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WATER AND RELATED RESOURCES
IN
THE KETTLE-GRANBY RIVER BASIN

PREPARED BY
DEBORAH E. SHERWOOD

OCTOBER 1986

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**Inland Waters Directorate
Pacific and Yukon Region
Vancouver, B.C.**

ENVIRONMENT CANADA
CONSERVATION AND PROTECTION

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ABSTRACT

The Kettle-Granby River Basin covers 8200 square kilometres of the southern interior of British Columbia. Rising in the Monashee Mountains, the Kettle River flows south into the State of Washington near Midway, British Columbia, then loops north to re-enter Canada near Grand Forks, British Columbia. On its final reach, the Kettle flows south from Christina Lake, crossing the international boundary for the third time near Cascade, British Columbia, and eventually empties into the reservoir of the Grand Coulee Dam in the State of Washington.

The Basin's topography is characterized by plateaux in the west and mountains in the east, both dissected by steep-walled valleys which widen along the international boundary. The climate is dominated by moderating air movements from the Pacific Ocean although influxes of Arctic air are common in winter. Streamflow peaks with snowmelt in May or June while minor peaks occur in the fall from rainstorms.

The Basin supports a variety of wildlife. Populations have declined in recent years due to loss of habitat through fire suppression, over-grazing, and forestry and mining activities. Some of the Basin's headwater lakes and streams support good sport fisheries, especially for rainbow trout, bass, and kokanee. Several of the streams experience high irrigation water demands in the summer creating low flows, warm stream temperatures, and fish kills.

Mining was the initial catalyst to economic activity in the Basin. A gold rush in the mid-1800's was followed by significant copper production during World War I. Today, the Basin's major industry is forestry with two major sawmills employing many of the Basin's residents. There are three small operating mines which produce mostly gold and silver; some placer activity when the price of gold is attractive; and considerable exploration activity in the Basin. Tourism and recreation are gaining in importance. Big White is a major ski destination resort and Christina Lake offers summer water-based activities. Agriculture, particularly ranching on the plateaux and farming near Grand Forks, remains a relatively stable but minor contributor to the Basin's economy.

There are no federal lands such as national parks or Indian Reserves in the Basin nor are there anadromous fish in the Basin's lakes and rivers. There are several areas of resource competition that are of concern, but most of these are the responsibility of the provincial government. There are no areas of concern for the Inland Waters Directorate (IWD), Environment Canada at this time. However, increased slag-mining operations in both Canada and the United States and inadequate sewage disposal systems in Canada are areas of potential concern. IWD's routine monitoring program should be adequate to detect changes in water quality conditions at the international boundary due to these activities. Another area of potential concern, and one which has not been explored in this report, is the effects of other existing and proposed economic activities in the State of Washington which may alter water quality or quantity in Canada.

RESUME

Le bassin Kettle-Granby draine une superf cie de 8200 kilom tres carr s   l'int rieur et au sud de la Colombie-Britannique (C.B.). La rivi re Kettle d bute dans les montagnes Monashee et s' coule vers le sud, traversant la fronti re de l' tat de Washington pr s de Midway, C.B. Ensuite, elle se dirige vers le nord pour entrer au Canada pr s de Grand Forks, C.B. Pr s de son embouchure, elle s' coule du lac Christina et se dirige encore au sud, traversant la fronti re internationale pour la troisi me fois pr s de Cascade, C.B. Elle se verse  ventuellement dans le r servoir du barrage Grand Cou  e de l' tat de Washington.

La topographie du bassin se d marque par des plateaux   l'ouest et des montagnes   l'est et tous deux sont travers s par des vall es escarp es qui s' largissent le long de la fronti re internationale. Le climat est mod r  par des courants d'air de l'oc an Pacifique quoiqu'il est souvent influenc  par des masses d'air de l'arctique, en hiver. La crue maximum arrive durant la fonte des neiges au printemps, soit en mai ou en juin, mais des crues mineures surgissent   l'automne, lors de temp tes de pluies.

La faune du bassin est tr s vari e. Toutefois, les populations de ces animaux baissent dern rement. Cela est d    la perte d'habitat caus e par les mesures de r pression de feu de for t, par la surexploitation de p turages et par les activit es foresti res et mini res. Tout de m me, il y a quelqu'uns des cours sup rieurs des lacs et des ruisseaux du bassin qui soutiennent de bonnes p ches sportives, particuli rement pour la truite arc-en-ciel, l'achigan et le kokani. Mais,   cause d'une forte demande d'eau pour l'irrigation, plusieurs ruisseaux subissent une diminution de flots durant l' t , ayant comme consequence un  coulement tr s r duit, un r chauffement d'eau et une mortalit  de poissons.

L'exploitation mini re fut le premier   stimuler l'activit   conomique du bassin, notamment la ru e vers l'or de la mi-1800 suivi par une production consid rable de cuivre durant la Premi re Guerre Mondiale.

Aujourd'hui l'industrie première du bassin est la sylviculture et deux de ses scieries emploient beaucoup de résidents. Du côté minier, il y a trois petites mines qui fonctionnent et qui produisent surtout de l'or et de l'argent. Il y a un peu d'exploration de gisement quand le prix d'or est assez élevé. Toutefois, il y a beaucoup plus d'exploration du terrain que d'exploitation. Le tourisme et le loisir deviennent plus important avec une station de ski majeure à Big White et une variété d'activités estivales au lac Christina. Quand à l'agriculture, particulièrement le ranching sur les plateaux et l'élevage près de Grand Forks, elle demeure toujours relativement stable mais reste une industrie secondaire à l'économie du bassin.

Dans le bassin il n'y a pas de territoire fédéral tels que des parcs nationaux ou des réserves indiennes, ni de poissons anadromes dans les lacs et les rivières. Par contre, il y a plusieurs domaines où la concurrence des ressources est d'intérêt mais qui se trouve pour la plupart sous la juridiction provinciale. Pour l'instant, la Direction générale des eaux intérieures (DGEI) d'Environnement Canada n'a pas d'inquiétude. Toutefois, l'augmentation d'opération de scories minières au Canada et aux Etats-Unis et des systèmes inadéquats d'évacuation de vidanges au Canada sont des domaines d'inquiétudes. Le programme de monitoring de routine de la DGEI devrait être suffisant pour discerner des changements de qualité d'eau à la frontière internationale dû à ces activités. Un autre domaine d'inquiétude possible, mais qui n'a pas été poursuivi dans cette étude, est l'effet d'autres activités d'importance économique actuelles et proposées de l'état de Washington. Ceux-ci peuvent affecter la qualité et la quantité d'eau au Canada.

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1. INTRODUCTION

A. Study Area

The study area for this report is the Kettle-Granby River Basin in the southern interior of British Columbia. The Basin is bounded to the west by the Okanagan River Basin, to the east by the Columbia River Basin, and to the north by the Shuswap River Basin, a tributary of the South Thompson River. The international boundary along the 49th parallel is the southern extent of the study area although the Kettle River Basin lies partially in the State of Washington (fig. 1).

The Kettle River rises in the Monashee Mountains, flows south to Rock Creek, and then east to Midway. The river then loops through the State of Washington and returns to Canada near Grand Forks where it is joined by its major tributary, the Granby River. From Grand Forks, the Kettle continues east to the outlet of Christina Lake then turns south, crosses the international boundary at Cascade, British Columbia, and eventually joins the reservoir of Grand Coulee Dam on the Columbia River near Kettle Falls, Washington.

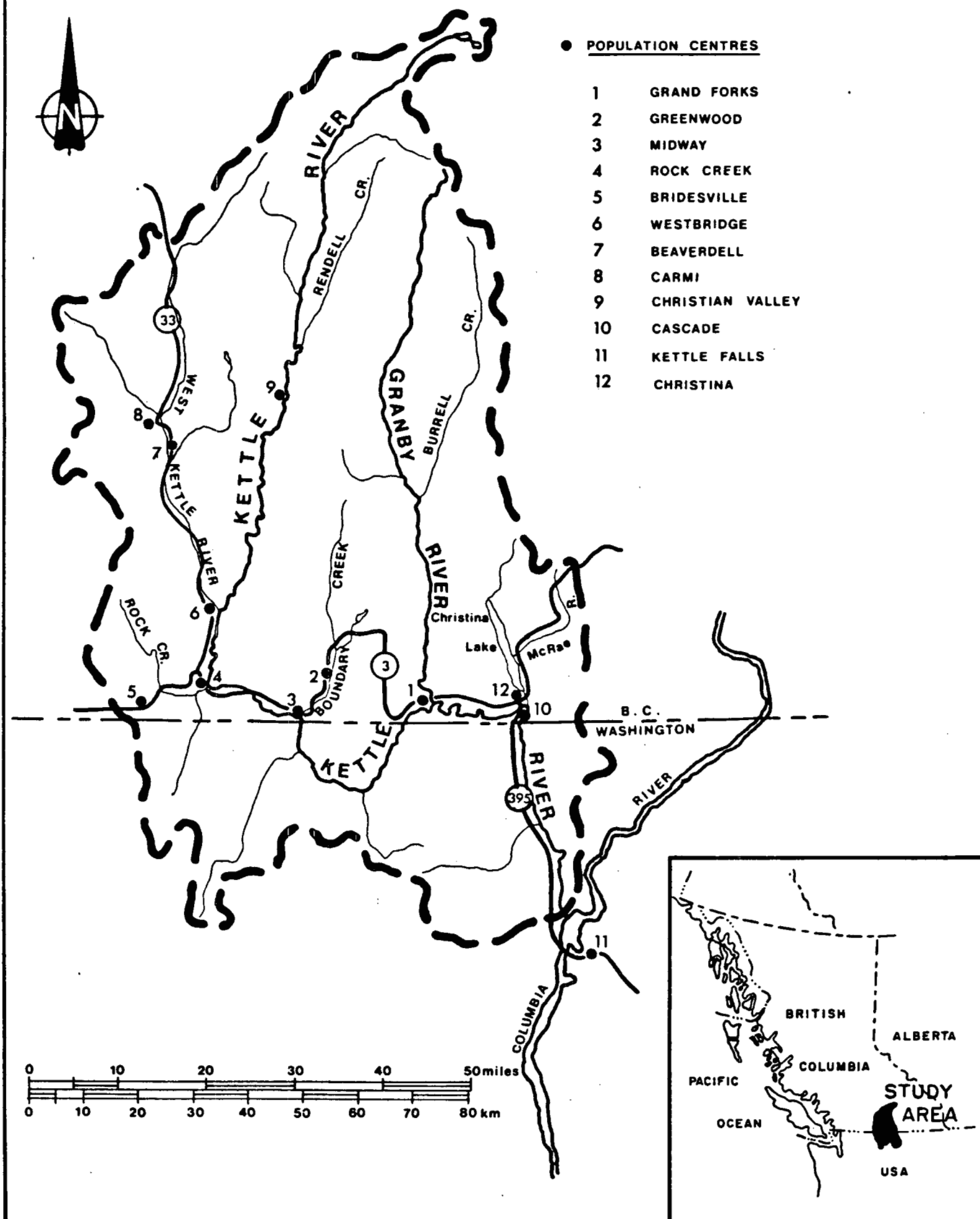
Its major tributaries are the West Kettle River, Boundary Creek, Granby River, and Christina Lake; all occupying north-south trending valleys. The Kettle River is about 290 kilometres long and drains an area over 8200 square kilometres in British Columbia.

B. Objective and Outline

The objective of this report is to describe the physical, biological, and socio-economic resources of the Kettle-Granby River Basin and identify potential areas of concern or involvement for the Inland Waters Directorate (IWD), Environment Canada.

Chapter Two of the report provides an overview of the Basin's water and related resources, including physiography, climate, water, vegetation, and fisheries and wildlife. The following chapter discusses man's use of the Basin's natural resources. It provides an historical perspective and description of the area's communities and amenities. The Basin's major industries are discussed with particular attention directed to any water quality or quantity questions that may be of concern.

