has been made for an achievement guideline due to an insufficiency of health data.

(ii) Comparison of Ambient Air Quality Criteria to Recommended Public Health Guidelines

A. Sulphur Dioxide

The recommended ambient air quality achievement guidelines for the Hat Creek Project are 300-400 $\mu g/m^3$ for the 24-hour average and 90-100 $\mu g/m^3$ for the annual average. No one hour average guideline is recommended. Compliance with British Columbia Level C[2] and the Canadian Federal "maximum acceptable guildelines"[13] is sufficient based on public health concerns.

B. Suspended Particulate Matter

Based on published data, a 24-hour guideline of 150-400 $\mu g/m^3$ and an annual guideline of 60-100 $\mu g/m^3$ are recommended to protect public health. A great deal of uncertainty exists regarding the potential toxicity of related particulate borne contaminants and efforts to achieve values in the lower end of the concentration range would be desirable.

C. Nitrogen Oxides (as NO_2)

Currently, health data suggest that a short-term (1-2 hour) range of 2000-3000 $\mu g/m^3$ would be appropriate to protect public health. However, because these data are so limited, a guideline is not recommended.

The most appropriate nitrogen guideline relates to long-term annual exposure. In this regard, achievement of nitrogen oxide concentrations of 100-200 $\mu g/m^3$ as an annual average is recommended to protect public health. Clearly, as for all contaminants, efforts should be directed toward the lower limit of the concentration range but the health benefits of achieving ambient concentrations below this range cannot be quantified. Compliance with the Canadian Federal "maximum acceptable" guideline[13] would be sufficient to protect public health.

D. Carbon Monoxide

A 1-hour carbon monoxide guideline range of 40-60 mg/m^3 and 8-hour guideline of 15-20 mg/m^3 are recommended. This contaminant has many diffuse physiological effects in particularly susceptible population subgroups and all efforts should be made to achieve concentrations in the lower end of the range. Compliance with British Columbia Level C[2] or the Canadian Federal "maximum acceptable" guideline[13] would be more than sufficient to protect public health.

E. Oxidants (as O_3)

Based on the review of existing health data, the recommended guideline for oxidants is the concentration range of 150-300 $\mu g/m^3$ for short-term (1/2-2 hour) exposure. Because of its reactive potential, every effort should be expended to maintain the lowest practicable concentration in this range.

Insufficient data exist to quantify the adverse effects of oxidant exposures for the 24-hour and annual time durations and it is premature to recommend guidelines for these two averaging periods. Compliance with the Canadian Federal "maximum acceptable" guideline[13] would be sufficient to protect public health.

The health data base was found to be lacking with respect to sulphur dioxide exposures for 1-hour duration, nitrogen oxides exposure for 1-hour and 24-hour durations and oxidant exposures for 24-hour and annual exposures. For these cases guidelines could not be recommended. Specifically, several deficiencies were noted. No studies have been conducted with sulphur dioxide at concentration ranges more common to the ambient air objectives for the 1-hour averaging time to quantify an effect-dose response. The limited short-term sulphur dioxide exposure data which exist, were derived primarily from occupational exposure studies and in these cases concentrations were an order of a magnitude greater than those set forth in existing 1-hour objectives. These data cannot appropriately be used to establish a defensible ambient air quality objective for 1-hour exposures to sulphur dioxide.

Insufficient data on nitrogen oxides exist upon which to support the recommendations of 1 hour of 24-hour guidelines. This condition arises largely because community studies focused on long-term effects. As with sulphur dioxide, the data derived from the occupational exposure studies cannot be directly extrapolated because they would invariably dictate guideline concentrations which would be unrealistically high.

The situation relative to oxidants is the antithesis of what is observed with nitrogen oxides; namely the fact that the primary concern has been for short-term effects with little concern for long-term oxidant exposures. As such, community studies have assessed the adverse health effects induced by peak oxidant exposures during 1 to 4 hour intervals. These studies form the bulk of our health knowledge relative to this contaminant. As a result, it is not possible at this time to establish guidelines for either 24-hour or annual averages. This concern with short-term exposures to the exclusion of other time periods derives from the fact that historically episodes of high ambient concentrations of oxidants have always occurred over short time periods.

All of the standards of objectives of the jurisdictions reviewed are more than adequate to protect public health. Of the contaminants studied, standards for suspended particulates are in close agreement with the recommended guideline range. This indicates that the standards set for suspended particulates are based primarily on human health considerations. Standards for the other contaminants are somewhat more stringent than the recommended health based guidelines. This situation is most likely the result of other factors, such as contaminant effects on vegetation, considered when these standards were established.

(iii) Health Risk Assessment for Trace Contaminants

Specific emission rates or ambient air quality controls for trace contaminants are not recommended for the Hat Creek Project. In view of the present knowledge of the effects of trace elements on public health, no adverse health risk is foreseen from the proposed Hat Creek powerplant. For gaseous fluorine, the predicted maximum 24-hour average ground level concentration is approximately one half of the most stringent ambient air quality objective. For the remaining trace elements, the predicted 24-hour average ground level concentration when compared with various North American ambient air quality objectives has shown that acceptable ambient levels are at least ten times higher than the levels predicted from the proposed Hat Creek powerplant. Epidemiological studies which relate morbidity to either suspended sulphate or nitrate exposure are considered inadequate to promulgate ambient air standards. It is not possible at this time to assess conclusively their impact on human health.

No recommendations are made for polycyclic organics or nitrosamines. Although several members within the class of polycyclic organic matter, including benz-a-pyrene and 3-methylcholanthrene, have been implicated as mutagens and carcinogens, the necessary epidemiological studies have not been conducted. It remains to be proven that these compounds, as encountered in the atmospheric environment, contribute to the incidence of cancer in humans. There is no evidence to suggest that nitrosamines are produced by the combustion of fossil fuels. While the formation of nitrosamines does require sources of both nitrogen oxides and organic amines, no potential sources of amines have been identified in the region of the Hat Creek Project. Therefore, nitrosamines would not be expected to appear as either primary or secondary contaminants.

A. Arsenic (As)

The maximum predicted 24-hour concentration of arsenic that would be expected from the Hat Creek powerplant is 0.024 $\mu g/m^3$.[6] Therefore, no risk to the public health is foreseen relative to atmospheric arsenic that would be emitted from the Hat Creek Project powerplant.

B. Beryllium (Be)

The predicted 24-hour maximum ground level concentration, that would be due to the Hat Creek Project, is 0.00083 $\mu g/m^3$.[6] When this value is compared to emission limits, no risk to the public health is foreseen from this potentially hazardous element.

C. Cadmium (Cd)

The predicted 24-hour maximum ground level concentration of cadmium that would be due to the Hat Creek Project is 0.00024 $\mu g/m^3$.[6] This level should cause no risk to human health.

D. Chromium (Cr)

In Canada, no agencies have suggested safe ambient levels for chromium. The predicted 24-hour maximum ground level concentration for chromium that would be due to the Hat Creek Project is 0.0029 $\mu g/m^3$.[6] No risk to the public health is predicted at this level.

E. Copper (Cu)

Copper is not generally considered to be an extremely toxic element in the concentrations normally encountered. The predicted 24-hour maximum ground level concentration of copper that would be due to the Hat Creek Project is 0.0012 $\mu g/m^3$.[6] No adverse health effects are predicted for the Hat Creek Project.

F. Fluorine (F)

Atmospheric standards for fluorides are difficult to set. The predicted 24-hour maximum ground level concentration for particulate fluoride that would be due to the Hat Creek Project is 0.032 $\mu g/m^3$.[6] This concentration should not present

4.1 POWERPLANT - (Cont'd)

a public health risk. The predicted 24-hour maximum ground level concentration of gaseous fluorine is 0.332 $\mu g/m^3$. This is approximately half of the maximum allowed by Ontario. No adverse health impact is predicted due to gaseous fluoride.

G. Lead (Pb)

The predicted 24-hour maximum ground level concentration of lead for the Hat Creek Project is 0.0095 $\mu g/m^3$.[6] This value is well below suggested standards and no risk to the public health is predicted.

H. Manganese (Mn)

The predicted 24-hour maximum ground level concentration of manganese that would be due to the Hat Creek Project is 0.0055 $\mu g/m^3$.[6] This value is far below any level at which adverse human health effects may result.

I. Mercury (Mg)

For the Hat Creek Project, the predicted 24-hour maximum ground level concentration for particulate mercury is 0.0075 $\mu g/m^3$.[6] This level would pose no threat to public health. Similarly, the gaseous portion of the mercury emissions would pose no threat to public health.

J. Nickel (Ni)

The predicted 24-hour maximum ground level concentration of nickel that would be due to the Hat Creek Project is 0.0039 $\mu g/m^3$.[6] No adverse health conditions are predicted.

K. Selenium (Se)

The predicted 24-hour maximum ground level concentration of selenium that would be due to the Hat Creek Project is 0.00021 $\mu g/m^3$.[6] No risk to public health is predicted. Similarly, potential gaseous emissions of selenium present no risk to public health.

L. Uranium (U)

Uranium is a highly dangerous element relative to human health due to its toxicity and radioactivity. For the Hat Creek Project, the predicted 24-hour maximum ground level concentration of uranium emitted through coal combustion is 0.0011 $\mu g/m^3$.[6] Based on a specific radioactivity of uranium of 6.77×10^{-1} μcurie/gm,[6] this uranium emission is equal to about 7.5×10^{-16} μcurie/ml. This level is far below the U.S. standard and no adverse health risk is predicted.

4.1 POWERPLANT - (Cont'd)

M. Vanadium (V)

The toxicology of vanadium is not extremely well known and thus agreement has not been reached as to its significance as a contaminant. Relative to present standards, the Hat Creek Project would present no risk to the public health through vanadium emission since the predicted 24-hour maximum ground level concentration of vanadium is 0.00015 $\mu g/m^3$.[6]

N. Zinc (Zn)

Relative to the other trace elements discussed in this document, zinc is less toxic. This maximum ground level concentration predicted value for the Hat Creek Project is 0.0083 $\mu g/m^3$.[6] No adverse health risk is predicted.

O. Polycyclic Organic Matter (POM)

An association between ambient levels of POM and adverse health effects has not been scientifically validated and no regulations for POM at ambient concentration levels have been promulgated. Therefore, no health risk assessment is made for the Hat Creek Project with respect to POM.

P. Suspended Sulphates (SO_4)

The controversy surrounding suspended sulphates resulted in the adoption of an ambient air quality standard (AAWS) for sulphates by only three states in the U.S.A.; no objectives have been adopted in Canada. Relative to the existing standards, the predicted maximum 12-hour average ambient concentration of 0.6 $\mu g/m^3$ for the Hat Creek Project should present no health risk.

Q. Suspended Nitrates (NO_3)

The current data base with respect to human health response to the inhalation of suspended inorganic nitrate is inadequate. However, the current data base does not suggest that suspended inorganic nitrates present a significant health hazard to humans.

R. Nitrosamines (NNA)

Coal-fired powerplants are not recognized as primary sources of nitrosamines. In addition, there is no source of amines in the region of the proposed Hat Creek powerplant. Therefore, nitrosamine formation in the atmosphere due to potential mixing and reaction between emission plumes is not expected. No public health risk is anticipated.

4.1 POWERPLANT - (Cont'd)

(iv) Conclusion

Based upon the results of the epidemiological literature review and the predicted ground level concentrations for both primary and trace contaminants, no adverse health impacts would be associated with operation of a thermal generating station at Hat Creek. Ambient concentrations of all contaminants would not exceed levels required to protect human health and in most cases the concentrations would be substantially below the respective guidelines.

(e) Effects on Terrestrial Wildlife

(i) Primary Air Contaminants

Combustion products represent the most significant potential impact source from the plant. Stack emissions, cooling tower drift, ash and waste disposal products have been analyzed with regard to their potential for wildlife damage. Of the stack emissions, sulphur dioxide (SO_2), oxides of nitrogen, hydrocarbons, carbon monoxide, ozone particulates and trace elements have been evaluated and would not be expected to result in measurable wildlife injury through habitat modification (e.g., loss of cover or food species), inhalation, ingestion, etc. Fluorine analyses were not available at the time of this writing. These conclusions are based on current state-of-the-art knowledge for these contaminant effects. Long-term subtle effects may yet be discovered.

The primary effects on vegetation and wildlife would arise from SO_2 and NO_2 ground level concentrations. If the 366 m stack height and flue gas desulphurization system is employed, certain species such as Pleurozuim schreberi and Salix spp. would be severely but locally affected by airborne contaminants. These species are, however, only components of larger more diverse and resistant habitats. Consequently, the indirect effects of habitat modification on wildlife should be nominal. A total of 23.4 km^2 would possibly be affected by this control technique. If the meteorological control system (MCS) is used on the same stack approximately 238 km^2 would may be measurably affected. If the MCS approach is used on a 244 m stack height, about 324 km^2 would be disturbed. Each of these latter predicted impacts would affect a wide variety of vegetation associations within a 25 km radius of the site. Some associations such as the Englemann Spruce Grouseberry are not sensitive to predicted levels of air contaminants; however, associations such as the Willow Sedge Bog would be sensitive to these levels and this would adversely affect wildlife populations through loss of food and cover resources. The air quality impact predictions are based on worst case conditions which would not likely occur. The more probable position is that vegetation effects would be much less than those projected. Subsequent indirect affects on wildlife would be directly related to any vegetation stresses.

(ii) Trace Elements

A. Sensitivity

Arsenic (As) causes a wide range of pathological changes including gastrointestinal (GI) and respiratory tract inflammation, skin lesions, degeneration of organs, hemorrhaging and lung congestion.[14] It has also been shown to be carcinogenic.[15] Water is the most frequent mode of ingestion since As usually does not accumulate in above ground vegetation. Concentrations of 0.4-10 ppm may be toxic to man, 13 ppm to livestock and 100-160 ppm to bitterling, minnows and carp.[16,17] Prolonged exposure to levels as low as 27 ppm may be lethal to minnows.[18] Arsenite (As^{+3}) is the most toxic form of arsenic, followed by arsenate (As^{+5}) while elemental As is much less toxic to animals.

The toxicity of cadmium (Cd) varies greatly between organisms. Some species are highly sensitive (e.g., horses,[19] rainbow trout[20] and aquatic invertebrates)[21] while others exhibit relatively high tolerances. Mammals tend to accumulate Cd in the liver and kidney and may, consequently, exhibit chronic symptoms.[18] Cadmium's primary toxic effect is on respiratory oxygen exchange. It has also been shown to affect reproductive potential,[22] DNA replication in chromosomes,[23] and haemoglolin production.[24] Levels of 9.9 ppm Cd in grass may be lethal to horses while as little as 0.0015 ppm in water could cause toxic effects on rainbow trout.[20]

Chromium (Cr) is relatively toxic to animals causing corrosion of the GI tract, neoplasms[25] and kidney lesions.[26] Hexavalent Cr is the most toxic form, although, lethal levels are poorly established. Low level chronic exposure may be more toxic than acute exposures in fish.[6] Mammals have also been shown to suffer from chronic exposure to 5 ppm in drinking water.

Although copper (Cu) is an essential element to animals, it can be lethal in excessive concentrations. Lethal concentrations range from 0.006-0.012 ppm for aquatic invertebrates,[27] 0.1 ppm for fish,[6] 725 ppm for sheep and 2000 ppm for rats.[15] Man may exhibit toxic symptoms on a diet including 330 ppm/day.[6] Excess Cu is accumulated in the liver and is usually eliminated in bile or urine.[28]

Excessive dietary fluoride (F) may interfere with calcium metobolism, enzymatic processes, normal cellular respiration and the immune biological response of the animal to certain diseases.[29] Physical symptoms include dental defects, bone deformation and mineralization of tendons. Forty to sixty ppm may cause weight loss in cattle.[30] Fluoride is accumulated in bones and teeth and consequently is rarely transferred up the food chain.[31]

In animals, lead (Pb) may be taken in by inhalation, ingestion and in the case of organic forms of Pb, by dermal translocation.[18,32] Symptoms of Pb poisoning include derangement of the central nervous system, gastrointestinal tract, musculature and the haemopoietic system.[33] Lead poisoning may also result in infertility,[34] cancer[25,35] and decreased resistence to infection.[36,37,38,39] The maximum safe value for portable water for animals is 0.5 ppm.[29] The World Health Organization drinking water standard is 0.05 ppm.[36] Fish exhibit great variation in their ability to tolerate Pb but, in general, 2.8 ppm and 0.1-50 ppm[16,29] in water are considered to be lethal to fish.

Mercury (Hg) may be ingested or inhaled by animals and is accumulated in the kidneys, liver, hair and other tissues. Organic Hg attacks the nervous system and impairs immunological responses and reproduction. As much as 50 percent of the Hg emitted from coal combustion may find its way to aquatic systems where 99 percent of it accumulates in sediments.[40] Dissolved concentrations of about 1 ppm are fatal to fish. Toxicity for all animals varies with the chemical form of Hg ingested. As little as 1-3 ppm of $HgCl_2$ has been shown to cause egg shell thinning in birds.[41]

Vanadium is a relatively non-toxic metal to animals.[16] *In large concen*trations (25-150 ppm) some forms of vanadium can suppress weight gain,[35] cause gastrointestinal irritation,[42] or increase mortality.[15,28]

Zinc (Zn) is an essential trace element for animals.[28] Zinc is relatively non-toxic to birds and mammals and a wide margin of safety exists between normal intakes and those likely to produce deleterious effects. Fish may be susceptible to zinc toxicity at concentrations varying between 0.14 to 7.21 ppm depending upon water hardness, temperature and growth stage.

B. Assessment

Arsenic concentrations in Hat Creek small mammals ranged up to 3.67 ppm.[6] These are generally above values reported in the literature.[43] Levels found in Hat Creek fish ranged from 0.07 to 2.3 ppm,[6] far below toxic levels. Stack emissions are very unlikely to significantly affect concentrations in living organisms since background soil levels range up to 170 ppm without adversely affecting existing organisms on the site.

Cadmium levels in Hat Creek and vicinity may be of some concern to fisheries since existing Cd levels in Hat Creek and Bonaparte River averaged 0.0013 ppm. Although Davies and Goettl[20] state that 0.0015 ppm could cause toxic effects to small rainbow trout more conservative estimates of toxic levels range from 0.003 to 0.01 ppm.[20,44] Cadmium fallout (Table 4.1-8) is not expected to cause ambient levels to rise into this range.

Existing chromium levels are relatively high in some soils (up to 530.0 ppm) and stream sediments (526.67 ppm) compared with published data.[6,26,43] Concentrations in water samples are far below those shown to cause toxicity symptoms and stack fallout would be insignificant as compared to existing exposure levels.

Measurements of existing copper (Cu) levels were extremely variable reaching a high of 171.67 ppm in one sample of small mammals. Although this is above the normal values reported in the literature,[15,43] it is far below the levels at which toxic symptoms occur. Stack emissions of Cu would not significantly affect fish or wildlife in the area.

Levels of fluoride in Hat Creek receptors, while higher than literature values for some soil, stream sediment and grass samples, are well below those known to cause toxicity. Fluoride would be a major constituent of stack emissions, however, projected accumulations (Table 4.1-8) would not likely cause toxicity in animals in the vicinity of the site.

Except for high lead (Pb) levels in water and small mammal samples, Pb concentrations in Hat Creek receptors are similar to values reported in the literature.[15,28,36,43] No Pb level in any receptor presently approach a toxic concentration and fallout from stack emissions would not likely increase these levels in terrestrial or aquatic organisms.

Concentrations of mercury in Hat Creek fish and small mammals appear to be of the same magnitude as levels in other studies.[6] Projected stack emissions are relatively low (Table 4.1-8) and would have a negligible impact on existing mercury levels.

Levels of vanadium in Hat Creek receptors were similar to literature derived values.[6] Vanadium is generally non-toxic to animals and stack emissions would be expected to have no adverse impacts on existing wildlife.

Zinc levels varied widely in Hat Creek receptors but were, for the most part, similar to values reported in the literature.[6] Because of the broad tolerance range exhibited by most organisms, zinc emissions from the stack would be unlikely to cause any impacts on wildlife.

(f) Effects on Terrestrial Vegetation

(i) Vegetation Injury Assessment Methodology

The rationale employed to assess the vegetation injury that would result from each of the proposed air quality control strategies (AQCS) is based upon the assumption that the air emissions from the Hat Creek Project would constantly occur in mixtures. The levels of SO_2 and NO_2 predicted by ERT for each AQCS[5] would occur in a ratio of approximately 3:1. Sulphur dioxide synergism would be possible at this ratio and at the predicted ambient SO_2 and NO_2 concentrations. Thus, the effects on vegetation were not evaluated for SO_2 individually but in combination with NO_2. The impact of SO_2 was assumed to be enhanced 50 percent and threshold concentrations reduced by 25 percent in the presence of NO_2 at the concentrations predicted by air quality modelling.

The method used to evaluate the projected emission levels was closely related to the locations of receptor points used by the ERT modelling programme.[8] The maximum concentrations for each of the air quality control strategies (AQCS) were evaluated at each receptor site and used to develop a general pattern of the predicted SO_2 concentrations within the project area. Seasonal peak concentrations and frequency isopleths were constructed and overlaid on vegetation maps to determine which vegetation types would be exposed to adverse SO_2 concentrations. Areas of vegetation associations that would be affected were determined by assuming a definite area around each receptor point, which varied according to the distance of the point from the assumed stack location. The area of vegetation association that would be affected was assumed to be equal to the land area determined for each receptor point.

The percentage of vegetation types within each association was determined and then used to compute the area of each vegetation type that would be affected in the vicinity of each receptor site. Sensitivity tables for SO_2/NO_2 were constructed for all plant species encountered within 25 km of the project (project locale).[45] The values presented in these tables take into account the responses of individual species to the different components of the emissions as well as the factors which modify the results.

(ii) Sensitivity

Injury to vegetation from exposure to toxic air contaminant levels can be either acute or chronic. Acute injury usually occurs as the result of a short-term exposure to high concentrations, while chronic injury may result from exposure to low concentrations over long periods of time. The term injury, as opposed to damage, is generally used to describe all plant responses to air contaminant exposures, and would include reversible effects on metabolism, physiological processes, necrosis, senescence and growth and development modifications. This definition of injury will be used in the context of this report. On the other hand, damage is used to define those effects which would reduce the value of the plant for its intended use, be it economic or ecological. The bulk of the work reported in the literature on air contaminant effects addresses acute responses, simply because experimentation with acute injuries is easier, less time consuming and yields the most conclusive and dramatic results. Another factor contributing to the dearth of data on chronic effects is the difficulty of ascertaining the effects of chronic exposures due to the long experimentation times required and the ability of plants to utilize or tolerate low concentrations of contaminants.

Air quality standards are developed as a means of compromise between complete vegetation protection from air contaminants and the economics required to achieve this goal. Available information on the effects of air contaminants on vegetation comprises the data base upon which standards are developed. However, as noted by Jacobsen,[46] compliance with standards does not ensure complete vegetation protection. Further, current standards are developed on the basis of single pollutants, while it is well established that different pollutants may interact with each other and elicit a biological response.

Threshold concentrations of toxic air contaminant levels are the lowest concentrations which cause deleterious effects to foliage. It is difficult to assign definite threshold concentrations to particular species for a number of reasons. Species, varieties, cultivars and even individual plants react differently to a given air contaminant independently of any external environmental factors which may affect susceptibility. The developmental stage of a plant, as well as nutrient supply and time of exposure during the day, largely determines the degree of sensitivity. The overall complexity of plant responses to air contaminants, especially when mixtures of air pollutants are involved, also negates the value of threshold concentrations. However, investigators must have some point of reference from which assessments of impacts can be generated.

A. Sulphur Dioxide

Sulphur is an essential plant macronutrient, which is required in relatively large quantities. Sulphur is obtained by plants primarily through root absorption of sulphate present in the soil. Some plants have been found to receive a portion of their sulphur requirements through direct foliar absorption of SO_2.[47] However, most plants exposed to SO_2 may suffer acute injury when absorption rates exceed the metabolic capability of foliar tissue to oxidize SO_2 to the less toxic sulphate ion.[48,49] Acute injury is typically manifested by localized interveinal necrosis on broad-leafed species[50] and by necrotic bands on needle tips and premature needle abscission on conifers.[51]

Generalized threshold concentration values have been developed for SO_2.[46,52] These values are based on interpretations of work performed by a number of individuals and thus should not be viewed as finite entities with a wide range of application. Threshold concentration curves as plotted from these values[52] for sensitive, intermediate and resistant species are presented in Fig. 4.1-12. A summary listing of estimated threshold SO_2 concentrations for visible injury to sensitive plant species from several sources is presented in Table 4.1-9. The responses to SO_2 of certain tree species common to the Hat Creek area are summarized in Table 4.1-10 and herbaceous species in Table 4.1-11. The information presented is by no means complete since only a small fraction of the species found in the Hat Creek region have been studied and the results reported in the scientific literature.

B. Nitrogen Dioxide

Nitrogen dioxide is one of the two most significant gases in the nitrogen oxide group which are produced during high temperature combustion. High concentrations of NO_2 are capable of causing injury to vegetation. Acute injury symptomology is typically manifested as water soaked lesions, which first appear on the adaxial leaf surface. The lesions disperse with time throughout the leaf causing necrotic patches. These patches are usually white to tan in color and strongly resemble SO_2 injury symptoms.

Concentrations of NO_2 required to cause visible plant injury are high relative to commonly occurring ambient levels. Thompson et. al.[77] suggest that threshold dosages causing visible injury range from 18 800 - 28 200 $\mu g/m^3$ for one hour, 4324 - 6580 $\mu g/m^3$ for 8-21 hours and 1880 $\mu g/m^3$ for 48-hour exposures. Some typical responses to NO_2 of vegetation indigenous to the Hat Creek area are summarized in Table 4.1-12. This summary is by no means conclusive of all plants upon which investigations have been conducted; however, the plant species indigenous to Hat Creek are are not commonly found in the literature. The concentrations which have been shown to be injurious to vegetation are much higher than the concentrations that would be emitted by the proposed powerplant.

C. Ozone

Ozone is generally considered to be the most injurious air pollutant to vegetation, although it is rarely a problem in the immediate vicinity of a combusition source. Due to the photochemical nature of ozone formation in the atmosphere, effects on vegetation from ozone fumigations are commonly observed some distance from the source.

The most common symptom of ozone injury on many deciduous trees, shrubs and some herbaceous species is small sharply defined dot-like lesions. These lesions may be dark brown, black, purple or red. The injured area is primarily confined to the adaxial leaf surface. The common symptom of most herbaceous species and many woody species is small unpigmented necrotic spots or more general adaxial surface bleaching.[86] Bifacial necrosis and chlorosis are also common injury symptoms. Ozone injury is usually found towards the tip of youngest leaves and over the entire leaf or near the base of oldest leaves. Leaves ranging from 65-95 percent of their full surface area are the most sensitive and are most likely injured in a fumigation incident. Syptoms of ozone injury on alfalfa, a species commonly grown in the Hat Creek area are extremely variable. Adaxial necrosis, bifacial necrosis and chlorosis are common symptoms.[86] Symptoms of ozone injury to ponderosa pine, another species common to the Hat Creek area, has been described as a chlorotic decline.[87] Chlorotic needle mottle symptoms also develop from the tip to the base of older age leaves. These symptoms are generally followed by a necrotic tip die back. The oldest leaves abscise early, while one year old leaves tend to remain on the injured tree.

Threshold concentrations of ozone for most sensitive species are generally considered to be in the range of 98.2 - 235.6 $\mu g/m^3$ for 2-4 hours.[86] Sensitive varieties of alfalfa and oats have been injured by 196.3 - 235.6 $\mu g/m^3$ for 2 hours.[88] Responses to ozone of vegetation typically found in the Hat Creek area are summarized in Table 4.1-13. Only the more commonly occurring species are listed since they are the only ones which have been studied.

D. Fluoride

The potentially injurious effects of fluoride on vegetation have been recognized in the past but losses due to fluoride injury have not become prevalent until recently. Fluoride is emitted as a gas (principally in the form of HF) during the combustion of coal and it is in this form that it may be a potential problem in the Hat Creek area. Fluoride does not appear to have any role in plant growth.[97]

The characteristic symptom of fluoride injury on many broad-leaved plants is necrosis, which occurs predominantly at the leaf tips and margins. A dull gray-green water-soaked discoloration of leaf tip and margin tissues is typical. Symptoms on conifers are similar. Necrotic areas first appear at the tip of the current years needles and then progress toward the base. In general, the young emerging needles are most sensitive and become more resistant with age.

The sensitivity of plants to fluoride, as with other air contaminants, varies considerably with environmental factors. It is generally thought that fluoride injury to vegetation commonly results from accumulation of fluoride in the plant tissue over periods of time.[98] Presumably, sensitive plant species are those that would be injured by low atmospheric concentrations of fluoride or when foliar levels reached a minimal amount. Differentiating plants into categories of sensitive, intermediate and resistant is highly arbitrary since many extenuating factors are involved. As a point of reference, plants which are injured by continuous exposure to 6.65 $\mu g/m^3$ HF or less for 7-9 days are considered to be sensitive.[99] Another investigator found that exposure to 2.1 $\mu g/m^3$ HF for 8 hours per day for 5 days a week in an extended period produced injury symptoms.[100] Clearly, the relationship between sensitivity and levels of atmospheric fluoride levels requires additional work before being utilized to assess impacts. Some typical responses to HF and F of plants common to the Hat Creek area are summarized in Table 4.1-14. Again, this is not a complete listing since many of the species found in Hat Creek have not been addressed in the scientific literature.

Air quality standards for fluoride are not common, primarily because of the degree of difficulty in defining acceptable levels. However, standards have been developed in Oregon to provide a means of protecting stone fruits. The standard was written by a committee of agricultural scientists and its effectiveness is evaluated by an air quality monitoring network coupled with a definite sampling methodology and periodic vegetation surveys. The levels and time periods of this standard are as follows: 4.5 ppb (5.98 $\mu g/m^3$) for 12 hours, 3.5 ppb (4.66 $\mu g/m^3$) for 24 hours, 2.0 ppb (2.66 $\mu g/m^3$) for 7 days, 1.0 ppb (1.33 $\mu g/m^3$) for 30 days, and 0.65 ppb (0.86 $\mu g/m^3$) for the growing season. Information on this standard is presented as a means of comparison and not as a proposed model for the Hat Creek Project.

E. Particulates

There have been few studies conducted on the effects of particulate matter on vegetation. Those studies which have been reported in the literature tend to address the nature of the plant response to particulates rather than injury threshold levels.[109] The effects of particulates on vegetation have been observed to inhibit stomate closure,[110] decrease incoming solar radiation,[109] or interfere with the atmospheric heat balance of the leaves.[111]

F. Acid Rain

Sulphur dioxide and NO_2 may be oxidized in the atmosphere to sulphuric (H_2SO_4) or sulphurous (H_2SO_3) acids and nitric acids (HNO_3).[112] The pH values of rain have been observed to be decreasing over the past 20 years in samples taken in the Northeastern United States. This lowering of the pH has been attributed to coal combustion and the associated accumulation of acids (H_2SO_4,H_2SO_3, HNO_3) in precipitation.[113]

Studies on the effects of acid rain on vegetation have centered on the responses rather than threshold concentrations. Laboratory investigations have tended to simulate application of acid rainfall on vegetation with the intent of eliciting a response. Some of the responses observed include necrotic spotting on yellow birch seedlings[114] and decreased needle length of Scotch pine.[115,116] Other effects due to rain have been postulated as changes in leaching rates of nutrients from foliage and soil and long-term decreases in forest productivity.[113] Clearly, the ecological effects of acid rain are largely unknown.

G. Air Pollutant Mixtures

Gaseous air contaminants are rarely found in isolation. Nitrogen oxides, as well as sulphur oxides are common products of coal combustion. The probability of these two contaminants causing foliar injury has been postulated and is a current topic of concern to many investigators. There have been several reports in the literature that combinations of SO_2 and NO_2, SO_2 and O_3 and SO_2 and HF may act synergistically. In a synergistic response, concentrations of each contaminant at a level below that considered to be injurious can result in visible injury. Typically, synergistic responses occur when the concentration of SO_2 exceeds that of the other contaminants.

The SO_2 threshold values presented in Table 4.1-9 may not apply to ambient levels which contain more than one air contaminant. Plant sensitivity may be increased when plants are simultaneously exposed to SO_2 and NO_2. However, plant responses to mixtures of SO_2 and NO_2 vary widely with species, environmental factors, plant age and dosage. The results of studies of the effects on vegetation from combinations of SO_2 and NO_2 have been summarized by Runeckles.[45] The summation demonstrates that the synergistic effects range from none to a many-fold increase in impact over that from exposure to SO_2 alone. It has been proposed that, based on the SO_2 and NO_2 levels predicted for Hat Creek, a general 25 percent reduction in SO_2 threshold levels and a 50 percent increase in injury over that caused by SO_2 alone would be caused by SO_2/NO_2 synergism.[45] Some typical responses from exposure to SO_2 and NO_2 of vegetation found in the Hat Creek Valley are summarized in Table 4.1-15.

Sulphur dioxide and ozone are the only other air contaminant combination which have been studied in some detail. These studies were designed more to elicit a response rather than determine threshold concentrations. Tobacco, alfalfa, broccoli, radish and soybeans have been investigated. The common finding was that SO_2-O_3 combinations at concentrations similar to those found in urban areas have consistently resulted in synergistic or additive effects.[64] The response of vegetation common in the Hat Creek area to this air contaminant combination is summarized in Table 4.1-16.

Studies regarding the effects due to combinations of SO_2 and HF have been rarely addressed in the literature. Mandel et al[70] found that 7 day exposures of corn to a concentration of 393 $\mu g/m^3$ SO_2 and 0.5 $\mu g/m^3$ HF for 23 days elicited a synergistic response. The level of gaseous fluoride emissions predicted for Hat Creek are a small percentage of SO_2. Based on the evidence available, it would not appear that the gaseous fluoride emissions from Hat Creek would influence the effects of SO_2 alone or in combination.

H. *Trace Elements*

Nine trace elements were selected for detailed study on the basis of existing high concentrations in coal or ash, capability for volatilization during combustion, potential for toxicity, existing high concentrations in Hat Creek receptor materials and existance of regulatory guidelines. These nine elements were analyzed in Hat Creek receptor materials at several sites during three separate seasons and compared to toxic levels or threshold concentrations as reported in the literature. The findings of the literature review are summarized below for each of the elements, with the exception of fluorine which was discussed previously.

Arsenic (As)

In general, As is not considered to be essential for plant growth, although low doses have been found to promote plant growth.[117] Arsenic toxicity in plants is dependent on the concentration of soluble As and not on the total As concentration in soils. The free elemental form is not considered to be as toxic as many of the associated compounds such as arsenite and arsenate.[118] The greatest toxic effect of As appears to be most prevalent at the seedling stage since high As concentrations have been demonstrated to arrest germination and reduce seed viability.[119] Plants generally accumulate As in the roots, especially in the tips of new roots. Arsenic does not typically accumulate in the above ground portion of plants and is not likely to become injested by grazing animals.

Most plants can normally tolerate total As concentrations in soils ranging from 1-40 ppm. Some plants, such as Douglas-fir have been observed to grow well on soils in the vicinity of heavy metal deposits where As concentration are reported to be as high as 8200 ppm.[120] High arsenic concentrations ranging from 3.4-9.5 ppm have been identified as the causal agent responsible for the reduced productivity of orchard soils in the Yakima Valley, Washington. Soil As concentrations greater than 2 ppm, in the soluble form, have been shown in cause damage to alfalfa and barley.[121]

Cadmium (Cd)

Cadmium is not considered to be an essential nutrient for plants.[120,122] It is readily absorbed by plants either from the soil via the roots or from the air via stomata.[123] In general, the effects of toxic Cd concentrations appear to be localized in leaf tissue. Primary effects include a reduction in leaf transpiration and a reduction in net photosynthesis due to a decrease in the total number of chloroplasts. Cadmium toxicity symptoms are usually manifest as either foliar chlorosis or necrosis. Cadmium concentrations of 1 ppm are considered to be non toxic.[117,124] Some depression in growth rates have been observed when Cd concentrations in plant tissue reach 3 ppm. Adverse effects at the organelle level have been noted at Cd concentrations of 2 ppm.

Chromium (Cr)

Chromium is not considered to be an essential element for plant growth.[125] However, the addition of 0.1-0.5 ppm Cr to soils has been noted to stimulate growth of lettuce and corn seedlings.[119] The presence of chromium has also been observed to increase nitrogen fixation in peas.[119]

Chromium toxicity to vegetation is a function of the chemical form, solubility and concentration. Chromium, as chromic or chromate, in concentrations of 8-16 ppm has been found to cause chlorosis in sugar beets grown in sand cultures. Chromate (Cr^{+6}) at concentrations between 0.03 and 64 ppm has been observed to inhibit the growth of algae. Some of the lower plants appear to be able to accumulate large amounts of Cr with no notable symptoms.[125]

Copper (Cu)

Copper is commonly regarded as a macro-nutrient that is essential to plants in large quantities. Copper is an important constituent of plant enzymes and proteins. Plants can accumulate copper, although in most plants, it is stored in the roots where it generally is unavailable to grazing animals. Some grain species have been found to accumulate up to 15 ppm Cu, which may be a hazard to grazing animals.[126] Symptoms of Cu toxicity are exhibited as foliar chlorosis caused by the interference with iron metabolism.[118]

Due to the essential status of copper, agricultural soil deficiencies are more common than toxic situations. Soils high in organic content of a sandy texture require Cu through fertilization. Copper toxicity is considered to be governed by soil pH. Spinach and gladiolus did not show toxicity symptoms from Cu concentrations of 93-130 ppm when soil pH was 4.5 to 4.7.

Some of the species considered to be sensitive to Cu toxicity include: alfalfa, clover, corn, bean and squash.[119] Toxic symptoms in plants can result when Cu concentrations in tissues approach 20 ppm. At concentrations exceeding 40 ppm, snapbeans were found to exhibit severe symptomology. Concentrations in the range of 20-30 ppm are also considered to cause reduced yields in snapbeans. Growth of cauliflower, lettuce, potato and carrots were reduced by 0.5-50 ppm of copper acetate.[127] Seedlings of some grass species (Agrostris s.) appear to develop tolerances to higher than normal Cu concentrations over a period of 10 weeks.

Lead (Pb)

Lead is not considered to be an essential element for plant growth, although it is commonly found in most plants.[117] Lead enters the plant through stomata. As a consequence, the plant organs involved with gas exchange tend to have higher lead concentrations than storage tissues. Organelles such as chloroplasts, mitochondria and nuclei often exhibit high Pb concentrations.

Leaf pubescence also seems to govern the rate of Pb accumulation. Generally, accumulations are higher in leaves with rough or hairy surfaces than in leaves with smooth surfaces. Translocation of Pb within the plant is reportedly low, therefore lead concentrations appear to be highest in leaf tissue.

Lead toxicity affects stomata resistance of plants, which in turn results in a reduced photosynthetic potential.[128,129] Lead ions can reduce CO_2 fixation in isolated chloroplasts which may also reduce photosynthetic potential of whole plants. Lead may also inhibit electron transport and enzyme activity.

