BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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Detailed Environmental Studies - Agriculture - Volume II -
Impact Assessment - January 1979

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B.C. HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

AGRICULTURE

VOLUME II - IMPACT ASSESSMENT

by

Canadian Bio Resources Consultants Ltd.

Surrey, B.C.

for

British Columbia Hydro & Power Authority

January 1979

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1.0 SUMMARY

1.2 IMPACT ASSESSMENT

(a) Method of Assessment

The overall impact of the proposed Hat Creek coal mine and thermal generating plant on the agricultural resource was based on the comparison of projected agricultural use without the project to that projected with the project. Agricultural use without the project was derived by considering the maximum development potential of the land, present agricultural development and other constraints to the realization of the maximum. Important constraints considered were the market for agricultural products, availability of irrigation water, and time period over which development would occur. Agricultural use with the project was derived by considering the sum effect of various project impacts (i.e., land alienation, noise, air emissions, etc.) on the agricultural resource.

Impacts were assessed in terms of the agricultural resources of the Hat Creek basin and two larger areal units, the Local Study Area and Regional Study Area.

(b) Project Impacts

(i) Preliminary Site Development

The impacts on the agricultural resource from the preliminary site development activities (including the drilling program and the bulk sampling program) were, apart from the bulk sample trenches which alienated about 10 ha (24.7 acres) of rangeland, considered of a minor and temporary nature.

(ii) Construction

A. Land Alienation

The base scheme project activities and facilities would alienate 3724.8 ha (9204 acres) of land predominantly (96 percent) lying at the northern end of upper Hat Creek valley.

Of the lands alienated, 2070.7 ha (5116.8 acres) lie within the Agricultural Land Reserve (ALR). This represents 14.3 percent of the ALR lands in the Hat Creek basin, 3.9 percent of ALR lands in the Local Study Area, and about 0.2 percent of ALR lands in the Regional Study Area.

Almost all (99 percent) of the land that would be alienated by the project is presently in natural range or forest cover. Alienation of 34.4 ha (85.0 acres) of presently irrigated hay and pasture land, however, would occur. This represents about 3 percent of presently irrigated lands in the Hat Creek Basin and about 0.8 percent of those in the Local Study Area.

For the agricultural land uses derived for the probable without the project case, the following would be alienated by the project: irrigated land, 295.8 ha (730.9 acres); spring rangeland, 1305.2 ha (3255.2 acres); and summer rangeland, 2123.8 ha (5217.9 acres). The alienation of irrigated land includes consideration of corn land and spring irrigated pasture projected to be irrigated in the future (though it is not at present) as well as presently irrigated hay and pasture lands.

In general, project land alienation was considered to be non-mitigable. A few suggestions, however, were offered regarding possible relocation of certain project facilities in order to diminish alienation impacts on productive agricultural land.

The effective loss was obtained by multiplying the potential percent injury for alfalfa by the area of the probable irrigated land in each sector of the air quality model developed by Environmental Research and Technology Inc.

The impact of SO_2 and NO_2 emissions of the 244 m stack MCS model on irrigated land (probable use without the project case) was estimated to result in an effective loss of 16 ha (39 acres).

The analysis of the expected impact of SO_2/NO_2 stack emissions on rangeland vegetation was not conclusive as injury levels for most range grass species used by cattle was not available.

Other potential impacts (air emission trace elements, cooling tower emissions, noise, and dust emissions) assessed for the operation phase of the project were not expected to have an adverse effect on agriculture.

(iv) Decommissioning

The decommissioning phase of the project, which would take place when the plant and mine are no longer in operation, is perceived as being associated with positive impacts on agriculture. Some land would be returned to agricultural production, project physical facilities would be removed, and additional water might be available for irrigation through the use of project storage reservoirs and water supply facilities.

(v) Induced Impacts

The Hat Creek project, which would result in a reduction of agricultural land and associated cattle production, would have some effect on the related agricultural industries of the area. The industries that would feel this effect the most are commercial services that operate at near marginal capacity at present.

(c) Overall Impact on Agriculture

The beef industry of the Hat Creek basin was used to indicate the overall effect that the proposed project would have on agriculture. This was considered to be a meaningful model since project impacts would be largely confined to the Hat Creek basin and the fact that agricultural production in the basin is and will continue to be oriented almost solely to beef.

Probable agricultural use with the project (as in the without case) was based on the available feed resources of the Hat Creek basin and the requirements of the cow-calf type of beef operation which is predominant in the basin.

The rate of improvement of the spring range (due mainly to re-seeding programs) and the offsetting rate of loss of spring range-land due to project alienation were perceived as controlling the rate of growth of the Hat Creek basin beef herd size. The basin beef industry with the project was projected to increase from the present (1977) herd size of approximately 2000 cows to 2038 cows by the year 1980 (same as without case), 2813 cows by the year 1990 (6 percent less than without case), 3009 cows by the year 2000 (6 percent less than the without case, and 3109 cows by the year 2020 (6 percent less than without case). The greatest differential in herd size between the two cases, this being 400 animals (19 percent less than the without case), was projected to occur at the end of project alienation, about 1985.

(d) Opportunities for Agricultural Enhancement

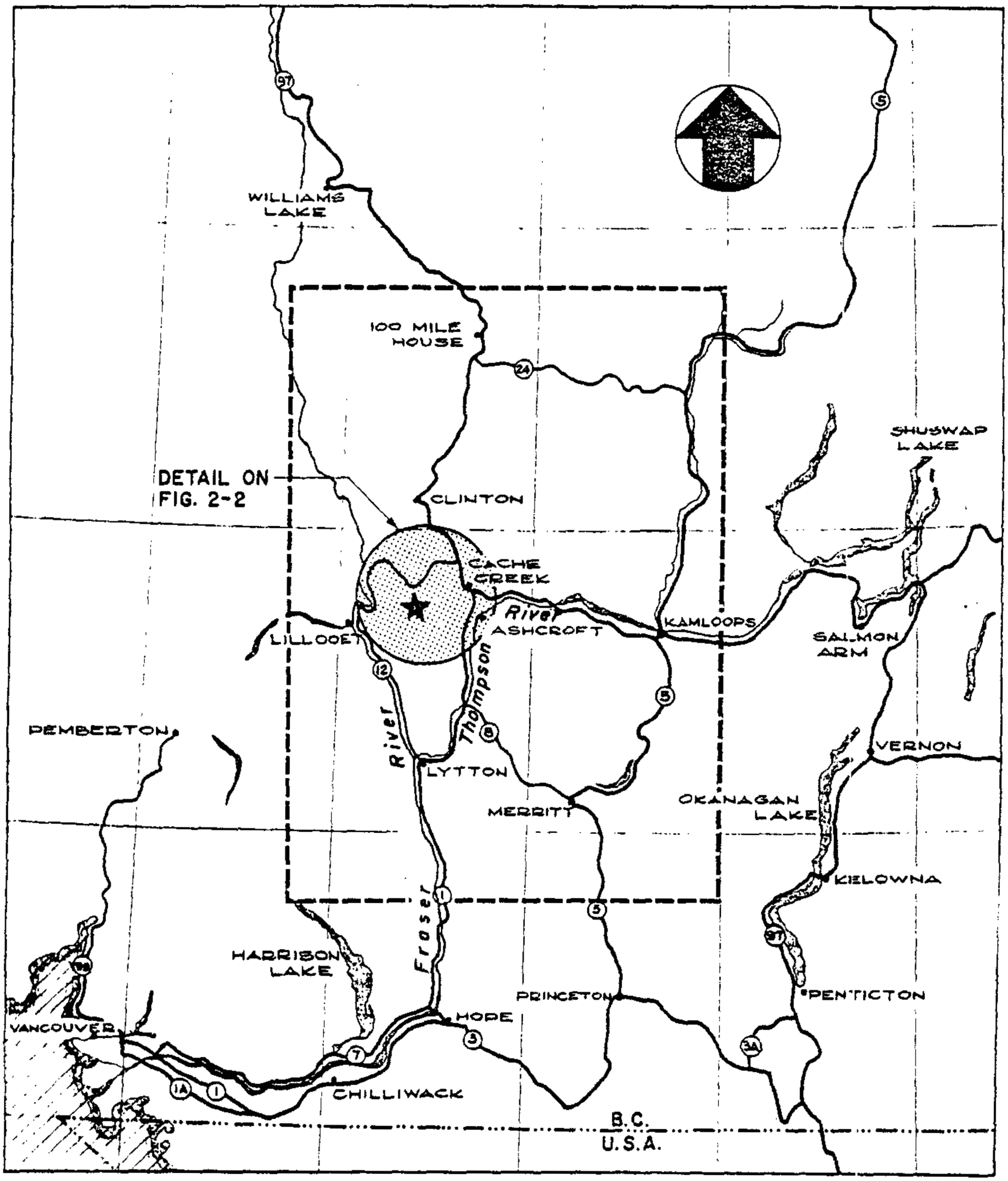
The use of power plant waste heat for the heating of on-site greenhouse facilities was the most promising enhancement concept assessed. More detailed analysis would be required, however, to determine the engineering and economic feasibility of this use for the Hat Creek development. Further study is recommended.

2.0 INTRODUCTION

The *Agriculture* study is a Land Resource Subgroup component of the Hat Creek Detailed Environmental Studies conducted for British Columbia Hydro and Power Authority to assess the impact of their proposed 2000-MW thermal plant and associated coal mine in the Hat Creek valley of British Columbia. Canadian Bio Resources Consultants Ltd., an agricultural consulting firm of Surrey, British Columbia was commissioned in July 1976 to carry out the *Agriculture* study.

The results of the study work are presented in two volumes. Volume I - *Inventory* describes the agricultural resource of the area in terms of climate capability and land capability for agriculture, Agricultural Land Reserves, and present agricultural use. Volume II - *Impact Assessment* describes the impact of the project on the agricultural resource primarily by comparing the projection of probable future agricultural use with the project to the projection of probable use without the project.

The agricultural resource was described by three levels of information providing regional, local, and site specific perspectives for assessment. The broadest level of information was prepared for the Regional Study Area and mapped at the scale of 1:250,000. Intermediate level information was prepared for the Local Study Area and mapped at the scale of 1:50,000. The most detailed level of information was prepared for the Site Specific Study Area and mapped at the scale of 1:24,000. Besides the resource perspectives provided by the three study areas, resource use was also placed in the context of the Hat Creek basin because of the potential impacts that would relate to the valley-based agricultural industry of the area. Figure 2-1 and 2-2 show the location of the three study areas and of the Hat Creek basin.

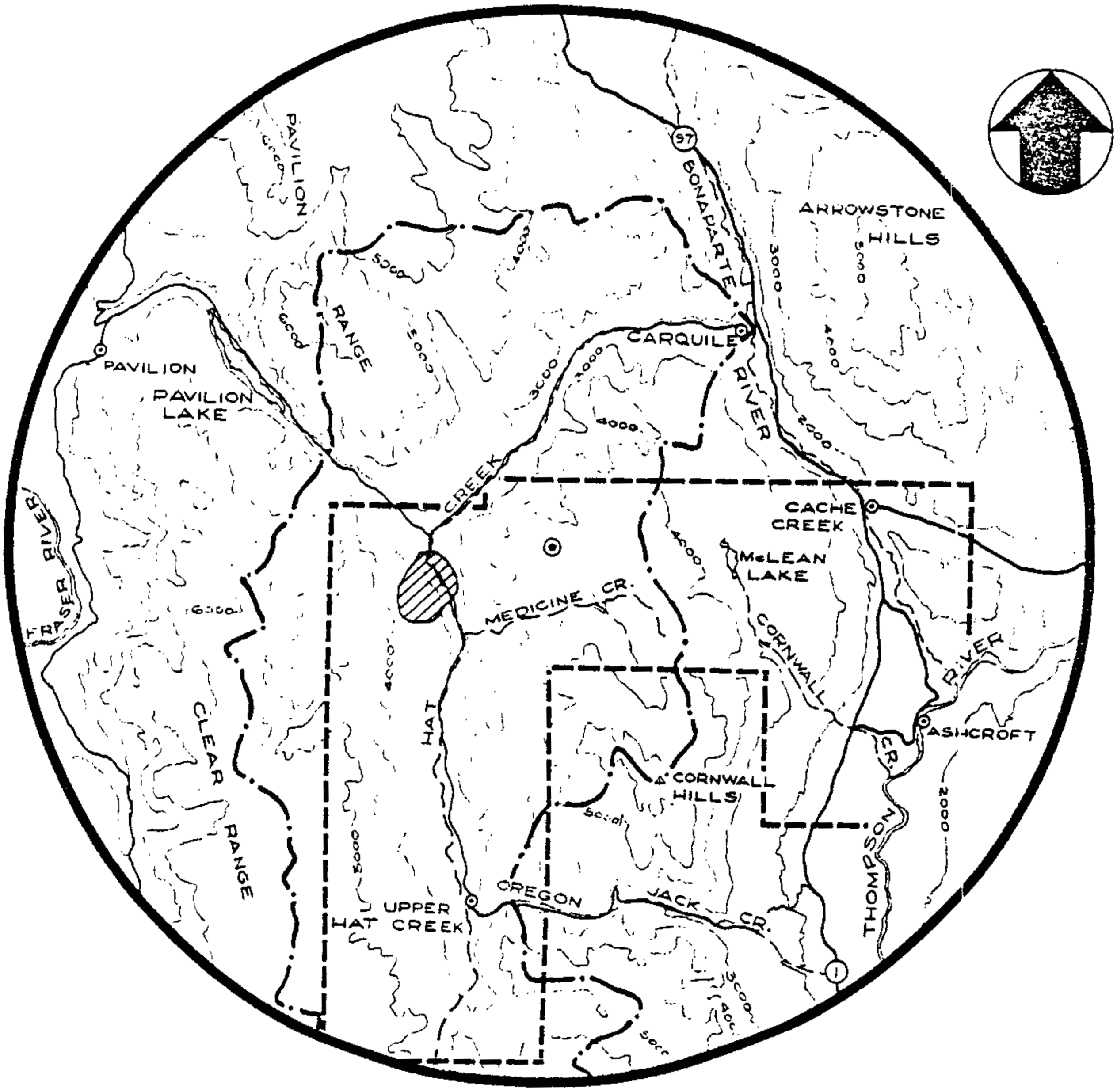


Scale 1:2,000,000

— — — Regional Study Area Boundary
Local Study Area
★ Hat Creek Coal Deposit

STUDY LOCATION PLAN

FIG. 2-1



Scale 1:300,000

Local Study Area Boundary
Site Specific Study Area Boundary
Hat Creek Basin Boundary
Proposed Thermal Generating Plant
Proposed Coal Mine

LOCATION PLAN
LOCAL & SITE SPECIFIC STUDY AREAS

FIG. 2-2

3.0 METHODOLOGY

3.2 IMPACT ASSESSMENT

(a) Agricultural Resource Projection Without the Project

The assessment of the overall impact of the project on the agricultural resource was based primarily on the comparison of projected future agricultural use with the project to that without the project. Projected agricultural use without the project (probable use) was derived by considering the maximum development potential of the land (potential use) in light of present use and other factors that would constrain the realization of that potential. Important constraints in the probable use analysis are the market for agricultural products, availability of irrigation water, and time period over which development is to occur.

In this section, methodology for the potential use analysis precedes that for the probable use analysis.

(i) Regional Study Area

A. Potential Agricultural Use

The potential for expansion and diversification of agricultural use in the Regional Study Area was qualitatively assessed by comparing resource capability with present use. For this comparison, resource capability was defined by inventory information of the Canada Land Inventory (CLI) agricultural capability classification system (see page 48, Vol. I), and present use by 1976 census statistics (see page 54, Vol. I).

Two reports prepared by the B.C. Ministry of Agriculture were consulted to provide specific examples of agricultural development potential within the Regional Study Area. One of the reports[54] assesses the irrigation potential of lands in the Cache Creek-Savona area. The other report[51] provides current information on range reseeding techniques and costs relevant to British Columbia.

B. Probable Agricultural Use

Agricultural Land Reserves

For the purpose of projecting the future status of the Agricultural Land Reserves (ALR) within the Regional Study Area, it was assumed that the ALR system and the administration of the Agricultural Land Commission Act would remain essentially as it exists today.

Irrigable Land

The use of irrigable lands in the future is dependent upon the economic, social and physical constraints that control agricultural land use practices. Information on agricultural industry trends, present agricultural use, potential agricultural use, and agricultural development costs was considered to qualitatively project the probable use of irrigable lands in the Regional Study Area.

Beef Industry

The future role of the beef industry within the Regional Study Area was qualitatively projected on the basis of analysis of industry trends and expectations of regional feed production.

Cash Crop Industry

The future role of the cash crop industry (vegetables and fruits) within the Regional Study Area was qualitatively projected on the basis of analysis of market demand trends and climate capability.

(ii) Local Study Area

A. Potential Agricultural Use

Irrigable Land

The potential crop production on irrigable lands within the Local Study Area was determined from Canada Land Inventory (CLI) agricultural capability information (see page 67, Vol. I), climate capability information (see page 65, Vol. I) and crop yield information.

Representative crop types were assigned to the potentially irrigable lands (CLI agricultural capability classes 1 - 5, see Figure 4-7, foldout, Vol. I). Each combination of CLI agricultural capability class and climate capability class represent a suitability for certain crops as set forth in the B.C. government publication *Climate Capability Classification for Agriculture*[3]. Areas with climate capability class 1b and CLI agricultural capability 1, 2, or 3 are suitable for the production of a very wide range of crops, including heat-loving crops such as tomatoes and vine vegetables. A tomato crop was assigned to all areas in this category for the potential use analysis. Areas with climate capability class 1 and CLI agricultural capability 1, 2, or 3 are suitable for the production of a wide range of crops, including corn and potatoes. A corn crop was assigned to all areas in this category. Areas with climate capability class 2 and CLI agricultural capability class of 2 or 3 are suitable for production of short season vegetables such as cabbage, lettuce, and cauliflower. A cabbage crop was assigned to all areas in this category. Areas with climate capability class 3 and CLI agricultural capability class 3 are suitable for the same crops as the previous category but with a reduced productivity. Cabbage was also assigned to this category. Areas with climate capability classes 1b, 1, 2, 3, or 4 and CLI agricultural capability class 4 are suited, primarily, to the production of forage crops like alfalfa and mixed grass hay. A hay crop type was assigned to all areas in this category. Areas with CLI agricultural capability class 5 are suited primarily to the production of irrigated pasture and this was the crop type assigned to these areas.

The land within the Local Study Area with the potential for the production of each of the above assigned crop types was measured for area.

Average crop yields[25,26,27] of the Local Study Area for the assigned crops (corn, tomatoes, cabbages, hay, and irrigated pasture) were used in conjunction with the potential area of each crop to provide an estimate of the total production potential of irrigable crops within the Local Study Area.

Rangeland

The potential grazing resource within the Local Study Area was estimated for the lands assigned grazing capability classes (see page 71, Vol. I). These lands are considered nonirrigable and are composed of CLI agricultural capability classes 6 and 7.

The estimate of range potential for livestock was derived by converting gross forage productivities of each grazing capability class, as established by Runka[8], to cattle carrying capacities by assuming a 45 percent carry-over of vegetation to avoid deterioration of the range and an air dried forage requirement of 300 kg-AUM^{-1} (660 lb-AUM^{-1})[28]. The potential carrying capacity for each grazing capability class was then multiplied by the respective area of each class and the values summed to obtain the estimate of total potential range production within the Local Study Area. The range potential so derived assumes total utilization of the range under conditions of climax vegetation in the grassland areas and well-stocked* conditions in forest areas. Excellent range management would be required to realize the range potential calculated.

For the Hat Creek basin, a second independent approach was used to estimate the range potential for livestock. This approach involved assigning potential cattle carrying capacities to each vegetation association[44] of the rangeland (composed of areas of CLI agricultural capability classes 6 and 7). In forested areas, carrying capacities were assigned on the basis of both well-stocked and clear-cut conditions. Carrying capacities for each vegetation association were established from range management publications[28,29,46] and from consultation with range specialists, including Dr. A. McLean of Canada Agriculture. Carrying capacities were based on the assumption of full utilization of the range under excellent range management. The carrying capacity of each vegetation association

* well-stocked - see Glossary

was multiplied by the respective area of each association to obtain an estimate of the total potential range production within the Hat Creek drainage basin. The results of this analysis were compared to the first approach which used grazing capability information.

B. Probable Agricultural Use

Agricultural Land Reserves

For the purpose of projecting the future status of the Agricultural Land Reserves (ALR) within the Local Study Area, it was assumed that the ALR system and the admistration of the Agricultural Land Commission Act would remain essentially as it exists today.

Land Tenure

For the purpose of defining the future status of land tenure in the Local Study Area, it was assumed that the types of land tenure and extent of each would remain essentially as they are at present.

Irrigable Land

The probable use of irrigable land within the Local Study Area was qualitatively projected on the basis of analysis of trends of the agricultural industry concerning production costs and market for products, present use compared to potential use, and the capability of supplying additional irrigation water. For the lands adjacent the Thompson River, probable irrigation development was interpreted from a government report prepared by the B. C. Ministry of Agriculture (BCMA) *Savona-Cache Creek-Basque Irrigation Development Study*[42]. In addition to the BCMA report, information on irrigable lands developed for the Site Specific Study Area (see

Section (iii)) was used to assess the probable use of irrigable lands in the Cache Creek-Ashcroft portion of the Local Study Area.

Rangeland

The probable use of rangeland within the Local Study Area was qualitatively projected on the basis of future trends perceived for rangeland use and the comparison of present use (see page 81, Vol. I) to potential use.

(iii) Site Specific Study Area

Potential use of the Site Specific Study Area is addressed in this section of the report. Probable use of the Site Specific Study Area has been split into two areal components which are ciscussed in other sections of the report where they most appropriately fit into the probable use analysis. Probable use of the portion of the Site Specific Study Area that covers the upper Hat Creek valley is addressed in the following section (Hat Creek Basin Beef Industry). Probable use of the portion of the Site Specific Study Area that extends east from Hat Creek to the Thompson River is addressed in the Local Study Area (see previous section).

A. Potential Agricultural Use

Irrigable Land

Location and use of irrigable land - The location and potential use of irrigable land (including land which may be presently irrigated) within the Site Specific Study Area were identified on the basis of soil series maps and soil unit descriptions[41,48] and the Climate Capability for Agriculture map (Figure 4-6, Foldout, Vol. I).

The soils information was used to identify land with soil and topographic characteristics suitable for cultivated crop production. Because of the semi-arid climate of the area, irrigation of these lands is necessary for crop production. Professional interpretation and judgement played a significant role in the identification of irrigable lands. In general, land with the following characteristics was identified as being irrigable:

(1) depth of topsoil being sufficient to ensure adequate drainage, rooting depth and prevention of salt buildup. Generally, greater than 30 cm (12 in) is required for cultivated crops, although lesser depths can be considered for irrigated pasture use;

(2) ground slope being suitable for cultivation and irrigation. Generally slopes less than 20 percent for land of an even slope and less than 10 percent for land of irregular or undulating slope are suitable;

(3) coarse texture components (coarse sand, gravel, stones) not present to an extent that would limit cultivation and irrigation;

(4) soil alkalinity and/or salt content not present to the extent that would limit crop growth.

As in the potential use analysis for the Local Study Area, crop types of tomatoes, corn, cabbages, hay, and irrigated pasture were assigned to the irrigable lands. Crop type was assigned on the basis of climate restrictions as represented by the Climate Capability for Agriculture map (Figure 4-6, foldout, Vol. I) and the soil and topographic characteristics considered above. These crops, in most cases, are not the only ones that could be grown. They represent the higher value crops that are suited to the different types of irrigable land.

The soil units that were mapped by the provincial soil survey[48] (Thompson River benches in vicinity of Cache Creek) had been rated for suitability for irrigation as part of that survey. Each soil unit was designated an irrigation class (not agricultural capability class) which was based on soil characteristics of depth, texture, stone content, topography, alkalinity and salt content. The irrigation class was used to identify the irrigable lands as well as the crop types for this area. Soil units with an irrigation class 1 or 2 were judged to be suitable for tomato, corn, or cabbage production with the determining factor between them being climate as described by the Climate Capability for Agriculture map (Figure 4-6, foldout, Vol. I). Climate capability class 1b indicates a suitability for tomatoes; class 1 indicates a suitability for corn; and climate capability class 2 or 3 indicates suitability for cabbage. Soil units with irrigation class 3 or 4 were judged suitable for hay production, except for certain irrigation class 3 soils where stoniness was not a major restriction thereby indicating a suitability for cabbage. Soil units with irrigation class 5 were judged suitable for irrigated pasture.

Potential crop yields for each irrigable land unit were based on reported information[25,26,27] and on professional judgement concerning specific site conditions.

Water quantity specifications for irrigation - The amount of water that would be required to irrigate the irrigable lands is an important factor in the consideration of possible future expansion of agricultural use of lands in the Site Specific Study Area. The amount of irrigation water required is a function of many variables including soil characteristics, crop characteristics, climate, method of water conveyance, field application method, and land area to be irrigated.

The amount of water required by a crop is called the irrigation requirement. It is strictly a function of crop needs and ooes not account for water conveyance losses, spray losses, and deep percolation losses that would have to be considered to arrive at total irrigation water use. Specifications were developed in this study to predict the irrigation requirement for irrigable lands of the upper Hat Creek valley. These specifications were part of the information used by Beak Consultants Ltd.[49] in the derivation of the amount of water presently used for irrigation in the Hat Creek basin and the total amount that would potentially be used considering all irrigable lands.

Irrigation requirement specifications for the Hat Creek valley were based on a model that accounts for soil, crop, and climate variables as well as an assumption of risk (based on climate probabilities) of actually requiring a higher rate of water application during any one season. The model is similar to a computer model used by Canada Department of Agriculture[56] in their determination of irrigation requirements for other agricultural areas in British Columbia. Soil series information (see page 98, Vol. I), potential crop types assigned to irrigable land units, and relevant climate data were used in developing the water quantity specifications.

The complete development of the irrigation requirement specifications is presented in Appendix C.

Water quality specifications for irrigation - The use of water for irrigation depends on it being chemically and physically suitable for this purpose. To some extent this is determined by the nature of the soil, type of crop, and climate of the area in which the water is to be used. Water quality specifications or guidelines for irrigation water suitable for use in the Site Specific Study Area were prepared from two handbooks[57,58] which deal with water quality criteria.

The qualities of natural waters in the Site Specific Study Area as reported in the *Hydrology, Drainage, Water Quality and Use* report[49] of the Hat Creek Detailed Environmental Studies were compared to the water quality specifications to assess their suitability for irrigation.

Rangeland

The potential grazing resource of the Site Specific Study Area was determined for rangeland areas (nonirrigable) by the same method used for estimating the range potential of the Hat Creek basin (Section 3.2(a)(ii)A).

(iv) Hat Creek Basin Beef Industry

The Hat Creek basin, because of its valley based farms and associated basin rangelands, is a logical agricultural unit by which to assess the local beef industry. The resources available to this industry, now and in the future, were described by utilizing information developed previously for the Local and Site Specific Study Areas.

A. Present Beef Industry

The resources presently available to the Hat Creek basin beef industry were projected in terms of seasonal feed components, these being winter, spring, and summer. Each component was analyzed separately for its cattle support ability and then combined to give an estimate of the total basin industry. This present use projection was compared to other estimates of the basin herd size presented in the *Inventory* volume with a representative present herd size selected for the probable use scenario.

B. Probable Beef Industry

Summary of Potential Agricultural Use

A summary of the potential resources available to the Hat Creek basin beef industry was used as the base from which probable use was derived. Since two fundamental methodologies were used to estimate potential agricultural use in previous sections, it was necessary to combine information of two levels of detail for the Hat Creek basin. A coarser method, for the Local Study Area including the total Hat Creek watershed, involved the use of Canada Land Inventory (CLI) data, while a detailed method, for the Site Specific Study Area including the upper Hat Creek area, involved the use of series level soil information.

The summary of potential irrigable land involves step-by-step calculations using information already presented in this report and the *Hydrology, Drainage, Water Quality and Use* report[49]. For clarity, the detailed methods and accompanying rationale are presented together with the calculations in Section 5.1(d)(ii)A.

For the same reason, the detailed methods for the summary of potential rangeland use of the Hat Creek basin are presented along with the results in Section 5.1(d)(ii)A.

Probable Use Analysis

In the analysis of potential use of the Local and Site Specific Study Areas, the projected maximum range carrying capacity and the projected maximum development of irrigable crop land and pasture were determined. These maximum levels may never be practical depending upon constraints to development. In the development of the scenario of probable use without the project, consideration of constraints was made. Constraints include the demand for feed by beef cattle, the availability of water for expanded irrigation, and the time required to improve certain range areas. The future feed demand of the beef industry was based on apparent industry trends ascertained from discussions with govermnent and industry representatives and ranchers of the Hat Creek basin. The supply of feed for livestock was based on the composite of the production yields expected of the probable irrigated lands (winter feed) and rangelands (spring and summer feed) within Hat Creek basin. Information on the amount and time of year that water would be available for irrigation was taken from the *Hydrology, Drainage, Water Quality and Use* report[49]. Details of the step-by-step analysis of probable use appear in Section 5.1(d)(ii)B.

(b) Agricultural Resource Changes as Result of the Project

(i) Preliminary Site Development

A. Drilling Program

Detailed information on the character and extent of the exploratory drilling program was not available for evaluation. The discussion of resource changes as a result of this program is limited to generalized remarks based on field observations and information supplied by B.C. Hydro[59].

B. Bulk Sampling Program

The bulk sampling program, carried out by B.C. Hydro in the summer of 1977, was in many ways a pilot project for aspects of the proposed full-scale mine development. Two reports[60,61] which discuss the program and provide information regarding the measured environmental effects (noise, dust, water quality, reclamation processes) were consulted to assess the agricultural resource changes resulting from this program. An earlier environmental impact assessment[62], prepared by consultants of the Land Resource Subgroup of the Hat Creek Detailed Environmental Studies prior to the completion of the bulk sampling program and based on design information only, was consulted for descriptions of the type and amount of agricultural land that would be directly affected by this program. These projections were compared with actual land alienation as provided by B.C. Hydro[59].