Figure 1
The Kettle-Granby River Basin

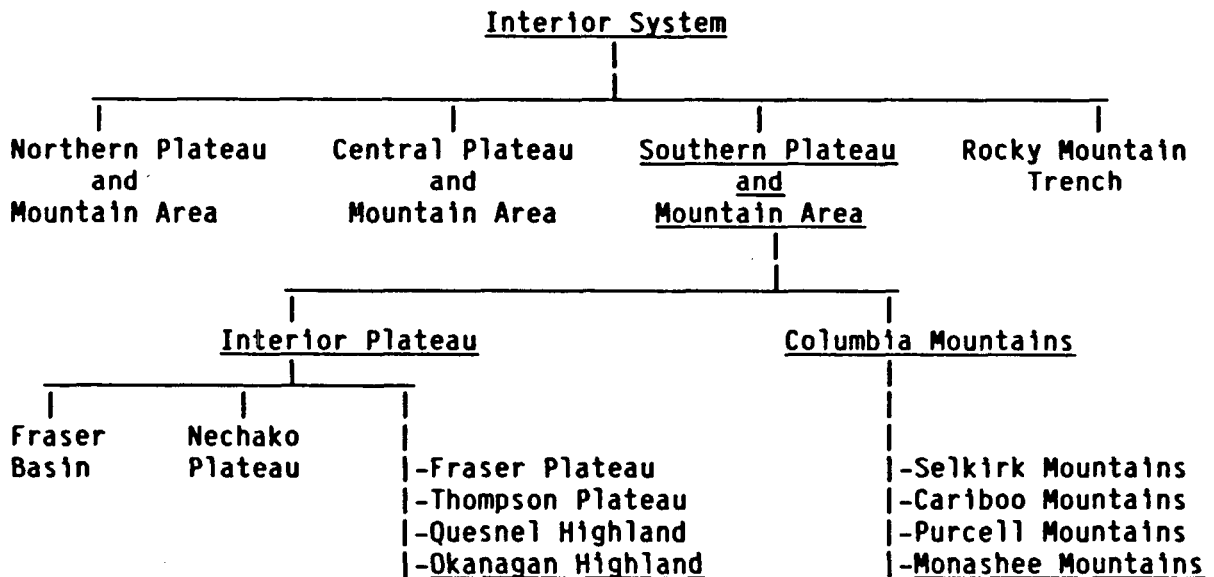


2. WATER AND RELATED RESOURCES

A. Physiography

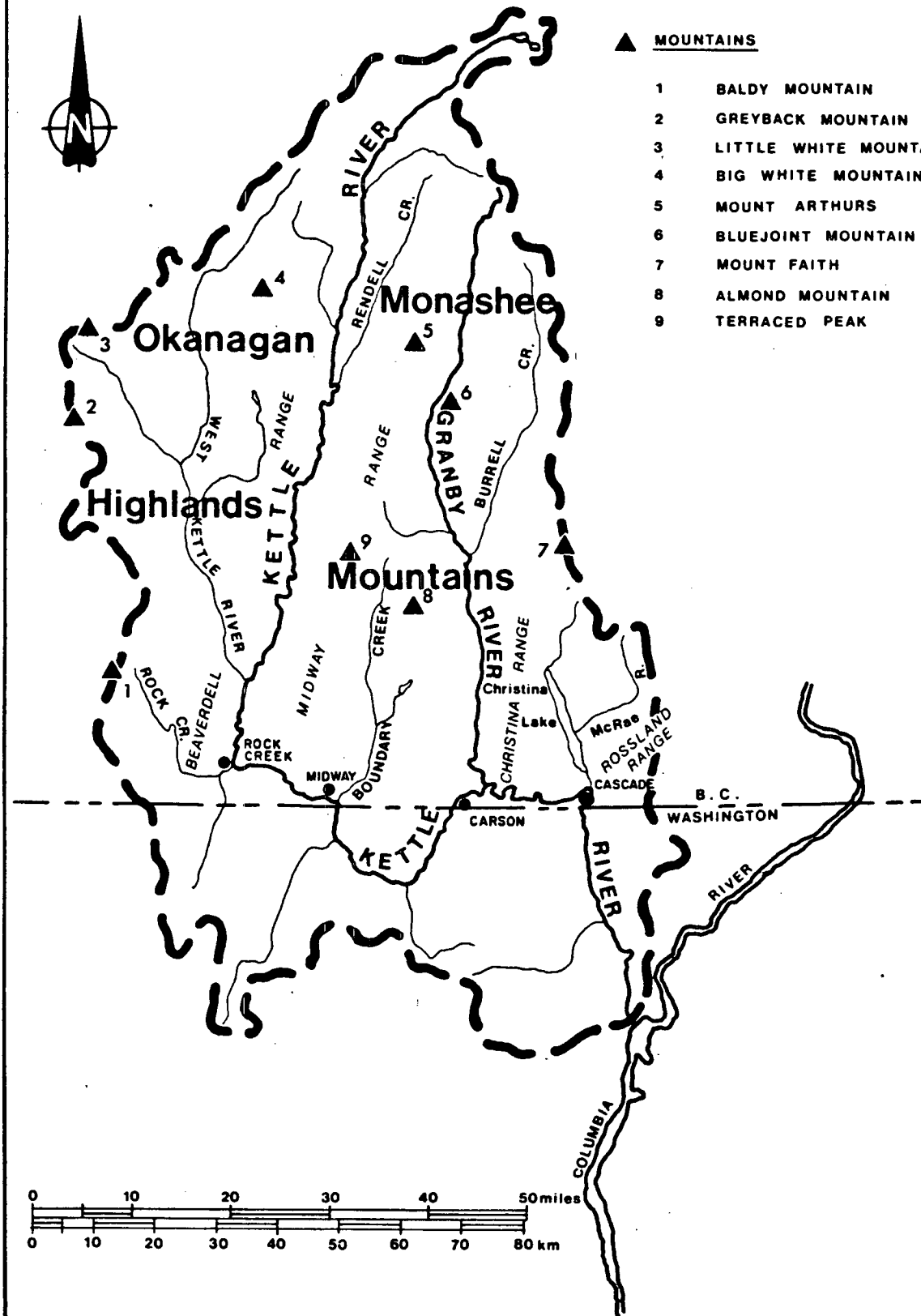
There are two physiographic regions in the Kettle-Granby River Basin: the Okanagan Highland, west of the Kettle River, and the Monashee Mountains, east of the river (fig. 2). The figure below depicts the relationship of the two regions to the Interior System and other physiographic subdivisions of the Canadian Cordillera as described by Holland (1976).

FIGURE 3. PHYSIOGRAPHIC SUBDIVISIONS OF THE CANADIAN CORDILLERA IN THE BASIN



The Okanagan Highland was glaciated during the last ice age but erosion was moderate, resulting in rounded mountains and ridges and a widespread mantle of drift on an upland surface. Much of the highland is underlain by gently-dipping gneisses which have weathered to produce open step-like slopes (Holland 1976: 74). The highest elevations in the Basin west of the West Kettle River are: Baldy Mountain, 2304 metres; Little White Mountain, 2169 metres; and Grayback Mountain, 2135 metres. The Beaverdell Range lies between the West Kettle and Kettle Rivers; its

Figure 2
Physiography



highest elevation is Big White Mountain at 2317 metres although most of the range lies between 762 and 1524 metres. The Beaverdell Range is a transition between the gently rolling Okanagan Highland to the west and the Monashee Mountains to the east.

The Monashee Mountains are represented in the Basin by three northerly trending ranges: the Midway Range between the Kettle and Granby Rivers, the Christina Range east of the Granby River to Christina and Lower Arrow Lakes, and the Rossland Range east of Christina Lake. Elevations generally range from 900-1800 metres in the Midway Range with the highest peaks being Almond Mountain, 2318 metres; Terraced Peak, 2303 metres; and Mount Arthurs, 2369 metres. The Christina Range is higher and more dramatically peaked than the Midway Range, with average elevations between 1520 metres and 1800 metres and peaks of 2279 metres at Mt. Faith and 2317 metres at Bluejoint Mountain. The elevation of Christina Lake is 467 metres. The easternmost part of the study area is occupied by the western foot of the Rossland Range. The Monashee Mountains are largely underlain by gneissic rocks of volcanic origin which give rise to many basaltic features and contribute to the area's mineral endowment.

The river valleys of the Monashee Mountains are intensely glaciated resulting in U-shaped valleys two to four kilometres wide, terraced or flat bottoms, steep walls, and a widespread mantle of glacial drift. Terraces may reach as high as 60 metres above the valley floor. Hanging valleys and alluvial fans are common features of the landscape. The major valleys in the Basin drain southward and are occupied by the West Kettle and Kettle Rivers, Boundary Creek, Granby River, and Christina Lake. These valleys drain into the Lower Kettle River which drains west to east along the international boundary from Rock Creek to Cascade.

B. Climate

The climate of the Kettle-Granby River Basin is dominated by moderating air movements from the Pacific Ocean with occasional influxes of cold continental Arctic air in the winter. The topography of the Basin influences local weather patterns: the uplands are cooler and

wetter than the valleys since temperature decreases and precipitation increases with rising elevation. The warmest and driest parts of the Basin are the southern valleys of the West Kettle, Kettle, and Granby Rivers and Boundary Creek. In these valleys, precipitation averages 350-450 millimetres annually including 120-250 centimetres of snowfall. The greatest total precipitation is in December while the greatest monthly rain fall occurs in June. Temperatures average 18°C in July, the warmest month, and -7°C in January, the coldest. The frost-free season is irregular, averaging 80-130 days in most valleys although Rock Creek and Grand Forks often experience 200-day seasons.

The climate in the remainder of the Basin becomes increasingly cooler and wetter with higher altitudes; western exposures generally receive more precipitation. The average precipitation in the Okanagan Highlands is 750 millimetres and 750-1000 millimetres in the Monashee Mountains. Mean annual snowfall is in the 200-500 centimetres range. Temperatures average 15.5°C in June and -9.5°C in January with a frost free season of around 60 days.

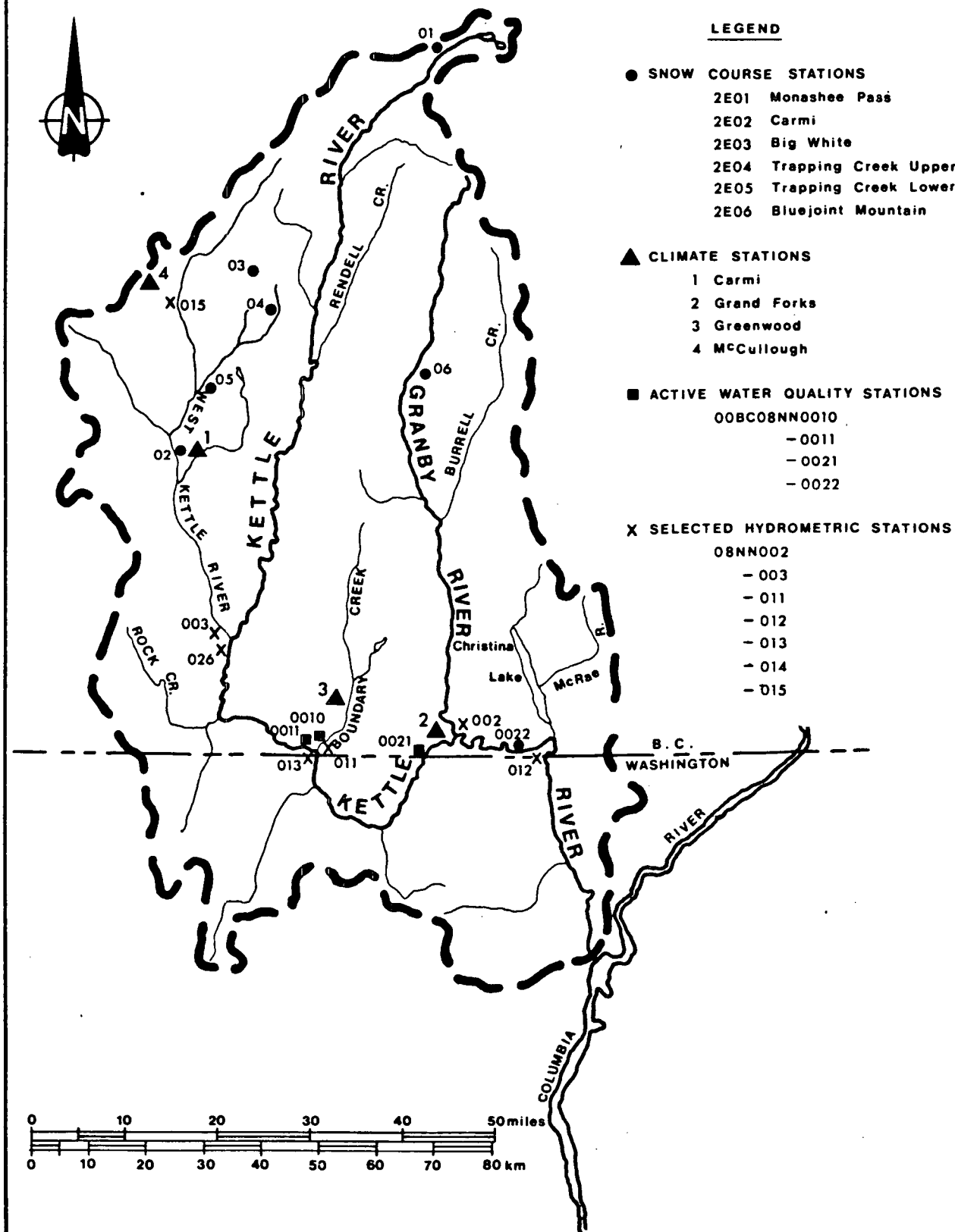
Winters throughout the Basin generally last from October through April and are characterized by cloud cover and moderate precipitation. The occasional Arctic system brings cold, clear days. June is the wettest month in the Basin followed by warm and dry summers in July and August.

Historical data for four climatological stations operated by the Atmospheric Environment Service are given in appendix 1; station locations are noted on figure 4.

C. Water

The Kettle River Basin upstream of Cascade covers about 9800 square kilometres, 8300 square kilometres are in British Columbia and 1500 in the State of Washington. The river is about 290 kilometres in length. From its headwaters in the Monashee Mountains to Rock Creek, it drops over 190 metres creating a gradient of 3.2 metres per kilometre, almost twice that of the West Kettle River. Below Rock Creek the gradient decreases to 1.2 metres per kilometre and the river meanders to its mouth, except for occasional rapids.

Figure 4
Climate and Hydrometric Stations



There are three main lakes in the Basin: Christina, Jewel, and Conkle. Smaller lakes occur throughout the Basin, particularly in the headwaters area. Christina Lake is the largest and is located in the Basin's southeast corner. The lake is approximately 18.5 kilometres long and 1.6 kilometres wide with an area of 25 square kilometres and a tributary drainage of about 466 square kilometres. The lake has a maximum depth of 54 metre and a mean depth of 36 metres. Water levels fluctuate over a 2 metre range with maximum levels occurring during the freshet in May and June and minimum levels in winter.

Conkle Lake is 16 kilometres northeast of Bridesville. The lake is 2.9 kilometres long and 0.6 kilometres at its widest point. Conkle Lake lies at 1068 metres and drains an area of 30 square kilometres.

Jewel Lake, the smallest of the three, is located about 10 kilometres northeast of Greenwood. It is 2.9 kilometres long and 0.3 kilometres wide with an area of 0.8 square kilometres. The lake's maximum depth is between 15-18 metres; it lies at 1144 metres elevation and drains an area of 7.2 square kilometres (British Columbia 1977: 3-5).

The Kettle-Granby River Basin's total mean annual discharge is 2.6 million cubic decameters (approximately 203 million acre-feet) (Canada 1983). Water Survey of Canada operates 13 hydrometric stations in the Basin; data for seven representative stations are shown in table 1 and their locations given in figure 4. Analysis of discharge data indicates a seasonal flow pattern characterized by spring flood peaks in May and June due to snowmelt and spring rains. Three-quarters of the annual flow occurs during this period. Discharge steadily declines during summer and early fall, and is insignificant in many tributaries. There is an occasional minor peak in October and November due to fall rains. Minimum flows occur from August to March.