Many plants exhibit retarded growth rates when exposed to 10 ppm Pb in solution culture.[117] Damage to french bean plants was noted following exposure to 30 ppm lead sulfate.[118] Lead concentrations of 10 ppm were responsible for reduced root growth in sheep fescue[118] and the growth rate of corn was reduced when nutrient solutions contained 200 ppm Pb.

Some plants such as grape, apple and orange tree seedlings were not affected by Pb concentrations ranging from 150-200 ppm.[119] Plants have also been shown to absorb large amounts of Pb without exhibiting toxicity symptoms. For example, Pb concentrations as high as 350 ppm were measured in stems of shrubs, with no visible injury symptoms. Lettuce has also been found to accumulate as much as 2 ppm Pb without any toxic symptoms.

Mercury (Hg)

Mercury is not an essential element for plant growth. Mercury compounds have been used as seed fungicides. Plants grown from these seeds have been found to contain higher than normal Hg concentrations. In general, Hg is not concentrated in plants growing on normal soils. Soil-bound Hg is typically not available for plant uptake, although many plants cannot prevent uptake of gaseous Hg through the roots.[130] Most higher vascular plants are resistant of Hg toxicity even though concentrations are present in tissues.

4.1 POWERPLANT - (Cont'd)

Mercury concentrations ($HgCl_2$ form) of 0.5-50 ppm were found to inhibit growth of cauliflower, lettuce, potato and carrot plants.[127] In algae, a $HgCl_2$ concentration of 3.5 ppm caused a 98 percent reduction in chlorophyll synthesis and a 50 percent reduction in galactolipid synthesis. The bulk of the studies on Hg toxicity as reported in the literature use algae as test species and the results are not applicable to situations involving higher plants.

Vanadium (V)

Vanadium is not considered to be an essential element for growth of higher plants, although V is thought to be an essential element for algal growth. There are no reports in the literature of either toxicity or deficiency of V to plants growing under field conditions.[119] It has been noted that some species accumulate V without exhibiting toxicity symptoms. Snap bean was found to contain 600 ppm V, cabbage 50 ppm, tomatoes and asparagus 30 ppm, without any apparent toxicity symptoms.

In laboratory studies, V was found to be toxic to germinating seeds and even more so to plants at later growth stages.[131] Toxicity to roots and tops of barley was reported when culture solutions contained 500 ppm V.[132] Barley was also found to be injured when 1 mg of V, as vanadium chloride, was added to solution and sand cultures. Decreased growth in orange tree seedlings was attributed to the addition of 10 ppm calcium vanadate to the soil, while total mortality was observed at 150 ppm. It has been suggested that 0.5 ppm V in nutrient solutions is the toxic level to plants.[119] Other studies have indicated that V concentrations of 10-20 ppm are slightly toxic to soybeans, 26 ppm to beets, 40 ppm to barley, 20 ppm to wheat and 22 ppm to oats.[133]

Zinc (Zn)

Zinc is not an essential element for growth of higher plants, although it is essential for some fungi and algae. Zinc is absorbed primarily by the roots and translocated to leaf tissue, although the primary storage organ appears to be the root system.[134] Most of the stored zinc is apparently bound within the cell wall in an insoluble form.[135] Toxic symptoms may be manifest by foliar chlorosis which is caused by Zn interference with iron uptake.

It has been reported that 12.5 percent total Zn in soil will stunt most vegetation.[118] Toxicity levels were found to vary considerably between species. Toxicity has been observed in oat leaves, when leaf concentrations ranged from 1700-7500 ppm, while the toxicity range for tomatoes was determined to be 526-1489 ppm.[119] Toxic levels for cowpeas and corn are reported to be 560 kg/ha and 784 kg/ha, respectively.[119]

Zinc toxicity has been found to vary with the soil type. Sandy soils were found to be most toxic and clay loamy soil least toxic. Toxic concentrations in peat soils of New York State range from 0.43-10.16 percent for such crops as carrots, spinach and lettuce.[119]

cover that would be affected in the vicinity of Cairn Peak and Blustry Mt. is approximately 110 km^2. The total cover that would be affected in the vicinities of Chipiun Mountain, Mt. Martley and Cornwall Hills is 30 km^2, 28 km^2 and 14 km^2, respectively. Pleurozium schreberi (62.5 km^2), Picea engelmannii (53.2 km^2), Pinus contorta (43.6 km^2), Pseudotsuga menziesii (19.7 km^2), Alectoria jubata (17.0 km^2), Salix nivalis (11.0 km^2) and Salix cascadensis (10.0 km^2) would be the species predicted to exhibit the largest total affected vegetative cover, on an annual basis. Seven species, Populus tremuloides, Abies lasiocarpa, Pleurozium schreberi, Poa pratensis, Salix nivalis, Salix cascadensis and Salix sp. would exhibit the greatest injury percentage with estimates of 9, 9, 13, 26, 52, 52 and 65 percent, respectively.

The areas of vegetation associations that would be disturbed by the potentially injurious air contaminant levels for each AQCS were summarized in Table 4.1-17. The Engelmann Spruce - Grouseberry and Engelmann Spruce - Grouseberry Pinegrass associations would be most affected with 100.86 and 46.56 km^2 of vegetative cover impacted. Impacts to these associations would be insignificant due to the low overall sensitivity ratings which have been assigned. The other associations with relatively large areas that would be affected include: Engelmann Spruce - Willow - Red Heather Parkland (22.7 km^2), Engelmann Spruce - Grouseberry - Lupines (29.3 km^2) and Douglas-fir - Pinegrass (18.5 km^2). The Engelmann Spruce - Willow - Red Heather Parkland would be the only association within this group which would have a severe impact due to its high overall sensitivity rating and relatively large area affected. The other vegetation associations affected by ground level concentrations were considered to have a negligible impact due to the small areas involved and the low to moderate sensitivity ratings. In total, 238.47 km^2 of vegetative cover would be disturbed by the 366 m stack with MCS.

244 m Stack Height with MCS

The maximum ground level concentrations predicted to occur from the proposed Hat Creek Project powerplant with a 244 m stack and MCS air quality control strategy were summarized in Table 4.1-6. On the basis of these predicted levels and the threshold values presented in the literature (see Subsection ii, Sensitivity), the potential for severe impacts to the vegetation within 25 km of the project due to SO_2 would be low, although slightly higher than the 366 m stack height with MCS case. The probability would remain low as long as the hourly SO_2 concentrations, which were combined to form the 3-hour average, remain at or below a value of 655 $\mu g/m^3$. The probability of adverse impacts to vegetation found at the higher elevations within 25 km of the plant could tend to increase if hourly concentrations exceed the 1000 $\mu g/m^3$ level.

As stated previously the assumption that SO_2 and NO_2 would act synergistically is highly conservative. The following assessment is for a worst case and it is highly unlikely that any potential impacts would be more severe than those presented in the following discussions.

The land areas where existing vegetation would be affected by the predicted SO_2/NO_2 emissions appear to be restricted to the higher elevations of Chipiun Mountain, where 30 km^2 of vegetative cover could be injured. The potential areal extent of vegetation injury, on an annual basis, at the higher elevations of Blustry Mountain, Cairn's and Moore Peak would be approximately 30, 20 and 35 km^2, respectively. Approximately 28, 17, 18 and 85 km^2 of vegetation would be affected in the vicinities of Mt. Martley, south Hat Creek Valley, Arrowstone Hills and Cornwall Hills, respectively. The vegetation species that would experience the greatest impacts, on the basis of total area affected, are Pleuorozium schreberi, Picea engelmannii, Pinus contorta, Pseudotsuga menziesii, Alectoria jubata, Salix cascadensis and Salix nivalis. The injury percentage of these species is estimated to be 14.3, 4.4, 4.4, 5.5, 5.5, 52 and 52 percent, respectively. Other species having a predicted high estimated injury percentage but not included in the above list due to the small total area affected include Salix ssp. (71.5 percent), Poa pratensis (28.6 percent) and Populus tremuloides (13.5 percent).

The areas of vegetation associations would be disturbed by the potentially injurious air emissions levels for each AQCS were summarized in Table 4.1-17. The Engelmann Spruce - Grouseberry Association would have the largest total area injured (124.0 km^2). The potential impact to this association is judged to be moderate due to the large area involved and the low overall sensitivity rating assigned to this association. Other associations with large areas of predicted injurious affects include Engelmann Spruce - Grouseberry - Pinegrass (68.7 km^2), Douglas-fir - Pinegrass (37.6 km^2), Engelmann Spruce - Grouseberry - Lupines (29.9 km^2), Engelmann Spruce - Willow - Red Heather Parkland (27.1 km^2) and Douglas-fir - Bunchgrass - Pinegrass (15.2 km^2). The Engelmann Spruce - Willow - Red Heather Parkland Association is the only one in this group which would be considered as having a significant impact due to the high overall sensitivity rating. The predicted impact to this association is considered to be moderate since the area involved is considered to be a more important factor than the high sensitivity rating. In total, 324.41 km^2 of vegetative cover are predicted to be injured on an annual basis. The impact from this strategy is considered to be more significant than either of the other two cases.

In conclusion the 244 m stack with MCS is considered to to have the highest potential impact. Lower stack heights would result in phytotoxic ground level SO_2/NO_2 concentrations in those areas where sensitive vegetation occurs.

Nitrogen Dioxide

The concentrations of nitrogen dioxide necessary to produce visible injury to vegetation are higher than the ground level concentrations predicted to occur from the powerplant. The maximum ground level NO_2 concentrations predicted for the plant were presented in Tables 4.1-3, 4.1-5 and 4.1-6. Threshold concentrations for visible injury are higher than the predicted levels. Thus, no impacts to vegetation from NO_2 (in isolation) would be anticipated. The effects of low NO_2 concentrations in synergism with SO_2 have been assessed in the preceding section.

Ozone

Ozone (O_3) formation is a photochemically driven reaction which is dependent on the concentration of NO_2/NO. Since the levels of NO_2 and NO are predicted to be low, low O_3 concentrations can also be expected. These low concentrations would generally be below the threshold levels for sensitive vegetation. Ozone is rarely considered to be a problem in the immediate vicinity of fossil fueled powerplants. It more commonly is a problem some distance from the source. Therefore, injury to vegetation from O_3 within 25 km of the project would be a remote possibility and the consequences of any impacts negligible.

Particulates

The rate of particulate emission predicted from the plant is approximately 40 000 kg/day. Based on predictions of SO_2 levels,[5] ratio of SO_2 to particulates and deposition velocity of 0.1 cm/sec, the greatest annual deposition would be 17 $\mu g/m^3$ for the 366 m stack with MCS and 35.2 $\mu g/m^3$ for the 244 m stack with MCS. On the basis of the available data in the literature, there is no evidence to suggest that any impacts would occur to the vegetation from these two deposition rates. With the exception of vanadium, no trace elements emitted as particulates are considered to be the cause of any potential impacts to the vegetation.

Acid Rain

Injury to vegetation from acid rain would occur primarily from wet deposition of sulfuric acid on the leaf surfaces. Dry deposition generally has little effect unless the plant surfaces have been wet. Little or no effect from acid precipitation would be anticipated within 100 km of the project site. The predicted reduction of rainfall pH to 3.7 for the worst case condition is considered to be at or above the threshold levels for visible injury. Thus, it appears that no direct injurious effects would occur.

Trace Elements

The projected annual ground level concentrations for each of the trace elements studied are presented in Table 4.1-18. The mean maximum concentrations measured in Hat Creek receptors and the project soil enrichment due to stack and cooling tower emissions for each of the trace elements studied are also presented in Table 4.1-18.

Arsenic levels in soil samples for Hat Creek were noted as being higher than background levels reported in the literature.[6] The effects of high As levels in soils on vegetation depend on the amount of soluble As and not total As. Thus, it is difficult to assess the present status of As toxicity to vegetation. However, there were no apparent As toxicity symptoms observed in the Hat Creek ecosystems.[6] The projected soil enrichment values, on an annual basis, (Table 4.1-8) are minimal and are not expected to raise As concentrations to toxic levels in Hat Creek ecosystems.

The mean maximum cadmium concentrations measured in Hat Creek soils (Table 4.1-8) appear to be higher than background levels reported in the literature. However, Cd toxicity to plants has never been demonstrated under natural conditions.[118] Cadmium levels in Hat Creek vegetation were below background levels reported in the literature. The projected soil enrichment values are low and no accumulations large enough to produce toxic effects in plants would be anticipated. However, plants do tend to accumulate Cd without exhibiting toxic symptoms. In this case, plants with high Cd concentrations would be a hazard to grazing animals. There is not enough information currently available to adequately evaluate this potential hazard.

The mean maximum chromium levels measured in Hat Creek vegetation and soils are consistent with background levels reported in the literature. All of the Cr concentrations measured in Hat Creek receptors appear to be below toxic levels. The additional amounts contributed by stack emissions(Table 4.1-18) would be quite low and would not result in any appreciable accumulations or soil enrichment (Table 4.1-8).

The maximum values recorded for copper in Hat Creek receptors is consistent with values reported in the literature, although large sample variability precludes any definitive conclusions. The levels measured were below reported toxic concentrations. The ambient concentrations (Table 4.1-18) and projected soil enrichment (Table 4.1-8) are quite low. As a result, Cu concentrations would not be expected to increase to the toxic level over the operational life of the powerplant.

The concentrations of lead recorded in plant and soil samples were consistent with background levels as reported in the literature. None of the levels measured approach toxic levels in Hat Creek receptors. Lead is not easily absorbed by plants or leached from soils. Any lead absorbed from the soil is stored primarily in the roots and would be unavailable to grazing animals. The projected soil enrichment values (Table 4.1-8) are low and would not result in toxic accumulations. Lead can also be absorbed through foliar tissue and can pose a potential hazard to animals. Predicted annual ground level concentrations (Table 4.1-18) are not high and would not accumulate to toxic levels in plants. The potential for lead distribution in the ecosystem is low due to the insolubility of lead compounds.

The naturally occurring mercury levels in Hat Creek receptors are within the range of background levels as reported in the literature. The projected annual soil enrichment values are low (Table 4.1-8) and it is unlikely that toxic accumulations would result. It has been reported that Hg deposited on soils is immobilized and that only small proportions of Hg absorbed by the soil is taken up by plants.[139] The factors regulating the accumulation of mercury in terrestrial ecosystems are not as well documented as in aquatic systems. However, on the basis of existing levels, projected emission rates and projected soil enrichment, no adverse impacts to vegetation from mercury accumulations would be anticipated.

The levels of naturally occurring vanadium in soils and vegetation of Hat Creek are within the range of background concentrations reported in the literature. There have been no reports of vanadium toxicity to plants growing under field conditions. This would also appear to be the situation at Hat Creek where existing values and predicted soil enrichment values are low (Table 4.1-8).

Like most of the other trace elements studied, the concentration of zinc in Hat Creek soil and vegetation are similar to background values reported in the literature. In general, zinc is relatively immobile in soils. However, the leachability of zinc from Hat Creek materials was demonstrated and the potential exists for the mobility of zinc in the ecosystem. Many plants have a high affinity for zinc, although there is a wide range of accumulation rates in plants. The predicted ambient concentration (4.1-18) and soil enrichment are considered to be low. It is also likely that most of the Zn deposited on the soil surface would be absorbed on hydrous metal oxides in the soil. Thus, the impacts to vegetation from Zn accumulations in soil would be minimal.

B. Forest Vegetation

Controlled Emissions - Sulphur Dioxide

It is anticipated that specific forest areas would become partially denuded due to the predicted SO_2 ground level concentrations. However, these areas cannot be specified either spatially or temporarily. The most likely case would be that low level concentrations would cause a growth reduction over a wide area. Individual trees would probably respond to these low levels according to their relative sensitivities and existing environmental conditions at the time of the fumigation incident. It is possible that effects due to short term fumigation incidents can be reversed, although continuous fumigation incidents would result in chronic injury symptoms. Growth reductions would occur at this point and ultimately crown thinning, should fumigations continue.

The assessment of impacts resulting from the various SO_2 levels as determined by the AQCS utilized is developed on the premise that:

4.1 POWERPLANT - (Cont'd)

1. Individual branches, branchlets or needles scattered throughout the crowns of trees would suffer partial or total necrosis, thus reducing growth rates.

2. Individual trees scattered throughout the Hat Creek Valley, which are sensitive to the contaminants would die during plant operation.

The values presented in the following discussions are the result of converting the sporadic scattered losses of trees or chronic growth reductions into an equivalent area of crown cover lost on an annual basis.

366 m Stack Height with FGD

The potential production lost each year due to ground level SO_2 concentrations from the powerplant employing a 366 m stack and flue gas desulphurization system in terms of mean annual increment (MAI) would be 12.6 m^3. This reduction translates into an annual value of $70 on the basis of $5.50 per m^3. It is possible that the actual loss would not be as great as the numbers presented, since some of the trees would possibly recover from the fumigations. Since the time period required for recovery cannot be predicted, the numbers generated are based on a no recovery case. These reductions presented are based solely on injury and the numbers presented are assessments and not actual measurements.

366 m Stack Height with MCS

The potential production lost each year due to ground level SO_2 concentrations from the powerplant employing a 366 m stack and meteorological control system (MCS) in terms of MAI would be 347.1 m^3. This reduction translates into an annual value loss of approximately $2000 based on $5.50 per m^3. As stated above, it is possible that the actual loss would possibly be less since the values derived are based on no recovery by the forest species. The annual total loss would be substantially larger than that determined for the 366 m stack with FGD case.

244 m Stack Height with MCS

The potential production lost each year due to ground level SO_2 concentrations from the powerplant employing a 244 m stack height with an MCS in terms of MAI would be 508.1 m^3. This reduction would translate into an annual loss of approximately $2800 based on $5.50 per m^3. As previously described, it is possible that the actual loss would be less, since the values were derived assuming no recovery from short-term fumigations. The annual total dollar value loss, should this stack height and control strategy by employed, would be greater than the 366 m stack height with MCS case and would therefore be considered as the most potentially harmful control strategy in terms of losses to the forestry resources.

Uncontrolled Emissions - Fluoride

The assessment of impacts to vegetation due to the predicted fluoride ground level concentrations was developed from two perspectives: a probable case; and a worst case. In the probable case of fluoride: SO_2 ratio of 8.92×10^{-4} was utilized in the derivation of ground level fluoride concentrations. In the worst case, all fluoride which could not be accounted for in the test burns was assumed to exit the stack in a gaseous state. Therefore, a larger fluoride: SO_2 ratio of 9.02×10^{-3} was utilized. These two cases were utilized due to discrepancies between results presented in the literature surveyed and results from a fluoride sampling program conducted as part of a bulk sample test burn programme. This approach is highly conservative since most of the data in the literature are derived from theoretical studies rather than from actual test samples. A complete description of the two cases, rationale for their selection and the fluoride emission rates for each case is presented in Section 5 of the Forestry Report.[140]

Probable Case

The ground level fluoride concentrations for a 24-hour averaging period were predicted to be 0.1 and 0.2 $\mu g/m^3$ based on SO_2 concentrations of 160.0 and 260.0 $\mu g/m^3$, respectively. The 0.1 $\mu g/m^3$ concentration is predicted to occur one day during the growing season (April-October). The areal extent of forest vegetation exposed to this concentration would be approximately 6176 ha. The ground level fluoride concentrations predicted for a 3-hour averaging period was computed to be 0.6 and 1.2 $\mu g/m^3$ on the basis of SO_2 concentrations of 655.0 and 1300.0 $\mu g/m^3$. The predicted exposure frequency of the 0.6 $\mu g/m^3$ concentration is 0.4 days during the growing season. The area of forest vegetation exposed to this concentration would be 23 857 ha. Concentrations of 0.4 and 0.8 $\mu g/m^3$ were predicted (one hour averaging period) on the basis of one-hour SO_2 concentrations of 450.0 and 900.0 $\mu g/m^3$, respectively. The predicted exposure frequency of the 0.4 $\mu g/m^3$ fluoride is 0.7 days during the growing season. The area of forest vegetation exposed to this concentration would be 132 272 ha. The predicted frequency of exposure to a ground level fluoride concentration of 0.8 $\mu g/m^3$ is 1.8 days within the growing season. The area of forest vegetation exposed to this concentration would be 34 390 ha. No short term effects would be anticipated to result from these dosages (concentration and exposure period). However, the potential for long-term accumulations (chronic injury) would exist. The magnitude of these chronic effects can not be assessed at this time due to the lack of definitive work in the literature regarding chronic injury.

Worst Case

The ground level fluoride concentrations for a 24-hour averaging period was computed to be 1.44 and 2.35 $\mu g/m^3$ on the basis of SO_2 concentrations of 160 and 260 $\mu g/m^3$, respectively. Exposure to 1.44 $\mu g/m^3$ fluoride during the predicted exposure period would possibly cause a reduction of 4100 m^3 in the MAI on 6176 ha of forest land within 25 km of the project.

The ground level fluoride concentrations for a 3-hour averaging period was computed to be 5.91 and 11.73 $\mu g/m^3$ on the basis of 655 and 1300 $\mu g/m^3$ SO_2 concentrations. A ground level fluoride concentration of 5.91 $\mu g/m^3$ for 0.4 days (during the growing season) would potentially reduce the MAI of the 23 857 ha of forest land by 15 800 m^3. Concentrations of 4.06 and 8.12 $\mu g/m^3$ were computed for a one-hour average based upon SO_2 concentrations of 450 and 900 $\mu g/m^3$. The 4.06 $\mu g/m^3$ fluoride concentration for 0.7 days would possibly cause a reduction of 88 000 m^3 in the MAI for the 132 272 ha of forest land affected. The 8.12 $\mu g/m^3$ fluoride concentration for 1.8 days (growing season) would possibly cause a reduction in the MAI of 22 900 m^3 in the 34 390 ha of land affected.

In summary, the value of the annual growth reductions in the probable case for the 366 m stack height with FGD would be $100. This value is based solely on losses ($100) due to SO_2 levels. In the worst case, the total annual loss from air emissions (366 m with FGD) would be $125,786. This value represents a contribution of $100 in losses from SO_2 emissions and $125,686 in losses from fluoride.

The total value lost on an annual basis for the probable case using a 366 m stack height and MCS would be $2000. The loss due to SO_2 would be $2000 of this total, that due to fluoride is nil. The total for the worst case (366 m with MCS) would be $127,586, which is comprised of $2000 from SO_2 emissions and $125,686 from fluoride.

The total value of the annual losses due to emissions for the probable case where a 244 m stack height with MCS would be $2800. This total is comprised solely of losses from SO_2. In the worst case, SO_2 emissions would result in a loss of $2800 and fluoride for $125,686, which totals $128,486 on an annual basis. The 366 m stack height with FGD control strategy would be the preferred case in terms of reducing losses to the forest resources.

C. Agricultural Vegetation

Potential air quality effects on agricultural crops resulting from powerplant operation are discussed in documents prepared by ERT,[6] Runeckles[45] and CBRC.[141] Results presented in the latter are summarized here. Sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) emissions have been identified as potential sources of crop injury. The ERT report concluded that release of trace elements would not likely be detrimental to terrestrial biota. Because of relatively high concentrations of fluoride in Hat Creek coal, this element is not included in the trace element category. The low concentrations of hydrogen fluoride predicted by the Hat Creek Local Air Quality Model[6] would not be expected to injure vegetation, although the long-term accumulation of fluoride in soils and woody plants would require monitoring.

Three air quality control systems were utilized in predicting operational ambient air quality. With a flue gas desulfurization system, predicted ambient concentrations would be insufficient to cause crop damage. Potential impacts of SO_2/NO_2 emissions predicted for the meteorological control system (MCS) with 366 m high and 244 m high stacks, are evaluated. The impact evaluation consists essentially of identifying irrigated and projected irrigated lands where stack emissions would injure alfalfa (which is particularly sensitive to SO_2) to a degree that agricultural use of the land would change from crop (including hay and irrigated pasture) production to cattle grazing. Changes from cropping activities to grazing were predicted for lands in the Hat Creek Valley and for lands elsewhere where modeled SO_2/NO_2 concentrations would cause 20 and 30 percent alfalfa injury, respectively.

366 m Stack with MCS

Areal extents of presently irrigated and projected irrigated land of the Upper Hat Creek Valley subject to injurious concentrations of SO_2/NO_2, are included in Table 4.1-19. Of the 737 ha of land potentially subject to injury, 243 ha of projected irrigated land and 162 irrigated ha would experience foliar injury equal to or greater than 20 percent, assuming worst-case conditions. Under these conditions, alfalfa injury would result in sections of the Fraser Plateau and Cornwall Hills but not at levels exceeding 20 percent.

Foliar injury levels predicted for average case conditions would equal or exceed 20 percent in 6 ha of irrigated land and in 9 ha where irrigation is projected. Portions of the Pavillion and Cornwall Hills areas would experience injury levels less than 20 percent. The changing of land use from cropping to grazing in 9 ha of the upper Hat Creek Valley was factored into beef production projected for the with-project case (assuming MCS with a 366 m stack and average conditions). A comparison of this amount of projected irrigated land lost with that which would be alienated by project land requirements (273 ha) indicates that air quality impacts would account for a relatively small portion of the projected irrigated land removed from crop (including irrigated pasture) production.

The responses of many grass species to SO_2/NO_2 have not been reported in the literature. Based on the small area of grazing land that would be exposed to concentrations generally considered potentially injurious, stack emissions would not reduce grazing land carrying capacity.

244 m Stack with MCS

Areas of presently irrigated and projected irrigated land where SO_2/NO_2 ground level concentrations modeled for MCS 244 m stack conditions cause alfalfa injury, are summarized in Table 4.1-19. Seven hundred and thirty-seven ha of projected irrigated land and 491 ha of presently irrigated land would experience concentrations causing foliar injury to alfalfa. Assuming worst-case conditions, foliar injury would exceed 20 percent in 413 ha of land where irrigation is projected and in 342 ha of presently irrigated land. With worst-case conditions, foliar injury would also occur in the Fraser Plateau, Pavilion area, Arrowstone Hills and Cornwall Hills. In the affected portions of the latter two areas of the Local Study area, the predicted foliar injury levels would exceed 20 percent.

Foliar injury to alfalfa, when predicted for average conditions, would equal or exceed 20 percent in 6 ha of irrigated land in 9 ha where irrigation is projected. Under these conditions, foliar injury would occur in the same area of the Local Study Area as predicted for worst-case conditions, but no injury levels greater than 20 percent would be expected in areas other than the Upper Hat Creek Valley.

The MCS with 244 m stack would possibly injure grass species in limited portions of the Local Study Area grazing land. This effect would not be expected to reduce range productivity, although the responses of important forage species such as Agropyron spp, Hordeum jubatum and Poa spp. to air contaminants are not known.

(g) Effects on Soil

There is little or no information available for assessing the effects of air contaminants on soils. Most sources address effects on vegetation or wildlife. In general, effects from air emissions are presumed to be the result of absorption by the vegetation and the subsequent transmittal to the soil by translocation to the root system, litterfall or by the washing action of throughfall or stemflow precipitation. In the case of particulates and acid rain, direct deposition would possibly occur. Generally, direct deposition has the greatest effect on soils and indirect deposition (litterfall, stemflow, and throughfall, root decomposition) the least.

Ground level concentrations of SO_2, NO_2 and hydrocarbons would not have an adverse impact on soils. Uptake of sulphur by soil from litterfall would have a minor effect, which would be beneficial in the event that soils are deficient in sulphur.

An adverse impact on soils due to acid precipitation would result should soil pH be reduced substantially. Soil pH reductions have been reported to occur as a result of sulfate and nitrate being removed from the atmosphere and deposited in the form of sulfuric or nitric acid. The reduction in soil pH would lead to a reduction in calcium and a reduced activity of the soil microbes. However, the significance of these impacts is considered negligible due to the high buffering capacility of soils within 25 km of the project.

Particulate deposition on soils would be of concern, because trace element composition may cause secondary impacts on wildlife or livestock. Relatively high concentrations, in comparison to background levels reported in the literature, of arsenic, cadmium, chromium, fluoride and selenium have been reported in the upper 5 cm of the soil within 25 km of the project.[6] The possibility exists that further additions of these trace elements would cause potentially high levels in vegetation grown on these soils. Selenium and arsenic are of particular concern, since ingestion of vegetation containing high levels of these elements could injure wildlife and livestock. The significance of these impacts or even the probability of occurrence can not be predicted, since many factors (soil pH, nutrient and moisture status) influence the rate of which elements are retained in the soil as well as the rate at which these elements are stored by vegetation.

4.1 POWERPLANT - (Cont'd)

(h) Effects on Water Resources

(i) Water Quality

Gaseous emissions from the Hat Creek project would have a potential for affecting the water resources of the surrounding region through the generation of acid precipitation. This phenomenon is not a continuous process, but instead would proceed episodically. Severe episodes would result in a short-term increase in the acidity of small lakes and streams. If this were to occur in the Hat Creek area, it would be most prevalent during the spring and summer seasons. Spring episodes would be caused by the release of pollutants by rainstorms. The magnitude of the impact, however, would be inversely related to watershed size as the geology and vegetation of a watershed modifies the chemistry of the precipitation and subsequently its affect on the water resource. Following such episodic events, a water body undergoes a recovery period as water chemistry values return to normal levels.

As these episodic events continue over the long-term, a water resource would exhibit a noticeable change in various constituent concentrations. The most obvious of these would be a decline in pH. This rate of acidification has been studied for groups of lakes in Sweden, Norway, Ontario, Canada and New York, U.S.A.[142] From these studies acidification rates have been reported to range from -0.015 to -0.1 pH units per year with an approximate average of -0.05. These pH decreases are the result of large industrialized areas emitting significantly greater concentrations of sulphur compounds than would be experienced in the Hat Creek area. Mechanisms to predict quantities of acid precipitation for a specific area from a specific point source discharge are not yet available. If, however, it is assumed that the Hat Creek project would cause the average acidification rate (-0.05 pH units per year), a conservatively high assumption, 10 years of plant operation would be required to lower the pH of the most sensitive lake[143] in the region (Rollie Lake located approximately 210 km from the Hat Creek Valley) to 6.0, which is considered the critical level. It should also be noted that only two other water bodies in the region, Moffat Lakes and Crooked Lake, have present pH values lower than 7.0.[143] Given this conservative time frame for impact identification, an appropriate monitoring program could be instituted to determine the specific effect of Hat Creek emissions on the sensitive water bodies of the area. If acidification or other negative effects are noted, remedial action in the form of operational or design modifications could be instituted before impacts become problematic.

(ii) Aquatic Ecology

Impact to all components of aquatic systems can result from the acidification of a water resource due to acid precipitation. Concerning decomposer organisms, the decomposition of cellulose was reduced by 50 percent at pH 5.2 when compared to controls at pH 7.0.[144] The rate of decay of birch leaves was greater at pH 7 than at pH 5.2, 3.5 or 4.0. Other laboratory studies suggest that a lowered pH tends to inhibit bacterial action, but not fungal growth.[145] The net result appears to be a slowed rate of decay, an accumulation of organic material, and lessened nutrient cycling.[144] Evidence concerning the effects of pH on phytoplankton is limited, although fewer species of the class Chlorophyceae were found at pH's less than 6.0 in one lake survey.[144]

Much greater quantities of epiliths grew in an artificial stream channel at pH 4 than in a similar channel containing similar water, where the pH was 6.[145] In Lake Öggevatn, a lake in Norway with a pH of 4.6, macrophytes were covered with heavy growths of filamentous algae.[146] However, the more acid tributaries of the River Huddon in England (pH less than 5.7) have less epiphytic growth than in less acid tributaries.[146]

Several authors report that Sphagnum spp. appears to replace other aquatic macrophytes at low pH.[146] However, quantitative support of this hypothesis is limited to the measured increase of Sphagnum spp. in shaded, shallow, sheltered locations as the pH is decreased.[147] The macrophyte Lobelia spp. has been studied in the laboratory, and was found to grow less well at pH 4 than at pH 6.[145]

In a lake survey, Wright et al.[144] found that more species of zooplankton were found in lakes with pH 6.5 to 7.0 than at higher and lower pH's. Lievestad et al.[145] reported that the occurrence of some zooplankton species was related to pH and that, below pH 6.5, a small but significant correlation between number of species and pH was found.

Among macroinvertebrates, Gammarus lacustris is rarely found below pH 6.0,[144] snails are rarely found at pH 5.2 - 5.8 and never found below pH 5.2.[145] Leivestad et al.[145] again found a low significant correlation between pH and number of species, when the pH was below 6.5.

The effects of increased acidity on fish have received greater attention than other aspects of the aquatic ecosystem. The Atlantic salmon catch in nine Norwegian Rivers has been decreasing since 1885, and was essentially 0 by 1972. The pH of these rivers now ranges from 4.5 to 5.5. This decline is thought by Wright et al.[144] to be due to reproductive failure of the population. They feel that pH's 5.0 - 5.5, 4.5 - 5.0 and 4.5 are the critical lower limits for successful reproduction of Atlantic salmon, sea trout (sea run brown trout) and brown trout, respectively.

Beamish[148] also concluded that the failure of fish populations to reproduce was the reason for their extinction from acidified lakes. He attributed this reproduction failure to a failure of females to produce ova. He feels that lower pH limits for reproduction are 5.5 - 6.0+ for smallmouth bass, walleye, and burbot, 5.2 - 5.5 for fathead minnows, 4.7 - 5.2 for brown bullhead, white sucker, and rock bass, and 4.5 - 4.7 for lake herring, yellow perch and lake chub.

Leivestad et al.[145] report several examples of the effects of low pH on fish. The Atlantic salmon catch in seven Swedish rivers with an average pH of 5.16 has decreased to zero, although the catch in other Swedish rivers (average pH = 6.57) has increased during the last 30 years. In the acidic Mandal River, 99 percent of Atlantic salmon eggs and fry died. In a more neutral tributary and in neutralized Mandal River water greater than 80 percent survival was achieved. Almost no brown trout fry were found in a brook with a pH of 4.8, even though spawning conditions were otherwise favorable. In a nearby brook with poor spawning conditions but a brook with pH 6.2 had a high rate of survival. Brown trout in the Tovdal River experienced an extensive fish kill during the spring of 1975. No perch mortalities were observed. The kill was attributed to a sharp drop in pH (from pH 5.0) associated with the initial period of snowmelt. In a lake survey, a lesser proportion of lakes with "good" populations of brown trout had a pH less than 6.0. Most lakes with "sparse population" had a pH greater than 4.5. It is interesting to note, however, that several lakes with a pH less than 4.5 had good trout populations. In a laboratory study, it was noted that the salmonids tested seemed to be sensitive to low pH in the order rainbow trout, Atlantic salmon, brown trout and brook trout. Older brook trout appeared to be less sensitive than younger brook trout. Leivestad et al.[145] also noted that individuals of the same species exhibit a diversity of sensitivity to lowered pH, and that differing sensitivities appeared to be a hereditable trait. This suggests the potential for genetic adaptation (natural selection) to low pH.

In the previous section on water quality, it was conservatively estimated that a significant pH depression would occur only after 10 years of plant operation. Given this time frame, an appropriate biological monitoring program could be instituted to determine any impacts on the biota of the water bodies due to acidification.

4.1.2 Cooling Tower System

(a) Effects of Cooling Tower Plumes

(i) Modelling Methodology

Fogging and icing from cooling tower plumes and visible plume length were assessed by ERT using the numerical model "COOLTWR". A second ERT model, "DEPOT", was used to estimate the spatial distribution of cooling tower salt drift deposition. "COOLWTR" is a numerical model that calculates the physical properties of moist plumes as a function of downwind distance from the cooling towers. It is designed to provide simultaneous solutions to a system of differential equations describing the conservation of plume mass, a total plume moisture, plume momentum, and plume specific entropy (a thermodynamic property). A series of thermodynamic routines are included to simulate phase changes of plume water along the trajectory of the cooling tower effluent. The "DEPOT" model uses plume trajectories computed by "COOLTWR" to simulate the processes by which drift droplets undergo transport, dispersion and evaporation in the atmosphere and fall to the ground. The features of both of these models are described in detail in Appendix D to the Air Quality and Climatic Effects Report.[149]

The data input to the models included the physical dimensions and operating characteristics of the towers, the emission characteristics (as outlined in the plant description), and selected ambient meteorological conditions. The meteorological parameters required were wind speed and direction, temperature, relative humidity, and atmospheric stability. One year of onsite data from mechanical weather station No. 7 (supplemented by data from the other stations) was used to provide the needed meteorological information. A complete description of the data base utilized is provided as Appendix A to the Air Quality and Climatic Effects Report.[9]

A complete set of calculations by both models was performed to estimate the nature and frequency of atmospheric effects due to the operation of four different cooling tower configurations (four rectangular mechanical draft towers' four round mechanical draft towers; four natural draft towers; and two natural draft towers). The results of these calculations are described in Appendix D to the Air Quality and Climatic Effects Report[149] and summarized in the sections that follow. As a consequence of this alternate cooling tower study and other studies, the two natural draft cooling tower arrangement described in Part Two was chosen as the preferred system. The orientation of the two towers now proposed is slightly different from that modelled; it is now proposed that the two towers be centered on a line oriented parallel to the plant axis rather than on an east-west line (see Part Two, Project Description). However, this small change in orientation is not expected to alter either the predicted magnitude or the location of the calculated effects in any significant way.

Other potential climatic effects of the cooling tower system (precipitation enhancement, thermal and humidity alterations, etc.) were investigated along with the potential climatic effects of the other project components through a detailed literature survey, an examination of field measurement programs, and an analysis of the existing climate. The details of this study and the postulated climatic effects of the Hat Creek Project are presented in Appendix E to the Air Quality and Climatic Effects Report.[11] A summary of the potential climatic effects of the cooling tower system is provided in Subsection vi, below.

(ii) Ground Level Fogging and Icing

Ground level fogging and icing due to cooling tower plumes occur when the plume intersects (impinges upon) the ground surface. In the vicinity of the towers, these effects are caused by plume downwash in high winds. High winds cause an aerodynamic wake to form downwind of the tower structure, and all or part of the plume is deflected into this region. Circulations within this wake can then mix the plume to the ground adjacent to the tower. Because of the height and shape of natural draft towers, the wake which forms downwind under high wind conditions is different than that for mechanical draft towers. Although there is some reduction in plume height from natural draft towers under high wind conditions, the plume generally does not become trapped by the circulations in the wake, and, in fact, no ground level fogging or icing is predicted in the vicinity of the Hat Creek towers on the basis of the model calculations.[149] Visible plumes would possibly impinge on the peaks of some of the surrounding hills, but the resulting fogging and/or icing would not be expected to affect any such location for more than 5-10 hr/yr. Icing due to drift water emissions, (liquid droplets emitted from the tower with the vapor plume) would also be expected to be insignificant.

Localized fogging and possibly icing would likely be produced by the evaporation of water from the make-up reservoir and ash pond and subsequent condensation in the air or on nearby surfaces on cold days in the fall and spring seasons. This fogging and icing (which should be confined to plant property) would be more significant in the plant vicinity than that which would result from operation of the cooling towers. However, both water bodies would likely be frozen over during the winter season and no additional fogging and icing would occur.