(ii) Construction

A. Land Alienation

Land alienation of the agricultural resource by the proposed project was assessed on the basis of the agricultural inventory information discussed previously in this report and on the description of project activities transmitted by the client in documents listed below:

"Hat Creek Mining Project, Engineering Description for Environmental Report" by the Mining Department of The Thermal Division of B.C. Hydro and Power Authority, dated 1977-08.[63]

"B.C. Hydro and Power Authority Hat Creek Project, Power Plant Description, Revision F" authored by INTEG-EBASCO and dated 1977-10-25.[64]

"B.C. Hydro and Power Authority, Hat Creek Project, Project Description, Section 5, Offsite Facilities" authored by The Thermal Engineering Department of The Thermal Division of B.C. Hydro and Power Authority and dated 1977-09.[65]

"British Columbia Hydro, Hat Creek Project, Report on Single Status Construction Camps", authored by H.A. Simons (International) Ltd. and dated 1977-09.[66]

"Supplemental Project Descriptions/Assumptions, Hat Creek Project", authored by Ebasco Services of Canada Ltd., and dated (rev.) to January 26, 1978.[67]

For the purpose of assessing changes to the agricultural resource, land alienation aspects have been dealt with within the construction phase of project development, even though some activities would produce partial or, in some cases, no actual loss to the resource during this phase. This approach was adopted because the effective phasing of project activities was not clearly defined by the aforementioned documents and because this approach results in a clear, concise reporting of all aspects of project land alienation.

Information on project activities, as defined for location and areal extent by the project descriptions[63-67], was consolidated in map (1:24,000)[68] and list format[69] for use in the environmental assessments. Project activities were subdivided into four major categories: construction camp (C); offsite facilities (O); mining (M); and power plant (P). A fifth category, indirect (I), was added in the agricultural assessment to identify lands that would be effectively alienated for agricultural use because of their close proximity to project activities. A total of 65 incividual activities were considered in the "base" development scheme; ten others were considered as alternative activities. The location of a few of the activities had not been defined at the time this analysis was carried out and thus could not be evaluated for land alienation.

For the purpose of the agricultural assessment, land alienation was grouped into one of two categories — "open", relating to project activities that do not completely alienate the land from agricultural use, e.g., buried pipelines and overhead transmission lines; and "closed", relating to activities that entirely eliminate the land from agricultural use, at least during the life of the project or life of a staged component of the project. Each project activity, associated area, and category of "open" or "closed" land alienation, along with a map of project activities in the "base" development scheme is provided in Appendix D.

Agricultural Land Reserves

The extent of land alienation of Agricultural Land Reserves (ALR) by each project activity was established by superimposing the project activity map (Figure D-1, foldout) onto the inventory map for ALR (Figure 4-10, foldout, Volume I). A table was prepared giving "open" and "closed" land alienation of ALR and non-ALR lands on the basis of the five major activity categories (construction camp, offsite facilities, mining, power plant, and indirect). The amount of ALR land alienated by the project was compared to the total amount of ALR land within the Local Study Area to provide perspective to the significance of this loss.

Soils

Land alienation of soils by each project activity was determined by superimposing the project activity map (Figure D-1) onto the inventory map for Agricultural Soils (Figure B-1, foldout, Vol. I). A summary table was prepared giving "open" and "closed" land alienation of each category of agricultural soil (high value, moderate high, moderate, moderate low, low, and nil) on the basis of the five activity categories. These land alienation losses were compared to the amounts of soils of each agricultural value category occurring within the mapped portion of the Site Specific Study Area to provide perspective of the significance of land alienation loss.

Present Use

Land alienation of present agricultural land use by each project activity was determined by superimposing the project activity map (Figure D-1) onto the inventory map for Present Agricultural Use (Figure 4-11, foldout, Vol. I). A summary table was prepared giving "open" and "closed" land alienation of different categories of present land use for each farm unit on the basis of the five activity categories. These land alienation losses were compared to the amounts of present agricultural land of the Local Study Area.

Resource Use Without the Project (Probable Use)

Land alienation of projected agricultural land use (without the project) by each project activity was determined by superimposing the project activity map (Figure D-1) onto the inventory map for Probable Use Without the Project (Figure 5-2). A summary table was prepared giving "open" and "closed" land alienation by land use category, farm unit, and major activity categories.

B. Noise

The assessment of impact on agriculture of noise created by the proposed project was carried out primarily by consulting information contained in the report of the Hat Creek Detailed Environmental Studies dealing with noise prepared by Harford, Kennedy, Wakefield Ltd.[70] This report relates predicted noise levels to the agricultural uses of the Site Specific Study Area to identify possible impacts. A report by Ames[71] was also consulted to assist in establishing the significance of noise impacts on cattle.

C. Dust Emissions

The impact of project fugitive dust emissions on the agricultural resource during the construction phase was analyzed in the context of the susceptibility of soils likely to be disturbed by the project to produce dust and the sensitivity and response of agricultural crops and animals to dust. Information on the dusting susceptibility of soils in the Site Specific Study Area was obtained from the *Physical Habitat and Range Vegetation* report[44] prepared as a component part of Hat Creek Detailed Environmental Studies. Since information on dust producing project activities and associated dust levels was very limited, conclusions as to possible impacts on agriculture were not specific and based largely on the assumption that standard measures would be implemented to control dust levels.

D. Physical Barriers

Land areas which would remain useful to agriculture but to which access would become totally or partially restricted by one or more project facilities were identified by superimposing the map of project activities onto the Probable Use Without the Project map (Figure 5-2, foldout). Restricted agricultural accesses were identified in terms of a farm unit or component of a farm unit (e.g., road access to the deeded portion of a farm unit may be restricted by certain project activities, while access to lease land or grazing permit land of this same farm unit may be unaffected).

[illegible] due to obstruction on cold air drainage system may decrease [illegible] growing season on some lands due to physical barriers.

(iii) Operation

A. Stack Emissions

Air emission patterns and vegetation injury levels as reported by Environmental Research and Technology (ERT)[72] and V.C. Runeckles[1] respectively provided the base from which stack emission impacts on agriculture were determined. For each air emission receptor sector (as per the ERT air quality model) in which some injury to vegetation was projected due to SO_2/NO_2 levels, the impact on the agricultural resource was described in terms of inventory information for that sector (Volume I).

In the Local Study Area crop species were not specifically mapped so alfalfa (*Medicago sativa*) was used in the air emission analysis to denote injury to cultivated crops. Alfalfa was selected since it is the most commonly occurring agricultural crop in the area and one of the most sensitive agricultural crops to SO_2/NO_2 emissions[1]. Therefore, its use in the analysis represents a conservative (high) estimate of the impact of stack emissions on agricultural crops.

For each sector the effective impacts on the productivity of cultivated crops were calculated by multiplying the areal extent of crop land within it by the percent injury. Consideration was given to the possibility that the severity of impact might cause a change in the type of use of some of the crop lands. The conclusion reached, based on professional opinion, was that no such effects would occur and that all lands would continue to economically support the same crops but at a reduced productivity. Although possible beneficial effects were identified these were not considered significant and ignored in the calculations. The analysis described above was used to calculate impact on present use in the Local Study Area and also on probable use without the project for the Upper Hat Creek valley.

The information on the effect of SO_2/NO_2 air emissions on rangeland was obtained from the *Physical Habitat and Range Vegetation* report[44] that was prepared as part of the Hat Creek Detailed Environmental Studies.

An ERT report[73] on trace elements in the ecosystem was reviewed to assess the impact of trace elements from the stack emissions on the agricultural resource.

B. Cooling Tower Emissions

Information on cooling tower emissions contained in an ERT report[74] and the Runeckles report[1] was reviewed to assess the impact of these emissions on the present and probable use of the agriculture resource. The potential salt loadings from the cooling tower emissions were compared to salt loadings that would be attendant the use of Hat Creek or Thompson River water for irrigation.

C. Waste Disposal

Other than land alienation, which has already been addressed, the impacts on agriculture relating to project waste disposal were based on the ERT report[73] which provides information on the leaching of trace elements from waste disposal facilities and on the various documents describing the project character[63-67].

D. Noise

The impact on agriculture of noise during the operation phase of the project was determined in the same manner as for the construction phase.

E. Dust Emissions

The impact of dust emissions on the agricultural resource during the operation phase of the project was examined using the information on the susceptibility of soils to produce dust and the location of these soils in relation to project activities and agricultural operations.

(iv) Decommissioning

The impact of decommissioning on the agricultural resource was qualitatively assessed since detailed information on the character of decommissioning was not available. Two reports, *Hydrology, Drainage, Water Quality and Use*[49] and *Physical Habitat and Range Vegetation*[44] that were prepared as part of the Hat Creek Detailed Environmental Studies, were also consulted.

(v) Induced Impacts

A. Farm Unit Multiplier Effects

The land impacts (alienation and air emission) previously identified on a farm unit basis were analysed in order to determine if there would be a multiplier effect (i.e., impacts on a portion of a farm unit resulting in a larger component of the farm or the entire farm to lose agricultural viability). As input to the analysis of farm unit multiplier effects, the following project assumptions, reviewed by B.C. Hydro[75], were used:

1) That B.C. Hydro will own deeded land and have purchased the lease and permit expectations of those farm units that will be impacted by project alienation. That other deeded, lease and permit interests will remain in the hands of private ranchers.

2) That lands effectively controlled by B.C. Hydro which are not alienated by the project are available for agricultural use. Lesser considerations for recreational, archaelogical, wildlife and forestry uses may apply.

3) That, under normal circumstances, the agricultural use of B.C. Hydro lands would not be less favourably disposed to economic farm activities (buildings, irrigation, and cultivation) than other privately held lands once project component locations are site specific thus allowing long term leases or disposal.

4) That consolidation of land parcels that B.C. Hydro has purchased will take place. This will maintain the economic base of the agricultural resource for good management practices.

5) That the following mitigation procedures are part of project base scheme:

- Provision of fence gates to allow agricultural use of lands.
- Provision of farm access roads and crossings to lands having present accesses affected by project, where economic.
- Maintenance of irrigation water supply for systems blocked by project but with irrigated land still intact, where economic.
- Fencing of project components from farm fields.
- Use of B.C. Hydro access roads for farm/range purposes where compatible.

B. Regional Effects

Induced (indirect) impacts of a regional nature associated with the Hat Creek project were subjectively determined by considering the ramifications that the primary impacts (losses and gains of agricultural production) would have on other segments of the regional agricultural industry.

(vi) Summary of Impacts

A summary was made of all impacts identified previously for farm units within the upper Hat Creek valley.

(c) Agricultural Resource Projection With the Project Hat Creek Basin Beef Industry

Probable use with the project was determined by subtracting project impacts from the probable use without the project case for the Hat Creek basin beef industry model. The text for the with case is developed in a fashion parallel to that of the without case.

5.0 IMPACT

5.1 AGRICULTURAL RESOURCE PROJECTION WITHOUT THE PROJECT

(a) Regional Study Area

(i) Potential Agricultural Use

There is potential for expansion and diversification of present agricultural use within the Regional Study Area. This is evident from a comparison of the quantity of high capability land (CLI classes 1 to 4, improved rating) with the quantity of present improved farmland. Within the Regional Study Area 4427 km^2 (1709 mi^2) are classified as high capability lands but only 577 km^2 (223 mi^2) are identified by 1976 census statistics as presently improved. This comparison indicates that approximately 87 percent of the high capability lands are not presently developed to their full agricultural potential. The primary reason for this underdevelopment is that irrigation has not been practical for many of the lands.

Expansion and intensification of the beef industry could occur if high capability lands that are not presently under production were developed. The Ashcroft - Cache Creek - Savona area contains such land and recent estimates by the B.C. Ministry of Agriculture[54] identified 81.4 km^2 (31.4 mi^2) of irrigable land. Of this total 24.1 km^2 (9.3 mi^2) or 30 percent were identified in the report as being presently irrigated and 22.3 km^2 (8.6 mi^2) or 27 percent were identified as having potential for development considering the field layout of irrigation systems. There has been no corsideration given to the economic feasibility of this development but preliminary costs of \$717 acre^{-1} have been estimated by the B.C. Ministry of Agriculture[54].

Another impetus for expansion and intensification of the beef industry would be an increase in the grazing productivity of the native grassland ranges. The B.C. Ministry of Agriculture has been carrying out an extensive research program over the past three years to develop range reseeding equipment and techniques. The initial results of this program are promising and successful reseeding of native grassland ranges has been accomplished for approximately \$75 to \$100 ha^{-1} (\$30 to \$40 acre^{-1})[51]. A recent Agriculture and Rural Development Agreement (ARDA) between British Columbia and the Canadian Government provides for funding in excess of \$20 million for range improvement. No published estimates are available of the amount of range that could be improved within the Regional Study Area. However, in general, the lower grasslands of the Ponderosa Pine - Bunchgrass biogeoclimatic zone possess the greatest potential for such range reseeding programs. Based on Tera Consultants map of biogeoclimatic zones of the Regional Study Area[44] these lower grasslands represent some 3253 km^2 (1256 mi^2) and are generally located at the lower to mid elevation points (up to 1067 m (3500 ft) above sea level) of the major river valleys and a few of the larger mountain valleys. Opportunities also exist for improving range production through methods such as reseeding clear-cut forested areas with selected grass species.

The potential for production of a wider range of field crops would involve a shift away from the current emphasis on production of alfalfa and other forage type crops. The high number of growing degree days and the productive soils of many of the areas within the Regional Study Area are well suited to the commercial production of potatoes, tomatoes, corn and vine crops (as indeed was the case in the Ashcroft area where commercial production of potatoes and tomatoes took place prior to 1960). The principal areas where this production could take place within the Regional Study Area include the benches on the east side of the Fraser River (generally between Lillooet and Lytton), the benches of the Thompson River (generally between Ashcroft and Savona), and on many of the flats adjacent to the Thompson River in the vicinity of Kamloops.

(ii) Probable Agricultural Use

A. Agricultural Land Reserves

The Agricultural Land Reserves (ALR), consisting of, in general, private and leased agricultural lands, are not expected to change markedly in the future within the Regional Study Area. There no doubt will be some adjustment to the ALR boundaries adjacent to urban centers in response to increases in population. However, it is expected that these adjustments would be minor in nature in relation to the areal extent of the ALRs regionally. The inclusion of forested grazing land administered by the B.C. Forest Service, which is not presently included in the reserve, is unlikely.

It is envisioned that the Agricultural Land Reserve system will remain effective in preserving the use of agricultural land in the province and that this will result in agriculture retaining a prominent position in the Regional Study Area.

B. Irrigable Land

The extent to which the potential of high capability agricultural land in the Regional Study Area will be developed is dependent upon the economic, social and physical constraints that control agricultural land use practices now and in the future. The majority of the irrigated land in the Regional Study Area presently produces forage to support the regional beef industry. It is expected that the beef industry will remain the dominant agricultural activity within the region and therefore the predominant probable use of high capability lands in the region will be for forage production.

Since production of agricultural crops in the Regional Study Area is dependent upon irrigation, the development of additional agricultural lands will be constrained by development of irrigation water. It is expected that these irrigation developments, for the main part, would consist of regional irrigation systems. This is based on indications from government officials and ranchers that readily accessible water supplies are almost entirely licensed and that the costs of systems for single site development are too high to stimulate development. This last item is largely based on an analysis of the development costs contained in a B.C. Water Investigation Branch report, *Preliminary Feasibility Study for Oregon Jack Creek Irrigation Proposals*[55] and a B.C. Ministry of Agriculture report, *B.C. Potential for Expansion of Feed Production*[54]. The first report indicates that irrigation developments can have a favourable cost-benefit situation if off-farm development costs are in the order of \$173 to \$247 ha^{-1} (\$70 to \$100 $acre^{-1}$). The potential off-farm costs for single farm irrigation system development derived in the latter report were in excess of \$741 ha^{-1} (\$300 $acre^{-1}$) and thus preclude economic development at the present time. It is not expected that the cost-benefit situation will change radically in the future so as to favour single farm irrigation systems as this type of development also has more expensive operating costs than regional schemes. Another constraint to the development of additional irrigated land is that large acreages of the high capability lands have a class 4 CLI agricultural capability. These lands would be restricted to forage production and, therefore, would only be irrigated if relatively inexpensive water of regional systems were available.

C. Beef Industry

A large portion of the Regional Study Area is presently used for agriculture with the predominant use involving a cow/calf type of beef enterprise. The river valleys are used mainly for production of winter feed and a large portion of the remaining land used for livestock grazing. Because of the relative advantages of the region in terms of beef cattle production it is expected that this activity will continue to be the predominant type of agriculture practiced.

Forage Production

As discussed previously, forage production is the predominant present use of irrigable land within the Regional Study Area and will continue to be the dominant use in the future. Grass and alfalfa hay crops are expected to continue to be the dominant forages grown, though silage corn production is expected to expand relative to that of hay because of its higher return and use in feedlot operations.

Grazing Land

The grazing lands within the Regional Study Area are generally used to their full stocking capability at the present time. However, expansion of grazing land use in the area would be possible through the seeding of forest clear-cut areas and reseeding of grassland ranges. At the present time extensive studies and demonstration seeding trials are being carried out by B.C. Forest Service, B.C. Ministry of Agriculture and Agriculture Canada researchers. Discussions with industry and government personnel indicate that many of these grassland ranges and clear-cut forest areas could reasonably be improved to the point where the region could support 10 to 20 percent more beef cattle.

D. Cash Crop Industry

A moderate increase in vegetable production within the Regional Study Area is expected in order to meet local demand. Any major increase in vegetable production will require large capital investments in required infrastructure such as storage, processing, marketing, and transportation facilities. The present excess capacity of the vegetable industry in the lower mainland of British Columbia in terms of available land and processing capability and the competitive position that the Pacific Northwest region of the United States holds in the British Columbia vegetable market are not favourable to the development of large scale vegetable industries in other parts of British Columbia in the near future.

Fruit production will continue to occupy only limited areas and will not become a commercial agricultural activity within the Regional Study Area. Although some areas have climates with the capability for tree fruit production, the risk factor associated with severe winter conditions is too high to encourage commercial orchard production.

(b) Local Study Area

(i) Potential Agricultural Use

A. Irrigable Land

The potential use analysis assumes that all irrigable land in the Local Study Area is irrigated, thereby giving a maximum value for irrigated crop production. In Table 5-1 the potential irrigated crop production of the Local Study Area is given in terms of each preferred crop type, the potential productivity, the potential area, and the total potential production for each preferred crop.

production of approximately 16,000 to 38,000 AUMs. Comparing these results to the potential annual range production of the Hat Creek basin obtained from the approach using the grazing capability classification, it is noted that the high value for the Hat Creek basin potential annual production (66,000 AUMs) obtained by the first approach appears to be unreasonably high. The low value of this approach (32,000 AUM), which is in the range of the potential production estimated by the second approach, seems to be a more reasonable estimate. This indicates that the low value calculated for the Local Study Area (90,000 AUM) is a reasonable estimate of potential range production and represents roughly three times the estimated present use (see page 81, Vol. I).

(ii) Probable Agricultural Use

A. Agricultural Land Reserves

At the present time the Agricultural Land Reserves (ALR) occupy 529 km² (204 mi²) which represents 27 percent of the total land area in the Local Study Area. As with the Regional Study Area, it is not expected that there will be any major change in the extent of lands within the ALR. There may be some minor adjustments in areas adjacent to the townsites of Ashcroft and Cache Creek in response to increases in the urban areas of these two centers. However, since most of the relatively flat land adjacent to these centers has capability for irrigated agriculture (see Figure 4-7, foldout, Vol. I) it is not expected that there will be a major alienation of this land from agriculture and it will probably remain in the ALR.

B. Land Tenure

Present land tenure in the Local Study Area was described as follows: private (deeded) land, 243 km² (94 mi²) or 12.4 percent;

agricultural and grazing lease land (Crown), 392 km^2 (151 mi^2) or 20.0 percent; Indian Reserves, 79 km^2 (31 mi^2) or 4.0 percent, and other Crown land, 1249 km^2 (482 mi^2) or 63.6 percent. The last category, other Crown land, includes those lands used for grazing that are administered by the B.C. Forest Service through grazing permits.

It is not expected that the land tenure situation will change markedly in the Local Study Area. This is based on the fact that the vast majority of the land is owned by the Crown with its primary use being the provision of summer grazing for livestock. It is anticipated that the Crown will continue to own this land and will administer it in a manner to provide a balance between the major users: agriculture (livestock grazing), forestry and wildlife.

C. Irrigable Land

Irrigated land presently occupies 45 km^2 (17 mi^2) or 2.3 percent of the land area within the Local Study Area and is used for cultivated crops and improved pasture. In Table 5-1, 260.0 km^2 (100 mi^2) in the Local Study Area are identified as having the potential for irrigated agriculture based on CLI agricultural capability. Vegetable crops, in particular, heat-loving vegetable crops such as tomatoes, could be produced within the Local Study Area. Another important potential crop is silage corn which could be used to provide a feed base for finishing cattle.

The development of the potential is dependent upon the economics of production, the market for products produced and the availability of water for irrigation. The last point is important since this is an arid area and irrigation water is not readily available. As discussed for the Regional Study Area the expansion of irrigation systems would be largely dependent upon regional developments due to the limited opportunities for development of off-farm irrigation facilities serving an individual farm or ranch.

One of the main areas for development of lands through irrigation is in the vicinity of Savona - Cache Creek where the B.C. Ministry of Agriculture[26] has identified 8137 ha (20,107 acres) as having potential for intensive agricultural production with irrigation. Of this total potential, 2405 ha (5943 acres) are presently irrigated and of the remainder, there are eleven distinct areas, totalling 2646 ha (6538 acres), identified as being of a parcel size that would make their development practical. Of these eleven areas, five are located within the Local Study Area and total 1319 ha (3259 acres). One of these areas of about 400 ha (988 acres) is located largely within an Indian Reserve. Consideration of comments contained in the BCMA report[26] pertaining to water availability for each of these areas indicates that three of the five areas totalling 786 ha (1942 acres) (about 60 percent of the potential of the five areas located within the Local Study Area), including that within the Indian Reserve, are favourably disposed to being developed.

The probable use of irrigable lands located within the Cache Creek - Ashcroft area of the Site Specific Study Area (Figure 5-1, foldout) was projected to be 1375 ha (3398 acres) of which about 315 ha (778 acres) are presently irrigated. The remaining 1060 ha (2619 acres) is larger than the above results derived from the BCMA report[26] due to additional irrigable lands identified for the Site Specific Study Area.

A discussion of the probable irrigation of lands within the Hat Creek basin is provided in Section 5.1(d).

As was the case for the Regional Study Area it is expected that the predominant type of agriculture practiced in the Local Study

Area will continue to be beef cattle ranching. Consequently, the irrigable lands that would be put into production would be used primarily for forage crops to support the beef industry. The production of silage corn as a feed for finishing beef cattle is expected to become more prominent.

It is not expected that there will be any major increase in the production of vegetables in the Local Study Area for the reasons discussed for the Regional Study Area.

D. Rangeland

At the present time the ranges within the Local Study Area are, in general, stocked to the full extent of their present capacities. The number of cattle stocked on the ranges is in the order of 5000 animals which is roughly one-third the estimated potential. Since the ranges are fully stocked with livestock at present, the potential can only be realized through better range management and reseeding grassland areas to improve productivity of presently deteriorated ranges. The rangelands administered by the B.C. Forest Service are presently under careful supervision which should result in some improvement in range production. However, many of the lower grasslands are badly overgrazed and reseeding offers the only feasible method of affecting relatively quick improvements. Better range management would provide improvement of these areas but because of their present poor condition, a relatively long time would be required to afford an effective increase in productivity. The analysis of the probable use of ranges within the Hat Creek basin is discussed in Section 5.1(d).

(c) Site Specific Study Area

(i) Potential Agricultural Use

A. Irrigable Lands

Location and Use of Irrigable Lands

The location of irrigable land (including land which may be presently irrigated) within the Site Specific Study Area is shown in Figure 5-1 (foldout). This figure shows that nearly all the irrigable lands within the study area are located within either the botton lands of the upper Hat Creek valley (portion of Hat Creek basin within the Site Specific Study Area) or the benches of the Thompson River.

The extent and potential productivity of the irrigable lands in the Site Specific Study Area is shown in Table 5-4. There are 65.5 km^2 (25.3 mi^2) of irrigable land in the study area with 38.2 km^2 (14.7 mi^2) or 58 percent located in the upper Hat Creek valley. The irrigable lands were divided into five categories on the basis of soil and climate characteristics and each assigned a preferred crop to demonstrate potential production. For those lands with the greatest range of production potential, tomatoes were used as the preferred crop. Within the Site Specific Study Area there are 1.7 km^2 (0.7 mi^2) with the potential to produce 5700 Mg (6281 tons) of tomatoes. For lands with similar soil characteristics but in a class 1 climate capability area, corn was used as the preferred crop. The potential production of corn (silage) in the Site Specific Study Area is 22,800 Mg (25,126 tons), all of which in this analysis would occur in the upper Hat Creek valley. Lands with similar soil characteristics but that are located in a class 2 or 3 climate capability area are represented by cabbage as the preferred crop. The production potential for cabbage in the Site Specific Study Area is 5400 Mg (5951 tons).

TABLE 5-4

POTENTIAL IRRIGABLE LAND PRODUCTION
SITE SPECIFIC STUDY AREA AND UPPER HAT CREEK VALLEY

Preferred Crop Type	Potential Productivity		Area (km^2)		Potential Annual Production (10^3 Mg)	
	$Mg\text{-}km^{-2}$	(tons-$acre^{-1}$)	SSSA	UHCV	SSSA	UHCV
Tomatoes	3362	(15)	1.7	0	5.7	0
Corn (Silage)	5604 - 6725	(25-30)	3.7	3.7	22.8*	22.8*
Cabbage	2242	(10)	2.4	0	5.4	0
Hay						
Thompson Valley Portion	1345 - 1793	(6-8)	6.8	0	10.7*	0
Hat Creek Portion						
- alfalfa hay	560	(2.5)	11.7	11.7	6.6	6.6
- wetland hay	673	(3.0)	3.7	3.7	2.5	2.5
- alfalfa hay	897	(4.0)	3.5	3.5	3.1	3.1
Pasture	0.2-0.3 $ha\text{-}AUM^{-1}$	(0.5-0.8) $acres\text{-}AUM^{-1}$	32.0	15.6	12800* AUM	6240* AUM
		Total	65.5	38.2		

* Based on the average of potential productivities given.

SSSA Site Specific Study Area

UHCV Upper Hat Creek Valley

Land with soil characteristics that limit annual cultivation were judged suitable for the production of perennial forage crops with hay and pasture selected as the preferred uses. The potential production of hay within the Site Specific Study Area was estimated to be 22,900 Mg (25,236 tons) with 12,200 Mg (13,444 tons) of this occuring in the upper Hat Creek valley.

For those lands designated as suitable for irrigated pasture, the potential production was estimated to be 12,800 AUMs within the Site Specific Study Area, including 6240 AUMs within the upper Hat Creek valley.

Water Quantity Specifications

The theoretical irrigation requirements (water quantity specifications) that were developed for the upper Hat Creek valley irrigable lands were based on the following assumptions and conditions: (1) that a single climate type (composed of temperature, sunshine, precipitation, and wind) is representative of the conditions of all the valley lowlands; (2) that a crop type with full vegetation ground cover, such as alfalfa or pasture, is to be irrigated; (3) that a 20 percent design risk of having insufficient water during any one year represents a reasonable risk for the hay and pasture crops (although a lower risk would be appropriate for higher value crops such as tomatoes and corn); (4) the agricultural soils were divided into two main groups as they affect irrigation requirement - the upland soils (soil units 5, 6A, 7, 10, 12, 13, 14, 16, 17, 18, 19, 21, and 23, see Appendix B, Vol. I) with an average available water storage capacity (AWSC) of 12 cm (4.7 in) and the floodplain soils (soil units 1, 2, 3 and 4) with an average AWSC of 20 cm (7.9 in). The floodplain soils, of finer texture and deeper than the upland soils, have lower seasonal water requirements.

The development of the model is presented in detail in Appendix C. The water quantity specifications are presented in Table 5-5, the upland soils having an average seasonal water requirement of 34 cm (13.4 in) and the floodplain soils having an average seasonal water requirement of 31 cm (12.2 in). These water quantity specifications do not take into account water conveyance losses, spray losses and deep percolation losses which have been estimated to account for between 30 and 50 percent of the water used to irrigate lands in upper Hat Creek valley[49].

Development of similar water quantity specifications for the Cache Creek - Ashcroft area of the Site Specific Study Area were beyond study terms of reference. However, published information[56] regarding the seasonal irrigation requirement of the Kamloops area was considered representative (because of similar climate) for that portion of the Site Specific Study Area. The seasonal requirement under similar conditions of soil (upland type), full cover crop, and 20 percent risk for Ashcroft would be close to the reported 48 cm (19 inches).[56]

The total seasonal water required to irrigate the potentially irrigable lands (including presently irrigated land) of the Site Specific Study Area was reported by the *Hydrology, Drainage, Water Quality and Use* component of the environmental studies.[49] These estimates account for expected water losses (not available for plant requirements) due to the method of conveyance, method of irrigation, and other management practices that affect irrigation efficiency. The seasonal estimate totals 2464 ha-m (19,976 acre-ft) of water required for the Hat Creek portion of the Site Specific Study Area (upper Hat Creek valley) including 124 ha-m (1005 acre-ft) for 272 ha (672 acres) of floodplain soil and 2340 ha-m (18,971 acre-ft) for 3531 ha (8725 acres) of upland soils.

TABLE 5-5

THEORETICAL WATER QUANTITY SPECIFICATIONS FOR IRRIGATION* (cm)
UPPER HAT CREEK VALLEY

	May	June	July	August	Sept.	Total
Upland Soils**	5.0	6.4	10.4	8.1	3.8	34
Floodplain Soils***	3.5	5.8	10.1	8.1	3.8	31

* Irrigation requirement of crop which does not include conveyance, spray, and deep percolation water losses.

** Soil units 5, 6A, 7, 10, 12, 13, 14, 16, 17, 18, 19, 21, 23 (see Appendix B, Vol. I).

*** Soil units 1, 2, 3 and 4 (see Appendix B, Vol. I).

For the Ashcroft irrigable lands, of which there is 2730 ha (6746 acres) in the Site Specific Study Area, seasonal water requirement, estimated using a 60 percent irrigation efficiency, was 2184 ha-m (17,706 acre-ft).

Water Quality Specifications

Irrigation water quality specifications, which were prepared by consulting two handbooks[57] [58] on water quality criteria, are shown in Table 5-6. The specification for each water quality parameter should be considered a general guideline; a more rigorous evaluation of water suitability would be required in specific cases, especially where the particular water in question appeared to be marginal or of low quality.

A comparison of these specifications with the present water quality of Hat Creek and Thompson River (see Table 5-6) shows that these surface waters are, as expected, suitable for irrigation use. The water quality of Goose/Fish Hook Lake, an alkali lake located in the Hat Creek basin, exhibits high ph, electrical conductivity, total dissolved solids, sulphates and sodium adsorption ratio[49], all of which make this source unsuitable for irrigation.

B. Rangeland

The potential use of the rangeland of the Site Specific Study Area, which was based on the approach using vegetation association information, is displayed on Figure 5-1. The potential carrying capacity of each rangeland vegetation association is given in Table 5-3.