Ground Water

The Kettle, Granby, and West Kettle River valleys are areas in which ground water is readily available. Well flows average 230-2300 litres per minute and the water is generally very hard. Wells producing more than 450 litres per minute are located in Grand Forks and Midway. There

TABLE 1. SUMMARY OF HYDROLOGIC DATA FOR
SELECTED STATIONS IN THE KETTLE-GRANBY RIVER BASIN

Station Name (and Number)	West Kettle R. Nr. McCulloch (08NN0015)	West Kettle R. @ Westbridge (08NN0003)	Kettle R. Nr. Westbridge (08NN0026)	Boundary Cr. Nr. Midway (08NN0011)	Kettle R. Nr. Ferry (08NN0013)	Granby R. @ Grand Forks (08NN0002)	Kettle R. Nr. Laurier (08NN0012)
					(International)		(International)
Period of Record	1949-	1914-	1975-	1929-1977	1928-	1914-	1929-
Drainage Area (km ²)	230	1870	2150	593	5700	2050	9840
Monthly Mean Discharge (m ³ /s)							
JAN	0.346	2.12	-	-	5.81	4.47	14.4
FEB	0.322	1.53	-	-	6.10	5.15	15.4
MAR	0.422	2.65	-	-	9.39	12.3	25.6
APR	2.02	19.5	26.8	6.17	62.0	53.7	136.0
MAY	14.5	57.9	112	14.5	192.0	130.0	349.0
JUNE	15.1	36.9	97.8	8.81	146.0	101.0	263.0
JULY	4.08	12.0	36.2	2.46	40.9	27.0	76.6
AUG	1.16	3.91	11.8	0.612	12.3	6.97	23.4
SEPT	1.20	3.46	10.5	0.363	10.2	6.67	18.6
OCT	1.08	2.34	-	0.225	11.0	8.19	19.9
NOV	0.861	2.35	-	0.247	10.2	7.94	20.9
DEC	0.551	2.05	-	-	7.3	5.52	17.1
Annual Mean Discharge (m ³ /s)	3.50	9.24	-	-	42.9	31.2	81.9
Total Mean Discharge (dam ³)	110 000	291 000	-	-	1 350 000	985 000	2 590 000
Max. Daily Discharge (m ³ /s)	48.1 (Jun 16/76)	135.00 (May 21/20)	250 (May 7/80)	-	575 (May 29/48)	385 (Jun 4/14)	968 (May 29/48)
Min. Daily Discharge (m ³ /s)	0.091 (Aug 26/70)	0.991 (Jan 1/17)	-	0 (Aug 22/43)	0.452 (Jan 16/30)	0.227 (Jul 26/29)	1.98 (Jan 11/30)

(Canada 1983)

are approximately 300 recorded ground water wells in the Kettle Basin; however, not all wells are recorded with the provincial Water Investigations Branch (Canada 1986).

More than half the wells are near Grand Forks while 80 percent of the wells are located along the Kettle River in the alluvial and glacial deposits which cover the valley bottom. Most of the other wells are located along the West Kettle River and some are near Boundary and Beaverdell Creeks. The distribution of wells in the Basin is given in table 2.

Ground water is sampled at several wells during spring freshet and autumn when the water table is low. Data is available from the provincial Water Management Branch.

Dams and Diversions

There are no major dams in the study area; however, there are several minor water diversions from the northwest portion of West Kettle River. These water licences are held by the City of Penticton and the South East Kelowna Irrigation District (SEKID). In several cases the water which is diverted is held in reserve such as at Howard Lake. Pear Lake has two licences allowing the SEKID to divert water; however, it has not been used as a storage area in many years and the lake has been allowed to return to its natural state. SEKID has held licences on Haynes Lake since 1926. The licences are for 1,200 acre feet of diversion and 2,000 acre feet of storage in the lake (now part of McCulloch Reservoir). Sterling Creek has two licences dating back to the early 1900's. The licences are for the diversion of water to McCulloch Reservoir where it is held in storage. SEKID has a licence for water diversion on Affleck Creek but the amount of water involved is very small (Regional District of Kootenay Boundary (RDKB) 1979: 34).

Snowpack

Measurement of snowpack is a good indicator of subsequent streamflow during freshet. The provincial Water Management Branch (MOE) operates six snow courses in the Basin; these are listed in table 3 and located on

TABLE 2. DISTRIBUTION OF GROUND WATER WELLS.
IN THE KETTLE-GRANBY RIVER BASIN

Location	Number of Wells
Grand Forks	161
Beaverdell	38
Midway	24
Rock Creek	18
Kettle Valley	14
Carson	12
Westbridge	8
Kettle River Valley north of Westbridge	7
Bridenville	5
West of Bridenville (Nine Mile Creek area)	5
Greenwood	3
Carmi	3
Christina Lake	2
Rhone	2
Cascade	1
Boundary Creek Provincial Park	1
Johnstone Creek Provincial Park	1
TOTAL	305

(British Columbia 1977)

figure 4. The Branch publishes monthly snow survey bulletins from January to June with streamflow forecasts given in the April and May editions. Data for table 3 was compiled from the "Summary of Snow Survey Measurements 1935-1980" (British Columbia 1981).

TABLE 3. SNOW SURVEY STATIONS

Station Number	Station Name	Elevation (m)	Years of Record	Monthly Means (water equivalent mm)				
				Jan	Feb	Mar	Apr	May
2E01	Monashee Pass	1370	1949-	160	240	317	356	326
2E02	Carmi	1250	1963-	94	130	158	167	51
2E03	Big White Mountain	1680	1966-	112	349	438	522	535
2E04	Trapping Creek (Upper)	1360	1966-	-	185	235	260	154
2E05	Trapping Creek (Lower)	930	1966-	-	109	136	98	0
2E06	Bluejoint Mountain	2040	1973-	-	-	549	629	729

(British Columbia 1980)

Water Quality

Water quality is sampled by both federal and provincial agencies. The Water Quality Branch, Inland Waters Directorate has four active stations near the international boundary which are sampled every two weeks (see fig. 4) and 52 inactive stations. In response to public

concerns over a cyanide-leaching process used at the Vulcan Mine in Washington State, the Branch initiated testing for cyanide levels at two stations on the Kettle River in November 1985 (Thorp 1985).

The provincial Waste Management Branch (MOE) samples eight sites, four to six times per year, upstream and downstream of development activities such as mines and tailings ponds, sawmills, and landfills (Bryan 1985). The locations of effluent discharge points and monitoring stations are shown on 1:50 000 scale maps and data are available on computer files from the Branch. MOE also has limited information on 27 inactive water quality stations.

Water quality in the Basin is generally considered good although there have been some problems in the past with tailings pond leachates and municipal discharges. Christina Lake is oligotrophic which indicates low productivity, although, at present, the lake water quality is good. MOE samples the lake twice a year in early spring and early fall.

D. Soils and Vegetation¹

Soils

The soils of the Kettle-Granby River Basin are derived, for the most part, from glacial deposits. In many areas, the mantle of glacial drift deposited over the Basin forms the parent material on which present soils have developed. On steep slopes, the drift has washed or slid off leaving extensive areas of exposed rock in mountainous regions. Soils have also developed on outwash sands and gravels, eskers, glacial lake deposits, and alluvial terraces and fans (British Columbia 1977: 2).

Soils in the Basin can be divided into two broad categories depending on whether they developed under forest or grass. Grassland soils have accumulations of organic matter in the surface mineral soil horizons. According to the colour derived from organic matter, these soils are classified as dark brown or black, each with various subgroups. Most of the soils suitable for agriculture are of this type and lie in the Kettle, West Kettle, and Granby River valleys, and in the Boundary Creek valley (ibid.).

¹ From British Columbia 1977 and RDKB 1979: 19.

Between the forest and grassland soils, a transitional dark grey soil group occurs. The horizon sequence is similar to that of the grassland soils with the decomposition of organic matter in the surface mineral horizons the distinguishing feature.

Forested soils can be separated into several groups and subgroups depending on the degree of weathering and movement of soil constituents. The groups are: brown wooded, grey wooded, grey forested, and acid brown wooded. Generally the brown wooded soils have the most lime and plant nutrients compared to the others. The acid brown wooded soils are the most impoverished and consequently are the least fertile of the above types (RDKB 1979: 19).

A comprehensive soil survey of the Basin was undertaken in 1963 by the B.C. Department of Agriculture. The report contains detailed descriptions of all of the soils within the Basin having capability for agricultural use (Sprout & Kelley 1964).

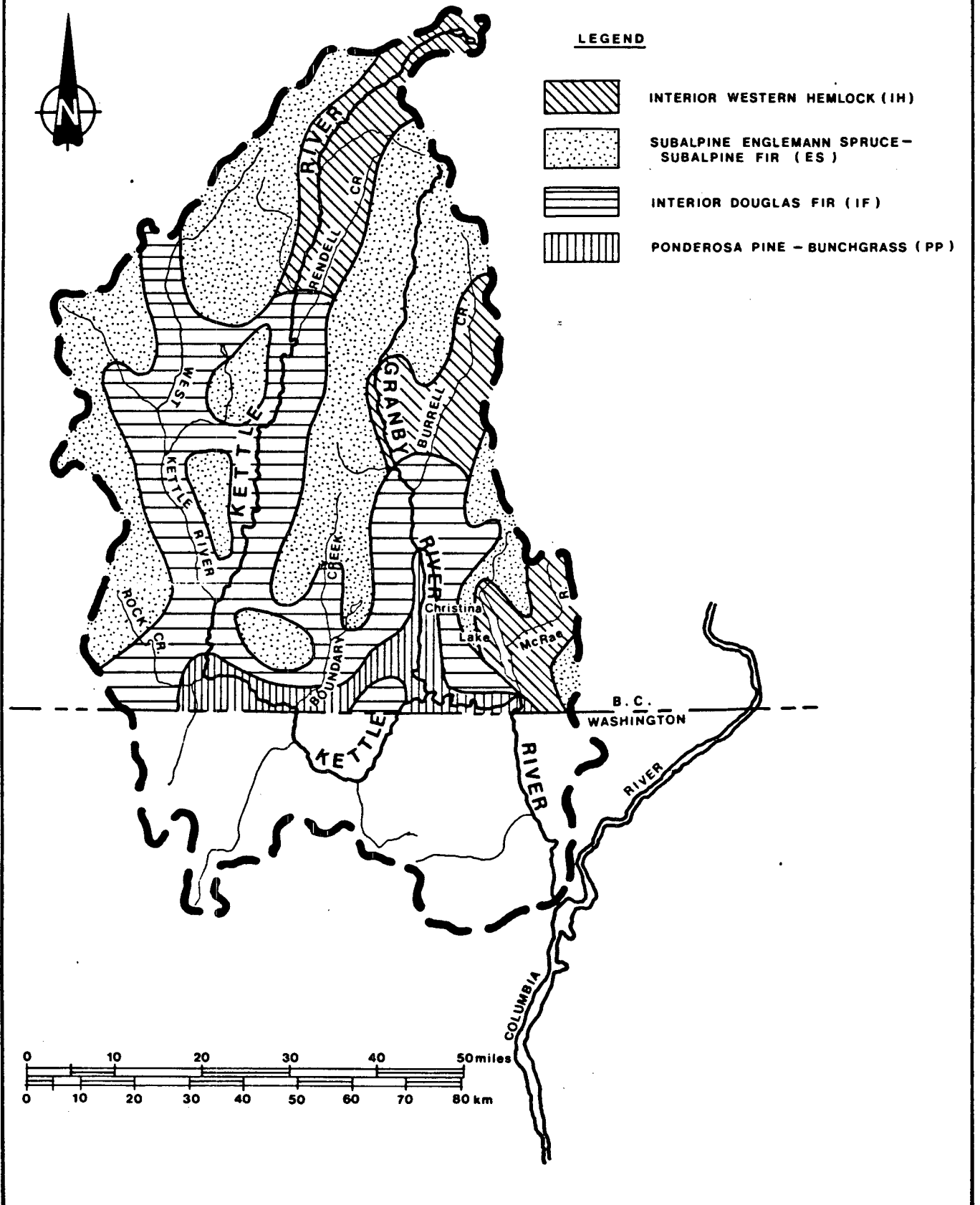
Vegetation

Krajina (1976) identified four broad biogeoclimatic zones in the Basin (fig. 5). The Ponderosa Pine-Bunchgrass Zone occurs in the southern Kettle Valley along the international border and on south-facing slopes between Bridesville and Grand Forks. It is the warmest and driest zone in the Basin and is characterized by open grasslands and semi-open dry forest. Light to moderate stands of ponderosa pine, interior Douglas fir, and western larch cover the lower slopes while deciduous trees including balsam poplar, trembling aspen, willow cottonwood, and birch fringe the main river.

The Interior Douglas Fir Zone covers most of the remaining river valleys and lower slopes (below 1216 m) in the Basin. This zone is the second warmest in the Basin and is dominated by light to moderate stands of interior Douglas fir and ponderosa pine. There is also some spruce, lodgepole pine, western white pine, grand fir, and western larch.

The Interior Western Hemlock Zone near the headwaters of the Kettle and Granby Rivers, is the wettest and the forests are more dense and productive. Interior Douglas fir, western white pine, lodgepole pine,

Figure 5
Biogeoclimatic Zones



western hemlock, western red cedar, Engelmann spruce, white and black spruce, and subalpine fir are common. Balsam poplar, trembling aspen, and paper birch are frequent deciduous trees in this zone.

The final zone, Engelmann Spruce-Subalpine Fir, occurs at higher elevations in the Basin with Engelmann spruce, white spruce, subalpine fir, lodgepole and western white pine, subalpine larch, and, at lower elevations, interior Douglas fir, western red cedar, and western hemlock. Alpine tundra occurs on scattered peaks above treeline (1830-1980 metres). A detailed analysis of forest types is given in the "Kettle Valley Rural Study" (RDKB 1979).

E. Wildlife and Fisheries

Wildlife

The capability of an area to support wildlife is influenced by climatic factors such as snow and soil depth, exposure, and moisture. The Canada Land Inventory (CLI) identifies a high land capability to support ungulates (Class 2W and some 1W) along the Basin's lower south and west-facing slopes (Canada 1968). These areas have low snow depth, protective cover, and adequate food supplies to provide critical winter habitat. Eastern-facing slopes and several tributary valleys, such as Boundary Creek and West Kettle River, are rated as Class 3W or summer and winter range with slight or occasional limitations depending on seasonal climatic characteristics. The headwaters of the Granby River are identified as important summer range for deer (Class 3); however, most other sub-alpine and alpine areas have fairly low capability as summer range and insignificant wintering capability (Class 4).

Mule deer, found mostly in the rocky upland areas, are the most abundant ungulate species in the Basin. White-tailed deer have moderate populations and seem to prefer semi-open lowland habitats in the Kettle and Granby River valleys. Elk are found in areas throughout the Basin while small numbers of moose are found near marshes on the plateau between the Kettle and West Kettle Rivers. There are some mountain goat in the Basin: two populations in the West Kettle Basin and one north of Christina Lake. Some California bighorn sheep have also been spotted in the Basin.

Black bears are common and there are a few grizzly bears in secluded upland areas. Other fur-bearers include cougars, lynx, coyotes, and occasionally wolves and wolverines. Smaller fur-bearers widely distributed throughout the Basin include raccoons, weasels, marten, badgers, porcupine, bobcats, beavers, squirrels, otters, muskrat, mink, and rabbits. Woodchucks, gophers, ferrets, and moles are also common.

Agricultural areas and open grassy hillsides provide natural habitat for several upland bird species. Limited numbers of ring-necked pheasants, Hungarian partridges and California quail are found in drier areas. Indigenous blue, willow, Franklin's, and ruffed grouse are associated with the forested areas while ptarmigan are found in subalpine areas. Falcons, red-tailed hawks, bald and golden eagles, numerous swallows, song birds, flickers, and mourning doves are also found in the Basin.