(iii) Visible Vapor Plumes

The length of the visible vapor plumes from the cooling towers have been estimated by the ERT model on a seasonal and annual basis. The annual pattern of visible plume frequencies is presented in Fig. 4.1-13. As indicated, the frequency of plume lengths greater than 5 km would be very small, (at most, about 10-15 hr/yr) with many of these occurrences at night or during conditions of low clouds, natural fog, or precipitation.

Most of the medium to long plumes (1-5 km), would likely occur in the winter season when the relative humidity is high. However, there would also be a small number of very long plumes (15-20 km) in the summer during cases of very high relative humidity. These very long visible plume predictions are probably excessive, caused by certain conservative assumptions in the model.

(iv) Salt Drift Deposition

Drift consists of liquid droplets emitted by the cooling tower with the vapor plume. While the vapor plume consists of relatively pure water (because it has been evaporated and then condensed),.the drift droplets have the same chemical constiuents as the cooling water, but with increased concentrations of dissolved salts. The increased concentrations occur because as the water recirculates within the plant's cooling system, some of it evaporates as nearly pure water, leaving the salt behind. As this process continues through several cycles, the salt concentration increases. The drift droplets are initially carried out of the tower along with the vapor plume, but because they are relatively large in size, they begin to fall out of the plume and the water begins to evaporate as they fall to the ground. It is the salt and salt solids in the droplets which fall to the ground which are referred to as the salt drift deposition.

Fig. 4.1-14 presents the predicted salt drift deposition for the preferred cooling tower system. The maximum annual deposition rate of 4700 $kg/km^2/yr$ is predicted to occur about 1 km east of the towers.[149] Annual salt drift deposition rates would fall to insignificant values (less than 100 $kg/km^2/yr$) at a distance of about 7-8 km to the east and at closer distances in the other directions.

(v) Acid Mist

Acid mist is formed by a somewhat different process than acid rain (see Section 4.1.1(c)(ii)). Acid rain is a problem generally associated with long-range transport and occurs as a result of the washout by natural rainfall of sulphur dioxide and sulphates in the stack plume. Acid mist, however, is a short-range phenomenon caused by the interaction of the sulphur dioxide in the stack plume and the water in the cooling tower plumes. Natural draft plumes have a relatively low initial vertical velocity, but by virtue of their mass, a very large bouyancy. The stack plume has a large exit velocity, but its bouyancy excess is more quickly dissipated than that of cooling tower plumes because of its smaller surface-to-volume ratio. As a result, both plumes will tend to level off at about the same height under certain infrequent meteorological conditions (this is more

4.1 POWERPLANT - (Cont'd)

(vii) Effects on Terrestrial Vegetation

A. Natural Vegetation

Salt Deposition

Weather conditions, ion toxicity, and plant sensitivity are factors which determine threshold aerial salt deposition rates producing toxic concentrations. Salt crystals impacted on leaf blades are washed off during periods of rain.[150] However, investigations of the effects of salt water cooling towers[150,151,152] on vegetation indicate that salts accumulating on leaf surfaces between rainfalls may be rapidly absorbed by foliar tissues when relative humidity is sufficient to maintain salts in the dissolved state. Plants may achieve relatively high concentrations of substances such as $SO_4^{=}$, and Cl, which are normally less available from the soil, through foliar absorption.

All soil elements may be toxic to plants in high concentrations,[153] although Cl^- has been the focus of salt water cooling tower studies because it represents a major component of emitted salts, and because it has been indetified as the toxic agent in experiments where foliar damage resulted from applications of sea spray or road salt.[154,155] Incidences of Cl^- toxicity have been partially attributed to the propensity of some plants to retain and concentrate Cl^- in leaf tissues.[155,156] The critical factor in assessing salt injury to vegetation appears to be the amount deposited on foliage between periods of precipitation, which would wash away toxic deposits. Research conducted by the Boyce Thompson Institute[151] on 12 relatively sensitive plant species indicates that, at 85 percent relative humidity, a deposition rate at or below 0.01 μg Cl^-/cm^2/min for exposures of 4 to 6 hours produces a risk of adverse effects on the most susceptible vegetation.

There is little information available regarding potentially injurious aerial deposition rates applicable to the other principal ions, $SO_4^{=}$ and Ca^{++}, which would be emitted from the two natural draft cooling towers. Sulfate and Ca^{++}, however, are essential macronutrients required by plants in much larger quantities than Cl^-, a plant micronutrient.[157] It has been demonstrated that during one growing season, rotation crops such as corn utilized about 16.8 kg sulfur (50.4 kg $SO_4^{=}$) and 39.2 kg calcium per ha, compared to 5.6 kg/ha of Cl^-.[158]

Isopleths of predicted annual salt deposition from two natural draft cooling towers were presented in Fig. 4.1-13. The maximum salt deposition rate would be 4700 kg/km^2/yr. The point of maximum deposition would be approximately 1.1 km due east from the proposed cooling tower location. This deposition would rate drop to 560 kg/km^2/yr approximately 3 km from the tower and would be further reduced to approximately 100 kg/km^2/yr 7-8 km from the towers. The deposition rate proposed by Boyce Thompson as having a potential for adverse effects[151] is 5.25 x 10^4 kg/km^2/yr. This rate is an order of magnitude higher than the maximum rate predicted. It would take approximately 11.2 years without rainfall for this level to accumulate on vegetation found at the point of maximum salt deposition. The time required for this level to accumulate on vegetation in the other two salt deposition zones (560 and 100 kg/km^2/yr) would be 93 and 525 years, respectively. This large difference between the potentially injurious rate and the projected deposition rates from the proposed cooling towers, the low probability that there would be no rainfall to remove salt depositions from the vegetation during the estimated time intervals, the fact that this maximum deposition rate occurs in a very small area in the vicinity of the plant site, and that the projected deposition rate for a large percentage of the area affected would be 112 kg/km^2/yr, would suggest that there would not be any adverse effects to vegetation from cooling tower salt deposition.

It is possible, but highly unlikely, that due to the wide range of tolerance of species to salt deposition, some sensitive species in the Hat Creek area would be injured on an annual basis. This would possibly occur even beyond the 3 km area where lower rates are predicted.

A probability of injury would exist within 1 km of the towers due to *continued deposition. However, quantitative assessment of such injuries is not* possible in the absence of specific data as to the effects of Thompson River salts applied in aerosol form.

Effects that would be due to increases in relative humidity and interaction between cooling tower plume and powerplant stack are considered to be remote due to the different release heights. Changes in micro-climate that would be due to cooling tower drift are possible, but highly unlikely.

Trace Elements

The effect of trace element deposition on vegetation would also be considered neglibible and for the most part imperceivable. The predicted annual deposition rates were presented in Table 4.1-8. These values correspond to the isopleths presented in Fig. 4.1-13. On the basis of the low values predicted, no significant effects on vegetation would likely occur due to accumulations of trace elements in the soil from cooling tower drift.

B. Agricultural Vegetation

Effects of salt deposited from the project cooling tower plumes were evaluated by ERT,[6] Runeckles,[45] and CBRC.[141] The small amounts of salt that would be deposited would not be expected to be a significant source of trace elements, and would be considered a minimal possible cause of vegetation injury. The small contribution of cooling tower salt to existing fluxes of salt resulting from irrigation water would not be expected to appreciably affect soil salinity.

(viii) Effects on Terrestrial Wildlife

A. Salt Deposition

Cooling towers associated with this facility would use water from the Thompson River. Some dissolved solids and salts originating from this river would be cast into the atmosphere and deposited some varying distances from the towers. Deposition rate data would be low enough to predict that cooling tower emissions would not result in measurable effects on wildlife (based on current literature). This same conclusion would be reached regardless of the cooling tower alternative suggested.

B. Trace Elements

The contribution of the cooling towers to trace element fallout in the vicinity of the plant would likely be minimal. No significant impact on any form of wildlife would be anticipated. A detailed discussion of the potential effects of selected trace elements may be found under Stack Emissions (Section 4.1.1(e)(ii)).

(ix) Effects on Soils

Salt Deposition

The potential effects of drift from cooling tower plumes on the soil resources would be increased moisture regimes and salt contents of the soil. The maximum annual predicted salt deposition would be 4700 $kg/km^2/yr$. The majority of soils within 25 km of the plant have high alkalinity and salinity problems and the addition of salts would possibly cause excessive salt levels. These high salt levels would possibly lead to secondary impacts on vegetation, livestock and wildlife. Vegetation, which cannot tolerate high salt levels would possibly be affected, which, in turn, would have an effect on wildlife or livestock. High salt concentrations could also alter the nutrient availability in the sub-surface soils. It is highly unlikely that any of these potential effects would occur due to the low deposition rates.

Trace Elements

The projected annual soil enrichment values from the trace elements that would be emitted from cooling tower drift are presented in Table 4.1-8. These projected concentrations are extremely small and would not increase background concentrations significantly.

(b) Consumptive Water Use

Based on the Hat Creek Project Water Management Study performed by Integ-Ebasco, the powerplant would require between 662 and 824 L/s of makeup water flow for an average plant capacity factor of 65 percent, dependent upon the ash transport system utilized. The largest consumptive water use would occur at the cooling tower system due to cooling tower evaporation and drift. Average daily cooling tower evaporation and drift is estimated at 625 L/s, representing 76 to 94 percent of total plant makeup at 65 percent capacity factor. According to the Air Quality and Climatic Effects Report[11] the local and regional effects of cooling tower evaporation on climate would be so minor that noticeable secondary effects on surface water hydrology would be highly improbable.

4.1.3 Material Storage and Solid Waste Handling Systems

(a) Ash Handling System Alternatives

(i) Water Quality

A. Groundwater

Estimates of seepage quantities for each ash handling system alternative are summarized as follows:

	Ash Handling System	Seepage to Groundwater (m^3/d)	Seepage to Surface Water (m^3/d)
Base Case	Combined Ash Pond at Upper Medicine Creek (UMC)	20	20 - 100
Alternate 1	Harry Lake - Bottom Ash Pond	20	20 - 100
	UMC - Fly Ash Pond	15	20 - 80
Alternate 2	Harry Lake - Dry Bottom Ash Disposal		
	Harry Lake - Dry Fly Ash Disposal	35	20 - 120

The quantity of ash that would be produced is approximately 6000 t/d, thus for the base case, seepage rates would be about 20 m^3/1000 t of ash per day. Existing base metal mine tailings operations in British Columbia experience seepages of 57.6 to 166 m^3/1000 t/d.

Leachate quality projections are presented in Table 4.1-20. They have been based on results of the total extractable salts tests presented in Section 3.3.1, Part Three. Since these tests utilized deionized water to facilitate the extraction, the results are conservatively high. The projected leachate concentrations also reflect the quality which would likely occur during the initial pore volume displacements of the pond and have accounted for, in an additive manner, the quality of the process water[160] which will be used to wet or sluice the ash. Initial pore volume concentrations represent a "worst case" analysis. As pore volume displacements increase, i.e. more water passes through the pond, constiuent concentrations would decrease and ultimately level off. The literature and the rate of release tests performed on other waste materials indicate that 5 to 15 pore volume displacements would be necessary before leachate quality levels off.

Seepage from the proposed ash disposal pond in UMC would be 20 m^3/d and can be compared to the existing groundwater flow of 175 m^3/d from the total reach above the ash pond embankment. A moderate dilution potential therefore exists for any contaminated percolation. There are no known groundwater users in the UMC Valley. It would thus seem unnecessary to require lining of the proposed ash pond to further reduce seepage and percolation. It would, however, be prudent to install a cutoff wall at the lower embankment such that contaminated seepages are intercepted before reaching aquifers in the Hat Creek Valley. It is also recommended that a surface and subsurface seepage recovery system below the retaining embankments be installed to collect seepage and return it to the pond. Provided this is done, the groundwaters of the valley would not be affected by these ash disposal operations.

Ash disposal to the Harry Lake region in the alternate schemes would also generate leachates. Bottom ash which is quite permeable would drain quite rapidly and exist after disposal in an unsaturated state. Fly ash having low permeability would effectively become a saturated dump after compaction. The geological nature of the Harry Lake area is not well defined at this stage as little testing has been performed. Disposal design strategies similar to those required in UMC would be necessary to prevent contamination of groundwaters.

B. Surface Water

The UMC ash pond should be designed to prevent leachate discharge. Considering this, there would be no direct interaction with surface water quality. Dusting around the edge of the ash pond would pose a potential minor impact on water quality of Medicine Creek and MacLaren Creek.

Concerning Alternate 1, fly ash pond water quality interactions would be the same as the base case. The bottom ash return water system would have to be designed to handle all precipitation and snowmelt runoff from and around the disposal area. Seepage through the water reclaim pond dam should also be collected to avoid contamination of lower Harry Creek water quality. If these actions are taken, there would effectively be no interaction with the surface waters outside the immediate area of the ash disposal area.

The dry ash disposal areas (Alternate 2) would be developed in sections such that as each section is completed it could be revegetated. The process would minimize the disturbed area subject to runoff, likewise the amount of contaminated runoff to be handled. A runoff holding pond would be included in this scheme with reuse of collected waters for dust control and presumably no positive discharge.

This course of action would be appropriate if it is conservatively assumed that runoff quality would be similar to the leachate data presented in Table 4.1-20. Considerations should also be given to constructing the runoff holding pond with impervious material to minimize seepage.

(ii) Hydrology

A. Groundwater

A till blanket covers most of the bedrock in the proposed UMC pond area. Field tests of the hydraulic conductivity of these bedrock sediments gave values of about 10^{-7} m/s. The depth to groundwater table in the bottom of the valley is about 20 m. By assuming the conditions shown in Fig. 4.1-15, the estimate of seepage to the groundwater underneath the western dam embankment is 20 m^3/d. Depending on the type of embankment construction, the seepage through this structure would be between 20 and 100 m^3/d. All westward flowing seepage if not intercepted would ultimately enter Hat Creek. Little data is available on the geology at the eastern side of the pond. However, the seepage to the groundwater beneath the pond flowing eastwards through the topographic divide is estimated at 10 m^3/d and would enter Cornwall Creek Valley. The results of all seepage would be a minor rise in the groundwater table.

In the wet ash disposal scheme at the Harry Lake site (Alternate 1), a considerable amount of seepage could flow both out of the toe of the ash spoil slope and under the dump itself (see Fig. 4.1-16). Most of the groundwater seepage would reappear in the channel of Harry Creek and would be collected in the catch basin. However, the estimated recharge added to the local deep groundwater flow system would be about 20 m^3/d. This groundwater flow system would discharge into the glaciofluvial aquifer in the buried bedrock valley which has an estimated flow of 5000 m^3/d. In addition, during the drier months, much of the flow in Harry Creek appears to seep down to this aquifer. The maximum annual above ground seepage (i.e., in the ash or retaining emabnkment) would be between 20 and 100 m^3/d. This seepage, plus seepage losses from Harry Creek would indirectly recharge the buried channel aquifer in the Hat Creek Valley. The net result of all seepage would be a very minor beneficial impact in that recharge to the aquifer would be increased. The disposal of fly ash in the UMC Valley would have similar impacts to the base scheme, but with a lower magnitude. Annual peak seepage flows through the embankment would be between 20 and 80 m^3/d.

For Alternate 2, the total seepage losses to the groundwater table from the bottom ash storage area, dewatering pond and fly ash storage area combined are estimated to be 35 m^3/d (see Fig. 4.1-17). Depending on the depth of the groundwater table and the thickness and hydraulic conductivity of the underlying till, some groundwater seepage could surface in Harry Creek. Above ground seepage would range between 20 and 120 m^3/d. If dewatering bins are utilized instead of a dewatering pond, precipitation and some residual moisture retained in the ash would seep down through the ash piles and eventually saturate the surficial sediments and bedrock below (see Fig. 4.1-18). The total seepage losses to the groundwater table in this case would also be about 35 m^3/d. The above ground seepages surfacing at the toe of the bottom ash pile would be between 20 and 120 m^3/d. As with Alternate Scheme 1, the seepage from these ash storage areas would indirectly recharge the buried channel aquifer, both as seepage from beneath the storage piles and as seepage losses resulting from increased flows in Harry Creek. The net result would again, be a minor beneficial one in that recharge is slightly increased.

B. Surface Water

All ash disposal schemes would involve the isolation of considerable areas from the Medicine Creek drainage area. The Medicine Creek ash disposal area (408 ha), the makeup water reservoir (62 ha) and the plant area (100 ha) would reduce the total drainage area of Medicine Creek by somewhat over 10 percent. Compared to the major impact on Medicine Creek discussed earlier (diversion into ditches and destruction of the natural channel) this small change in runoff would be insignificant. The dry ash disposal schemes, however, would avoid the infilling of the UMC Valley and the associated destruction of 5 km of natural Medicine Creek channel and are, therefore, preferable. In veiw of the fact that Lower Medicine Creek would have to be diverted around the large mine spoil dump, this is not a major benefit.

Whether Medicine Creek runoff would be diverted to MacLaren Creek appears to be uncertain at this time. A diversion of limited flow from Medicine Creek to MacLaren Creek is presently operating and could be enlarged to handle all possible flows. MacLaren Creek's channel morphology would need to be examined to determine whether or not it could accept such flows without adverse impact such as erosion and gullying.

(iii) Water Use

There are no operational phase activities at the plant site which would have an impact on existing groundwater use. Surface water use would be affected if a portion of Medicine Creek's flow is diverted around the UMC ash pond to MacLaren Creek. This would decrease the amount of water flowing to Hat Creek and thus have a minor impact on use of irrigation water in Hat Creek Valley. It could, however, be beneficial to users in the Cornwall Creek drainage area.

Medicine Creek water may also be considered for use as powerplant makeup. Details of this alternative have not been developed at this time and therefore, the potential effects cannot be fully quantified. In such a case, users, in both the Hat Creek Valley and the Thompson River area would be affected. The total water to be collected and used during the irrigation season would probably displace current licensed water use. In addition, up to 216 x $10^4 m^3$ of freshet water normally diverted and stored in McLean Lake could also be affected.

(b) Ash Sluice Water Treatment Sludge Disposal System

Several of the alternatives for ash disposal would require treatment of the recycled ash pond supernatant to avoid scaling of the sluicing system pipelines. This treatment would generate a calcium carbonate, magnesium hydroxide and calcium sulphate type sludge which would be disposed of in a sludge storage pond. The size of the disposal area that would be required over the life span of the powerplant is estimated at 2-4 ha and would contain 6 000 000 t of dewatered sludge. Leachate data are not available for this material. However, seepage losses would be low due to the presence of till at or near the ground surface. With adequate pond preparation using relatively impermeable tills and with a location suitably above local groundwater, the operation would likely not impact groundwater quality or groundwater flows. The nature of the sludge, being highly alkaline, would also prevent dissolution of most metal constituents in the sludge.

It would also be necessary to ensure isolation of this area from interaction with uncontaminated surface runoff by means of diking and diversion ditches. Provided runoff from the dump is contained for reuse and/or evaporated, there would be no contamination of surface water systems.

(c) Flue Gas Desulphurization Sludge Disposal

The alternative of a Meteorological Control System for controlling chimney emissions is a partial Flue Gas Desulphurization (FGD) system. The quantity of sludge that would be expected from this process is about 7.1×10^6 t over the plant life, requiring an area of approximately 80 ha. All process wastewaters would be recycled, thus eliminating any positive discharge. A specific disposal site has not been identified at this time. If FGD is chosen, the site selection phase should examine specific impacts on groundwater and surface waters. Leachates from this material can contain extremely elevated levels of calcium, sulphates, chlorides, total dissolved solids and possibly metals. The quantity of leachates, however, would be very dependent on the permeability of the sludge, which can vary considerably, and the pond lining material. If leachate can be adequately contained, impacts should be minimal.

(d) Coal Pile Storage Runoff

Runoff and leachate from the potential plant site coal pile would be collected, routed to a holding basin and subsequently reused in the ash handling system. The quality of this water would be poor, but since there would be no positive discharge, there would be no interaction with uncontaminated ground and/or surface waters in the plant site area.

4.1 POWERPLANT - (Cont'd)

4.1.4 Socio-economics

(a) Labour Force, Population and Income

(i) Labour Force and Employment

A. Direct Project Employment

The proposed plant would require about 250 employees through the operation phase. Staff requirements as each 500 MW unit comes on line are presented in Table 4.1-21. The plant would entail a three-shift operation, seven days a week.

B. Regional Labour Force Participation in Direct Employment

Skill shortages would be a major limitation in the absence of extensive job switching. Also, some qualified regional residents might not obtain employment because of the hiring requirements dictated by the several collective union agreements to which B.C. Hydro is a party. Job security and locational advantages over other regional mining jobs, wages, fringe benefits and the uniqueness of the Project would draw regional residents for potential employment at the plant. Given the above considerations, Table 3.4-4 provides an estimate of direct local and regional participation for operation of the Hat Creek Project.

Through discussions with B.C. Hydro officials, it was concluded that a few clerical, general tradesmen, and operating and maintenance helpers would be the most likely positions for which local qualifications would be suitable and for which union constraints would be least significant. These positions would account for a potential 80 out of the 247 jobs in the plant. In estimating regional participation, 75 percent of the 80 potential jobs would likely be filled by regional residents. Local residents would be expected to fill about half of the regional total.

C. Indirect and Induced Employment

The operating phase of the plant would not likely contribute to direct regional purchases. General hardware items might be purchased regionally if prices are competitive with Lower Mainland supplies.

Within the local study area, induced employment increments for the operating phase are assumed to occur in the settlement community of the operating workforce. Table 3.4-5 provides estimates of the indirect and induced employment likely to occur in the region.

D. Regional Participation in Indirect and Induced Employment

The reader is referred to section 3.4.1 for relevant discussion.

E. Labour Supply for Other Regional Industries

The reader is referred to Section 3.4.1 for relevant discussion.

(ii) Population

A. Population Growth

The general discussion on population growth in Section 3.4.1 is perintent to this section concerned with plant operation.

Operating employees, as well as indirect and induced employees, would be expected to reside in the communities and surrounding rural areas. Direct operating employees, in-migrating to the communities and rural areas would be expected to be about 25 percent single and 75 percent married with the latter averaging 2.8 dependents. Indirect and induced employees would be expected to have similar marital and demographic characteristics to the direct operating employees.

B. Settlement Patterns of Incremental Population in the Local Study Area

The reader is referred to Section 3.4.1 for relevant discussion.

C. Socio-cultural Characteristics of the Incremental Population

The following discussion highlights the anticipated changes in the composition of the population associated with various communities. The reader is referred to the Socio-economic Report[10] for details. Table 4.1-22 provides a summary of major population characteristics by community "With" and "Without" the project.

The population of 40-50 ranchers in the Valley would be reduced substantially although it is anticipated that there would be little change in the characteristics of the existing, long time residents of the ranching community. The incoming population associated with the Hat Creek Project would be relatively young with nearly one-half in the prime employment years, age 20 to 44 years. Of the remaining population, an equal number will be children or young adults with only a small proportion of the population over 45 years of age. This reflects a younger age distribution than that associated with existing mining workforces in the Highland Valley. About three-quarters of the incoming population over the age of 15 would be married and thus similar to the marital status of the Lornex and Bethlehem workforce. Based on the three surrogate communities an average family size of 3.8 persons with 1.8 children and an average household size of 3.4 persons would be anticipated for the incoming population. The anticipated family size would be less than that in some of the study area communities and would have implications for the delivery of services which was discussed in Section 3.5.4.

With respect to education levels, over a third of those 15 years of age and over and not attending school would probably have acheived grade 11, 12 or 13 level in the school system. Less than 10 percent would have completed some university training. About one-third of the incoming population would have a grade 8 education or less, while a slightly smaller proportion would have a grade 9 or 10 education.

(iii) Income

A. Direct Net Income

The total wage expenditures for the operating phase of the project would be around $720 million, in 1976 dollars. Table 4.1-23 contains the estimated direct increases in net regional and local income. The study region would likely receive a direct income gain of $683 million during the 35 year life of the project. The local study area would receive, paradoxically, greater direct net regional income benefits than the region of which it is a part; $686 million for the local study area versus $683 million for the region. The paradox is explained by the process of deducting Unemployment Insurance Commission income losses from unemployed residents that would work on the project.

B. Indirect and Induced Income

Indirect and induced income increases in the region and local area are shown in Table 4.1-24. Indirect income gains would likely be realized in the Kamloops area. Also, most of the induced regional income over that generated in the local study area would accrue to Kamloops.

C. Total Net Income Gains - Construction and Operation

The Hat Creek Project would significantly stimulate the expansion of income throughout the study region and the local area. The project would contribute about $1,426 million to the region and $1,071 million to the local study area, in 1976 dollars.

D. Regional and Local Income Distribution Implications

The western part of the region, centred at Ashcroft and Cache Creek would expand its relative contribution to overall regional income levels and growth. Ashcroft and Cache Creek would be expected to obtain the largest share of total income benefits within the local area. Construction related activities would result in an increase in the income of the region's construction workforce both union and non-union, as well as benefit owners of commercial ventures. Local landowners would benefit from capital gains, expected to be moderate, realized on the sale of their land.

Although women would not share proportionately more of the income benefits of the project than in regional income growth without the project, any reduction in the seasonality of employment positions traditionally held by women would be of benefit to them.

It can be expected that the distribution of personal income would shift upwards in the local area. Also, the range of personal income would probably spread rather than narrow as a result of the Hat Creek Project.

E. Effects of the Project on Local Prices

Although price increases would affect rural and municipal land, the increases would probably be moderate. The greatest land price increases might occur in lakeshore properties, such as at Pavilion and Loon Lakes, in short supply around the vicinity of the project. Price pressures are likely to take place in temporary accommodations and restaurants. However, the general level of consumer prices in the area are not expected to be significantly affected by the project.

(b) Recreation

(i) Physical Effects

Once the plant, mine and offsite facilities are completed and fully operational, project impacts affecting recreational activites would be of three separated kinds; gradual filling of the ash and mine waste disposal area; potential impacts to the surrounding vegetation caused by reduction in air quality; and dust, stack emissions and cooling tower plumes affecting scenic values beyond the physical presence of the project itself.

Gradual filling of ash disposal areas would predominantly affect backroad travel as most game of interest to hunters would likely be dispersed due to the presence of machines and human activity. It is assumed that backroad travel could continue in the unfilled portions of project disposal areas. No further fishing impacts area would be assumed to occur in the operational phase beyond those preempted by construction. It is possible that fishing could improve during the operational phase but its extent remains unknown because of potential adverse impacts (such as acid rain) that could conceivably affect the water quality of valley lakes. Other activities which would include nature study, plant collecting and walking are assumed to affect 100 activity days annually through preemption of land during the operation phase.

Project facility emissions would affect natural scenic values adversely, however, the physical presence of the project is expected to attract sightseers. Thus the net impact of the project on sightseeing would be to increase activity levels (as will be described later).

The impact of stack gas emissions on recreation is difficult to demonstrate or quantify. Indications are that there would be a low, but not impossible, chance for vegetation to be affected by stack emissions. If such chance occurrences were to take place in summer, vegetation such as Englemann Spruce could be affected at high points including Cornwall lookout. The extent to which this would offset visitation is unknown but is considered to be small as the occurrences (if any) are expected to be infrequent. Operational practices would be intended to avoid occurrences of this kind. Effects on humans would be negligible or nil as the pollutant concentrations expected - should a chance occurrence take place - would be below detectable levels. It is assumed therefore that stack emissions would not directly affect visitation or other activities in the upper reaches of the hills and mountains surrounding the valley. Annual estimates of activity day impacts associated with project operation in Area A (refer to Fig. 2.5-1, Part Three) are shown in Table 4.1-25.

(ii) Induced Recreational Activity Impacts

The recreational impacts caused by project activities described in the proceding section would probably create shifts in the location of activities rather than decreases in the amount of activity. All activities that would be affected by the project are dispersed, thus locations at which the activity takes place can be shifted by participants. There are many areas where backroad travel, angling, hunting and sightseeing can take place that are relatively close to the project site. In the preceding sections recreational assets available in Areas B, C and D (illustrated in Fig. 2.5-1, Part Three) were described, all of which are capable of absorbing the loss of recreational resources within Area A.

The most important recreational impact of the project would not be the loss of recreational resources within Area A, but the introduction of new population in the Hat Creek Valley and adjoining towns. This population growth would be expected to create significant increases in recreational activity levels throughout all areas near the project site and environs.

Increases in population created by the project are of two kinds: those associated with the construction work force and those who would operate the facility. Both of these would tend to overlap to some degree as the project would be built in stages, with generating units going into operation while others are still being built. Recreation activity levels associated with increases in population would be incremental to those already forecast for the "without the project" case and reflect a 5 percent annual increase in participation rates overall. It is assumed, however, that participation rates between the construction and operational work force would be different. It is quite possible that recreation levels for camp construction workers would be higher than those for residents of nearby communities becasue the labor force is physically located within the valley. It is expected that construction workers would use the valley for recreation after hours and on weekends except those who may travel home on days off. A further assumption is that the resident farming population of 35 persons would be reduced as their lands are preempted by B.C. Hydro for use in the project. Where agriculture continues it is quite possible that the recreational pressure induced by a large resident work force could conflict with agricultural and grazing areas as off-duty workers seek the fish and game available.

In a survey of Bethlehem-Lornex miners residing in Ashcroft, it was found that there are no major significant differences in recreation patterns for miners in comparison to the entire population. It is assumed, therefore, that the Hat Creek work force resident in Ashcroft, Cache Creek, Clinton and rural areas would not differ in participation from the existing and forecast population. The work force resident in the Hat Creek Valley camps are assumed to have higher participation levels however, largely due to the life style available to a largely male group semi-isolated from nearby communities. While it is possible to estimate local work force participation rates and recreation days for various activities, the consequences to local resources (including fish and game, for example) are unknown. Hopeful anglers may fish Hat Creek and surrounding lakes even if the prospects of a catch are remote, or perhpas more likely, as catch rates diminish sportsmen would range farther afield or turn to other pursuits. In sheer numbers, the potential for extreme pressure on wildlife in the valley and environs would likely be high. Should natural resources become endangered as a result, restrictions may be in order.

A. Total Incremental Recreation Activity Days

Table 4.1-25 portrays the type of phenomena expected with the introduction of a major industrial installation in a semi-remote area. Population, and as a consequence forecasted recreation activity, show strong increases during the early years, peaking when construction is at a plateau and operations are beginning. As the construction work force declines and the permanent staff takes up residence, recreation activity totals decline and then stabilize.

The forecast in Table 4.1-26 reflects a number of forces at work; first is the absolute increase in population directly attributable to the project as forecast in the Socio-economic Study[10] (this population is incremental to the normal growth expected in the study area without the project shown in Table 4.1-27); second, differences in participation rates assumed in some activities for construction campsite workers; and third, an assumed growth of 5 percent in recreation activity participation rates overall.

A comparison of activity days forecast for area residents and for project workers is provided in Table 4.1-28. These data indicate that in 1984 and 1986, project induced recreation activity levels would exceed those forecast for local population without the project. Total activity days "with the project" would be the sum of both as it is assumed that local population recreation increases would occur whether the project proceeds or not.

B. Distribution of Incremental Recreation Activity Days

The locations where further recreational activity will take place are difficult to ascertain. A forecast of distribution of activities for recreational growth "without the project" was presented in the prededing section and it could be assumed that the future distribution of activities for the "with the project" case would be smilar. There are three problems associated with this assumption. First, is the introduction of a large resident work force within the valley, coupled with major physical disturbances in the lower reaches; second, is the question of the capability of the valley's lands and water to absorb the increases forecast; and third, is possible changes in the locations of recreation activity by non-local recreationists who may choose to partake in activities elsewhere as a result of the project.

It was indicated earlier that the inroduction of the large construction work force into the valley would induce great pressure on the available natural resources. Canadian Land Inventory (CLI) data indicate that while the valley is not highly rated for recreational capability, it does possess attributes suitable for low density recreation such as sightseeing, hunting, and backroad travel - for which the area is already used. What is lacking, however, are measures of carrying capacity and management programs to ensure that recreation carrying capability levels are not exceeded. With the exception of fish stocking in local lakes, the predominant thrust of provincial management policies in the valley is toward agriculture (including irrigated agriculture) grazing and forestry. Recreation is not a dominant theme in the valley as it is at Marble Canyon Park and Pavilion Lake to the northwest along Highway 12.

Lacking distinctive and explicit recreational policies for the valley, two scenarios have been prepared outlining what could occur under differing management assumptions. For both scenarios it should be borne in mind that substitution is an important factor related to all activities presently occurring in the Hat Creek Valley. There are a large number of areas nearby (many, such as lake fishing sites, operating at below capacity) to which recreationists can turn if the recreation experience in the Hat Creek Valley proves unsatisfactory. This substitution opportunity could possibly affect non-local recreationists (who have traveled some distance from home and thus have more flexibility in destination than local day-use recreationists who are comprised predominantly of the project camp construction workers and resident of nearby communities.

Scenario One - Predominantly Unrestricted Activity

Assuming no restrictions on angling or hunting would be imposed other than those existing at present it is quite conceivable that local fishing in Hat Creek and adjacent valley lakes could be eliminated for all practical purposes. Pavilion Lake would be an exception and assuming public access is not improved, pressure would increase through greater use of the private boat launching ramp. Pavilion Lake does have the capacity to accept greater fishing pressure and is generously stocked on an annual basis. It is doubtful however that Pavilion Lake would be capable of accepting a major increase without affecting the resource. The Thompson River and major fishing resources available in Area D would most likely absorb much of the increased pressure brought about by project workers - as they do for local community residents now.

Assuming no basic change in hunting regulations it is conceivable that the resident camp force would exert extreme pressure on existing game resources, perhaps to the point of permanent depletion. Forecast total project work force hunter days would exceed present hunter days in the valley in the early 1980's. If the majority of this activity takes place in the valley, and assuming no change in present and projected valley hunting activity, hunting levels could double. The extent to which wildlife population in the valley could tolerate this potential to increase in pressure is unknown as data on sustainable yields by species are lacking.

Backroad travel in the valley would likely increase to very high levels particularly as some farming would be discontinued with grazing and pasture lands turned over to project related activities. The extent to which air emissions would affect domestic grazing and wildlife forage is unknown. Impacts are anticipated to be low, but chance occurrences would be possible. In essence it is conceivable that all-terrain or four-wheel drive vehicles could penetrate most areas of the valley except actively farmed areas within the upper Hat Creek area. Similar impacts could occur in winter with probably active use of snowmobiles (some snowmobile enthusiasts have been known to drive game to the point of exhaustion, thus affecting wildlife).

All "other" activities would also grow, likely resulting in severe congestion at Marble Canyon Park with the possible spread of picnicking and other activities to undesignated areas throughout the valley and along roadsides.

Scenario Two - Restricted Activity

A more stringent - and perhpas likely - approach, depending on the experience gained as construction begins and work force numbers grow, would be to limit recreation activities that are found to exert heavy pressure on resources. Fishing activity could be banned or catches limited at local lakes; the length of open season could be limited by the Fish and Wildlife Branch for hunting of threatened game species; valley areas could be posted to restrict off-road vehicles where agricultural conflicts occur, game is harassed or vegetative and soil damage occur (this may be particularly important in arid areas). Coincidental with the imposition of restrictions would be the introduction of substitute indoor organized activities for construction camp workers, perhaps under the direction of a recreation supervisor. Indoor and outdoor sports and game, including non-destructive activities such as cross-country skiing, target shooting, ice skating, auto racing and other similar pursuits could divert pressure from local natural resource based recreation activities. Providing facilities and equipment for these activities would enhance participation. Local community parks could be established offering opportunities for baseball, football, hockey and similar activities to help relieve outdoor recreation demands caused by population increases in local communities. An additional step would be to direct construction camp outdoor recreationists to sites and facilities in Area D capable of accepting increased pressure.

4.1 POWERPLANT - (Cont'd)

C. Project Operation Impacts 1986 - 2020

Once the Hat Creek Project is completed and in operation no further increase in recreational activity demands would be caused by the project itself as the permanent resident work force would be expected to be constant in number. Growth in population in local nearby communities would likely continue, but the forces causing growth would not be due to the project as the most significant effects of the project-related population on total local population would already have been felt.

As a result, increases in project induced recreation activity levels would grow in concert with local activity at a projected rate of 5 percent annually. Growth in total activity beyond the assumed annual increase in participation rate would occur through increases in local population unrelated to the project.

(iii) Project Site Visitation

Assuming B.C. Hydro would follow a visitor program, visits to the site by tourists and others could be substantial. The Hat Creek Project would be close to main travel arteries and its unique size and type of activity could attract numbers of visitors, particularly as it would be situated near Highway 12 leading from Carquille through Marble Canyon to Pavilion Lake and Lillooet. Access would also be available on the new access road from Highway 1 near Ashcroft to the project site. It is assumed that visits to the site would vary between 1000 and 2000 persons per year.

(iv) Non-local Recreational Growth

Data are lacking which can be used to forecast recreational growth in Areas C and D caused by non-local residents. As stated earlier, indirect evidence points to non-local recreationists, particularly B.C. residents from the Lower Mainland, as being a dominant factor in overall recreation patterns. The extent to which growth in British Columbia as a whole would affect recreation patterns in Areas C and D is unknown.

(c) Aesthetics

When the plant is completed, it would consist of a number of diverse elements, many of which would have a large impact on the visual aspects of the environment. The plant stack is dealt with as a separate item because its impact would be greatest due to the considerable heights which are proposed. Other major elements of the plant are:

1. Switchyard, electric towers, and cables required to tie into the 500 kV corridor.

2. Generating facility itself, consisting of the turbine hall, the boiler plant, and the precipitators.

3. Buildings for administration, service and warehousing.

4. Facilities for ash water and fly ash.

5. Fuel oil and water tanks.

6. Coal storage area and conveyor system.

7. Ash slurry pipes.

8. Cooling towers.

9. Approach from the access road.

Principal measurements of the plant structure are 280 m long, 92 m wide, and 94 m high, and for each of two hyperbolic cooling towers, about 100 m in diameter and 138 m in height. The major exterior building materials would be concrete, metal cladding, steel and glass.

The visual impacts associated with the massings of the major plant elements would be upon Marble Canyon, upper Hat Creek Valley, Medicine Creek Valley, Highway No. 12, Cornwall Lookout, and Trachyte Hills. The extent of impact on these and other areas are more fully described in the *Aesthetics Report.*[162]

(i) The Stack

The stack would be a very dominant visual element in the region of the plant. It would be either 244 or 366 m high - depending upon air quality determinations - and would have a top diameter of about 22 m. Minimal plume effect would be expected in the summer, but there would be a visible plume in winter months.

Visually impacted areas from this stack would be: Marble Canyon, upper Hat Creek Valley, Medicine Creek Valley, Cattle Valley, Highway No. 12, Highway No. 1, Cornwall Lookout and Trachyte Hills. The reader should consult the Aesthetics Report[162] for details.

Fig. 1.0-1, Part Two presented the arrangement of the major project elements. Fig. 4.1-19 is a graphic representation of these elements and their relationships to the visual units previously enumerated. Fig. 4.1-20 is the site plan of the powerplant island. Fig. 4.1-21 is a perspective sketch of the powerplant island.