An examination of Figure 5-1 shows a considerable area of potentially highly productive Kentucky Bluegrass range (grazing rating A) in the vicinity of Medicine Creek and McLean Lake. A relatively large area

TABLE 5-6

WATER QUALITY SPECIFICATIONS FOR IRRIGATION USE
UPPER HAT CREEK VALLEY

Parameter	Recommended Maximum	Present Water Quality (Annual Means)**	
		Hat Creek	Thompson River
Temperature	55°C at source	6.6°C	8.0°C
pH	4.5* - 9	8.4	7.8
Electrical Conductivity	2.0 mmhos/cm @ 25°C	0.489 mmhos/cm @ 25°C	0.093 mmhos/cm @ 25°C
Total Dissolved Solids	1400 mg/l	342 mg/l	74 mg/l
Suspended Solids	**	6 mg/l	3 mg/l
Chemical or Biochemical Oxygen Demand	**	21 mg/l (COD)	21 mg/l (COD)
Chlorides	15 meq/l	0.03 meq/l	0.05 meq/l
Sulphates	15 meq/l	1.13 meq/l	0.16 meq/l
Sodium Adsorption Ratio	10	0.58 (calc.)	0.23 (calc.)
Residual Sodium Carbonate	2 meq/l	≈ 0 (calc.)	≈ 0 (calc.)
Radionuclides:			
Alpha Concentration	1 picocurie/l	NA	NA
Beta Concentration	10 picocuries/l	NA	NA
Trace Elements:			
Aluminum	20.0 mg/l	<0.01 mg/l	<0.017 mg/l
Arsenic	2.0 mg/l	<0.005 mg/l	<0.005 mg/l
Beryllium	0.5 mg/l	NA	NA
Boron	1.0 - 2.0 mg/l***	<0.1 mg/l	<0.1 mg/l
Cadmium	0.05 mg/l	<0.005 mg/l	<0.005 mg/l
Chromium	1.0 mg/l	<0.01 mg/l	<0.01 mg/l
Cobalt	5.0 mg/l	NA	NA
Copper	5.0 mg/l	<0.005 mg/l	<0.005 mg/l
Fluoride	15.0 mg/l	0.16 mg/l	0.11 mg/l
Iron	20.0 mg/l	<0.026 mg/l	<0.022 mg/l
Lead	10.0 mg/l	<0.01 mg/l	<0.01 mg/l
Lithium	2.5 mg/l	0.002 mg/l	<0.001 mg/l
Manganese	10.0 mg/l	NA	NA
Molybdenum	0.01 mg/l	<0.02 mg/l	<0.02 mg/l
Nickel	2.0 mg/l	NA	NA
Selenium	0.02 mg/l	<0.003 mg/l	<0.003 mg/l
Vanadium	1.0 mg/l	<0.005 mg/l	<0.005 mg/l
Zinc	10.0 mg/l	<0.007 mg/l	0.017 mg/l

* Minimum

** Limited information available on maximum limit but literature suggests that high values may produce adverse effects.

*** 1.0 for semi-tolerant crops including: potatoes, tomatoes, corn, and oats; 2.0 for tolerant crops including: alfalfa, cabbage, lettuce, and carrots.

NA Not available.

of potentially highly productive Bunchgrass - Kentucky Bluegrass range (grazing rating B) is found on the lower benches on the east side of the Hat Creek valley. Douglas-fir - Pinegrass and Englemann Spruce - Grouseberry - Pinegrass ranges (grazing rating G and H, respectively) of relatively low potential carrying capacity are predominant on the ranges on the west side of the Hat Creek valley.

(d) Hat Creek Basin Beef Industry

(i) Present Beef Industry

A logical agricultural unit for which to assess the beef industry is the Hat Creek basin. In a previous section, Section 4.2(d)(iii) of the *Inventory* report, the number of cattle presently stocked on grazing permit ranges in the Hat Creek basin was estimated at 2050 head using permit information. A projection of the number of animals for the basin was also estimated by analysis of the beef industry feed resources.

A. Winter Feed

After the cattle are brought in from the range they are fed for a short period on hay stubble and then carried through the winter on hay. This total feeding period lasts for seven months and the feed obtained from grazing hay stubble is included as part of the hay productivity estimates. Present hayland in the Hat Creek basin totals 879 ha (2172 acres) and exhibits three levels of productivity as identified in the *Inventory* report (see page 101, Vol. I). The estimate of present winter feed production is presented in Table 5-7.

Based on an animal feed demand of 1.59 $Mg\text{-}year^{-1}$ for a seven month feeding season the estimate of winter feed presently produced in Hat Creek would have a potential to maintain 3395 animal units.

TABLE 5-7

PRESENT WINTER FEED
HAT CREEK BASIN BEEF INDUSTRY

Crop Type	Area (ha)	Present* Productivity ($Mg\text{-}ha^{-1}$)	Production (Mg)
Alfalfa grass	649	5.6	3634
Wetland hay	139	6.8	945
Alfalfa grass	91	9.0	819
Total	879		5398
			or
		Animal Units,	3395**
			or
		AUM,	23,765**

* these expected productivities are based on soils, climate and to some extent reflect present management practices.

** derived on the basis of a seven month fall/winter season with a feed requirement of 1.59 $Mg\text{-}animal\ unit^{-1}$.

B. Spring Feed

Calculation of the present spring resource based on the present range condition reported in Volume I and range vegetation association data[44] yielded results presented in Table 5-8 The estimate for the present spring grazing resource is 3916 AUMs which for a two-month spring grazing period is capable of carrying 1958 animals. It is felt that this value is more likely to be an over-estimate than an under-estimate.

C. Summer Feed

Calculation of the present production of summer grazing lands, based on present range conditions reported in Volume I and range vegetation association data[44], yielded the results presented in Table 5-9. For a three-month summer grazing season, the present summer grazing resource of 9141 AUMs is capable of carrying 3047 animals.

D. Beef Industry Composite

A comparison of the three beef industry feed resources indicates that the present spring grazing resource is the limiting factor restricting the present herd size in the Hat Creek basin to approximately 1958 head. This could be increased somewhat by supplementing spring grazing with extra hay that is produced or allowing spring grazing on some of the irrigated hay lands. Even though some of the extra winter feed production could be used in this manner, it is evident that the estimate for present hay production is probably higher than actual production. The assigned present hay productivities seem too high in relation to the associated land areas used in the analysis. One cause of this difference may be that the unequal distribution of water over some hay fields by present ditch irrigation systems was not adequately accounted for in the analysis.

TABLE 5-8

PRESENT SPRING FEED
HAT CREEK BASIN BEEF INDUSTRY

	Grazing Rating	Area (ha)	Present Carrying Capacity ($ha\text{-}AUM^{-1}$)	Annual Production (AUM)
Rangeland Vegetation Association				
Kentucky Blue grass	A	2800	2.0	1400
Bunchgrass - Kentucky Bluegrass	B	4700 4700	2.4	1958
Sagebrush - Bunchgrass	C	500	2.4	208
Irrigated Land	Pasture	210	0.6*	350
Total		8210		3916

* a seasonal carrying capacity of 0.3 $ha\text{-}AUM^{-1}$ is evenly proportioned between spring and summer for this analysis.

TABLE 5-9

PRESENT SUMMER FEED
HAT CREEK BASIN BEEF INDUSTRY

	Grazing Rating	Area (ha)	Present Carrying Capacity (ha-AUM^{-1})	Annual Production (AUM)
Rangeland Vegetation Association				
Douglas-fir - Bunchgrass	D	2,700	5	540
Highland Grasslands and Alpine Tundra Zone	E	1,000	6	167
Douglas-fir - Bunchgrass - Pinegrass	F	7,000	6	1,167
Douglas-fir - Pinegrass	G	19,800	6	3,300
Engelmann Spruce - Grouseberry - Pinegrass	H	17,500	6	2,917
Engelmann Spruce - Subalpine Fir - Grouseberry; Engelmann Spruce - Grouseberry - White Rhododendron; and Engelmann Spruce - Grouseberry - Lupines	J	7,000	10	700
Irrigated Land	Pasture	210	0.6*	350
Total		55,210		9,141

* carrying capacity evenly proportioned between spring and summer.

Comparing the two estimates of the size of the present beef industry in Hat Creek basin it is evident that the estimate by permit information at 2050 is slightly larger than the estimate by feed resource information at 1958 animal units.

(ii) Probable Beef Industry

A. Summary of Potential Agricultural Use

Irrigable Land

Using Canada Land Inventory (CLI) information, the irrigable land for the total Hat Creek basin was derived as the sum of CLI classes 1 through 5. The CLI estimate is expected to be conservative (high). From Table 4-10 (see page 70, Vol. I) and Table 5-1 the total CLI estimate for potentially irrigated lands in the Hat Creek basin is 68 km^2 (26 mi^2).

Using the more detailed soil series information yielded (Table 5-4) an estimate of 38.2 km^2 (14.75 mi^2) for the upper Hat Creek valley portion of the Site Specific Study Area. This compares with an estimate of 38.0 km^2 presented in the *Hydrology, Drainage, Water Quality and Use* report[49]. The difference is due to a slightly different boundary between upper Hat Creek and lower Hat Creek components of the Hat Creek basin.

The estimate of the potentially irrigated land in the lower Hat Creek area is 22.3 km^2 (8.6 mi^2)[49]. This estimate was based upon CLI information and is considered a conservative (high) estimate. This estimate, when adjusted for the slight difference in boundary definition, approximates 22.1 km^2 (8.5 mi^2); this adjusted figure was used in this analysis. A comparison of the two CLI estimates of

68.0 km^2 (26 mi^2) for the total Hat Creek basin and 22.1 km^2 (8.5 mi^2) for the lower Hat Creek area yields a CLI estimate of 45.9 km^2 (17.7 mi^2) for the upper Hat Creek area. Further, a comparison of the CLI estimate of 45.9 km^2 (17.7 mi^2) and the detailed estimate of 38.2 km^2 (14.7 mi^2) provides a measure of the conservativeness of the CLI method. A more accurate estimate of potentially irrigated lands in the lower Hat Creek area might be obtained by reducing the CLI estimate of 22.1 km^2 (8.5 mi^2) by the ratio 38.2/45.9; but as the ratio of CLI class 5 to CLI class 1 through 4 and the ratio of uplands to lowlands varies between the upper Hat Creek and lower Hat Creek, it was elected that the more conservative estimate of 22.1 km^2 be used. This is consistent with the method selected in the *Hydrology, Drainage, Water Quality and Use* report[49]. The potentially irrigable land of the Hat Creek basin is given in Table 5-10.

Rangeland

Assuming that the potentially irrigable lands are all utilized then the remainder of the area of the Hat Creek basin is available for grazing use. Table 4-10 (Vol. I) provides that out of an area of 641 km^2 (247 mi^2) for the total Hat Creek basin, 68 km^2 (26 mi^2) is classed as irrigable land and 573 km^2 (221 mi^2) as rangeland. The adjustment of total irrigable area to 60.3 km^2 (23.3 mi^2) effectively increases the grazing land by 7.7 km^2 (3.0 mi^2) to 580.7 km^2 (224.2 mi^2). Applying this increase proportionately to the vegetation associations shown in Table 5-3 results in the summary of grazing lands for the total Hat Creek basin as shown in Table 5-10.

B. Probable Use Analysis

The present Hat Creek beef industry is defined as a cow-calf operation. Calves are exported yearly out of the area with the exception of those retained for herd replacements. Probable agricultural use without

TABLE 5-10

POTENTIAL USE SUMMARY
IRRIGABLE LAND AND RANGELAND

HAT CREEK BASIN

		Area (km^2)
Irrigable Land		
Upper Hat Creek		38.2
Lower Hat Creek		22.1
	Sub Total	60.3
Rangeland		
Grazing Rating	Vegetation Association	
A	Kentucky Bluegrass	23
B	Bunchgrass - Kentucky Bluegrass	24
C	Sagebrush - Bunchgrass	5
D	Douglas-fir - Bunchgrass	24
E	Highland Grasslands and Alpine Tundra Zone	10
F	Douglas-fir - Bunchgrass - Pinegrass	70
G	Douglas-fir - Pinegrass	180
H	Engelmann Spruce - Grouseberry - Pinegrass	175
J	Engelmann Spruce - Subalpine Fir - Grouseberry; Engelmann Spruce - Lupines - Grouseberry; Engelmann Spruce - Grouseberry - White Rhododendron	70*
	Sub Total	581
Total		641

* includes rock outcrops and water bodies.

the project was based on available resources and the requirements of the cow-calf type of operation. It was further assumed that the Hat Creek basin industry would effectively represent a closed feed system, i.e., crops grown in the basin would be totally consumed by the basin beef industry.

The probable use analysis for Hat Creek basin is described in terms of individual farm units and in terms of a Hat Creek basin beef industry model.

Base Irrigated Land

The potential irrigable lands outlined previously represent the lands that could be brought into production provided water was non-limiting, but estimates of available irrigation water for the valley indicate that water is limiting.

As reported by Beak Consultants Ltd.[49], water available for all-season irrigation (May through September) is fully licensed under present use as fisheries require the water remaining in Hat Creek during the summer months. There is additional water available in Hat Creek during the spring which could be utilized for irrigating spring pasture, where spring pasture is defined as land irrigated for about six weeks from the first of May to the middle of June. The irrigable corn lands identified in the Hat Creek valley and the tomato and cabbage irrigable lands identified on the Thompson bench lands (located in the Site Specific Study Area) would probably justify the creation of new storage facilities that could provide the additional all-season irrigation water required to develop these lands. Corn, which is not presently grown in the upper Hat Creek valley, could stimulate development of a backgrounding and/or finishing cattle operation in the valley. Prior to large scale development of this resource, though, field trials would be necessary to substantiate the corn producing ability of this area. If economics or actual capability of the designated corn land precludes its development for corn, then this land would likely remain as rangeland (predominantly of grazing rating F). The remaining irrigable lands of the Hat Creek basin are unlikely to receive water during the life of the proposed project and therefore are considered only as a rangeland resource in the projection of probable use.

The amount of probable irrigated lands of the upper Hat Creek valley (Figure 5-2) are broken out on an individual farm unit basis and presented in Table 5-11. All the land suitable for corn has been included in corn production and totals 340 ha (840 acres). Hay production is restricted to irrigable land where hay is the preferred crop; the amount of this land totals 738 ha (1824 acres). All-season irrigated pasture, totalling 124 ha (306 acres), are those irrigable pasture lands which are irrigated over the entire growing season. The sum of the probable hay land and all-season irrigated pasture land is restricted by the amount of water available under present irrigation licenses. Probable spring pasture covers 418 ha (1033 acres) of presently non-irrigated hay and pasture lands located in close proximity to all-season irrigation works.

The amount of probable irrigated lands for the lower Hat Creek valley is presented in Table 5-12 which provides a summary for the entire Hat Creek basin. The total of 2.1 km^2 (0.81 mi^2)[49] of irrigable lands was broken down between hay land and all-season pasture land on the basis of present use. Probable spring pasture was estimated according to the ratio of spring pasture to all-season hay and pasture for upper Hat Creek valley. The results are 1.6 km^2 (0.62 mi^2) of hay land, 0.5 km^2 (0.19 mi^2) of all-season irrigated pasture and 1.0 km^2 (0.39 mi^2) of spring pasture.

As water quality is acceptable for present use irrigation it was assumed that water quality would be acceptable and non-limiting for probable use without the project.

TABLE 5-11

PROBABLE USE WITHOUT THE PROJECT - IRRIGATED LAND (ha)
UPPER HAT CREEK VALLEY

Crop Type	Tenure	Farm Unit Number*											
		1	2	3	4	5	6	7	8	11 (I.R.)	14	Unclass.	Total
Corn	D	-	-	-	-	-	0.4	30.8	-	53.8	-	7.3	92.3
	L	-	-	-	-	248.5	-	-	-	-	-	-	248.5
	Σ	-	-	-	-	248.5	0.4	30.8	-	53.8	-	7.3	340.8
Hay	D	105.2	50.6	40.5	223.8	167.1	10.5	40.5	-	28.3	52.6	10.1	729.2
	L	-	-	-	-	9.7	-	-	-	-	-	-	9.7
	Σ	105.2	50.6	40.5	223.8	176.8	10.5	40.5	-	28.3	52.6	10.1	738.9
All-Season Pasture	D	24.3	10.1	-	0.8	5.3	15.0	40.4	-	-	-	-	95.9
	L	-	-	-	2.0	-	-	18.6	7.3	-	-	-	27.9
	Σ	24.3	10.1	-	2.8	5.3	15.0	59.0	7.3	-	-	-	123.8
Spring Pasture	D	45.3	30.4	20.2	113.3	54.6	4.9	11.3	-	16.2	26.3	-	322.5
	L	19.4	-	-	-	36.4	-	39.3	-	-	-	-	95.1
	Σ	64.7	30.4	20.2	113.3	91.0	4.9	50.6	-	16.2	26.3	-	417.6
Total Irrigated	D	174.8	91.1	60.7	337.9	227.0	30.8	123.0	-	98.3	78.9	17.4	1239.9
	L	19.4	-	-	2.0	294.6	-	57.9	7.3	-	-	-	381.2
	Σ	194.2	91.1	60.7	339.9	521.6	30.8	180.9	7.3	98.3	78.9	17.4	1621.1

* refer to Figure 5-2 (foldout) for location
D Deeded
L Leased

TABLE 5-12

PROBABLE USE WITHOUT THE PROJECT
BASE IRRIGATED LAND (km^2)
HAT CREEK BASIN

Crop Type	Upper Hat Creek Valley	Lower Hat Creek Valley	Total Basin
Corn	3.4	-	3.4
Hay	7.4	1.6[49]	9.0
All-Season Pasture	1.2	0.5[49]	1.7
Spring Pasture*	4.2	1.0	5.2
	16.2	3.1	19.3

* irrigated during May and the first half of June.

Base Rangeland

The total probable rangeland base of the Hat Creek basin is shown in Figure 5-2. It is made up of the dry land grazing area identified in potential use plus the nonirrigated potentially irrigable hay and pasture lands. Table 5-10 provides the dry land grazing component by the various grazing ratings; which totals 581 km^2 (224 mi^2). The nonirrigated potentially irrigable lands, at 41 km^2 (16 mi^2), was obtained by subtracting the amount of the probable irrigated land, Table 5-12, from the amount of potentially irrigable land, Table 5-10. The total probable rangeland base is, therefore, 622 km^2 (240 mi^2).

The nonirrigated potentially irrigable land component of probable rangeland was broken out according to vegetation association with the following results: 4 km^2 (1.5 mi^2) of grazing rating A; 19 km^2 (7.3 mi^2) of grazing rating B; 3 km^2 (1.2 mi^2) of grazing rating D; and 15 km^2 (5.8 mi^2) of grazing rating G.

For the purpose of ultimately relating the project impact on the grazing resource to the probable use projection is was necessary to distribute the base probable rangeland according to farm units located in the upper Hat Creek valley. Table 5-13 provides this breakdown for deeded and leased land. There is a total of 19.1 km^2 (7.4 mi^2) of deeded rangeland and 125.7 km^2 (48.5 mi^2) of leased rangeland. These lands are further broken down on the basis of grazing rating (vegetation association).

Base Spring Range - Spring range comprises those rangelands with a grazing rating of A, B, or C. Table 5-14 summarizes the base probable spring rangeland in the Hat Creek basin. The total of 75 km^2

TABLE 5-14

PROBABLE USE WITHOUT THE PROJECT
BASE RANGELAND (km^2)
HAT CREEK BASIN

Grazing Rating*	Nonirrigable Component	Irrigable Component**	Total
Spring Range			
A	23	4	27
B	24	19	43
C	5	0	5
Sub Total	52	23	75
Summer Range			
D	24	3	27
E	10	0	10
F	70	0	70
G	180	15	195
H	175	0	175
J	70	0	70
Sub Total	529	18	547
Total	581	41	622

* see Table 5-8 for corresponding vegetation association.

** potentially irrigable land which, in probable use, is not irrigated and reverts to rangeland.

(29 mi^2) probable spring range comprises 52 km^2 (20 mi^2) of dryland range (nonirrigable component) and 23 km^2 (9 mi^2) of nonirrigated potentially irrigable land.

Base Summer Range - Summer range comprises those rangelands with grazing ratings other than A, B, and C (spring range). From Table 5-14 the area of summer rangeland in the Hat Creek basin is 547 km^2 (211 mi^2) and is composed of 529 km^2 (204 mi^2) of dryland range (non-irrigable component) and 18 km^2 (7 mi^2) of nonirrigated potentially irrigable land.

Probable Beef Industry

The probable beef industry was projected for the Hat Creek basin in an analagous manner to that for the projection of the present beef industry, by using basin totals of the beef feed resources.

Winter Feed - From Table 5-12, the total probable hay land in the Hat Creek basin is 9.0 km^2 (3.5 mi^2). The three levels of productivity for haylands, presented in the *Inventory* section (see page 101, Vol. I), and the ratio of the amount of land in each productivity category, as defined by the present beef industry projection, were used to project probable hay production. This projection of the probable winter feed production of the Hat Creek basin is presented in Table 5-15.

Based on an animal feed demand of 1.59 Mg-animal unit^{-1} for a seven month fall/winter feeding season the herd size which could be wintered in the Hat Creek basin would be 3476 animal units (5527 Mg divided by 1.59 Mg-animal unit^{-1}).

TABLE 5-15

PROBABLE USE WITHOUT THE PROJECT
WINTER FEED
HAT CREEK BASIN BEEF INDUSTRY

Crop Type*	Area (ha)	Probable Productivity ($Mg\text{-}ha^{-1}$)	Production (Mg)
Alfalfa grass	665	5.6	3724
Wetland hay	142	6.8	966
Alfalfa grass	93	9.0	837
Total	900		5527
			or
		Animal Units,	3476**
			or
		AUM,	24332**

* probable corn land, 340 ha, not included.

** derived on the basis of a seven month fall/winter season with a feed requirement of 1.59 $Mg\text{-}animal\ unit^{-1}$.

Spring Feed - The probable spring grazing resource of the Hat Creek basin was projected on the basis that present spring ranges could be improved through extensive range reseeding programs to the extent that at the end of a 20 year period these lands would produce between 60 to 70 percent of their potential. The full realization of the potential cannot be reached due to less than optimal range access, grazing patterns, and distribution of range watering sites, and expected occurrences of less than normal annual forage productivity in some years due to climate variation. It is further projected that spring feed would be supplemented by spring irrigated pasture to reduce grazing pressure on dryland spring ranges while they were being reseeded.

Probable spring feed for the Hat Creek basin is summarizec in Table 5-16. Assuming that the total spring production of 9465 AUMs would be required for at least a two-month period, 4733 animals could be carried by the probable spring grazing resource once range improvement was completed.

Summer Feed - The probable summer grazing resource was projected as being comparable to the present use of this resource as most of these grazing lands are presently in good condition. Effectively, this use represents about 65 percent of the potential. Probable use of summer ranges also assumes that clear-cut logging activity would effectively remain constant with that presently existing in the area. Should the amount of clear-cutting increase, this would effectively increase the overall probable use of this resource.

Probable summer feed for the beef industry of the Hat Creek basin is shown in Table 5-17. The 548.7 km^2 (212 mi^2) of summer dryland range and all-season pasture contributing to summer feed are projected to have a support capacity of 9081 AUM. As the summer grazing season is a three-month period this results in the probable summer grazing resource to be 3027 animal units.

TABLE 5-16

PROBABLE USE WITHOUT THE PROJECT
SPRING FEED
HAT CREEK BASIN BEEF INDUSTRY

Grazing Rating*	Area (ha)	Probable Carrying Capacity ($ha \cdot AUM^{-1}$)	Production** (AUM)
A	2700	0.62	4355
B	4300	1.23	3496
C	500	1.23	407
Spring Pasture	520	0.6	867
All-Season Pasture	170	0.5***	340
Total	8190		9465
			or
			Animal Units, 4733****

* see Table 5-8 for corresponding vegetation association.

** assuming other seasons not limiting.

*** carrying capacity proportioned evenly between spring and summer.

**** derived on the basis of a two-month spring season.

TABLE 5-17

PROBABLE USE WITHOUT THE PROJECT
SUMMER FEED
HAT CREEK BASIN BEEF INDUSTRY

Grazing Rating*	Area (ha)	Probable Carrying Capacity ($ha\text{-}AUM^{-1}$)	Production** (AUM)
D	2700	5	540
E	1000	6	167
F	7000	6	1167
G	19500	6	3250
H	17500	6	2917
J	7000***	10	700
All-Season Pasture	170	0.5****	340
Total	54870		9081
			or
			Animal Units, 3027*****

* see Table 5-9 for vegetation association.

** assuming other seasons not limiting. Note that spring rangeland, not included, could also be used during the summer.

*** includes rock outcrops and water bodies.

**** carrying capacity evenly proportioned between spring and summer.

***** derived on the basis of a three-month summer season.

Beef Industry Composite - The preceding analyses for the three feed resource seasons are summarized in Table 5-18. The summer season would impose the greatest limitation on the probable herd size of the Hat Creek basin beef industry assuming no assistance from the feed resources of the other seasons. However, spring feed can also be used during the summer and if the total projected production for both seasons were optimumly utilized together over five months, a herd size of 3709 animal units could be supported during that period. The probable winter herd size of 3476 animals units, however, would become the limiting factor and unless the purchase of additional winter feed became economic, 1166 AUM of the probable spring feed production would remain undeveloped. It is logical that spring rangeland with the highest probable productivity, grazing rating A, would be improved in preference to rangeland with lower productivity, grazing ratings B and C. In this case, about 2942 ha (7270 acres) of B and C rangeland would remain unimproved (not reseeded) which is 39 percent of the total base spring rangeland. Depending on economic tradeoffs it is also possible that spring pasture would cease to be irrigated once the productivity of the spring ranges was increased, with additional reseeded B and C rangeland substituted for this component of the feed resource.

The rate of improvement of the spring range is perceived as being the controlling factor in the rate of growth of the Hat Creek basin beef herd size. The increase in hay production (winter feed), which would have to accompany range improvement in order to balance the seasonal feed resources, would respond, it is thought, more rapidly to production requirements. The summer rangelands are presently at their best probable condition and, therefore, no further development of this resource would occur. With 3476 animal units as the maximum probable herd size in Hat Creek valley, the maximum spring and summer feed production needed would be 17,380 AUM (3476 animal units feeding for five months). The summer resource

TABLE 5-18

PROBABLE USE WITHOUT THE PROJECT
SEASONAL RESOURCE SUMMARY
HAT CREEK BASIN BEEF INDUSTRY

Season	Production* (AUM)	Maximum Probable* Herd Size (Animal Units)
Winter (7 months)	22,904	3,476
Spring (2 months)	9,465	4,733
Summer (3 months)	9,081	3,027

• assuming no limitations or assistance from resources associated with other seasons.

portion of this would be 9081 AUM; the remaining 8299 AUM would come from spring resources, of which 6952 AUM would be used during the two month spring season, and the rest, 1347 AUM, during the summer season.

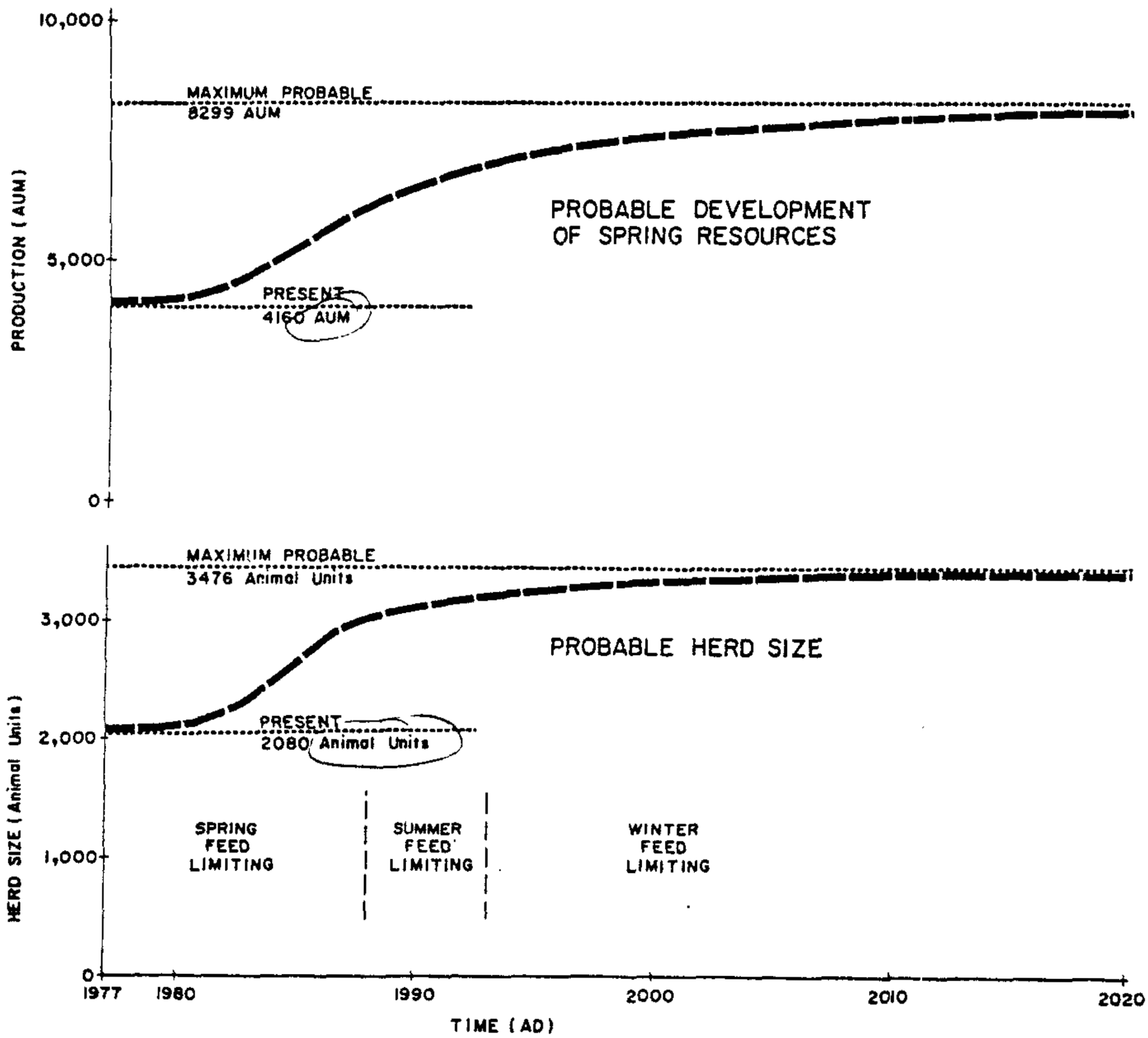
The probable development of the spring feed resource is illustrated in Fiqure 5-3. The present (1977) spring range production based on a herd size selected at 2080 animal units, would approximate 4160 AUM. The development curve (Figure 5-3) would depend primarily on reseeding technology and monetary incentives provided by the government; in this projection it approaches the maximum probable spring feed requirement of 8299 AUM. A corresponding curve of projected herd size is also shown in Figure 5-3.