The Basin has a low CLI capability rating for waterfowl production (Class 6 and 7), although small numbers of ducks, Canada geese, teals, and mergansers are common along the Kettle River and some of the smaller lakes. In addition, several great blue herons have been sighted along the Kettle River. One notable exception to the general lack of large concentrations of waterfowl population is Myers Lake (Class 2) southwest of Kettle Valley, which supports an abundance of waterfowl and associated wildlife.

Fisheries

The provincial Fish and Wildlife Branch have identified priority streams in the Basin and special management opportunities and problems for each stream. These data are available from the branch in Penticton; a partial listing of available data is given in table 4. The Branch has also classified some of the Basin's lakes.

Generally, rainbow trout is the most important game species in the Basin with Wilkinson and Beaverdell Creeks providing valuable habitat. However, the capability of the West Kettle drainage lakes to supply a good quality and quantity of rainbow trout far exceeds that of the West Kettle River and tributary streams. In many years, low summer flows

TABLE 4. FISHERIES VALUE PRIORITIES
FOR SELECTED STREAMS IN THE BASIN

Area	Fisheries Priority	Problems & Opportunities ¹
Wilkinson Creek	A (most important)	Impending logging. Water shortage if licences utilized; poor public access through farms.
Beaverdell Creek	A (2nd most important)	
West Kettle River at McCulloch	A	Excessive coarse fish populations. Beaver ponds necessary to conserve water.
Kallis Creek	A	
Goathide Creek	A	Two dams on Conkle Lake would interfere with trout spawning in creek; poor public access to private property. Habitat severely damaged by logging. ²
Saunier Creek	A	
Conkle Creek	A	
Trapping Creek	B	Water storage could augment low summer streamflows. Unique forest first ½ mile deserves preservation.
Hall Creek	B	
China Creek	B	
Stirling Creek	B	Potential water storage insufficient spawning substrate. Railroad culvert and log jams limit fish movement.
Dale Creek	B	
Carmi Creek	B	Log and brush jams.
Tuzo Creek	B	

¹ Management problems and opportunities listed here are specific and do not include more general management needs such as forestry leave strips, road culvert design, and maintenance of minimum summer stream flows.

² Increasing spring runoff and clear cut logging of riparian belt causing erosion of stream banks, stream siltation, and formation of log jams. Removal of stream bank cover has created high summer stream temperatures detrimental to fish survival and growth. Operation of logging equipment along stream has damaged stream banks and disrupted stream substrata.

augmented by high water temperatures cause fish kills in the West Kettle River (British Columbia 1985e). Some lakes in the Basin are stocked every three to five years; stocking of Christina Lake has been discontinued due to low productivity. Whitefish are taken in the Kettle River between Westbridge and Midway in the early spring. Other fish found in the Basin include bass, sculpin, and squawfish.

3. EXISTING AND POTENTIAL RESOURCE USE

A. Historical Perspective¹

Mining and Railways

The activities which shaped many of the Basin's physical and social characteristics began in 1858 with the discovery of placer gold near Rock Creek. Within a year there were 500 placer miners in the previously unsettled Basin. In 1860 a customs post was established at Rock Creek and a gold commissioner appointed to manage the influx of people. However, by 1862 prospectors were abandoning the Boundary District for either the Cariboo or the Salmon River in Oregon.

Access to the Basin at this time was through the United States across the 49th parallel which had been established as the Canada-United States border in 1846. To provide a direct overland route from the British Columbia coast to the interior mining areas, the provincial government constructed the Dewdney Trail in 1865 from Hope to Rock Creek and then on to Fort Steele in the East Kootenays. The Dewdney Trail provided the only east-west route across the southern interior until the building of railways and roads caused its abandonment.

During the search for gold, rich copper deposits were found in several locations in the Basin. The first mineral claims, in bedrock, were staked in 1884 northeast of Camp McKinney on Baldy Mountain. In 1891, Camp McKinney was the site of a major gold strike and between 1894 and 1903 more than a million dollars was taken from the Cariboo Amelia Mine.

Valuable ore bodies near Beaverdell were staked in 1896 and 1897. Initially only small amounts of silver-lead-zinc ore were shipped out for refining, but with the completion of the Kettle Valley Railway in 1915 intensive development was undertaken.

¹ (The text for this section was taken from Sprout & Kelley 1964: 9-14 and RDKB 1979: 6-8).

A two-stamp mill, erected in 1892 at Boundary Falls to reduce quartz ore from nearby claims, was the first industry established in the Basin. In 1899 the Granby Consolidated Mining, Smelting and Power Co. built the Granby copper smelter at Grand Forks. Smelter Lake, which occupied 271 hectares, was formed by damming Granby River in a narrow channel four kilometres from its junction with Kettle River. This lake provided the smelter with a water supply and was used as storage for a small power plant. The power plant was dismantled along with the smelter in 1919, leaving a huge slag pile as a legacy.

In 1900 a hydroelectric power plant was built at Cascade Falls on the Kettle River by an English syndicate. The plant, known as the Cascade Water, Light and Power Co., Ltd., operated until 1920. A power line was built westward to supply the Phoenix, Greenwood, and Boundary Falls mining and smelting industry.

About 1900 the British Columbia Copper Co. Ltd., with mines at Deadwood Camp and Phoenix, built the Greenwood Smelter and the Standard Pyritic Smelting Co. plant at Boundary Falls. From the start of mining and smelting operations in 1900, the volume of ore increased annually and reached a peak in 1913, when 1,250,000 tons were treated by the Greenwood, Boundary Falls, and Granby smelters. During the First World War the Boundary District was the most important copper-producing area in the British Empire. In the total period of operation the Phoenix and Deadwood camps supplied about 22 million tons of ore, which contained about 1.5 percent copper. Gold and silver extracted from the copper had an average value of \$0.75 per ton of ore. By 1919 the highgrade ore was nearing exhaustion and, in conjunction with a labour strike in the Crowsnest coalfield which cut off the supply of coke, led to the abandonment of the mines and smelters. From 1920 to 1958, mining in the Greenwood-Phoenix area consisted only of intermittent development work and apart from a short period in the 1960's and early 1970's when the Phoenix mine reopened as an open-pit operation, mining ceased to have a significant impact on the Basin.

Several railway companies competed for the mining industry's lucrative business. In 1905, the Great Northern Railway Company (now the

Burlington Northern) constructed the Vancouver, Victoria, and Eastern Railway from Ferry, Washington to Midway. From Midway the rail line was built west to Bridesville where it turned south to recross the international boundary at Molson, Washington. From Molson the railroad proceeded westerly to Oroville, Washington. These tracks are now abandoned.

In 1910, the Canadian Pacific Railway obtained a charter to build the Kettle Valley Railway from Midway to Hope. The rail link was completed in 1915 and provided passenger service until 1964. Very little economic development occurred in the Kettle River Valley prior to construction of this railway. Agriculture was limited to the small farms of local miners and forestry development was virtually non-existent. With the start of railway construction, selective cutting of Douglas fir and western larch for railroad ties was undertaken by small mill operators. By 1951, there were about 60 small mills, most of them three or four man operations, operating in the Kettle Valley between Carmi and Midway. Between 1951 and 1965 most of these mills ceased operation.

Agriculture

The importance of adequate water for irrigation was appreciated by the first white settlers of the Boundary District. They obtained property close to rivers and creeks. The first settler to establish a water right was James McConnell in 1875. Settlement of the black soils of the Anarchist Mountain area dates from the placer mining boom in Rock Creek.

The first livestock herd crossed the boundary from the United States at Osoyoos in 1858 to supply horses, mules, and meat animals for the gold mining camps. J.C. Haynes, Customs Officer and W.H. Howe, chief constable, began cattle ranching in 1866, obtaining cripples and other stock from the drovers. By the time Haynes died in 1888, he and Howe had acquired some 3,000 head of cattle and 8 500 hectares of land in the Osoyoos and Anarchist Mountain area. By 1892, there were about 20,000 head of cattle on the ranges of the Similkameen, Osoyoos, and Boundary areas.

The first attempt at large-scale irrigation in the area was made by the Kettle Valley Irrigation Fruit Lands Company Ltd. on about 810 hectares on the south side of the Kettle River. The company obtained water rights for irrigation in 1906. This water, diverted by means of a dam located 800 metres from the confluence of Rock Creek and Kettle River, was distributed to the land by means of flumes, ditches, and pipes. The company subdivided their land into lots of about 3.6 hectares and distributed these lots singly and in larger parcels to settling families. These settlers, mostly retired British army personnel, were inexperienced in agriculture and their orchards grew poorly because of the severe climate and inadequate water supply. Unfavourable conditions for tree fruit production and enlistment to serve in the First World War started a decline that led to abandonment of this project. In 1927, only seven settlers remained and jointly they had 50 hectares under irrigation. To date little evidence other than the subdivided lots remains to indicate this settlement ever existed.

Immigration of members of the Doukhobor sect from Saskatchewan to the Kootenays in the early 1900's brought a surge of agricultural activity to the eastern portion of the Basin. Their communal form of living evolved around a village composed of two large community houses for each 40 hectares. Many of the two-storey square brick houses are still occupied though some are derelict. The communal system flourished during the lifetime of their leader, Peter Verigin, but became disorganized after he died in 1924.

Ranchers started to settle the West Kettle Valley during the 1920's and 1930's. The first water licence in the West Kettle Valley was granted for 123 acre feet from Beaverdell Creek. During the Second World War, Grand Forks gained importance for Canadian seed production; however, notoreity was shortlived as imported seed controlled the market after the war. After the Second World War there was an upsurge of water licence applications for irrigation use but the biggest growth was in the forest industry which remains the principal economic activity in the Basin.

Historical Development of Communities

Midway, originally called Eholt's after its founder, was so named

because it is about midway between the Rocky Mountains and the Pacific Ocean. The townsite was acquired in 1892 by a Montreal group and by 1899, had a court house, mining recorder, registrar of vital statistics, coroner, and constable, as well as its own newspaper. In 1899, the town became important as the terminal of the Columbia and Western Railway. In 1905, the Vancouver, Victoria, and Eastern Railway, a branch of the Great Northern was built through Midway from Ferry, Washington. By 1914, Midway's population was about 300.

Greenwood, beginning with a few prospectors' cabins, was established as a city in 1893. Robert Wood obtained the 260-hectare site in 1895 and the city was incorporated with mines at Deadwood Camp and Phoenix. The Greenwood Smelter and the Standard Pyritic Smelting Company plant at Boundary Falls were built and the Boundary Falls plant was later taken over by the Montreal-Boston Copper Company. The population of Greenwood fluctuated from 1,359 in 1901 to 363 in 1941. In 1942, about 1,200 Japanese Canadians were interned in Greenwood by the Canadian government as part of a Second World War policy of removal of Japanese Canadians from the Pacific Coast. Today, a significant portion of Greenwood's population is of Japanese descent.

Grand Forks, originally called Grand Prairie, boomed from 1890-1910 and still owes its compact urban character to its quick development during a period when solid brick commercial buildings and elegant two-storey white houses were fashionable and when most people walked within the city limits. Grand Forks was incorporated in 1897 with an area of 1726 acres. The city obtained a water right for domestic supply in 1900. In 1901 the population was 1,012 and grew to 3,000 in 1914. The decline of mining and smelting caused the population to decline to 1,298 by 1931.

B. Communities, Population, and Transportation¹

Communities

Grand Forks, Greenwood, and Midway are still the three principal communities in the Kettle-Granby River Basin (fig. 1). Grand Forks,

¹ Information for this section was derived from RDKB 1979; RDKB and The Economic Development Commission (EDC) 1985; and, Cumberland Group 1981.

located at the confluence of the Kettle and Granby Rivers, is the largest community with a population of approximately 3,336 in 1984. Table 5 indicates population change from 1976 to 1984 in Grand Forks and the rest of the Basin. Since 1981, the population of Grand Forks has decreased slightly.

Water is supplied to Grand Forks from four ground water wells. There is a need for an additional reservoir to solve water pressure problems and provide storage capacity for new development. The city is served with a treatment lagoon which discharges directly into the Kettle River. There have been some problems with operation of the lagoon in the past but it is apparently operating efficiently now. Grand Forks is serviced by West Kootenay Power and Light Co., Inland Natural Gas Co., and B.C. Telephone Co. Grand Forks has all the amenities of a small community including a hospital, secondary school, three elementary schools, museum, art gallery, seven motels, three campgrounds, service clubs, churches, and restaurants. There is also a campus of Selkirk College in Grand Forks offering courses of interest to the community.

Midway was incorporated in 1967 and owes its existence to Pope and Talbot Ltd., the Basin's largest single employer which operates forest products mills in both Midway and Grand Forks. Greenwood boasts of being the smallest city in Canada and was incorporated in 1897 during the mining boom. Both communities offer a range of goods and services including banking facilities, tourist accommodations, museums, sewer and water systems, and various community and recreational facilities.

The remaining population is mostly rural and scattered throughout the Basin. Unincorporated centres include Beaverdell, Westbridge, Christian Valley, Bridesville, Rock Creek, and Christina Lake. Each has a general store, post office, and gas station. Beaverdell also has a cafe, two hotels, and highways and forests service offices. Rock Creek has a restaurant, motel, hotel, and medical clinic. Christina Lake, an all-season resort area 21 kilometres east of Grand Forks, has five motels and six campgrounds. Some of the remoter areas of the Basin are not serviced with electricity or telephone.

TABLE 5. POPULATION CHANGE

	1976	1981	1982*	1983*	1984*
Grand Forks	3096	3486	3496	3434	3336
Greenwood	931	856	871	887	932
Midway	589	633	638	656	710
Rural Areas	4976	5318	-	-	-
Total	9592	10,293			

* estimates
(RDKB and EDC 1985: 1-2)

TABLE 6. EMPLOYMENT BY SECTOR (1981)

	Total	Rural Areas (Electoral Areas) (C, D, E)	Grand Forks	Greenwood	Midway
Labour Force	4495	2330	1545	370	250
Primary Industries	885	640	165	70	10
Manufacturing	750	310	240	90	110
Construction	455	290	130	30	5
Transportation & Utilities	230	90	110	20	10
Trade	555	215	270	25	45
Finance, Insurance & Real Estate	115	25	60	20	10
Service Business	1240	640	455	105	40
Public Admin.	210	85	100	10	15
Other	55	35	15	0	5

(RDKB & EDC 1985: 4)

Population and Employment

The Basin has a higher proportion of older people than the provincial average and a lower proportion of the 25-40 age group. This suggests that job creation has not kept pace with urban areas of the province. There were 4,495 people employed in the Basin in 1981. Table 6 provides the number employed by sector or industry. The major primary industries are forestry and mining; wood processing is a significant component of the manufacturing sector. Since 1981, approximately 300 permanent jobs have been lost in the Basin; most of these in the primary and manufacturing industries.