These four figures should be examined for overall orientation purposes prior to perusal of Figs. 4.1-22, 4.1-23 and 4.1-24. These latter figures demonstrate impacts to views from selected locations by means of before and after sketches.

(d) Other Socio-economic Considerations

During the operation phase of the powerplant, impacts on land use, housing, services, community and regional infrastructure, local and regional government, social environment, and

Native Indians would occur. The impacts of plant operation for each of the socio-economic considerations identified above were discussed with construction related impacts. The reader is therefore referred to the appropriate socio-economic considerations in Sections 3.4.2 through 3.4.8.

4.1.5 Noise

The Hat Creek Project would comprise many separate facilities but in no one year would all these facilities produce their maximum levels. The noise analysis of the plant and mine impact is based on the maximum noise impact generated by these facilities which would occur during Mine Stage 6 in the years 2013 - 2018.

(a) Plant Operation Noise Model

The plant would be capable of operating in either the "base load" or "two-shift mode". Base load would involve full time operation while two-shift operation would involve 6 to 9 hour interruptions as well as weekend shutdowns. Since it has not yet been established in which mode the plant would operate, it was conservatively assumed that the plant would operate on "base load".

Plant operation noise can be characterized by continuous noise from combustion, power generation and air handling processes punctuated by intermittent noises from steam vents and circuit breakers. The contributions of both the continuous and intermittent noise sources have been accounted for in calculating the total yearly average day/night noise levels (YDNL's) for plant operation.

Six plant continuous noise sources potentially strong enough to influence the overall YDNL beyond the plant boundaries would be:

Boiler House and Turbine Building
Eight (8) Forced Draft Fans
Eight (8) Primary Air Fans
Eight (8) Induced Draft Fans
Twelve (12) Transformers
Two (2) Natural Draft Cooling Towers

Two plant intermittent noise sources able to contribute to the overall YDNL would be:

Eight (8) Electromatic Relief Valves
Fourteen (14) Air-Blast Circuit Breakers

(b) Mine Operation Noise Model

During its production life, the coal mine (open pit, coal preparation facilities and waste dumps) would produce a relatively constant noise output punctuated by periodic impulsive noise from blasting. All pit operations are considered to take place below the original level of the valley floor so that some degree of shielding would be provided by the pit walls. The removal of superficials (overburden) would be largely carried out by scrapers which would stay at or near the surface of the pit, and consequently pit wall attenuation would be negligible.

The major noise sources of the coal preparation facilities would be the coal stacker-reclaimer and the associated conveyors, mobile cleanup equipment and the primary and secondary crushers.

Compared to the levels of activity involved with pit excavation and superficials removal, the waste dump activities would produce much lower noise levels.

Blasting activities would be a regular part of the mining operation, and therefore blasting has been incorporated in the calculations of YDNL generated by the mine.

(c) Plant and Mine Environs

Total yearly average noise levels (YDNL's) around the plant and mine would be mainly comprised of contributions from mine mobile equipment, coal preparation facilities, contributions from pit blasting and powerplant facilities. The noise levels to be generated by the above major sources were estimated and projected to the various receptors as described in Chapter 3.0, Part Four. The resulting impact at each significant receptor location is described below.

(i) Bonaparte Indian Reserve 1

The areas of Reserve 1 in which the combined future ambient and operation noise levels during Mine Stage 6 would exceed YDNL 55 and therefore would be incompatible with residential land use are shown hachured in Fig. 4.1-25. The broad strip of land along the southern end of the reserve would be impacted by coal preparation and mine noise, and it is presently occupied by one dwelling with four to six residents. The strip of incompatible land along Highway 12 is impacted primarily by the non-project traffic during Mine Stage 6, as shown in Figs. 4.1-26 and 4.1-27. By applying the sensitivity correction of Table 3.5-4 (Chapter 3.0) to the sound levels, produced by the mine and plant operation (Fig. 4.1-26), it is seen that the normalized project YDNL's would range from 50 to 72 dB(A), at the northeast and southwest corner of the Reserve, respectively. Fig. 3.5-2 (Chapter 3.0) indicates then that the expected community reaction is from "no reaction" to "threats of legal action". Since YDNL 65 will not be exceeded anywhere on Reserve 1 during Mine Stage 6, cattle grazing would be compatible everywhere.

(ii) Bonaparte Indian Reserve 2

The only project noise that would reach Reserve 2 would be the traffic noise from project-related vehicles using Highway 12. The increase in Highway 12 traffic noise due to project-associated traffic would be less during Mine Stage 6 than it would be during the first year of project construction because of the predicted 5 dB(A) increase in non-project traffic noise in the interim. This increase in non-project traffic noise would possibly cause residents on Reserve 2, who are within 45 m of Highway 12, to experience a noise level exceeding YDNL 55 dB(A).

(iii) Hat Creek Valley Ranches

At the time of this writing, there were seven occupied ranches in the Hat Creek Valley that would be within the range of audibility of the mine and plant. The Ed Lehman Ranch would be vacated before Mine Stage 6 occurred because of its close proximity to the rim of the pit. The remaining six houses are listed in Table 4.1-29 and their locations are shown in Fig. 3.5-6 (see Chapter 3.0). Table 4.1-29 shows the existing ambient YDNL, the project YDNL, the combined total YDNL and the normalized YDNL at each ranch location. This table shows the expected resident reaction to the project noise, which ranges between "no reaction" at the G. Parke Ranch to "vigorous action" at the M Saulte and Ike Lehman Ranches. The project noise would render the Soulte and Lehman Ranches incompatible with residential land uses since the expected YDNL of 63 dB(A) exceeds the recommended YDNL of 55 dB(A).

It is estimated that the grazing land alienated by noise (impacted by an YDNL greater than 65 dB(A)) would extend for about 600 m beyond the rim of the pit during Mine Stage 6, as shown in Fig. 4.1-26. This land would comprise an area of about 6.5 km^2 if it is considered that without mining noise, grazing could be carried out up to the rim of the pit. However, because range fencing would be erected within 100 m of the pit rim, the area alienated from grazing by noise alone would be substantially less.

(iv) Trachyte Hills

Based on the assumption that relatively noisy forced draft and primary air fans would be installed in the plant, the area incompatible with grazing (YDNL exceeds 65 dB(A)) would be about 4.0 km^2 which includes about 0.65 km^2 of the makeup water reservoir site, as shown in Fig. 4.1-28. However, the potentially impacted area is judged by Canadian Bio Resources Consultants[141] to provide spring range only, and of it, 10 percent has high grazing potential whereas 90 percent has low potential.

4.2 MINE

4.2.1 Meteorology - Air Quality

(a) Introduction

Air quality effects of particulate emissions resulting from activities related to the Hat Creek coal mine were assessed by ERT using a steady-state Gaussian diffusion model for multiple sources which is described in detail in Appendix B to the Air Quality and Climatic Effects Report.[1] This model, called ERTAQ, is similar to the Hat Creek Model (HCM) utilized for prediction of local scale air quality concentrations resulting from operation of the powerplant, except that it is designed for applications using multiple sources, including point, line, and area sources. It incorporates most of the same basic assumptions as the HCM in that: (1) steady-state meteorological conditions are assumed; (2) dispersion is assumed to conform to Gaussian (bell-shaped); and (3) removal processes (chemical transformation and deposition) are not considered. However, terrain effects are not considered and, because mine emissions occur at or near ground level and have no excess buoyancy or velocity, no plume rise calculations are included. Instead, emissions are assumed to be uniformly mixed through an initial 10 m depth.

Meteorological input to the ERTAQ model depend on whether short-term or long-term calculations are being performed. For annual average concentration calculations, an annual stability wind rose developed for the mine analysis from hourly data collected during 1975 at the B.C. Hydro mechanical weather station WS-5 (located in upper Hat Creek Valley near the mine site) was used as input. Short-term concentrations (24-hour averages) were computed on the basis of a range of potential "worst-case" and "typical" dispersion conditions. These conditions were identified from the stability wind rose and wind persistence statistics developed from data from the mechanical weather stations in the valley. Light-wind/stable (stagnation and high-wind/neutral conditions were investigated, as well as several other more typical scenarios.

For modelling purposes, the mining operations described in Part Two of this report were divided into a number of geometrically idealized line and area sources (Fig. 4.2-1), representing the year of maximum production and activity (2017-2018). Emissions of suspended particulate matter from these mining operations were then quantified.

The important mining operations in terms of suspended particulate production would be:

1. Surficial material removal.

2. Overburden removal.

3. Coal removal.

4. Haul road traffic and repair.

5. Coal stockpiling.

Dust-producing processes associated with these operations include scraping, shoveling, blasting, hauling, and dumping. Emissions from these activities were estimated on the basis of published factors from the literature and projected operating information for the year of maximum production and activity from the proposed mine plan.[2]

Erosion of exposed surfaces and storage areas by the wind would also be an important potential source of fugitive dust associated with mining activities. Emissions that would be due to wind erosion at the Hat Creek Mine were computed by ERT to reflect local meteorological conditions, soil properties, and the orientation of the mine with respect to the prevailing wind.

Table 4.2-1 lists emission factors, source operating units, and the annual controlled emission rates assumed for each mining activity. The tabulated values represent very conservative estimates, based primarily on studies of the air quality effects of strip mining operatings in Wyoming and Colorado. These emissions account only for the assumed fraction of disturbed material in particle sizes small enough to remain suspended beyond the mine area. As evidenced in Table 4.2-1, wind erosion in disturbed areas (based on the annual average wind speed) would be the major dust source for the Hat Creek Mine. The emissions given for this source are believed to be particularly conservative because it was assumed by ERT that wind erosion would occur throughout the year. In reality, emissions would decrease to near zero during periods of precipitation and during the winter, with its extended periods of snowcover and frozen ground.

After wind erosion, the major sources of fugitive dust would be haul-road traffic, overburden removal, and surficial removal. However, most of these activities would take place within the pit, below ground level. Realistically, the depth below ground level at which a source is emitting should exert considerable influence on reducing the resulting amount of suspended particulates carried downwind. However, this feature is difficult to treat quantitatively, and all sources for the Hat Creek Mine were conservatively assumed to be emitting at ground level.

A number of assumptions regarding dust control techniques were included by ERT in the calculation of emissions:[2]

1. Frequent watering of haul roads and exposed surfaces was assumed, resulting in 50 percent control of dust emissions.

2. A speed limit of 24 kph was used on all haul roads to give a control efficiency of 80 percent, in addition to the control by watering.

3. The land reclaimed from the waste dumps midway in the life of the mine (year 2005-2006) was assumed to be the only area that would be reclaimed at the time of the model year 2017-2018. This is a reasonable but conservative assumption for the proposed mining method; reclamation of an open pit mine and waste dumps would not be possible on a large scale until mining is completed.

4. The conveyor system would be completely enclosed resulting in approximately 100 percent control for this source.

The emissions listed in Table 4.2-1 include consideration of these control measures.

A complete description of the modelling methodology, the meteorological input, the emission parameters, and the resulting predictions of the air contaminant concentrations and climatic modifications is provided in the Air Quality and Climatic Effects Report and its Appendices.[2] A summary of the results is provided in the following two sections.

(b) Air Quality

Estimates of the incremental arithmetic mean annual suspended particulate concentrations (based on the conservative assumptions discussed above) that would result from the mine's operation are presented in Fig. 4.2-2. Calculated values greater than 100 $\mu g/m^3$ are confined to the immediate vicinity of the mine pit. The 50 $\mu g/m^3$ contour extends northeastward approximately 3 km beyond the upper-lower junction of Hat Creek Valley, and southward to within about 1 km of Anderson Creek. Annual concentrations generally between 25 and 50 $\mu g/m^3$, with peak values of about 60 $\mu g/m^3$, are predicted for the Indian Reserve north of the mine in the lower valley. To all these values must be added the existing background suspended particulate concentrations described in Part Three, Section 3.2.2(b). ERT has assumed background values of 20-40 μg/m³ depending on location.[8] More recent B.C. Hydro data indicate an annual average background of 10-20 μg/m³. On the basis of either of these estimates for background, the calculations indicate that the 60 μg/m³ annual geometric mean assumed guideline (see Section 4.1.1(a)(ii)) would possibly be exceeded over the area within a few kilometres of the mine.

Nine separate sets of meteorological conditions were input to the model by ERT to calculate "worst-case" and "typical" incremental 24-hour suspended particulate concentrations that would be due to emissions from the mine. Of the possible "worst-case" conditions investigated, the predicted concentrations were highest for stable diffusion conditions with very light winds (2.77 kph) persisting from a single direction (SSW) for 14 hours out of the 24-hour period. The results are presented in Fig. 4.2-3. Incremental 24-hour concentrations in excess of 200 μg/m³ are predicted for the southern section of the Indian Reserve located above the junction in the eastern branch of the lower valley. The 150 μg/m³ contour extends to the northern boundary of the Reserve. With background concentrations added, the calculations indicate that the 150 μg/m³ 24-hour average assumed guideline (see Section 4.1.1(a)) would be exceeded for several kilometres offsite. However, these "worst-case" meteorological conditions would occur only a few times per year and the concentrations predicted are likely to be overestimates due to the conservatism of the modelling assumptions.

Results for one of the cases with more typical meteorological conditions (moderate winds (8-hours of persistent north winds at 8.04 kph) with neutral stability) are depicted in Fig. 4.2-4. ERT believes[2] that this and similar cases would represent typical afternoon conditions in the upper valley. The results indicate that the dust-producing processes in the mine contribute to much lower ambient suspended particulate levels; no incremental values greater than 100 μg/m³ are predicted, even near the mine pit, for these more typical conditions.

The quantities of trace elements in the fugitive dust emissions from mining operations were determined by ERT to be insignificant in terms of their potential contributions to ambient contaminant levels. A discussion of maximum predicted concentrations for selected trace elements due to coal combustion in the Hat Creek Powerplant is presented in Appendix F to the Air Quality and Climatic Effects Report,[3] and summarized in Section 4.1.1(b)(i) of this report.

In terms of commitment of the air resource due to mining activities, only total suspended particulates are significant air contaminants. Since predicted annual average concentrations exceed the assumed ambient guidelines, it is concluded that 100 percent of the air resource will be used in some areas of the upper and lower Hat Creek Valley and Marble Canyon. The significance of mine emissions outside of these valleys would be negligible.

(c) Meteorology

The methodology used in the investigation of the potential effects of project operation on climatic conditions has been discussed in Section 4.1.1(c)(i). ERT investigated a variety of climatic parameters which could potentially be modified as a result of project operation. Only two climatic effects due to mining operations were postulated: thermal alterations and visibility degradation.

Potential thermal alterations are discussed by ERT in Appendix E to the Air Quality and Climatic Effects Report[4] while visibility degradation is discussed in Appendix B.[1] Summaries of ERT's conclusions on these topics are presented here.

A slight and very localized annual temperature decrease would possibly occur directly over the mine pit due to scattering of incoming radiation by sustained particulate loadings in that area. Theoretical model simulations of atmospheric processes support this contention. Any effect of this kind would certainly be smaller in magnitude than the natural year-to-year variability of annual average temperature and would not have any significant impact on agricultural activities.

The effects of dust emissions from mining activities on visibility within Hat Creek Valley were estimated by ERT using the linear system of visual acuity. This approach allows one to estimate the extent to which the visual detail of the object is obscured as the concentration of aerosols increases. As noted in the previous section, typical background suspended particulate concentrations on the Indian Reserve 3 km north of the mine were estimated by ERT to be about 20 $\mu g/m^3$. According to ERT;s analysis,[2] the eye can distinguish fine, moderate, and coarse detail at distances of about 14.6 km, 36 km and 54 km, respectively, with this particulate loading. The maximum annual increase in suspended particulates predicted for this location (60 $\mu g/m^3$) is expected to reduce the visible ranges for fine, moderate and coarse detail to 3.6, 9.0 and 13.5 km, respectively. A more typical incremental annual particulate value that would be expected to occur within the Indian Reserve is 25 $\mu g/m^3$. This value added to background would be expected to reduce the distances at which fine, moderate, and coarse detail are discernible to about 6.5, 16.0 and 24.0 km, respectively. On the basis of these modelling results, ERT concluded[2] that emissions from the mine would reduce the annual average visible range by about a factor of four near the northern boundary of the mine site, and by no more than a factor of two beyond 5 km from the mine. More severe short-term visibility reductions beyond the site limits may occasionally occur, especially with persistent, light winds and stable dispersion conditions. However, no such effects would be expected at locations outside of the Hat Creek Valley.

(d) Effects on Human Health

Predicted fugitive dust concentrations in excess of the assumed guidelines for total suspended particulates (TSP) alone are an inadequate basis to predict adverse human health effects. Without specific data on the respirable fraction and chemical constituency, it is difficult to determine what the epidemiological consequences would be of exposures to TSP concentrations predicted for Hat Creek. The projected TSP concentrations for Hat Creek are based upon fugitive dust emissions alone and do not include combustion sources.[5]

Fugitive dust is typically characterized by particles of large mass, median diameter. Such particles are neither respirable to any great extent, nor are they composed of materials commonly associated with adverse health effects. For these reasons, fugitive dust may be more of an operational or nuisance problem than an epidemiological concern.

Scientists are concerned about fine particles, those 2.5 µm and less, because they can be inhaled and deposited in the deep lung or gas exchange areas. Particles larger than 15 µm most likely do not significantly affect human respiratory systems.[5a] The toxic fraction of fugitive dust sources in rural areas is considered to be small because such areas are generally not exposed to potential contamination by industrial fallout or affected by adsorption of gaseous pollutants, such as are prevalent in urban atmospheres.[5b] When the source is determined to have a specific health impact, reasonably available control measures to minimize impact can be undertaken.[5b]

4.2.2 Water Resources

(a) Water Quality

(i) Groundwater

Seepage from the mine waste disposal areas would represent the most significant operational impact on groundwater quality. The maximum volume of seepage would, however, be relatively low, totalling about 400 m^3/d from the proposed Houth Meadows disposal area and 40 m^3/d from the Medicine Creek disposal area. The estimated quality of seepage that would emanate from each disposal area is indicated in Table 4.2-2 for conditions of initial pore volume displacement. The overburden material would be similar to that proposed for disposal in the Medicine Creek area, whereas the waste rock would be similar to the claystone material proposed for disposal in the Houth Meadows area. Seepage from the Medicine Creek area would be expected to have elevated levels of iron and copper, but since the flow would be insignificant, impacts to groundwater quality would be slight. Seepage from the Houth Meadows area would be expected to have elevated levels of arsenic, chromium, copper, iron and dissolved solids. Since this seepage flow is expected to increase total groundwater flow by 50 percent, a degradation in the water quality of the aquifer would be expected. This aquifer, however, ultimately discharges to Hat Creek and comprises less than 1 percent of this creek's average flow. Long-term impacts on Hat Creek water quality, therefore, would be negligible. It is recommended, however, that monitoring wells be installed in the Houth Meadows and Marble Canyon areas to discern the quantity and quality of any seepage from this disposal area to ensure long-term water quality integrity.

Mine area and pit dewatering are extraction processes and as such would not be expected to pose any hazard to the quality of the remaining groundwater resources in the valley. The poor quality of leachates from the coal pile and low-grade waste disposal area has been discussed previously. Provided base construction for each area utilizes well compacted impermeable material, percolation of leachates to groundwater would be insignificant. Sewage and refuse disposal would cause insignificant impairment to groundwater quality provided the treated sewage storage pond and landfill are situated above the groundwater table and precipitation infiltration minimized.

(ii) Surface Water

The main impacts to surface water during operation of the mine would be from: disposal of mine water from pit area dewatering; sediment loss from disturbed areas and fugitive dust precipitation washout; seepage from the Houth Meadows and Medicine Creek waste disposal areas and nutrient loss from fertilization activities during reclamation.

It is assumed that due to the probable poor water quality of leachate and runoff from the coal pile and low-grade waste disposal area, these sources of contamination would not be discharged to surface water streams.

The degree of dewatering increases substantially in the operation phase to about 30 L/s from dewatering wells and from mine seepage. A further 9-125 L/s would require pumping from the pit during and following precipitation events. The estimated quality of this water was presented in Table 3.2-4. Due to this increased flow, the quantities of colour, BOD_5 and ammonia (the latter from possible blasting residuals) would no longer be acceptable for discharge to Hat Creek after sedimentation. Colour addition would possibly cause a minor aesthetic impact while a BOD_5 addition of about 20 kg/d would possibly reduce the dissolved oxygen level in Hat Creek to less than 5 mg/1. The ammonia level would possibly be substantially above regulatory levels (0.50 mg/L).[7] Given that this is a "worse case" water quality estimate and dependent upon the dilution potential of precipitation, it is recommended that the effluent from the sedimentation pond be closely monitored and that provisions for additional treatment be incorporated into the lagoon design.

Mine facilities and overburden disposal areas would be subject to precipitation runoff and sediment loss. Due to the short contact time of precipitation runoff, the major water quality parametre of concern would be suspended solids. Mean values ranging from about 0-1300 mg/L during baseline conditions to values ranging from 250-3900 mg/L during rain events have been observed by others[8] in studies of sedimentation ponds at surface mining operations. As presently designed, the lagoons that would service the waste disposal areas and other disturbed areas would also intercept surface runoff from undisturbed areas. This arrangement would not provide the best approach to sediment and erosion control. Lagoons of a "dedicated" nature function better and can therefore be smaller in size. It may also be necessary to add coagulants to increase sedimentation efficiency. If this is contemplated, consideration should be given to the possible effects of the coagulant on downstream water quality. Runoff to Harry Creek which would be near the coal preparation area may be subject to impact from coal fines. Consideration should be given to placing a settling basin on this creek to protect Hat Creek water quality.

Under normal circumstances of low precipitation, there would be insignificant runoff from the overburden disposal areas. Under these conditions the only discharge would be seepage from the toe drains of these areas. The quality of these flows, as predicted in Table 4.2-2, would contain elevated dissolved solids and metals such as chromium, copper and iron in excess of regulatory guidelines.[7] Treatment by sedimentation alone would not be expected to reduce levels of dissolved metals. Without additional treatment, or a no-discharge mode of operation, the impact on water quality of Hat Creek would be high.

Reclamation during mining would probably require the application of fertilizers. Based on present reclamation plans, the contribution of nitrogen and phosphorous to Hat Creek from fertilizer contained in runoff were calculated for two possible cases: (1) a single application of fertilizer at the time of the first seeding or (2) annual application of fertilizer over all reclaimed land. The values are:

	Single Fertilization		Annual Fertilization	
	Nitrogen (N)	Phosphorous (P)	Nitrogen (N)	Phosphorous (P)
From Startup to Midpoint of Mining	0.003 mg/L	0.0002 mg/L	0.023 mg/L	0.001 mg/L
From Midpoint to End of Mining	0.015 mg/L	0.001 mg/L	0.172 mg/L	0.001 mg/L

This loss of nutrients could foster algae and slime growth in Hat Creek and subsequently care should be taken to minimize fertilizer loss.

Reclamation of disturbed areas, however, would have a number of beneficial impacts. These would include the diminishing of the rates of soil erosion, chemical leaching and wind caused dust from previously disturbed areas. These would benefit both surface and subsurface water quality.

In order to project a probable maximum change in the quality of Hat Creek during mine operation, a water quality balance was made of these main discharges. A period of summer low flow was assumed when the dilution effect is minimal; surface runoff is negligible; mine water from dewatering and waste disposal area surface seepages would be at a maximum. Minor groundwater subsurface flows from waste disposal areas were not considered. In order to derive the resultant concentration of any water quality parametre in the final combined flow downstream of all discharges, the following water quality balance formula was utilized:

$$C = \frac{Q_1C_1 + Q_2C_2 + Q_3C_3 + Q_4C_4}{Q_1 + Q_2 + Q_3 + Q_4}$$

where C = the concentration of a particular parametre in the combined discharge.

$C_1 - C_4$ = the concentrations of the parametres in component discharges presented in Tables 3.2-4, 4.2-2 and 3.4-1, Part Three.

and, Q_1 = Mine Water Flow = 0.030 m^3/s

Q_2 = Houth Meadows Disposal Area Seepage = 0.017 m^3/s

Q_3 = Medicine Creek Disposal Area Seepage = 0.023 m^3/s

Q_4 = Hat Creek Flow = 0.12 m^3/s

Q_5 = Total Flow = 0.19 m^3/s

A number of assumptions were also incorporated into this balance and include:

1. Those parametres, except sulphate, which would exceed the current regulatory Level "A" Objectives[7] were reduced to the objective level to simulate the result of treatment

prior to discharge. Sulphate was deleted from this assumption since there is no cost effective technology available for removing sulphate and the objective is presently under review.

2. The quality of the discharge was averaged where necessary. For instance, the quality of the Medicine Creek disposal area seepage is assumed to be the average of that produced by Overburden 76-1 and 76-13 of Table 4.2-2.

3. The level of suspended solids after treatment is assumed to be less than or equal to the Level "A" requirement of 50 mg/l.[7]

4. The maximum temperature is assumed to be the value projected to occur in the diversion canal (see Sub-section 4.3.5(b) for discussion of this topic).

5. The nutrient levels are assumed to be those values projected to result from reclamation fertilization on an annual basis, plus contributions from seepage and mine waters to be discharged to Hat Creek. It does not include any contribution from blasting residuals.

The resulting water quality derived from this balance is given in Table 4.2-3 for pertinent parametres. The results indicate a substantial (90 percent) increase would be expected in the dissolved solids level of Hat Creek which would possibly present problems to aquatic life. Increases are also projected in the alkalinity, sodium and chloride levels. The level of arsenic would exceed the acceptable drinking water level of 0.01 mg/L,[9] but would still be considerably lower than the maximum permissible level of 0.05 mg/L. The projected levels of chromium, copper, iron and lead would remain below the acceptable limits. Water temperature could pose a severe problem to the existing fisheries resource and would also be above the maximum level deemed acceptable for drinking purposes (15°C).[9] The projected level of suspended solids would be such that the corresponding turbidity would be about 7 NTU which is somewhat above the acceptable receiving water and drinking water level of 5 NTU. All other parametres would remain within the Objective Level of Recommended Limits for Drinking Water.[9]

Predictions have not been made for BOD_5 or dissolved oxygen levels because existing data are not considered sufficiently reliable. If further testing indicates that the BOD_5 load would be above about 50 kg/d, biological treatment could be required to maintain adequate oxygen levels in lower Hat Creek. The projected "worst case" levels of the nutrients, nitrogen and phosphorous, indicate a significant increase would be possible. These levels are considerably in excess of those generally accepted as being able to stimulate algae growth.

With the exception of low flow periods, the impact of changes in Hat Creek water quality would have an insignificant effect on the Bonaparte River. During low flow the level of dissolved solids could increase by 10-20 percent based on the "worst case" analysis for Hat Creek. The nutrient levels could also increase during this period and would foster some increased algae growth. Considering the dilution potential available in the

Thompson River, water quality changes in this water body would be insignificant. The Hat Creek development would also result in an increase in the population of the village of Cache Creek and Ashcroft. The impact of additional sewage on the Bonaparte and Thompson rivers should be minimal.

(b) Hydrology

(i) Groundwater

The major impacts to the groundwater hydrological regime of the area would be caused by placement of vast quantities of waste rock and overburden in disposal areas. When dumping commences in Houth Meadows some major changes in groundwater flow patterns would likely occur particularly in the limestone bedrock at the north of the disposal area. Initially when the waste rock is dumped it would be loose with a hydraulic conductivity between 10^{-5} and 10^{-3} m/s and seepage water would easily pass through. As the dump height increased the material in the bottom of the dump would become more compact and reduce hydraulic conductivities to about 10^{-11} m/s. This would tend to seal off the seepage flow through the base of the dump. The water table in the limestone bedrock would then rise at about the same rate that the dump surface rises. Groundwater seepage and surface runoff from the limestone bedrock would flow toward the dump until the water table in the dump became higher than the groundwater divide in the bedrock. At this point seepage from the dump would flow into the bedrock (see illustrations in Fig. 4.2-5). The major seepage losses to the groundwater table would occur in the northeastern corner, around the saddle embankments and beneath the east embankment (see illustration in Fig. 4.2-5). Estimated seepages from the dump through the limestone bedrock are 10-50 m^3/d (Q_1) under the east embankment and 200-600 m^3/d (Q_2) northward around the saddle embankments. The result would be a diversion of an estimated additional water flow of 400 m^3/d toward the surficial aquifer in Marble Canyon. This would represent about a 50 percent increase in groundwater flow in the limestone bedrock on the south side of the canyon. The groundwater level in the canyon aquifer, which flows eastwards, would rise by a few metres, but would not reach the ground surface. The result would be a major beneficial impact on the canyon aquifer in that recharge is greatly increased and assuming seepage water quality would be satisfactory for any intended use. Seepage flows through the embankment structures, while not strictly groundwater flows have been estimated to be between 300 and 1500 m^3/d.

The depth to the groundwater table below the base of the Medicine Creek disposal area is about 30 m below ground surface and hydraulic conductivities of underlying bedrock and surficial sediments are low (10^{-8} to 10^{-7} m/s). Initially waste material would be "free-draining" for a period of a few months after placement. However, the effects of weathering and consolidation would reduce hydraulic conductivities to values similar to those given for the Houth Meadows area. Recharge would come from precipitation on the loose surface materials (assumed to be relatively coarse), leakage from diversion canals around the disposal area and from seepage from the small pond behind the embankment at the eastern end of the area. This would result in a rise of the water table by 10-30 m and possibly to the ground surface. Eventually, the steeper hydraulic gradient toward the Hat

Creek Valley would dominate and groundwater seepage would become greatest in this direction (see Fig. 4.2-6). Seepage losses, in the order of about 20-50 m^3/d, would be expected and a minor beneficial impact would result. The estimated maximum short-term seepage through the embankment would be between 300 and 2000 m^3/d. Two other activities will continue to affect the groundwater resource during the operational phase of the mine. These include pit and area dewatering and drainage ditching and diversions. Both topics have been previously discussed in Section 3.2.2. The maximum zone of influence due to pit dewatering was shown in Fig. 3.2-1 and there would be no impact on local aquifers beyond this zone. Drainage ditching and diversions would continue to have ambivalent impacts in that groundwater recharge would be redistributed from naturally occurring areas.

(ii) Surface Water

In the course of mining, large areas that produce practically no surface runoff in their natural state would be converted to relatively impervious runoff-producing areas. Surface runoff from these artificial, relatively smooth surfaces would be rapid and the proposed extensive system of drainage ditches would contribute further to this unnaturally rapid response. The proposed two major lagoons and the large sump capacity in the mine would, however, act in the opposite sense by permitting regulation of outflows. The combined effect of these facilities would be that lagoon releases following a 10-year, 24-hour rainstorm would only amount to 0.35 m^3/s and thus, no significant changes in the frequency of flooding or in channel morphology would be likely.

Surface runoff would only be occurring infrequently at the mine site. Except during snowmelt, which would not normally last for more than a month, there would be very few runoff-producing rainstorms. During the remaining time the effect of the mining operation would mainly consist of releasing some treated effluent and flow from dewatering wells. Practically all this flow is now entering the creek as groundwater seepage. The resulting changes in natural flows would be far too small to have noticeable effects on channel morphology, but increased dry weather flows would be a beneficial impact.

Reclamation of embankments and waste disposal area surfaces would create surfaces with similar hydrological properties as the original natural surface. The volume of runoff from reclaimed surfaces would therefore return to approximately its natural value. The time distribution of runoff, however, would remain affected by the project since terrain slopes would be changed permanently and the system of ditches and lagoons would remain in place.

(c) Water Use

(i) Groundwater

Some groundwater could be developed to supply water for irrigation of revegetated areas in waste disposal areas. Well development would cause an impact ranging from minor to significant depending on the quantities required.

(ii) Surface Water

The impact of project operations on irrigation water use is summarized in Table 4.2-4. Project operations (base scheme) could affect the availability of approximately $60 \times 10^4 m^3/a$ of water for irrigation use. Because water usage would be partially composed of non-consumptive uses that would only change the location of water availability, the net impact on irrigation water use would more than likely be less than the above quantity.

Domestic, municipal and industrial water usage increases that would be due to area population changes have been discussed under Section 3.2.2.

(d) Aquatic Ecology

Impacts to the aquatic biota of the Hat Creek watershed associated with the open pit mining operation would result from the loss of approximately 7 km of aquatic habitat due to diversion of Hat Creek around the mine and from changes in water quality and or quantity that would be due to mine discharges. Certain lesser impacts to the aquatic community would possibly result from the activities of the increased human population associated with the mining operation.

Habitat loss would commence with the operational phase of the Hat Creek diversion, at the commencement of mine preparation, but is considered to be an impact of mine operations. The 7000 m that would actually be removed from the system by the diversion represents a 17 percent reduction in available natural Hat Creek habitat. Based on fish density estimates developed in this report (see Part Three, Chapter 3.0) approximately 2900 rainbow trout greater than 100 mm in length occupy this stream segment. It has been estimated that the total trout population (including those individuals less than 100 mm in length) ranges from 3000-5000 fish.[10] Since the Hat Creek trout population is at present relatively unexploited, the carrying capacity of the watershed would be decreased by at least approximately 17 percent due to mine operations. While the reservoirs that would be constructed as part of the overall creek diversion scheme represent possible productive habitat which could be stocked or exploited by native trout populations, increased production from this new habitat would likely be offset by a loss of productivity in the reach of Hat Creek directly downstream of the mine, due to a combination of the loss of input to the lower reach via "drift" and the expected water quality impairment from mine dewatering and runoff from waste dumps and disturbed areas. Use of these reservoirs, however, is discussed further in Part Five, Mitigative Measures.

Table 4.5-3 provides an estimate of projected water quality and a comparison with existing water parametres in Hat Creek. The potential impact of these water quality changes was discussed in Sub-section (a) above. The principal impact would be an increased potential for algal growth in the creek itself due to the potentially high nutrient levels. No significant effect from these water quality changes would be expected downstream after mixing with the Bonaparte River.

4.2 MINE - (Cont'd)

4.2.3 Land Resources

(a) Physical Environment

The only significant impact that operation of the mine would have on the physical environment is that derived from erosion and dusting problems. Fugitive dust emissions would come primarily from the movement of heavy equipment within the pit and along the unpaved haul roads and from blasting within the confines of the pit. Other areas surrounding the pit, which had been cleared of vegetation during the construction phase could also contribute to the dusting problem through wind erosion. ERT has predicted that wind erosion would be the most significant generator of dust. The predicted dust levels for wind erosion is 941 000 kg/yr as compared to 381 000 kg/yr from overburden haul roads and 196 000 kg/yr from overburden removal.[2] The predicted total amount of dust produced is based on the assumptions: that dust would be controlled by 50 percent through watering, a 25 kph speed limit would be imposed on all haul roads to achieve a dust control efficiency of 80 percent, land reclaimed from waste disposal areas midway in the life of the mine would be the only reclaimed area by the year 2017-2018, and the complete enclosure of the conveyor system would result in 100 percent dust control. It is very probable that the dust levels predicted could be lower, since many of the activities associated with mine operation would occur below ground level.

The amounts of dust released from mine operation could affect the climate, although any effect would be restricted to the immediate vicinity of pit and waste disposal areas. The possible effect on climate would be a decrease in ambient temperature due to the interception of solar radiation by dust particles. The solar interception causes a reduction in ground level solar radiation. This degree of cooling would be negligible in comparison to the natural variability of the mean annual temperatures and would not be expected to have an effect on the growing season.

(b) Natural Vegetation

The effects due to fugitive dust emissions could be a problem during the operation of the mine. The quantity, extent and possible dust sources were discussed in the proceeding section "Physical Environment". To briefly summarize, a total of 2 288 800 kg/yr of dust emissions was predicted to occur from mining activities.[2] In terms of dust concentrations, the highest concentrations are predicted to occur adjacent to the pit area. Within 4 km of the mine, dust concentrations are predicted to exceed the normal background levels by 30 $\mu g/m^3$ (annual average). An annual average of 10 $\mu g/m^3$ above background is predicted to occur up to 10 km from the centre of the pit. The 24-hour worst case concentration is predicted to be 700 $\mu g/m^3$, however, this level was based on a set of meteorological conditions which would rarely occur.

Dusting has been shown to affect vegetation by causing a reduction in photosynthetic activity and an increase in the probability of insect infestations or disease. There is very little information in the literature on threshold dust levels, although it has been suggested that a concentration of 28 000 $\mu g/m^3$ for 8-10 hour periods would reduce photosynthetic activity by 30 percent. The levels predicted from mining activities are substantially lower than reported threshold values and on this basis impacts to vegetation would be negligible.

4.2 MINE - (Cont'd)

(c) Wildlife

From a wildlife resource viewpoint, mine operation impacts would be extensions of mine construction impacts and were, therefore, considered in the relevant discussion presented in Sub-section 3.3.2(c).

(d) Forestry

No impacts would be anticipated on the forestry resource from fugitive dust emissions released during operational activities associated with the mine. This assessment is based on the assumption that the dust control strategies employed would be sufficient to minimize dust levels.

(e) Agriculture

The effect of dust on local agricultural operations cannot be predicted. Dust impacts, however, could be minimized through appropriate dust suppression measures.

(f) Cultural Heritage Resources

To the extent that expansive operation of the mine would continue the ground disturbing activities begun during construction, it would contribute to the adverse impacts on the projected 147 sites in the area as discussed in Sub-section 3.3.2(f).

(g) Geology

(i) Introduction

The impact of the project on the availability and use of the natural resources within the project area would be primarily related to the operation of the proposed open pit and its associated waste disposal areas. Of the resources inventoried in previous sections, the only resources potentially affected by the open pit mine would be the fossil fuel and rock aggregate deposits of the project area.

(ii) Fossil Fuels

Obviously the operation of the plant and mine would have a significant impact upon the availability and utilization of the coal reserves within the upper Hat Creek Valley. The coal would be excavated to fuel the powerplant and the coal waste would be either stockpiled for later use or discarded in waste areas. The coal reserves within the valley and specifically the No. 1 deposit would be more than ample to satisfy plant fuel consumption during the design-life of the facility.

Since the plant would use only about 10 percent of the total estimated coal reserves within the upper Hat Creek Valley, the impact upon the availability and use of these coal deposits by the operation of the plant and mine would be moderate.

(iii) Rock Resources

The operation of the open pit mine and associated waste disposal areas would directly affect the rock resources of the project area by the sterilization, excavation and/or consumption of these deposits.

Approximately 445 Mt of aggregate would be temporarily sterilized on the east bench of the upper Hat Creek quarry by the open pit and approximately 200 Mt would be mined as a by-product of coal extraction. The project would use approximately 110-115 Mt of aggregate. Thus a large supply could be stockpiled for other uses. After coal extraction has terminated, the temporarily sterilized deposits could be excavated. Since less than 20 percent of the total aggregate reserves within the valley would be consumed during the plant life and the rest would be ultimately available for exploitation, the temporary sterilization of the aggregate deposits at the quarry is considered to be a moderate impact.