The shape of the curves shown in Figure 5-3 were based on the following rationale:

1) that there would be a lag time before spring resources production would increase significantly because, as a relatively new technology, large scale range reseecing projects would require time to gain rancher acceptance and time for specialized equipment to become available.

2) that the most rapid range development would probably occur during the period when spring feed was limiting since the highest return of investment would occur at this time when the increased spring productivity, used over a two month season, would be complemented by existing summer resources over the following three months.

3) that the rate of development would probably slow down during the period when summer feed became the limiting resource. This would occur once the spring resources were improved to a support capability of 3027 animal units (6054 AUM over two months). Further spring range improvement



PROBABLE DEVELOPMENT WITHOUT THE PROJECT
SPRING RESOURCES PRODUCTION & HERD SIZE VERSUS TIME
HAT CREEK BASIN BEEF INDUSTRY

FIG. 5-3

would actually supplement the summer feed resource as well as provide additional spring feed, thereby the increase in feed production (spring range) would be used during both the spring and summer seasons, five months, rather than only two as in the previous period.

4) that the probable basin herd size during the scenario period would approach but not attain the maximum probable of 3476 animal units derived by considering the optimum combination of feed resources. An analysis of the feed resources of individual farm units in upper Hat Creek valley showed that the maximum probable herd size of about half of them would be limited by spring feed, rather than winter feed as per the basin model, if only the resources on deeded and leased land were considered. Even though about one-third of the spring rangeland occurs on permit land (which was not considered in the farm unit analysis) some of which would be used during the spring season and some of which may even be improved by reseeding by the Crown, the non ideal distribution of resources amongst the farm units would still tend to limit the Hat Creek basin herd size to something less than the maximum probable.

It was assumed in the preceding scenario development that constraints would be such that the increase in winter feed production would not be developed faster than necessary for the base herd requirements. If conditions were favorable for more rapid development then additional feed (hay) would be available for sale or backgrounding until the development of spring resources caught up.

The production of corn silage in the basin and its use for possible backgrounding and finishing of cattle was not included as part of the basin resource model. The true ability of the land to produce corn, while favourably indicated by the resource analysis of this study, has not been proved; field trials would be required prior to any large scale development of this resource and of the associated feedlot enterprise. The economics of producing corn on this land would also require more rigorous attention to establish feasibility; the cost of providing irrigation water would be one of the key considerations of this economic analysis. Because more doubt exists as to the probability of the corn land being ultimately developed, it was felt to be unjustified to include the corn and feedlot enterprises in the development of the probable Hat Creek beef industry model or to associate a definite economic return to this possible use.

If the probable corn land was developed, the estimated total production of 21,000 Mg (23,140 tons) of corn silage (3.4 km^2 x 6165 $Mg\text{-}km^{-2}$, see Tables 5-12 and 5-4) could provide the silage portion of a feed ration for a feedlot operation producing approximately 11,500 head of beef cattle for slaughter each year (based on the silage requirement of 1.82 $Mg\text{-}animal^{-1}$ (2 $tons\text{-}animal^{-1}$)) If the corn land was not developed, it would remain as dryland range with a grazing rating of F.

Table 5-19 shows the economic analysis of the beef industry for five selected dates from the present (1977) to the year 2020 AD. This analysis is based on the premise that world food prices would remain as they are today relative to other goods and services. In carrying out the economic evaluation it was necessary to look in detail at the economic components as shown in Table 5-19. The herd size in animal units indicated on the graph, Figure 5-3, was adjusted to give number of cows by dividing animal units by the factor 1.04 to account for bulls in the herd. Calves produced, half being steers and half heifers, were estimated to be 85 percent of the number of cows. Annual mortality in the herd was selected at 2 percent which is reflected in the number of available heifers

TABLE 5-19

PROBABLE USE WITHOUT THE PROJECT

SCENARIO ECONOMICS

HAT CREEK BASIN BEEF INDUSTRY

	1977 AD	1980 AD	1990 AD	2000 AD	2020 AD
a) Cows (from model analysis)	2000	2038	3005	3200	3300
b) Calves Produced (85% a)	1700	1732	2554	2720	2805
c) Steer Calves Sold (50% b)	850	866	1277	1360	1403
d) Cow Mortality (2% a)	40	41	60	64	66
e) Cull Cows Sold (12% a)	240	245	361	384	396
f) Heifer Calves for Replacement (d + e)	280	286	421	448	462
g) Heifer Calves Sold (50% b - f)	570	581	856	912	941
h) Value of Steer Calves Sold (c × Sale Price**)	$132,600	$169,736	$250,292	$266,560	$274,988
i) Value of Cows Sold (e × Sale Price**)	$ 70,800	$ 72,275	$106,495	$113,280	$116,820
j) Value of Heifer Calves Sold (g × Sale Price**)	$ 67,260	$ 85,988	$126,668	$134,976	$139,968
k) Total Revenue (h + i + j)	$270,660	$327,999	$483,475	$514,816	$531,076
l) Total Cost (a × $Cost \cdot Cow^{-1}$, Table 5-20)	$255,020	$259,865	$383,168	$408,032	$420,783
m) Total Net Revenue (k - l)	$ 15,640	$ 68,134	$100,307	$106,784	$110,293
n) Net $Revenue \cdot Cow^{-1}$ ($m \times a^{-1}$)	$8	$33	$33	$33	$33

**Sale Prices

	Steer Calves	Cull Cows	Heifer Calves
1977	$156	$295	$118
Other Dates	$196	$295	$148

** 1977 is based on actual prices which happen to be on the low end of the normal price cycle. Prices for other dates are estimated to be the average price of the normal cycle based on 1977 dollars.

for sale. Heifer calves for sale were further modified by a 12 percent requirement for replacement heifers in the cow herd. Total gross revenue for the basin beef industry for each of the five dates was calculated and is shown in Table 5-19. The net revenue was obtained by subtracting the costs of production as detailed in Table 5-20.

The 1977 net revenue was based on actual sale prices and demonstrates the very low return to this segment of the beef industry for that year. The net revenue for the other dates considered was based on a sale price which represents the average sale price of beef cattle over a normal price cycle.

TABLE 5-20

PROBABLE USE WITHOUT THE PROJECT
DETAILED PROJECTED EXPENSES***
HAT CREEK BASIN BEEF INDUSTRY

Item	Annual Cost-Cow^{-1}*
Salt, Vitamins & Minerals	$ 2.00
Veterinary Expense	3.00
Utilities & Miscellaneous	3.00
Labour (4 hrs @ $3.50)	14.00
Cost of Capital	13.50
Bull Depreciation	2.50
Building Depreciation	1.25
Building Interest	1.12
Bull Interest****	3.38
Winter Feed Production Cost (1.65 Mg x $44 Mg^{-1})**	72.60
Rangeland Charge*****	3.86
Irrigated Pasture Expense**	1.00
Management Expense	6.30
Total	$127.51

* Includes bull expenses (each 25 cows requires 1 bull)

** Estimated by CBRC staff.

*** "Estimating Cost of Beef Production" Pub No. 1506, Agriculture Canada.

B.C. Ministry of Agriculture, June 1975, Farm Business Management.

**** Bull value assumed at $1500.

***** Includes grazing permit and grazing lease charges and cost of reseeding spring rangeland.

5.2 AGRICULTURAL RESOURCE CHANGES AS RESULT OF PROJECT

(a) Preliminary Site Development

(i) Drilling Program

The impact of the drilling program was difficult to assess as very little information on the extent and location of these activities was made available. Field observations, made prior to the completion of a major portion of the drill site reclamation program, were the major source of information used for this assessment.

While the actual drilling sites were small in area the degree of disturbance associated with an individual site was found to be extremely variable. The major contributions to disturbance by this program were associated with site access and the construction of water holding ponds required for the drilling. Where reclamation procedures had been implemented, reestablishment of the previous natural environment was evident. In other cases, however, reclamation efforts were not obvious especially for some drilling sites in the lower grasslands. These areas showed little in the way of re-establishment of vegetative cover and appeared particularly susceptible to wind erosion. It should be noted, however, that a large number of these sites had not yet been reclaimed and they were scheduled for seeding in the spring.[59] The extent of the drilling program and the overall attention paid to reestablishment of vegetation cover of the disturbed areas would largely determine the impact of this activity on the grazing resource of the region. The determination of the full effects of wind erosion and grazing on revegetated drill sites is part of an ongoing revegetation monitoring program. From the limited field information gathered it would seem that apart from those areas in direct vicinity of the proposed mining operation, where the drilling program was probably most extensive, that impacts on the agricultural resource from this activity would be minor and temporary in nature.

(ii) Bulk Sampling Program

A review of the findings reported[60,61] for the Bulk Sampling Program would indicate that apart from areas directly alienated by this activity, minimal impacts were perceived on the agricultural resource. Other effects appeared to be of short duration and very localized in nature.

Areas of direct alienation due to the Bulk Sampling Program included two excavation trenches, associated waste piles and topsoil storage areas; coal waste areas, revegetation test plots, road access, and other fenced areas. The land that had been projected[62] as being alienated as a result of the program consisted of 38 ha (94 acres) lying within the Agricultural Land Reserve and presently used for livestock grazing. Ten hectares (24.7 acres) of this was projected as being physically disturbed and completely lost to agricultural use, while the remaining 28 ha (69 acres) had been identified as lying within a dense activity zone and effectively restricted for agricultural use, at least during the duration of the program. The actual alienation was reported to be less than 10 ha (24.7 acres) for the two trenches.[59]

Other potential impacts of the Bulk Sampling Program were siltation and contamination of ground and surface water sources, dusting from the excavation, storage, and transportation of disturbed materials, destruction of vegetation as a result of these activities, and noise associated with the activities. Monitoring was carried out to assess these impacts. The results of the monitoring have indicated that the Bulk Sampling Program caused no signifant impacts relating to these parameters. Aspects such as dusting and noise while significantly altered during the period of excavation were of short duration and very localized in extent. Dusting associated with stock piles and related wind or water erosion were found to be insignificant and any long term damages associated with these parameters are not expected. B.C. Hydro is maintaining a dust monitoring program on the site to document the long term impacts of this program.

While the assessment pertaining to revegetation of waste materials is in progress and inconclusive to date, no major impacts to the agricultural resource are anticipated in terms of the feasibility of reclaiming the trenches should the project not proceed.

(b) Construction

Construction includes both the construction activity and the creation of facilities. The base project scheme as defined by the client[63-67] (see Appendix D) includes project activities which have been broken out on the basis of construction camp (temporary facilities) mine, plant and offsites.

The project construction impacts were considered on the basis of land alienation, noise, dust emissions and physical barriers. Any impact from these construction activities with respect to agriculture necessitates analysis on the basis of individual farm units and upon the subregional agricultural industry, namely, the beef industry of the Hat Creek basin.

(i) Land Alienation

The alienation of land by the base project scheme (see Appendix D) was tabulated in terms of Agricultural Land Reserves, soils, present agricultural use and probable agricultural use without the project. The basic agricultural resources used to determine agricultural productivity are the various components of irrigated lands and rangelands described previously for the present use and probable use analyses. Agricultural Land Reserves and soils are useful for descriptive purposes of agricultural significance but are not directly useful in defining the agricultural resource.

Project alienation was broken out on the basis of project "open" areas and project "closed" areas, where "open" and "closed" refer to the degree of restriction to agricultural use. The "open' areas include land alienation due to transmission line right-of-ways and buried pipeline right-of-ways which do not completely alienate land from agricultural use. "Closed" areas are those which are eliminated entirely from possible agricultural use. Project alienation was also separated according to project activity category (construction camp, mine, plant and offsites) and an indirect component where the latter was defined as those lands adjacent to the project which would be effectively totally alienated with respect to agricultural use. A map of base project scheme alienation and indirect alienation is included in Appendix D describing the project. Though alienation impacts are grouped by activity category in this report, the impact of individual activities on various agricultural resource parameters can be seen by overlaying the map of project activities, Figure D-1 (foldout) onto the individual resource maps of the same 1:24,000 scale.

A. Agricultural Land Reserves

Superimposition of the base project upon the ALR map for the Site Specific Study Area gave that 2070.7 ha (5116.8 acres) of ALR land and 1654.1 ha (4087.4 acres) of non-ALR land are alienated by the base project. The breakdown of this area by project activity category is provided in Table 5-21. There is a single predominant ALR unit which lies within the upper Hat Creek valley and extends slightly into the lower Hat Creek valley. The project cuts across this ALR unit at the north end of the upper Hat Creek valley and

TABLE 5-21
LAND ALIENATION - AGRICULTURAL LAND RESERVE
LOCAL STUDY AREA

Area Before Alienation (ha)	Project Activity	"OPEN" Alienation (ha)	"CLOSED" Alienation (ha)	Total
ALR	C	2.8	5.3	8.1
	O	44.9	155.8	200.7
52,900	M	-	1,675.4	1,675.4
	P	-	48.1	48.1
	I	-	138.4	138.4
	Σ	47.7	2,023.0	2,070.7
Non-ALR	C	1.6	-	1.6
	O	39.7	83.8	123.5
143,400	M	-	653.6	653.6
	P	4.9	786.3	791.2
	I	-	84.2	84.2
	Σ	46.2	1,607.9	1,654.1
Total	C	4.4	5.3	9.7
	O	84.6	239.6	324.2
196,300	M	-	2,329.0	2,329.0
	P	4.9	834.4	839.3
	I	-	222.6	222.6
	Σ	93.9	3,630.9	3,724.8

C - Construction O - Offsites M - Mine P - Plant I - Indirect divides the small portion of the ALR unit located in the lower Hat Creek valley from the portion of the ALR unit remaining in the upper Hat Creek valley.

B. Soils

Superimposition of the base project upon the soils map of the Site Specific Study Area resulted in the land alienation of soils given in Table 5-22. Of the total 3724.8 ha (9204.2 acres) of alienated soils, 749.5 ha (1852.1 acres) or 20 percent are of moderate high, moderate, and moderate low agricultural significance, signifying suitability for arable agricultural or pasture use.

C. Present Use

The inventory elements for present use included deeded irrigated, deeded nonirrigated, leased, and permit lands. A tabulation for project "open" areas is presented in Table 5-23a and for project "closed" areas in Table 5-23b. These inventory elements were broken out on the basis of individual farm units in order that the farm unit analysis necessary in the probable use with the project case could be carried out later. It is seen that 93.9 ha (232.0 acres) of project alienation are classified as project "open" areas (affecting six farm units). Project "closed" areas involve 3630.9 ha (8972.1 acres) of land (affecting six farm units). Of the total 3724.8 ha (9204.2 acres) of farm land alienated, 664.5 (1642.0) or 17.8 percent is deeded land including 34.4 ha (85.0 acres) which are presently irrigated. Leased land accounts for 2687.2 ha (6640.2 acres) or 72.2 percent of alienated farm land. Permit land accounts for 373.1 ha (921.9 acres) or 10.0 percent of the alienated farm land. The farm units affected are Number 4 with 207.2 ha (512.0 acres), Number 5 with 1197.2 ha (2958.3 acres), Number 6 with 976.5 ha (2412.9 acres), Number 7 with 295.5 ha (730.2 acres), Number 8 with 719.9 ha (1178.9 acres), Number 9 with 80.1 ha (197.9 acres), Number 13 with 4.9 ha (12.1 acres), unclassified with 242 ha (599.7 acres) and the Indian Reserve with 0.8 ha (2.0 acres).

TABLE 5-22

LAND ALIENATION - SOILS
SITE SPECIFIC STUDY AREA

Agricultural Significance	Area Before Alienation (ha)	Project Activity	"OPEN" Alienation (ha)	"CLOSED" Alienation (ha)	Total
Moderate High	1,654	C	2.0	5.3	7.3
		O	10.9	26.3	37.2
		M	-	222.6	222.6
		P	-	-	-
		I	-	12.9	12.9
		Σ	12.9	267.1	280.0
Moderate	500	C	-	-	-
		O	-	24.3	24.3
		M	-	69.2	69.2
		P	-	23.9	23.9
		I	-	.8	.8
		Σ	-	118.2	118.2
Moderate Low	808	C	-	-	-
		O	-	6.5	6.5
		M	-	331.0	331.0
		P	-	-	-
		I	-	13.8	13.8
		Σ	-	351.3	351.3
Low	15,978	C	2.4	-	2.4
		O	65.2	160.6	225.8
		M	-	1,477.9	1,477.9
		P	4.9	734.9	739.8
		I	-	153.0	153.0
		Σ	72.5	2,526.4	2,598.9
Nil	928	C	-	-	-
		O	6.1	9.3	15.4
		M	-	156.6	156.6
		P	-	15.0	15.0
		I	-	19.4	19.4
		Σ	6.1	200.3	206.4
Unclassified (outside inventory area)	N/A	C	-	-	-
		O	2.4	12.6	15.0
		M	-	71.6	71.6
		P	-	60.7	60.7
		I	-	22.7	22.7
		Σ	2.4	167.6	170.0
Total		C	4.4	5.3	9.7
		O	84.6	239.6	324.2
		M	-	2,329.0	2,329.0
		P	4.9	834.4	839.3
		I	-	222.6	222.6
		Σ	93.9	3,630.9	3,724.8

C - Construction O - Offsites M - Mine P - Plant I - Indirect

TABLE 5-23b

LAND ALIENATION - PRESENT USE
SITE SPECIFIC STUDY AREA

Land Status	Project Activity	"CLOSED" Alienation by Farm Unit (ha)							
		4*	5	6	7	8	9	Unclass.	Total
Deeded Irrigated	C	-	-	-	-	-	-	-	-
	O	-	7.3	-	5.7	-	-	3.6	16.6
	M	-	-	10.5	-	-	-	-	10.5
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
	Σ	-	7.3	10.5	5.7	-	-	3.6	27.1
Deeded Nonirrigated	C	-	-	-	-	-	-	-	-
	O	10.9	63.1	0.4	13.0	3.2	-	1.6	92.2
	M	-	-	277.7	0.4	-	-	208.4	486.5
	P	-	-	-	-	-	-	-	-
	I	-	5.7	28.3	-	-	-	-	34.0
	Σ	10.9	68.8	306.4	13.4	3.2	-	210.0	612.7
Leased	C	-	5.3	-	-	-	-	-	5.3
	O	6.5	82.6	-	4.0	19.0	-	-	112.1
	M	176.8	771.8	588.4	257.0**	2.8	-	17.4	1814.2
	P	-	151.7	-	-	367.1***	-	-	518.8
	I	13.0	85.4	70.4	15.0**	-	-	3.2	187.0
	Σ	196.3	1096.8	658.8	276.0	388.9	-	20.6	2637.4
Permit	C	-	-	-	-	-	-	-	-
	O	-	-	-	-	17.0	1.6	-	18.6
	M	-	-	-	-	4.0	13.8	-	17.8
	P	-	-	-	-	279.3***	36.4	-	315.7
	I	-	-	-	-	-	1.6	-	1.6
	Σ	-	-	-	-	300.3	53.4	-	353.7
Total "CLOSED" Alienation	C	-	5.3	-	-	-	-	-	5.3
	O	17.4	153.0	0.4	22.7	39.2	1.6	5.2	239.5
	M	176.8	771.8	876.6	257.4	6.8	13.8	225.8	2329.0
	P	-	151.7	-	-	646.4	36.4	-	834.5
	I	13.0	91.1	98.7	15.0	-	1.6	3.2	222.6
	Σ	207.2	1172.9	975.7	295.1	692.4	53.4	234.2	3630.9

C - Construction   O - Offsites   M - Mine   P - Plant   I - Indirect

* Farm Unit Number, see Figure 5-2 (foldout) for location.

** Farm #7, mine component of lease includes 0.4 ha irrigated and the indirect component of lease includes 1.6 ha irrigated.

*** Farm #8, plant component of lease includes 7.3 ha irrigated and the plant component of permit includes 8.9 ha irrigated.

D. Probable Use

Base Project Scheme

Impacts of the proposed project on probable agricultural use (as defined by Figure 5-2) were used in determining probable agricultural use with the project. As with project alienation of present use, the alienation of probable use was broken out on the basis of individual farm units. Tables are presented for alienation of deeded irrigated land (Table 5-24a and 5-24b), deeded rangeland (Table 5-25a and 5-25b), leased irrigated land (Table 5-26), leased rangeland (Table 5-27), and permit land (Table 5-28).

Alienation of probable irrigated land is presented in terms of three categories - present use, new storage, and spring pasture. Rangeland is presented by grazing rating where the ratings correspond to vegetation associations (see Table 5-3). Spring rangeland corresponds to grazing ratings A, B, and C; and summer rangeland corresponds to grazing ratings D, E, F, G, H, and J.

The alienation of probable deeded irrigated land amounts to 143.3 ha (354.1 acres) (Table 5-24a and 5-24b) and that of probable leased irrigated land, 143.6 ha (354.8 acres) (Table 5-26). The latter amount is high with respect to normal relationships between deeded and leased land but the majority of the leased amount is attributable to probable irrigated land which has potential for corn production and as this land is not yet developed it is still under leased tenure. A further 8.9 ha (22.0 acres) of permit land is also irrigated. The amount of alienated irrigated land, 295.8 ha (730.9 acres), is about 8 percent of the total land alienated by the project, 3724.8 ha (9204.2 acres).

The alienation of probable deeded rangeland amounts to 521.2 ha (1287.9 acres) (Table 5-25a and 5-25b), that of probable leased rangeland,

TABLE 5-24a

LAND ALIENATION - PROBABLE USE
DEEDED IRRIGATED LAND
SITE SPECIFIC STUDY AREA

Irrigation Status	Project Activity	"OPEN" Alienation by Farm Unit (ha)							
		6*	7	8	9	11 (I.R.)	13	Uncl.	Total
Present Use	C	-	-	-	-	-	-	-	-
	O	-	-	0.8[P]	-	-	4.5[H]	2.0[H]	7.3
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
New Storage	C	-	-	-	-	-	-	-	-
	O	-	0.4	-	2.5	-	0.4	0.8	4.1
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
Spring Pasture	C	-	-	-	-	-	-	-	-
	O	-	-	-	-	0.4	-	-	0.4
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
Total "OPEN" Alienation of Deeded Irrigated Land	C	-	-	-	-	-	-	-	-
	O	-	0.4	0.8	2.5	0.4	4.9	2.8	11.8
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-

C - Construction O - Offsites M - Mine P - Plant I - Indirect

H - Hay P - Pasture

* Farm Unit Number, See Figure 5-2 (foldout) for location.

TABLE 5-24b

LAND ALIENATION - PROBABLE USE
DEEDED IRRIGATED LAND
SITE SPECIFIC STUDY AREA

Irrigation Status	Project Activity	"CLOSED" Alienation by Farm Unit (ha)						
		4*	5	6	7	8	Unclass.	Total
Present	C	-	-	-	-	-	-	-
	O	-	7.3(7.3)^H	-	5.6^H	-	3.6(3.6)^H	16.5
	M	-	-	10.5^H	-	-	-	10.5
	P	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	Σ	-	7.3	10.5	5.6	-	3.6	27.0
New Storage	C	-	-	-	-	-	-	-
	O	-	49.8(49.8)	0.4	-	-	0.4(0.4)	50.6
	M	-	-	-	-	-	7.3	7.3
	P	-	-	-	-	-	-	-
	I	-	5.7(5.7)	-	-	-	-	5.7
	Σ	-	55.5	0.4	-	-	7.7	63.6
Spring Pasture	C	-	-	-	-	-	-	-
	O	-	-	-	5.3	-	-	5.3
	M	-	-	3.7	0.4	-	13.2	22.3
	P	-	-	-	-	-	-	-
	I	-	-	1.2	-	-	-	1.2
	Σ	-	-	4.9	5.7	-	18.2	28.8
Total "CLOSED" Alienation of Deeded Irrigated Land	C	-	-	-	-	-	-	-
	O	-	57.1	0.4	10.9	-	4.0	72.4
	M	-	-	14.2	0.4	-	25.5	40.1
	P	-	-	-	-	-	-	-
	I	-	5.7	1.2	-	-	-	6.9
	Σ	-	62.8	15.8	11.3	-	29.5	119.4

Numbers in brackets refer to alienation outside upper Hat Creek valley.

H - Hay

C - Construction   O - Offsites   M - Mine   P - Plant   I - Indirect

* Farm Unit Number, see Figure 5-2 (foldout) for location.

TABLE 5-25a

LAND ALIENATION - PROBABLE USE
DEEDED RANGELAND
SITE SPECIFIC STUDY AREA

Grazing Rating*	Project Activity	"OPEN" Alienation by Farm Unit (ha) 6**	7	8	9	11 (I.R.)	13	Uncl.	Total
C	C	-	-	-	-	-	-	-	-
	O	-	-	-	0.8	-	-	4.1	4.9
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
D	C	-	-	-	-	-	-	-	-
	O	0.8	-	-	-	0.4	-	-	1.2
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
Unclassified Rangeland	C	-	-	-	-	-	-	-	-
	O	-	-	4.0	1.2	-	-	1.6	6.8
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-
Total "OPEN" Alienation of Deeded Rangeland	C	-	-	-	-	-	-	-	-
	O	0.8	-	4.0	2.0	0.4	-	5.7	12.9
	M	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-

C - Construction O - Offsites M - Mine P - Plant I - Indirect

* See Figure 5-2 (foldout) for descriptions.

** Farm Unit Number, see Figure 5-2 (foldout) for location

TABLE 5-25b

LAND ALIENATION - PROBABLE USE
DEEDED RANGELAND
SITE SPECIFIC STUDY AREA

Grazing Rating*	Project Activity	"CLOSED" Alienation by Farm Unit (ha) 4**	5	6	7	8	Unclass.	Total
A	C	-	-	-	-	-	-	-
	O	-	-	-	-	-	-	-
	M	-	-	163.0	-	-	-	163.0
	P	-	-	-	-	-	-	-
	I	-	-	18.6	-	-	-	18.6
	Σ							181.6
B	C	-	-	-	-	-	-	-
	O	10.5	4.0(4.0)	-	7.4	-	-	21.9
	M	-	-	1.2	-	-	22.3	23.5
	P	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	Σ							45.4
C	C	-	-	-	-	-	-	-
	O	-	5.3(5.3)	-	-	-	1.2(0.4)	6.5
	M	-	-	21.9	-	-	160.6	182.5
	P	-	-	-	-	-	-	-
	I	-	-	0.8	-	-	-	0.8
	Σ							189.8
D	C	-	-	-	-	-	-	-
	O	-	-	-	-	-	-	-
	M			10.5	-	-	-	10.5
	P	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	Σ							10.5
F	C	-	-	-	-	-	-	-
	O	-	4.0(4.0)	-	0.4	-	-	4.4
	M	-	-	25.1	-	-	-	25.1
	P	-	-	-	-	-	-	-
	I	-	-	7.3	-	-	-	7.3
	Σ							36.8
G	C	-	-	-	-	-	-	-
	O	0.4	-	-	-	-	-	0.4
	M	-	-	29.6	-	-	-	29.6
	P	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	Σ							30.0
RO	C	-	-	-	-	-	-	-
	O	-	-	-	-	-	-	-
	M	-	-	22.7	-	-	-	22.7
	P	-	-	-	-	-	-	-
	I	-	-	0.4	-	-	-	0.4
	Σ	-	-	-	-	-	-	23.1
Unclassified	C	-	-	-	-	-	-	-
	O	-	-	-	-	3.2(3.2)	-	3.2
	M	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	Σ							3.2
Total "CLOSED" Alienation of Deeded Rangeland	C	-	-	-	-	-	-	-
	O	10.9	13.3	-	7.8	3.2	1.2	36.4
	M	-	-	274.0	-	-	182.9	456.9
	P	-	-	-	-	-	-	-
	I	-	-	27.1	-	-	-	27.1
	Σ							520.4

C - Construction O - Offsites M - Mine P - Plant I - Indirect

* See Figure 5-2 (foldout) for descriptions

** Farm Unit Number, see Figure 5-2 (foldout) for location.

( ) Indicates alienation outside upper Hat Creek valley.