The 1976 Kootenay Report found that the poor are poorer in the Kootenays than in British Columbia as a whole (British Columbia 1976). This is attributed to the presence of seasonal work, small service sector, greater number of older persons, and lack of upper management and professional employment. While there are proportionately fewer wealthy people in the Kootenays, the middle income earners have a higher than average income. This is due to high wages paid in the primary resource industries.

The ethnic composition of the Basin is quite unusual with respect to the rest of the province. While people of British descent are still the largest ethnic group (46 percent), those of Russian descent comprise 22 percent, followed by German and Asian. In Greenwood, 23 percent of the population is of Japanese descent reflecting its location as an internment camp in the Second World War.

Transportation

There are two railway systems, offering freight service only, remaining in the Basin: Canadian Pacific Railway (CPR) and Burlington Northern. CPR connects Midway and Grand Forks with Castlegar four times per week. The Midway to Penticton portion of CPR's Kettle Valley Railway was officially abandoned in 1978. Burlington Northern connects Grand Forks and Spokane, Washington with freight service twice a week. There is also a branch line connecting the two mainlines.

Greyhound Coach Lines provides bus service three times daily along Highway 3 to Vancouver and Calgary. Republic Colville Stage travels once a day (except Sundays and holidays) from Grand Forks south to Colville, Washington. Empire Lines links Colville with Spokane.

There are a number of small airstrips in the Basin: Beaverdell, Midway, Kettle Valley, and Christian Valley. Grand Forks airstrip accommodates Twin Otters and Dash 7's. Northern Thunderbird Airlines operates a scheduled service from Grand Forks to Penticton and Castlegar. Pacific Western Airlines flies out of Penticton and Castlegar to Vancouver, Edmonton, and Calgary.

The most heavily used of all transportation systems is, of course, highways. Highway 3 runs east to west through the southern portion of the Basin linking the major communities with the rest of B.C. There are several junctions with Washington State Highways maintaining the strong north-south ties of this region. Highway 33 provides an alternative route to Kelowna and the North Okanagan from Rock Creek. Traffic on this route has increased in recent years perhaps due to increased logging activity in the area or the abandonment of the Kettle Valley Railway from Midway to Penticton. A forestry service road up the Kettle River valley through Christian Valley provides an alternate route to Arrow Lakes.

C. Forestry

Since the Second World War, forestry has emerged as the major industry in the Basin. Initially there were a large number of small, independent logging contractors and sawmills; now the industry is dominated by one large foreign-owned corporation. Pope and Talbot Ltd. bought out Boundary Sawmills of Midway in 1969 and has since invested heavily in upgrading the mill to maintain a competitive edge.. Smaller operators in the Basin have gradually been bought out or closed down due to lack of capital and higher production costs. Capital is necessary to purchase or modernize mill machinery to meet new industry standards such as handling of smaller diameter logs and close utilization or more intense use of each log. For example, Pope and Talbot converts much of their waste material to chips and sells to Western Pulpmill in Castlegar.

Weyerhaeuser Canada Ltd. also controls cutting rights in a major portion of the Basin. Their mill is located in the Northern Okanagan.

Most of the Basin is included in the Boundary Timber Supply Area (TSA), although a small portion of the West Kettle drainage is in the Okanagan TSA. The Boundary TSA covers approximately 580 900 hectares; table 7 indicates the areas of productive forest land in this TSA. The total 20-year forest supply area is 186 000 hectares (excluding TFL #8); of this supply, 21 000 hectares are considered good quality, 124 000 medium and 41 000 poor. Table 7 provides the classifications for the Crown forest area in the Boundary TSA. In comparison with the rugged Kootenay Region, the Kettle River Basin contains a relatively large proportion of good growing sites. Land inventory maps indicating forest capability classes are available from the provincial Ministry of Environment.

A yield analysis conducted by the Ministry of Forests reveals that a harvest level of 695 000 m³ annually can be sustained for 120 years or 841 242 m³ for 30-60 years. This figure is variable, of course, depending on such variables as restocking, silviculture techniques, technological improvements, and inclusion of problem forest types. The present cut commitment in the Boundary TSA is slightly above the long-run sustained yield. Table 8 indicates the annual allowable cut and distribution of cutting rights among licencees. The higher the short term annual allowable cut, the sooner the 'falldown' effect will be felt in the region. Falldown refers to the effect of harvesting new, younger crops and the resulting lower volume per hectare.

The major species commercially harvested include, in order of importance, spruce, balsam, interior Douglas fir, western larch, lodgepole pine, white ponderosa pine, western cedar, and western hemlock. Lodgepole pine is a relatively new commercial species: up to 15 years ago it was considered a weed because it required kiln-drying before it could meet the structural specifications for building materials.

1 Tree farm licence 8 is held by Pope and Talbot Ltd. and has an annual allowable cut of 145 000 m³; it covers 77 750 hectares which is not included in the Boundary TSA.

TABLE 7. FOREST AREA CLASSIFICATIONS:
BOUNDARY TSA

Classification	Hectares
Alienated	65 800
Crown - Non forest	91 700
Sub-Total	157 500
Crown Forest: ¹	
- Mature	98 900
- Immature	298 800
- Residual	8 800
- NSR	12 800
- DSD	4 100
- NC	700
Sub-Total	423 400
Total	580 900

* Area classification is a current estimate based on the last forest inventory. Mature forest area includes lodgepole pine and deciduous stands over 80 years and all other species types over 120 years.

Includes TFL 8.

¹ Not all forest area is available to logging depending on such factors as slope, soil stability, and environmental values.

(British Columbia 1981b: 8).

TABLE 8. FOREST AND TIMBER SALE LICENCES:
BOUNDARY TSA

AAC Apportionment (excluding TFL #8)

Approved AAC	700 000 m ³	or	100.0% of AAC
Forest Licences	528 940 m ³	or	75.6% of AAC
Timber Sale Licences			
Designated Applicants	16 250 m ³	or	2.3% of AAC
Timber Sale Licences			
Small Business Enterprise Program			
Category 1	56 000 m ³	or	8.0% of AAC
Category 2	35 000 m ³	or	5.0% of AAC
Woodlot Licences	7 000 m ³	or	1.0% of AAC
Forest Service Reserve	56 810 m ³	or	8.1% of AAC

Specifically, the following forest, timber sale, and tree farm licences are approved:

Forest Licences

Licensee	Approved AAC in m ³
Pope & Talbot Ltd., Midway	457 420
Weyerhaeuser Canada Ltd., Kamloops	71 520
Total	528 940

Timber Sale Licences

Licensee	Approved AAC in m ³
W. Bannert	420
S. & O. Sawmills Ltd., Christina Lake*	2 080
James Forshaw Ltd., Greenwood	8 430
Gorman Bros. Lumber Ltd.	4 000
T.T. Hamagami	680
T.J. Kelly, Rock Creek	640
Total	16 250

* out of business.

Tree Farm Licences (#8)

Licensee	Approved AAC in m ³
Pope and Talbot Ltd.	145 000

(British Columbia 1984, unpub.)

Infestations of mountain pine beetle are a problem with this species and a great deal of salvage logging is being undertaken in the Basin in efforts to manage this pest. As a result of salvage logging, Pope and Talbot are harvesting nearly 150 percent of their annual allowable cut on Tree Farm Licence #8 and just more than 100 percent of the annual allowable cut on the Kettle Public Sustained Yield Unit is being harvested. Spruce bark beetle infestations and mistletoe infections also occur in the Basin but, as yet, are considered minor problems.

Pope and Talbot Ltd. employs 580 people directly and 275 people indirectly. The two mills produce 185 million board feet of lumber and about 90,000 units of pulp chips annually. Pope and Talbot has been able to operate continuously despite market conditions and has provided relatively stable employment to the region. There has been a reduction of 44 people in recent years, 24 of these were in September 1985 due to mill modernization at Midway (discussed below).

Pope and Talbot produces a variety of lumber products including decking, machine-stress rated lumber, siding, wood chips, and hog fuel. The biggest market is the United States although some lumber is sold domestically, mostly to the prairie provinces. As mentioned above, wood chips are sold to the Westar Mill in Castlegar; some are also sold to the United States. Most of the hog fuel is shipped to the Washington State Power plant at Kettle Falls.

Pope and Talbot has recently embarked on a \$19 million, three-year modernization plan to increase timber utilization at both the Grand Forks and Midway mills. The modernization is expected to slightly increase productivity at Grand Forks from 414 296 m³ to 438 095 m³; this phase will cost \$9 million and result in the loss of two to three jobs. The \$10 million Midway modernization will not increase productivity but will increase utilization therefore creating less waste and higher quality by-products (Pope and Talbot 1985).

There are several companies in the Basin in the wood manufacturing industries. Canpar Industries, employing 33 people, operates a particle board manufacturing plant in Grand Forks using a sawdust by-product from Pope and Talbot's Grand Forks mill. This company was recently

established to reopen the plant after Parta Industries closed; the changeover resulted in a loss of 50 jobs to the region. Interior Mill Equipment Ltd., a subsidiary of Boundary Industries Ltd., designs and manufactures equipment for the lumber and mining industries. This operation employs 70 people while another 50 work for Interior Mill Construction Ltd. which installs and services the equipment. Sandner Bros. sawmill and trucking operation at Christina Lake closed in 1984 resulting in a loss of 50 jobs and 12 more in related logging activities.

Despite the depressed market conditions, the outlook for Pope and Talbot, Canpar, and the small specialty industries looks promising. All companies are hoping to expand their markets in the United States. There is a potential for additional manufacturing plants; however, distance to markets is a problem. Cottage industries supplying specialty items to the local market are a possibility.

The future of the forest industry in the region depends not only on the outcome of the free trade negotiations but also on a secure supply of raw materials. Evidently, the Boundary TSA has recently come under pressure from adjacent licence holders who have exhausted their supply. A reduction in the TSA will certainly have an effect on the future economy of the Basin (RDKB & EDC 1985).

D. Mining

Until the Second World War, mining was the dominant economic activity in the Kettle-Granby River Basin. In the mid-1800's a significant gold rush in the McKinney area near Baldy Mountain drew considerable attention to the Basin. Later, in the early 1900's, Greenwood and environs became famous for copper production. Today, however, there are no major mineral producers in the Basin nor are there any prospects for large-scale mining activities. Mining in 1981 and 1982 was valued at \$4-\$5 million annually (table 9).

An upswing in market prices or the introduction of new technologies may bring some of the area's mineral deposits into small- to medium-scale production. Mineral inventories carried out in the Basin indicate significant reserves of copper, silver, gold, lead, and zinc. Uranium

TABLE 9. MINERAL PRODUCTION:
GREENWOOD MINING DIVISION

	1981	1982
	\$	\$
Gold	162,580	58,119
Silver	3,902,843	3,740,918
Lead	106,820	45,407
Zinc	114,395	76,308
Other	1,362	257
Total Metals	4,288,000	3,921,009
Industrial Minerals		
Granite Limestone	240,171	185,123
Structural Materials		
Lime, Sand & Gravel	502,807	407,937

Total Production Value	5,030,978	4,514,069

(RDKB & EDC 1985: 12)

and molybdenum are also found in the Basin. Mineral inventory maps at 1:125 000 and data are available from the B.C. Ministry of Energy, Mines and Petroleum Resources.

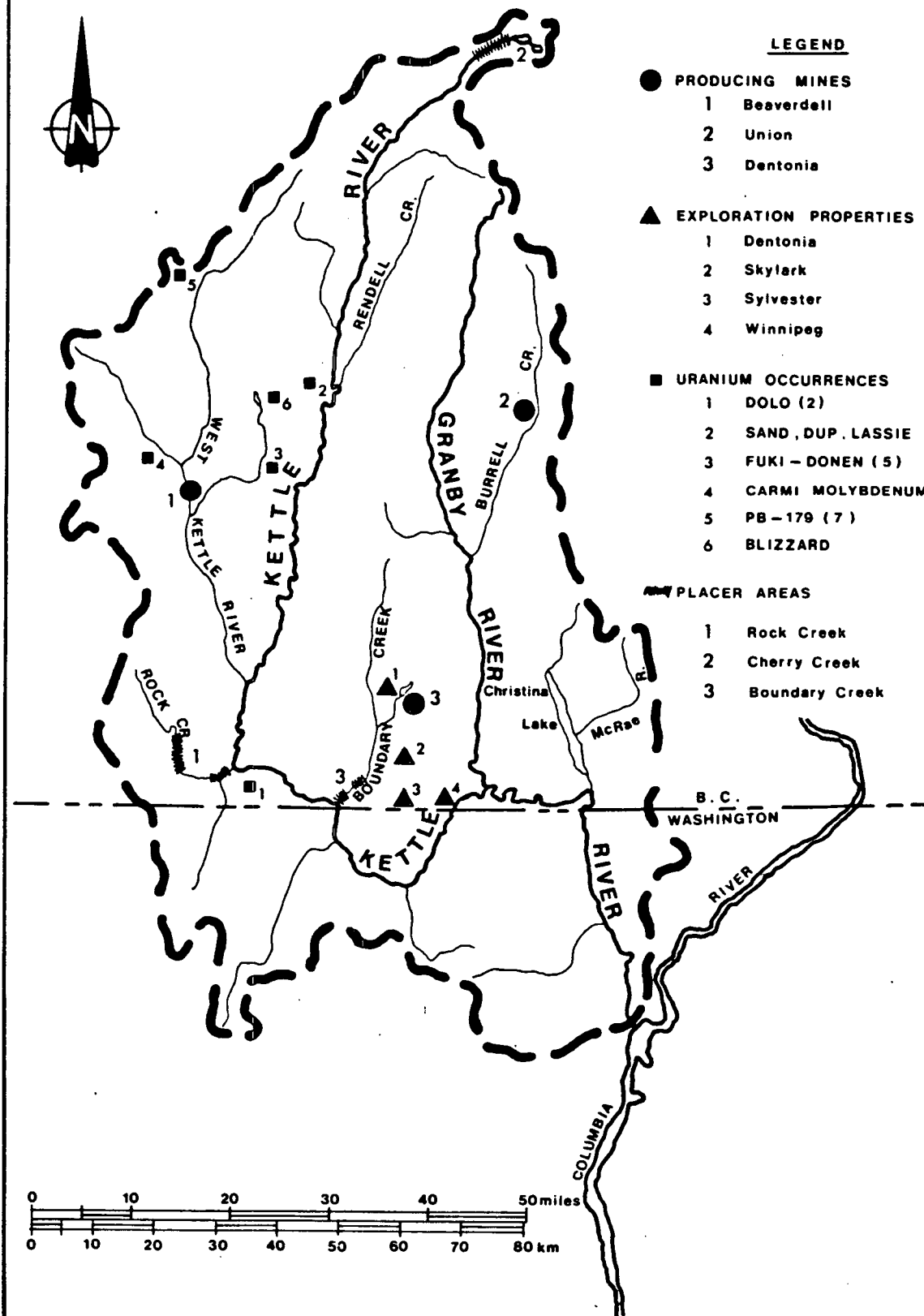
There are currently three small producing mines in the Basin: Beaverdell, Dentonia, and Union (fig. 6). Teck Corporation's Beaverdell Mine, known before 1970 as Highland-Bell, is a producing silver-lead-zinc mine and mill east of the community of Beaverdell. The operation employs 35-45 people, most of whom live in Beaverdell. The mine has operated since 1900 making it the longest producing mine in British Columbia; to date, it has produced approximately 40 million ounces of silver.