Limestone deposits within the waste disposal site at Houth Meadows would be permanently sterilized by the project. Depending upon the final disposal area design, 30-360 Mt of limestone could be affected. However, vast quantities of limestone available within the immediate vicinity of the site area would make this impact insignificant.

Excavation by-products consisting of approximately 1060 Mt of combined bentonitic and kaolinitic claystone and siltstone, as well as, coal waste, aggregate and baked claystone would be made available as a result of coal mine operations. The well defined distribution of the claystone and baked claystone within the coal formations would make feasible the separation and storage of most of this material. If viable markets could be found, then mine operations would have the potential to supply these raw materials that otherwise would not have been economically available. The potential use of these coal mine by-products would be a beneficial impact on the resources of the upper Hat Creek Valley.

4.2.4 Socio-economics

(a) Income, Labour Force and Population

(i) Labour Force and Employment

A. Direct Project Employment

Table 4.2-5 presents direct employment by skill for seven stages of the operation phase from 1980. Overall mine employment would be essentially constant past 1990. The mine, analogous to the plant, would operate on a three shift basis each day of the week.

4.2 MINE - (Cont'd)

B. *Regional Labour Force Participation in Direct Employment*

Skill shortages and competition from experienced non-regional workers would possibly impede regional participation. The union jurisdiction for the mine operation has not yet been defined but representation other than by the existing B.C. Hydro unions would most likely enhance regional participation. The availability of a large number of jobs encompassing a range of skill requirements and an open hiring policy would influence regional residents to seek mine employment.

Given the lack of a suitable estimating model, it has been assumed that the regional and local participation currently being experienced by Bethlehem and Lornex mines would be expected at the Hat Creek mine. These proportions have, therefore, been used in the estimation of regional participation as shown in Table 3.4-4.

C. Other Labour and Employment Considerations

The reader is referred to Section 4.1.4 for relevant discussion concerning indirect and induced employment; regional participation in such employment and labour supply for other regional industries.

(ii) *Population and Income*

The reader is referred to Section 4.1.4 for relevant discussion on population and income impacts associated with the mine.

(b) Aesthetics

The open pit mine would encompass an area of 470 ha by the year 1994 and over 750 ha by 2021. The pit would be excavated in the form of benches about 15 m high and these benches would accommodate equipment for excavations. It is expected that the mine would reach a depth of 187 m by the year 2021. Three conveyors would be used to transport the coal out of the mine and they would require a right-of-way of about 62 m. Impacted areas associated with the mine are upper Hat Creek Valley, Medicine Creek Valley, Highway No. 12 and Trachyte Hills.

Blending facilities and stockpiles would be located next to the entrances to Marble Canyon, Highway No. 12 and upper Hat Creek Valley visual units. They would be necessary to the coal operation and consist of primary and secondary crushers, a coal preparation area, blenders and spreaders for stockpiling. Four large stockpiles of coal 780 m long by 62 m wide and 15 m high along with the 50 ha surface material dump are part of the blending facilities area. The access road to the plant from Highway No. 12 would pass through the blending area. Fig. 4.2-7 is a site plan of the mine service area. Fig. 4.2-8 is an accompanying perspective sketch of the elements of the mine service area.

4.2 MINE - (Cont'd)

(c) Other Socio-Economic Considerations

Mine related impacts on land use, housing, services, infrastructure, government, social environment and native Indians have been discussed with the powerplant construction impacts. Therefore the reader is referred to the appropriate topical coverage in Sections 3.5.2 through 3.5.8. With respect to mine related impacts on recreation, the reader is referred to Section 4.1.4(b) for relevant discussion.

4.2.5 Noise

Because of the cumulative effect on various work sources, the noise impact produced by the mine operation activities was evaluated and discussed in Section 4.1.5 together with the environmental noise effects of the plant operation.

4.3 OFFSITE FACILITIES

4.3.1 Meteorology - Air Quality

(a) Access Road

After the plant and mine are in operation, the access road would be one of the few offsite facilities whose operation would have the potential to directly result in air contaminant emissions of any significance. The volume of traffic created by employees travelling to and from work is estimated to be 200-300 vehicles per day in 1984, increasing to 500-600 per day by the year 2010.[1] Commercial and private vehicles would also use the access road, but in small numbers and on an irregular basis. Since the road would be paved, no significant incremental dust would be anticipated. Vehicular emissions of carbon monoxide, oxides of nitrogen and hydrocarbons along the roadway would peak around shift changes, but, for the projected traffic volumes, the effects on air quality would be negligible.

(b) Airstrip

The airstrip is another offsite facility whose operation would result in air contaminant emissions of potential significance. Such emissions would be produced by business aircraft involved with the Hat Creek Project as well as by other commercial and recreational air traffic. No information is presently available concerning the anticipated air traffic volume or the types of aircraft that would be using the facility other than the fact that the airstrip would be suitable for most executive type jet aircraft. Emissions from both general aviation (turboprop and piston) and business jet aircraft consist primarily of carbon monoxide, oxides of nitrogen and hydrocarbons. Assuming a usage level which could reasonably be expected for an airport facility of this type, one would expect that air quality effects would be negligible.

(c) Equipment Offloading Facilities

Most air contaminant emissions from this source would occur when the plant is in the construction stage. At that time, about 10 semi-trailer trucks would be entering and leaving the offloading area during a normal day.[2] Once the plant is in operation, activity at these facilities would greatly diminish. Air contaminant emissions would be produced by the vehicles entering and leaving the area and by fugitive dust (both windblown dust and dust produced by vehicles moving on the unpaved area). Based on the expected level of activity, air quality effects due to vehicular emissions would be negligible. Because of the small area of disturbed land (approximately 3 ha as opposed to about 1500 ha for the mine and associated waste disposal areas), windblown dust would not be a significant problem. Watering would be used as necessary to control fugitive dust emissions.

4.3.2 Water Resources

(a) Intake Structure

Even under extreme conditions, water withdrawal at the intake structure would deplete the Thompson River by little more than 1 percent, so that there would be no significant hydrologic effects on the Thompson River. The discharge of water treatment clarification plant sludge blowdown to the Thompson River would cause minor localized turbidity.

The potential effects of the facility on aquatic ecology would be limited to the withdrawal of as much as 1580 l/s of water from the Thompson River and to impingement of fish. The intake was designed to minimize habitat disruption with its placement in the river (Fig. 3.2-2). It also incorporates several fish protection design parametres to reduce potential impingement losses.

The most important aquatic resources potentially affected by the intake would be the populations of anadromous salmonids. The vulnerability of the several species depends primarily upon the particular life stage affected, the duration of exposure and the swimming ability of the fish affected.

There is no suitable spawning substrate in the immediate vicinity of the intake structure. Some limited pink, coho and chinook spawning occurs in the lower reaches of the Bonaparte River and a large pink salmon spawning concentration occurs approximately 0.8 km above the proposed intake site (see Fig. 3.2-3). Large numbers of pink salmon fry and sockeye smolts would pass the intake on their downstream migration to the sea. Additionally a smaller number of chinook and coho salmon and steelhead trout would be exposed to the intake. With the possible exception of pink salmon fry, these fish would possess sufficient swimming ability to avoid the intake and the intake should not attract or concentrate fish to any appreciable extent.[3] Even small (about 2.5 cm) pink salmon and rainbow trout fry would likely possess sufficient swimming capability to avoid the intake velocity (refer to Water Intake Report).[4]

The design of the Thompson River intake includes three principal fish protection parametres which would greatly reduce any potential impingement. These principal features are: a small mesh (2.5 mm clear opening) screen cloth; a low (0.12 m/s) intake velocity and a bypass current across the screen face. The small mesh screen cloth precludes all but the smallest organisms from entrainment in the cooling water. The low velocity across the screen face would permit those fish coming in contact with the screen face to avoid being trapped against it. Although no actual measurements of swimming abilities for pink salmon or rainbow trout fry were developed for this study, equations developed to measure critical swim speeds of sockeye salmon[5] indicate that fish of the size range of salmon and trout fry would be capable of swim speeds in excess of that at the screen face of the proposed intake. Provision for a bypass channel and upstream inlet between the curtain wall and intake screens would permit a net downstream current across the screen face at all river flows and intake pumping modes. These features would direct fish downstream and out of the intake.

Although few fish would become impinged at the intake, calculations were made in an attempt to model possible intake scenarios should the fish protection measures fail to perform as expected. Assuming the average plant pumping factor and mean river discharge during downstream pink salmon fry migration, the calculated annual reduction to the commercial fishery in terms of returning adults from a run of 8 million fish could potentially be on the order of 800 adult fish. This estimate is based upon the assumption that none of the fish protection design features function and that all fish impinged would be lost (100 percent mortality). There is, however, sufficient design flexibility inherent in the project to totally mitigate this impact should it occur. This redundancy is discussed in Part Five, Mitigation.

(b) Access Road

Water quality concerns related to the operation of the access roads would be minor sediment losses channeled into Cornwall Creek via runoff ditches and possible excessive use of deicing compounds near creek crossings and shallow groundwaters. Neither of these interactions are quantifiable, but are considered minor negative potential impacts.

The main hydrological impact of this facility would be the effect of increased surface runoff from the paved surface. Since 7 km of the road would parallel Cornwall Creek, up to 200 L/s could possibly find its way into Cornwall Creek following a 10-year 1-hour rainfall where it could temporarily constitute a significant addition to normal summer flows (20-100 L/s). The 4 km road segment along McLaren Creek could similarly contribute to that stream. Morphologically the road runoff would be insignificant in both cases. Significant effects on McLean Lake would be precluded due to the size of that lake.

The intermittent nature of much of Cornwall Creek would preclude any significant impact to the aquatic community. The subsequent discharge of Cornwall Creek and the attendant runoff contaminants, to the Thompson River should not affect the pink salmon spawning grounds located downstream of Cornwall Creek.

(c) Makeup Water Line

Operation of the water supply pipeline and pump stations would not cause any significant impact on groundwater resources. Provisions would be provided at each pump station for safe disposal of lubricating liquids, other waste materials and sanitary wastewaster.

Discharge of pipeline drainage to Cornwall Creek and the Bonaparte River are proposed during line maintenance procedures. It would be necessary to establish a controlled drainage rate below which turbidity levels would not disturb natural stream values or downstream water users. Present design indicates that chlorination for control of bacterial growth in the pipeline may be necessary. It is unlikely that the level of chlorine would be very high, however, sufficient detention time should be provided to ensure total residual chlorine concentrations are within acceptable limits.

From a hydrological viewpoint, operation of the pipeline would not cause any major impacts. The most significant impact would likely result from minor failures of drainage and erosion control measures during the first few years of operation, before revegetation of the right-of-way would have been established. These features would cause some erosion damage, which would have to be repaired. A major pipeline rupture would be highly unlikely. It would release a large flow of short duration, which would cause significant erosion damage, depending on the location of the rupture. The capacity of the pipeline drain to the Bonaparte River would be too small to introduce significant flows in that stream.

(d) Creek Diversions

(i) Water Quality

The diversion of Hat Creek would raise water temperatures because the surface area exposed to solar radiation would increase significantly. Estimates were made of the maximum water temperatures that could be expected at the downstream end of the diversion canal for the base diversion scheme and powerplant water supply alternative.

For the base case, Hat Creek's 2-year return flow, 0.12 m^3/s, was used and the water temperature at the end of the diversion channel was calculated to be approximately 40°C, almost independent of the water temperature at the beginning of the channel. For the water supply alternative, the water temperature at the end of the diversion channel could be as high as 35°C, based on the minimum flow of this alternative, 0.23 m^3/s and a temperature of 20°C at the beginning of the channel.

Temperatures in Hat Creek below the diversion would likely be less than the predicted values because of plunge pool design, tributary additions and increased downstream evaporative cooling. It is difficult, however, to quantify these effects so it was assumed, as a worse case, that water temperatures of 40°C or 35°C could persist in Hat Creek down to the confluence with the Bonaparte River. This would only increase the temperature in the Bonaparte River by 0.5°C, at low flow conditions. Predicted Hat Creek mid-summer water temperatures would be well in excess of the 15°C maximum temperature recommended for drinking water supplies.[6] Further study would be warranted to improve the reliability of the temperature predictions and to investigate methods to minimize water temperature increases in lower Hat Creek.

Nitrogen supersaturation could also result in the downstream waters of Hat Creek from both temperature increases in the diversion canal and the discharge of diverted waters from the conduit into a plunge pool. If water saturated with nitrogen at 15°C was heated to 40°C, with no release of nitrogen gas, nitrogen concentrations of 140 percent of saturation would result. Similarly, when water is discharged into a plunge pool, there is considerable turbulence. As a result, air is entrained in the water and the increased pressure forces more nitrogen into solution than would be the case at the water surface. When the water returns to a point closer to the surface, the nitrogen concentrations in the water could again be as much as 140 percent of those corresponding to saturation at the water surface.

(ii) Hydrology

Significant interactions with the groundwater regime would not be expected from the creek diversions. The total seepage over the entire Hat Creek canal length would be approximately 637 m^3/d. Most of the seepage would, however, be collected in the pit dewatering wells with a small amount of recharge entering the buried channel aquifer. From a groundwater quality position Hat Creek water is of higher quality than the groundwaters of the area and thus the impact from seepage would be rated beneficial although insignificant. The headworks reservoir dam would lower the groundwater table in the alluvial aquifer downstream of the dam to prevent water from flowing into the pit. There would, however, be a corresponding rise of between 20 and 35 m in the groundwater tables along each side of the valley south of the embankment. The overall impact on the alluvial aquifer would be ambivalent and would not result in any effects outside the valley. The alternative reservoir scheme would result in the same ambivalent impacts, but each with a larger magnitude.

From a surface water hydrology point of view, the diversion of Hat Creek would represent a significant project action in that approximately 9 km of the natural Hat Creek channel would be replaced by 500 m of reservoir, 6.4 km of open canal and 1.9 km of buried conduit. The headworks reservoir would be too small to modify Hat Creek discharges significantly. It would, however, decrease the mean annual suspended sediment load of Hat Creek which would lead to some morphological adjustments. They would be minor because Hat Creek is a degrading stream in its natural state, with the bed becoming active only during infrequent major floods. The stream would gradually develop the appearance of a lake-outlet channel with a better defined channel than at present. The change would probably not be noticeable except through careful before and after surveys and it would not extend more than 1-2 km beyond the diversion. Water levels and the extent of flooding would decline slightly, but this also would be too small and too slow a change to be noticeable.

The effects of the alternative diversion scheme, involving significant upstream storage, would be much more noticeable and would extend to the Bonaparte River, as this scheme would effectively regulate Hat Creek. Over a period of a few years, Hat Creek would develop a smaller and better defined channel downstream of the diversion and most of the floodplain would not be flooded again except under conditions approaching the maximum probable flood. Being smaller and more regulated, Hat Creek could become more attractive to beavers and this could tend to counteract the above tendencies. The overall effect of the diversion on Hat Creek flows including changes evaporation rates, seepage and the inflow of mine dewatering would be small, probably too small to be detectable.

4.3 OFFSITE FACILITIES - (Cont'd)

(iii) Aquatic Ecology

The effects of operation of the creek diversion would be primarily those associated with changes in the hydrology and temperature of Hat Creek downstream of the diversion. The impact from habitat loss suffered that would be due to the diversion of Hat Creek around the mine area has been described under the section dealing with the operation of the mine.

Hat Creek downstream of the mine would consist primarily of water from the diversion impoundment and an unknown quantity from the mine treatment lagoons. The temperature of the water discharged from the diversion would possibly reach 40°C during the summer. Flows would be low or non-existent during the winter. In addition, nitrogen concentrations as great as 140 percent saturation are predicted.

Upper lethal temperature limits reported for rainbow trout are 27°C for short periods of time and 23-24°C for longer exposures.[7] Growth of rainbow trout ceases at water temperatures above 19°C.[8] This would indicate that few, if any, rainbow trout would occur in Hat Creek directly downstream of the diversion discharge during the summertime. No fish kills, however, would be expected unless the daily temperature variations are large. As water temperatures approach critical levels, fish inhabiting the creek would move downstream into the cooler waters of the Bonaparte River.[9]

The extent and severity of the downstream temperature increases is difficult to predict at this time. Some cooling would expected to occur, but for purposes of this assessment, it has been assumed that Hat Creek temperatures would exceed the lethal (27°C) limit downstream to its confluence with the Bonaprate River. Should this prove to be the case, no rainbow trout would be expected to reside in Hat Creek on a permanent basis, although the creek would likely still support the species in an indirect manner. For example, should available food resources limit the numbers of rainbow trout in the Bonaparte River, it would be possible that increased food resources available in lower Hat Creek could increase the rainbow trout carrying capacity of the Bonaparte River. Warmer temperatures could also allow earlier spawning. Increasing the time period for spawning can decrease the chance of a catastrophic event harming a single year class, leading to more consistent year class success and a more stable population.

It should be possible to modify the design of the diversion canal in a manner to ameliorate the temperature impacts associated with the present design. These possible modifications are discussed in Part Five, Mitigation Measures. Mitigation which would allow trout populations to remain in Hat Creek would require regulation of the hydrologic regime in order to provide adequate instream flow to maintain aquatic productivity. A recommended flow regime for Hat Creek was provided in Table 3.3-3. Flows of this magnitude would allow sufficient water to provide for benthic production, the spawning requirements for trout and flushing of accumulated sediments. Coupled with adequate water treatment of mine wastes, this would permit continued use of lower Hat Creek as trout habitat.

The possibility for other adverse effects, such as gas bubble disease due to nitrogen supersaturation and potential damage to bank and stream bed due to wash and scour by water discharged from the chute back into the stream bed would also exist. Amelioration of this impact is discussed above and in the mitigation section. Again, this effect would be moot unless measures were taken to reduce the increase in stream temperatures caused by the diversion discharges.

(e) Airport and Equipment Offloading Facilities

Normal operation of these facilities would not cause any affect on the water resources of the area. Design specifications for the disposal of sewage and refuse and for the control of runoff should ensure compliance with all regulatory guidelines.[10] A spill prevention control and countermeasure plan should be developed for the handling of all hazardous materials.

4.3.3 Land Resources

(a) Physical Environment

The operation of the offsite facilities would have a minimal effect on the soils' component of the physical environment. Soils in the vicinity of the intake and associated structures, along the makeup water pipeline right-of-way (ROW) and along the main access road ROW could be subject to dusting and erosion problems. These problems would be manifest should slope and soil stabilization programmes not be initiated immediately upon completion of construction activities or should these programmes fail to be maintained or continued throughout the life of the project. These potential impacts are considered to be insignificant due to the small areas involved and the inclusion of soil and slope stability programmes within the development plans for the project.

There could also be an occasional rock or mud slide along the access road ROW in areas where deep cuts would be required for construction. These slides would be unavoidable and would have negligible impact to the local landforms.

(b) Natural Vegetation

Operation of the offsite facilities would have no direct impacts on the vegetation in the immediate vicinity of the facility components. The vegetation would be indirectly affected by fugitive dust emissions from access roads along the makeup water pipeline, to pumping stations and to substations. The accumulation of dust on foliage could cause overheating and increase the susceptibility to disease and insect infestation. The impacts due to dusting would be localized along the access routes and should be minor. Another indirect impact could occur on the natural vegetation due to competition from plant species used in revegetation or slope stability plans. This impact could be significant should the revegetation species invade areas of existing natural vegetation and cause a change in the natural successional patterns of the area.

4.3 OFFSITE FACILITIES - (Cont'd)

(c) Wildlife

The operation of the offsite facilities would have no direct effect on the wildlife resource. The minor disturbance to the vegetation noted previously as well as that resulting from ROW maintenance would not affect wildlife habitats or existing wildlife. There would be some potential for collision between access road traffic and wildlife. The impact of this effect should be minimal if appropriate fencing and signs are used to warn motorists of wildlife crossing areas.

(d) Forestry

The operation of the offsite facilities would not have any major effects on the forestry resource. Fugitive dust emission from all access roads and areas where soils have not been stabilized could accumulate on tree foliage. These dust accumulations could cause overheating and increase the susceptibility to disease and insect infestations. The impacts due to dust emissions would be negligible, since the dusting problems would be localized in areas where forest productivity is poor to low.

(e) Agriculture

The effects due to operation of offsite facilities would be minimal. The potential exists for conflicts between traffic on the main access road and cattle movement between the grazing areas in the valley. The significance of this impact on the grazing resource would be minimal since fencing and cattle guards, where appropriate, would be employed.

(f) Cultural Heritage Resources

There would be no direct impact from the operation of the offsite facilities. Any encroachment upon previously undisturbed ground during maintenance has the potential to adversely impact cultural heritage resources sites. New areas to be disturbed should be examined by professional cultural resources specialists prior to any disturbances, so that relocation of the proposed area of disturbance or mitigation of adverse impact on affected cultural heritage resources sites could be performed.

To the extent that these facilities would permit the penetration of adjacent areas by amateur archaeologists or curiosity seekers, cultural heritage resources sites adjacent to these areas would be placed in danger of vandalization. The magnitude of this indirect impact cannot be estimated.

(g) Geology

Operation of the water makeup pipeline would restrict access to the aggregate deposits at Boston Flats. However, abundant aggregate is found throughout the project area, and thus, this impact would be minor.

4.3 OFFSITE FACILITIES - (Cont'd)

4.3.4 Socio-economics

Offsite facility related impacts on labour force, population, income, land use, housing, services, infrastructure, government, social environment and native Indians have been discussed with the powerplant construction impacts. Therefore the reader is referred to the appropriate topical coverage in Sections 3.5.1 through 3.5.8. Impacts on recreation resources as a result of offsite facility operation are treated with mine and powerplant operation impacts in Section 4.1.4 to which the reader is referred for details. Aesthetics impacts are discussed below.

(a) Intake Structure

The intake structure would be located in the Thompson River just above the mouth of the Bonaparte River. This structure is about 34 m long, 9 m wide and 9 m above high water. Associated with the intake structure would be the clarifier (30 m in diameter), the 6 m diameter clearwell and the high pressure pumping station. The station would be 60 m long, 13 m wide and 13 m high. These three structures would be located just south of the mouth of the Bonaparte River. Foreground and middleground views from the Thompson River would be impacted by the imposition of the storage and pumping facilities.

Table 4.3-1 lists the numerical ranking of the visual impacts imposed upon the defined visual units by the project elements. Table 4.3-2 presents an average ranking of visual impacts, along with the number of visual units that would be affected and a descriptive word denoting the level of impact.

(b) Access Road

The access road would provide entry to the plant site and mine facilities from Highway No. 1. It would follow an existing trail from the highway up Cornwall Creek, past Cattle and Medicine Creek valleys to the plant site. It would then proceed westward through the blending facilities and thence to Highway No. 12. The total road length would be 31 km. Maximum gradient would be 8 percent and maximum design speed would be 80 kph. The total right-of-way required for the road would be between 100 and 122 ha of land and it would be as wide as 100 m in places.

The following areas would be impacted by the road placement: Marble Canyon, upper Hat Creek Valley, Medicine Creek Valley, Cattle Valley, Highway No. 12, Highway No. 1 and Cornwall Lookout. Refer to Tables 4.3-1 and 4.3-2 for the numerical ranking and average ranking of these visual impacts.

(c) Water Line

The water pipeline would link the Thompson River pumping station to the water reservoir. The pipeline would be an 800 mm diameter steel pipe, buried in the ground. Along its corridor there would be four surge tanks and a booster pumping station with a clearwell. There would also be a service road located within the pipeline corridor.

The following areas would be impacted visually by this corridor: Medicine Creek Valley, Cattle Valley, Thompson River, Highway No. 1 and Trachyte Hills. Refer to Tables 4.3-1 and 4.3-2 for the numerical ranking and average ranking of these visual impacts.

(d) Transmission Line

Two 500 kV transmission lines would be located in the transmission corridor that links Kelly Lake to the Nicola Substation. The existing right-of-way passes near Cattle Valley. A link from this corridor would be made to the Hat Creek powerplant.

Areas which would be impacted by the 500 kV transmission corridor include: Medicine Creek Valley, Cattle Valley, Highway No. 12, Cache Creek, Highway No. 1, Cornwall Lookout and Trachyte Hills. Refer to Tables 4.3-1 and 4.3-2 for the numerical ranking and average ranking of these visual impacts.

(e) Creek Diversion

The Hat Creek diversion would entail a 7 km canal, a 2.2 km discharge conduit, a canal service road and the access road to the upper Hat Creek Valley. The main canal and road right-of-way would vary in width from 37 to 62 m and require 30 ha of land. There would also be water reservoirs in connection with this diversion and they would vary from 7.3 to over 80 ha (alternative).

Impacted areas would include upper Hat Creek Valley, Medicine Creek Valley and Trachyte Hills. Refer to Tables 4.3-1 and 4.3-2 for the numerical ranking and average ranking of these visual impacts.

(f) Airstrip

A 1500 m runway would be located about 1.5 km west of Highway No. 1 and 1.0 km south of the new access road to the plant site. This paved runway would be suitable for small aircraft landings and takeoffs, including executive-type jet aircraft.

There would be a distant view of the runway embankment from Highway No. 1 and a minor impact associated with this view. Refer to Tables 4.3-1 and 4.3-2 for the numerical ranking and average ranking of these visual impacts.

4.3.5 Noise

(a) Access Road

Peak access road traffic noise levels would not occur during Mine Stage 6 but rather during the peak construction years in the early 1980s. Consequently, 1983 has been selected as the year to predict the impact of access road traffic noise.

As can be seen from Fig. 3.5-11 (Chapter 3.0), the road access traffic YDNL would not exceed 65 dB(A) on the McLean Lake Reserve and therefore cattle grazing areas would remain compatible. In the Cornwall Hills and other range country through which the access road would pass, the width of the strip along each side of the road incompatible with grazing (exceeding YDNL 65) would vary from 9-6 m depending upon road gradient.

The natural background noise level of the McLean Lake Reserve would be between 30-40 dB(A). Peak noise levels from trucks on the access road would vary between 53-70 dB(A) from the northern to the southern edges of the reserve. Peak intrusions of truck noise could cause annoyance to people involved in recreational activities on the Reserve. However, some of the annoyance factor could be offset by the benefit of improved access to the Reserve.

(b) Makeup Water Line

The only potential sources of noise impact during the operation of the makeup cooling water supply system would be the two booster pumping stations.

Booster pumping station No. 1 would be located about 90 m from the nearest residence in the small community at the Bonaparte-Thompson confluence as shown in Fig. 3.5-8 (see Chapter 3.0). Because the ventilation fans in each pumphouse would be silenced, the noise levels produced in the aforementioned community are expected to range between YDNL 36 and 46 dB(A). By applying the sensitivity corrections shown in Table 3.5-4 (see Chapter 3.0), it is seen that the normalized YNDLs levels would range from 46-56 dB(A) and the community reaction would range from "no reaction" to "sporadic complaints". It should be noted that most of the residential area of the above community has existing train-dominated noise levels which are incompatible with residential land use (YDNL 56-62), as shown in Fig. 3.5-8 (Chapter 3.0). At the booster pumping station No. 2 fan noise control would be incorporated such that the area incompatible with grazing (YDNL greater than 65 dB(A)) would be restricted to within 15 m of the pumphouse walls.

(c) Transmission Lines

The only significant sources of noise associated with the operation of the 69 kV transmission lines would be the various substation transformers. For the Rattlesnake Substation, two possible sites have been selected on the hillside located northeast of Cache Creek. The noise levels that would be produced by the two transformers in the nearest residential area about 1.5 km from those sites would be YDNL of 40 dB(A). Thus, because the ambient noise levels in the area were measured (in 1975 as part of another study) to be Ld_n 55-60 dB(A), transformer noise would not produce a significant impact. When a community sensitivity correction of +10 dB(A) is applied (+5 dB(A) for no prior exposure and +5 dB(A) for pure tone character) and added to the YDNL of the transformer, the normalized YNDL become 50 dB(A). Fig. 3.5-2 (Chapter 3.0) reveals then that "no community reaction" would be anticipated. Because accoustical treatment would be implemented for the reduction of the noise from the mine substation transformers, no significant noise impact would be expected at Bonaparte Indian Reserve 1. The plant construction substation transformers would neither produce a significant impact at Bonaparte Indian Reserve 1, nor disturb sleeping at the plant construction camp.

(d) Creek Diversions

The operating noise of the creek diversion facilities would be limited to that created by a pumphouse at the pit rim reservoir to be located about 300 m downstream of the confluence of the Medicine and Hat creeks. Because the pit rim reservoir would displace the two nearest presently occupied residences, leaving more than 3.2 km distance to the next nearest ranch house, no significant impact would be expected.

(e) Airport

Aircraft noise levels are based on a total of four take-offs and four landings per day, all during daytime. At Site "A", the YDNLs of aircraft noise levels that would equal or exceed the existing ambient levels (about Ld_n 35) would not reach any populated areas. The compatible noise limits for grazing (YDNL 65) and agriculture (Le_q (24)70) would not be exceeded beyond the cleared area of the airstrip itself. At Site "C", Highway 1 traffic noise levels in the year 2013 (during Mine Stage 6) would vary from YDNL 50-62 dB(A) over an area occupied by the group of buildings about 300 m west of the airstrip, as shown in Fig. 4.3-1.

Based on eight aircraft movements per day (see Fig. 4.3-2), the combined noise levels of the road traffic and aircraft operations would range from YDNL 53-62 in the residential area west of the airstrip as shown in Fig. 4.3-3. Given the locations of buildings shown in Fig. 4.3-1, no previously compatible location (i.e. YDNL ≤55) would be made incompatible by airstrip operation. If however, buildings now exist at locations not shown in Fig. 4.3-1, it would be possible for residential incompatibility to develop, although the actual increase in the YDNL would be less than 1 dB(A). Applying the sensitivity correction from Table 3.5-4 (see Chapter 3.0) to the airstrip YDNLs shown on Fig. 4.3-3, the normalized sound levels west of the airstrip would range from YDNL 40-50 dB(A). Therefore, based on Fig. 3.5-2 (Chapter 3.0), "no adverse reaction" would be anticipated from the residents in the group of buildings west of the airstrip. The aircraft noise events, although few, would, however, be very noticeable and therefore the actual reaction will depend on individual cases.

(f) Equipment Offloading Facilities

The noise impact due to operation of the offloading facilities at the Ashcroft site would be primarily due to the daytime movements of trucks through the adjacent community. The initial trucking route would likely be along the old highway (now a side street) past residential areas, parks and a school, as shown in Fig. 4.3-4. The noise entering the receptor areas, due to the truck movements, would vary from YDNL of 51-55 dB(A), depending on road grade. The existing (and future) ambient noise levels along the trucking route are estimated to be from YDNL 54-58 dB(A), hence, houses bordering directly on the old highway could be exposed to incompatible levels of noise (exceeding YDNL of 55 dB(A).

By applying the sensitivity correction from Table 3.5-4 (Chapter 3.0), it can be seen that the normalized project YDNL along the trucking route would vary from 51-60 dB(A). Thus based on Fig. 3.5-2 (Chapter 3.0) the community reaction is expected to vary widely from "no reaction" to "widespread complaints".

4.3 OFFSITE FACILITIES - (Cont'd)

It is possible, that in the future an alternate trucking route would be designated to run parallel to the CNR line from the industrial zone to the Ashcroft-Cache Creek highway, as shown in Fig. 4.3-4. This route would be shorter and over a more level grade, therefore the impact of trucking would be less.

The precise locations of the offloading sites at Kelly Lake and Spences Bridge are not known, but the potential noise impact at these two sites would probably be less than at the Ashcroft offloading site. Kelly Lake is already exposed to existing traffic noise produced by ore trucks, whereas Spences Bridge is already impacted by both traffic noise from Highway 1 and the nearby railroad movements noise from Canadian Pacific (CPR) and Canadian National (CNR) mainlines.

CHAPTER 5.0 - ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

In this chapter it is assumed that at the end of the planned 35-year life of the project all project structures would be dismantled and removed or otherwise permanently disposed of and that the mine and all solid waste facilities (e.g. ash and mine wastes) would be graded and revegetated, or otherwise acceptably treated for permanent abandonment. This chapter discusses the impacts of such actions.

It is recognized that decommissioning of some or most of the facilities may not occur. At this point there are no actual plans by B.C. Hydro regarding ultimate disposition of the facilities. Furthermore, it cannot be known whether the actual project life will be 35 years or some other, likely longer, period of time.

However, it is known that at some point in time the mine pit would have to be decommissioned and that many other facilities would ultimately become too uneconomical to continue using. If these are removed or otherwise decommissioned, for whatever reason, including replacement, there would be environmental impacts that would have resulted from the project, hence the inclusion of this chapter in the EIAR.

5.1 AIR QUALITY AND METEOROLOGY

It is assumed that the plant and offsite facilities would be removed and their areas restored to near-natural conditions and that the final mine surfaces would be graded for reclamation. Significant quantities of fugitive dust emissions would be generated during demolition and disposal of the powerplant and offsite facilities as well as during reclamation of the mine. This dust would produce elevated localized suspended particulate concentrations, although appropriate dust control measures would be implemented. Vehicular emissions would also produce locally elevated gaseous contaminant concentrations. The mine site and waste disposal areas would be revegetated. This would permanently eliminate dust problems that would occur because of wind erosion of open ground.

5.2 WATER RESOURCES

5.2.1 Powerplant

(a) Water Quality

(i) Groundwater

Reclamation of the plant site and all associated disposal areas and facilities would have a beneficial impact on groundwater quality in that the quantity of precipitation infiltrating and percolating through disturbed areas would be reduced. Because of the permeability of fly ash, however, many years would pass before leachates would cease to emanate from the upper Medicine Creek ash pond even after reclamation. After topsoil addition and revegetation, fertilization and possibly irrigation would possibly be used to expedite the process. Some residual nutrients would inevitably migrate into the surficial groundwater system and then eventually into the surface water regime. The impact of this activity would not be significant.

5.2 WATER RESOURCES - (Cont'd)

Reclamation of the alternative dry ash disposal system dumps would proceed throughout the "operation" phase and would be almost fully completed by the plant decommissioning stage. The fly ash disposal area would continue to produce seepage after reclamation, however, because the permeability of the ash dictates a very slow desaturation process. Bottom ash on the other hand would become unsaturated in a relatively short period of time and once revegetated should effectively become "inactive" relative to inner drainage.

(ii) Surface Water

Minor impacts relating to sediment loss from short-term area disturbances during removal of plant infrastructure would be expected to occur. It is assumed that the water supply reservoir would be left intact and no interactions would be visualized if this is done. Continued existence of drainage facilities would be a beneficial impact as these facilities would protect the integrity of waste disposal areas and control runoff erosion. Any demands on the buffer capacity of the water resources that would have resulted from gaseous plant emissions would be eliminated.

(b) Hydrology

The cessation of ash transport water discharge and the planting of vegetation on disposal area surfaces would reduce groundwater recharge. However, the rate of recharge would still be slightly greater than the preconstruction rates. The net result would be a minor beneficial impact in that the groundwater table would remain slightly elevated.

The main impact on surface water hydrology due to plant decommissioning would be the permanent diversion of Medicine Creek. The side hill canal would require continuing maintenance, because any blockage (e.g. debris jams, beaver dams, ice or slides) could lead to overtopping of the banks, diverting the flow to the ash pond. The ash pond would then have to contain a spillway to ensure structural integrity.

(c) Water Use

The impacts of decommissioning on water use cannot adequately be subdivided among project facilities. Since most activities affecting water use would be related to the valley area, this topic is discussed in detail in Section 5.2.2.

(d) Aquatic Ecology

Since the precise effects of the plants gaseous emissions have not been determined, the impacts of decommissiong can not be accurately predicted. Impacts which do result from decommissioning, however, are expected to be beneficial in nature.

5.2 WATER RESOURCES - (Cont'd)

5.2.2 Mine

(a) Water Quality

(i) Groundwater

The total area that would be reclaimed in the decommissioning phase of the mine is 2035 ha. Reclamation would have a beneficial impact on groundwater quality in that precipitation infiltrating and percolating through disturbed areas would be lessened. Cover material would also prevent further oxidation and weathering of waste materials. Flooding of the pit would not cause any significant groundwater quality impairment because groundwaters would be emanating into the pit lake rather than out from the lake. There would be a recharge into the valley alluvium and buried bedrock channel aquifers of approximately 500-700 m^3/d. The quality of the water in the channel aquifer is presently unknown and the quality of the lake water requires further study. The projected impact of this recharge is thus indeterminate at this stage.

(ii) Surface Water

Impacts on surface water quality during decommissioning would result from increased nutrient loads to Hat Creek due to fertilization of reclaimed disturbed areas. The contribution from fertilizer to the nitrogen and phosphorous levels in Hat Creek was calculated to be 0.63 mg/L as N and 0.004 mg/L as P from a single fertilization event and 0.063 mg/L as N and 0.039 mg/L as P from annual fertilization. These increases could foster biomass production in the creek to its eventual detriment. Extreme care in fertilizer application would therefore be warranted. With respect to the Bonaparte River, nutrient increases from a single fertilizer addition would be 3.9 percent for nitrogen and 1.7 percent for phosphorous. These should not exert any noticeable effect on biomass levels. In the case of annual addition, however, the increase would be 39 percent for nitrogen and 17 percent for phosphorous. The resultant concentrations could be detrimental and preventative measures would have to be implemented.

Creation of a lake by flooding the mine pit would likely have a positive effect on the suspended solids level of Hat Creek in that the creek's entire sediment load would be deposited in the lake at all times of the year. This impoundment would, however, increase water temperatures above normal temperatures in Hat Creek. The temperature of water leaving the flooded pit could be as high as 25°C. The chemical effect on water quality is difficult to predict and it is recommended that this aspect be studied further when more details are known of the probable top dressing materials. Water column studies should be undertaken to help predict the dissolved solids leaching rates from the proposed lake bottom sediments. Since the lake would be of substantial size and depth (335 ha and 120 m deep), it could be subject to thermal stratification and semi-annual turnover.

5.2 WATER RESOURCES - (Cont'd)

(b) Hydrology

(i) Groundwater

In the pit area the groundwater table would return to its present elevation. Based on present geotechnical data this could cause significant pit slope instability and very severe downhill slope movement. This movement would make the task of maintaining the diversion canal very difficult and extremely expensive. Groundwater recharge to the alluvial and buried bedrock valley aquifers would be restored to slightly more than preconstruction flows.

The canal would continue to recharge groundwater to local aquifers resulting in a minor beneficial impact on groundwater resources. Some groundwater could also be used to irrigate the revegetated disposal areas. The recharge to groundwater would be negligible and considerably less than during the operating stages. The overall impact on groundwater would, therefore, be ambivalent.

(ii) Surface Water

Reclamation would return disturbed areas to reasonably natural water balances. The main permanent impact on surface water hydrology would result from filling of the mine pit and its conversion to a lake. Downstream of the lake, Hat Creek would be significantly depleted during the 26-year filling period and then highly regulated. As in the case of the alternate diversion scheme, it would eventually develop a much smaller, but better defined stream channel. The entire present floodplain would be converted to low terraces. Extensive beaver activity could, however, change this and could result in extensive flooding. A simple, gated control structure at the lake outlet could give almost complete control over flows in lower Hat Creek. Depending on developments in the lower Hat Creek Valley at this time, regulation could constitute a very beneficial impact. The relatively deep lake might not freeze during winter or it might only freeze late in winter. The large open water surface will have some climatic effects, particularly during cold spells, when open water tends to generate fog.