TABLE 5-26

LAND ALIENATION - PROBABLE USE
LEASED IRRIGATED LAND
SITE SPECIFIC STUDY AREA

Irrigation Status	Project Activity	"OPEN" Alienation (ha) by Farm Unit			"CLOSED" Alienation (ha) by Farm Unit			Total
		5*	8	9	5	7	8	
Present Use	C	-	-	-	-	-	-	
	O	-	-	-	-	-	-	
	M	-	-	-	-	0.4^{P}	-	
	P	-	-	-	-	-	7.3^{P}	
	I	-	-	-	-	1.6^{P}	-	
	Σ	-	-	-	-	2.0	7.3	9.3
New Storage	C	2.1	-	-	5.3	-	-	
	O	3.6	4.8	0.4	9.7	-	-	
	M	-	-	-	90.6	-	-	
	P	-	-	-	-	-	-	
	I	-	-	-	4.1	-	-	
	Σ	5.7	4.8	0.4	109.7	-	-	120.6
Spring Pasture	C	-	-	-	-	-	-	
	O	-	-	-	-	0.4	-	
	M	-	-	-	-	11.7	-	
	P	-	-	-	-	-	-	
	I	-	-	-	-	0.4	-	
	Σ	-	-	-	-	12.5	-	12.5
Total Alienation of Leased Irrigated Land	C	2.1	-	-	5.3	-	-	
	O	3.6	4.8	0.4	9.7	0.4		
	M	-	-	-	90.6	12.1	-	
	P	-	-	-	-	-	7.3	
	I	-	-	-	4.1	2.0	-	
	Σ	5.7	4.8	0.4	109.7	14.5	7.3	142.4

C - Construction O - Offsites M - Mine P - Plant I - Indirect

P - Pasture

* Farm Unit Number, see Figure 5-2 (foldout) for location

TABLE 5-27

LAND ALIENATION - PROBABLE USE
LEASED RANGELAND
SITE SPECIFIC STUDY AREA

Grazing Rating*	Project Activity	"OPEN" Alienation (ha) by Farm Unit			"CLOSED" Alienation (ha) by Farm Unit						Total
		5**	8	9	4	5	6	7	8	Unclass.	
A	C	0.8	-	-	-	-	-	-	-	-	
	O	0.8	-	-	-	15.8(5.3)	-	-	4.9	-	
	M	-	-	-	26.3	225.4	27.5	-	1.2	-	
	P	0.4	-	-	-	65.2	-	-	120.3	-	
	I	-	-	-	-	31.2	0.4	-	-	-	
	Σ	2.0	-	-	26.3	337.6	27.9	-	126.4	-	520.2
B	C	-	-	-	-	-	-	-	-	-	
	O	-	-	-	5.3	2.4	-	3.6	-	-	
	M	-	-	-	31.2	2.4	-	25.1	-	-	
	P	-	-	-	-	-	-	-	-	-	
	I	-	-	-	0.8	0.8	-	8.5	-	-	
	Σ	-	-	-	37.3	5.6	-	37.2	-	-	80.1
C	C	-	-	-	-	-	-	-	-	-	
	O	-	1.6	3.6	-	0.4	-	-	1.6	-	
	M	-	-	-	-	40.9	138.4	38.9	-	-	
	P	-	-	-	-	-	-	-	-	-	
	I	-	-	-	-	0.8	6.5	-	-	-	
	Σ	-	1.6	3.6	-	42.1	144.9	38.9	1.6	-	232.7
D	C	-	-	-	-	-	-	-	-	-	
	O	-	-	-	-	-	-	-	-	-	
	M	-	-	-	-	1.6	0.4	90.7	-	-	
	P	-	-	-	-	-	-	-	-	-	
	I	-	-	-	-	-	0.4	-	-	-	
	Σ	-	-	-	-	1.6	0.8	90.7	-	-	93.1
F	C	0.8	-	-	-	-	-	-	-	-	
	O	4.1	-	-	1.2	24.7(6.9)	-	-	-	-	
	M	-	-	-	111.2	222.2	2.0	1.6	1.2	-	
	P	-	-	-	-	3.6	-	-	-	-	
	I	-	-	-	12.2	37.2	-	0.4	-	-	
	Σ	4.9	-	-	124.6	287.7	2.0	2.0	1.2	-	422.4

(continued)

TABLE 5-27 (continued)

Grazing Rating*	Project Activity	"OPEN" Alienation (ha) by Farm Unit			"CLOSED" Alienation (ha) by Farm Unit						Total
		5**	8	9	4	5	6	7	8	Unclass.	
G	C	0.8	-	-	-	-	-	-	-	-	
	O	7.3	1.2	-	-	25.9(11.7)	-	-	4.4		
	M	-	-	-	8.1	188.7	365.9	88.6	0.4	-	
	P	3.6	0.8	-	-	72.9	-	-	170.3		
	I	-	-	-	-	11.3	55.0	4.1	-	-	
	Σ	11.7	2.0	-	8.1	298.8	420.9	92.7	175.1	-	1009.3
H	C	-	-	-	-	-	-	-	-	-	
	O	-	4.1	-	-	3.6	-	-	8.1		
	M	-	-	-	-	-	-	-	-	-	
	P	-	-	-	-	10.1	-	-	69.2	-	
	I	-	-	-	-	-	-	-	-	-	
	Σ	-	4.1	-	-	13.7	-	-	77.3	-	95.1
RO	C	-	-	-	-	-	-	-	-	-	
	O	-	0.4	-	-	-	-	-	-	-	
	M	-	-	-	-	-	54.2	-	-	17.4	
	P	-	-	-	-	-	-	-	-	-	
	I	-	-	-	-	-	8.1	-	-	3.2	
	Σ	-	0.4	-	-	-	62.3	-	-	20.6	83.3
Unclass.	C	-	-	-	-	-	-	-	-	-	
	O	-	-	8.6	-	-	-	-	-	-	
	M	-	-	-	-	-	-	-	-	-	
	P	-	-	-	-	-	-	-	-	-	
	I	-	-	-	-	-	-	-	-	-	
	Σ	-	-	8.6	-	-	-	-	-	-	8.6
Total Alienation of Leased Rangeland	C	2.4	-	-	-	-	-	-	-	-	
	O	12.2	7.3	12.2	6.5	72.9	-	3.6	19.0	-	
	M	-	-	-	176.8	681.2	588.4	244.9	2.8	17.4	
	P	4.0	0.8	-	-	151.7	-	-	359.8	-	
	I	-	-	-	13.0	81.3	70.4	13.0	-	3.2	
	Σ	18.6	8.1	12.2	196.3	987.1	658.8	261.5	381.6	20.6	2544.8

C - Construction O - Offsites M - Mine P - Plant I - Indirect

* See Figure 5-2 (foldout) for descriptions.

** Farm Unit Number, see Figure 5-2 (foldout) for location.

TABLE 5-28

LAND ALIENATION - PROBABLE USE
PERMIT LAND
SITE SPECIFIC STUDY AREA

Grazing Rating*	Project Activity	"OPEN" Alienation (ha) by Farm Unit 8**	"OPEN" Alienation (ha) by Farm Unit 9	"CLOSED" Alienation (ha) by Farm Unit 8	"CLOSED" Alienation (ha) by Farm Unit 9	Total
A	C	-	-	-	-	
	O	-	2.8	-	0.4	
	M	-	-	-	-	
	P	-	-	69.2	0.4	
	I	-	-	-	-	
	Σ	-	2.8	69.2	0.8	72.8
D	C	-	-	-	-	
	O	-	1.2	-	-	
	M	-	-	-	11.8	
	P	-	-	-	-	
	I	-	-	-	1.6	
	Σ	-	1.2	-	13.4	14.6
F	C	-	-	-	-	
	O	-	5.3	-	1.2	
	M	-	-	-	2.0	
	P	-	-	-	-	
	I	-	-	-	-	
	Σ	-	5.3	-	3.2	8.5
G	C	-	-	-	-	
	O	9.7	0.4	17.0(15.8)	-	
	M	-	-	2.8	-	
	P	-	-	159.9	36.0	
	I	-	-	-	-	
	Σ	9.7	0.4	179.7	36.0	225.8
H	C	-	-	-	-	
	O	-	-	-	-	
	M	-	-	1.2	-	
	P	-	-	50.2		
	I	-	-	-	-	
	Σ	-	-	51.4	-	51.4
Total Alienation of Permit Land	C	-	-	-	-	
	O	9.7	9.7	17.0	1.6	
	M	-	-	4.0	13.8	
	P	-	-	279.3	35.4	
	I	-	-	-	1.6	
	Σ	9.7	9.7	300.3	53.4	373.1

C - Construction O - Offsites M - Mine P - Plant I - Indirect

* See Figure 5-2 (foldout) for descriptions.

** Farm Unit Number, see Figure 5-2 (foldout) for location.

*** Includes 8.9 ha present use irrigated pasture.

( ) Indicates alienation outside upper Hat Creek valley.

2543.6 ha (6285.4 acres) (Table 5-27), and that of probable permit rangeland, 364.2 ha (900.0 acres) excluding the 8.9 ha (22.0 acres) irrigated permit land (Table 5-28). The total alienated rangeland of 3429.0 ha (8473.2 acres) amounts to about 92 percent of the total land alienated by the project. The spring range alienated includes 409.6 ha (1012.1 acres) of deeded land, 831.7 ha (2055.2 acres) of leased land, and 63.9 ha (157.9 acres) of permit land for a total of 1305.2 ha (3225.2 acres) which is 35 percent of the total alienated land and approximately 17 percent of the probable spring range of the Hat Creek basin (Table 5-16).

A summary of land alienation of probable agricultural use is presented in Table 5-29a and 5-29b.

Alternate Project Schemes

A comparison of the alienation attributable to various alternate project schemes is presented in Table 5-30. Alternate activities so examined include the Hat Creek water supply reservoir, airport sites A and C, and four ash disposal schemes (including that of the base scheme).

The Hat Creek water supply reservoir alternate (project facilities OD7 and OD8) would, in part, replace the Thompson water supply system. It is not clear exactly how this alternate would affect the balance of land alienation associated with project water supply, but it is apparent that this alternate would increase the impact on probable agriculture because of the irrigated land, about 69.4 ha (171.5 acres) that would be alienated in upper Hat Creek valley.

Of the two airports, Site A, the preferred project site, would alienate somewhat more land in total but the land alienation impacts on probable agricultural use would be less severe than that of Site C, where the land alienated would have the potential for tomatoes, a high value crop.

TABLE 5-29a

LAND ALIENATION - PROBABLE USE
SITE SPECIFIC STUDY AREA
BASE SCHEME SUMMARY

Land Status	Project Activity	"OPEN" Alienation by Farm Unit (ha) 4*	5	6	7	8	9	11(1R)	13	Unclass.	Total
Deeded and Leased Irrigated Land	C	-	2.1	-	-	-	-	-	-	-	2.1
	O	-	3.6	-	0.4	5.6	2.9	0.4	4.9	2.8	20.6
	M*	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-	-	-
	Σ	-	5.7	-	-	5.6	2.9	0.4	4.9	2.8	22.7
Deeded and Leased Rangeland	C	-	2.4	-	-	-	-	-	-	-	2.4
	O	-	12.2	0.8	-	11.3	14.2	0.4	-	5.7	44.6
	M	-	-	-	-	-	-	-	-	-	-
	P	-	4.0	-	-	0.8	-	-	-	-	4.8
	I	-	-	-	-	-	-	-	-	-	-
	Σ	-	18.6	0.8	-	12.1	14.2	0.4	-	5.7	51.8
Permit Rangeland	C	-	-	-	-	-	-	-	-	-	-
	O	-	-	-	-	9.7	9.7	-	-	-	19.4
	M	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-	-	-	-
	Σ	-	-	-	-	9.7	9.7	-	-	-	19.4
Total "OPEN" Alienation	C	-	4.5	-	-	-	-	-	-	-	4.5
	O	-	15.8	0.8	0.4	26.6	26.8	0.8	4.9	8.5	84.6
	M	-	-	-	-	-	-	-	-	-	-
	P	-	4.0	-	-	0.8	-	-	-	-	4.8
	I	-	-	-	-	-	-	-	-	-	-
	Σ	-	24.3	0.8	0.4	27.4	26.8	0.8	4.9	8.5	93.9

C- Construction O - Offsites M - Mine P - Plant I - Indirect

* Farm Unit Number, see figure 5-2 (foldout) for location.

TABLE 5-29b

LAND ALIENATION - PROBABLE USE
SITE SPECIFIC STUDY AREA
BASE SCHEME SUMMARY

Land Status	Project Activity	"CLOSED" Alienation by Farm Unit (ha) 4*	5	6	7	8	9	11(1R)	13	Unclass.	Total
Deeded and Leased Irrigated Land	C	-	5.3	-	-	-	-	-	-	-	5.3
	O	-	66.8	0.4	11.3	-	-	-	-	4.0	82.5
	M	-	90.6	14.2	12.5	-	-	-	-	25.5	142.8
	P	-	-	-	-	7.3	-	-	-	-	7.3
	I	-	9.8	1.2	2.0	-	-	-	-	-	13.0
	Σ	-	172.5	15.8	25.8	7.3	-	-	-	29.5	250.9
Deeded and Leased Rangeland	C	-	-	-	-	-	-	-	-	-	-
	O	17.4	86.2	-	11.4	22.2	-	-	-	1.2	138.4
	M	176.8	681.2	862.4	244.9	2.8	-	-	-	200.3	2168.4
	P	-	151.7	-	-	359.8	-	-	-	-	511.5
	I	13.0	81.3	97.5	13.0	-	-	-	-	3.2	207.9
	Σ	207.2	1000.4	959.9	269.3	384.8	-	-	-	204.7	3026.3
Permit Rangeland	C	-	-	-	-	-	-	-	-	-	-
	O	-	-	-	-	17.0	1.6	-	-	-	18.6
	M	-	-	-	-	4.0	13.8	-	-	-	17.8
	P	-	-	-	-	279.3	36.4	-	-	-	315.7
	I	-	-	-	-	-	1.6	-	-	-	1.6
	Σ	-	-	-	-	300.3	53.4	-	-	-	353.7
Total "CLOSED" Alienation	C	-	5.3	-	-	-	-	-	-	-	5.3
	O	17.4	153.0	0.4	22.7	39.2	1.6	-	-	5.2	239.5
	M	176.8	771.8	876.6	257.4	6.8	13.8	-	-	225.8	2329.0
	P	-	151.7	-	-	646.4	36.4	-	-	-	834.5
	I	13.0	91.1	98.7	15.0	-	1.6	-	-	3.2	222.6
	Σ	207.2	1172.9	975.7	295.1	692.4	53.4	-	-	234.2	3630.9

C- Construction O - Offsites M - Mine P - Plant I - Indirect

* Farm Unit Number, see figure 5-2 (foldout) for location.

TABLE 5-30

LAND ALIENATION - PROBABLE USE
ALTERNATE SCHEMES COMPARISON (ha)
SITE SPECIFIC STUDY AREA

	Alt. Reservoir	Airports		Ash Disposal Schemes			
	OD7+OD8*	Site A (OA1+OA4)	Site C (OA3+OA6)	Base Scheme P6+P7	Wet Alternate P6+P7.5 +Alt. Pipeline	Dry I P8,9	Dry II P10-13
Irrigated Crop							
Tomatoes			38.5***				
Corn	0.8						
Cabbage		29.5**					
Hay	68.6						
All season pasture		13.0		16.2	16.2		
Spring Grazing Rating****							
A	4.5			230.5	396.3	255.9	205.4
B	51.4	4.3					
C		3.0					
Summer Grazing Rating****							
F	0.8			7.3	8.3	26.7	13.4
G	1.6			348.0	365.6	21.0	41.7
H				71.6	71.6		
Total	127.7	49.8	38.5	673.6	858.0	303.6	260.5

* Project facility codes (see Appendix D).
** Based on Site Specific Study Area analysis.
*** Based on Local Study Area analysis.
**** Refer to figure 5-2 (foldout) for description.

The most significant alienation impacts of the four ash disposal schemes are on spring range, where from 205.4 ha (508 acres) in the Dry Ash Scheme II to 396.3 ha (979 acres) in the Alternate Wet Scheme are alienated. Comparing alienation impacts, the two dry ash schemes have similar impacts and would be preferable from the standpoint of agriculture. As the alternate wet scheme alienates equal or greater quantities of land in every category of probable use than the others, it is obviously the least desirable choice.

(ii) Noise

A review of literature indicated that only a limited amount of definitive information is available on the impact of noise on agricultural operations. Ames[71] points out that when applying compatibility criteria, it should be kept in mind that animals become conditioned to sound and these conditioned animals do not show the same stress symptoms as animals that are not conditioned.

Guidelines for compatible and marginally compatible sound levels for agriculture, including and excluding livestock production, as given in the Harford, Kennedy, Wakefield report[70] are summarized following:

1) Livestock Farming
   - maximum compatible day-night average sound level, YDNL* 65
   - marginally compatible day-night average sound level, range YDNL 65-75.
2) Agriculture with No Livestock
   - maximum compatible day-night average sound level, YDNL 75
   - marginally compatible day-night average sound level range, YDNL 75-85.

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* YDNL (yearly day night average sound level) - the logarithmic average of the day night average sound level over a full year. (For more complete definition of noise level parameters, consult reference[70]).

The impact of construction noise on agriculture would be minimal. For example, during the first year of the project, when the peak construction noise would occur, the cattle-grazing criteria of YDNL 65 would only be exceeded within about 150 m (500 ft.) of the project activity areas of the north valley dump and access road, respectively.[70] However, ranch fencing would probably be installed within about 50 to 100 m (160 to 330 ft.) of the pit and dump operations, thus precluding cattle grazing in those potential noise impact areas.[70]

(iii) Dust Emissions

The soils within the Site Specific Study Area are moderately to highly susceptible to dusting. As a result, dusting will be a potential problem attendant the construction of all facilities and roads. The amount of dust produced by construction activities could be reduced by spraying disturbed soils with water or dust suppression chemicals.

Photosynthesis of vegetation can be restricted by dust that covers or partially covers leaf surfaces. In an arid environment, such as the Site Specific Area, where rainfall does not often wash the plants, dust coverage could reduce plant productivity. Information on such losses was not available since such conditions are not easy to quantify. Reduced photosynthesis activity would not be a problem with agricultural crops of the area since they are irrigated and removal of the dust from the plants would occur. However, heavy dusting of agricultural crops during field drying or while being stored would reduce their value.

The effect of dust on livestock is not well defined. It is felt by some animal scientists that livestock exposed to dust could be more prone to respiratory disease. However, studies are not available to substantiate this feeling.

Considering the generally localized distribution of dusting that would be attributable to construction activities and that dusting could be reduced by dust suppression techniques, it is perceived that the impact of dust on agriculture would not be a significant problem.

(iv) Physical Barriers

Without mitigation the project would impose significant barrier impacts on at least six of the main farm units within the Local Study Area by restricting animal and vehicle movement. Farm units 4, 5, 6, 7 and 8 would be affected by these barrier impacts.

The greatest impacts due to barriers would be associated with farm unit 5 where project facilities would restrict access to four separate areas on deeded land and restrict access to 21 separate areas on leased land. For farm unit 7, project facilities would restrict access to five separate areas on deeded land and restrict access to five separate areas on leased land. There would be 15 other separate land areas among the remaining three farm units that would be affected by barrier restrictions.

In general, so long as appropriate mitigation measures are implemented to alleviate the barrier impacts, this type of impact is not considered a serious deterrent to the use of the agricultural lands affected. Mitigation aspects are discussed in more detail in Section 6.1(a) (iii).

(c) Operation

(i) Stack Emissions

A. Sulfur Dioxide/Nitrogen Dioxide

Present Use

The Environmental Research and Technology report[72] and the Runeckles report[1] were the primary documents reviewed in the assessment of air emission impacts. These reports provide projections of air emission patterns and injury to vegetation for three different emission cases — the 366 m stack Flue Gas Desulfurization (FGD) air quality model, the 366 m stack Meteorological Control Strategy (MCS) air quality model, and the 244 m stack MCS air quality model.

There are no regional impacts on vegetation identified for the stack emissions of any of the ERT models assessed. The impacts identified were of a local nature and were addressed on the basis of the Local Study Area.

No significant impacts were identified for the 366 m stack FGD model.

The amount of presently irrigated land that lies within air emission receptor sectors (as per the ERT air quality models) subject to potential impacts from air emissions of the two MCS systems[1] is provided in Table 5-31. The anticipated average impacts within each sector in terms of percent injury to alfalfa for the two MCS systems are provided in Table 5-32. The effective impacts (derived from Tables 5-31 and 5-32) on presently irrigated land within the Local Study Area from SO_2 and NO_2 emissions of the two MCS systems are shown in Table 5-33, and are broken down in terms of the following areas: Hat Creek valley, Pavilion area, Arrowstone Hills and Cornwall Hills.

TABLE 5-31

SO_2 AND NO_2 EMISSIONS

PRESENT AND POTENTIAL IRRIGATED LAND
SUBJECT TO POTENTIAL IMPACT (km^2)

LOCAL STUDY AREA

		CLI Agricultural Land Capability Class**				
Sector	Present Irrigation*	1	2	3	4	5
5	0.64	-	-	-	1.43	-
6	1.16		-	-	2.65	0.65
12	1.49	-	-	-	3.74 1.12***	-
13	1.56	-	-	-	3.22 2.53***	-
14	0.06	-	-	-	0.30	5.22
20	-	-	-	-	-	-
23	-	-	-	-	-	-
43	0.33	-	-	2.51***	-	-
44	-	-	-	-	-	-
45	-	-	-	-	0.47	-
52	-	-	-	-	-	-
85	0.42	-	-	-	9.25	0.20
86	-	-	-	-	1.72	10.90
93	0.61	0.47	-	0.20	2.60	-
94	-	-	-	-	0.46	-
107	-	-	-	-	-	-
116	-	-	-	-	2.47	-
125	-	-	-	0.79*** 1.30	-	-
126	-	-	-	1.00*** 0.24	-	4.27

* From Figure 4-9
** From Figure 4-7
*** Indicates land that is probably less suitable than indicated by CLI class, based on climate data. (Figure 4-7 legend).

TABLE 5-32

SO_2 AND NO_2 EMISSIONS
AVERAGE POTENTIAL PERCENT INJURY FOR ALFALFA
LOCAL STUDY AREA

Sector	366 m Stack*	244 m Stack*
5	-	2
6	-	2
12	-	+
13	5	4
14	10	10
20	+	1
23	+	+
43	1	2
44	1	3
45	-	2
52	-	1
85	-	3
86	-	3
93	-	7
94	-	7
107	-	1
116	1	6
125	1	3
126	-	1
Range of Injury	1-10	1-10

note

* Meteorological Control Strategy Air Quality Models
\+ Possible beneficial effect of SO_2 on growth

TABLE 5-33

SO_2 AND NO_2 EMISSIONS

EFFECTIVE IMPACT ON PRESENTLY IRRIGATED AND CLI IRRIGABLE LANDS (ha)

LOCAL STUDY AREA

	Hat Creek* Valley	Pavilion* Area	Arrowstone* Hills	Cornwall* Hills	Total
366 m Stack**					
Present Use	8.7	-	-	-	8.7
CLI 1	-	-	-	-	-
CLI 2	-	-	-	-	-
CLI 3	2.5	-	-	2.1	4.6
CLI 4	31.8	-	-	2.5	34.3
CLI 5	-	-	-	-	-
244 m Stack**					
Present Use	11.1	-	5.6	-	16.7
CLI 1	-	-	3.3	-	3.3
CLI 2	-	-	-	-	-
CLI 3	5	-	1.4	7.5	13.9
CLI 4	34.2	0.9	54.4	14.8	104.3
CLI 5	53.5	-	33.3	4.3	91.1

* Receptor sectors subject to potential impact:
Hat Creek Valley: 5,6,12,13,14,20,43,52
Pavilion Area: 44,45
Arrowstone Hills: 85,86,93,94
Cornwall Hills: 107,116,125,126

** Meteorological Control Strategy Air Quality Models.

The Hat Creek valley receives the largest effective impacts on present irrigated land which range from 8.7 to 11.1 ha (21 to 27 acres) for the 366 m stack MCS model to the 244 m stack MCS model respectively. There are approximately 1100 ha (2718 acres) of presently irrigated land in this area which means that the effective emission impacts would be about one percent of this total. The effective impact on CLI irrigable lands would be somewhat greater, up to 93 ha (229 acres) in the 224 m stack case.

The Pavilion area, which includes all areas north and northeast of the town of Pavilion, would receive no impact on present use and about 0.9 ha (2 acres) would be the effective impacts on CLI irrigable lands in the 224 m stack case.

In the Arrowstone Hills area, which includes the land within and northeast of the Bonaparte valley, no impacts would occur from the 366 m stack case but significant effective impacts would occur in the 244 m stack case, these being 56 ha (138 acres) of presently irrigated land and 92 ha (228 acres) of CLI irrigable lands.

In the Cornwall Hills area which includes lands south of the Bonaparte valley and east of the Hat Creek valley, no impact on presently irrigated land would occur. The effective impacts on CLI irrigable lands would be 4.6 ha (11 acres) and 26.6 ha (66 acres) in the 366 m stack and 244 m stack cases respectively.

An analysis was done regarding the expected impact of stack emissions on the vegetation of rangelands within the Local Study Area. The details of this analysis are included in the *Physical Habitat and Range Vegetation* report[44] that was prepared as part of the overall environmental studies. This analysis was based on the ERT[72] and Runeckles[1] reports and is subject to the limitations of these reports. The major limitation was that information was not available on the dose-response characteristics of most range grass species found within the Local Study Area and therefore it was impossible to predict with any meaningful accuracy the impact on these species.

Poa pratensis was the one range grass species for which injury predictions were made. No significant injury was predicted due to air emissions of 366 m stack FGD air quality model; 1.7 km^2/yr. (0.7 mi^2/yr) of species cover with an injury level between 1 to 7 percent was predicted to be affected by the emissions of the 366 m stack MCS air quality model; and 2.2 km^2/yr (0.8 mi^2/yr) of species cover with an injury level between 1 to 14.4 percent was predicted to be affected by the emissions of the 244 m stack MCS air quality model. Other quantitative injury predictiors for a few woody vegetation species important to livestock, included in the TERA report[44], are of less magnitude than for *Poa pratensis*. The significance of these results with respect to livestock use of the range resource is not estimable due to the lack of information for other range species.

Probable Use

The anticipated impacts of SO_2/NO_2 stack emissions on the probable agricultural use of the upper Hat Creek valley was assessed in a manner similar to that for present use with the results providing input to the projection of probable agricultural use with the project (see Section 5.3).

The probable irrigated land that would be subject to potential impact from SO_2/NO_2 emissions is shown in Table 5-34. This land is subdivided for the deeded and leased component of each farm unit on the basis of the probable irrigated use categories of hay, all-season pasture and spring pasture.

Effective impacts (Table 5-35) were obtained by multiplying the potential percent injury for alfalfa (see Table 5-32) by the area of probable irrigated land (see Table 5-34) for each sector.

TABLE 5-34

SO_2 AND NO_2 EMISSIONS -
PROBABLE IRRIGATED LAND SUBJECT TO POTENTIAL IMPACT (ha)
UPPER HAT CREEK VALLEY

Crop Type	Sector	Farm Unit Number* 1 D	1 L	2 D	2 L	3 D	3 L	4 D	4 L	5 D	5 L	Total
Hay	5	26	-	23	-	4	-	-	-	-	-	53
	6	68	-	27	-	-	-	-	-	-	-	95
	12**	-	-	-	-	-	-	112	-	33	2	147
	13	5	-	1	-	36	-	112	-	-	-	154
	14	5	-	-	-	-	-	-	-	-	-	5
All-Season Pasture	5	6	-	5	-	-	-	-	-	-	-	11
	6	16	-	5	-	-	-	-	-	-	-	21
	12**	-	-	-	-	-	-	-	1	1	-	2
	13	1	-	-	-	-	-	-	1	-	-	2
	14	1	-	-	-	-	-	-	-	-	-	1
Spring Pasture	5	11	5	14	-	2	-	-	-	-	-	32
	6	29	13	16	-	-	-	-	-	-	-	58
	12**	-	-	-	-	-	-	57	-	11	7	75
	13	2	1	-	-	18	-	57	-	-	-	78
	14	2	1	-	-	-	-	-	-	-	-	3
Total	5	43	5	42	-	6	-	-	-	-	-	96
	6	113	13	48	-	-	-	-	-	-	-	174
	12**	-	-	-	-	-	-	169	1	45	9	224
	13	8	1	1	-	54	-	169	1	-	-	234
	14	8	1	-	-	-	-	-	-	-	-	9

* See Figure 5-2 (foldout) for location.

** The only impact identified for sector 12 was possible beneficial effect in the 244 in MCS model

D Deeded L Leased

TABLE 5-35

SO_2 AND NO_2 EMISSIONS
AVERAGE EFFECTIVE IMPACT ON PROBABLE IRRIGATED LAND (ha)
UPPER HAT CREEK VALLEY

	Farm Unit Number*						
	1		2	3	4		
	D	L	D	D	D	L	Total
366 m Stack***, **							
Hay	0.75		0.05	1.8	5.6	-	8.20
All-Season Pasture	0.15	-	-	-	-	0.05	0.20
Spring Pasture	0.3	0.15	-	0.9	2.85	-	4.20
Total	1.2	0.15	0.05	2.7	8.45	0.05	12.60
244 m Stack**							
Hay	2.58	-	1.04	1.52	4.48	-	9.62
All-Season Pasture	0.58	-	0.2	-	-	0.04	0.82
Spring Pasture	1.08	0.5	0.6	0.76	2.28	-	5.22
Total	4.24	0.5	1.84	2.28	6.76	0.04	15.66

* See Figure 5-2 (foldout) for location.
** Meteorological Control Strategy Air Quality Models.
*** This case was used to calculate the "with" case for Hat Creek basin.
( ) Indicates area that would be downgraded to grazing class "B" (included in bracketed number)
D Deeded
L Leased

The 366 m and 244 m stacks have effective impacts on probable irrigated land of the upper Hat Creek valley of about 13 and 16 ha (31 and 39 acres) respectively. Farm units 1 and 4 would receive the highest impacts, containing 78 percent and 71 percent of the effective impacts from the 366 m and 244 m stacks respectively.

B. Trace Elements

The conclusion reached by ERT in their report on trace elements is that "*release of trace elements from coal mining and electric power generating activities of the Hat Creek project is not expected to be detrimental to terrestrial or aquatic ecosystems.*[73] On the basis of this report, no significant impacts from the emission of trace elements from the power plant stack on the agricultural resource are expected.

There is some evidence that certain trace elements presently exist at higher levels in the soil than would normally be expected. These trace elements include arsenic, cadmium, chromium, fluorine and selenium of which arsenic and selenium are of particular concern since they presently exist at certain sites at levels[73] that may be harmful to livestock or wildlife that feed on the vegetation growing on these soils. As well, since fluorine tends to be accumulated by vegetation and can have adverse effects on livestock, there would be a need to monitor the levels of arsenic, selenium and fluorine in the soils and vegetation prior and during operation of the proposed power plant.

(ii) Cooling Tower Emissions

The cooling tower emissions are not expected to have an adverse effect on the agricultural resource. This assessment was based on the ERT report on cooling towers which states "*cooling towers* *will not be a significant source of trace elements to terrestrial and aquatic ecosystems*"[74] and the Runeckles report which states that "*cooling tower emissions are expected to have minimal adverse effects on vegetation.*"[1]

Calculations on the amount of salt that would be added to the land as a result of the cooling tower emissions showed that this amount would be very small in comparison to the amount that would be added if the land were irrigated with water from Hat Creek or Thompson River.

(iii) Waste Disposal

The waste disposal impact on agriculture included consideration of the loss of agricultural land, the possible leaching of deleterious materials from these waste disposal areas and the land disposal of sewage wastes.

The direct loss of land due to alienation by waste disposal facilities was presented in Section 5.2(b)(i). On the basis of the ERT report on trace elements[73] the leaching of waste disposal areas would not result in the release of trace elements at a level that would affect agriculture. The land application of sewage would provide a benefit to agriculture since it would provide both nutrients and water.

(iv) Noise

The maximum noise impacts from the project are expected during full plant and mine operation. However, as outlined in Section 5.2(b)(ii) which considered the impact of noise during construction, livestock become accustomed to noise and, in general, the impact on agriculture would be minimal.

During the operation phase the noise level criteria of YDNL 65 would be exceeded over a small area east of the plant but as this area is not highly productive grazing land, the impact on grazing from plant operation is considered insignificant. However, the area immediately adjacent the pit and coal preparation area would be of some concern to agriculture. It was estimated[70] that livestock grazing would be incompatible with noise from the mine within approximately 600 m (1969 ft) of the rim of the pit. Range fencing would cordon off the areas between the pit and the two major waste dumps and also all the other area within about 100 m (330 ft) of the pit rim thus reducing the potential impact area.

The impact is not considered as an outright loss, but rather some loss in productivity. A reduction in the use of the grazing resource would probably occur since the animals may be reluctant to graze this area as intensively as areas further away from the pit rim.

(v) Dust Emissions

The operation phase of the project would have dust problems similar to those outlined for the construction phase with similar potential impacts on agriculture. These impacts can be reduced through the use of dust suppression techniques.