The mill operates year round averaging 110 tons of ore or 1000 ounces of silver per day. The cutoff grade varies with market price; if prices increase previously abandoned sections of the mine may be reactivated. The ore is trucked to the nearby mill where it is weighed, sorted, and crushed. Each month the crushed ore concentrates are trucked to Cominco's smelter in Trail. It is not known how long the mine will remain in production (Goetting, n.d.).

A small gold mine at Jewel Lake, 11 kilometres northeast of Greenwood, is operated by Dentonia Resources Ltd. The Dentonia mine employs three people and produces mostly gold, but also some silver, lead, zinc, and copper. The ore is milled at Robert's Mines, a nearby mine and mill operation which operates periodically depending on gold prices.

The most recent mine opening is Pearl Resources Ltd. reworking of the abandoned Union gold mine on Burrell Creek, 75 kilometres north of Grand Forks. The six-man operation includes exploration of new areas, reworking and rehabilitation of the old mine shafts, and remilling of old tailings and dumps. A major aspect of this project is the remilling of the tailings which will be carried out using a cyanide heap-leaching process. Environment Canada reviewed the mine application and commented "proper operation of the heap-leaching facilities with appropriate environmental controls will ensure no significant impact on water quality at the international boundary" (Canada May 1985). Data indicates that 60 000 to 85 000 tonnes of untreated tailings grading about 0.05 ounces

Figure 6
Producing Mines and
Major Exploration Properties



gold and 1.502 silver are available for leaching. There is also 18 000 tonnes in three dumps grading 0.065 ounces gold and 1.9 ounces silver for crushing then leaching.

A valuable resource in the Boundary Region is mining slag, notably the deposits at Grand Forks and Greenwood. Pacific Abrasives and Supply Inc., which has been operating in Grand Forks for 15 years, produces graded abrasives in bulk or by bag. A major use for the product is in sandblasting paint from United States navy and merchant marine ships and equipment. The company currently employs six to eight people but is looking forward to future expansion (RDKB & EDC 1985: 13).

Pacific Enercon Inc. has been operating in Grand Forks for six years and manufactures a mineral wool insulation called "Energlas". This new product offers greater insulation value and sound deadening properties than traditional fibreglass. The company has a 4923 square metre plant and employs 50 people. The business has improved tremendously in recent years and Enercon hopes to increase its markets and products within the next couple of years. An important by-product worth mentioning is abundant, high-quality, clean waste-heat which is presently not utilized.

Until recently, the Boundary Region had two quarries: Mighty White Dolomite at Rock Creek and V.T.S. Quarry at Grand Forks. Mighty White produces white stucco sands, landscaping gravel, and commercial filler. The company employs 11 people and ships to markets throughout Western Canada and Washington. Mighty White has plans for new products and plant expansion, although high transportation costs are cited as the major constraint to development.

The V.T.S. Quarry employed eight people until it closed in 1984. The operation may reopen on a reduced scale in the future (RDKB & EDC 1985).

Placer mining activities occur periodically in the Basin depending on the price of gold. There are several creeks designated for placer mining in the Basin, two of which have been worked recently: Rock Creek and Cherry Creek (fig. 6). Rock Creek includes the McKinney area and was extensively worked during the gold rush. It is unlikely that a significant placer industry will develop here. In 1984, Orocan Placer Inc. worked three claims covering 1000 square metres on McKinney Creek

(MacQuarrie 1985). Some hand panning was carried out on several leases in the Cherry Creek Designated Area, near the headwaters of Kettle River. There was no reported placer activity in either area in 1985.

There is a considerable amount of exploration activity in the Basin, although levels have dropped off recently. In 1980, the Greenwood Mining Division recorded 1630 new claims; 1094 in 1981; 1503 in 1982; 4394 in 1983; and 1386 in 1985 (British Columbia & Yukon Chamber of Mines 1984: 11). The four major exploration properties in 1984 focussed on precious metals. These properties include Skylark, 2.4 kilometres east of Greenwood, a new silver and gold discovery by Skylark Resources and Viscount Resources that may go into production at 90 tonnes per day in 1986; the Winnipeg Mine, drilled by Consolidated Boundary Exploration and Grand Forks Mines Ltd. and yielding gold values; Sylvester K deposit, near Greenwood, a joint venture by Kettle River Resources and Noranda Exploration Co. Ltd.; and Jewel Lake, developed by Dentonia Resources Ltd. yielded new ore. Another potential producer is the 30 million ton molybdenum deposit at Carmi grading 0.1 percent. A more detailed list of exploration activities by company in 1984 is given in appendix 2.

During the early 1970's, the Kettle-Granby River Basin was gaining importance for its uranium prospects. At least six major radioactive occurrences are found in the Basin (fig. 6). If uranium mining is approved in British Columbia, the Basin, especially the Beaverdell area, could receive significant economic benefits. However, since the environmental costs of mining uranium remain uncertain, it is unlikely that uranium will provide any economic benefit to the Basin in the foreseeable future.

There is one final issue which has not been included in this report's terms of reference. The mineralization which has provided much economic benefit to the Basin also continues into Washington State where many of the same patterns of development are evident. There is at least one mine -- Vulcan, near Danville, Washington, three kilometres southwest of Grand Forks -- that is using a cyanide-heap leaching process to treat mine tailings. In view of these activities, the Water Quality Branch, IWD recently began monitoring for cyanide at all international boundary

crossings in the Kettle-Granby River Basin. As mentioned earlier, if adequate environmental controls are adopted there should be no water quality degradation across the boundary.

E. Agriculture

Agriculture does not provide significant economic benefits to the region; however, it is important culturally. In the 1960's, the Christian Valley area became an enclave for communal homes and farms striving for self-sufficiency; many groups did not succeed but several have stayed on and achieved their goal. Others augment their income with part-time work in other sectors of the economy. There are over 350 farms or ranches in the Basin; most of these are small and not self-supporting (table 10). Only 75 people are employed full-time in agriculture.

The major agricultural activity in the Basin is ranching; correspondingly, hay and forage - mostly alfalfa - are the major crops. The numbers and variety of livestock and hectares of crop types are provided in table 11. Seed potatoes are gaining in importance and comprise 55 percent of vegetable production. Recently, nurseries, orchards, asparagus, and specialty garden produce have been doing well while market gardens are declining in importance. A study is underway by the Boundary Agricultural Development Society to determine the feasibility of establishing fruit and vegetable processing industries in the Basin. Most of the farming occurs in the Grand Forks area and the southern valleys, while ranching dominates the McKinney and Bridesville areas. Ranchers have been facing low commodity prices lately making it difficult to sustain operations. Sheep and lamb production may offer possibilities in the future. In the summer, agricultural water demands are high but there is still irrigable land and water available for expansion (RDKB 1979). However, it is unlikely that the agricultural sector will increase significantly due to competition from southern markets and transportation costs.

F. Tourism, Recreation, and Parks

Tourism is not a major employer in the Basin but revenue from tourism has grown since the 1970's. From 1980-1984 tourism revenues increased

TABLE 10. FARM SIZE

Hectares	(Acres)	Total
0.4 - 1.1	(1-2)	5
1.2 - 3.9	(3-9)	63
4.0 - 28.2	(10-69)	115
28.3 - 97.1	(70-239)	71
97.2 - 161.8	(240-399)	45
161.9 - 226.6	(400-559)	23
226.7 - 307.6	(560-759)	16
307.7 - 485.7	(760-1199)	16
485.8+	(1200+)	17
		<hr/> 371

(Canada 1981)

TABLE 11. AGRICULTURAL DATA FOR THE
KETTLE-GRANBY RIVER BASIN

Crops	Hectares
Grains & Oil Seed	904
Hay & Fodder Crops	6707
Other Crops	177
Tree Crops	36
Berries & Grapes	0.8
Vegetables	116
Improved Pasture	3438
Irrigated Area	3291
<hr/>	
Livestock	Number
Cattle	18,607
Cows (dairy)	1,158
Cows (beef)	6,911
Heifers (for dairy)	185
Heifers (for beef)	1,749
Heifers (for slaughter)	596
Steers	1,164
Calves	6,279
Pigs	1,638
Sheep	575
Horses & Ponies	693
Hens & Chicken	12,020
Turkeys	394
Geese	139
Ducks	270

(Canada 1981)

38 percent to \$90 million compared to a 27 percent increase for the province. Conversely, from 1980-1984 there has been a 7.5 percent decline in overnight visits compared to a 1.5 percent decline for the province as a whole (RDKB & EDC 1985: 21-24). This is, in part, attributable to a significant drop in revenues in 1983 and a slow recovery. The Kootenay Country Tourism Association has recently been established and is providing a coordinated marketing effort which should increase tourism in the Basin. The promotion of Highway 3 as the scenic Crowsnest Route, Expo 86, and the 1988 Olympics are all hoped to add to tourism revenues in the Basin.

There are three main tourist and recreation destination areas in the Basin: Big White and Baldy Mountain ski areas and Christina Lake. Big White, 45 kilometres east of Kelowna, is becoming a major destination resort drawing skiers from Western Canada and the northwestern United States. The area offers good facilities, multiple chairlifts, a variety of skiing terrain, restaurants, bars, and ample on-site accommodations. Baldy Mountain, 15 kilometres north of Bridesville, also has excellent powder skiing although on a smaller scale than Big White. There are two T-bars and a rope tow, restaurant and bar, and numerous private chalets and condominiums. Baldy Mountain draws skiers from the Kettle River Basin as well as the Southern Okanagan. A new access road from Oliver opened in 1984 and is expected to increase use of the area. There is also a small ski hill near Greenwood.

Christina Lake, 19 kilometres east of Grand Forks, offers warm water swimming and most water sports in the summer. The lake area has approximately 1100 permanent residents and 900 summer residences. There is limited road access to the lake due to the surrounding steep, rugged mountain slopes. The terrain also limits the kinds of recreational activities available, for instance, hiking, hunting, and camping opportunities are restricted. The area does have an international cross-country ski trail system. The Christina Lake Study (RDKB 1975) identified potential resource management concerns associated with logging in the watershed, inadequate disposal sewage for waterfront homes, and the need for controlled development and better services.

The lower portions of the Kettle River provide good opportunities for camping, angling, canoeing, swimming, and wildlife viewing. In many places throughout the Basin pioneer history can be observed in the form of abandoned mines, smelters, and tailings; historic buildings, bridges, and railway stations; and, museums. Horseback riding and cross-country skiing are popular activities with the residents. The use of all-terrain vehicles is also popular but is damaging rangeland in several areas.

The Basin's communities offer various recreational activities for residents and tourists alike, including ball diamonds, ice curling rinks, swimming pools, playing fields, and a golf course. Grand Forks has six parks and playgrounds, but according to population-to-park ratios the land area devoted to parks is below average. The community is hoping to have a new recreation center and indoor swimming pool soon and there is discussion of re-creating Smelter Lake for recreation.

Historically, the Kettle River area was well known as a white-tailed and mule deer hunting area. However, there has been a decline in hunting and wildlife populations in recent years due to the loss of habitat from fire suppression, over-grazing, mineral exploration, improved access, and weed infestations. Coordinated Resource Management Plans, supervised by the B.C. Ministry of Forests, are being undertaken in several areas of the Basin to provide better habitat management.

The Kettle River and headwater lakes provide good fishing opportunities, particularly rainbow trout, bass, and kokanee. As mentioned earlier, overuse of water for irrigation in the West Kettle River in the summer often causes fishkills.

Parks

The Basin has nine provincial parks covering an area of 1067 hectares and two ecological reserves (fig. 7). Conkle Lake Park is the largest and covers over half of the Basin's total park area. A complete list of parks, their areas, and use is given in table 12.

Ole Johnson Park is accessible only by boat and Conkle Lake is accessible by off-road vehicle. Six of the parks have water systems; eight have toilets. Jewel Lake, established in 1981, has neither toilets nor a water system.