(c) Water Use

Decommissioning of the project would be associated with major potential benefits to irrigation through the use of project reservoirs for water storage. Over 1000 x 10^4 m^3 of water of the Hat Creek drainage basin could be made available for irrigation in this way. This is roughly one and one-half times the current use of water for irrigation in the Hat Creek Valley. This assumes that potential water use facilities would be maintained (e.g. maintenance of flow in the canal and/or maintenance of creek diversions). Table 5.2-1 summarizes the project activities, causes and water quantities associated with the benefits of decommissioning.

Regarding industrial water use, mine and plant water requirements would return to zero. Domestic surface water usage would reduce as people move away from the surrounding area. However, some water demand in excess of the "without project" usage would remain as a percentage of the

5.2 WATER RESOURCES - (Cont'd)

people who worked on the project would stay to retire or wait until other work would become available.

(d) Aquatic Ecology

The cessation of the mines' aqueous discharges to Hat Creek would have little immediate effect because continued operation of the diversion canal would cause continued high summer water temperature and thus, continue to prevent resident fish populations from becoming established. The reduction in nutrients which would result from the lessened discharge would cause a reduction in periphyton productivity and biomass. The reduction of flow in the lower portion of Hat Creek from discharge reductions and other causes would restrict transitory fish population. After the mine pit lake is filled, the discharge canal decommissioned, normal flow in the lower portion of Hat Creek resumed and aqueous discharges lessened, resident fish populations should become established.

5.2.3 Offsite Facilities

(a) Intake Structure

Decommissioning of the intake structure would have minor beneficial implications on water quality. Phase out would mean no further discharges of grit and silt from the water clarification tank to the Thompson River. Cessation of intake operation would also eliminate any potential for impingement of the anadromous salmonids of the Thompson River.

(b) Access Road

This facility should remain intact and therefore the discussion presented in Section 4.3.2 would apply to this project phase.

(c) Makeup Water Line

This action would have minor beneficial implications on water quality. The need for emergency drainages from the pipeline to both the Cornwall Creek and Bonaparte River would cease to exist. It is, however, assumed that the pipeline itself would be left in place.

(d) Transmission Line

This action should not impact on the water resources of the area.

(e) Creek Diversion

Decommissioning of the Hat Creek diversion in association with creation of a lake in the pit would offer both beneficial and negative impacts. Physical water quality in terms of temperature should improve. The newly created lake would also reduce sediment loads. The chemical impacts on water quality would be negative. This would be due to the potential degradation of the Hat Creek water quality in passing through the lake. The continued existence of the reservoirs associated with the diversion (in upper Hat Creek) would be an ambivalent impact. The reservoirs would reduce sediment levels in Hat Creek, but they would also continue to cause increased water temperatures.

5.2 WATER RESOURCES - (Cont'd)

The ecology of the mine pit lake is difficult to predict, especially when water quality predictions are unavailable. Lake depth would increase at a rate of approximately 8 m/yr for 26 years until it is filled. This would inhibit the development of a littoral zone and its associated macrophyte and benthic communities. Fish, which often use lake margins for spawning, would have difficulty in establishing self sustaining populations.[2] Lake productivity would be largely dependent on plankton communities which would develop to the extent that nutrients would be available.

After the lake level stabilizes, potential for a well developed littoral zone would be high. It should be possible to maintain a water level such that the upper mine bench would be approximately 1 m under water. This would create a littoral zone extending at least 20 m from shore. This littoral zone, combined with upper portions of Hat Creek, should provide adequate habitat for fish spawning.

Productivity in the stabilized lake would not likely be high. If phosphorous concentrations found in Hat Creek are assumed to approximate total phosphorous concentrations in the lake, no more than 2 mg/m^3 chlorophyll would be predicted in the mine pit lake.[3,4] Two mg/m^3 chlorophyll is regarded as the maximum average concentration which should be maintained "where it is desirable to maintain hypolimnetic concentrations of oxygen in excess of 5 mg/L to preserve cold water fisheries. The lake would be very unproductive".[4] Using concentrations of total dissolved solids found in upper Hat Creek, the morphoedaphic index[5] suggests that the lake would be oligotrophic, but would be more productive than Lake Tahoe, Lake Superior, Buttle Lake, Great Bear Lake or Rainbow Lake and less productive than Lake Huron, Lake Athalbaska or Slave Lake.

Other lakes in British Columbia, representing a wide variation in morphometry, contain significant salmonid populations. Between 20 and 49 percent of the fish communities in Osoyoos, Vaseux, Skaha, Okanagan, Kalamalka and Wood lakes are salmonids.[6] Cultus, Chilko, Shuswap and Fraser lakes also contain large populations of salmonids. The only obvious relationship explaining the relative success of salmonids in these lakes, is that salmonids appear to be more successful in oligotrophic lakes. On this basis, a signficant salmonid population would be expected to develop in the mine pit lake.

(f) Airport

This facility should remain intact and therefore the discussion presented in Section 5.3.6 would apply to this project phase.

(g) Equipment Offloading Facilities

This action should not impact on the water resources of the area.

5.3 LAND RESOURCES

5.3.1 Introduction

The potential impacts from the decommissioning of the plant, mine and offsite facilities associated with the Hat Creek project would be generically similar, with the only notable differences being the total areas affected in each case. The impacts to the land resource components as described in the following sections are general enough to be applicable to the plant, mine and offsite facilities and, therefore, all are presented under the heading of the plant. It should, therefore, be noted that the following discussions will not be reiterated for the mine and offsite facilities.

5.3.2 Physical Environment

The decommissioning phase of the project would not have an impact on climate. Any impacts to land forms would be a function of the degree of land restoration. Land restoration would involve the recontouring of land, which generally results in changes to existing slopes and drainage patterns. No adverse impacts would occur on the geology of the area from the decommissioning phase. A complete discussion of the effects on geology is presented in the Minerals and Petroleum Report.[1]

The impacts of the decommissioning phase on the soils would be minimal and would only occur over a short-time period when restoration activities would be in progress. Some of the impacts anticipated could occur from dusting, erosion and alkalinity-salinity problems. However, these effects could be moderated during the restoration by revegetating as quickly as possible, maintaining minimum slopes specifically on those areas with erosion potential and the use of dust control measures. In this manner, the restoration programme could have a beneficial effect on the soils by providing the means for reduction of adverse soil conditions.

5.3.3 Natural Vegetation

There would be no direct impacts predicted to occur on vegetation from decommissioning of the project facilities. An indirect impact to the vegetation could develop at some time interval after the decommissioning phase due to revegetation of ash disposal areas. These impacts could result when trace elements in the ash and waste disposal areas either migrate to the soil subsurface and become available to vegetation or are absorbed by roots. The plants affected would be those used in the revegetation of these areas and those commonly categorized as pioneers, which are typically shallow rooted.

There are a large number of environmental factors which define the availability of the elements, uptake rate by plants, etc. Due to the lack of definitive data, however, predictions of the effects are difficult.

In general, the impact of the decommissioning phase would be beneficial since disturbed areas would be restored during this phase. The revegetation could provide stabilization to the exposed areas and create new habitats for the invasion of native plant species. The waste disposal areas could provide an unwanted source of seed for noxious range and forest weeds which could result in a further degradation of the range areas. In addition, certain revegetation species could have an adverse impact on native vegetation by competing for available space. This competition could result in changes to the species composition of an area, which in turn would affect natural successional patterns. This impact could be minimized through careful selection of revegetation species.

5.3.4 Wildlife

Powerplant site reclamation plans have not yet been developed in sufficient detail to allow for an adequate evaluation. The waste disposal areas, topsoil stockpiles and coal storage and blending areas combined comprise nearly all of the total habitat losses. The reclamation of these areas would play a major role in determining the ultimate project impact upon the wildlife resource in the local study area.

The revegetation programme is designed to restore land to biological productivity. The type of vegetation re-established on disturbed areas would determine, to a large extent, the types and numbers of wildlife that would utilize those areas. Detailed plans of the revegetation programmes have not been finalized but general characteristics of the process can be presented.

The initial flora would be established by seeding. One primary objective of revegetation is slope stabilization and prevention of erosion. This objective would be met by using grasses and legumes which would establish quickly, as pioneer species, under Hat Creek climatic conditions. Successional progression from the expected original grass-legume community would be very slow. Succession on the reclaimed areas would approach primary succession which would require the weathering of soils, the establishment of soil biota and the incorporation of organic material within the soils before many other types of plant species would invade. Accordingly wildlife occupation of the reclaimed areas would succeed with plant community development.

The vegetation that would grow in the revegetated waste disposal areas would be rooted in soil which may have relatively large amounts of trace elements. The possibility would exist that this vegetation could contain quantities of trace elements toxic to wildlife.

In most soils, the trace elements are largely unavailable to plants because the elements are bound (absorbed) to the surface of organic or inorganic soil particles. The lack of organic material in the revegetated soils could mean that some elements would be more available in recent overburden than they would be in mature soils.

After years of mining another 26 years would be required to fill the pit with water. Hat Creek would then again flow in its natural channel. At that time, the riparian habitat would begin to re-establish. Other presently existing habitats in the upper Hat Creek Valley would be replaced by grassland similar to the current low and mid elevation grasslands, but without swales, aspen clumps or other edaphic variability.

The overall effect of project decommissioning on wildlife species would be directly related to the final land reclamation policies. Regardless of what B.C. Hydro does to the disturbed areas, these areas would probably support some wildlife. However, if a serious attempt is going to be made to accommodate local wildlife species, an effort should be made to incorporate species habitat requirements into the early planning stages of the decommissioning programme.

The only game species that might utilize the reclaimed areas are mourning doves and blue grouse. However, mourning doves are relatively uncommon in the Hat Creek Valley and because blue grouse utilize mainly the grassland-forest edge, they would rarely use the central portions of the reclaimed area. Thus one would expect little benefit to upland gamebird populations as a result of land reclamation.

Among the non-game birds, only a few species were regularly encountered in the semi-arid grasslands of the Hat Creek Valley and many of the characteristic species of open range were noted to be attracted to saline depressions or to micro-riparian habitats. Consequently, few species would gain habitat with decommissioning.

5.3 LAND RESOURCES - (Cont'd)

Based on the current distribution of small mammals, deer mice would be expected to predominate in the reclaimed ecosystem and voles, chipmunks and marmots would occur sporadically or in very low densities.

Reclaimed land would be of little value to most furbearers except for the coyote. The eventual reconnection of the upper and lower reaches of Hat Creek via the pit lake could have a positive effect upon some aquatic or semi-aquatic furbearers, such as river otter and mink. These animals would again have access between the upper and lower reaches of Hat Creek.

Riparian vegetation is an important part of habitat requirements of moose, black bear and deer in the upper Hat Creek Valley. The opportunities for development of this kind of habitat under the proposed decommissioning plans appear minimal. Mule deer would also benefit from the development of riparian habitat, however, final landscaping and the choice of plant species used in the revegetation programme would also play a large part in determining the eventual use of the area by deer.

The reclaimed land may prodive habitat attractive to grassland rare and endangered species. The prairie falcon and turkey vulture would be the most likely species to utilize the reclaimed lands. The reclaimed land would be peripheral to the range of these species and would not add significantly to their regional numbers or population stability.

The formation of a pit lake could provide a more direct benefit to some rare or endangered species. The pit lake could provide new habitat for common loons, ospreys, bald eagles or trumpeter swans. The lake would be stocked with fish and, as such, would provide a new foraging and/or breeding area for loons, ospreys and eagles. Trumpeter swans could find the large lake suitable as a stop-over site.

Upland mine areas would respond to decommissioning as described above for the plant area.

Field wildlife data do not allow a breakdown by offsite facility components of wildlife decommissioning effects. In general, however, these effects would parallel those described for the plant and mine.

5.3.5 Forestry

No impacts to the merchantable timber stands would occur during the decommissioning phase.

5.3.6 Agriculture

Decommissioning effects on agricultural resources would be of a beneficial nature. Portions of the area alienated for project construction and operation would be reclaimed and returned to agricultural production. The potential would exist for utilizing project water supplies for crop irrigation. Assuming an irrigation demand of 0.76 m to 0.91 m, water from project reservoirs could support 1126 to 1349 ha of irrigated land, while continued pumping of water from the Thompson River through the project pipeline could theoretically irrigate an additional 700 to 1100 ha.

5.3 LAND RESOURCES - (Cont'd)

5.3.7 Cultural Heritage Resources

There should, in general, be no adverse impact on the cultural heritage resources due to the decommissioning of the plant, mine and offsites. Adverse impacts could result from the decommissioning of the Hat Creek diversion reservoir, canal and conduit to the extent that a new water course would be created that cuts through previously undisturbed ground. To the extent that salvage of materials or scrap recovery would be attempted from the plant, mine and offsite areas, there would be the possibility of encroachment upon previously undisturbed areas with the potential for adverse impact on the resources. Decommissioning would curtail access to the plant, mine and offiste areas thereby decreasing adverse indirect impacts such as vandalism of the cultural heritage resources sites.

5.3.8 Geology

Although the process of decommissioning the waste disposal areas would begin as soon as the final surface contours have been developed, the open pit mine would not be decommissioned until after the mine is abandoned. If the mine is to be abandoned immediataly after the coal required for the project has been recovered, then re-establishment of the flow of Hat Creek through the pit areas, allowing it to become a lake, would effectively sterilize the 447 Mt of thermal coal in the No. 1 deposit and 445 Mt of aggregate in the upper Hat Creek quarry. The proportion of the remaining coal within the No. 1 deposit made inaccessible to further exploitation is 12.2 percent of the remaining coal reserves within the upper Hat Creek Valley. The large reserves of coal and aggregate in the area tend to mitigate any adverse impact mine decommissioning would have on the future availability of these two resources. Decommissioning of the waste disposal areas would not further affect geologic resources of the valley.

5.4 SOCIO-ECONOMICS

5.4.1 Overall Considerations

(a) Introduction

All operating and other project-related employment would terminate after the 35-year operating life of the proposed powerplant. The social and economic consequences of such a closure would depend upon the technology, social, political and economic conditions prevailing at furture points in time. The following discussion, recognizing the difficulty in projecting future conditions, makes assumptions about alternative future "states" and identifies potential impacts for each alternative scenario.

(b) Scenario-expanded and Diversified Economic Base

In this scenario, other large scale developments such as an aluminum smelter operation, using Hat Creek coal and provincial energy supplies, and a coal gasification plant are assumed to occur prior to closure of the proposed Hat Creek Project. If this scenario was correct, the workforce displaced from the powerplant would be absorbed by the new labour requirements of other projects. The population size, income level, housing requirement and service demands would not be significantly changed. The communities would probably realize some land use and physical structure changes.

5.4 SOCIO-ECONOMICS - (Cont'd)

(c) Scenario-alternative Developments

In this scenario, it is anticipated that other development projects such as copper mining would not be able to absorb all the employees displaced from the powerplant closure. The subsequent loss in population, other conditions held constant, would probably result in business failure, excess capacity in social infrastructure, a loss in community cohesion, loss in property and higher tax burden. The future economic state of the communities might be strong however and the communities would be able to provide employment and income opportunities thus absorbing displaced workers and their families.

(d) Scenario-limited Employment Opportunities

The closure of the powerplant at a time when there is no alternative developments to provide employment would obviously be disruptive to the communities. In the local private and public sectors, the full in demand for goods and service would result in a decline in income, employment and probably prices. Excess capacity in housing and social infrastructure would likely occur with the associated economic consequences. Social adjustment problems would be expected as well.

5.4.2 Aesthetic Considerations

The various elements of the powerplant and its appurtenant installations have been divided into two general groups depending on their visual presence. The first group consists of elements which would be structures and have a considerable height or width or length. Included are the plant - including the turbine enclosures, stack, administration building, etc. - and the intake structure, transmission lines, airport structures and other above-ground improvements.

The second general group consists of installations which would be either on or in the ground. This would include the mine, roads, water line and the creek diversion installation.

Basic assumptions have been made regarding the intent of the term "decommissioning". The groups of elements outlined above were considered from the standpoint "moth balling" - that is, taking the plant structures out of service and protecting them by covering them with long-lasting materials, sealing windows and doors, boarding up openings, putting protective lubricant coating on machinery, etc. In other words, the plant would cease to operate but would not be dismantled or, perhaps, partially dismantled if certain equipment were to be used elsewhere. The second standpoint is based on the option of removing all equipment for disposal and/or use elsewhere and dismantling and razing the buildings.

In the event that the decision is made to "moth ball" the structures, there is no way to "moth ball" roads and mines, the visual intrusions would remain the same as they were while the plant was operational. The transient observer may be puzzled by the looks of the structures but the resident observer would probably become adapted to the presence of the decommissioned, closed plant buildings.

In the event that the buildings would be razed, however, it seems probable that the areas involved would return to their natural appearance, if left alone; or to farming or grazing pursuits, if cultivated. Determinations would have to be made in the future as to the uses desired for the decommissioned lands. If the area occupied by the plant were to be considered for revegetation for grazing purposes or for agricultural cropland, the foundations of the buildings would have to be removed to an appropriate depth and the prepared areas would have to be filled in with topsoil and planted for the intended use. This assumed procedure would, obviously, completely remove any environmental impact occurring from the plant and would restore the area to its preconstruction aspect.

In-ground or subterranean units of the plant would present different options and treatment procedures. It is assumed, for example, that the water line piping would simply be cut off and left in the ground, since it would be costly to excavate and remove it. The pumphouses associated with the line would be razed and the areas formerly occupied by them would be seeded or planted. The reservoir would presumably be drained, filled in and planted. The access road could either be removed (and the area it formerly occupied seeded); or it could be cut off and abandoned. The Hat Creek diversion canal, conduits, and associated reservoirs and roads could be abandoned and, in the case of the reservoirs and canal, drained and filled in.

In these instances of major in-ground installations, such as the Hat Creek diversion, the water reservoir and the access road (and their appurtenant structures), it seems reasonable to assume that the provincial government would be interested in obtaining some or all elements as major improvements to the area. Arrangements could be made to deed them over to the Crown, if further use could be made of the installations for agricultural irrigation and transportation needs.

The largest single in-ground installation is the mine and it is also the one which would occasion the greatest amount of effort in the event of decommissioning. At this time it is not known whether the decommissioning of the plant would be coincident with the decommissioning of the mine. It is possible for the plant to shut down permanently and coal from the mine to be marketed elsewhere.

With the cessation of mine production and its shutdown, enormous amounts of material would be required to fill in the excavated area. Consideration could be given to fill in the mine with material from the waste disposal areas with a final covering of about 5 m of soil and grass/shrub/tree planting. This may be a suitable approach, since the vast quantities of soil required for a complete fill-in would be of prohibitive expense, even if it were possible to obtain the necessary material.

5.4.3 Recreation

Quantifying recreational activity days in the project area for the post-operational stage is not deemed feasible because of the extremely long time horizons involved. Post operational impacts would therefore be related to the physical conditions that could prevail beyond 2020. The major changes at that time would be the removal of the physical facilities including the plant, conveyor, transmission structures and other features directly related to the function of electric power generation and coal handling. Major infrastructure items such as access roads and water line would or could remain. The landscape would have been changed by the creation of ash disposal areas (which it is assumed would have been covered and revegetated) and the open pit mine. Assuming the mine could be filled with water by natural drainage over a few years, and further assuming the water is of adequate quality to support aquatic life, a recreational asset would have been created. It is quite conceivable, assuming steadily increasing demands, that people would be attracted to what could be known as "Hat Lake" and either a public camping site or a private resort development could conceivably be developed. The adjacent ash disposal areas and plant site would have been covered, seeded and allowed to regrow to as natural a condition as feasible thus attracting game species and allowing for increased levels of hunting, backroad travel and other outdoor pursuits that may be popular at the time. Angling would increase and boating would be possible due to the presence of the water-filled mine. In addition, angling would continue on Hat Creek itself. In summary, from the perspective of outdoor recreation opportunities, positive advantages could accrue in the post-operational phase.

5.5 NOISE

5.5.1 Plant

At the time of this writing there is not enough information available about the procedures and equipment that would be required for plant decommissioning to allow a quantitative analysis of the resulting noise impact.

5.5.2 Mine

By comparing the total volume of material to be moved per year during mine production with that to be moved during pit reclamation, it would appear that the level of activity during reclamation would be about 2 to 4 percent of that during mining. This would correspond to about 14 to 17 dB(A) reduction in pit generated noise assuming similar equipment is used. Also, there would be little activity at ground level to correspond to the removal of superficials during mining and both blasting and coal preparation noise would be absent. Combining this with the much shorter duration of the reclamation activity (5 years versus 35 years for mining) it is concluded that the overall noise impact of pit reclamation would be much lower than the preceeding mining activities.

The reclamation of waste disposal areas be complete by the time mining activity ends. Hence, this reclamation activity noise would be masked by the noise produced by the mine operation.

5.5.3 Offsite Facilities

As with the plant, no detailed plans have been made yet regarding the decommissioning of the offsite facilities. However, on a qualitative basis, the noise impact of offsites decommissioning would be less than that of their construction.

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PART FIVE

MITIGATION, COMPENSATION AND MONITORING PROGRAMMES

CONTENTS

CONTENTS - (Cont'd)

TABLES

Table No.

CHAPTER 3.0 - ENVIRONMENTAL MONITORING PROGRAMME

CHAPTER 1.0 - RECOMMENDED MITIGATION MEASURES

1.1 INTRODUCTION

Part Five of this EIAR addresses mitigation and compensation measures which would protect the environment and minimize disturbances to humans should the Hat Creek Project proceed. Mitigation refers to siting and design features which would avoid or minimize adverse impacts. Mitigation measures include: (1) siting, (2) design features incorporated during conceptual and preliminary project design, (3) planning for construction and operation activities and (4) standard B.C. Hydro environmental requirements for construction contracts. Compensation, in contrast, refers to payments for resource impacts which cannot be mitigated.

Mitigation measures incorporated during preliminary design were developed in the following manner. Each major project component as well as its location was evaluated during the preliminary engineering phase. Proposed systems were then selected from the alternatives by comparing the technical engineering, engineering-economic and environmental benefits associated with each system alternative.

Mitigation measures developed from the preliminary design phase are based upon the impacts presented in Part Four of the EIAR and the concerns of the various environmental resource specialists. Data on costs, effects on system reliability and the environmental consequences of substantial cross-discipline tradeoffs have not been included in this discussion. Thus, proposals to mitigate project impacts are based upon partial information and should be treated as preliminary in nature.

Formal evaluation of the proposed mitigation and compensation programmes would be undertaken in the benefit-cost analysis and the results presented in the Environmental Impact Statement. These data would serve as the basis for the ultimate mitigation programme which would be developed through the licensing process should the project proceed.

Chapter 1.0 is developed topically on the project time horizon according to preconstruction, construction, operation, decommissioning and reclamation activities. Mitigation is developed by resource area. Design features presently incorporated, and actions planned for construction and operation are discussed.

1.2 PRECONSTRUCTION MITIGATION PROGRAMMES

Preconstruction site activities for the powerplant, mine and offsite facilities were comparatively minor events associated with geotechnical exploration, the bulk sample programme and surveying. Specific site activities included:

1. Construction and operation of the drill camp.

2. Construction of temporary access roads.

3. Installation of temporary power lines.

4. Exploratory drilling.

1.2 PRECONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

5. Surveying.

6. A Bulk Sample Programme.

7. Land acquisition.

8. Environmental sampling.

9. Archaeological exploration.

Mitigation measures were developed for the Bulk Sample, Environmental Sampling and Drill Programmes.

1.2.1 Bulk Sample Programme

Bulk Sample Programme mitigation measures included the designation of a buffer zone running parallel to Hat Creek in which no activity took place. The design of the waste rock and overburden dump, and its location protected Hat Creek from increased suspended solids and mine leachates caused by excavation. The design of the lower face of the main dump required that coarse material provide a rip-rap cover. To ensure that runoff from the coal, coal waste storage piles and work areas would not drain into any open water courses, areas were ditched and small dams constructed for runoff impoundment. Selection of the coal truck haul routes and the scheduling minimized conflict with local traffic and the public well-being.

1.2.2 Environmental Sampling Programme

The Environmental Sampling Programme required that all intrusions by project personnel in Hat Creek Valley be carefully scheduled with the onsite coordinator to minimize disturbance of area residents.

1.2.3 Geological Drilling Programme

The Geological Drilling Programme required that geotechnical exploration be preceeded by archaeologists who examined each drillsite and site access road prior to disturbance by the drill crews and heavy machinery operators. Preliminary site activity mitigation measures benefitted the programme of archaeological exploration in the valley because it increased surficial coverage of cultural heritage resources. In addition to the measures already implemented, a commitment has been made that all preconstruction facilities, access roads and structures would be removed and the site reclaimed should the project not proceed.

1.3 CONSTRUCTION MITIGATION PROGRAMMES

Proposed construction mitigation measures include both typical B.C. Hydro contractual requirements to protect the environment and minimize disturbance to others during construction, and specific technical recommendations to protect air quality, water resources, land resources, social considerations, archaeological and historic sites.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

1.3.1 B.C. Hydro Contractual Requirements which would Mitigate Construction Impacts

Typical mitigation measures specified in B.C. Hydro contracts are designed to protect environmental quality. The following list highlights the standard contract terms of reference:

1. Preservation of Flora and Fauna

   B.C. Hydro would refrain from destroying, removing or clearing trees, timber and shrubs to an extent greater than is necessary for project construction. Such measures also include sanctions against employees illegally hunting, disturbing, capturing or destroying animals and birds, or illegally taking fish from any waters.

2. Fossils

   All fossils, articles of value or antiquity and structures, and other remains or things of geological or archaeological interest discovered on the site would be the absolute property of B.C. Hydro. All reasonable precautions would be taken to prevent workmen or any other persons from removing or damaging articles of historic or archaeological importance.

3. Erosion Control Seeding

   Erosion control seeding would be applied to soil slopes where required to protect the soil. Seeding, fertilizing, mulching and watering would be performed to minimize erosion. All slopes would be erosion-control seeded and the seed mixture would be developed in concert with B.C. Hydro specialists.

4. Soil Testing

   Soil to be seeded would be tested to determine the requirements for water, fertilizer, mulch and seed species.

5. Soil Preparation

   B.C. Hydro would repair all erosion and other damage to slopes prior to the application of fertilizer and seed.

6. Seeding

   Seed, fertilizer and mulch would be applied evenly in one operation with a hydro-seeding machine using water as a carrier, or in a manner approved by B.C. Hydro specialists.

7. Convenience to Others

   To avoid inconvenience to local residents, B.C. Hydro would give notice 14 days in advance of starting any work which might inconvenience or endanger traffic. Notice of road closures and provision for detours would also be standard protocol. All work would be conducted in such a manner as to ensure the least interference with other traffic.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

8. Availability and Use of the Site

B.C. Hydro would comply with the Highway Act, observe load limitations and clearances which were in force for governing and regulation of traffic on any public roads over which it was necessary to transport materials. Temporary roads would be built if necessary to maintain access on public and private roads.

9. Prevention of Water Pollution

B.C. Hydro would ensure that solid matter, debris and other contaminants and wastes would not enter streams, flowing or dry watercourses, lakes or underground water sources.

10. Dust Abatement

During construction B.C. Hydro would provide all equipment and materials to minimize dust.

11. Water Supply

B.C. Hydro would operate and maintain supplies of water required for the construction work. This would include provision of storage, pumps, piping and ancillary equipment required to satisfy water needs.

12. Dewatering and Drainage

Design, construction and operation of all diversions and dewatering drainage systems necessary for construction would be the responsibility of B.C. Hydro.

13. Sewage Disposal and Wastewater

B.C. Hydro would provide and maintain facilities for the disposal of sewage and wastewater. On no account would B.C. Hydro discharge raw sewage or polluted water into natural watercourses, lakes or ponds, or near reservoir sites, camps, worksites or buildings.

14. Refuse Disposal

B.C. Hydro would collect and dispose of refuse from the project premises. The refuse would be deposited in metal, covered, flyproof cans set in approved locations. Garbage would be removed at least twice per week.

15. Borrow Areas

Only designated or approved borrow areas would be developed by B.C. Hydro.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

16. Spoil Disposal Areas

Surplus materials would be removed to spoil disposal areas. Each spoil fill would be developed in an orderly manner and in such a way that it would not interfere with the natural drainage in the area. The amount of materials placed in any spoil disposal area, and the height and slopes would be controlled. Spoil fills would be stable within themselves and would not cause instability of adjacent natural slopes.

These 16 generic construction mitigation measures would be evaluated on a site specific basis prior to implementation. They could be superseded or modified by site environmental personnel or by measures identified in the Detailed Environmental Studies.

1.3.2 Recommendations to Mitigate Powerplant Construction Impacts

The specific technical recommendations summarized in this section are based upon the results of the Detailed Environmental Studies Programme for mitigation of construction impacts. Only major project actions which would require mitigation measures are addressed. The general environmental mitigation measures described in the foregoing would apply to each project component.

(a) Meteorology - Air Quality

During the construction of the powerplant, the main air quality concern would be fugitive dust emissions. Activities which produce fugitive dust include road construction, grading and excavation, erection of buildings and facilities, and concrete batching. Gaseous vehicular emissions would also be produced, but their air quality impact is expected to be negligible. Steps which are suggested to reduce the air quality impact of plant construction activities are therefore directed at reducing fugitive dust emissions. These measures include watering of roadways and other construction areas, revegetation of construction areas as soon as possible after construction activities have ceased, and covering of vehicles in motion when transporting materials which are likely to become airborne.

(b) Water Resources

(i) Surface and Groundwater

The following mitigation measures should be examined during the detailed design phase. These steps would ameliorate potential construction impacts.

1. Ponds or lagoons which receive contaminated water should be constructed to minimize groundwater contamination. Areas to be utilized for coal storage should also be prepared to minimize seepage.

2. After definitive geotechnical results are available, a final determination on whether to line ash ponds should be made. Although the area is characterized by relatively low soil permeabilities, the potential to mitigate any groundwater contamination from heavy metal leachates by lining ponds with highly sorptive and low permeability materials, such as bentonite, should be studied prior to construction.

3. Reclamation should proceed as soon as possible on all disturbed areas. This would include short-term reclamation measures on all areas temporarily inactive.

4. Vegetated filter strips should be utilized where possible between all disturbed areas and surface drainage ditches, creeks and streams to control and minimize sediment loss.

5. Stripping of vegetation and topsoil from sites designated for development of project facilities should be limited to only areas needed for construction.

6. No significant terrain disturbances should be undertaken before the relevant drainage and erosion control measures were installed.

7. Consideration should also be given to utilizing "dedicated" sedimentation lagoons to minimize the inclusion of runoff from undisturbed areas.

8. Discharge of sanitary wastes to Harry Creek should be avoided. Consideration should be given to the design of a single sanitary waste treatment system to serve both camp and construction facilities. Sedimentation lagoons discharging to Harry Creek should be designed to ensure that the combination of lagoon releases and natural flow do not exceed the creek's natural capacity. If coagulant use is deemed necessary for storm water clarification, potential water quality effects should be assessed in conjunction with coagulant choice.

(ii) Fisheries and Benthos

It is recommended that mitigation of powerplant construction impacts include adequate erosion control to prevent siltation of Hat Creek. This could take the principal form of settling basins constructed along Medicine Creek, since this creek valley would ultimately be used for ash and mine waste permanent storage. Runoff from the plant site could be diverted to this drainage basin. Revegetation of all disturbed areas should be completed as soon as practicable in order to minimize siltation to water sources. The timing of major construction activities which could introduce suspended solids into Hat Creek should avoid trout spawning and rearing periods (i.e. late May to August).

Increased fishing pressures from the work force could be limited by prohibiting fishing, although this course of action is probably neither practical nor enforceable. It is expected that much of the increased fishing pressure due to the presence of the construction force would be exerted on the Thompson River and other more attractive fishing areas outside of Hat Creek Valley. This should be regulated or might be compensated by stocking and management measures on those water bodies capable of sustaining increased fishing pressures.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

(c) Land Resources

(i) Physical Environment

Soils have been identified as the principal component of the physical environment which would be affected by powerplant construction. In general, the potential impact to the soils in the vicinity of the powerplant and associated facilities is considered to be minimal. However, there are several soil units which have the potential for dusting, alkalinity-salinity and erosion problems. These units are found in the vicinity of the proposed Medicine Creek ash disposal area. These soil units are potential problems which should be mitigated during construction.

Minimizing the erosion of these soil units in particular, and others affected by plant construction, would reduce the impacts. It is recommended that the soil units susceptible to erosion be avoided during construction. In the event that they must be disturbed, stabilizing techniques such as contour slopes and revegetation should be implemented immediately after disturbance. Vehicular and construction traffic should be restricted to specially constructed access roads to minimize disturbance to soil retaining vegetation. Where such vegetation must be disturbed, chemical and water sprays should be used to stabilize slopes while the revegetation progammes are conducted.

(ii) Natural Vegetation

Engelmann Spruce - Grouseberry - Pinegrass, Douglas-fir - Pinegrass and Kentucky Bluegrass would be the largest natural vegetation associations disturbed by plant construction.

Each of these associations, with the exception of the Kentucky Bluegrass Association, have been rated as low in overall sensitivity. The resultant impacts are considered to be minimal. One other association, Willow-Sedge Bog, is rated high sensitivity. This association occurs in the Medicine Creek ash disposal area.

The primary means to mitigate the loss of sensitive vegetation is to relocate the facilities. However, due to the small area of sensitive vegetation involved and the importance of optimizing facility locations for economic and operational efficiency reasons, alternate measures should be the primary consideration. Construction activities should be planned to disturb as little vegetation as possible. Vegetation associations with characteristically unstable slopes should be avoided. Access by construction machinery and personnel beyond a predefined work area for each facility should be restricted. Traffic should be confined to access roads and passage through undisturbed areas prevented. Vegetation losses can be minimized by designing minimal width rights of way.

Revegetation programmes could minimize the impact of vegetation losses. These programmes should be initiated after construction activities stop. Plant species used to revegetate land should be carefully selected to minimize the effects on established vegetative associations caused by rapid changes in species composition due to competition from exotic species.

Effects due to dusting could be minimized by following the mitigative measures for soils as described in the preceding subsection, Physical Environment. Mitigation of indirect effects, such as interception of near-surface seepage water could be achieved through identification of very shallow groundwater areas and avoidance. These areas are particularly susceptible to effects from facilities which require extensive foundations and supporting structures.

(iii) Wildlife

Most irreversible environmental impacts of plant construction on wildlife are associated with habitat removal. The habitats most sensitive to disturbance in the Hat Creek Valley are the wetlands, the riparian, and the sagebrush wildlife habitats. The impact of habitat losses in these areas could be reduced by:

1. Measures to minimize loss of sagebrush habitat wherever possible (e.g. relocation of temporary topsoil stockpiles would reduce sagebrush habitat loss by 66 ha).

2. Careful location of construction facilities, which would avoid the destruction of the wetland and riparian habitats.

Human population influx associated with the construction of the Hat Creek facility would increase local hunting pressure. Measures are recommended to distribute this hunting pressure over a large area by discouraging hunting in Hat Creek Valley and along the access corridors of Medicine Creek and Cornwall Creek. This hunting restriction should include waterfowl, upland game birds, furbearers and big game. The B.C. Fish and Wildlife Branch should be consulted concerning regulation of hunting activities in the valley.

In addition to hunting pressure, uncontrolled access would disturb wildlife due to increased recreation in the remaining natural areas of the Hat Creek Valley. Should recreational facilities such as dirt bike trails and cross-country ski trails be developed, they should be located to avoid important wildlife habitat. In particular, prime waterfowl habitat, such as wetland, should be protected from uncontrolled access.

The domestic garbage associated with the construction camp should be disposed of in such a manner that it is unattractive (burned) and unavailable (fenced and buried) to black and grizzly bears. All barbed-wire fences erected to exclude livestock should be constructed so as not to block or obstruct deer movements.

Revegetation programmes associated with construction activities should take into consideration the forage species favoured by the local big game. An effort should be made to establish these species on exposed or disturbed areas.

(iv) Forestry

A large percentage of the land disturbed by construction of the plant is considered to be productive forest land. This forested land comprises 0.42 percent of the total forested land within 25 km of the plant site. The majority of the productive land rated as "good site class" is found in the area of the proposed Medicine Creek ash disposal site. Mitigation of the impact to forestry could be approached in two different ways, by forest resources and by forest industry. To mitigate effects on forest resources, project facilities should not be located on good or medium rated forest land. Rather, areas rated as either poor or low site class, or those which have been logged within the preceeding 5 years, and are not in regenerative growth stages, should be used for facility siting. To mitigate effects on the forest industry, clearing and grubbing should be coordinated with logging operations. In this manner, little or no timber of commercial value would be lost.

Added traffic during construction could also affect logging traffic in the valley. This effect can be mitigated through the development of multiple use roads. New roads could be sited to minimize conflicts with long-term logging operations and recreational traffic on Highway 12. Multiple use of construction access roads could also be accomplished by radio controlled traffic.

(v) Agriculture

Construction impacts associated with the plant, mine and offsite facilities on agricultural activities could be ameliorated by the following measures.

1. Activities which produce dust should be controlled by watering and revegetation. (Such control is now planned by B.C. Hydro.)

2. Loss of irrigated crop land should be reduced by the relocation of drainage ditches away from presently irrigated fields.

(vi) Cultural Heritage Resources

An agreement to mitigate adverse impacts from construction of the plant should be reached between B.C. Hydro and the Office of the Provincial Archaeologist in accordance with the Heritage Conservation Act of 1977.[1] Options to be considered range from preservation by avoidance, to complete or partial excavation of all, or a selected sample, of the cultural heritage resources sites prior to construction. The presence of cultural heritage resource specialists in the field during construction would provide for timely attention to sites encountered unexpectedly by that activity.

(d) Socio-economics

(i) Overall Considerations

The mitigative measures outlined in Section 1.3.2(e), Noise, would minimize the impact of noise on residential areas near the project during plant construction. The recommendations in Section 1.3.2(a), Meteorology - Air Quality, would reduce fugitive dust emissions which would affect visibility and the aesthetic quality of the land resources.

It is recommended that B.C. Hydro provide sufficient lead time between the announcement of a decision to proceed with the project and the start of construction to ensure both the timely availability of several lots for immigrant residents and the time needed for expansion and structural changes in the local government administrations.

In order to reduce pressure upon community recreation facilities, it is recommended that B.C. Hydro provide a basic quality playing field as a part of the construction camp facilities. It is also recommended that B.C. Hydro contract a scheduled bus service for evening recreation to and from the construction camp and the villages of Ashcroft and Cache Creek. This service would minimize parking pressure in the communities and minimize traffic related problems.

(ii) Recreation

In general, mitigation of recreational impacts can be accomplished either by shifting the location of the project or by modifying operational modes. Shifting the location of the project to a site outside the valley is not a viable option, but changing the location of project components could possibly reduce impacts. Changes in operational mode could also affect recreation by possibly decreasing impacts on natural resources. Changes in project component locations or operational mode would make only small changes in recreation impact, but those options which cluster facilities are better than those in which facilities are dispersed, and those operational modes that achieve higher levels of water and air quality with least disturbance of natural resources would be desirable.