(d) Decommissioning

The decommissioning phase of the project would take place when the plant and mine are no longer in operation. During this phase the facilities wherever possible would be removed with the exception of those that would be used for an alternate function. Possible alternate functions would be the use of the water pipeline from the Thompson River and the various reservoirs to provide irrigation water. Final land reclamation would be carried out during this phase and all revegetation would be completed.

The impact of decommissioning on agriculture would probably be positive. This conclusion is based on the premise that some land alienated by the project would be returned to agricultural production, that physical barriers would largely be removed and that additional water might be available for irrigating previously non irrigated lands if use of project water supply facilities is feasible.

The reclamation of the mine waste dumps and the plant fly ash dumps is dealt with in detail in the *Physical Habitat and Range Vegetation* report[44] that was prepared as part of these overall environmental studies. Of particular interest to agriculture would be the planting of these reclaimed areas with suitable agricultural forage species and the recontouring of areas to improve their agricultural value. Much of this work should be done on a continuing basis throughout the operation phase so that the end use could be obtained in an efficient and economic manner. Cropland or rangeland use of these waste dumps, however, may be restricted by harmful levels of trace elements within the dump materials and this situation would need to be carefully monitored.

The *Hydrology, Drainage, Water Quality and Use* report[49] projects that 1600 ha-m (12,971 acre-ft) of storage would be available in project reservoirs; 1036 ha-m (8399 acre-ft) of this storage water could be available for irrigation. Assuming an irrigation demand of 0.76 to 0.91 m (2.5 to 3.0 ft) this storage could supply irrigation water for between 1349 and 1126 hs (3333 and 2782 acres). The water supply pipeline from the Thompson River could also supply irrigation water to an estimated additional 700 to 1100 ha (1730 to 2718 acres).

(e) Induced Impacts

(i) Farm Unit Multiplier Effects

A multiplier effect occurs if any impact on a portion of an individual farm causes a larger component of the farm or the entire farm to fail. In considering the multiplier effect on a farm unit basis for the upper Hat Creek valley farm units 5, 6, 7 and 8 are the most severely impacted (see tables 5-29a, 5-29b and 15-35) and if they were to remain individual farm units might have exhibited multiplier effects. However, these units were assumed to be under B.C. Hydro ownership[75] and were treated along with other B.C. Hydro property including farm unit 14 as a single block. Conceptually, the B.C. Hydro block or combination or original individual farm units could be operated as one farm or be redivided into two or three new individually operated farm units. It is anticipated that new units could be so defined as to be free of any multiplier effects. A more detailed analysis would be needed to determine the most efficient allocation of farm units.

The remaining individual farm units which would experience impacts from the project are 1, 2, 3, 4 and 11 (see tables 5-29a, 5-29b and 5-35). These farm units appear to suffer comparatively minor impacts under the project base case and no multiplier effects are foreseen. That is, only a small percentage of farm resources would be lost and the resultant net farm resource <u>with</u> the project appears to be ample to sustain a viable farm unit operation.

(ii) Regional Effects

Induced (indirect) impacts of a more regional nature are those that would occur as the result of the primary impacts (losses or gains of agricultural production) and those that would gain impetus because of the Hat Creek development. The main induced impacts perceived in this case are the anticipated reduction in regional agri-service business, the possible encroachment of urban housing and associated services on to agricultural land, and the possible effects that the change of land ownership might have.

The Hat Creek project, which would result in a reduction of agricultural land and associated cattle production, would have some effect on related agricultural industries of the area. The industries that would feel this effect the most are commercial services that operate at near marginal capacity at present. This includes feed and fertilizer suppliers, farm equipment suppliers, a cattle saleyard, and the associated agricultural transport industry. Any reduction in demand for these services caused by the Hat Creek project may affect industry efficiency and therefore viability.

The project would generate increased economic activity within the region that would result in an increased demand for urban housing and associated service businesses. The location of these onto agricultural land will result in attendent loss of agricultural production. The most likely areas for this encroachment to occur would be near the present towns of Cache Creek and Ashcroft.

The change of agricultural land ownership that has already occurred and that which would further accompany the Hat Creek development may have an impact on agricultural production that is difficult to predict. If, as assumed in the analysis of farm units of upper Hat Creek valley that lands owned by B.C. Hydro but not lost to the project would continue to be utilized for agricultural production in an efficient manner, then this change in ownership should not result in a great deviation from the expectations of agricultural production projected for the <u>with</u> project case (see Section 5-3 following). This change in ownership may, however, contribute to agricultural production that deviates from that projected due to the temporary production losses occurring during initial ownership changeover and longer term production losses occurring as a result of the time interval between the purchase of lands by B.C. Hydro and the successful rearrangement of this land into active production units. There is also the opportunity for an improved level of production from these B.C. Hydro lands over that projected should farm enhancement be encouraged and supported.

(f) Summary of Impacts

Tables 5-36 and 5-37 provide a summary of impacts within the upper Hat Creek valley on an individual farm unit basis. The impacts tabulated include the land totally alienated by construction activities and land effectively alienated by SO_2/NO_2 emissions. Impacts do not include noise impacts described qualitatively earlier nor do they include any barrier impacts which are viewed as being minimal assuming that appropriate and successful mitigation could be implemented.

The total impacted probable irrigated lands in upper Hat Creek valley amount to 196.7 ha (486.1 acres), about 12 percent of the total probable irrigated lands for the without the project case. The impact on rangeland, occurring only within upper Hat Creek valley, as shown in table 5-37 is 3321.8 ha (8208.3 acres), about 5 percent of rangeland within the Hat Creek basin. Of this total, impacted deeded and leased probable grazing lands in upper Hat Creek valley amount to 2983.9 ha (7373.4 acres) or 21 percent of the total deeded and leased probable grazing lands for the without project case. The alienation of permit land, 337.9 ha (835.0 acres), is an extremely small percentage of the total basin permit area.

TABLE 5-36

SUMMARY OF IMPACTS* ON PROBABLE IRRIGATED LAND (ha)

UPPER HAT CREEK VALLEY

Crop Type		Farm Unit Number** 1	3	4	5	6	7	8	Unclass.	Total
Corn	D	-	-	-	-	0.4	-	-	7.3	7.7
	L	-	-	-	109.7	-	-	-	-	109.7
Hay	D	0.7***	1.8***	5.6***	-	10.5	5.6	-	-	24.2
	L	-	-	-	-	-	-	-	-	-
All-Season	D	0.2***	-	-	-	-	-	-	-	0.2
Pasture	L	-	-	0.1	-	-	2.0	7.3	-	9.4
Spring	D	0.3***	0.9***	2.8***	-	4.9	5.7	-	18.2****	32.8
Pasture	L	0.2***	-	-	-	-	12.5	-	-	12.7
Total		1.4	2.7	8.5	109.7	15.8	25.8	7.3	25.5	196.7

* Includes "CLOSED" alienation and SO_2/NO_2 air emission impacts.

** See Figure 5-2 (foldout) for location.

*** Impact from 366 m stack Meteorological Control Strategy Air Quality Model.

**** Farm Unit 14.

D Deeded

L Leased

TABLE 5-37

SUMMARY OF IMPACTS* ON PROBABLE RANGELAND (ha)

UPPER HAT CREEK VALLEY

Grazing Rating**		Farm Unit Number** 4	5	6	7	8	9	Unclass.	Total
A	D	-	-	181.6	-	-	-	-	181.6
	L	26.3	332.3	27.9	-	126.4	-	-	512.9
	P	-	-	-	-	69.2	0.8	-	70.0
B	D	10.5	-	1.2	7.4	-	-	22.3	41.4
	L	37.3	5.6	-	37.2	-	-	-	80.1
	P	-	-	-	-	-	-	-	-
C	D	-	-	22.7	-	-	-	161.4	184.1
	L	-	42.1	144.9	38.9	-	-	-	225.9
	P	-	-	-	-	-	-	-	-
D	D	-	-	10.5	-	-	-	-	10.5
	L	-	1.6	0.8	90.7	-	-	-	93.1
	P	-	-	-	-	-	13.4	-	13.4
F	D	-	-	32.4	0.4	-	-	-	32.8
	L	124.6	280.8	2.0	2.0	1.2	-	-	410.6
	P	-	-	-	-	-	3.2	-	3.2
G	D	0.4	-	29.6	-	-	-	-	30.0
	L	8.1	287.1	420.9	92.7	175.1	-	-	983.9
	P	-	-	-	-	163.9	36.0	-	199.9
H	D	-	-	-	-	-	-	-	-
	L	-	13.7	-	-	77.3	-	-	91.0
	P	-	-	-	-	51.4	-	-	51.4
RO	D	-	-	23.1	-	-	-	-	23.1
	L	-	-	62.3	-	-	-	20.6	82.9
	P	-	-	-	-	-	-	-	-
Total		207.2	963.2	959.9	269.3	664.5	53.4	204.3	3321.8

* Includes "CLOSED" alienation and SO_2/NO_2 air emission impacts.

** See Figure 5-2 (foldout) for location and description.

D Deeded
L Leased
P Permit

5.3 AGRICULTURAL RESOURCE PROJECTION WITH THE PROJECT HAT CREEK BASIN BEEF INDUSTRY

The probable beef industry of Hat Creek basin and the associated farm unit activities were projected for the with project case by subtracting project impacts from the probable without the project case. The tabulation of probable use with the project case for irrigated land and deeded and leased rangeland of the upper Hat Creek valley by farm units is given in Tables 5-38 and 5-39 respectively.

Probable agricultural use with the project as in the without case, was based on the available feed resources of the Hat Creek basin and the requirements of the cow-calf type of operation. It was determined in the previous section dealing with assessment of individual farm units that there would be no apparent multiplier effect on individual farm units or the composite B.C. Hydro farm holding. The individual impacts on the feed resources of the beef industry were summed for each resource over the total Hat Creek basin and a projection made to determine the available resources for the with case. It was again assumed that the Hat Creek basin industry would effectively represent a closed feed system, i.e., crops grown in the basin would be totally consumed by the basin beef industry.

(a) Base Irrigated Land

Combining the with case probable irrigated land (Table 5-38) for the upper Hat Creek valley with values for the lower Hat Creek valley, where no significant impact occurs, results in the probable irrigated lands with the project for the entire Hat Creek basin as shown in Table 5-40.

TABLE 5-38

PROBABLE USE WITH THE PROJECT - IRRIGATED LAND (ha)
UPPER HAT CREEK VALLEY

Crop Type	Tenure	Farm Unit Number* 1	2	3	4	5	6	7	8	11 (I.R.)	14	Unclass.	Total
Corn	D	-	-	-	-	-	-	30.8	-	53.8	-	-	84.6
	L	-	-	-	-	138.8	-	-	-	-	-	-	138.8
	Σ	-	-	-	-	138.8	-	30.8	-	53.8	-	-	223.4
Hay	D	104.5	50.6	38.7	218.2	167.1	-	34.9	-	28.3	52.6	10.1	705.0
	L	-	-	-	-	9.7	-	-	-	-	-	-	9.7
	Σ	104.5	50.6	38.7	218.2	176.8	-	34.9	-	28.3	52.6	10.1	714.7
All-Season Pasture	D	24.1	10.1	-	0.8	5.3	15.0	40.4	-	-	-	-	95.7
	L	-	-	-	1.9	-	-	16.6	-	-	-	-	18.5
	Σ	24.1	10.1	-	2.7	5.3	15.0	57.0	-	-	-	-	114.2
Spring Pasture	D	45.0	30.4	19.3	110.5	54.6	-	5.6	-	16.2	8.1	-	289.7
	L	19.2	-	-	-	36.4	-	26.8	-	-	-	-	82.4
	Σ	64.2	30.4	19.3	110.5	91.0	-	32.4	-	16.2	8.1	-	372.1
Total Irrigated	D	173.6	91.1	58.0	329.5	227.0	15.0	111.7	-	98.3	60.7	10.1	1175.0
	L	19.2	-	-	1.9	184.9	-	43.4	-	-	-	-	249.4
	Σ	192.8	91.1	58.0	331.4	411.9	15.0	155.1	-	98.3	60.7	10.1	1424.4

* refer to Figure 5-2 (foldout) for location

D Deeded

L Leased

1621.1 from pg 5-11
1424.4
196.70 ha

TABLE 5-39

PROBABLE USE WITH THE PROJECT - DEEDED AND LEASED RANGELAND (ha)
UPPER HAT CREEK VALLEY

Grazing Rating*	Tenure	Farm Unit Number* 1	2	3	4	5	6	7	8	11 (I.R.)	14	Unclass.	Total
	D	-	11.3	-	-	-	82.7	-	-	36.0	-	-	130.0
A	L	18.6	23.9	125.1	45.7	673.8	47.8	3.6	55.7	-	-	-	994.2
	Σ	18.6	35.2	125.1	45.7	673.8	130.5	3.6	55.7	36.0	-	-	1124.2
	D	116.6	130.3	4.1	214.9	64.3	51.4	49.7	-	-	147.7	32.3	811.3
B	L	16.2	120.6	68.4	1606.6	220.5	61.1	90.3	-	-	-	-	2183.7
	Σ	132.8	250.9	72.5	1821.5	284.8	112.5	140.0	-	-	147.7	32.3	2995.0
	D	-	-	-	-	-	23.4	10.9	-	-	-	7.8	42.1
C	L	-	-	-	-	-	26.3	36.4	-	-	-	-	62.7
	Σ	-	-	-	-	-	49.7	47.3	-	-	-	7.8	104.8
	D	-	-	-	-	-	15.8	-	33.6	-	-	-	49.4
D	L	-	-	-	-	-	81.8	-	-	-	-	-	81.8
	Σ	-	-	-	-	-	97.6	-	33.6	-	-	-	131.2
	D	-	3.2	-	-	-	2.0	11.3	-	98.4	-	1.6	116.5
F	L	22.7	1.6	39.7	944.2	378.0	13.4	17.0	-	-	-	-	1416.6
	Σ	22.7	4.8	39.7	944.2	378.0	15.4	28.3	-	98.4	-	1.6	1533.1
	D	68.8	5.7	-	67.6	-	8.4	22.3	-	-	-	-	172.8
G	L	279.2	210.1	293.8	716.7	1178.7	1241.2	358.9	227.6	-	-	2.8	4509.0
	Σ	348.0	215.8	293.8	784.3	1178.7	1249.6	381.2	227.6	-	-	2.8	4681.8
	D	-	-	-	-	-	-	41.3	-	-	-	-	41.3
H	L	-	-	25.1	12.9	29.6	123.4	-	333.1	-	-	-	524.1
	Σ	-	-	25.1	12.9	29.6	123.4	41.3	333.1	-	-	-	565.4
	D	-	-	-	-	-	-	0.8	-	-	-	-	0.8
J	L	-	-	-	85.4	17.0	9.3	-	-	-	-	-	111.7
	Σ	-	-	-	85.4	17.0	9.3	0.8	-	-	-	-	112.5
Rock Outcrop	D	28.3	17.4	-	-	-	-	-	-	-	-	19.8	45.7
and	L	-	-	30.8	-	-	155.4	-	-	-	-	-	206.0
Water Bodies	Σ	28.3	17.4	30.8	-	-	155.4	-	-	-	-	19.8	251.7
Total	D	213.7	167.9	4.1	282.5	64.3	183.7	136.3	33.6	134.4	147.7	41.7	1409.9
Rangeland	L	336.7	356.2	582.9	3411.5	2497.6	1759.7	506.2	616.4	-	-	22.6	10089.8
	Σ	550.4	524.1	587.0	3694.0	2561.9	1943.4	642.5	650.0	134.4	147.7	64.3	11499.7

* refer to Figure 5-2 (foldout) for description and location.
D Deeded
L Leased

TABLE 5-40

PROBABLE USE WITH THE PROJECT
BASE IRRIGATED LAND (km^2)
HAT CREEK BASIN

Crop Type	Upper Hat Creek Valley	Lower Hat Creek Valley	Total Basin
Corn	2.2	-	2.2
Hay	7.1	1.6	8.7
All-Season Pasture	1.1	0.5	1.6
Spring Pasture*	3.7	1.0	4.7
Total	14.1	3.1**	17.2

* irrigated during May and first half of June.

** no significant loss of irrigated land in lower Hat Creek valley.

As there would be no significant impact on water quality for irrigation[49] it was assumed that water quality would be acceptable and non-limiting for probable use with the project.

(b) Base Rangeland

The base rangeland for the with case, derived by subtracting the impacts from the without case, is shown in Table 5-41. The total base rangeland is reduced from 622 km^2 (240 mi^2) to 590 km^2 (228 mi^2); a 17 percent reduction of spring rangeland and a 3 percent reduction of summer rangeland would occur.

(c) Probable Beef Industry

The probable beef industry for the with case was projected for the Hat Creek basin in an analagous manner to that for the without case by using basin totals for each of the base beef feed resources.

(i) Winter Feed

From Table 5-40, the total probable hay land in the Hat Creek Basin is 8.7 km^2 (3.4 mi^2). The three levels of productivity for haylands, presented in the *Inventory* volume (see page 101, Vol. I) and the ratio of the amount of land in each productivity category, as defined by the present beef industry projection, were used to project probable hay production. This projection of the probable winter feed production of the Hat Creek basin is presented in Table 5-42.

Based on an animal feed demand of 1.59 Mg-animal $unit^{-1}$ for a seven month fall/winter feeding season the herd size which could be wintered in the Hat Creek basin would be 3360 animal units (5343 Mg divided by 1.59 Mg-animal $unit^{-1}$). This is 3 percent less than that projected for the without case.

TABLE 5- 41

PROBABLE USE WITH THE PROJECT
BASE RANGELAND (km^2)
HAT CREEK BASIN

Grazing Rating*	Probable Without	Impact**	Probable With
Spring Range			
A	27	8	19
B	43	1	42
C	5	4	1
Sub Total	75	13	62
Summer Range			
D	27	1	26
E	10	-	10
F	70	5	65
G	195	12	183
H	175	1	174
J	70	-	70
Sub Total	547	19	528
Total	622	32	590

* see Table 5-8 for corresponding vegetation association.

** all impact on grazing in Hat Creek basin occurs in Upper Hat Creek valley as shown in Table 5- 37

TABLE 5-42

PROBABLE USE WITH THE PROJECT
WINTER FEED
HAT CREEK BASIN BEEF INDUSTRY

Crop Type*	Area (ha)	Probable Productivity (Mg-ha^{-1})	Production (Mg)
Alfalfa grass	642	5.6	3595
Wetland hay	138	6.8	938
Alfalfa grass	90	9.0	810
Total	870		5343
			or
		Animal Units,	3360**
			or
		AUM,	23520**

* probable corn land, 220 ha, not included.

** derived on the basis of a seven month fall/winter season with a feed requirement of 1.59 Mg-animal unit^{-1}.

(ii) Spring Feed

As in the without case, the probable spring grazing resource of the Hat Creek basin was projected on the basis that present spring ranges could be improved within about 20 years through extensive range reseeding programs to the extent that these lands would produce about 65 percent of their potential.

The various components of probable spring feed, from Tables 5-40 and 5-41, are summarized in Table 5-43. Assuming that the total spring production of 7664 AUM would be required for about a two-month period, 3832 animal units could be carried by the probable spring grazing resource once range improvement was completed assuming no limitations in other seasons. This is 19 percent less than that projected for the without case.

(iii) Summer Feed

The various components of probable summer feed, from Tables 5-40 and 5-41, are shown in Table 5-44. The 529.6 km^2 (204 mi^2) of summer dryland range and all-season pasture contributing to summer feed are projected to have a support capacity of 8740 AUM. As the summer grazing season is a three-month period this results in the probable herd size supported by the summer grazing resource to be 2913 animal units. This is 4 percent less than that projected for the without case.

(iv) Beef Industry Composite

The preceding analyses for the three feed resource seasons are summarized in Table 5-45 for the <u>with</u> case. Spring resources would be lowered substantially by the project but as in probable use <u>without</u> the project the summer season would still impose the greatest limitation on the probable herd size of the Hat Creek basin beef industry assuming no assistance

TABLE 5- 43

PROBABLE USE WITH THE PROJECT
SPRING FEED
HAT CREEK BASIN BEEF INDUSTRY

Grazing Rating*	Area (ha)	Probable Carrying Capacity ($ha\text{-}AUM^{-1}$)	Production** (AUM)
A	1900	0.62	3065
B	4200	1.23	3415
C	100	1.23	81
Spring Pasture	470	0.6	783
All-Season Pasture	160	0.5***	320
Total	6830		7664
			or
		Animal Units,	3832****

* see Table 5-8 for corresponding vegetation association.

** assuming other seasons not limiting.

*** carrying capacity proportioned evenly between spring and summer.

**** derived on the basis of a two-month spring season.

TABLE 5-44

PROBABLE USE WITH THE PROJECT
SUMMER FEED
HAT CREEK BASIN BEEF INDUSTRY

Grazing Rating*	Area (ha)	Probable Carrying Capacity ($ha\text{-}AUM^{-1}$)	Procuction** (AUM)
D	2,600	5	520
E	1,000	6	167
F	6,500	6	1,083
G	18,300	6	3,050
H	17,400	6	2,900
J	7,000***	10	700
All-Season Pasture	160	0.5****	320
Total	52,960		8,740
			or
		Animal Units,	2,913*****

* see Table 5-8 for vegetation association.

** assuming other seasons not limiting. Note that spring rangeland, not included, could also be used during the summer.

*** includes rock outcrops and water bodies.

**** carrying capacity evenly proportioned between spring and summer.

***** derived on the basis of a three-month summer season.

TABLE 5- 45

PROBABLE USE WITH THE PROJECT
SEASONAL RESOURCE SUMMARY
HAT CREEK BASIN BEEF INDUSTRY

Season	Production* (AUM)	Maximum Probable* Herd Size (Animal Units)
Winter (7 months)	23,520	3,360
Spring (2 months)	7,664	3,832
Summer (3 months)	8,740	2,913

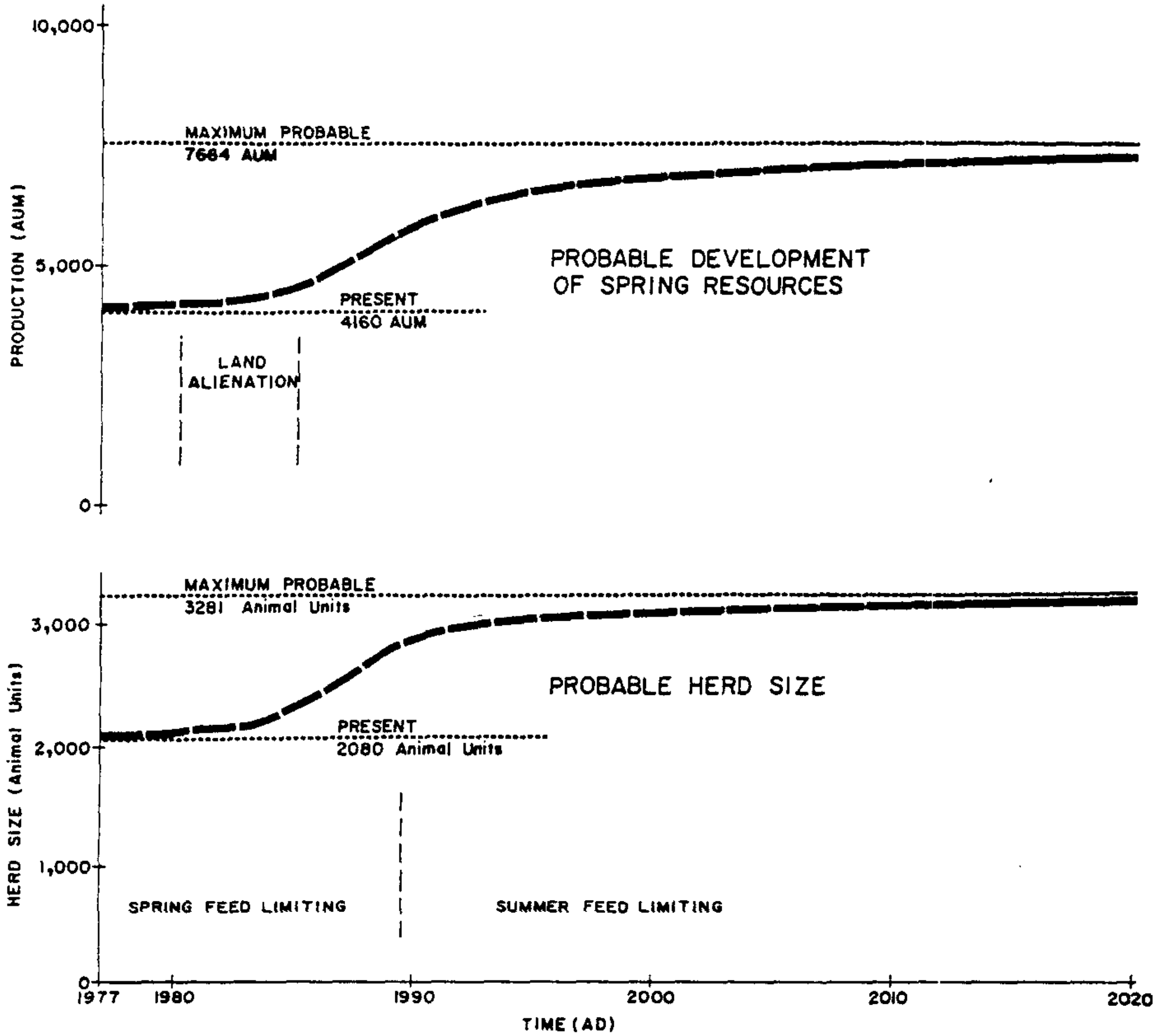
* assuming no limitations or assistance from resources associated with other seasons.

from tne feed resources of the other seasons. When the resources are optimally combined by shifting the 1102 AUM of the spring resources to the summer season, the maximum probable herd size of 3281 animal units (total of spring and summer production, 16,404 AUM, used over five months) is just under the herd size determined for the winter season. Therefore, in the with case, the scenario would not quite enter a winter limiting period as it did for the without case projection.

The probable development of the spring feed resource, illustrated in Figure 5-4, results from the consideration of the loss of spring rangeland alienated by the project and the increase of productivity of non-alienated spring rangeland due to reseeding. The present spring range production of 4160 AUM eventually approaches the probable maximum of 7664 AUM. Note that some of this development would be used during the summer season. The corresponding curve of projected herd size is also shown in Figure 5-4, starting from the present size of 2080 animal units and approaching 3281. These curves are based on the same rationale as that used in the without case with the addition of the following:

1. That the entire direct effect on the project due to land alienation would be felt during the period from 1980 to 1985 when most of the construction would occur. The rate of alienation and its effect on the beef industry would be gradual at first with the greatest rate occurring during the middle of the construction period, thus suppressing the increase of the basin herd (over that of the without case) the greatest at this time.

2. That the development of non-alienated spring resources would increase at the same rate as in the without case during the "spring feed limiting" period except for end effects from the adjoining "summer limiting" period which would occur sooner after the period of peak range development than in the without case.



PROBABLE DEVELOPMENT WITH THE PROJECT
SPRING RESOURCES PRODUCTION & HERD SIZE VERSUS TIME
HAT CREEK BASIN BEEF INDUSTRY

FIG. 5-4

3. That in the development of spring resources during the "summer feed limiting" period, the approach to the maximum would be identical to the without case.

Alienation of spring rangeland would be the most significant factor in the determination of project impact on the herd size. This is due to the relatively large amount of alienation of this land category (17 percent) and the fact that this feed resource would be the factor controlling the growth of herd size. At the end of the land alienation period, the impact on spring production would be 19 percent or about 800 AUM and since spring feed would still be limiting at this time, the corresponding impact on herd size would therefore be about 400 animal units. This impact would become less severe with time as the maximum probable herd size of 3281 animal units is only 6 percent less than the size which would be reached without the project.

As in the without project case, it was assumed that constraints would be such that the increase in winter feed production would not be developed faster than necessary for the base herd requirements. If conditions were favorable for more rapid development then additional feed (hay) would be available for sale or backgrounding until the development of spring resources caught up.

The production of corn silage in the basin and its use for possible backgrounding and finishing of cattle was not included as part of the basin resource model for reasons explained in the without case. If the probable corn land was developed, the estimated total production of 13,563 Mg (14,951 tons) of corn silage (2.2 km^2 x 6165 $Mg\text{-}km^{-2}$, see Tables 5-40 and 5-4) could provide the silage portion of a feed ration for a feedlot operation producing approximately 7500 head of beef cattle for slaughter each year (based on the silage requirement of 1.82 $Mg\text{-}animal^{-1}$ (2 $tons\text{-}animal^{-1}$). If the corn land was not developed, it would remain as dryland range with a grazing rating of F.

Table 5-46 shows the economic analysis of the probable with case beef industry for the same five dates from the present (1977) to the year 2020 AD, used in the probable without case analysis. The table is arranged identically to that of the scenario economics for the without case (Table 5-19) to facilitate comparison of the various economic elements. Additional economic analysis of the impact of the Hat Creek project on agriculture is presented in the Hat Creek detailed Environmental Studies component report dealing with *Resource Evaluation* authored by Strong, Hall and Associates Ltd.

TABLE 5-46

PROBABLE USE WITH THE PROJECT

SCENARIO ECONOMICS

HAT CREEK BASIN BEEF INDUSTRY

	1977 AD	1980 AD	1990 AD	2000 AD	2020 AD
a) Cows (from model analysis)	2000	2038	2813	3009	3109
b) Calves Produced (85% a)	1700	1732	2391	2558	2643
c) Steer Calves Sold (50% b)	850	866	1196	1279	1321
d) Cow Mortality (2% a)	40	41	56	60	62
e) Cull Cows Sold (12% a)	240	245	338	361	373
f) Heifer Calves for Replacement (d + e)	280	286	394	421	435
g) Heifer Calves Sold (50% b - f)	570	581	802	858	886
h) Value of Steer Calves Sold (c × Sale Price**)	$132,600	$169,736	$234,416	$250,684	$258,916
i) Value of Cows Sold (e × Sale Price**)	$ 70,800	$ 72,275	$ 99,710	$106,495	$110,035
j) Value of Heifer Calves Sold (g × Sale Price**)	$ 67,260	$ 85,988	$118,696	$126,984	$131,128
k) Total Revenue (h + i + j)	$270,660	$327,999	$452,822	$484,164	$500,079
l) Total Cost (a × Cost·Cow^{-1}, Table 5-20)	$255,020	$259,865	$358,686	$383,673	$396,429
m) Total Net Revenue (k - l)	$ 15,640	$ 68,134	$ 94,136	$100,485	$103,650
n) Net Revenue·Cow^{-1} (m × a^{-1})	$8	$33	$33	$33	$33

**Sale Prices

	Steer Calves	Cull Cows	Heifer Calves
1977	$156	$295	$118
Other Dates	$196	$295	$148

** 1977 is based on actual prices which happen to be on the low end of the normal price cycle. Prices for other dates are estimated to be the average price of the normal cycle based on 1977 dollars.