Figure 7
Provincial Parks

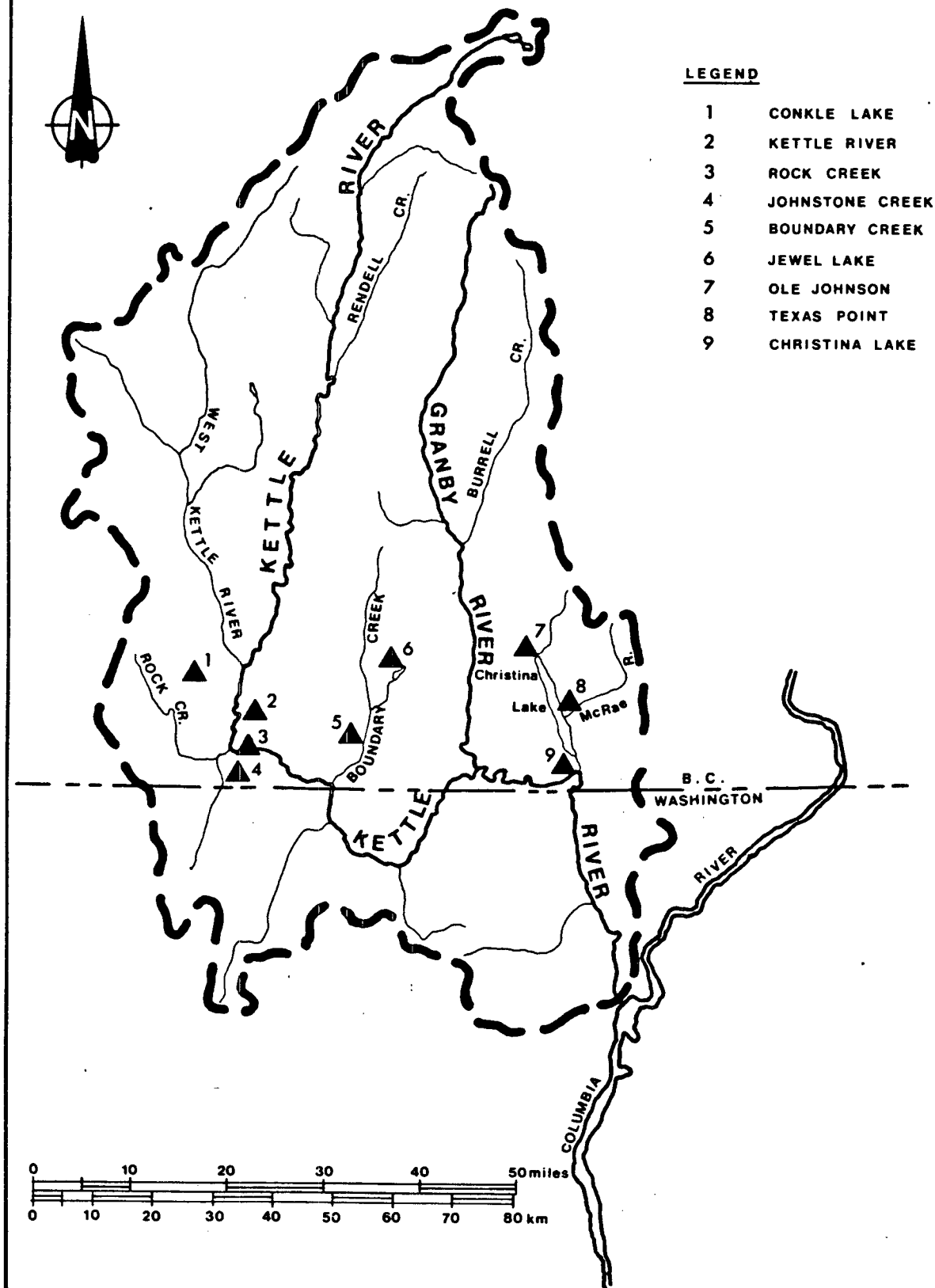


TABLE 12. PROVINCIAL PARK DATA

Park	Area (hectares)	Campsites	Campground (people)	Day-Use (people)	Boating (boats)	Activities (people)
Boundary Creek Class A6	2	18	3 738	37 611	-	-
Christina Lake Class A6	6	0	-	100 712	-	-
Conkle Lake Class A6	587	24	3 088	1 498	-	-
Jewel Lake Class A	49	0	-	-	-	-
Johnstone Creek Class A3	38	16	4 077	18 085	-	-
Kettle River Rec-Area	179	49	12 038	26 582	-	3 416
Ole Johnson Class A6	15	10	-	-	797	-
Rock Creek Class C4	2	6	-	-	-	-
Texas Point Reserve	189	10	5 574	36 344	-	-
TOTALS	1 067	133	28 515	220 832	797	3 416

(British Columbia 1985g: 28)

There are no provincial parks along the Kettle River upstream of Westbridge although a number of sites are proposed for park development. The sites most likely to be developed, in order of priority, are Thone Creek, Canyon Creek, Damfino Creek, and Nevertouch Lake (RDKB 1979: 87). There is currently a forest service road which connects Christian Valley with Highway #6 and Vernon. This road and nearby headwater lakes have numerous camping and picnicking spots which are well kept by the B.C. Forest Service (British Columbia 1985f).

In the eastern section of the Basin, the proximity of Grand Forks to Christina Lake and the narrowness of the Granby Valley indicates little need and poor potential for park development. Christina Lake is a major recreational resource for people who live in the area and accommodates a large number of day users (table 12). All of the existing and proposed parks in the Kettle-Granby River Basin are water-related with a lake or stream as the focus.

Two ecological reserves have been established in the Basin. A 124 hectare reserve northeast of Little White Mountain protects a marsh area with many varieties of wild flowers and a 951 hectare reserve near Big White Mountain protects representative sub-alpine and alpine plant communities (British Columbia 1983).

4. SUMMARY AND CONCLUSIONS

The Kettle-Granby River Basin drains an area over 8200 square kilometres in Canada. The Kettle River is approximately 290 kilometres long and crosses the international boundary three times. The Kettle rises in the Monashee Mountains of British Columbia's southern interior and flows south to Rock Creek then east to Midway. The Kettle loops through the State of Washington and returns to Canada near Grand Forks where it is joined by a major tributary, the Granby River, before continuing east to Christina Lake. Turning south, the Kettle flows across the international boundary, for the third time, and eventually joins the Columbia River at the reservoir of the Grand Coulee Dam. The Kettle's major tributaries include the West Kettle River, Boundary Creek, Granby River, and Christina Lake.

The Basin has two distinctive physiographic subdivisions: rolling plateaux west of the Kettle River which are part of the Okanagan Highland; and the Monashee Mountains east of the Kettle River. Both the plateaux and mountains are dissected by north-south trending rivers with steep-walled valleys in the upper reaches and wide U-shaped valleys along the international boundary. The climate is dominated by moderating air movements from the Pacific Ocean although influxes of Arctic air are common in winter. Temperatures average 15.5°C in June and -9.5°C in January with a frost-free season around 60 days.

Total mean annual discharge in the Kettle-Granby River Basin is about 2.6 million cubic decametres (approximately 203 million acre feet). Seasonal flow patterns are characterized by peak discharges in May or June from snowmelt and spring rains with minor peaks in October or November from rainstorms. Minimum flows occur from August to March, with insignificant flows in many of the smaller streams and tributaries. Water quality is generally considered good, although placer and slag-mining operations and sewage disposal from municipalities and Christina Lake area are closely monitored.

The Basin supports a variety of wildlife with mule deer the most abundant ungulate species. Critical winter habitat is limited, a problem which has been exacerbated in recent years due to fire suppression

policies, over-grazing, forestry and mining activities, weed infestations, and power and road right-of-ways. The provincial Fish and Wildlife Branch is working with the area's ranchers and foresters to improve habitat management techniques. The Basin offers good sport fishing opportunities in many streams and headwater lakes, particularly rainbow trout, bass, and kokanee. Heavy irrigation demands in summer cause low flows, warm water temperatures, and fishkills in the West Kettle River.

Mining was the first major catalyst to economic activity in the Basin. A gold rush in the McKinney area in the mid-1800's was followed by significant copper production near Greenwood during World War I. Today, the Basin's major economic activity is forestry. Two mills operated by Pope and Talbot Ltd. directly and indirectly employ many of the Basin's residents. The future of the forest industry in British Columbia will dictate, in large part, the future economic prosperity of the Boundary Region. Currently, the annual allowable cut is being exceeded and there is some discussion that timber allotment will be reduced.

There are three small operating mines in the Basin, producing mostly gold and silver. Several companies are using slag deposits to produce by-products such as abrasives and insulation. Placer mining activities occur periodically at several designated locations, depending on the price of gold. There is considerable exploration activity in the Basin, with several deposits rated as potential producers. Significant uranium occurrences were identified in the 1970's prior to the moratorium.

Agriculture, particularly ranching on the plateaux and farming near Grand Forks, remains a relatively stable but minor contribution to the Basin's economy. Tourism and recreation are gaining importance. Big White, 45 kilometres east of Kelowna, is becoming a major ski destination resort while Christina Lake offers summer water-based activities. Pioneer history abounds for the tourist: museums, abandoned mines and smelters, historic buildings and sites, and derelict railway stations are prevalent. Fishing, canoeing, horseback riding, and cross-country and downhill skiing are popular activities for the Basin's residents. All-terrain vehicles are also popular but have caused some habitat deterioration in several areas.

The Kettle-Granby River Basin is a unique area in British Columbia; it is rich with history, ethnic groups, and natural resources. There are several resource use concerns in the Basin; most can be alleviated with effective planning and management and most are under provincial jurisdiction. An overriding concern to the Basin's residents is their future economic survival. The Basin's economy is strongly linked to the forest and wood processing industries. Diversification into other sectors of the economy such as fruit processing, slag by-products, sheep ranching, seed potato nurseries, specialty crops, and tourist promotion would help to lessen the negative effects of this staple-dependent economy.

Resource management concerns associated with forest harvesting - its effects on visual landscapes, water quality, rangeland and wildlife habitat - are the responsibility of the Ministry of Forests and, for the most part, are being handled by that agency through the creation of Coordinated Resource Management Plans.

The Regional District of Kootenay-Boundary has prepared various documents relating to land use in the Basin. The "Christina Lake Study" identifies many concerns of a local nature such as shoreline development, improved beach access and services, and water supply and water quality problems. The study also offers policy recommendations to solve these problems.

There are no federal lands in the Basin such as Indian Reserves and national parks. Neither are there anadromous fisheries in the Basin which may warrant attention from the Department of Fisheries and Oceans. At present, there seems to be few areas of concern or involvement for the federal government, particularly the Inland Waters Directorate. Water quality deterioration from increased slag-mining operations and inadequate sewage disposal systems in Canada could be a problem in the future, although the Directorate's routine monitoring program should be adequate to detect water quality changes from these activities. Any future development on either side of the boundary which may affect water quality or quantity on the other side could require federal involvement as the Kettle is an international river.

Activities in the State of Washington were not reviewed during this study and represent an area worthy of further investigation. In 1985, residents in Grand Forks complained of potential water quality deterioration from a cyanide-leaching operation near Danville, Washington. While the Inland Waters Directorate is now monitoring all three border crossings for cyanide levels and to date have found no evidence for alarm, water quality deterioration from other United States' activities, such as sewage disposal and placer and other mining operations, remains a potential problem.

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**APPENDIX 1. HISTORICAL CLIMATE DATA FOR
SELECTED STATIONS**

CARM		LATITUDE 49 30 N LONGITUDE 119 05 W ELEVATION 4084 FT ASL													
MEAN DAILY TEMPERATURE (DEG F)	17.5	24.3	28.6	38.0	47.0	52.9	59.9	58.5	51.4	40.6	27.7	20.9	38.9	2	
MEAN DAILY MAXIMUM TEMPERATURE	23.6	31.8	37.6	47.9	57.8	63.6	73.0	71.1	63.1	48.9	33.1	26.3	48.2	2	
MEAN DAILY MINIMUM TEMPERATURE	11.3	16.6	19.6	27.9	36.2	42.1	46.8	45.7	39.6	32.3	22.2	15.5	29.7	2	
EXTREME MAXIMUM TEMPERATURE	48	55	62	76	83	88	95	97	87	79	64	46	97	1	
NO. OF YEARS OF RECORD	30	31	30	30	30	30	30	30	30	30	30	30	30		
EXTREME MINIMUM TEMPERATURE	-31	-23	-21	10	15	28	32	31	23	12	-21	-37	-37	1	
NO. OF YEARS OF RECORD	30	31	31	30	30	30	30	30	30	30	30	30	30		
NO. OF DAYS WITH FROST	31	28	30	24	10	1	*	*	4	16	28	31	203	2	
MEAN RAINFALL (INCHES)	0.05	0.07	0.13	0.53	1.62	2.33	1.47	1.68	1.39	0.93	0.45	0.08	10.73	2	
MEAN SNOWFALL	24.5	17.4	13.2	8.6	2.3	7	0.0	0.0	0.4	6.4	16.6	24.5	113.9	2	
MEAN TOTAL PRECIPITATION	2.51	1.80	1.47	1.39	1.86	2.33	1.47	1.68	1.42	1.57	2.12	2.53	22.15	2	
GREATEST RAINFALL IN 24 HRS	0.40	0.91	0.95	1.03	1.07	1.25	1.74	2.52	2.68	0.78	3.87	1.00	3.87	1	
NO. OF YEARS OF RECORD	33	33	32	32	32	32	32	32	31	30	31	30	30		
GREATEST SNOWFALL IN 24 HRS	12.6	8.9	8.8	11.0	5.0	0.1	7	0.0	2.8	22.5	11.4	8.0	22.5	1	
NO. OF YEARS OF RECORD	31	33	32	32	32	32	32	32	31	31	31	30	30		
GREATEST PRECIPITATION IN 24 HRS	1.26	0.91	0.95	1.10	1.07	1.25	1.74	2.52	2.68	2.25	3.87	1.00	3.87	1	
NO. OF YEARS OF RECORD	31	33	32	32	32	32	32	32	31	30	31	30	30		
NO. OF DAYS WITH MEASURABLE RAIN	1	1	2	4	10	12	7	9	8	8	3	1	66	2	
NO. OF DAYS WITH MEASURABLE SNOW	17	13	11	6	2	*	0	0	8	4	11	17	81	2	
NO. OF DAYS WITH M. PRECIPITATION	17	14	12	9	11	12	7	9	8	11	14	17	141	2	

GRAND FORKS		LATITUDE 49 02 N LONGITUDE 118 28 W ELEVATION 1746 FT ASL													
MEAN DAILY TEMPERATURE (DEG F)	20.3	28.1	36.3	46.7	54.9	61.2	67.5	65.6	57.8	45.5	33.1	24.8	45.2	1	
MEAN DAILY MAXIMUM TEMPERATURE	27.9	37.3	47.3	60.1	69.2	75.3	84.9	82.7	73.7	57.4	40.2	31.3	57.3	1	
MEAN DAILY MINIMUM TEMPERATURE	12.6	18.8	25.3	33.3	40.6	47.0	50.1	48.6	41.8	33.5	25.9	18.4	33.0	1	
EXTREME MAXIMUM TEMPERATURE	61	67	71	86	97	108	103	98	86	63	77	108	108	1	
NO. OF YEARS OF RECORD	29	30	29	30	30	30	30	30	30	30	28	30	30		
EXTREME MINIMUM TEMPERATURE	-38	-31	-9	17	17	29	34	32	21	12	-10	-36	-38	1	
NO. OF YEARS OF RECORD	29	30	30	30	29	28	29	29	30	30	30	30	30		
NO. OF DAYS WITH FROST	30	27	26	14	4	0	0	0	3	14	23	29	170	2	
MEAN RAINFALL (INCHES)	0.44	0.59	0.78	0.98	1.64	2.02	0.84	1.27	1.09	1.53	1.17	0.54	12.89	1	
MEAN SNOWFALL	15.2	7.9	2.5	0.4	0.0	0.0	0.0	0.0	0.0	0.4	5.2	16.6	44.2	1	
MEAN TOTAL PRECIPITATION	1.96	1.38	1.03	1.02	1.64	2.02	0.84	1.27	1.09	1.57	1.69	2.20	17.71	1	
GREATEST RAINFALL IN 24 HRS	0.58	0.67	0.71	0.86	1.23	1.63	0.83	1.09	0.96	1.08	0.59	0.59	1.63	1	
NO. OF YEARS OF RECORD	30	29	30	30	30	30	30	29	30	30	30	30	30		
GREATEST SNOWFALL IN 24 HRS	16.0	10.0	7.0	4.0	7	0.0	0.0	0.0	0.0	3.0	7.0	12.0	16.0	1	
NO. OF YEARS OF RECORD	30	30	30	30	30	30	30	30	30	30	30	30	30		
GREATEST PRECIPITATION IN 24 HRS	1.60	1.00	0.71	0.86	1.23	1.63	0.83	1.09	0.96	1.08	0.70	1.20	1.63	1	
NO. OF YEARS OF RECORD	30	29	30	30	30	30	30	29	30	30	30	30	30		
NO. OF DAYS WITH MEASURABLE RAIN	3	4	6	7	10	11	5	7	7	9	8	4	81	1	
NO. OF DAYS WITH MEASURABLE SNOW	10	5	2	*	0	0	0	0	0	8	4	10	31	1	
NO. OF DAYS WITH M. PRECIPITATION	13	9	8	8	10	11	5	7	7	9	12	14	113	1	
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	TYPE