Specific mitigation suggestions include the following:

1. Precautions to limit dust emissions, noise, erosion, vegetation damage and disturbance of wildlife.

2. To the extent feasible, schedule construction activities to coincide with periods of low recreation demand.

(iii) Aesthetics

Construction activities would create noise, dust and debris in the area. Fortunately, the aesthetic impact of these operations on residences would be minimal. However certain mitigation measures are suggested.

Contractors should be required to establish cleaning procedures on local roads, so that debris, mud and dust would not be "tracked" from the construction site into local commercial and residential areas. Onsite dust control measures, including water sprinkling and/or chemical treatment of roads and construction areas, should be undertaken to keep dust to a minimum. In addition, steps should be taken to assure an orderly development of the powerplant complex with a minimum of disruption to the site. All areas which would not be occupied by project facilities should be left in their native, undisturbed states. If necessary, fencing, flagging, or other means of identification should be employed to prevent unauthorized persons or equipment from entering undisturbed areas.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

(e) Noise

During plant construction, it is recommended that the following acoustical measures be implemented to minimize noise levels.

1. Silencing equipment on all vehicles should be maintained in good working condition.

2. Blasting activities should be scheduled during the normal working hours.

3. Plant construction activities should be conducted during a single 8-hour day shift.

4. Public address system noise should be controlled.

5. Steam line outlets could be fitted with silencers to reduce the noise levels produced during steam blowout prior to startup of each generating unit. (This non-efficiency measure would be costly, however, and would be an extreme measure to control noise during a single short clean-out period for each unit.)

1.3.3 Recommendations to Mitigate Mine Preproduction Phase Impacts

(a) Meteorology - Air Quality

Preproduction development of the mine would consist of typical mining activities. These include removal of surficial material and overburden, conveying and dumping. Such activities, as well as windblown dust from exposed areas, would produce elevated suspended particulate concentrations in the immediate mine vicinity out to a few kilometres from the excavation. Suspended particulate concentrations would have some impact on visibility in the adjacent surrounding area. It could produce some slight decrease in temperature in the immediate vicinity of the mine.

Various mitigation measures to keep the expected air quality and climatic effects of mine construction activities at minimal levels should be implemented. These include frequent watering of haul roads and exposed surfaces, a speed limit for haul-road traffic, revegetation of disturbed areas soon after activities have ceased, and enclosure of the conveyors and transfer points.

(b) Water Resources

(i) Surface Water and Groundwater

The following measures are recommended either for implementation or evaluation. The cost effectiveness of each recommendation should be considered prior to incorporation in the project design or preproduction plan. It is recommended that:

1. Areas to be utilized for storage of coal and low grade waste be prepared in a manner to minimize seepage and groundwater contamination.

2. In addition to the proposed main sediment control lagoons, temporary drainage ditches and settling basins be constructed as required to minimize sediment in runoff.

3. The Houth Meadows and Medicine Creek waste disposal containments (embankments) be designed to minimize seepage through the structures in order to reduce the quantity of contaminated water to be treated and discharged to Hat Creek.

4. Access by livestock to coal stockpile drainage waters, and perhaps mine seepage, be prevented because of the potentially poor quality of these waters.

5. Consideration be given to implementing for the mine those mitigation measures pertaining to revegetation, and sediment and erosion control previously discussed under powerplant construction (Section 1.3.2(b)).

The following measures are recommended for further consideration:

1. Finney Lake is judged to have some aesthetic and recreational value. Consideration should be given to maintaining the lake, provided it is shown not to contribute to groundwater recharge and slope instability in the area. If the existing discharge control structure at the lake outlet were lowered to a level 1 m below the present average summer levels, natural seepage could be negligible and large portions of the lake would remain. This would also prevent a potential impact on livestock water supply.

2. If Finney and Aleece lakes were drained, the procedure should be conducted during high flow in Hat Creek. In addition, the quality of the bottom water should be assessed prior to draining in order to allow better prediction of any impact on Hat Creek water quality.

(ii) Fisheries and Benthos

The primary impact to aquatic biology of the construction of the mine is the loss of approximately 7 km of the natural stream habitat. Some of the lost production could be offset to a degree by the additional reservoir habitat constructed at the head of the creek diversion. Proper management and stocking of this small lake could result in the establishment of a rainbow trout population. Because the rainbow trout population of Hat Creek represents a healthy and stable, but not unique, resource, and because the increased population due to the work force could be expected to increase the fishing pressure in the immediate project environs, mitigation could include both stocking and habitat enhancement measures. Any planned enhancement programme should be coordinated with B.C. Fish and Wildlife Branch.

(c) Land Resources

(i) Physical Environment

Several soil units have the potential for dusting, alkalinity-salinity and erosion problems. These units have been rated as high in overall sensitivity. Five of these are found in the area of the proposed mine, one in the Medicine Creek waste dump,

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

five in the Houth Meadows waste dump and one in the topsoil storage area. Erosion and dust control should receive particular attention in these soil areas.

(ii) Natural Vegetation

Among the vegetation associations for which impacts have been predicted in the mine area, the Sagebrush - Bluebunch Wheatgrass Association is the only one which would be significantly affected by mine construction activities.

To mitigate this impact, construction activities should be planned to disturb as little of the native vegetation as possible. Access by construction machinery and personnel beyond a predefined work area should be controlled, and traffic should be restricted to access roads and passage through undisturbed areas prohibited.

Unavoidable loss or disturbance of vegetation should be mitigated by revegetation programmes which should be initiated immediately upon completion of construction. Plant species used in these programmes should be carefully selected to avoid additional stress on existing vegetation through competition. Impacts due to dusting would be minimized by effective dust control measures.

(iii) Forestry

A large percentage of the land disturbed by construction of the mine and associated facilities is productive forest land. However, approximately 95 percent of this forest land is rated as "poor site class". Mitigative measures applicable to the forest resources could involve relocation of waste disposal boundaries to minimize timber losses of commercial value. However, implementation of these measures would not have great economic benefit because of the poor forestry conditions.

Mitigation measures specific to the forest industry should include the coordination of clearing operations with logging activities. The development of multiple use roadways would also reduce potential conflicts. Radio controlled traffic could accomplish this objective.

Potential problems from fugitive dust could be reduced by effective dust control. Periodic spraying of forest species with water in conjunction with the spraying of roads would reduce dust accumulations.

(d) Socio-economics

The mitigation measures suggested for the preproduction phase of mining are essentially the same as those for construction of the powerplant. These are discussed in Section 1.3.2(d).

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

(e) Noise

Mitigation measures to reduce noise effects during the preproduction phase of the mine are similar to those for the powerplant construction (see Section 1.3.2(e)).

1.3.4 Recommendations to Mitigate Offsite Facilities Construction Impacts

(a) Meteorology - Air Quality

Construction of the offsite facilities would not produce air contaminant emissions of any consequence other than fugitive dust. Mitigation should attempt to reduce dust emissions by watering of roadways and other construction areas, revegetation as soon as possible after construction has ceased, and covering of vehicles in motion when transporting materials which are likely to produce dust.

(b) Water Resources

(i) Surface and Groundwater

The following measures are recommended to mitigate potential impacts.

1. The landfill area for the intake-structure excavation spoil should be chosen to minimize sediments entering the Thompson River.

2. In the case of the alternate schemes for supplying plant water from Hat Creek and/or Medicine Creek, adequate base flows in Hat Creek should be ensured in order to protect current irrigation licenses, especially those located immediately downstream of the project reservoirs.

3. In addition, consideration should be given to mitigation by revegetation and by sediment and erosion control previously discussed under plant construction (Section 1.3.2(b)).

Measures which should be evaluated further include the following:

1. Dewatering of the intake structure construction area should be performed at a controlled rate to minimize sediment concentration increases in the water discharged to the Thompson River.

2. For the Hat Creek diversion canal the feasibility of other canal cross sections should be examined in order to reduce surface area and avoid water temperature increases. Other mitigative measures, including artificial cooling, the use of a rock-lined creek bed for discharge (rather than the proposed steel discharge conduit) and the use of shade trees along the canal route, should also be considered.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

3. The feasibility of alternate discharge conduit and plunge pool designs should be investigated to avoid effects on fish from dissolved gas supersaturation in lower Hat Creek.

4. Blockage of the present irrigation systems by the Finney Creek and Hat Creek diversion channels might be mitigated by providing water control outlets on these channels to allow continued use of the present ditch systems. Alternatively, new routes or water supply systems could mitigate the impact on present conveyance systems.

(ii) Fisheries and Benthos

Two crossings of the Bonaparte River, the access road and the water pipeline, are needed for the project. The overall impact of the access road bridge construction on the Bonaparte River is expected to be beneficial because it would result in the removal of an older wooden structure which now disrupts flow. It would also be possible to mitigate the impact of the pipeline crossing of the Bonaparte River. Spawning habitat disruption from burial of this water line could be repaired utilizing correctly sized gravels and maintaining a proper flow contour. If these factors are considered, it would be possible to upgrade and even expand spawning habitat in the Bonaparte River, thus creating a beneficial impact.

(c) Land Resources

(i) Physical Environment

Construction of the access road and pipeline appear to affect soil units rated as high in overall sensitivity. These units are subject to erosion and dusting problems. The mitigative measures which should be employed include the use of water or chemical sprays for dust control, disturbing as little of the soil stabilizing vegetation as possible, and the immediate revegetation of disturbed areas upon completion of construction activities.

(ii) Natural Vegetation

The Saline Depression Vegetation Association would be dusturbed by the airstrip, the Riparian Association by the pit rim reservoir, and the Cultivated Fields and the Bunchgrass - Kentucky Bluegrass/Saline Depression Complex by the site two storage reservoir. Construction activities should be designed to disturb as little vegetation as possible. Within the access corridors, associations which characteristically stabilize soils should be avoided. Access by construction machinery and personnel beyond predetermined work areas for each facility should be restricted. Revegetation programmes at the conclusion of construction would minimize adverse effects. Species which would not disrupt the composition of existing communities should be chosen for revegetation work. Effects due to fugitive dust should be minimized by dust control procedures.

1.3 CONSTRUCTION MITIGATION PROGRAMMES - (Cont'd)

(iii) Forestry

The area of forest land disturbed by construction of offsite facilities is small in comparison to the areas required for plant and mine construction, and approximately 70 percent of this forested land is rated as poor site class. The minimal impact predicted for the forest resources could be reduced further by limiting the removal of the productive forest species. Access route rights of way for both construction and operational phases should be designed to minimum widths to limit disturbance to vegetation.

Mitigation of the impact to the forest industry could include coordination of the land clearing operations with local logging activities. Potential problems resulting from fugitive dust would be reduced by dust control. Periodic spraying of forest species with water, in coordination with construction dust control procedures, would minimize dust accumulations on foliage in the vicinity of the construction activities.

(d) Socio-economics

The measures suggested to mitigate the effects of the offsite facilities are the same as those suggested for powerplant construction (Section 1.3.2(d)).

(e) Noise

Mitigation measures to reduce the effects of noise from construction of the offsite facilities are similar to those specified for powerplant construction (Section 1.3.2(e)).

1.4 OPERATIONAL MITIGATION PROGRAMMES

This section presents both non-efficiency engineering design features evaluated during preliminary project design and suggested operational constraints to mitigate environmental impacts.

1.4.1 Conceptual and Preliminary Design Features Evaluated to Mitigate Operational Impacts

Design features evaluated during conceptual and preliminary engineering design are summarized in Part Two, Project Description. Nonefficiency measures include any mitigation measures or design features evaluated for purely environmental reasons. The base plant includes features which would mitigate anticipated impacts during operation. Mitigative measures consist of:

1. Facility site selection.

2. Stack and cooling tower emission controls.

3. Liquid effluent reuse and control.

4. Access corridor consolidation.

5. Water supply pipeline emergency discharge limitations.

(a) Facility Site Selection

One of the most significant mitigation measures incorporated in the project design involves the plant location itself. Site selection was an iterative refinement of the site evaluation study prepared by Integ-Ebasco.[1] Prior to the Detailed Environmental Studies, gas tracer studies were conducted by North American Weather Consultants[2] to investigate the meteorological dispersion potential of two prospective plant sites. The first site was in Hat Creek Valley near the proposed mine at an elevation of approximately 950 m. The second site was east of the upper Hat Creek Valley in the Trachyte hills at an elevation of about 1350 m. The results of these dispersion studies revealed that adverse ambient air quality effects would be significantly less for the second, higher site than for the valley location. The site now proposed for the plant is very close to the Trachyte hills location except that it was moved to the top of a small hill to take full advantage of the increased dispersion potential. The elevation of the smoke stack base is now planned to be 1418 m.

(b) Stack and Cooling Tower Emission Controls

Stack and cooling tower emission control concerns centered on the need to (1) protect ambient air quality from excessive concentrations of flue gas contaminants, and (2) reject waste heat in an environmentally acceptable manner.

The air quality control systems represent a major effort to minimize air contaminant emissions. Although the design criteria and the type of electrostatic precipitators have not yet been selected, cold side electrostatic precipitators located after the air preheaters are proposed at this time.[3] It is estimated that a collection efficiency of 99.52 percent is necessary to meet the emission objectives recommended by B.C. Hydro[4] for particulates (229 mg/m^3) using the worst acceptable coal and assuming that 80 percent of the ash is fly ash. Use of these high-efficiency electrostatic precipitators would, to a large extent, mitigate the effects of particulate emissions.

The Hat Creek boilers, would be designed to meet the provincial objectives recommended by B.C. Hydro[4] for NO_x emissions (1146 mg/m^3). Although the boiler design has not yet been selected, it is anticipated that the design specification would include both low excess air and low flame temperature to minimize NO_x formation.[3] Emissions for actual operating conditions with 30 percent excess air should be well below the emission objective.

The control system for sulphur dioxide has not yet been selected. Partial flue gas desulphurization (FGD) and meteorological control systems (MCS) with two possible stack heights (244 and 366 m) are under consideration. Whichever system were to be selected it would be designed to mitigate potential adverse effects of ambient sulphur dioxide concentrations by maintaining concentrations at levels at or below the ambient guideline values (see Part Four, Section 4.1.1(a)(ii)). The partial FGD system studied would consist of two scrubbers (plus one back up) for each unit. Approximately 60 percent of the flue gas would enter the wet scrubbers; the remainder would bypass these absorbers and be used to provide reheat for the gas from the scrubber. The system would be designed to achieve 54 percent removal of sulphur dioxide on a continuous basis.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

The MCS system, on the other hand, would provide a systematic plan for reducing sulphur dioxide emissions only in response to predicted or observed high ambient concentrations. For the analyses in this report, it has been assumed that low sulphur coal would be stockpiled for use during periods of adverse dispersion potential during the winter months. During the remainder of the year, uniform load reduction of all units was assumed to be the preferred control measure. The results of the MCS analyses suggest that control actions would need to be taken but a few times per year with a 366 m stack, or for about 280 hr/yr (about 3 percent of the time) when used with a 244 m stack.[5]

Although the stack height has not yet been determined, construction of either a 244 or 366 m stack represents an important feature to mitigate potential air quality effects at ground level. The single tall stack (containing four flues) would be designed to lift the air contaminants to sufficient altitudes that upon dispersal to ground level, their concentrations would be reduced to values below the assumed ambient guidelines even at points of elevated terrain. A single, multi-flued stack performs better in this regard than separate stacks of equivalent height because plume rise is enhanced. The use of a tall stack would also allow the plume to remain above the influence of most local mountain-valley circulations and surface based inversions. These have the potential to cause high ground level concentrations when plumes come under their influence.

A system of two natural draft cooling towers has been selected from four alternatives (four rectangular mechanical draft, four round mechanical draft, two natural draft and four natural draft) for use on the Hat Creek Project.[3] The selected cooling tower system is the most desirable from the standpoint of air quality and climatic effects. Operation of two natural draft towers would result in high plume rise, a minimum of fogging and icing, and the smallest maximum drift deposition rate of the alternatives studied. The location and orientation of the tower system would also minimize the interaction of the cooling tower plumes with the stack plume.

(c) Liquid Effluent Reuse and Control

Liquid effluent reuse and control systems were selected to minimize consumptive water use and to avoid blowdown of plant-contaminated waters. Selected systems include the natural draft cooling towers, plant water treatment systems, wet ash disposal and reuse of wastewater to control mine fugitive dust emissions.

(d) Access Corridor Consolidation

Alternative access corridors were evaluated with the objective of minimizing land use impacts from linear developments. Mitigation proposals include consolidation of the project access road and water supply pipeline routes where possible.

(e) Water Supply Pipeline Emergency Discharge Limitation

Provisions for water supply pipeline emergency discharges include selection of discharge areas and drainages, as well as restrictions on the allowable volume and rate of discharge. Mitigative measures are proposed to prevent disorientation of fish and habitat destruction in the Bonaparte River and Thompson River.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

1.4.2 Recommendations to Mitigate Powerplant Operational Impacts

Specific recommendations to mitigate operational impacts of the Hat Creek thermal generating facility are developed below. These recommendations represent current understanding of the Provincial Guidelines and Objectives governing ambient air quality, water resources, fisheries protection, effects on human resources and archaeological and historic site preservation.

(a) Meteorology - Air Quality

All measures currently recommended to mitigate potential meteorological or air quality impacts have been incorporated into the preliminary design (or alternatives in cases where the design has not yet been decided upon). Should the monitoring programme described in Chapter 3.0 indicate that additional measures are required to mitigate impacts, additional operational constraints would need to be considered.

(b) Water Resources

(i) Surface and Groundwater

The following measures are recommended to mitigate powerplant operational impacts. Each measure should be evaluated in detail prior to implementation at the site.

1. Fertilization during reclamation should be minimized to reduce nitrogen and phosphorous additions to nearby streams.

2. Seepage through the upper Medicine Creek ash disposal retaining embankment should be collected and returned to the ash pond. Because the permeability of fly ash is considerably lower than bottom ash, the advantages of placing the fly ash in the westerly end of the pond should be considered as a means of reducing seepage through the embankment.

3. If subsurface seepage were to occur in the vicinity of the channel of Harry Creek, a well or series of wells could be installed along the toe of the waste embankments to collect the seepage and pump the water to the sluice water pond.

(ii) Fisheries and Benthos

The operation of the plant should have no major direct adverse aquatic impacts; therefore, no mitigation measures are recommended. Should the results of the monitoring programme (described in Chapter 3.0) detect acidification of local water bodies as a result of stack contaminant emissions in critical salmonid habitats, then mitigative measures would be required.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

(c) Land Resources

These recommendations are based solely upon criteria that land-resource impacts be minimized or reduced to zero. The recommendation does not consider costs associated with the FGD system nor the substantial environmental effects of increased land use for sludge disposal, consumptive water use or limestone mining and handling.

(i) Physical Environment

The operation of the proposed powerplant could affect soils through the direct deposition of trace element particulates and through acid rain. Reductions in soil pH due to acid rain have been identified as a potential effect resulting from plant operation. In addition, the potential exists for trace element accumulations to reach toxic levels in soils, although the predicted trace element emission rates from the stack are minimal.

Measures to mitigate each of these effects would involve changes in the emission control systems and/or the stack height. The use of flue gas desulphurization (FGD) would reduce SO_2 emissions which in turn govern the potential for acid precipitation. The quantitative effect of FGD on trace elements is not known, but it is possible that these emissions might be reduced to some extent.

A tall stack would tend to disperse the contaminants, allowing for the present land use patterns to continue within the vicinity of the plant. There is a tendency for acid rain to occur some distance from the powerplant when tall stacks are employed. The preference, based solely on mitigation of soil effects, would be for a 366 m stack with FGD.

(ii) Natural Vegetation

A. Primary Contaminants

The effects of SO_2 on vegetation are well documented in the literature. The sensitivity of the various existing vegetation associations to SO_2/NO_2 injury, and the areas occupied by these associations, were both considered in predicting impacts from each of the three AQCS/stack height configurations.

For the FGD system with 366 m stack the total area in which injury to any association would be expected is approximately 23 km^2. Within this area highly sensitive associations occupy 1.4 km^2. The remainder is vegetated by associations of moderate to low sensitivity. An FGD with 366 m stack would provide greater vegetation protection than either of the MCS alternatives discussed below. This sytem is predicted to result in minimal effects on vegetation.

For the MCS with 366 m stack the total area in which injury to any association would be expected is about 238 km^2. Within this area associations having high sensitivity occupy 27 km^2 and associations having moderate sensitivity occupy 37 km^2. The remainder is vegetated by associations having either low sensitivity or, in small areas, associations that were not classified for sensitivity.

For the MCS with 244 m stack the total area in which injury to any association would be expected is 324 km^2. Highly sensitive associations occupy 33 km^2 and moderately sensitive associations occupy 48 km^2.

In any condition where the hourly concentration of SO_2 exceeds 1000 $\mu g/m^3$ the probability of adverse impacts to vegetation would increase. This condition at high terrain elevations would be more likely with the MCS alternatives than with FGD.

B. Trace Elements

Trace element effects on vegetation could result from soil enrichment. However, the predicted trace element deposition rates from the stack are minimal. The effectiveness of FGD in reducing trace element emissions is not known, but it is possible that these emissions might be reduced to some extent.

C. Salt Deposition

The effects due to salt deposition from the cooling towers should only occur when toxic concentrations accumulate in the absence of rainfall. These potential effects are considered to be negligible, because low deposition rates are predicted. Any effects on vegetation found at the point of maximum deposition near the towers could be mitigated by washing off salt accumulations with periodic water sprays during the summer months when rain periods are infrequent.

(iii) Wildlife

Most of the impacts of powerplant operation on wildlife are associated with direct habitat removal. As indicated under powerplant construction (Section 1.3.2), the habitats most sensitive to disturbance in the Hat Creek Valley are the wetlands, riparian and sagebrush wildlife habitats. Impacts on these habitats should be mitigated as much as possible through avoidance. As in the case for construction, human population influx associated with facility operation would tend to increase local hunting pressure and intrude in natural resource areas for recreation purposes.

The lighting on the stack and cooling towers should consist of dim red flashing lights or of a strobe-system of red lights for aircraft warning. This would minimize potential nocturnal bird strikes. During April, May, September and October, which are the migration periods of birds, it is recommended that spotlights not be used on stack, cooling towers or any other building prominence. It is recognized that all illumination schemes would require approval by the Ministry of Transport.

Revegetation programmes associated with the powerplant operation phase should take into consideration the forage species favoured by the local big game. Also, an effort should be made to establish these species in disturbed areas.

(iv) Forestry

The potential wood production lost each year due to ground level SO_2 concentrations from the proposed powerplant employing the alternative 366 m stack with FGD, the 366 m stack with MCS or the 244 m stack with MCS is approximately 13 347 and 508 m^3, respectively. These annual losses translate into $70, $2000 and $2800 based on $5.50 per m^3. The losses from clearing forested areas for project facilities are predicted to be $18,100 on an annual basis. In comparison, the predicted losses from air contaminants for the 366 m FGD, 366 m and 244 m MCS are 0.4, 10 and 13.4 percent of the respective total losses from development of the project.

The predicted annual losses from ground level fluoride concentrations for the conservative case are $125,686 for each of the air quality control strategies (AQCS). Combining the losses due to fluoride with SO_2 and construction losses results in totals of $143,856, $145,786 and $146,586 for 366 m/FGD, 366 m/MCS and 244 m/MCS, respectively. These numbers are based on the assumption that fluoride emissions would not be affected by the FGD system. Extrapolation of these losses over the 35-year life of the plant using a discount of 3 percent yields a total of $3.3 million for 366 m/FGD, $3.45 million for 366 m/MCS and $3.36 million for 244 m/MCS. The predicted forestry losses do not support the preference of an FGD system over an MCS. This is due in part to the assumption that HF emissions are not affected by FGD. However, on the basis of predicted losses from increased SO_2 concentrations, the impact from the 366 m/MCS would be 20 times that from 366 m/FGD. As a result, an FGD system is the preferred alternative from the perspective of minimizing operating impacts on forestry.

The development of an intensive management programme of forested land within 25 km of the project could serve to mitigate the effect that the presence of dead trees would have on aesthetics and public opinion. It is recommended that all crown lands within 25 km of the project be designated a special unit where intensive local forest management could be practiced. There would be little effect on the allowable annual cut in the Botanic Public Sustained Yield Unit (PSYU) due to the formation of this management unit, because the AAC has already been adjusted to compensate for development of the mine. The intermittent loss of forest trees due to flooding or deposition of soil around roots, which could occur in the areas adjacent to reservoirs, waste and ash disposal areas, could be avoided by clearing a buffer zone around each of these facilities.

(v) Agriculture

Project impacts on agricultural activities due to facility operation should be ameliorated as economically as possible through implementation of the following measures. It is recommended that:

1. *B.C. Hydro provide fence gates and fencing of project components to permit use of* agricultural lands adjacent to the site.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

2. Access for farm/range purposes be provided through construction of necessary roads.

3. B.C. Hydro maintain the remaining segments of irrigation systems intercepted by facility components and servicing lands not disturbed by construction.

Mitigation of farm land and range lost to production could involve the use of powerplant waste heat to extend the growing season or increase productivity.

Dispersal of cooling tower water heat could theoretically serve a variety of agricultural purposes, although to date few cooling towers are coupled to agricultural operations. Potential uses of this heat are greenhouse operation, thermal regulation of animal enclosures, irrigation-promoted prolongation of crop growing season, aquaculture and promotion of animal waste treatment processes.[6]

(vi) Cultural Heritage Resources

An agreement as to the survey attention to be directed to new areas of ground disturbance during maintenance or facility expansion should be reached between B.C. Hydro and the Office of the Provincial Archaeologist.

(d) Socio-economics

(i) Overall Considerations

The mitigation measures discussed in Section 1.3.2(d)(i) apply to the operation phase as well as the construction phase of the powerplant. Therefore the reader is referred to this section for pertinent measures.

(ii) Recreation

The mitigation measures discussed in Section 1.3.2(d)(iii) cover the construction and operation phases together. The reader should consult this section for relevant discussion.

(iii) Aesthetics

It is recommended that the following concepts be evaluated to mitigate aesthetic impacts from the operation of the Hat Creek generating station:

Foreground Views: A system of structures and form could be developed that provide architectural design continuity among all powerplant elements. Landscaped terraces for various powerplant elements would add interest, variety and scale to the site. Landscaping around the powerplant site and grouping smaller, functionally related buildings would provide a scale to which users and visitors could relate. Well defined circulation patterns for clear visual definition and for orientation within this high technology environment would be established.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

Middleground Views: Strong architectural forms for the conveyor, the transmission take-off and the ash transport system could be developed in order to complement the scale of the powerplant elements.

Background Views: The distant view of the powerplant elements would be a strong unified unit if foreground mitigation measures are implemented. Form and texture could be used to indicate the presence of a high technology environment. Because of its high visibility, the stack would be treated as a separate entity. With its proposed height of 244 or 366 m, efforts to mitigate its visual effect are limited to attempts to integrate its design with other powerplant elements by consideration of using alternative shapes, textures and colours.

Mitigation measures suggested for further consideration at the Medicine Creek *dump are:*

Foreground: Contour and landscape the face, crest and toe of the retaining embankment to blend into existing terrain. A sequential dumping - reclamation method for revegetation would minimize visual impact of spoil areas.

Middleground and Background: Progressive clearing programmes would minimize the need to clear the ultimate spoil area. Contours and revegetation would fit the spoil area *into the existing landscape. If possible, dump relocation to Houth Meadows would* maintain the existing landscape.

The suggested mitigative measures for ash dump are as follows:

Foreground: Contouring and landscaping of the embankment face and top would fit it into the existing terrain pattern. Design berms would screen views of the ash dump.

Middleground: A landscape programme that would compensate for growth of the ash dump area and provide screening from future viewable areas could be developed. Alternative access road locations to minimize the number of views of the ash dump from this road could also be explored as could the potential of using other sites for an ash dump.

Background: Existing vegetation to screen and to minimize the amount of clearing during construction could be retained.

(e) Noise

During powerplant operation the following acoustical measures are recommended in order to assure that the noise levels presented in this report would not be exceeded:

1. A judicious selection of the Induced Draft Fans should be made, taking into account the maximum operational noise levels of this equipment and the corresponding sound levels shown in "Axial Flow Fan Summary" of Harford, Kennedy and Wakefield.[7]

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

2. A judicious selection of Forced-Draft and Primary-Air Fans should be made, taking into account the maximum operational noise levels of this equipment and the corresponding sound levels shown in "Axial Flow Fan Summary" of Harford, Kennedy and Wakefield.[7]

3. The 200 MVA transformers should be purchased with noise levels not to exceed the values presented in Table 8-6 of Harford, Kennedy and Wakefield.[7]

4. The discharge pipes of the boiler electromatic relief valves should be fitted with silencers, to reduce the noise produced by the escaping steam flow.

5. Prior to station operation, the orientation and the power input to the outdoor loudspeakers should be adjusted as much as possible, to reduce the noise impact.

6. Unattenuated sound levels would be obtained for the 500 kV air blast circuit breakers and attenuation measures would be provided, if required.

1.4.3 Recommendations to Mitigate Mine Production Phase Impacts

(a) Meteorology - Air Quality

The primary air quality and climatic effects expected as a result of mine operation are caused by activities which produce fugitive dust. These activities include those already discussed under mine construction (Section 1.3.3(a)) except that they will occur on a larger scale when the mine is in operation. Included are surficial material removal, overburden removal, coal removal, haul road traffic and repair, and coal stockpiling. Wind erosion of exposed surfaces and storage areas is also an important source of fugitive dust. The elevated suspended particulate concentrations expected to result from these sources are anticipated to occur in the immediate mine vicinity and out to a few kilometres from the mine area in the valleys.

The mitigation measures which are suggested to keep these effects to a minimum are the same as those already discussed under mine construction. They include frequent watering of haul roads and exposed surfaces, a speed limit on haul road traffic, revegetation of disturbed areas as soon as possible after activities have ceased and enclosure of the conveyor system.

(b) Water Resources

(i) Surface and Groundwater

The following measures should be evaluated in the detailed design and operation phase to ameliorate impacts:

1. Overburden and stockpiled materials should not be placed over deep snow in order to minimize leachate drainage from the materials.

2. On terraced embankments, reverse slopes should be utilized to minimize runoff concentration.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

3. Surface runoff and leachate from the coal pile and low grade waste storage areas should be contained and not discharged to Hat Creek unless further studies establish that treatment for organics, colour and trace metals can be achieved to acceptable levels.

4. Consideration should be given to placing a settling basin on lower Harry Creek to control sediment losses from fugitive dust from the coal stockpile, coal blending and coal preparation operations.

5. If seepage through and around the Houth Meadows waste disposal area became significant or if groundwater quality became unacceptable, this water could be collected by installing shallow wells and could be returned to a temporary storage pond for possible reuse. Consideration should also be given to ensuring that the waste rock is adequately compacted.

(ii) Fisheries and Benthos

Mitigation of aquatic impacts due to the mine production phase are chiefly associated with changes in water quality treatment and discharge. Siltation and sedimentation should be mitigated through construction of settling lagoons. Care should be taken to assure that mine dewatering and waste dump runoff discharges are not toxic in order to protect the trout population of lower Hat Creek.

(c) Land Resources

(i) Physical Environment

Dusting and erosion problems are the only effects predicted to occur on the physical environment due to mine operation. Mitigation of these effects would involve periodic spraying with water and other soil stabilizing chemicals, the imposing of speed limit restrictions on all haul and access roads, complete enclosure of conveyor systems, and immediate revegetation of disturbed areas and recontoured slopes.

(ii) Natural Vegetation

Dust emissions from the operation of the mine could affect the vegetation in the immediate vicinity of the pit. This effect should be mitigated by dust control measures.

(iii) Forestry

No effects were predicted to the forestry resource due to mine operation. The spray programmes proposed in the natural vegetation section could be extended to forest species if the proposed dust control strategies prove inadequate and potentially injurious levels accumulate on foliage.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

(iv) Geology

The temporary unavailability of aggregate from the Hat Creek Valley could be mitigated by stockpiling the approximately 200 Mt of this resource as a by-product of the mining operations. This aggregate would be available for use throughout the area, and should be adequate to meet demand during the life of the project.

Additionally, excavation by-products of bentonitic and kaolinitic claystone and siltstone, coaly waste and baked claystone could be stored and made available as raw materials for possible commercial recovery.

(d) Socio-economics

(i) Overall Considerations

The mitigation measures suggested for the construction phase of the powerplant apply equally to the mine preproduction phase. Therefore, the reader is referred to Section 1.3.2(d)(i).

(ii) Recreation

Mitigation measures to reduce impacts on recreation resources are discussed in Section 1.3.2(d)(ii).

(iii) Aesthetics

Suggested mitigation measures for the conveyor during the operational period could include:

Foreground: Conveyor systems could be designed as a strong architectural design element that emphasized the link between the blending facilities and the powerplant. Structural elements should be designed to complement the other powerplant structures.

Middleground and Background: Alignment of the conveyor could be made as direct as possible between powerplant and blending area to visually strengthen the linkage between the two. The design of the conveyor could express the high technology requirements of the project to provide a contrast to the existing landscape.

Mitigation measures suggested for the open pit mine are:

Foreground: Strong edge definition using drainage ditches and the perimeter road where required should be developed.

Middleground and Background: Depending on the mining technique, B.C. Hydro could define the ultimate perimeter at each stage to provide a strong identifiable edge to the open pit. Public access to pit area should be directed to viewpoints that provide opportunities to display the orderly appearance of the mining operation. Haphazard erection of maintenance and storage facilities in the open pit mine area should be minimized.

Mitigation measures for the blending facilities and stockpiles should include:

Foreground: An alternate access around the pit facilities could be developed to eliminate conflicts between the public and operation of facilities and to minimize foreground views through this area. Site plans should maximize the separation from the entrance to Marble Canyon and Highway 12.

Middleground: The use of man-made landscape elements such as extensions to Houth Meadows spoil dam and a lake to separate pit facilities from the entrance to Marble Canyon should be explored.

Background: Elements should be organized into an orderly design by grouping related facilities and keeping stockpiles confined in a well-defined area.

(e) Noise

During mine operation the following acoustical measures would be implemented to assure that the noise levels presented in this report would not be exceeded:

1. Exterior noise levels would be obtained for all mobile equipment to be used for the operation of the mine and compared with the levels presented in Table 8-2 of Harford, Kennedy and Wakefield.[7] These noise levels should not exceed those given in the reference.

2. All mobile equipment would be maintained with silencing equipment, such as exhaust mufflers, in good working condition.

3. Blasting activities would be scheduled during the daytime hours and blasting noise levels would be monitored.

4. Prior to mine operation, the orientation of the loudspeakers and the power input to the mine public address system would be adjusted as much as possible, to reduce the noise impact. Also the use of portable two-way radio system to complement the P/A system would be investigated.

1.4.4 Recommendations to Mitigate Offsite Facilities Operational Impacts

(a) *Meteorology - Air Quality*

During the operational phase of the project use of the access road, airport and equipment offloading facilities are not expected to result in air contaminant emissions of any significance. Air quality and climatic effects resulting from these emissions are predicted to be negligible. The only mitigative measure suggested is to control fugitive dust from the equipment offloading facilities by watering as necessary.

(b) Water Resources

(i) Surface and Groundwater

The following measures should be evaluated to mitigate impacts from offsite facilities operation:

1. Discharges to Cornwall Creek and the Bonaparte River from the makeup water line should be performed at a low, controlled flow rate to minimize channel disruption.

2. De-icing compounds utilized during access road maintenance should be avoided in areas where they can enter surface drainages.

3. Consideration should be given to disposing intake structure clarifier wastes and screen washings in a landfill operation, thus negating any potential water quality impacts.

4. Ground movements on the mine slopes could damage the natural and artificial lining materials of the Hat Creek diversion canal. This could result in increased seepage losses which would, in turn, cause more slope instability. During mine operation, the dewatering wells would help to control the instability. During decommissioning, however, when mine activity and dewatering cease, severe slope instability could result and thus the canal may be very difficult to maintain. Consideration should be given to driving a low-level tunnel further to the east of the pit. This diversion tunnel could be constructed either at the start of the project or to replace a temporary diversion canal before the end of mining.

5. Spill control measures should be developed for the equipment offloading facility and the airport to control accidental releases of hazardous materials.

(ii) Fisheries and Benthos

Should fish impingement at the intake occur, mitigation is available directly through the imposition of operational constraints. Present plant design provides a large makeup water reservoir at the plant site. This reservoir is presently sized to allow as much as 70 consecutive days drawdown without affecting powerplant operation. This flexibility could allow closing or decreasing the use of the intake during the passage of downstream migrant salmonid fry. An additional alternative would be to pump just during the day, or night, should significant diurnal variations occur in the downstream movement of fish.

(c) Land Resources

(i) Physical Environment

The operation of the offsite facilities was predicted to have minimal effects on soils. The effects predicted result from the susceptibility of the soils in the immediate vicinity of the offsite facilities to dusting and erosion problems. The dusting and erosion effects could be mitigated by the maintenance of the revegetation and dust control programmes initiated during the construction phase. Dusting problems along the pipeline and transmission line access roads can be minimized by paving these roads and maintaining a vegetation cover on either side of the right-of-way. Should paving not be practical, the road surface should be covered with crushed rock, oiled, or sprayed periodically with a soil stabilizing solution. It is recommended that the roads should not be allowed to remain as dirt surface roads.

(ii) Natural Vegetation

Operation of offsite facilities should only have indirect effects on vegetation. One indirect effect could result from dust accumulations due to fugitive dust emissions from access road traffic. However, if the measures suggested for mitigating the effects on soils are followed, then little or no effects should occur on vegetation and no mitigative measures are necessary.

There is still the likelihood that dust can accumulate on vegetation, especially during dry periods when dusting problems are prevalent and accumulations are not removed by rainfall. It is suggested that a contingency plan be developed whereby the vegetation would be sprayed, when necessary, to remove potentially injurious dust accumulations.

Another indirect effect may result from competition between revegetation and native species. This effect could be mitigated by carefully choosing revegetation species having the same tolerance range to environmental factors as existing native species. Another means of reducing this effect would involve revegetating with native species. Sufficient supplies of native species seed could be obtained from onsite nurseries, which should be started prior to construction activities.

(iii) Forestry

The accumulation of dust on foliage of forest species was identified as a potential effect resulting from operation of offsite facilities. Presumably, implementation of the mitigative measures identified for reducing the effects on soils should result in little or no dust emissions. However, some dust emissions are inevitable and plans to remove potentially injurious dust accumulations should be devised. The basic approach would involve spraying the affected trees with water during exceptionally dry periods, when rainfall is insufficient for dust removal.

(d) Socio-economics

(i) Overall Considerations

The No. 1 booster pumping station for the water intake system, located near the mouth of the Bonaparte River, would generate noise levels incompatible with residential land use for 15 to 20 residents located in its immediate vicinity. The mitigation measures recommended in the noise section below are reiterated assuming they are cost effective and more efficient than possible compensatory measures in correcting "economic welfare" losses.