6.0 OPPORTUNITIES FOR MITIGATION, COMPENSATION, & ENHANCEMENT

6.1 MITIGATION

(a) Land Alienation Impacts

In general, land alienation caused by project "closed" facilities and activities is considered non-mitigable. A limited number of suggestions, however, are offered in this and Section (iii) (Physical Barrier Impacts) regarding possible relocation of certain project facilities in order to diminish alienation impacts on productive agricultural land.

The facilities associated with the mine construction camp, denoted as CM 1, 2, 3, 5, & 6 (Figure D-1), are presently located on land that, while not presently cultivated, has potential for the production of corn. It would be advantageous from the standpoint of agriculture to relocate these facilities onto lower agricultural capability land so that approximately 7 ha (17.3 acres) of potential corn land would not be alienated. As well, and perhaps as important, relocating these facilities would allow more efficient agricultural use of the adjacent potential corn land that otherwise would be divided and infringed upon by the mine construction camp facilities.

The following guideline measures are provided to minimize land alienation impacts on the agricultural resource.

1) All project right-of-way widths and project facilities should be kept to minimum size.

2) Road traffic should be kept to pre-determined road alignments and not allowed over undisturbed open range vegetation. If disturbances outside construction sites occur, revegetation of the disturbed areas with suitable range species should take place immediately to maintain the range resource.

(b) Dust Emission Impacts

Fugitive dust emissions of the project, while not projected to be of significant impact on agriculture, should be kept to a minimum by the judicious use of water and/or chemical spray controls.

(c) Physical Barrier Impacts

General mitigation measures to reduce the impacts caused by project barriers are covered by the following list proposed by B.C. Hydro.[75]

1) Provision of fence gates to allow agricultural use of land.

2) Provision of farm access roads and crossings to lands having present accesses affected by project, where economic.

3) Maintenance of irrigation water supply for systems blocked by project but with irrigated land still intact, where economic.

4) Fencing of project components from farm fields.

5) Use of B.C. Hydro access roads for farm/range purposes where compatible.

The selection of the mitigation measures appropriate to land use expectations will depend to a large extent on the eventual arrangement of farm unit parcels under the ownership of B.C. Hydro.

Relocation of the following project facilities are suggested to reduce barrier impacts.

1) Relocation of the project drainage ditches near the south-west extremity of the mine pit so as to avoid splitting a presently irrigated field into two pieces;

2) Partial relocation of the main access road (OR1) and conveyors (M17) to minimize the partition of the potential corn land located northeast of the mine pit. It is possible that the preferred location of both the road and conveyor has little flexibility, but optimum compatibility with agricultural land use should be considered.

6.2 COMPENSATION

Two categories of compensation measures are addressed in this section of the report; namely, those that compensate individual ranches and ranch owners and those that compensate on the regional and provincial accounts. The latter includes consideration of induced (indirect) impacts that would not normally be part of compensation to individual ranchers.

Individual ranches or ranch owners may be compensated for project impacts through:

1) The purchase, by B.C. Hydro, of the ranch or the portion of the ranch affected by the project,

2) The trade, by B.C. Hydro, of the ranch or the portion of the ranch affected by the project for comparable lands and/or facilities.

3) The improvement, by B.C. Hydro, of lands and/or facilities owned by the ranch to offset the impact on the ranch. One example would be the supply of irrigation water to increase the productivity of the land not impacted.

Consideration of compensation to the regional and provincial agriculture accounts would relate to some of the induced impacts identified in Section 5.2(e). These impacts are associated with the anticipated reduced level of activity in certain of the other agricultural industries of the region resulting from the reduced production and expectations of the beef industry of the area. These impacts would include reduced marketings through the local sale yards, reduced transportation activity associated with transporting livestock to the sale yard and then to their ultimate market, and reduced activity in the service industries associated with agriculture such as feed mills, farm machinery supply, etc. These induced impacts have not been quantified in this study and appropriate compensation would need to be discussed between B.C. Hydro, the industries affected and various government agencies.

The concept of maintenance of the productivity of agriculture on a regional or provincial basis has been advanced by some government representatives interviewed during this study. This concept involves maintaining agricultural productivity (in lieu of losses to agriculture caused by non agricultural development) through the development of agricultural production in areas that would not be brought into production using current benefit-cost relationships. The rationalization of this concept was not part of this study and is left for discussion between B.C. Hydro and the appropriate government agencies.

6.3 ENHANCEMENT

(a) Agricultural Use of Cooling System Waste Heat

(i) Introduction

The purpose of this section is to update and add to studies done previously which specifically address the potential for waste heat utilization by agriculture as applied to the Hat Creek situation. These studies include one by the Ministry of Agriculture (BCMA) *Report on Waste Energy Utilization for Agriculture, Hat Creek Greenhouse Proposal*[77] and a brief in-house report prepared by B.C. Hydro.[78]

The use of waste heat by agriculture is conceptually very appealing as it uses energy not otherwise beneficially utilized. Also, under certain circumstances this use of waste heat might conceivably replace a portion of the plant cooling system which would otherwise be required. However, in all cases there are additional capital and operating costs over those of the conventional systems which have to be considered.

Various waste heat uses have been considered with most attention given to greenhouse use since this seems to be most promising. Aspects which are common to greenhouse use and other alternatives are discussed in detail in the greenhouse section only.

(ii) Hat Creek Location and Climate

Figure D-1 (foldout) shows the proposed location of the power plant at an elevation of about 1400 m (4593 ft), which is 300 m (984 ft) above Hat Creek valley bottom. A preliminary analysis of B.C. Hydro meteorological measurements[79] indicates that temperatures near the plant site are comparable with the valley bottom, but perhaps not as extreme, i.e., not quite as cold in winter and not quite as warm in summer.

South Surrey, a relatively intensive agricultural area, was selected by Baehr[77] as a logical location with which to compare the climate of Hat Creek. Climatic information available indicates a winter outside design temperature of -34°C (-30°F) for Hat Creek compared to -9°C (+15°F) in the south Surrey area.
A similar comparison on degree days below 18°C (65°F) indicates 5556 (10,000) for Hat Creek and 3111 (5600) for south Surrey. In heating requirement data sheets prepared by B.C. Hydro, the peak heating demand would be approximately 50 percent greater in Hat Creek.[77]

No processed information on light is available for Hat Creek. The nearest station with data available is Lytton (refer to Table 6-1) and an examination of these records indicate similar conditions to Abbotsford in the Fraser Valley.

Further detailed information of light, temperature and dew point has been gathered by B.C. Hydro and it is expected that this information will be processed and available for any further studies.

(iii) Waste Heat Characteristics

Current plant character was defined as per the 1977 Integ-Ebasco report[64] and expanded upon by more recent consultation with P. Gurney of Iteg-Ebasco and F. G. Hathorn of B.C. Hydro. The Hat Creek plant would have four 500 MW (1.71 x 10^6 Btu-hr^{-1}) generating units each designed to generate 560 MW (1.91 x 10^6 BTU-hr^{-1}) gross of which 60 MW (0.20 x 10^6 Btu-hr^{-1}) would be used for

TABLE 6-1

CLIMATE COMPARISON
HAT CREEK AND FRASER VALLEY[77]

Temperature and Precipitation Records for Hat Creek and Surrey

ELEMENT and STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR	
BRITISH COLUMBIA														
ooo HAT CREEK	LATITUDE 50 45 N LONGITUDE 121 35 W ELEVATION 2950 FT ASL													
MEAN DAILY TEMPERATURE (DEG F)	12.2	21.7	28.8	38.7	48.3	54.2	59.1	57.5	50.9	39.4	25.9	17.1	37.8	8
MEAN DAILY MAXIMUM TEMPERATURE	22.8	33.8	40.2	51.1	62.4	68.2	75.1	73.2	66.1	51.3	35.4	26.7	50.5	8
MEAN DAILY MINIMUM TEMPERATURE	1.5	9.6	17.3	26.2	34.1	40.2	43.0	41.7	35.7	27.5	16.3	7.5	25.1	8
EXTREME MAXIMUM TEMPERATURE	53	56	63	70	82	93	94	94	88	74	56	50	94	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	11	11		
EXTREME MINIMUM TEMPERATURE	-41	-13	-18	12	18	26	31	28	19	10	-27	-45	-45	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	11	11		
NO. OF DAYS WITH FROST	31	28	31	27	16	2	1	1	9	24	30	31	231	6
MEAN RAINFALL (INCHES)	0.10	0.11	0.21	0.32	0.70	1.38	1.14	1.25	0.79	0.84	0.26	0.14	7.24	8
MEAN SNOWFALL	14.5	6.2	4.0	3.2	1.5	0.0	0.0	0.0	0.2	1.5	9.[illegible]	12.2	52.4	8
MEAN TOTAL PRECIPITATION	1.55	0.73	0.61	0.64	0.85	1.38	1.14	1.25	0.81	0.99	1.1[illegible]	1.36	12.48	8
GREATEST RAINFALL IN 24 HRS	0.40	0.20	0.12	0.37	0.65	0.89	1.53	1.18	1.05	0.69	0.21	0.30	1.53	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	9	10	11	11		
GREATEST SNOWFALL IN 24 HRS	16.7	3.3	3.6	4.7	3.7	0.0	0.0	0.0	T	3.4	7.5	8.7	16.7	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	11	11		
GREATEST PRECIPITATION IN 24 HRS	1.67	0.40	0.36	0.62	0.65	0.89	1.53	1.18	1.05	0.69	0.7[illegible]	0.87	1.67	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	9	10	11	11		
NO. OF DAYS WITH MEASURABLE RAIN	1	2	2	4	6	7	8	7	6	5	2	1	51	6
NO. OF DAYS WITH MEASURABLE SNOW	10	5	5	3	1	0	0	0	0	1	7	10	42	6
NO. OF DAYS WITH M. PRECIPITATION	10	6	6	5	7	7	8	7	6	6	9	11	88	6
ooo SURREY NEWTON	LATITUDE 49 08 N LONGITUDE 122 51 W ELEVATION 250 FT ASL													
MEAN DAILY TEMPERATURE (DEG F)	35.6	40.0	42.2	47.4	53.2	58.1	62.0	61.6	57.7	49.9	42.0	37.9	49.0	8
MEAN DAILY MAXIMUM TEMPERATURE	41.0	46.8	50.1	56.2	63.1	67.9	73.1	72.7	68.4	58.4	48.2	42.9	57.4	8
MEAN DAILY MINIMUM TEMPERATURE	30.1	33.2	34.3	38.5	43.2	48.3	50.9	50.4	46.9	41.4	35.8	32.8	40.5	8
EXTREME MAXIMUM TEMPERATURE	57	67	69	74	89	92	94	92	86	75	63	62	94	6
NO. OF YEARS OF RECORD	9	9	9	9	9	9	9	9	10	10	9	10		
EXTREME MINIMUM TEMPERATURE	1	15	20	27	30	37	40	41	31	25	19	- 2	- 2	6
NO. OF YEARS OF RECORD	9	9	9	8	9	9	9	9	10	10	10	10		
NO. OF DAYS WITH FROST	17	12	13	5	1	0	0	0	*	2	7	14	71	6
MEAN RAINFALL (INCHES)	6.75	5.61	4.39	3.44	2.45	2.11	1.27	2.07	3.19	6.74	7.31	7.25	52.58	8
MEAN SNOWFALL	9.5	2.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	5.9	21.5	8
MEAN TOTAL PRECIPITATION	7.70	5.86	4.61	3.44	2.45	2.11	1.27	2.07	3.19	6.74	7.45	7.84	54.73	8
GREATEST RAINFALL IN 24 HRS	4.20	2.05	1.95	1.55	1.10	0.98	1.12	1.14	2.39	2.01	2.81	2.55	4.20	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	11	11		
GREATEST SNOWFALL IN 24 HRS	9.0	8.0	7.0	T	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.0	10.0	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	10	11		
GREATEST PRECIPITATION IN 24 HRS	4.20	2.05	1.95	1.55	1.10	0.98	1.12	1.14	2.39	2.01	2.81	2.70	4.20	6
NO. OF YEARS OF RECORD	10	10	10	10	10	10	10	10	10	10	11	11		
NO. OF DAYS WITH MEASURABLE RAIN	18	15	16	15	10	9	7	8	10	17	19	17	161	6
NO. OF DAYS WITH MEASURABLE SNOW	4	1	1	0	0	0	0	0	0	0	1	4	11	6
NO. OF DAYS WITH M. PRECIPITATION	21	16	16	15	10	9	7	8	11	17	20	20	170	6

Hours of Bright Sunshine for Lytton and Abbotsford (3 year averages).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Abbotsford	58	71	98	146	233	147	321	295	159	150	57	51	1,786
Lytton	52	96	142	194	270	240	312	274	167	137	57	40	1,941

auxiliaries. Approximately 3017 MW (10.3×10^6 Btu-hr^{-1}) would be rejected as waste heat when all four units are operating. However, over the 35-year lifetime of the project about 65 percent of the maximum possible output would be produced. The periods when the load may be partially reduced are at night, on weekends, and during the summer.[59] Discussions with project designers indicated that it would be unlikely, except towards the end of plant lifetime when the plant capacity factor would be lower, that total shutdowns would be planned. It is improbable also from the point of view of failure that all four units would be shut down at the same time.

Two natural draft hyperbolic cooling towers, each 116.4 m (382 ft) high, would discharge most of the waste heat to the atmosphere in the form of water vapour. It is possible that agriculture could beneficially use part of this waste heat. There would be two possible points of access to this waste heat.

- Steam between last turbine and the main power plant condenser.
- Condenser cooling water between condenser and cooling towers, about 606 m^3-min^{-1} (160,000 US gal-min^{-1}) for each 500 MW unit in operation.

The former source would supply temperatures comparable to those used in a conventional hot water system. It is not normally feasible to remove very low pressure steam from the closed power plant cycle which has very high water quality requirements and therefore any extension of the system to be used by agriculture would also have to be part of the same closed cycle. The system would have to be strictly regulated to insure that the steam was returned to the plant at the correct temperature and pressure to maintain optimum plant efficiency. Several installations in Romania, however, use this type of system.[80] The high-grade heat is a very important advantage. Very little information was available from which to assess the feasibility of using the steam source alternative and therefore it is not considered further in this report.

The expected monthly temperatures of the condenser cooling water which might be partially available for agricultural use are:[77]

Month		Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Temp.	°C	27	27	27	31	37	40	44	41	38	33	28	27
	°F	80	80	80	87	98	104	122	105	101	91	82	80

The minimum temperature would not be allowed to drop below 27°C (80°F) because of restrictions in cooling tower ability due to risk of icing. Agriculture would further need to account for heat loss in piping between the plant and the point of agricultural use of the waste heat.

This water would be available at an elevation of about 1400 m (4593 ft) and would have from 15 to 18 m (49 to 59 ft) of pressure head. Water used by agriculture could be returned into the sump at the bottom of the cooling towers if cooler than 27°C (80°).

The quality of water is expected to be directly related to the quality of the Thompson River water. Table 6-2 shows the design makeup water analysis. These values would be concentrated from 15 to 20 times in the condenser cooling water. In addition, chlorine would be added to control algae and sulfuric acid to control scaling.

TABLE 6-2

DESIGN MAKE-UP WATER ANALYSIS[64]

Parameter*	Average	Maximum
Total Dissolved Solids**	57.4	72.0
Total solids**	60.4	74.0
Suspended Solids**	3.1	7.6
Turbidity (JTU)**	1.8	8.5
Specific Conductance (μmho-cm^{-1})**	98	225
Oil & Grease**	1.0	2.0
pH (units)**	7.5	8.6
Alkalinity ($CaCo_3$)**	35.1	44.8
Hardness ($CaCO_3$)**	38.2	47.6
Calcium (dissolved)**	12.1	14.6
Magnesium (dissolved)**	1.9	2.6
Chloride**	1.5	3.1
Sulphate**	7.2	10.0
Silica**(as SiO_2)	4.8	6.5
Colloidal Silic	-	2.1
Nitrate-Nitrogen**	0.005	0.005
Ammonia Nitrogen	0.012	0.03
Total Kjeldahl Nitorgen	0.1	0.24
Nitrogen, Organic	0.08	0.15
Phosphorous as p**	0.007	0.021
Organic Carbon**	3.12	10.0
Inorganic Carbon**	7.4	10.0
Phenol	0.002	0.003
Arsenic, Dissolved	0.005	0.005
Chromium, Dissolved	0.005	0.005
Chromium, Total	0.005	0.005
Copper, Dissolved	0.006	0.06
Iron, Dissolved	0.09	0.10
Lead, Dissolved	0.0015	0.003
Lead, Total	0.0019	0.003
Mercury, Total (μg-l^{-1})	0.05	0.25
Manganese, Total	0.01	0.01
Molybdenum, Dissolved (μg-l^{-1})	0.5	0.7
Potassium	0.85	0.9
Sodium	2.24	3.2
Zinc, Dissolved	0.02	0.12

* All parameters express in mg-l^{-1} unless otherwise noted.

** Average values represent monthly annual averages, all other parameters represent total sample averages.

(iv) Agricultural Uses of Waste Heat

A. Greenhouses

Potential Application

It appears that the greenhouse application may be the most suitable single use of waste heat for agriculture in Hat Creek. There is evidence of technical feasibility: previous experiments in other situations have been successful using direct contact heat exchange with relatively low-grade heat, yielding satisfactory harvests of various vegetables. Dry heat exchange has been ruled out because of the low grade of heat available in the case being considered, i.e., using condenser cooling water rather than steam from the turbine.

There have been some encouraging experiments with simple low capital systems. An experiment[81] in Japan successfully utilized warm water open ponds as direct heat exchangers. Walker[82] reports that research is currently underway at the Illinois Power Company's Vermillion power plant studying a system which applies low-grade heated water to the outside surface of the greehouse and a full scale commercial greenhouse is being planned.

A number of economic questions are still unresolved. More detailed studies, review of current experiments, and perhaps a demonstration would be necessary before it is known whether or not this use of waste heat would be economical for the conditions of relatively severe climate and low waste water temperatures that would be encountered in Hat Creek.

Both the air and soil in greenhouses are potential receptors of waste heat. Standard practice has been to apply heat directly to the air but recent research indicates advantages to applying heat so that soil is warmed as well.[80]

It has been calculated[77] that there would be sufficient waste heat to support up to 162 ha (400 acres) of greenhouses. However, in the near future, the likelihood of this size of project in Hat Creek is remote, especially considering that the largest existing greenhouse complexes in the world are smaller. There are in total about 203 ha (502 acres) under plastic and glass in Canada devoted to vegetable production.[83] Total greenhouse area in British Columbia is about 37 ha (92 acres).[84] The main types of plants grown and the areas of each are shown in Table 6-3. Note that the areas given are not exclusive, as many greenhouses produce different crops in different seasons.

There is an opportunity for greenhouse expansion in British Columbia evidenced by the fact that a large portion of the vegetables and flowers, normally grown in greenhouses in British Columbia, are imported. For example, approximately 85 percent of the table tomatoes marketed in British Columbia are imported.

<u>Advantages</u>

The obvious advantage to agriculture in using waste heat in greenhouse production is the potential fuel savings. Fuel costs were estimated to be 17 percent of total greenhouse costs in 1973 and 37 percent in 1975.[83] As this trend is expected to continue, the advantage of using waste heat would also increase.

Using the current British Columbia price for natural gas service, \$0.078 m^{-3} (\$0.0022 ft^{-3}), the potential annual savings is

TABLE 6-3

GREENHOUSE AREA IN BRITISH COLUMBIA (ha)

	Tomatoes	Cucumbers	Cut Flowers*
Lower Mainland	6.21	3.69	12.21
Vancouver Island	9.38	2.41	4.63
Southern Interior	1.37	0.37	0.34
Northern Interior	0.17	0.14	0.01
B.C. Total	17.13	6.61	17.19

* Assuming 0.19 m^2 (2 ft^2) per flat for forced bulbs.

\$76,440 ha^{-1} (\$30,935 $acre^{-1}$) assuming a gas volume of 9.8 x 10 m^3-ha^{-1} (1.4 x 10^7 ft^3-$acre^{-1}$).[83] Assuming a 10-year future value discount this amount has a present value of \$483,193 ha^{-1} (\$195,541 $acre^{-1}$) at 10 percent interest. The following formula[85] which assumes a continuous cash flow was used in calculating the above value:

$$PV = \frac{S}{r} (1-e^{-ry})$$

where: PV = present value
S = rate of saving (dollars-yr^{-1})
r = interest discount rate
y = discount period (yr)

Lower land taxes and land costs that would be associated with the Hat Creek site would increase this figure somewhat but the actual amount of extra capital costs that could be justified in order to make use of "free" waste heat is expected to be substantially lower due to other economic considerations such as increased freight costs, additional hot water transmission costs and perhaps additional costs resulting from a difficult construction site. A detailed comparison, taking into account some of these, based on the 3716 m^2 (40,000 ft^2) BCMA Income Assurance Program model for tomatoes[77], showed a net advantage of \$2.47 $case^{-1}$ for a Hat Creek greenhouse or about 22 percent of the cost of production.

An advantage of the direct contact system over the conventional dry contact system is the possibility of cooling during hot summer weather. Tennessee Valley Authority results[80] showed that when their system was used as an evaporative cooler the temperature of the air leaving the heat exchanger was 2 to 3°C (4 to 6°F) cooler than the ambient air. It was determined in a feasibility study for the Denver area that a design wet bulb temperature of 18°C (65°F) would be favorable for summer cooling.[86] The Hat Creek design wet bulb temperature would be 14°C (57°F)[64], well under the acceptable value determined in the Denver study. This also brings with it a potential advantage to the power plant. Since the greenhouses would be capable of dissipating a constant load[86] all year round, the design requirements for plant cooling towers could be adjusted with savings in capital costs if the greenhouse system proved, possibly through pilot study, to be reliable enough.

Another potential advantage to the plant is that water losses would be less than for cooling towers if the water condensing on the greenhouse surfaces were collected and returned. The importance of this advantage lies in offsetting the high cost of pumping water from the Thompson River. Calculations with reported quantities of condensation water in previous experiments[86] show that the power plant makeup requirement could be up to 16% less during certain periods of the year if in the unlikely situation that the cooling towers were completely replaced by greenhouses. The collected greenhouse condensation could also be used to supply the needs of the crops being raised and/or provide high quality makeup water for the power plant cooling system.

Potential Problems

Various potential problems are envisioned for this proposal. They include low temperature conditions, low light conditions, plant shutdowns, high humidity, water requirements, market restrictions, physical location, restricted suitable soil availability, and air pollution.

Temperatures. Hat Creek, being situated at a northerly latitude, experiences lower ambient temperatures than are usually being designed for both conventional and waste heat utilization complexes.[87] It is not known whether an efficient, yet inexpensive exchange system can be built to provide adequate heating with low-grade heat in this environment.

However, Gillham[80] reports that for the severest conditions in areas adjacent to the Great Lakes in Ontario, based upon the test results of contact exchange systems discussed in his report, it would not be unreasonable to assume that night-time temperatures could be maintained at 5.6°C (10°F) below the temperature of the water supply. Since Hat Creek, with an average minimum of -17°C (1.5°F) (see Table 6-1) is about as cold as the Ontario conditions reported by Gillham, an average minimum of -18°C (0°F) in the Algonquin Park area and in the Sudbury area, it was inferred that a temperature of about 21°C (70°F) could be maintained in a Hat Creek greenhouse with the minimum water supply temperature of 27°C (80°F). This temperature of 21°C (70°F) is near the optimum growth temperature for tomatoes; lettuce has an optimum of about 13°C (56°F) and cucumbers an optimum of about 29°C (84°F)[80].

Baehr[77] calculated that heat requirements would be about 50 percent higher in Hat Creek than in the Fraser Valley. It should be noted that even without considering temperature, heat losses could be up to 50 percent higher than standard greenhouses due to higher relative humidity[81]. It is probable, that conservation of heat by means of a second layer of plastic on the greenhouse roof and walls for insulation would prove economical. The use of double layer plastic as opposed to single glazed glass houses can reduce heat losses by as much as 40 percent[80,86]. Another possibility which may lessen the steep temperature gradient problem is that a system which incorporates soil warming may not require as high air temperature.

Light. Much of the greenhouse vegetable production in British Columbia currently is idle during mid-winter due to heating costs and insufficient light. The availability of "free" heat in the Hat Creek proposal would probably warrant all year round operation if the lighting problem does not become limiting.

This low light condition is of particular concern from November to March but it may be possible to remedy this with artificial lighting. Many growers in other parts of the country, including several in the Fraser Valley, are now installing high intensity lights, such as 400 to 1000 watt (1366 to 3414 Btu-hr^{-1}) sodium vapour lamps, to supplement the natural daylight. Although supplemental lighting significantly increases production costs[83] these costs can be offset through increases in crop productivity and quality.[88]

Plant Shutdowns. As only partial plant shutdowns are expected on a normal basis, this feature is not expected to greatly affect the feasibility of greenhouses but would be a limiting factor on the total size of the operation. The greenhouse complex would probably be designed to use not more than one-quarter to one-half of the waste heat available since it is projected that this amount would have a high probability of being available at any time.

Though the variations in waste heat availability are not expected to be great enough to make supplementary heating necessary it is nevertheless still a possibility. A critical element in greenhouse design would be that the temperature could not be allowed to drop below the frost level, otherwise the entire crop could be lost. Natural gas is used in most conventional greenhouses but this may not be readily available near the power plant. Various other possibilities exist for supplementary heat sources:

- heat pump
- electric heat
- furnace using cheap coal
- artificial light

The heat pump, still a relatively novel device for heating in Canada is generally uneconomic for many applications[77,89]. A brief investigation confirmed that this is so on a small scale but that this alternative on a larger scale may become competitive with electric heat or a furnace burning cheap coal. Artificial light, which would significantly supplement heat, as well as light, is also quite expensive. However, this alternative is being used in the greenhouse industry today.

Heat storage may also be a worthwhile alternative feature to help smooth out the variation in heat availability. Heat storage media could include rocks or water. Various experiments have demonstrated the use of rocks as a heat storage medium in greenhouses but none are known to use water even though it has a significantly higher heat storage capacity. Perhaps the reason for this is that it would require a more complicated and thus more costly structure. Assuming heat losses of 3.34 $MW\text{-}ha^{-1}$ (4.62×10^6 $Btu\text{-}hr^{-1}$ $acre^{-1}$)[80], calculations show that about one meter (3.3 ft.) of water under the entire greenhouse area could store enough heat to prevent an unacceptable temperature drop during a 24-hour period.

The probability of complete plant shutdowns would need to be considered carefully in planning a greenhouse complex. A risk analysis using the power plant loss of load probability would probably be needed to assess the effects. If the probability of emergency shutdowns was low enough the greenhouse industry would probably account for it in planning by accepting the risk of losing productivity during those times.

Humidity. Direct contact heat exchange always brings along with it the feature of high humidity. High humidity (above 85 percent) has traditionally been blamed for fungus, disease, and lowered production.[86] Icing and fogging in cold weather are also potential problems.[80] A supplemental dry heat exchanger in series after the contact exchanger is one of the possible solutions to high humidity but this option would add significant capital cost to the system. Insulation techniques and artificial lighting may lessen the potential problems of icing and fogging.

Various reports indicate that the apparent high humidity problem can be reduced adequately without adding additional sensible heat. Pile[90] cites experiments in Muscle Shoals, Alabama with tomatoes and cucumbers grown at various relative humidities. Although lower humidities helped in disease control, acceptable yields of high quality vegetables were produced in a near saturated environment by following a rigid disease control program. Pile concludes that the necessity of humidity reduction equipment needs to be further evaluated and mentions that further demonstrations have been planned at the Brown's Ferry Nuclear Plant. Studies of the use of waste heat in greenhouses involving the joint efforts of the University of Arizona and the University of Sonora at Puerto Pensco, Mexico report that the closed environment itself greatly improved the yields of a wide variety of crops even though relative humidity was near 100 percent; the most successful varieties were those developed in hot humid areas.[86] Watanabe[81] cites waste heat experiments in Japan which have grown tomatoes in an environment often at 100 percent relative humidity. The harvests were as good as the standard greenhouse.

The necessity for humidity control is still uncertain. This factor could have a pronounced effect on the economics of the contact exchange system and consequently must be resolved.

Water Requirements. Greenhouses plants normally consume a significant amoung of water in the evapotranspiration process.

In a nigh humidity environment, however, very little direct irrigation would be required. In one study[81], the only irrigation requirement was for application of liquid fertilizer. The amount of additional water that would be required would depend on the amount lost due to air changes required for greenhouse ventilation. In any event, the total amount required would be small compared to the capacity of the makeup water pipeline proposed for the plant. For example, 50 ha (124 acres) might use about 33 ha-m-yr^{-1}). This is less than one percent of the capacity of the makeup pipeline.

The possible use of the cooling water as the source of greenhouse irrigation water would depend on the water being of acceptable quality. A comparison of the recommended maximum water quality limits given in table 5-6 with highest expected average concentrations in the condenser cooling water (20 times source water analysis) showed that at least three parameters would be close to the recommended maximum indicating that this water would only barely be acceptable as a source of irrigation water. These parameters are molybdenum, at a concentration of 0.01 mg-l^{-1}, specific conductance, at a value of 2.0 mmhos-cm^{-1} and total dissolved solids at a concentration of 1148 mg-l^{-1} (1400 mg-l^{-1} recommended maximum).

<u>Market Restrictions</u>. The basic cost of production for greenhouse tomatoes in British Columbia as established by the B.C. Ministry of Agriculture Farm Income Assurance cost of production model is \$11.93 case^{-1} plus \$1.46 case^{-1} as a marketing cost. In 1976 the gross market return for greenhouse tomatoes was \$8.85 case^{-1} which resulted in a deficit to the producer of \$4.54 case^{-1}. Although the use of Hat Creek waste heat could give an apparent saving of approximately \$2.47 case^{-1} [77] there would still remain a deficit of at least \$2.07 case^{-1} if the tomatoes were sold during the regular marketing period

from April to September. An even greater deficit would remain if there was a depression of the present market for British Columbia greenhouse tomatoes which would likely occur with a sizeable industry at Hat Creek. Records show that the price of tomatoes is substantially higher, \$3.00 to \$4.00 $case^{-1}$, during the remainder of the year with mostly imported tomatoes on the market and that producing tomatoes for market during this period appears upon initial examination to be a reasonable alternative.

Physical Location. The possibilities of physically locating a sizeable greenhouse complex near the proposed location of the Hat Creek generating plant are quite limited due to steep topography and poor soils in the area. Previous studies[80] indicate that economics dictate that the greenhouse complex needs to be almost adjacent to the plant, otherwise insulating and piping costs quickly eat up any advantage to the use of the waste heat. The case of constructing a greenhouse complex near the plant on relatively steep topography and importing suitable soil or hydroponic media such as fine gravel or sawdust would need to be compared with a complex located further away on suitable soil and flatter ground. The latter case would not be found favorable unless a very large complex was planned, perhaps in the order of 50 ha (124 acres) or more. In the former case, perhaps topsoil proposed for stockpiling could be used for the greenhouses since this would be a higher use if it were not too expensive to transport; project conveyors might be able to assist in transporting the topsoil.