GREENWOOD		LATITUDE 49 05 N LONGITUDE 118 41 W ELEVATION 2490 FT ASL													
TEMP. MOYENNE QUOTIDIENNE (DEG F)	19.0	26.8	33.9	43.4	51.6	57.1	62.9	61.0	53.8	43.7	32.0	23.3	42.4	1	
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	26.7	35.7	45.2	57.5	67.2	72.9	81.5	79.9	71.5	57.5	41.2	30.7	55.6	1	
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	11.2	17.8	22.4	29.4	36.0	41.4	44.1	42.1	36.0	29.8	22.7	15.8	29.1	1	
TEMPERATURE MAXIMALE	53	56	75	92	95	102	110	104	99	91	68	55	110	1	
NOMBRE D'ANNEES EN RECORD	54	57	54	55	58	60	58	59	58	60	58	59	59		
TEMPERATURE MINIMALE	-38	-41	-13	-3	19	24	29	25	15	-4	-14	-40	-41	1	
NOMBRE D'ANNEES EN RECORD	55	57	53	56	58	60	58	58	58	60	59	59	59		
NOMBRE DE JOURS DE GEL	30	27	29	23	9	1	0	1	9	21	27	31	208	2	
HAUTEUR DE PLUIE MOYENNE (POUCES)	0.16	0.26	0.50	0.89	2.20	2.40	1.03	1.20	1.12	1.20	0.71	0.24	11.91	2	
CHUTE DE NEIGE MOYENNE	20.9	11.7	7.0	1.9	0.1	0.0	0.0	0.0	0.0	1.3	8.7	17.5	69.1	2	
PRECIPITATION TOTALE MOYENNE	2.25	1.43	1.20	1.08	2.21	2.40	1.03	1.20	1.12	1.33	1.59	1.98	18.82	2	
PLUIE MAXIMUM EN 24 HEURES	1.00	1.00	1.00	1.50	4.20	2.00	1.50	2.00	1.00	1.00	1.90	1.00	4.20	1	
NOMBRE D'ANNEES EN RECORD	57	56	57	55	56	59	57	59	60	60	60	58	58		
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	18.4	15.0	10.0	5.5	1.5	0.0	0.0	0.0	3.0	7.0	13.8	14.0	18.4	1	
NOMBRE D'ANNEES EN RECORD	57	55	56	57	57	60	59	60	60	60	60	58	58		
PRECIPITATION MAXIMUM EN 24 HEURES	1.89	1.50	1.00	1.50	4.20	2.00	1.50	2.00	1.00	1.00	1.90	1.40	4.20	1	
NOMBRE D'ANNEES EN RECORD	57	55	56	55	56	59	57	59	60	60	60	58	58		
NOMBRE DE JOURS AVEC PLUIE MESURABLE	1	2	3	5	9	10	5	5	6	7	4	2	59	2	
NOMBRE DE JOURS AVEC NEIGE MESURABLE	9	6	4	1	0	0	0	0	0	1	5	8	34	2	
NBRE DE JRS AVEC PRECIPITATION MBLE.	10	8	7	7	9	10	5	5	6	7	8	10	92	2	

MCCULLOCH		LATITUDE 49 48 N LONGITUDE 119 12 W ELEVATION 4100 FT ASL															
TEMP. MOYENNE QUOTIDIENNE (DEG F)	16.0	22.1	25.8	35.3	44.6	50.7	56.0	54.6	48.2	39.1	26.5	20.0	36.6	1			
TEMPERATURE MAX. QUOTIDIENNE MOYENNE	25.0	33.0	38.1	47.8	58.7	65.0	72.7	71.6	63.3	50.3	35.1	28.2	49.1	1			
TEMPERATURE MIN. QUOTIDIENNE MOYENNE	6.8	11.2	13.5	22.8	30.4	36.3	39.2	37.7	33.1	27.8	18.0	11.7	24.0	1			
TEMPERATURE MAXIMALE	53	53	63	76	87	87	98	93	87	77	65	45	98	1			
NOMBRE D'ANNEES EN RECORD	34	35	35	35	35	33	35	34	34	34	34	34					
TEMPERATURE MINIMALE	-43	-38	-35	-15	9	19	24	22	14	5	-34	-43	-43	1			
NOMBRE D'ANNEES EN RECORD	34	35	35	35	34	34	35	35	35	35	34	34					
NOMRE DE JOURS DE GEL	31	28	31	28	21	9	4	7	15	23	29	31	257	2			
HAUTEUR DE PLUIE MOYENNE (POUCES)	0.04	0.09	0.16	0.69	1.94	2.72	1.84	1.84	1.88	1.12	0.28	0.03	12.63	1			
CHUTE DE NEIGE MOYENNE	28.8	22.6	18.3	11.2	3.4	7	0.0	0.0	0.3	8.4	20.8	31.3	145.1	1			
PRECIPITATION TOTALE MOYENNE	2.92	2.35	1.98	1.83	2.28	2.72	1.84	1.84	1.90	1.96	2.36	3.16	27.14	1			
PLUIE MAXIMUM EN 24 HEURES	0.35	0.31	1.01	1.21	1.14	2.28	1.66	1.09	1.19	0.99	0.58	0.45	2.28	1			
NOMBRE D'ANNEES EN RECORD	47	46	47	46	46	45	46	45	47	47	48	48					
CHUTE DE NEIGE MAXIMUM EN 24 HEURES	12.8	17.0	10.0	13.0	11.5	1.5	0.0	0.0	5.0	14.0	9.0	12.0	17.0	1			
NOMBRE D'ANNEES EN RECORD	47	46	47	47	47	46	47	47	47	47	48	46					
PRECIPITATION MAXIMUM EN 24 HEURES	1.28	1.70	1.01	1.65	1.15	2.28	1.66	1.09	1.19	1.40	0.90	1.20	2.28	1			
NOMBRE D'ANNEES EN RECORD	47	46	47	46	46	45	46	45	47	47	48	46					
NOMRE DE JOURS AVEC PLUIE MESURABLE	*	1	2	4	10	13	8	9	9	7	2	*	65	1			
NOMRE DE JOURS AVEC NEIGE MESURABLE	14	11	11	7	1	*	0	0	*	4	11	15	74	1			
NOMRE DE JRS AVEC PRECIPITATION MBLE.	14	12	12	10	11	13	8	9	9	10	13	15	136	2			

(Canada, 1970)

APPENDIX 2. MINERAL EXPLORATION ACTIVITIES (1984)
(British Columbia and Yukon Chamber of Mines, 1984)

BAY ANN RESOURCES LTD. conducted trenching on its Amandy property in the Greenwood area, B.C.

BRICAN RESOURCES LTD. conducted geological, geochemical and geophysical surveys on the Walt property in the Greenwood area.

BUNYORO RESOURCES INC. owns the 20 unit May 1 claim situated on the southeast slope of Mount Attwood in the Phoenix Mining Camp.

CANADIAN PAWNEE OIL CORPORATION purchased a 95% share of GRENOBLE ENERGY LTD.'s interest in the Lexington property located southeast of Greenwood, B.C. Previous work in this property has outlined reserves estimated to contain 900,000 tons grading 1.19% copper and 0.171 oz./ton gold. The company also acquired the right to earn a 50% interest in CONSOLIDATED BOUNDARY's Crown-granted property located in the Phoenix camp where drilling in 1984 has indicated the presence of a mineralized zone containing significant gold-silver-copper mineralization.

CANSTAT PETROLEUM CORPORATION completed a program of diamond drilling to test three areas of mineralization on its Beaverdell property, 50 miles east of Kelowna, B.C.

CHROMEX NICKEL MINES LTD. completed diamond drilling on its low-grade Chromex nickel property near Christina Lake, B.C.

CIESTA GOLD EXPLORATION LTD. completed approximately one-third of a recommended program of geochemical and geophysical surveying on its Goldstream claim located 15 km southwest of Camp McKinney in the Osoyoos Mining Division of B.C.

CONSOLIDATED BOUNDARY EXPLORATION LTD. completed 1071 meters of drilling in 11 holes on its Crown group of mineral claims located in the Phoenix camp in southern B.C.

DENTONIA RESOURCES LTD. began production from its Jewel Mine located near Greenwood, B.C. The first shipment assayed 0.255 oz./ton gold and 2.1 oz./ton silver, and 84.7% silica. The company plans to continue producing in 1985.

DIPLOMAT RESOURCES INC. holds a 50% interest in the Mt. McKinney gold prospect in the Greenwood Mining Division. The company completed a trenching and sampling program with encouraging results. Further evaluation in favourable areas is planned for 1985.

FIRST WESTERN RESOURCES INC. holds the Chrome group in the Greenwood Mining Division about four km north of Rock Creek, B.C.

FORT KNOX MINERALS LTD. completed surface exploration on its 12 unit claim located three km southeast of Greenwood, B.C.

GRAND FORKS MINES LTD., in joint venture with CONSOLIDATED BOUNDARY EXPLORATION LTD., holds the Winnipeg property, a former gold producer, in the Phoenix camp, Grand Forks, B.C.

GRANVILLE RESOURCES INC. hold the Knob 1 property, located three km southwest of the Phoenix Mine property, on which a gold-silver vein has been located.

HIGHLAND VALLEY RESOURCES LTD. holds the Tel 4 mineral claim located seven miles northeast of Greenwood, B.C.

INTERNATIONAL TILLEX ENTERPRISES LTD. holds the 16 unit Italy claim located east of Christina Lake in the Greenwood Mining Division of B.C. A program of geochemical sampling and geological mapping indicated the presence of copper, gold and silver in scarny gossan zones containing pyrite and pyrrhotite.

KENERGY RESOURCE CORPORATION holds a group of claims in the Tillicum Mountain area of B.C. and has a 25% interest in a claim group located seven miles from the Sylvester K deposit in the Kettle River area of B.C.

KETTLE RIVER RESOURCES LTD., in joint venture with NORANDA EXPLORATION CO. LTD., holds three large claim blocks in the Greenwood area of B.C. Work completed in 1984 consisted of an airborne geophysical survey, detailed ground geophysics, geochemistry and geological mapping and the drilling of 953 feet in four holes. This drilling resulted in the discovery of a possible gold horizon rimming the old workings of the Brooklyn Mine. The program planned for 1985 consists of diamond drilling, trenching and further geophysical, geochemical and geological surveys.

LOST LAKE RESOURCES LTD. completed geological, geochemical and geophysical surveys on its Park claim located near Rock Creek, B.C. in the Greenwood Mining Division.

PALMYRIA RESOURCES CORP. holds the Hail 3 property in the Tillicum Mountain area and the Knob property near Greenwood, B.C.

PEARL RESOURCES LTD. conducted underground drifting and rehabilitation, underground drilling and sampling on its Union gold property located near Grand Forks, B.C.

PROMINENT RESOURCES CORPORATION optioned 17 Crown-granted and 38 contiguous mineral claims located 40 miles east of Grand Forks, B.C. from CONSOLIDATED BOUNDARY EXPLORATIONS LTD. and completed 1,300 feet of diamond drilling in a series of short holes. Geochemical, EM and magnetometer surveys were completed by the company on the rock mineral claim in the Greenwood Mining Division of B.C. The company also holds a property adjacent to the Eureka gold prospect.

QUADREX RESOURCES LTD. holds the 19 unit Set claims located 13 km from Greenwood, B.C. on the south slope of Mount Attwood.

QUILLO RESOURCES INC. conducted detailed geological, geochemical and geophysical surveys on its High II claim located 29 km east of Osoyoos, B.C. and four km west of Rock Creek.

QUINELLA EXPLORATION LTD. holds the Rock mineral claims located 32 km south of Beaverdell, B.C. Work on the property to date has indicated the presence of quartz veins containing sulphides and minor gold.

REX SILVER MINES LTD. conducted limited exploration programs on a number of properties in B.C. Significant gold values were obtained on the McKinney and Bird properties.

ROCKMASTER RESOURCES LTD. holds the Amber 1-5 claims located six km east of Beaverdell, B.C.

SCOTIA RESOURCES LTD. completed assessment work on its Legal Tender property near Greenwood, B.C. and then sold the property for 50,000 free trading shares of CONSOLIDATED BOUNDARY EXPLORATION LTD.

SHANDON RESOURCES INC. holds the six unit Dale claim located 10 km northeast of Greenwood, B.C.

SILVER CLOUD MINES LTD. is a joint venture partner with HIGHLAND VALLEY RESOURCES LTD. on the Jewel Lake property located 10 km north of Greenwood, B.C.

SILVERLEAF RESOURCES LTD. conducted detailed geological, geophysical and geochemical surveys on its Cann #2 mineral claim in the Canyon Creek area of the Greenwood Mining Division, B.C.

SKYLARK RESOURCES LTD. owns the Skylark claims and has an option on the adjoining OB claims located near Greenwood, B.C. The company completed a program of backhoe trenching and diamond drilling on the property in 1984. This work outlined a zone of silver-gold mineralization associated with a strong fault zone. A program of geophysical surveying and further diamond drilling is planned for 1985.

TARGET RESOURCES LTD. conducted surface exploration on its High 1 mineral claim located five km west of Rock Creek in the Greenwood Mining Division, B.C.

VISCOUNT RESOURCES LTD. completed a backhoe trenching program on its OB claims located near Greenwood, B.C. This work exposed a silver-bearing zone over a length of 325 feet. The company optioned the property to SKYLARK RESOURCES LTD. which conducted a diamond drill program on the property.

WESTBRIDGE RESOURCES LTD. completed geological, geochemical and geophysical surveys on its Rock 4 mineral claim located in the Camp McKinney area near Greenwood, B.C. This work located a southwestern anomalous silver-zinc zone that will be further evaluated by trenching, sampling, mapping and IP in 1985.

XENEX INDUSTRIES AND RESOURCES LTD. holds the 20 unit Gillis claim in the Greenwood Mining Division of B.C.

XING HAI RESOURCES LTD. conducted surface exploration on its Brown claim located in the Greenwood Mining Division of B.C.

ZUNI ENERGY CORP. optioned a 50% interest in its Camp McKinney property north of Osoyoos, B.C. to DIPLOMAT RESOURCES CORP. Zuni completed geophysical and geochemical surveys on the property prior to its optioning the claims.