(ii) Recreation

Mitigation measures to reduce recreation impacts are discussed in Section 1.3.2(d)(ii) to which the reader is referred.

(iii) Aesthetics

Suggested enhancement and mitigative measures for the intake structure and related facilities are:

1. Develop the intake structure as an architectural element that relates the form, colour, texture and line of the existing landscape components.

2. The design and implementation of landscape planting would provide a transition between the structures and the existing landscape, thereby minimizing the visual impact of the structure.

Mitigation measures for the access road could include:

Foreground: Relocation of the road near the ash dump to maximize natural screening and to minimize this dump's visual impact should be considered. Relocation of the road to an alignment east of the plant should also be considered. Public access through the blending area should be avoided.

Foreground, Middleground and Background: The road alignment design should take advantage of opening new vistas of the natural and man-made elements.

Mitigation measures for the water pipeline corridor should be:

Foreground, Middleground and Background: Clearing should be modulated through heavily treed areas to resemble the existing pattern of vegetation. Access roads at various points could minimize visual impact of a continuous service road which emphasizes linearity of the corridor. Surge tank design, booster pumping stations, and clearwell could complement colour, texture and form of the natural landscape.

Mitigation measures for the transmission line could consist of:

Foreground, Middleground and Background: A corridor clearing plan should be developed that modulates edges to reflect the existing open and treed areas. Alignments that utilize natural contours to minimize linearity, and avoid ridgelines and steep side slopes would minimize transmission line exposure. Design of linkages from plant switchyard to transmission corridor could relate the high technology environment at the plant site to the simpler structures of the towers.

Mitigation measures that should be considered for the creek diversion are:

Foreground: The road could meet access and service requirements to minimize the *right-of-way required. Landscaping could blend in with the existing pattern of* vegetation. Opportunities to create natural reservoirs at canal intersects on the creeks flowing into the upper Hat Creek Valley could be examined.

Middleground: Shoreline of reservoirs could be developed to reflect existing lakes in the valley. Cuts and fills should be blended to minimize their visual impact.

Background: Edges of canals should be developed to soften visual impacts by blending into the existing landscapes.

(e) Offsite Facilities

(i) Intake Structure

Because the intake structure is not expected to be a significant operational noise source, no special mitigation measures are being contemplated at this time. At booster pumping station No. 1, ventilation fan mitigation measures would be implemented by a judicious fan selection and/or fan intake and exhaust silencers. Also, transformer noise would be reduced by improving its internal design or by installing a shielding wall around the transformer. At booster pumping station No. 2, fan noise control would be incorporated similar to the one contemplated for the booster pumping station No. 1.

(ii) Access Road

The supply trucks that would be using the access road during the construction years would be fitted with standard exhaust silencers, and these silencers would be checked periodically for signs of deterioration.

(iii) Water Line

If major maintenance would be required during the operation of the pipeline, the repair crews would take precautionary measures near inhabited areas, such as scheduling daytime working hours and maintaining silencing equipment in good working conditions.

(iv) Transmission Line

To reduce the mine substation transformer noise levels (particuarly during the nighttime), acoustical treatment would be implemented. This treatment would be either in the form of internal transformer acoustical design or an acoustical barrier around the equipment.

1.4 OPERATIONAL MITIGATION PROGRAMMES - (Cont'd)

(v) Creek Diversions

Because the operation of the creek diversion facilities is not expected to be a significant source of noise, no special mitigation measures are being contemplated at this time.

(vi) Airport

At airstrip site "C" mitigation measures such as using glide slopes steeper than 3 percent on aircraft approach to the airstrip, and/or relocating the airstrip, would be investigated. At airstrip site "A" no special mitigation measures would be required.

(vii) Equipment Offloading Facilities

1. Both the highway trucks and the equipment offloading equipment such as forklifts and cranes would be equipped and maintained with exhaust mufflers in good working conditions.

2. Highway trucks noise levels would not exceed the values shown in Table 8-3 of Harford, Kennedy and Wakefield.[7]

1.5 DECOMMISSIONING MITIGATION PROGRAMMES

1.5.1 Water Resources

The following measures are recommended to mitigate potential impacts on water resources:

1. The use of fertilizer during reclamation should be minimized and its application carefully controlled to prevent an increase in the nitrogen and phosphorous levels of Hat Creek.

2. As previously discussed in Section 1.4.4(b), alternate Hat Creek diversion canal designs should be considered to ensure the stability of this facility during mine pit filling.

3. The creation of the mine pit lake requires further study to ensure that Hat Creek water quality will not deteriorate.

4. Consideration should be given to placing a simple, gated control structure at the mine pit lake outlet. This would allow almost complete control of the flows in lower Hat Creek which depending on the developments in the valley at this time could constitute a very beneficial impact.

1.5.2 Socio-economics

B.C. Hydro could undertake a number of steps to offset a general socio-economic decline should no alternative developments arise in the area. The steps might include prolonging the economic life of

1.5 *DECOMMISSIONING MITIGATION PROGRAMMES* - (Cont'd)

the thermal powerplant with the additional coal supplies in the Hat Creek Valley, or investigating other potential uses for the coal deposits.

1.6 RECLAMATION

1.6.1 Objectives of Reclamation

In devising the reclamation programme B.C. Hydro has considered both long and short-term objectives. The rapid establishment of vegetation on the disturbed area is the primary short-term goal. This is required to improve surface stability, by preventing wind or water-borne erosion and to enhance the aesthetics of the waste piles. In the long-term, vegetation should be self-sustaining and not require continued additions of fertilizer or water (irrigation).

An essential aspect of reclamation planning is the determination of the ultimate land use of the disturbed areas following reclamation. In general terms, the potential land use should not be less than that prior to disturbance. The present land use in the Hat Creek Valley is primarily directed towards cattle ranching. There are 13 dependent ranching operations in the valley of which six would be directly affected. In total, approximately 3300 ha would be disturbed by the mine and associated waste dumps of which the vast majority is presently unimproved range land.

Long-term use or exploitation of the revegetated waste dumps has also been examined. Several alternatives have been considered, for example, wildlife habitat, recreation, agriculture (ranching) and forestry. At present B.C. Hydro favours a mixed agriculture (ranching) and wildlife habitat alternative since these activities constitute the primary land use in the area of development.[1]

1.6.2 Studies to Evaluate Reclamation Alternatives

As part of the reclamation planning for the Hat Creek project studies have been undertaken to examine the site-specific factors likely to influence the future revegetation of waste piles. Test plots have been constructed using a variety of discrete waste materials excavated during a bulk coal sample excavation programme undertaken during the summer of 1977. In addition, plots to test revegetation at various slopes have been developed. A wide variety of revegetation species, suitable for establishment of vegetation in the dry climate at Hat Creek were examined and 12 were selected for testing. Three seed mixes of four species each were prepared. Each material was tested for nutrients and appropriate fertilizer added during seeding. Material test plots were hand seeded with the three different seed mixes while plots to test revegetation at different slopes were hydroseeded using only one seed mix, a mulch and binder. A monitoring programme would be undertaken to determine emergence success and productivity of species under each field test condition.[1]

1.6.3 Proposed Reclamation Alternatives

The mine would be an open pit design extending down, in benches, 215 m below the valley floor, with an approximate diameter at the surface of 3.0 km. A total loose dumping volume of 765 Mm^3 of wastes would be required during the life of the mine. Two major types of waste are expected.

1. Surficial glacial deposits of till, sand and gravel.

2. Pit waste, comprised of very weak rocks ranging from clayey siltstone to conglomerate as well as weak waste material segregated from coal interbeds.

Present plans indicate that much of the surficial glacial materials would be utilized in the construction of compacted dump retaining embankments to be located at the entrance to two natural containment areas, Houth Meadows and Medicine Creek. The other waste materials would be placed in behind these embankments. The dump surfaces would ultimately be broad expanses gently sloped at between 20:1 (3^{o}) and 10:1 (6^{o}).

The ultimate fate of the pit is presently being evaluated. Preliminary results of these evaluations were used to suggest that the pit would be allowed to fill with water. Both natural drainage and diversion of the spring freshet were considered to achieve this goal. However, if it is finally determined that the pit should not be allowed to fill with water, pit slopes would be graded and revegetated to stabilize them and the area fenced to preclude access.

With an assumed in service date for the first powerplant unit of 1986, the mining operation would commence approximately 4 years earlier with the stripping of surficial materials. Revegetation would commence as soon as possible on waste embankments, areas disturbed during construction and other possible retaining structures associated with the development as a whole.[1]

1.6.4 Additional Studies Required

Pending the success of the studies described under Section 1.6.2, B.C. Hydro would undertake studies to determine the compatibility of the proposed reclamation scheme and the proposed ultimate land uses (i.e. wildlife habitat, recreation, agriculture (ranching) and forestry).

The analysis of leachates from mine rock, overburden and waste coal presented in the Solid Wastes Disposal-Coal Storage-Land Reclamation Report[2] indicates the potential release of heavy and trace metals from these mine wastes. The potential for uptake of these heavy metals by vegetation was proposed in the Physical Habitat and Range Vegetation Report.[3] Additional studies would be required to monitor and evaluate the extent of metals uptake by the vegetation. These results would be extrapolated to project the potential impact of bio-accumulation of these metals up the food chain.

1.7 ENHANCEMENT

1.7.1 Recommendations for Affirmative Action

The Hat Creek Project would generate a large number of employment opportunities in the study region through the creation of direct, indirect and induced jobs. It might be desirable to enhance these employment opportunities for the local labour force through priority programmes.

However, there are no B.C. Hydro plans at the present time to encourage specific groups in their hiring programmes and to do so would require the agreement of the unions with which B.C. Hydro is involved. There is no clear government employment policy guiding employers in terms of establishing priorities among regional residents, other provincial residents and other Canadian residents.

1.7 ENHANCEMENT - (Cont'd)

Some initiatives in the Yukon and the proposed northeast coal developments, however, have recently been taken by specific federal and provincial departments to promote affirmative action programmes on large-scale resource projects for regional or social development purposes.

On the basis of these precedents, it is recommended that B.C. Hydro initiate discussions immediately with the Ministry of Labour, the Ministry of Economic Development and other institutions, as appropriate, with a view to establishing employment priorities in a manner which would orient the potential benefits from increased employment accruing from this project in the desired manner. Any programmes implemented should be tailored to the specific needs of the specific target group.

1.7.2 Recommendations for Enhancing Benefits for the Town of Clinton

Clinton has recently experienced a number of sawmill closures that have reduced the community's economic base and resulted in a gradual decline in population. Through this period they have received some government indications of future economic growth potential, but nothing has yet materialized and the outlook is not encouraging. Should Clinton receive a greater share of the projected in-migrant population, than that which is expected, this growth would likely be considered beneficial.

The existing project description proposes the construction of a new access road rather than using Highway No. 12 which would tend to favour settlement in Ashcroft and Cache Creek at the expense of Clinton. Also, the construction of this road would cost considerably more than upgrading Highway No. 12. However, the increased use of Highway No. 12 would have potential negative noise and safety effects on the Indian population on the Bonaparte Reserve adjacent to the highway which have not been fully evaluated. It is, therefore, recommended that B.C. Hydro discuss with the Bonaparte Indians, the possibility of utilizing Highway No. 12 as the sole project access road.

CHAPTER 2.0 - RECOMMENDED COMPENSATION

2.1 INTRODUCTION

This chapter presents suggested compensation measures which would be evaluated should the project proceed. Compensation refers to substitution, replacement or payment for resource impacts which cannot be mitigated. Suggestions presented are those proposed by the various subconsultants involved in the Detailed Environmental Studies and are listed by resource.

2.2 WATER RESOURCES

The major water resources impact of the project which could involve compensation is the loss of the fisheries and benthic resource in the 7000 m section of Hat Creek diverted by the mine. A range of compensation options would be considered; examples include the establishment or enhancement of an existing fishery resource in the local area or the provision of increased access to existing but poorly accessible fisheries.

Adverse impacts which result in a loss to the salmon fishery could be compensated by the provision for increased production through the restoration of spawning areas in the Bonaparte River. Removal of the barrier at Bonaparte Falls would provide access to the spawning habitat available above the falls. This measure would be a preferrable alternative to other forms of compensation such as payment for individual fish losses.

2.3 LAND RESOURCES

Ranch owners could be compensated for project impacts through:

1. Purchase of ranches in portion or entirety.

2. Exchange of lands or facilities for comparable ones affected by the project.

3. Improvement (such as irrigation) of ranch lands to offset project impacts.

Adoption of any one or all of these approaches would be predicated on the final project design configuration, the location of offsite facility components and on the availability of project lands for agricultural use.

2.4 SOCIO-ECONOMICS

2.4.1 Overall Considerations

1. The alternative to mitigation would be to compensate affected individuals for the losses in residential satisfaction incurred as a result of the increased noise and dust levels. The most appropriate course of action, if compensation were the preferred alternative, would be for B.C. Hydro to

negotiate the purchase of the affected residential rights. The appropriate value of these rights would be that which made residents equally well off by foregoing their residential rights as retaining them. The compensation option should be compared to the overall costs of noise and dust mitigation, rather than to each individually.

2. The location of the project and its nature in relation to the former nature of valley land use; noise, dust and general activity levels during project construction and operation; alterations in valley aesthetics; alterations in fishery populations and wildlife habitat; and other resource changes, when taken in concert, might reduce the residential amenities of other existing residents at their settlement locations in the upper Hat Creek Valley and Bonaparte Reserve No. 1. Given that mitigative measures, such as altering the location of project, could not be effected, the most appropriate compensation would likely be in the form of an offer to purchase the property of affected residents. If possible, however, a land trade could be effected with the Indian people. In other cases where property rights are not at issue, compensation could simply be in the form of payments for relocation costs.

3. If the lead time necessary for expanding local government administrations (Section 1.3.2(d)(i)) is not adequate, initial community design studies could be undertaken prior to a decision to proceed with the project. This would remove some of the risks to the municipalities near the project.

4. The Hat Creek Project would involve the rapid growth of both the industrialized economy and the non-Indian population around the local Indian communities. This would create pressures and impacts that would lead to an increased erosion of local Indian cultural, identity and potential for Indians to pursue their traditional economy and lifestyle. It is reasonable, therefore, that B.C. Hydro might take some compensatory action to help local Indian people cope with the potential adverse effects of the project on their social and cultural development. One way in which this could be done would be to participate with local Indian representatives and appropriate government agencies in the creation of an organization that would work to advance the socio-economic and cultural development of local Indian people. The economic opportunities that the Hat Creek Project could offer might be a significant factor in the success of such an organization. The exact nature of B.C. Hydro involvement in the funding of such a development, would have to be determined by discussion with the appropriate government agencies.

5. If mitigation measures related to extending the economic life of the project beyond 35 years that are identified in Section 1.5(b) are not efficient, then a series of studies on providing compensation should be conducted every 10 years during the operating period of the Hat Creek Project. These studies would determine the expected economic lifespan of the plant, the expected changes in employment levels in the plant, new technological changes possibly affecting the operating life and the potential activities which may absorb employment in or adjacent to the Hat Creek region. These studies would keep B.C. Hydro, their employees and the residents of the communities aware of the ongoing economic development potential of the area. If it appears that major employment and population losses would be inevitable as a result of changes in the Hat Creek operations, sufficient advance warning would be provided to discourage community investments that would prove non-viable. For individuals losing their employment positions, B.C. Hydro should attempt to place as many as possible in alternative employment positions with the company.

2.4 SOCIO-ECONOMICS - (Cont'd)

2.4.2 Recreation

Game and fish are natural resources which would be affected by increased recreational activities resulting from the project. The Fish and Wildlife Branch is empowered to manage these natural resources. In Hat Creek Valley their objectives are to manage the wildlife populations and maintain these resources at healthy levels. Increased impacts attributable to the Hat Creek Project could be compensated for either by payments to aid the management of the resources or in payment to increase the number of game species available. Other possible compensation options are presented below.

Limitations on hunting and fishing would likely be required within the valley. Active farming could be maintained to the greatest practical extent in keeping with the orderly development of the project. Such a course of action would tend to retain some of the existing land use patterns and scenic values. Lands could be purchased, set aside and developed at Pavilion, Langley and Blue Earth lakes (with appropriate restrictions) to provide opportunities for picnicing, fishing and swimming. Improved access to the Thompson River could be provided as partial compensation for the loss of Hat Creek fisheries. In addition to the provision of indoor and outdoor recreational facilities at and near the Hat Creek Valley camps, with an appropriate recreational director in charge, similar facilities could be provided in the communities of Cache Creek, Ashcroft and Clinton to offset the increased recreational demand that resident miners would have on those communities.

2.5 NOISE

Two types of compensation for project noise impacts would be possible:

1. Compensation through benefits that accrue as a direct result of project actions.

2. Compensation in the form of a cash settlement or replacement in kind.

The inherent project benefits which could be considered to directly offset noise impact would be limited to:

1. Improved accessibility to the McClean Lake Reserve by native peoples would likely offset some of the annoyance to be caused by the access road construction and traffic.

2. The improve airstrip facility would offset the impact of its construction and operation noise only if the affected residents at its west end would make use of it.

Economic benefits such as employment and increased commerce would act to offset all types of project impacts. However, if such benefits are attained by the residents of areas in which noise would be a major project impact, then the benefits could be considered to compensate primarily for noise impact. This situation could arise to some degree at the following locations:

1. Bonaparte Indian Reserve 1: Noise impact significance would be "moderate" during both project construction and operation. Some residents may find employment during project construction and/or operation.

2. North Ashcroft Residential Areas: Noise impact significance for various project activities would vary from "low" to "high" ("low to moderate" if noise mitigation carried out). Residents in this area could benefit both from project employment and commercial growth.

In terms of cash settlements or replacement in kind, it is unlikely that monetary compensation would be sought by those residents who are exposed only to temporary noise impact, especially if genuine noise mitigation measures are taken. Therefore, the areas in which direct monetary settlement or replacement in kind would be appropriate are limited to the Hat Creek Valley itself and possibly Bonaparte Indian Reserve 1.

CHAPTER 3.0 - ENVIRONMENTAL MONITORING PROGRAMMES

3.1 INTRODUCTION

B.C. Hydro recognizes the need to assess project effects over the life span of the development. To accomplish this objective B.C. Hydro would develop a detailed monitoring programme in concert with appropriate representatives of the Provincial Government. The approach and philosophy proposed by B.C. Hydro to guide monitoring at Hat Creek and to satisfy the Provincial guidelines is described below.

A detailed monitoring plan would be developed to assess changes in the environmental, social and economic conditions from construction, operation and decommissioning of the Hat Creek development. In concept, the programme would satisfy the general environmental monitoring objectives of the Coal Development Guidelines.[1] Specific purposes of the programme would be:

1. To monitor construction activities to insure that guidelines to mitigate construction impacts are enforced and effective.

2. To monitor operational activities to insure that guidelines to mitigate operational impacts are enforced and effective.

3. To monitor decommissioning activities to insure that decommissioning impacts are mitigated.

To ensure consistency with the Coal Development Guidelines B.C. Hydro would:

1. Perform compliance monitoring of mitigation systems.

2. Develop an experimental system to detect physical and biological project impacts.

3. Implement programmes to obtain socio-economic information for community planning.

Implementation of such programmes would focus upon the sensitive receptors identified during the Detailed Environmental Studies and the field performance of the mitigation measures incorporated in the final design. Monitoring of sensitive receptors would begin prior to operation and would establish their pre-project status. An experimental system consisting of statistical models and sampling methods would be designed for testing hypotheses made about impacts of project actions. Cause and effect relationships would be estimated as well as pertinent confidence intervals. This information would be used to verify impact estimates, to establish damage functions and to quantify impacts predicted in the EIAR.

Compliance monitoring would determine the efficacy of the installed mitigation features. Deviations in compliance with relevant Provincial Guidelines and Objectives or design performance specifications would be detected and used to initiate corrective action.

During the conduct of the monitoring studies all programmes would be subject to modification as the analysis and interpretation of data revealed unanticipated impacts, additional receptors or deficiencies in the mitigation measures implemented. Thus, objectives, allocation of manpower and scope of work would be keyed to the actual environmental needs of the project. Programmes would be reviewed

3.1 INTRODUCTION - (Cont'd)

frequently and recommendations made to continue, modify or cease work based upon the results of studies completed.

Table 3.1-1 depicts the receptors and resources which could be affected by the project. The table and the specific proposals that follow summarize the potential resource effects which would require detailed monitoring. Recommended studies which would satisfy either the needs for compliance monitoring, detect physio-chemical and biological impacts, or provide data for community planning are described by resource area. These proposals would serve as the basis for the joint development of the actual monitoring programme should the project proceed.

3.2 COMPLIANCE MONITORING PROGRAMME

3.2.1 *Meteorology - Air Quality*

The full-scale pre-operational meteorological and air quality monitoring programme previously described in Part Three, Methodology, was designed to provide appropriate baseline data for environmental impact assessment and detailed plant design. It is anticipated that portions of this programme would carry over into the operational phase to assess the air quality and climatic effects. Specific design aspects of the operational monitoring programme would be deferred until just before plant operation so that advances in monitoring technology could be incorporated and the specific receptor locations identified. The number and type of meteorological/air quality monitoring stations would be determined in cooperation with the appropriate government agencies.

If a meteorological control system is chosen to control sulphur dioxide, an extensive meteorological/air quality monitoring programme suitable to support a real-time air quality prediction system would be instituted. Design of such a monitoring network would be based on data obtained from the full-scale pre-operational monitoring programme, the results of air quality dispersion studies, and specific needs identified by B.C. Hydro and the appropriate government agencies.

3.2.2 Water Resources

(a) Water Quality

(i) Groundwater

Domestic wells should continue to be monitored with regard to the parameters measured in the Detailed Environmental Studies. Manganese and nickel should be added to the list of parameters. For each waste disposal area, test wells should be developed in strategic groundwater flow locations. Monitoring should continue on a quarterly basis and should be evaluated yearly to incorporate or delete specific parameters.

(ii) Surface Water

Monitoring should be carried out at sample stations established during the DES on Hat Creek and the Bonaparte River. Monitoring should be performed quarterly for all baseline parameters. Manganese and nickel should be added to the list of parameters sampled. In addition to existing stations, it is recommended that sample stations be established on McLaren Creek and Cornwall Creek to detect any effects from the ash pond and the access road. All parameters monitored at other surface water sample points should be included at these sites as well. Monitoring of all point source discharges to receiving waters should be performed to ensure that Pollution Control Board Guidelines are met.

To predict the effects of acid rain, a complete materials balance should be performed on a watershed judged to be sensitive to the effects of acidification. The balance should include snowpack and rainfall (direct and indirect) quantity and quality, predominant soil types and their chemical composition and watershed inflow and outflow quality and quantity. If the watershed contains a lake, chemical profiles should also be obtained.

(b) Hydrology

(i) Groundwater

Groundwater level piezometers should be installed in boreholes located around the ash and waste disposal areas. These piezometers would supplement the three existing piezometer stations in the valley. At least three piezometers should be installed at different depths in each borehole. Water levels should be monitored on a monthly basis. One borehole with three piezometers would be installed adjacent to Finney Lake and along Highway No. 12 just west of Indian Reserve No. 4 in Marble Canyon. Each station should monitor the effects of lake discharge and recharge and/or withdrawals from the Marble Canyon aquifer.

(ii) Surface Water

Stream gauging stations on Hat Creek and its tributaries should be monitored until they must be abandoned because of the proposed project developments. The gauging station on upper Hat Creek should be moved further upstream and a new station established just below the development. Each gauging station on Medicine Creek should be reviewed for possible relocation once the facility design is firmly established. Gauging Cornwall Creek may be necessary if this stream is diverted in the final design. Discharges from the sedimentation lagoons should be gauged. Sediment accumulation in the Hat Creek diversion headworks reservoir should also be monitored.

(c) Water Use

(i) Surface Water

The discharge of project wastewaters should be monitored and controlled to ensure acceptable water quality for irrigation and other agricultural uses.

3.2 COMPLIANCE MONITORING PROGRAMME - (Cont'd)

3.2.3 Cultural Heritage Resources

During each of the development phases, a qualified archaeologist should be present to monitor land alteration activities where cultural heritage resources are expected to occur. An in-field identification and assessment would be made and mitigative actions proposed when resources are encountered.

3.2.4 Noise

Noise and vibration levels caused by project facilities and blasting would be monitored to assure compliance with the guidelines.

3.3 EXPERIMENTAL MONITORING PROGRAMMES

3.3.1 Land Resources

(a) Stack Emissions

(i) Vegetation

The approach proposed to monitor the effects of stack emissions on vegetation (natural, forest and agricultural) would involve two phases, pre-operational and operational. The objective of the pre-operational phase is the acquisition of information pertaining to the sensitivities of the vegetation types found within the area of the proposed development to various combinations of pollutants at various dosages. The identification of pollutant combinations and dosages causing acute injury under natural field conditions would be the only feasible objective due to the length of time required for plants to exhibit chronic injury symptoms. Chronic injury experimentation would not be feasible unless conducted during the operational phase.

The objectives of the operational phase monitoring would be to identify the correct causal agent (insects, disease or plant emissions) of vegetation injury symptoms within 25 km of the plant; determine a tolerance range for the vegetation in areas of potentially injurious emission levels, as well as selecting those individuals which appear to be resistant; and study the effects of long-term low emission levels.

A. Pre-operational Phase

Two types of pre-operational monitoring should be considered: dose response studies on selected species and field fumigation within the project locale (25 km radius). The dose response studies would be designed to estabish SO_2/NO_2 threshold concentrations for those species found in the project locale which have not been included in any sensitivity lists or have not been assigned a threshold concentration in the scientific literature. These studies would be primarily laboratory oriented. Plants should be selected from the field, transplanted to a greenhouse and maintained in a manner closely approximating actual field conditions. The types of plants used should include herbaceous, shrubs and canopy trees. However, in the case of shrubs and trees, seedlings should be selected due to size restrictions. A total of 38 plants have been identified as important enough for study. These plants have been ranked into seven categories on the basis of their importance to the local vegetation associations, wildlife or livestock.[1]

The experimental procedure proposed is identical to that used by Larsen and Heck[2] in which a dose response function is derived for each species from observations of acute injury symptoms induced in a number of specimens. This method is of some advantage over other types of approaches since a model is developed from which injury levels from other dosage levels may be predicted within broad confidence limits.

The field fumigation study proposed is similar to the programme currently in progress at Colstrip, Montana. In the Colstrip programme, termed Zonal Air Pollution System (ZAPS), field plots representing the common vegetation associations are identified and fumigated with a continuous predetermined average SO_2 level throughout a growing season.[3]

Three fumigations and three control plots within the project locale are proposed for study. Plot number one should be located in the Clear Range approximately 20 km to the SSW of the stack location. The site selected should be at the transition of the Alpine Sedge-Grassland associations, preferrably in the Engelmann Spruce - Grouseberry Association. Plot number two should be approximately 15 km ENE of the stack location in the Arrowstone hills. This plot should be located at the transition of the Douglas-fir - Bunchgrass - Pinegrass and Big Sage - Bunchgrass associations. Plot number three should be located in the Cornwall hills approximately 12 km to the SSE of the stack. This site should be at the transition of the Engelmann Spruce - Grouseberry Pinegrass and Engelmann Spruce - Willow - Red Heather associations. A plot size of 20 m x 20 m is considered appropriate. The concentration of SO_2 used to fumigate the plots should be identical to that predicted by ERT to occur from the powerplant operation. The duration of exposure is suggested to be no less than 1 month and should be initiated in early summer. Control plots should be similar in vegetation composition and be oriented approximately 50 m from the fumigation plots in a position that the prevailing winds would not carry SO_2 to the control plots.

Observations should be made at each plot over the course of a monthly fumigation period and should focus upon herbaceous level vegetation. Detailed information on the distribution and cover of each species should be collected at the end of monthly fumigation periods. The above-ground biomass from a number of 1 m^2 quadrats, which include a representative sample of species present, should be harvested from control and fumigation plots at the completion of monthly fumigations. Comparison of the results from fumigated versus the control should give some indication as to the effect of SO_2 on vegetative growth.

3.3 EXPERIMENTAL MONITORING PROGRAMMES - (Cont'd)

B. Operational Phase

The proposed operation phase monitoring programme is basically a field-oriented programme designed to identify and catalogue any potential changes in vegetation associations due to stack emissions. It is suggested that a number of vegetation plots be monitored in the vegetation associations found in areas where the predicted high SO_2 emissions may occur. The number of vegetation associations, which should be sampled, varies according to the air quality control strategy selected. Control plots should be established outside the area where predicted ambient ground level changes may occur. These plots should be in vegetation associations which are identical or similar in composition to the monitor plots. Monthly observations and floristic analyses are recommended for each plot (control and monitor) with emphasis on the detection of symptoms resulting from air emissions. Colour infrared imagery may prove useful in such investigations. Annual colour infrared aerial photography can also be a useful tool to document changes or rapidly identify large injured areas with minimal effort. Those plots located in the areas where SO_2 concentrations are predicted to exceed background levels should be utilized for the collection of detailed vegetation information such as: biomass, mechanical vegetation cover estimates, insect and disease damage, growth and productivity measurements. These measurements should be compared with control plots to determine if the observed effects are due to natural variability or air emissions. The vegetation plots should be located adjacent to or in the vicinity of the air pollution monitors so that the effects observed on the vegetation can be correlated with actual ambient levels collected on a real-time basis. The ambient ground level concentrations would be essential data for the programme.

The accumulation of trace elements released from the stack is an important soil parameter to monitor. It is recommended that the soil sampling plots and control plots be contained within the vegetation sampling plots. In this manner, the extent of potential accumulation as well as any potential effects on the vegetation could be simultaneously determined. It is recommended that soil and vegetation samples be analyzed for arsenic, selenium, cadmium, chromium and fluorine because these elements have been identified with potential problems. The recommended sampling interval is seasonal, with the numbers of samples per soil plot determined from a statistical test for sample sizes. The sampling should be initiated at least 1 year prior to initial operation of the plant, and should be continued throughout the operational phase. The number of samples and sampling interval could be adjusted once the results from the initial sampling period are analyzed.

(ii) Wildlife

A. Trace Elements

Wildlife receive trace elements from a variety of sources and may be subjected to bio-accumulation or bio-magnification of trace elements, an event which no amount of trace element measurement in abiotic receptors could reveal. A large number of wildlife sampling sites is unnecessary due to high wildlife mobility. Sampling plots should be located in Cornwall hills and Trachyte hills, the northern portion of the Hat Creek Valley and in the vicinity of the pit and waste dumps and other potentially toxic waste materials. A partial control should be located in the southern half of the Hat Creek Valley and full control outside the valley, perhaps in the Venables Valley.

Sampling should be conducted on a seasonal basis. Birds are the recommended indicator mammal because small mammals are considered to be unreliable indicators of environmental pollution. Gamebirds taken inside and outside of the Hat Creek Valley should also be monitored for trace element accumulations. This could be accomplished by taking tissue samples from game reported at the Cache Creek Check Station. Tissue samples should be analyzed for arsenic, cadmium, copper, fluorine, lead, mercury, vanadium, zinc, boron, selenium, tin and thallium.

An effective means of monitoring environmental fluorine is through the use of honeybees. Pollinators have been shown to have the highest body burden of fluorine in ecosystems which have been contaminated by exposure to atmospheric fluorides. Hives could be established in several locations within and around the Hat Creek Valley. Elevated levels of fluorine in these bees would indicate problems of fluorine accumulation before the effects were noticeable in ungulates or gamebirds.

B. Major Air Emissions

The direct impact of air pollutants on most wildlife is expected to be minor. Birds may be an exception to this rule. It is recommended that birds be periodically collected (once or twice a year) and autopsied to determine what acute injury may have occurred to their respiratory system. Chickadees would make a suitable subject for these investigations because they are permanent residents and are relatively common throughout most of the local study area.

C. Ecosystem Responses to Chronic Stress

It is recommended that wildlife be monitored by the use of a roadside breeding bird survey similar to that used in the inventory section of this report. Theoretical considerations and limited data from the U.S. IBP (International Biological Programme) Grassland Biome Programme indicate that grassland bird species diversity, equitability and species richness are apparently buffered from response to normally encountered environmental variations, but may respond to ecosystem changes brought about by chronic air pollution. The relatively cost effective roadside bird census may be ideal for collecting sample data which would be responsive to other extraneous variables.

Monitoring should consist of an investigator travelling a specified route, making stops at specified locales, and recording the birds observed within a defined time and space. This need only be done once or twice per year in the spring.

The roadside bird census would be valuable as an index of change for all wildlife. However, changes in the distribution and abundance of big game are sufficiently controversial that an additional monitoring programme for big game is warranted. This monitoring should be done using pellet group transects. Aerial surveys of game animals are costly, can constitute harassment of the animals and do not provide an adequate picture of the year-round animal habitat relationships. The number and locations of pellet group transects should be related to stack emissions and to habitat (vegetation). It is recommended that pellet group transects be established in conjunction with vegetation monitoring plots.

(b) Cooling Tower Emissions

(i) Vegetation

A number of vegetation plots, in addition to those proposed for monitoring the effects of stack emissions, should be located in the areas where maximum cooling tower drift deposition are predicted. Control plots should likewise be located in areas where drift deposition is not predicted. Fewer plots are required (control and monitoring) than those for stack emissions because the cooling tower drift does not affect as large an area. Both visual observations and detailed information should be collected at each of the plots. One or more plots should be located in each vegetation association subjected to salt concentrations that are predicted to exceed background levels. The frequency of sampling should be monthly prior to and during the first year of operation. The frequency can be adjusted as needed, once these 2 years of data are analyzed. The programme proposed should be closely related to the monitoring salt deposition on soils.

(ii) Soils

The deposition of cooling tower drift on soils would affect soil moisture and salt levels, which may in turn have an effect on vegetation. The soil monitoring plots should be established within the vegetation plots. Control plots should also be situated within the vegetation plots designed as controls. Precipitation samplers should be set up on both the monitoring and control plots to collect samples of rainfall and cooling tower drift. Samples of Thompson River water should be analyzed for the various salts as well as for the predominant trace elements (arsenic, selenium, cadmium, chromium and fluorine). The soil horizons within each soil plot should be identified as well as the soil moisture, pH and conductivity. Soil samples from the top three horizons should be analyzed for the same salts and trace elements as the precipitation samples. The cooling water makeup should also be anlayzed for the same parameters as the precipitation and soil samples.

(c) Ash and Mine Waste Disposal

The waste dumps and ash disposal areas may contain large amounts of potentially toxic trace elements. It is highly unlikely that these elements would be released to the environment because the disposal areas would be engineered to minimize such occurrences. A monitoring programme is proposed to ensure that vegetation and soils in the vicinity of these areas are not affected by trace element releases.

3.3 EXPERIMENTAL MONITORING PROGRAMMES - (Cont'd)

The suggested approach is to sample leaves, stems and roots of trees, grasses, shrubs and herbaceous species growing in the vicinity of these areas. Replicate samples of each tissue from each species sampled should be collected seasonally. Sampling should start 1 year prior to initiation of disposal activities and continue throughout the period of disposal operations. Soil and seepage water samples should be collected at the same time, at the same frequency and over the same time period as the vegetation samples. Vegetation and soil samples should be analyzed for the trace elements of concern as identified by ERT.[4]

(d) Dust

The accumulation of dust on foliage can potentially cause a reduction in productivity. A programme to monitor the effects on vegetation due to fugitive dust emissions from operation of the mine is recommended. The proposed approach would utilize six vegetation plots located at different distances form the mine and at various elevations to account for terrain effects. Six control plots would also be located in close proximity but in an area unaffected by dust emissions. Visual observations of leaf condition and presence of insects or diseases should be made on a monthly basis at each plot. These observations should be conducted prior to and during operation of the mine. Growth measurements of trees, shrubs and herbaceous species should be taken on a seasonal basis. The visual observations and growth measurement should be correlated with climatic data as well as data from high volume samplers situated at/or near each vegetation plot. The dust samples should be analyzed for particle size and chemical composition (including the trace elements of concern).

3.3.2 Water Resources

(a) Fisheries and Benthos

Fish tagging studies should be initiated in Hat Creek prior to spawning, with recapture during June, July and early September supplemented by additional marking. Selected stations would be sampled in June and early September to document fish and invertebrate populations and conditions. Efforts should also be directed at documenting aquatic habitat conditions, particuarly with respect to possible sediment buildup in Hat Creek below the mine site. The programme should be conducted annually during the construction and startup phases, and decreased in frequency and scope after the system has achieved relative stability.

The intake on the Thompson River should be monitored during downstream salmon fry migration periods to determine if loss of juveniles occurs. Similarly, monitoring during upstream spawning migrations should be undertaken to assure that disorientation of adult spawners does not occur. Sampling to determine downstream spatial-temporal distributions of migrant juvenile salmonids could be undertaken if impingement proves to be significant during operation.

3.4 SOCIO-ECONOMICS

3.4.1 Planning Information Relevant to Community Service

Rapid population growth in the local study area would likely result in short-term reductions in the quality of life for area residents as a result of temporary lags in public services during the process of staff and facility expansion. These lags would affect a fairly broad sector of the Ashcroft, Cache Creek and surrounding populations which are reliant on village-located services. The effects would include:

1. Periods of overcrowding and consequent decline in the quality of service delivery in most existing social and community services.

2. A period when existing service deficiencies, particularly dental and mental health services, would become more acute.

The severity of these impacts and their specific duration cannot be predicted, as they depend on the timeliness of public sector responses in relation to growing demand. However, the general government practice of service delivery in response to demonstrated demand, rather than in anticipation of demand, would suggest their likely occurrence. Given these uncertainties, a cash compensation payment is not considered a reasonable approach.

Because one of the critical determinants of the extent to which impacts might occur is the timely availability of service demand information, B.C. Hydro could assist the service delivery process by providing this information. It is recommended, therefore, that B.C. Hydro fund a monitoring programme oriented towards the provision of on-going planning information to assist in the timely provision of community and social services. Discussions should be held with the Thompson Nicola Regional District, provincial agencies and the local communities to determine the appropriate sponsoring and controlling agency.

3.4.2 Planning Information Relevant to Social Problems and Adequate Compensation

Small rural communities undergoing rapid expansion due to the construction of large-scale industrial projects may experience a variety of community social problems related to the development. Increased transiency, personal conflicts and adjustment requirements can result in an increased incidence of petty crime, juvenile delinquency, alcohol abuse, family problems and other social problems. The extent to which the local study area communities would experience some or all of these problems cannot be predicted. However, they have occurred in similar development situations and their occurrence in the local area could be expected to reduce the quality of life in these communities.

It is recommended that B.C. Hydro also fund an expanded monitoring study, in addition to over that identified above, to provide sufficient information on which to determine whether further compensation should be provided. The requirements for the nature and value of potential compensation can only be determined from actual information as the project evolves.

PART FIVE

REFERENCES

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Section 1.3 - Construction Mitigation Programmes

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CHAPTER 3.0 - ENVIRONMENTAL MONITORING PROGRAMME

Section 3.1 - Introduction

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Section 3.3 - Experimental Monitoring Programme

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