Pollution. The ERT report[72] and the Runeckles report[1] indicate that SO_2/NO_2 stack emissions would not be a problem in the area surrounding the plant. The closest potentially harmful concentration levels of air emissions would occur about 7 km (4.4 mi) from the plant. Salt deposition due to cooling tower drift may pose a potential hazard to vegetation within 3 km (1.9 mi) of the plant.[1] It has not been determined whether or not this would pose a threat to greenhouse crops. In any case, aerosols could be eliminated from the greenhouse air supply by filtering.

Water quality is also a possible concern. If chemicals such as chromates were used for water treatment, the plants in the greenhouses may be detrimentally affected. Similarly, the pollen from the greenhouse might detrimentally affect the cooling system by requiring additional water treatment.[86] The determination of whether such effects will occur requires further study.

Conclusion

Since, in general, the use of Hat Creek waste heat for greenhouse crop production appears promising, it is concluded that a detailed investigation should be carried out to ascertain the practical potential of this use. There appear to be unresolved questions in all areas, a few in engineering and more in economics and institutional arrangements. More analysis would be required to determine if a greenhouse complex using waste heat could be adapted to the relatively severe climate of Hat Creek and the difficult terrain that exists around the proposed power plant location. The impact on greenhouse operations of the thermal plant reliability and the need to supply backup heating in the event of waste heat interruption would require study. Careful consideration of crop marketing, greenhouse ownership and control, and the skilled labour situation would be required as well.

It may be found that a field site demonstration project, such as the one proposed earlier by BCMA[77], would still be necessary to answer some of the technical unknowns. It would be advantageous to proceed with these studies as soon as possible so that appropriate modifications could be taken into account in the power plant design should it be determined early enough that an economical use of waste heat can be incorporated.

B. Environmental Control of Animal Enclosures

The use of thermal discharge water for heating or cooling animal enclosures would bring certain benefits, although the potential savings do not appear to be as great as in the greenhouse situation since greenhouses have a much higher heat requirement.[80] There is a lack of supporting experimental evidence but, in general, it is expected that many of the same problems as in the greenhouse situation would be encountered.

Based upon the growth response to temperature, the production of swine and broilers are considered to have the greatest potential use for waste heat[86,91]. It has also been found that with cattle, feed conversion is improved and efficiency in production is significantly increased in a controlled environment[92]. Since cattle production is the major agricultural industry around Hat Creek, this alternative may have ready application but suitable available space near the plant site would probably restrict this alternative as large areas are required for animal confinement. Economic studies have not been carried out but it is expected that this alternative would be less favorable than the greenhouse alternative.

C. Irrigation

Irrigation has been used for frost protection and extending the growing season for certain high value crops such as citrus fruits. This application requires once-through cooling water which is not compatible with the concept of the cooling system of the Hat Creek plant, therefore, it is very unlikely that a beneficial use could be made of waste heat through irrigation.

D. Aquaculture

Aquaculture production is a relatively new enterprise in this country and the technology is still in the process of development.

To date, studies and demonstrations of this use of waste heat have mainly been with once-through cooling systems because of the greater potential problems with a closed-cycle system as is proposed for Hat Creek. Although higher water temperatures are an advantage with the closed-cycle system, water quality is of concern for both the aquatic production unit and the power plant. If the main recirculation stream was used, the effect of particulates and high concentration levels of dissolved solids, biocides, copper, and free chlorine on the aquatic organisms being produced would have to be considered. Fish wastes may also have to be treated prior to recirculation to the power plant condenser and this additional treatment system would have to be considered. Possible means of circumventing some but not all of the above potential problems have been documented.[86]

Another possibility is to circulate the water through some sort of heat exchange system to maintain the temperature of ponds or even a building which houses aquaria or fish culture tanks. Demonstrations, discussed by Rimberg[86], investigating this concept are underway and their results should be consulted prior to considering this concept for Hat Creek.

For the Hat Creek proposal, if the entire waste water flow of 2422 m^3-min^{-1} (540,000 US gal-min^{-1}) could be utilized for aquaculture, about 400 ha (988 acres) of area would be required depending on the depths of tanks used. Many species that would require sea water are questionable since these conditions would be difficult to duplicate near Hat Creek.

Several species considered for this endeavour are catfish, preferring a temperature between 27 and 32°C (80 and 90°F), shrimp preferring 21 to 32°C (70 to 90°F), algae preferring 10 to 21°C (50 to 70°F) and rainbow trout which grow well at about 16°C (60°F). Other species that could be considered are oysters, lobsters and carp.

The market conditions are not obvious for a major aquaculture venture. Currently, catfish production, while relatively popular in other parts of the continent, is nearly nonexistent in British Columbia. At the present time, there is no existing market for algae single cell proteins but it is possible that animal feed could be a potential market[88]. In general, there is little statistical data at present to indicate the extent of demand for cultured aquatic foods in the province[86].

E. Waste Treatment

Currently there are no obvious applications for the use of waste heat near Hat Creek to aid waste treatment processes. It is possible, however, that it could be incorporated as part of an integrated system that included treatment of animal production wastes. The temperature of digesters and treatment ponds could be increased resulting in more rapid decomposition and the more efficient treatment of wastes under cool climate conditions[80].

F. Integrated Systems

Any of the alternative uses of waste heat, if economically feasible alone, would likely be even more favorable in combination since certain costs could be shared. For example, if greenhouses and aquaculture could share the same building and the same heat, savings would occur. This would be technically feasible under different arrangements for both the high and low temperature species. A recent newspaper release cited a proposal of this sort made for the Bruce Nuclear Power Station in Ontario. Tennessee Valley Authority is proposing to build a greenhouse/animal shelter complex at Brown's Ferry Nuclear Project[92]. Perhaps heat transported long distances could actually be transported under roadways thus helping to ease winter snow and ice removal costs.

The main advantage of integration is the more efficient use of total energy. This advantage is not unique to a waste heat utilization situation, but in the case of a large development like the Hat Creek power project, there would be more opportunity to take advantage of the integrated system concept because of the large quantity of energy available allowing a greater scope in planning of such systems.

(b) Supply of Irrigation Water

(i) Waste Water

Waste water quantities are expected to be small, consequently its potential use for irrigation is limited.

There are two potential waste water sources, one is domestic waste water and the other, cooling system blowdown. The potential quantity of the former is not known, while the quantity from cooling system blowdown would be about 0.4 m^3-min^{-1} (100 US gal-m^1). This quantity could be capable of irrigating about 5 ha (12 acres) of land.

(ii) Provision of Extra Capacity

If irrigation water could be supplied to the farm gate for about \$120 ha^{-1}-m^{-1} (\$15 $acre^{-1}$-ft^{-1}) there would be considerable potential for enhancement to agriculture based on the relatively large amount of potentially irrigable lands that is likely to remain unirrigated in the future due to the lack of an economic supply of water. The marginal costs of providing extra capacity in project storage reservoirs and/or the main project supply pipeline would need to compare favorably with the above cost guideline. Although detailed economic information was not available for this comparison to be made, the projected average cost of supplying water from the Thompson River to the plant is two orders of magnitude greater than the desired cost of irrigation water, indicating the unlikelyhood of an economic supply of irrigation water being available from the plant supply pipeline. The marginal cost for additional capacity in this system, however, would be lower for irrigation supply near the Thompson River end of the supply line than for irrigation supply at the plant end of the supply line.

7.0 RECOMMENDATIONS

1. In response to the findings of the Runeckles air emission report[1] and the ERT trace element report[73], as they pertain to agriculture, it is recommended that a monitoring program be designed and implemented for both the immediate without project case and the with project case later. Such a monitoring program emphasizing the agricultural resource - both cultivated crops and rangeland vegetation - would conceivably form a component of a broader monitoring program as envisaged in the biological monitoring program recommendations contained in the *Physical Habitat and Range Vegetation* report[44].

More specific to concerns regarding trace elements and their effect on the agricultural resource, it is further recommended that a trace element monitoring program be implemented to assess present and potential (with the project) levels of trace elements in soils, vegetation, and livestock animals. Arsenic, selenium and fluorine are of particular concern.

2. As a follow-up to the basic study assumption that B.C. Hydro lands would be realigned into new farm units where required and made available for agricultural use, it is recommended that:

a) feasibility studies be carried out to define new farm units, specifically including both an agricultural economic assessment of farm unit viability and an agricultural development assessment. An adjunct to the latter assessment would be the carrying out of field corn trials in the Hat Creek valley to confirm the predicted use of certain lands prior to any large scale corn development planning.

b) an agricultural development plan be prepared.

3. Following the findings on mitigation, compensation, and enhancement it is recommended that:

a) an assessment of relocating project facilities (mine construction camp, access road, and conveyor) be made to optimize project compatibility with agricultural land use of the area.

b) an agricultural assessment be made of alterations to farm units involving the incorporation of any substitute lands being considered as a means of compensation.

c) pertaining to the utilization of waste heat it is recommended that further study be undertaken on greenhouse, animal enclosure, and aquaculture uses. Greenhouse use appears to have the best potential.

4. Where project effluent is being considered for landspreading on agricultural crops, it is recommended that an agricultural assessment of the water and nutrient budgets be carried out to determine both the desirability of landspreading and the required application rates and scheduling.

5. Recommendations pertaining to agricultural soils and agricultural water use are presented in the *Physical Habitat and Range Vegetation*[44] and *Hydrology, Drainage, Water Quality & Use*[49] reports respectively and are supported from the standpoint of agriculture.

8.0 GLOSSARY

Agricultural Land Reserve (ALR) - land preserved for agricultural use as designated by the Province of British Columbia under the British Columbia Land Commission Act.

Animal Unit Month (AUM) - a feed equivalent used to indicate the number of grazing animals a range area can support. One AUM is one cow and calf or one 454 kg (1000 lb) steer grazing for one month.

arable land - land that is capable of being cultivated for crop production.

backgrounding - the feeding of weaned calves or yearlings in a manner to prepare them for finishing.

Biogeoclimatic Zone - a geographic area characterized by a certain combination of macro-climates, zonal soils and zonal (climax) vegetation.

carrying capacity - capability of a range to support livestock over a long period of time. Expressed as area per AUM.

clear-cut - forested land where all trees are cut down.

climax vegetation - the stable vegetation form resulting from the progressive natural replacement of earlier vegetation.

cool-loving vegetables - those which thrive in moderate temperatures, including cabbage, cauliflower, and broccoli.

<u>farm unit</u> - in this report, the total deeded and leased land holdings associated with an independent farm operation. Most operations in the study areas are cattle operations which also have Crown grazing permit areas associated with them.

<u>field crops</u> - include all plants that are grown for their seed.

<u>finishing</u> - feeding cattle on grass or in a feedlot to an age and weight suitable for slaughter.

<u>forage crops</u> - includes all crops which have their vegetative or seed components eaten by livestock.

<u>frost free period</u> - length of time in days between the last day in the spring and the first day in the fall when the temperature is at or below 0°C (32°F).

<u>growing degree days</u> - the accumulated temperature based on the daily mean above 5°C (≈42°F) per season.

<u>heat-loving vegetables</u> - those which thrive in high temperatures, including tomatoes and vine crops.

<u>irrigable land</u> - in this report, includes presently irrigated land and other areas with suitable soil, climate and topographic characteristics for crop production (thus requiring irrigation in the semi-arid climate of this study area).

<u>potential agricultural use</u> - refers to the full (maximum) agricultural use of the land resource, based entirely on land and climate capability information.

potential evapotranspiration - is the maximum quantity of water water capable of being lost as water vapor, in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. It is dependent on meteorological conditions, since there are no soil or crop limitations.

probable agricultural use - is derived from potential agricultural use by considering additional constraints, i.e., water availability, economic, social and certain physical factors.

stocking rate - number of cattle that a range actually supports. Expressed as area per AUM.

vegetation association - has a definite uniform vegetation composition and physiognomy and is associated with a certain set of environmental and physical factors. Each vegetation association is named using the dominant overstory and understory species in a climatic climax state.

well-stocked forest - with reference to B.C. Forest Service classification system, indicates a fully-stocked high yield stand containing deciduous and coniferous trees (excepting lodgepole pine).

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APPENDIX C

IRRIGATION REQUIREMENT (WATER QUANTITY) MODEL FOR THE HAT CREEK VALLEY

IRRIGATION REQUIREMENT MODEL

$$IR = R\left[(f \cdot PE) - P - SU\right], \text{ not less than zero} \qquad (1)$$

where,

IR represents the irrigation requirement of the crop, expressed as a depth of water;

R represents a risk factor, which is a function of the risk of not having enough irrigation water to meet the consumptive needs of the crop. Risk is synonymous with probability, but usually implies a hazard. It is expressed as a cumulative percentage and indicates the number of years out of 100 when the values used are exceeded. When the risk factor is greater than 1.00 the risk is less than 50 percent.

A reasonable planning risk of not having enough water for the irrigation of hay and pasture, the major crops of the Hat Creek valley, was determined to be 20 percent (i.e., there would be the probability that 20 years out of 100, the calculated seasonal irrigation requirement would be less than the water requirement based on actual climatic conditions). This figure was based on current design specifications [1] and discussion with a B.C. Ministry of Agriculture irrigation specialist regarding actual risks assumed in current farming practices.

The risk factor, R, was obtained by averaging the ratio of irrigation requirements for the desired risk (in this case 20 percent) to irrigation requirements for a 50 percent risk, as documented for various surrounding locations by Canada Department of Agriculture computer analyses [2,3,4,5] . The risk factor so obtained was:

$$R = 1.15;$$

f represents a consumptive use factor. This is defined as the ratio of consumptive use of water by a crop to potential evapotranspiration. Consumptive use is defined as the sum of the depths of water transpired by the plants, evaporated from the soil surface, and intercepted precipitation evaporated from plant foliage. Potential evapotranspiration is the maximum quantity of water capable of being lost as water vapor, for a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water.

The consumptive use factor, f, is 1.00 for an actively growing crop that completely covers the soil over a large area and that has access to an ample supply of readily available soil water (water that is within the root zone of the crop and that supplies the water requirements of the crop without limitation to transpiration). If the crop area is small or the individual plants are high and spaced in rows so that heat can be carried into the space below the top of the canopy, the consumptive use factor may exceed 1.00. Where plants are short and do not cover the ground so that bare soil is showing, the consumptive use factor is less than 1.00. Maturing crops that are not actively transpiring have a consumptive use factor of less than 1.00 Consumptive use factors have been established for a number of crops and climatic conditions [6,7]. The hay and pasture of Hat Creek valley are representative of crop cover with a consumptive use factor of 1.00.

PE represents potential evapotranspiration, which is defined as the maximum quantity of water capable of being lost as water vapor, in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. It depends only on meteorological conditions.

Potential evapotranspiration was determined by utilizing a formula that is currently used by the Canada Department of Agriculture [2] in estimating irrigation requirements. This formula, which is a modified version of an original regression model proposed by Baier and Robertson[8] is based on energy balance principles and relates daily latent evaporation to meteorological and astronomical variables. This method differs from the less rigorous Thornthwaite method of determining potential evapotranspiration which uses the parameters of mean monthly temperature and length of day, and the assumption of a fixed sharing of the heat budget. The Thornthwaite method was developed primarily for arriving at annual consumptive use values for hydrological studies but is not considered as reliable as some other methods for calculating specific irrigation requirements for shorter periods[9]. The Baier and Robertson formula is more conservative, i.e., yields higher potential evapotranspiration rates than the Thornthwaite method.

The particulars of the formula used for estimating the potential evapotranspiration in the Hat Creek valley are given below:

$$LE = -53.39 + 0.337\ \text{Max} + 0.531\ \text{Range} + 0.0107\ Q_o + 0.0512\ Q_s + 0.0977\ \text{Wind} + 1.77\ (e_w - e_s) \qquad (2)$$

where,

LE = estimated latent evaporation, in cc/day; as observed from black Bellani plate atmometers.

Estimates of LE (in cc/day) convert to estimates of PE (in inches/day) by a factor of 0.0034 inch/cc.

Max = daily maximum temperature (°F),

Range = difference between daily maximum and minimum temperature (°F),

Q_o = solar energy at the top of the atmosphere, in cal cm^{-2} day^{-1} obtainable from published tables .

Q_s = total sky and solar energy on a horizontal surface, in cal cm^{-2} day^{-1}.

Q_s is estimated from the formula:

$$Q_s = Q_o(0.251 + 0.616\ (n/N)) \qquad (3)$$

where,

n = duration of bright sunshine, in hours,

N = length of day, in hours, obtainable from published tables .

Wind = total daily wind run, in miles, at 6 feet above the ground.
Wind records taken at higher levels were adjusted to the 6-foot height by the formula:

$$U_6 = U_x \frac{\log 6}{\log h_x} \qquad (4)$$

where,

U_6 = wind run at 6-foot height,

U_x = wind run at height (h_x),

h_x = height of anemometer, in feet.

$e_w - e_s$ = Vapor pressure deficit (mb) from saturation vapor pressure at mean air temperature $(\frac{Max + Min}{2})$ and mean daily dew-point temperature.

Long-term records of daily extreme temperatures and precipitation are available for many stations, but the corresponding records of daily sunshine, wind run, and dew-point temperature are often missing or incomplete. Special procedures have been developed to use available daily temperature and precipitation records and to estimate daily values of the missing elements in equation (2). An equation relating minimum and maximum temperatures to mean daily dew-point temperature (T_d) was evolved from daily climatological records at eight Canada Department of Agriculture stations across Canada for 1956-57:

$$T_d = -12.58 + 0.52\ Min + 0.92\ Max - 0.005\ Max^2 \quad (5)$$

Monthly values for potential evapotranspiration were derived for the Hat Creek valley from the above formulae by using specific climatic and physical properties data[9,10,11,12,13]. Climatic variables were assumed to be constant for the valley lowlands, on which all irrigation occurs, though some variation would be expected due to the difference in elevation between the south end of the valley and the north end where Hat Creek joins the Bonaparte River. At the time that this derivation was made, climatic information for Hat Creek valley was limited and did not allow for the possible variation in climate to be taken into account.

P represents precipitation. Data for average monthly precipitation were obtained from meteorological records of the Atmospheric Environment Service[10] monitoring station, "Hat Creek".

SU represents storage utilization, which is the amount of water stored in the soil at the start of the season that could be utilized efficiently under normal irrigation scheduling.

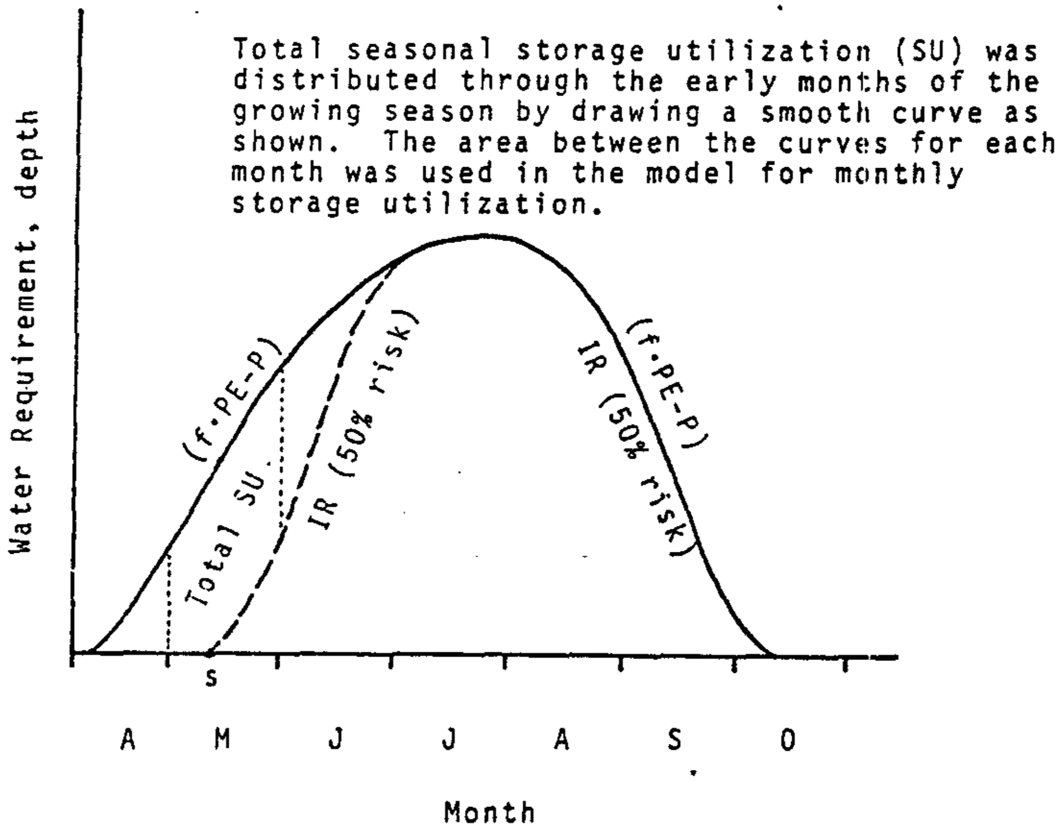
The amount of storage utilization is a function of the soil texture and crop rooting depth. Based on current irrigation scheduling practices the total seasonal storage utilization would be one-half of the readily available water, which, in turn, for most crop types is 50 percent of the total soil water between field capacity and wilting point (available water storage capacity, AWSC).

For Hat Creek valley, storage utilization was determined for two dominant soil-crop combinations presently found in the valley: hay on floodplain soils and hay or pasture on upland soils. The value of AWSC for these soil-crop combinations was based on published AWSC values[1] representative of soil textures encountered in typical soil profiles (ground surface to crop rooting depth) of each soil type. The resulting available water storage capacities were 20 cm (7.9 in) for the floodplain soils and 12 cm (4.7 in) for the upland soils. Seasonal storage utilization was calculated as 5 cm (2.0 in) and 3 cm (1.2 in) for the floodplain and upland soils respectively.

The seasonal storage utilization (for each of the two soil types) was distributed throughout the early months of the irrigation season by the graphical technique shown in Figure C-1. The curve for net consumptive use (f·PE-P) is representative of actual conditions. The starting date of the irrigation season was calculated to be the date at which there would remain a 15 percent risk (current design value for determining irrigation cycle [1]) of not meeting the irrigation requirements during the first irrigation cycle. This date was determined for each soil type as the number of days of a maximum length cycle before the date at which all readily available water would be depleted if no irrigation water was applied. The calculated irrigation starting dates, May 5 for upland soils and May 15 for floodplain soils, agreed well with field observations of farm practices in Hat Creek.

The monthly values determined for potential evapotranspiration (PE), precipitation (P), and storage utilization (SU) for both the flood-plain and upland soil types of the Hat Creek valley are presented in Table C-1.

The calculated monthly irrigation requirements, IR, for the floodplain and upland soils are also given in Table C-1. The table shows that the irrigation season is from May to September inclusive. The seasonal irrigation requirement of the two soils are 31 cm (12.2 in) and 34 cm (13.4 in) for the floodplain and upland soils respectively. The floodplain soil type requires less irrigation water in May and June because of their greater storage utilization.



point "s" represents the start of the irrigation season.

MONTHLY DISTRIBUTION OF SEASONAL STORAGE UTILIZATION (SU)

FIGURE C-1

TABLE C-1

MONTHLY HAT CREEK VALLEY IRRIGATION MODEL PARAMETERS AND IRRIGATION REQUIREMENT RESULTS

IR = R[(f•PE)-P-SU], not less than zero (1)

	April	May	June	July	Aug	Sept	Oct	Total
R	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
f	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PE (cm)	3.58	7.70	9.14	11.96	10.24	5.38	0.0	48.0
PE (in)	1.41	3.03	3.60	4.71	4.03	2.12	0.0	18.9
P (cm)	1.63	2.16	3.51	2.90	3.18	2.06	2.51	17.9
P (in)	0.64	0.85	1.38	1.14	1.25	0.81	0.99	7.1
SU								
Hay/Pasture* on Upland Soil (cm)	1.95	1.22	0.04	0.0	0.0	0.0	0.0	3.2
Hay/Pasture* on Upland Soil (in)	0.77	0.48	0.02	0.0	0.0	0.0	0.0	1.27
Hay on Floodplain Soil (cm)	1.95	2.49	0.55	0.25	0.0	0.0	0.0	5.0
Hay on Floodplain Soil (in)	0.77	0.98	0.22	0.10	0.0	0.0	0.0	1.97
IR								
Hay/Pasture* on Upland Soil (cm)	0.0	4.98**	6.43	10.44	8.13	3.84	0.0	33.8
Hay/Pasture* on Upland Soil (in)	0.0	1.96	2.53	4.11	3.20	1.51	0.0	13.3
Hay on Floodplain Soil (cm)	0.0	3.51***	5.84	10.13	8.13	3.84	0.0	31.5
Hay on Floodplain Soil (in)	0.0	1.38	2.30	3.99	3.20	1.51	0.0	12.4

* Assumes that pasture is irrigated the full irrigation season.
** Start of irrigation season calculated to be May 5th.
*** Start of irrigation season calculated to be May 15th.

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APPENDIX D

PROJECT FACILITIES

TABLE D-1

PROJECT FACILITIES*

	Area (ha)	Code
Base Scheme - "CLOSED" Alienation		
a) Construction Camp		
Mine Construction Camp Housing and Parking	5.1	CM1
Mine Construction Camp Sanitary Effluent Treatment Plant	0.02	CM2
Mine Construction Camp Effluent Treatment Basin	0.07	CM3
Mine Construction Camp Substation	0.02	CM4
Mine Construction Camp Water Storage Reservoir	0.06	CM5
Power Plant Construction Camp Housing and Parking	**	CP1
Power Plant Construction Camp Sanitary Effluent Treatment Plant	**	CP2
Power Plant Construction Camp Effluent Plant	0.06	CP3
Power Plant Construction Substation	**	CP4
Power Plant Construction Camp Water Storage Reservoir	**	CP5
Subtotal	5.3	
b) Mine		
Open Pit #1, to 600 ft. Excavation	767.0	M1
Medicine Creek Waste Dump	487.0	M2
North Valley Waste Dump	48.0	M3
Houth Meadow Waste Dump	615.1	M4
Lagoon 1	1.2	M5
Lagoon 2	0.4	M6
Lagoon 3	0.4	M7
Lagoon 4	0.8	M8
Lagoon 5	0.5	M9
Lagoon 6	0.5	M10
Topsoil Stockpile, Mine Entrance	22.8	M11
Topsoil Stockpile, Landing Strip	61.8	M12
Topsoil Stockpile, South Medicine Creek	99.4	M13
Coal Blending Area	29.5	M14
Low Grade Coal Stocking Area	123.5	M15
Temporary Topsoil Stockpile	2.8	M16
Conveyors	30.5	M17
Shop and Maintenance Buildings	2.6	M18
Drainage Ditches	35.0	M19
Subtotal	2329.0	

* See Figure D-1 (foldout) for location of facilities.

** Within P1.

TABLE D-1 (continued)

PROJECT FACILITIES*

Base Scheme - "CLOSED" Alienation (continued)	Area (ha)	Code
c) Power Plant		
Power Plant Site, entire area within fence	92.1	P1
Craft Parking Lot	1.1	P2
Office Parking Lot	0.3	P3
Make-up Water Reservoir and Dams	67.3	P4
Wet Ash Disposal Scheme Ash Pond and Dam	660.8	P6
Wet Disposal Schemce Ash Conveyance System	12.9	P7
Subtotal	834.5	
d) Offsite		
Main Access Road	120.1	OR1
Power Plant Site Access Road	7.5	OR2
Water Intake Station Access Road	0.8	OR3
Booster Pumping Station I Access Road	1.6	OR4
Headworks Reservoir and Dam	7.3	OD1
Hat Creek Diversion Canal	30.1	OD2
Pit Rim Reservoir and Dam	11.5	OD4
Finney Creek Diversion Canal	6.9	OD9
Booster Pumping Station I	2.0	OW2
Booster Pumping Station II	1.6	OW3
Water Intake Station	nil	OW4
Summit Surge Tank	0.02	OW6
One-way Surge Tank	0.02	OW7
Rattlesnake Substation	3.2	OT7
Airstrip, Site A	45.4	OA1
Airstrip Access Road, Site A	4.5	OA4
Subtotal	239.5	
e) Indirect Alienation	222.6	I
Subtotal	222.6	
Total "CLOSED" Alienation	3630.6	

*See Figure D-1 for location of facilities.

TABLE D-1 (continued)

PROJECT FACILITIES *

Base Scheme - "OPEN" Alienation	Area (ha)	Code
a) Construction Camp		
Mine Construction Camp Water Supply Pipeline	1.5	CM6
Power Plant Construction Camp Water Supply Pipeline	3.0	CP6
Subtotal	4.5	
b) Power Plant		
Water Pipeline between Reservoir and Power Plant	4.8	P5
Subtotal	4.8	
c) Offsites		
Hat Creek Diversion Canal Discharge Conduit	6.3	OD3
Pipeline, Pit Rim Reservoir to Diversion Canal	0.6	OD5
Make-up Water Pipeline from Thompson River	39.0	OW1
Drainage Pipeline	1.6	OW8
69 kV Transmission Line to Construction Substation	2.4	OT1
Twin 69 kV Transmission Line between Construction Substations	10.8	OT2
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station I	21.2	OT4
69 kV Transmission Line Tie-in	2.7	OT5
Subtotal	84.6	
Total "OPEN" Alienation	93.9	

*See Figure D-1 for location of facilities.

TABLE D-1 (continued)

PROJECT FACILITIES*

	Area (ha)	Code
Base Scheme Undefined Facilities		
Booster Pumping Station II Access Road	9.6	OR5
Spoil Areas	?	OR6
Borrow Pits	?	OR7
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station II	12.2	OT3
Offloading Area	3.0	OF1
Offloading Railroad Spur	?	OF2
Offloading Access Road	?	OF3
Medicine and Ambusten Creeks Canal Crossings	?	OD10
Alternate Schemes Alienation		
Wet Ash Disposal Scheme Alternative Bottom Ash Dump (including return water pipeline)	184.6	P7.5
Dry Ash Disposal Scheme I, Ash Dumps	303.6	P8,P9
Dry Ash Disposal Scheme II, Ash Dumps	260.5	P10,P11 P12,P13
Site 2 Storage Reservoir and Dam	120.0	OD7
Possible Pipeline from Diversion Canal to Make-up Reservoir	7.7	OD8
Airstrip, Site A	37.0	OA3
Airstrip Access Road, Site A	1.5	OA6
Total	914.9	

* See Figure D-1 for location of facilities.